

THE ECONOMICS OF ALTERNATIVE
PASTURE SYSTEMS IN RELATION TO
SIZE OF DAIRY HERD

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By

Geoffrey Harrison Wollen

AN ABSTRACT

Submitted to the College of Agriculture Michigan State University
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C. Raymond Hoglund

ABSTRACT

The purpose of this study was to investigate the economics of three alternative pasture systems - improved grazing, green chopping, and storage feeding - with particular emphasis on their relative profitability with different sizes of dairy herd.

The study was based on research data collected during a five year pasture study conducted from 1954 to 1958 by C. R. Hoglund, and on additional information obtained in a survey carried out by the author at the conclusion of the pasture study. A total of 60 farmers were included in the pasture study for periods of from one to five years, and information was obtained from 44 farmers in the survey.

Two approaches were used in this study. One was to make budgets for the three pasture systems at three sizes of dairy herd on a farm whose acreage was fixed, subject to specific assumptions. The inputs and outputs used were developed from the original pasture study, and the prices used were those typically found in Michigan during 1958 and the first four months of 1959. The acreage of the budget farm was near the modal acreage of the farms in the survey, and the three sizes of dairy herd were those found in the survey for 1954 and those which farmers expected to have in the future.

It was found that improved grazing was the most profitable system for a 30 cow herd on a 200 acre farm under the assumptions of the budgets, and that for a 60 and a 100 cow herd green chopping and storage feeding were both

more profitable than improved grazing, the latter more so than the former in both cases. The substitution of machinery, fuel, and labor for land, which is involved in going from an improved grazing system to a green chopping or storage feeding system, was thus found to become profitable as, with increasing herd size, the machinery was more fully used, and its cost spread over a greater output.

The second approach made in the study was to discover the changes which had actually been taking place on the farms in the survey from 1954 to 1958, and to discuss with farmers the reasons why they had made these changes.

It was found that from 1954 to 1958 the average acreage of the farms in the survey had increased from 188 to 210 acres, and the average size of dairy herd had increased from 31 to 45 cows. During the same period, 19 farmers had changed from an improved grazing system to a green chopping or storage feeding system. Of the 44 farmers, 16 were using a green chopping system in 1958, and 14 were using a storage feeding system.

The majority of farmers who had made changes had done some sort of figuring, but only six said that they had done this on paper rather than in their heads. The reasons which farmers gave for and against changing their pasture systems were more often technical than directly economic, being concerned with the effect of topography, shortage of labor, quality of feed, and unfavorable weather, rather than with costs, returns, profit, and fixed costs. It was recognized, however, that the technical aspects do indirectly affect costs and returns.

Although the physical and human resources of individual farms were therefore shown to be important in farm planning, the results of the budgets made in this study were in line with the changes which had been occurring on farms. It was concluded that the preparation of budgets with assumed conditions similar to those on farms to which the results of the budgets were to be applied appeared to be a useful technique for research and extension.

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CHAPTER ONE

INTRODUCTION

1. The problem.

The present trend in dairy farming in Michigan is leading to a reduction in the number of dairy farms, and an increase in the size of those that remain. This expansion affects herd size particularly, while less change is taking place in farm size, and in the labor force per farm.

Between 1944 and 1954, the number of farms in Michigan reporting dairy cows in the United States Census of Agriculture decreased by 38 percent, and the number of cows per farm increased by 31 percent. The acres pastured per farm increased over the same period by 3 percent. The figures from which these changes have been calculated are shown in table 1a. The figures for farm labor in the 1954 United States Census are not comparable with earlier ones, as they refer to labor on the farm at a different time of year. However, some idea of the situation can be gained by looking at the average number of workers per farm, which, at 1.7, was the same in both 1940 and 1950.

Recent data applying to a group of farms in south-central Michigan are shown in table 1b. These farms are typical of the more specialized dairy farms in the State. From 1950 to 1958, the number of dairy cows per dairy farm in this group increased by 85 percent.

For all the farms in the group, the number of tillable acres per farm increased by 23 percent over the same period, while the number of men per farm remained constant at 1.7.

This expansion depends ultimately on advances in technology. Cochrane¹ has discussed technological advance and its effect of lowering prices and so calling forth further advance. The use of a new input is not usually forced upon a farmer in any immediate sense, however, but is rather incorporated into his farming system as an economic adjustment, when it pays to do so.

One exception to this seems to be the bulk milk tank, adoption of which may be forced on a farmer, although it often is not economic. Ishee and Barr² have concluded that the added costs of changing from customary can cooling to bulk handling were greater than added returns for most farmers. Under their most favorable set of assumptions, added returns were less than added costs below a herd size of 29 cows. Wheeler and Hoglund³ found that with a herd of 20 cows, the investment involved would not be amortized for 13 years; this period was reduced to 6 1/2 years for a herd of 30 cows. They noted

¹ W. W. Cochrane, Farm Prices, Myth and Reality, U. of Minnesota Press, Minneapolis, 1958.

² S. Ishee and W. L. Barr, Economics of Bulk Milk Handling, Pennsylvania Agricultural Experiment Station, Bulletin 631, Mar. 1958.

³ R. G. Wheeler and C. R. Hoglund, Can I Afford a Bulk Tank?, Michigan Farm Economics No. 153, October 1955.

that to install a bulk milk tank might be the only way for an operator to avoid losing his fluid milk market.

Substitution of machinery for labor becomes more profitable when full use is made of the machinery so that its fixed cost is spread over a large output. This is done when herd size is increased concurrently with investment in a milking parlor, bulk milk tank, forage chopper, and other machinery and equipment. This is shown in table 2, which shows figures developed by Hoglund for the application of improved forage harvesting methods with three sizes of dairy herds.

Wheeler¹ has discussed the impact of technological changes on milk production. He sees a trend towards specialization, and towards increase in size, and states that it is most usual in the North Eastern area of the United States for the number of cows per farm to be increased, but not the number of acres or men.

Increase in herd size necessitates an increase in forage supplies. This can come from one or from a combination of three sources. These are, (1) to increase the forage acreage within the farm or by renting, (2) to buy forage from outside the farm, or (3) to intensify the forage system. This last method involves a land-saving technology, and will result in increased aggregate output and lower prices, unless

¹ R. G. Wheeler, The Impact of Technological Changes on Milk Production, Journal of Farm Economics, 37: 996, 1955.

offset by land going out of dairying. It does seem, however, to be the most promising source at first sight. Extra forage acreage within the farm may have a high opportunity cost, and land outside the farm may be difficult or expensive to obtain. Any increase in pasture acreage suffers from the drawback that it is at an increased distance from the dairy buildings.

Some progressive dairy farmers are reaching the limits of intensification of grazing, and many are considering, or are already practising, green chopping or storage feeding. Larsen¹ gave the following figures for dairy farmers in the Midwest in 1958: those practising controlled grazing, 15 percent; green chopping, 5-10 percent; and storage feeding, 5 percent. It is a fundamental problem in extension whether or not to concentrate on the more progressive farmers. Certainly the most exciting results can be obtained from them. The less progressive are often those who like to wait and see, and therefore cannot be approached except indirectly through the example of the innovators.

2. Objective and method of study.

This study is concerned with some of the problems being dealt with by the more progressive dairy farmers in Michigan. These are

¹ H. J. Larsen, 1958 Grassland Proceedings, American Grassland Council.

problems which have to do with increase in herd size, and the adoption of new technologies.

There is a need for information on the effect of an increase in scale on total returns, and on the extra investment and management ability with which it is associated. Information is also needed on what is the best way to expand, since relationships change with increase in scale, and it is not usual for a farmer to increase all his inputs in the same proportion.

These changing relationships will affect the adoption of new technologies which require an increase in investment, since the extra fixed costs per unit decrease with the increase in scale. This study is concerned with the effect of new technologies on investments, receipts, and expenses.

The particular technologies which are here studied in detail are the alternative pasture systems of improved grazing, green chopping, and storage feeding. Improved grazing contrasts with continuous grazing in that stocking rates are controlled, and pasture areas are rested between grazings. The pasture is re-seeded as required, and recommended rates of fertilizers are applied. In addition to the grazing, the cows are given some supplementary feed in the form of hay or silage. Green chopping, which has also been given the names solling, zero grazing, and green feeding, involves the daily or twice daily chopping of legumes and grasses from improved pastures, and

occasionally of sudan grass or oats, which are hauled to the dairy cows and fed to them in dry lot. Some supplementary feeding of hay is also practised. With storage feeding, the cows are also kept in dry lot, and in this case are fed grass silage and hay throughout the pasture season.

In chapter two, previous research on green chopping and storage feeding is reviewed, and the results and recommendations reached are presented. In chapter three, a recently completed five year study of dairy farms in Michigan is described. This study provided much of the data on which the budgets in chapter four were based. In chapter four, nine budgets are presented, which show the relationships between the three pasture systems at three different sizes of dairy herd, for a 200 acre farm. In chapter five, some of the problems involved in applying the budgets to individual farms are considered, together with the changes in pasture systems which have occurred, and the attitudes of farmers towards the adoption of the alternative systems. These aspects were investigated in a survey of the farms in the study, which was carried out by the author while assisting in the completion of the study.

CHAPTER TWO
PREVIOUS RESEARCH ON GREEN CHOPPING
AND STORAGE FEEDING

1. Early experiments.

The feeding of fresh cut green forage or of silage in the summer is not new. It has traditionally and often been done to supplement pastures during the summer months. The agricultural experiment stations have always worked with problems of contemporary importance, and investigation of their published research shows a continued interest in soilage and silage from their earliest years.

In 1893, Wilson¹ reported an experiment in Iowa in which a succession of crops, including peas and oats, and clover, was cut and fed in a barn, and the drop in milk production caused by bare, droughty pastures was overcome. Several other experiment stations reported work in this area in the early years of this century. Linfield² conducted several experiments comparing soiling with pasturing, in Utah. Although the forage which was soiled lasted longer than an equivalent acreage of pasture, and supplied some hay as well, milk production was adversely affected. A probably reason

¹ J. Wilson, Soiling, Iowa Agricultural Experiment Station Bulletin 23, 1893.

² F. B. Linfield, Experiments with Dairy Cows, Utah Agricultural Experiment Station Bulletin 68, 1900.

for this was that the fodder was usually cut only every second day, and must have heated and become less palatable. Lyon and Haecker¹ reported on some forage plants for summer feed in Nebraska. They obtained about twice as much feed from alfalfa soiled than from alfalfa pastured, while the daily milk production was a little less. Lane² described some experiments with soiling crops in New Jersey. He developed a long list of crops to be used in order from May to October, so as to maintain the flow of milk, and attained a stocking rate of 3 1/4 cows per acre for those six months. He made no comparison with pasturing, but obtained a greater yield per cow than during the six winter months, when silage was fed, although a uniform number of cows were freshening throughout the year.

Carlyle, Danks, and Morton³ reported on some experiments with partial soiling in Wisconsin, in 1903. A succession of crops was fed, and the cows were allowed into pasture at night. The milk flow was maintained under this system, and the pasture requirement

¹ T. L. Lyon and A. L. Haecker, Some Forage Plants for Summer Feed, Nebraska Agricultural Experiment Station Bulletin 69, 1901.

² C. B. Lane, Soiling Crop Experiments, New Jersey Agricultural Experiment Station Bulletin 158, 1902.

³ W. L. Carlyle, J. R. Danks, and G. E. Morton, Soiling Crops for Dairy Cows in Wisconsin, Wisconsin Agricultural Experiment Station Bulletin 103, 1903.

per cow from mid-May to mid-October was reduced from 2 acres to 1 acre plus 0.2 acres of soilage crops. In Kansas, Otis¹ compared soiling alfalfa, oats, and corn, with pasturing prairie and tame grasses. Although 1899 was a good pasture year, over a period of 144 days soilage required 0.71 acres per cow to 3.63 for pasturage. Billings², in New Jersey, reported that a herd of dairy cows had been maintained for 10 years by summer soiling. He gave details of an experiment comparing soilage with silage which came out slightly to the advantage of soilage, but since it was only run over a period of 21 days this cannot be very significant.

Woll, Humphrey, and Oosterhuis³, comparing soiling and silage for dairy cows in the summer, at Wisconsin in 1914, found little difference in milk production, but declared in favor of silage as it required much less time per day to feed. To provide soilage for 12 cows took a man and a horse from 1 to 2 hours per day. Gillette, McCandlish, and Kildee⁴ described a system of partial soiling at

¹ D. H. Otis, Experiments with Dairy Cows, Kansas Agricultural Experiment Station Bulletin 125, 1904.

² G. A. Billings, Summer Silage vs Soiling, New Jersey Agricultural Experiment Station Bulletin 204, 1907.

³ F. W. Woll, G. C. Humphrey, and A. C. Oosterhuis, Soiling Crops vs Silage for Dairy Cows in Summer, Wisconsin Agricultural Experiment Station Bulletin 235, 1914.

⁴ L. S. Gillette, A. C. McCandlish, and H. H. Kildee, Soiling Crops for Milk Production, Iowa Agricultural Experiment Station Bulletin 187, 1919.

Iowa in 1919, the pasture being supplemented, and not replaced, by soilage. Forage was cut daily for 40 cows, and this took 2 men and a team of horses 2 hours. As an average over 7 years, a total of 0.76 acres were grazed or cut per cow over a partial soiling season of 167 days.

In 1921, Frandsen et al.¹ reported on a comparison of soilage with silage for dairy cows under Nebraska conditions where the hot summer months result in a shortage of pasture. Soilage reduced the acreage requirement per cow for a pasture season of 122 days from 2 acres to 0.53, using peas and oats, and corn. When only silage and hay were fed, the acreage requirement came down to 0.41 per cow, but the milk flow was not satisfactory. Frandsen suggested that soilage was a good system where labor was cheap and land expensive, and saw the beginnings of mechanization which would reduce the cost of labor, and make the system more attractive.

Experiments were carried out by Graves et al.² of the U. S. D. A. in 1928 and 1929, to compare the feeding value for milk production of pasture grasses when grazed, when fed green, and when fed as hay or silage. The plots were of under an acre in size, and were irrigated

¹ J. H. Frandsen et al. Journal of Dairy Science 4: 124, 1921.

² R. R. Graves et al. Feeding Value for Milk Production of Pasture Grasses, United States Department of Agriculture Technical Bulletin 381, 1933.

between grazings and cuttings. In the first year, it was attempted to feed the cows an amount of cut grass equal to what the grazing cows were eating. The number of cows on a plot was adjusted continually to match the growth of grass, and cows were moved directly from one treatment to another, so that the treatment often had little time to have any effect. The grazed plot supported an average of 1.84 cows per acre for 99 days, which produced 4575 lbs. of milk. The cut plot supported an average of 2.60 cows per acre for the same length of time, but produced only 4041 lbs. of milk. No supplementary feed was fed in either treatment. In the second year, the cows being fed chopped material were allowed to feed to appetite. As a result, the cut plot supported a similar number of cows as the grazed plot, and again produced less milk. There seem to be three main reasons for these results. First, the pasture consisted of a mixture of grass species including brome grass and orchard grass, with white clover and alsike clover. These are not tall growing, succulent species from which the maximum benefit of cutting is likely to be obtained. Second, the grazing cows lost more weight than those fed cut material; and third, one cow which was a very high producer was kept on the grazing treatment for most of the experiment.

In 1933, Tretsvén¹ reported some experiments at Montana. He

¹ J. O. Tretsvén, Feeds for Dairy Cattle, Montana Agricultural Experiment Station Bulletin 282, 1933.

found little difference in milk yields whether alfalfa was cut and fed to cows or was pastured, but under the former treatment fewer acres of forage were needed per cow. . He concluded that there was no economic advantage for soiling, because of its greater labor requirements.

The general conclusion from these early experiments is that with suitable crops and good management milk flow can be kept up on a limited acreage in mid-summer by soiling or by feeding silage. This supplementary feeding is worth while if the acreage is limited, but has the disadvantages of a high labor requirement, and a need for increased facilities for storing silage. Until recent years, supplementary summer feeding has only been carried out where absolutely necessary, and to a limited extent.

In the United Kingdom, much the same conclusion had been reached. Watson¹ had the following to say about soilage in 1956:

"A properly designed soilage system enables a larger head of stock to be carried on a given acreage in the drier areas. Soilage is now restricted to dairy farms in dry areas where pastures are liable to give out during July to September."

¹ J. A. S. Watson and J. A. More, Agriculture, Oliver and Boyd, London, 1956.

2. Recent research results.

In recent years, numerous Experiment Stations have once more become interested in the mechanical harvesting of pasture. Green chopping and storage feeding have again come into prominence as they not only can be used to supplement dry pastures as before, but also can be used with profit throughout the whole grazing season, since they require the use of fewer acres of pasture than does grazing. This has come about with the recent advances in, and adoption of, feeding practices involving field choppers, self-feeding wagons, side-unloading wagons, and mechanical feeders.

Machinery is developed slowly through a number of years, and it is difficult to say when a particular stage of development has been reached, or what the potentialities of a machine are at a particular date. Whistler and Frushour¹ considered that the developments of modern forage harvesting machinery began in 1938. They reported that Allis Chalmers carried out a well defined test program from 1942 to 1952, and had by the latter date produced an efficient direct-chop machine. Peterson², writing in 1949, described the fore-runners of

¹ P. A. Whistler and G. V. Frushour, Engineers Advance Art of Making Grass Silage, Agricultural Engineering, 34: 315, May 1953.

² W. R. Peterson, Development of Mechanical Equipment for Unloading Chopped Forage, Agricultural Engineering, 30: 188, April 1949.

present-day machinery for handling chopped forage, and said that the increased demand for the self-unloading wagons which were being developed at the time resulted from the increased field chopping of forages.

Workers at several agricultural experiment stations have conducted experiments under controlled conditions in order to define input-output functions for green chopping and storage feeding. These include Bateman and co-workers in Utah¹, Gullickson and Wilcox in Minnesota², Henderson, Cobble, and Cook in Rhode Island³, Kennedy and co-workers at Cornell⁴, and Larsen and co-workers in Wisconsin⁵. Stone, in Louisiana⁶, has given details of experiments in the Southern

¹ G. Q. Bateman, G. E. Stoddard, and C. H. Mickelsen, Self Service or Maid Service?, Utah Agricultural Experiment Station Farm and Home Science 19: 2, March 1958.

² T. W. Gullickson and C. L. Wilcox, Soilage or Rotational Grazing? Minnesota Agricultural Experiment Station Farm and Home Science 13, 18, Feb. 1956.

³ B. W. Henderson, J. W. Cobble, and H. J. Cook, Soilage Feeding of Dairy Cattle, Rhode Island Agricultural Experiment Station Bulletin 336, June 1957.

⁴ W. K. Kennedy, J. T. Reid, and M. J. Anderson, 1958 Grassland Proceedings, American Grassland Council.

⁵ H. J. Larsen, 1958 Grassland Proceedings, American Grassland Council.

⁶ E. J. Stone, 1958 Grassland Proceedings, American Grassland Council.

area of the United States, and in the United Kingdom an experiment has been reported from Edinburgh University^{1, 2}. At the University of California, Ittner and co-workers^{3, 4} have conducted experiments with beef steers, and Hull and co-workers⁵ with sheep. Experiments with beef cattle have also been made at the Michigan Experiment Station by Branaman, Harrison, and Deans⁶.

Results from these experiments are detailed in tables 3, 4, 5, and 6, and are discussed under the headings: stocking rate and yield per acre, machinery and equipment, and labor.

A. Stocking rate and yield per acre.

Results from experiments and surveys are presented in table 3. The relationship between stocking rate and yield per acre depends on the production per cow. In most cases, production per cow was a

¹ K. V. Runcie, Zero Grazing of Dairy Cattle, Agriculture, 65: 129, 1958.

² K. V. Runcie, Zero Grazing of Dairy Cows, Agricultural Review, 4 (2): 16, July 1958.

³ N. R. Ittner, G. P. Lofgren, and J. H. Meyer, A Study of Pasturing and Soiling Alfalfa with Beef Steers, Journal of Animal Science 13: 37, 1954.

⁴ J. H. Meyer, G. P. Lofgren, and N. R. Ittner, Further Studies on the Utilization of Alfalfa by Beef Steers, Journal of Animal Science 15: 64, 1956.

⁵ J. L. Hull, et al., Studies in Forage Utilization by Steers and Sheep, Journal of Animal Science, 16: 757, 1957.

⁶ G. A. Branaman, C. M. Harrison, and R. J. Deans, Summer Grazing and Fattening Steers, Department of Animal Husbandry A. H. 32, Sept. 1958.

little less under a green chopping program than under a grazing program; in these cases, percentage increase in yield per acre associated with green chopping was less than the percentage increase in stocking rate. The results as a whole are variable, reflecting the differences in productivity of pastures and cows in the experiments, differences in management, and the different lengths of the experimental periods.

In Wisconsin, data were obtained over a span of three consecutive years from experiments at the Marshfield and Ashland stations. Production per cow per day was greater for green chopping and storage feeding than for rotation grazing. The production per acre for grazing was very low, and green chopping and storage feeding showed a large increase in production as compared to grazing. The analysis was complicated by the fact that level of grain feeding was adjusted to individual animal need. Milk yield per acre was adjusted by multiplying the total yield by the percentage of the T.D.N. which was received from forage. This may not accurately reflect the effect of different levels of concentrate feeding, especially in view of the wide divergences which occurred. The level of concentrate feeding to animals on storage feeding was 85 percent greater than for rotation grazing, and 70 percent greater than for green chopping.

Experiments were carried out in Minnesota in 1953, 1954, and 1955 to compare green chopping with rotational grazing. The milk yields per cow were very similar under the two treatments. In two

of the years, when tall-growing crops of sudan grass and oats were grown in addition to alfalfa-brome grass, the yield per acre showed increases of 68 and 81 percent for the green chopping treatment. In the year when alfalfa-brome grass alone was grown, the increase was only 2 percent. The reason given was that the differences arise when a tall-growing crop is trampled down under a grazing treatment. Another factor should be taken into account when comparing these results, which is that considerable amounts of hay were fed, more of which went to the cows on the grazing treatment than to those on the green chopping treatment.

Unpublished results from an experiment at the same research station in 1956 compare green chopping with storage feeding. A group of cows was placed on each treatment, and their total milk production was found to be identical. The group on the green chopping program required 15.9 acres, and the group on the storage feeding program required 16.5 acres.

At the Utah experiment station, no difference in yield per acre was found when equal acreages were used for equal numbers of cow-days on the two treatments of grazing and green chopping. The green chopping was started later than the grazing, and 53 percent of the total milk produced on the green chopping treatment came from the first of the four cuttings. It appears that the forage was allowed to become overmature and caused a large drop in milk yield. The results of this experiment

were affected by the additional factor of irrigation.

Results from Cornell were used to stress the importance of heavy stocking in evaluating different systems, and the inadvisability of adjusting cow numbers to the apparent availability of forage. The decrease in milk production with green chopping was not adjusted for the fact that more excess forage was harvested from the zero grazed area than from the pasture, but the author nevertheless states that it is questionable if the extra forage would have offset the decrease in milk production which occurred with zero grazing. The Edinburgh, Scotland, experiment resulted in a reduction in the acreage requirement of 11.3 percent for green chopping compared with strip grazing.

In the experiments in California, green chopping resulted in increases in meat production per acre of from 25 to 69 percent for steers, and from 6 to 8 percent for sheep, when compared with pasturing. There were no significant differences in the steers' daily weight gains as between soiling and pasturing, but the sheep put on weight significantly faster on pasture.

At Michigan State University, an experiment was conducted with yearling steers, which were fed chopped forage or grazed. No supplementary feed was given. Green chopping approximately doubled the stocking rate and production per acre, when compared with grazing, but showed little advantage over strip grazing. This part of the experiment was run for 83 days. With pasture charged at \$10 per acre first crop

and \$5 per acre second crop, analysis of the complete fattening process showed that there was no advantage from green chopping when compared with grazing. The steers fed green chopped material gained in weight quite fast the first month, but much less later, and began to appear listless; in the subsequent fattening period they did less well than the other groups of steers. Trouble was experienced with spoilage of the green chopped forage, as attempts were made to feed it as seldom as possible.

Green chopping has been found to have a beneficial effect on the persistency of milk production during the summer, and so on total yield. McCullough¹ found a significant correlation between dry matter digestibility and persistency of milk production. The beneficial effect of green chopping in this respect depends on the relative management ability applied to it and to pasturing, as well as on any potential difference between the two systems. Calder², in the United Kingdom, found that milk yields were maintained after the spring flush under a green chopping program, and with regular year round freshenings obtained the highest milk production in August and early September.

¹ M. E. McCullough, A Study of Techniques for Measuring Differences in Forage Quality using Dairy Cows, Georgia Agricultural Experiment Station Technical Bulletin N.S. 4., 1953.

² A. Calder, Zero Grazing on a Cheshire Farm, Agriculture 65: 542, 1959.

Henderson, Cobble, and Cook¹, however, did not find that the influence of soilage feeding on total milk production per cow when compared with grazing of the same forage was of significant importance.

An advantage of mechanical harvesting which has often been put forward is that it allows better control of bloat. The cows' intake of succulent green fodder can be controlled, and they can easily be fed roughage in addition. Calder², working with dairy cows, reported only one case of bloat in three years, which was less than would be expected with a grazing program. Hull et al.³, in experiments with beef steers, only had trouble with bloat among the steers which were pastured on alfalfa, and had none with those which were fed chopped alfalfa.

Although higher yields per acre have not been consistently achieved when forage has been mechanically harvested in experiments, it is apparent from these experiments that they are possible under some circumstances.

These circumstances include high-yielding forage stands coupled with good management which ensures a continued supply of high-quality forage throughout the season. In order to ensure this

¹ B. W. Henderson, J. W. Cobble, and H. J. Cook, op. cit.

² A. Calder, op. cit.

³ J. L. Hull et al., op. cit.

supply, either a succession of stands should be chopped, none of which is allowed to become overmature, or the forage should be ensiled at its optimum stage, and stored with the minimum of losses and spoilage.

Agronomists have explained the relative inefficiency of grazing in terms of the effect of the grazing animal on the sward. When the animal is on the pasture, its dunging renders a considerable area unfit for grazing. Selective grazing also prevents full utilization of the pasture. Edmond¹, in experiments in New Zealand with perennial rye grass and white clover, has found that treading reduces the growth vigor of the sward. The harmful effects of treading are likely to be greater on a tall-growing species, and Kennedy, Reid, and Anderson², comparing zero grazing, strip grazing, and rotational grazing, found that the best stand of alfalfa was maintained on the zero grazed plots.

B. Machinery and equipment.

McCutcheon³ has described the machinery and equipment needed for a zero grazing program. These are a direct cut forage harvester, and a self-feeding wagon or a self-unloading wagon and feed bunks.

¹ D. B. Edmond, Animal Treading and Pastures, Agricultural Review, 4(2): 8, 1958.

² W. K. Kennedy, J. T. Reid, and M. J. Anderson, op. cit.

³ G. K. McCutcheon, Green Feeding of Livestock, Agricultural Engineering, 36: 321, May 1955.

He suggested that a self-feeding wagon is not suitable for more than 20-25 cows, due to the limited access to the feed.

Runcie¹ has made a similar statement, but Berge, Duffee, and Finner² have described a self-feeding wagon able to supply up to 54 cows. It is of course only a matter of building the box long enough to accomodate the required number of cows, but beyond a certain size the length must become unmanageable and the weight excessive. In a study at Michigan State University, the maximum number of cows fed from one wagon was 34; in this case the wagon was 20 feet long. The most common length of wagon was 14 feet.

Feed bunks are best arranged in an unbroken line along the fence of the feed lot so as to facilitate unloading, which can be done without pause, and without entering the feed lot and getting among the cows. Henderson, Cobble, and Cook³ used both a self-feeding wagon and a side-delivery wagon in different years. Although no time was needed for feeding from a self-feeding wagon, they found that the total time taken to feed 12 cows was only a little less since the self-feeding wagon had to be hauled slower than the side-delivery wagon. There

¹ K. V. Runcie, Zero Grazing of Dairy Cattle, Agriculture 65: 129, 1958.

² O. I. Berge, F. W. Duffee, and M. F. Finner, Wagon Rack for Self Feeding, Wisconsin Agricultural Experiment Station Special Bulletin 5, 1958.

³ B. W. Henderson, J. W. Cobble, and H. J. Cook, op. cit.

is no general agreement as to whether chopping should be done once or twice a day, and no experiments report a comparison of the two. Once a day feeding reduces the labor requirements, but may result in heating and spoilage of the material. In a survey of 26 dairy farms in Illinois, Cash and Finlay¹ found that 11 farms chopped twice daily, 12 once daily, and 3 did both for some period. Chopping once daily involved larger loads, and required slower hauling speeds.

For a storage feeding program, mechanical or self-feeding silage equipment is desirable. It is not necessary to own a forage chopper unless a sufficiently large acreage of silage is harvested.

Green chopping is a daily chore, and the animals must be fed regardless of the weather conditions. The tractor pulling the forage harvester and wagon should therefore be powerful enough to do its job under adverse conditions. Although there may be some damage to the fields, it is not very often that it has been impossible to chop any forage. Larsen², at Wisconsin, only lost a week in three years due to bad weather; Calder³, reporting on a farm in the United Kingdom, said that it had been necessary to feed silage instead of green-chopped material once in each of three years; this had had no adverse effect on

¹ J. G. Cash and R. M. Finley, Green Chopping Forages, University of Illinois Department of Agricultural Economics Farm Management Letter No. 142, July 1957.

² H. J. Larsen, op. cit.

³ A. Calder, op. cit.

production. An alternative is to have a field near the barn into which the cows can be turned. Henderson¹ found no significant differences in production in a 7 week experiment in which cows were soiled for five days and then pastured for two. An arrangement of this sort could be used to reduce the labor requirements over week-ends, and to provide for feeding in the event of mechanical breakdown.

C. Labor.

The labor requirements for green chopping are an important factor in decisions regarding its use. The requirements vary according to the number of cows to be fed, the method of harvesting and feeding, whether chopping is done once or twice a day, the distance to the fields, and the thickness of the crop. The effect of these various factors are shown in tables 5 and 6.

Table 5 also shows the labor requirements when the cows are grazed, for moving fences, watering, and clipping and raking the pastures. Figures are also shown giving the labor requirements of storage feeding. These figures are not directly comparable, however, since the labor is used at different times of day, and at different times of the year, so that it interferes with other farm work to varying degrees. A storage feeding program involves a peak of labor requirements in

¹ B. W. Henderson, Progress Report on Soilage Feeding of Dairy Cattle, Journal of Dairy Science, 39: 936, 1956.

early June, and may necessitate the hiring of additional help.

The figures in table 5 vary quite considerably, even for similar arrangements of machinery and herd size. This shows up the importance of management in organizing and arranging for the most efficient use of available time and labor.

D. Advantages and disadvantages.

As a result of their experience with green chopping, several workers have summarized its major advantages and disadvantages.

These are as follows:

- Advantages:
1. Less fluctuation in the milk flow, and milk production is kept up.
 2. Less acreage needed per cow.
 3. Greater production per acre.
 4. No fences or water to look after. Simplified farm layout. Distant fields can be used for forage production.
 5. Animals kept near buildings, under observation and out of hot sun. Bloat can be better controlled.

Disadvantages:

1. Additional machinery and equipment needed.
2. Extra labor requirement, which may interfere with other farm work.
3. Bad weather may make it impossible to chop.

4. More attention needed for cattle in dry lot;
sanitation difficulties.

5. Management more difficult.

Storage feeding has the same advantages, but its disadvantages are less in numbers 2 and 3 above. Hoglund and Harrison¹ have estimated that a high level of managerial skill is needed for a green chopping program, and a medium level for improved grazing and for storage feeding. This is mainly due to the necessity, in green chopping, of ensuring that good quality forage is continuously available.

¹ C.R. Hoglund and C.M. Harrison, A Research Report on the Economics of Alternative Pasture Systems, Michigan State University Agricultural Economics Department, Ag. Econ. No. 698, Oct. 1957.

CHAPTER THREE

THE PASTURE STUDY AND SURVEY

Because of the difficulties of using pasture research data for economic analysis, a farm study of pasture systems on Michigan dairy farms was started in 1954 by Hoglund^{1, 2, 3}. This study was completed after the 1958 pasture season. A total of 60 farms were included in the study for periods of from one to five years. As a result of the study, it has been possible to estimate the inputs and outputs to be expected when the different pasture systems are used on farms. Results from the study are included in tables 3 and 5, and are discussed in this chapter.

While assisting in the final stages of the study, the author carried out a survey in order to obtain information concerning farmers' reasons for their adoption of the different pasture systems, and also summarized data concerning the changes in farm size, size of dairy herd, labor force, and pasture systems used, which occurred over the five year period. These are discussed in section 3 of chapter four, and in chapter five.

¹ C.R. Hoglund, Green-chopping vs Grazing of Forages on Michigan Dairy Farms, Michigan Agricultural Experiment Station Quarterly Bulletin 37: 550, 1955.

² C.R. Hoglund, Economics of Hauling vs Grazing of Forages on Michigan Dairy Farms, Michigan Agricultural Experiment Station Quarterly Bulletin, 38: 628, 1956.

³ C.R. Hoglund and C.M. Harrison, op. cit.

1. Cow days per acre.

The pasture season was found to differ in length according to the pasture system used. An average grazing and green chopping season is 150 days, while an average storage feeding season is 130 days. This is explained by the necessity of extending the winter feeding period until the new season alfalfa-brome silage has been made and can be fed out in place of the corn silage.

In order to compare the production from the different systems, the average number of full season acres of pasture required per cow when grazed, green chopped, and storage fed, was computed. A small acreage of sudan grass or similar crop was commonly found associated with the green chopping system. The acreage per cow was, for improved grazing, 1.26, for green chopping, 0.83 plus 0.16 acres of sudan grass, and for storage feeding, 0.84. These figures were then divided into the number of days in each pasture season in order to arrive at the number of cow-days per acre. These are, for improved grazing, 120 days, for green chopping, 152 days, and for storage feeding, 154 days. Thus, green chopping and storage feeding both show an increase over improved grazing of about 28 percent.

2. Labor

In the survey, farmers were asked for details of the amount of labor available on their farms from May through September, in terms of total man-months, a man-month being defined as the labor supplied

by one full-time adult man for a month. The five month period from May through September covers the usual pasture period in southern Michigan.

The average number of man-months per farm in 1954 was 10.6; in 1958 this had increased to 11.7, in line with the increase in average herd size which occurred over the same period. From the data, it was possible to estimate the differences in labor usage between farms which were following a grazing program, a green chopping program, and a storage feeding program. The average number of man-months per farm for all farms which were grazing in either 1954 or 1958 was 11.0; for all farms which were green chopping it was 11.6; and for all farms which were storage feeding it was 11.8. The differences between the systems were found by a t test not to be significant at the five percent level.

Farmers were also asked how long it took them daily to feed their cows during the pasture season. For a grazing system, this included the time taken to drive cows to and from pasture, and to move fences; for a green chopping system this included the time spent daily on chopping forage, hauling, and feeding it; and for a storage feeding system it included removing and feeding silage, but not harvesting it and filling silos.

The average time spent per cow daily was, for grazing, 1.10 minutes; for green chopping, 1.83 minutes; and for storage feeding,

1.56 minutes. In arriving at this last figure, the data from three farms were eliminated, because they were outside the range of the rest of the data. The average time per cow for these three farms was 0.26 minutes: this was made possible by their convenient layout, use of machinery, and efficient management.

The range of times for the rest of the farms was great for all three systems. The time was reduced in the larger herds, and, for green chopping and storage feeding, by increased mechanization. Nearly 50 percent of the green chopping farms achieved a time of 1.88 minutes per cow, which was the maximum time reported by a grazing farm. The minimum time for a green chopping farm was 0.83 minutes. This shows that one of the disadvantages of green chopping, the time taken daily to feed the cows, can be reduced if sufficient attention is paid to the problem.

3. Machinery and equipment.

Unpublished results from the pasture study by Hoglund provide information on various items of machinery and equipment owned by farmers. The results illustrate the effect both of the alternative pasture systems and of increase in herd size, and are shown in table 7.

Farmers following an improved grazing system had an average of 30.0 cows. Over 80 percent owned a baler, but only just over half owned a field chopper. All owned a chopper wagon.

Farmers following a green chopping program had more cows on

an average, the average herd size being 38.1 cows. Nevertheless, no more than 70 percent owned a baler, although they all owned a field chopper, chopper wagon, and self-feeding wagon. Two of the farmers owned a second field chopper, which was used exclusively for the green chopping operation; a field chopper is an essential piece of machinery in a green chopping program. Thirty percent of the farmers owned a silo unloader. Farmers following a storage feeding program had an average of 50.8 cows. This size of operation makes it possible not only to own equipment which is essential to the system, but also equipment which replaces custom hiring and hand labor. Nearly 90 percent of these farmers owned balers, and all owned field choppers and chopper wagons. Sixty-three percent of the farmers owned a silo unloader and mechanical bunk feeder. The remainder either fed out silage by hand, or arranged for the cows to self-feed it from a bunker silo.

Total investment per cow in forage equipment and silos was, for grazing, \$164; for green chopping, \$193; and for storage feeding, \$189.

CHAPTER FOUR

BUDGETARY ANALYSIS

1. Relevant concepts in static production economics..

The production of forage on a farm is a function of the inputs used. These inputs include the land, the labor, the machinery, and the seed and fertilizers. Some of these inputs will be fixed. Profit is maximized in any one technology when the variable inputs corresponding to that technology are combined in the least cost combination, and used at such a level that their marginal value product equals their price.

In the case of variable inputs, the least cost combination is that combination at which their marginal rate of substitution equals the ratio of their prices. That is, when:

$$\frac{MPPx_1}{Px_1} = \frac{MPPx_2}{Px_2} = \dots = \frac{MPPx_n}{Px_n}$$

At this combination, the maximum output is being obtained for a given input, or a particular output is being obtained with the least cost.

There are least cost combinations for all levels of output, and a line joining these points can be called a scale line. It will not necessarily be straight, that is, the optimum combination of inputs may change at different levels, if the marginal rate of substitution between them changes.

A straight line from the origin of a graph showing a two-variable factor relationship shows how greater outputs may be

obtained when the two factors are increased in constant proportions. Thus, the scale line and the line of constant proportions do not necessarily coincide. Figure A i shows a scale line and line of constant proportions for two variable inputs.

Different technologies involve the use of different inputs, and have separate production functions corresponding to those inputs. These production functions will differ in their elasticity, or, as Heady¹ has put it, in the efficiency and capacity of the technical unit. Three such production functions are shown in figure A ii. At all points on these production functions, the inputs are combined in the least cost combination which is made possible by each technology. As output increases, not only does the least cost combination of inputs vary within each technology, but also the relative profitability of different technologies changes.

2. Procedure.

This study investigates the optimum method of producing forage on a farm on which the size of the dairy herd is being increased. Since increase in herd size is taking place on many farms with little increase in acreage, a single farm size was selected for the study.

¹ E. O. Heady, Economics of Agricultural Production and Resource Use, Prentice Hall, Englewood Cliffs, N. J., 1957, page 302.

This procedure also was chosen because it would demonstrate the effect on the organization of the farm and on net income of proceeding from a situation in which large quantities of feed are sold to one in which large quantities of feed are purchased.

Three alternative pasture systems are considered: improved grazing, green chopping, and storage feeding. Green chopping and storage feeding are being adopted by a considerable number of Michigan dairy farmers. These systems lead to a more intensive use of pasture than grazing, and so would be expected to become important as the number of dairy cows on a given acreage increases. They involve greater costs than does grazing, but the relationships would be expected to change as herd size increases, as fixed costs per unit are reduced and extra investment becomes necessary for the grazing system as well as for the other two systems. The amount of investment will vary according to the pasture system used and the size of the dairy herd.

As the size of the herd is increased, therefore, a true increase in scale, with proportions kept constant, does not occur, as not all the inputs are increased in the same proportions. Olson¹ has explained the matter as follows:

¹ R. O. Olson, Resource Productivity, Returns to Scale, and Farm Size, ed. by E. O. Heady et al., Iowa State College Press, Ames, 1956, p. 54.

"From the view-point of the individual farmer who is considering what adjustments in size will be profitable, primary concern is with the effect of variations in farm size on total costs and returns. He can increase the size of his business through true scale variations, or by making disproportionate increases in the inputs. True scale adjustments may be of little concern to him. He is generally concerned with the effect on income of adding one or more inputs without proportionate increases in the other resources. In the first place, it is seldom possible to vary all productive services on a farm proportionately. Many resources cannot be varied at will, or at least they cannot be varied continuously. Also, the most efficient combination of resources may vary with size of farm."

At the same time expansion need not occur along the same production function, since it may become profitable to change from one technology to another. Three sizes of herd were chosen in order to discover which technology was the most profitable at three levels of output. Thus for each herd size, three budgets were developed corresponding to the three pasture systems, in each of which the inputs were combined in the least cost combination. There are therefore nine budgets in all.

Since a large increase in the size of a dairy herd on a farm involves significant changes in the overall organization of the farm, especially with respect to investment in housing and milking equipment, and in the cropping program, complete budgets were made in all nine cases. For a comparison of the alternative pasture systems alone, partial budgets, in which only changes in inputs and outputs resulting from a change in the pasture system are considered, would have been sufficient.

The complete budgets were drawn up under the assumptions given in section four. . In accordance with specified inputs and outputs, the required inventory of buildings, machinery, and equipment was drawn up, and a cropping plan worked out which would be suitable for each situation. Although each budget represents the situation expected after the plans have been in effect for a few years, some flexibility was maintained at the 60 cow level in order to facilitate further expansion.

Prices were then applied to the inputs and outputs so obtained, and the income and expenses were calculated.

3. Farm acreage and herd size found in the survey.

The survey was described in Chapter three. Figures were obtained for the number of tillable acres and the number of dairy cows, on farms in both 1954 and 1958. Complete data were collected from 40 farms, and the results were used as a guide in making the assumptions for the budgets.

The average size of the farms in 1954 was 188 acres; in 1958, the average size of these same farms was 210, an increase of about 10 percent. The acreage of thirteen of these farms in 1958 lay between 170 and 215 acres. Of fifteen farmers who estimated their farm acreage five years in the future, only two foresaw any expansion, although this does not mean that the other farmers would not increase their acreage if a good opportunity to do so presented itself.

The average herd size on the farms in 1954 was 30.7 cows; in 1958, this had increased to 44.5, an increase of nearly 50 percent. The farmers were asked about their plans for herd size five years in the future. One of the farmers said that he was going out of dairying; the average of the estimates of the remaining thirty-nine was 56.6 cows. Fourteen farmers estimated that their herd size would be between 55 and 65, and three estimated their herd size at 100.

4. Assumptions for the budgets.

The farm size selected for the study was 200 acres, which was near the mode of those in the survey in 1958. The farm was assumed to consist primarily of moderately productive soil of the Miami series, with some Conover and Hillsdale series, and to be situated in south-central Michigan.

The initial herd size considered was 30 cows, which was near the average size in 1954. With this size of herd, a 200 acre farm would have considerable quantities of corn for sale. The second herd size considered was 60 cows, the size of herd at which a considerable number of dairymen are aiming, and one which would about consume all the feed produced on the farm. The third size considered was 100 cows, for which a considerable amount of both grain and forage would have to be purchased.

The three pasture systems considered were improved grazing, green chopping, and storage feeding. Improved grazing involves the

rotational grazing of alfalfa-brome grass pasture for 150 days, and the supplementary feeding of alfalfa-brome grass silage for 120 of these days, at the rate of 16 pounds per cow per day. An equivalent quantity of hay - 6 pounds - could have substituted for the silage (2.6 pounds of 65 percent moisture grass silage = 1 pound of hay in feeding value.). Green chopping involves the daily chopping of alfalfa-brome grass pasture for 130 days, and also of a small acreage of sudan grass for 20 days to assist in the production of succulent forage throughout the season. A majority of farmers in the study used sudan grass or some other mid-season crop for this purpose. Supplementary hay is fed for 130 days at the rate of 6 pounds per cow per day. Storage feeding involves the feeding of 140 pounds of alfalfa-brome grass silage and 6 pounds of hay per cow per day for 130 days, the winter feeding period being 20 days longer than in the other two systems, as explained in section one of chapter three. The daily quantities of forage for each system include feed for replacement heifers as well as for the cows.

The farm labor force is assumed to consist of the operator working full time, and his 15 year old son working for five months in the summer, from May through September. The operator is assumed to have the capability of applying good management practices.

Hired labor is introduced as necessary, as explained in sections 5 A, 6 A, and 7A of this chapter. The feasibility of the assumptions as to labor force were checked by calculating the man-hour requirements

for two-week periods from April through September.

For the 30 cow herd, there was always sufficient labor available, but never so much that the hired man could be dispensed with. For the 60 cow herd, it was assumed that it took 90 minutes daily to chop forage in the green chopping system, and 30 minutes daily to feed silage in the storage feeding system. There was sufficient labor available in both the grazing and the green chopping systems, and the maximum requirement, in June, was no greater in the green chopping system since no alfalfa-brome silage was made. In the storage feeding system there was a peak of labor requirements in the first two weeks of June due to the large acreage of alfalfa-brome silage. This was met by the additional hired labor. The second cutting hay caused a second peak which was just in excess of the available labor, but which could be overcome by working longer hours for a few days. The labor requirements are shown for the three systems at the 60 cow level in figure B.

For the 100 cow herd, it was assumed that green chopping took 110 minutes per day, and that feeding silage out of storage took 40 minutes per day. Labor requirements were stretched in all three systems in April, May, and September, but not to such an extent that an extra man could be fully used, nor that increased efficiency could not remedy the situation. Labor requirements were again less in June in the green chopping system than in the grazing system. In the storage feeding system, there was again a peak of labor requirements in early

June caused by the alfalfa-brome grass silage, which was met by the additional hired labor.

The necessary investments for each system at each herd size are included in the budgets, and are explained as they occur. Fencing is needed for the grazing system, but is reduced to a minimum for the green chopping and storage feeding systems. The silos are of such a capacity that they can hold the amount of corn silage required for the winter feeding period. Since the same silo can be used for the storage feeding system in the summer, no extra investment in silos is needed for this system.

The inputs, outputs, and prices used in making up the budgets are shown in table 8. The prices used are those which were typically found in Michigan during 1958 and the first four months of 1959. These prices were developed in the realization that the relationships between them were more important than their absolute level, for the purpose of making comparisons between alternatives rather than predicting the outcome of any one plan.

5. The 30 cow herd.

A. Housing, feeding systems, and labor requirements.

The cows are milked in a stanchion barn, and the milk is carried by hand to a 350 gallon bulk tank. There is a single silo, measuring 18 x 50, which is fed out by hand in the winter, and in the summer also in the storage feeding system, when feed bunks with an automatic feeder

are used. For the green chopping system, investment is made in a self-feeding wagon and a direct-chop head for the forage chopper. For all three systems, four months of labor are hired. In addition, 8 days of labor are hired to help harvest the first crop alfalfa-brome grass silage in the storage feeding system.

B. Cropping and feed utilization.

For the grazing system, the annual roughage requirements are satisfied by 72 acres of alfalfa-brome grass, and 20 acres of corn silage. Corn and oats for grain are grown, with the alfalfa-brome grass seeded in the oats. A total of 5,034 bushels of corn are produced for sale. As in every cropping plan, rye is grown after corn silage when the latter is followed by corn.

Green chopping requires 59 acres of alfalfa-brome grass, 5 acres of sudan grass, and 20 acres of corn silage, for a whole year. The sudan grass is followed by alfalfa-brome grass. An additional 855 bushels of corn are produced for sale.

Storage feeding requires 61 acres of alfalfa-brome grass and 22 acres of corn silage. Seven hundred and fifty-five more bushels of corn are produced for sale than in the grazing system. Details of all the cropping systems are given in table 9.

C. Investment and annual fixed costs of buildings, equipment, and machinery.

The three systems will hereafter be referred to as 'grazing', 'green chopping', and 'storage feeding' for simplicity. For grazing, a chopper is not owned, and the silage is custom chopped. A baler is owned, and total investment in buildings, machinery, and equipment is \$33,510. Depreciation, repairs, and insurance are charged at rates from 4 to 19 percent, and the annual cost comes to \$3,395. For green chopping, there is a reduction in investment in fencing from \$1,200 to \$400. Added investment consists of a concrete slab, a self-feeding wagon, a chopper wagon, and a field chopper with a direct chop head. A baler is not owned, and the hay is custom baled. Total investment is increased by \$2,150, and the annual cost is increased by \$283. For storage feeding there is a similar reduction in investment in fencing; added investment consists of a concrete slab, an automatic feeder, and a field chopper and wagon. Total investment is greater than for grazing by \$1,750, and annual cost is increased by \$210. As for green chopping, a baler is not owned, and hay is custom baled. The investments are shown in table 10.

D. Changes in costs and net income.

The net incomes obtained from the three systems are: grazing, \$7,572; green chopping, \$7,500; and storage feeding, \$7,373. These do not differ greatly, but show a slight advantage in favor of grazing,

with green chopping \$72 behind, and storage feeding \$199 behind. The small difference in net income between a grazing and a green chopping increases the importance of factors not included in the budgets, such as the increased labor load associated with green chopping and the preferences of the farmer. The complete budgets are shown in table 11 and partial budgets in table 12.

It can be seen that the extra income from corn sales with green chopping and storage feeding is offset by the extra machinery cost, and by the greater cost of custom baling hay as compared with the cost of custom chopping the silage in the grazing system. Another important increase in cost is for the fertilizers used on the extra corn, and for growing sudan grass, which, as mentioned in the assumptions, is here considered to be a necessary part of green chopping, although it is more expensive to grow than alfalfa-brome grass, since it is an annual crop.

6. The 60 cow herd.

A. Housing, feeding systems, and labor requirement.

A significant increase in investment is necessary when a change is made to a loose housing and milking parlor system. It is generally considered that a 60 cow herd is large enough to cover the extra fixed costs involved. The stanchions are removed from the stanchion barn, and investment is made in a pole barn, so that together with the converted stanchion barn there is loose housing accomodation for the 60 cows and

the young stock. A herringbone milking parlor is built, with a double row of four standings, but in a building large enough to take double five in case of further expansion. The bulk milk tank is replaced with one holding 700 gallons.

An alternative would have been to build additional loose housing for 30 cows only, and to keep all the stanchions in the barn and milk the cows in two shifts, or to keep about seven of the stanchions and pass all the cows through them. Although this would involve less investment, the labor requirement would be high, and in addition opposition might be met with from area or local health inspectors representing some markets. This alternative is not included in the budgets.

With the adoption of a loose housing system, certain investments must be made regardless of the pasture system. A second silo is added, measuring 18 x 60. This is the same diameter as the old one, and so the silo unloader which is purchased can be used in both silos. A concrete slab and mechanical silo unloader and feeder are also needed for all three systems.

It was necessary to hire 8 months of labor in changing from a 30 to a 60 cow herd. In addition, for storage feeding, 10 days of seasonal labor are hired to help with the alfalfa-brome grass silage harvesting.

B. Cropping and feed utilization.

The total acreage in alfalfa-brome grass under the grazing system is 125. Fifty-five acres of corn silage are needed. As a result of this, oats are dropped from the rotation, and the alfalfa-brome grass is seeded in wide-row corn. Twenty acres of corn are harvested for grain, and 1,500 bushels must be purchased. The feasibility of seeding in wide row corn has been investigated recently^{1,2}; it results in slightly lowered corn yields, and better than average skill, especially as to timing of operations, is required to establish good seedings.

For the green chopping system, 97 acres are in alfalfa-brome grass, and 10 acres in sudan grass. Of the remaining 93 acres, 54 are harvested for corn silage, and 39 for grain. Only 241 bushels of corn need be purchased.

For the storage feeding system, 98 acres are in alfalfa-brome grass. Of the remaining 102 acres, 59 acres are harvested for corn silage, and 43 for grain. The amount of corn which must be purchased is further reduced to 50 bushels.

¹ C.R. Hoglund, Economics of Feed Production in South-central Michigan, Michigan Agricultural Experiment Station Special Bulletin 420, Sept. 1958.

² M.B. Tesar, Establishment of Alfalfa in Wide-row Corn, Agronomy Journal 49: 63, 1957.

C. Investment and annual fixed costs of buildings, equipment, and machinery.

The acreage of hay and silage has increased to such an extent that it is worth while to own a baler and a chopper and wagon for all three systems.

The total investment is therefore the same for all three systems, except that investment in fencing remains as it was at the 30 cow level for green chopping and storage feeding, and increases to \$2,000 for grazing; a second difference is that a direct chop head is needed for the field chopper for the green chopping system. Investment for the grazing system is \$55,210, for green chopping is \$54,210, and for storage feeding is \$53,610. Annual costs of depreciation, repairs, and insurance are \$5,252, \$5,204, and \$5,102, respectively.

D. Changes in costs and net income.

The net incomes obtained from the three systems are: grazing, \$7,798, green chopping, \$8,339, and storage feeding, \$8,498. Thus, at the 60 cow level, the advantage lies with green chopping and storage feeding to the extent of \$541 and \$700, respectively. In money terms there is not a great deal to choose between these two systems, although other factors, such as the necessity, in the green chopping system, to chop daily including Sundays, and the uncertainty caused by the possibility of bad weather and breakdowns, may be important in a farmer's decision as to which to adopt. The increase in income from storage

feeding at the 60 cow level over grazing at the 30 cow level, where the latter was found to be the most profitable system, is \$926.

The advantage for green chopping and storage feeding lies in the reduced amount of grain which must be bought. Indeed, these systems allow the 200 acre farm to be self-supporting in both grain and forage for 60 cows. Any increase in herd size will involve buying first grain, and then forage, as will be seen for the 100 cow herd. The added costs needed for green chopping and storage feeding are considerable, but are not as great as the savings in purchases of grain. These costs are mainly for fuel, and for fertilizers. The increase in cost for fertilizers was explained in connection with the 30 cow herd. The extra fuel requirement is caused largely by the daily green chopping, and by the 76 acres of alfalfa-brome grass which must be ensiled for the storage feeding system. Extra fuel is also needed in both systems for hauling manure in the summer, and for the extra acreage of corn grain and rye.

7. The 100 cow herd.

A. Housing, feeding systems, and labor requirements.

With increase in herd size from 60 to 100 cows, some extra investment in housing and in feeding equipment is necessary, but not so much as for the expansion from 30 to 60 cows. The loose housing is expanded so as to accomodate 100 cows and the concreted area is extended. A third silo is erected: in order to store the increased

amount of silage required, this measures 24 x 50. A second silo unloader is needed as this silo has a different diameter to the other two. The mechanical feeders are lengthened to satisfy the requirements of the additional cows. The double four herringbone milking parlor is expanded to a double five, and the 700 gallon bulk tank is replaced by one holding 1,000 gallons. As in the case of the 60 cow herd, all this equipment is necessary for efficient winter feeding of the cows, regardless of the summer pasture system.

With the increase to 100 cows, a full-time hired man is employed. The amount of labor available in the summer therefore remains the same as it was at the 60 cow level. This is made possible by the reduction in the acreage of corn, and by the elimination of hay-making. The additional work needed for green chopping is made easier by the presence of a high capacity chopper, and by the availability of a second chopper. For the storage feeding system, 12 days of labor are hired to help harvest the alfalfa-brome grass silage.

B. Cropping and feed utilization.

Under a grazing system, the total farm acreage in alfalfa-brome grass is 141 acres. The remaining 59 acres are taken for corn silage. All the grain required by the dairy herd, 4,500 bushels, must be purchased. No hay is made on the farm, as all the alfalfa-brome grass is either grazed or taken for silage to feed in the summer, with a little left over to feed in the winter, and so 376 tons of hay must be purchased.

Due to the shortage of corn silage to feed in the winter, hay takes an important place in the ration; and since purchased hay is likely to be of poorer quality than hay produced on the farm, the requirement of protein concentrate is increased.

Under a green chopping system, 82 acres of alfalfa-brome grass are required, and 17 acres of sudan grass. Of the remaining 101 acres, 90 are taken for corn silage, and 11 for corn grain. Six hundred and sixty fewer bushels of grain need be purchased, and 112 fewer tons of hay.

Under a storage feeding system, 84 acres are in alfalfa-brome grass. Of the remaining 116 acres, 99 are taken for corn silage, and 17 for grain. As compared with the grazing system, 1,020 fewer bushels of grain need be purchased, and 102 fewer tons of hay.

C. Investment and annual fixed costs of buildings, equipment, and machinery.

For the 100 cow herd, all the hay must be bought, and so the baler is sold. The chopper is replaced with one of greater capacity, and a second chopper is bought for the green chopping system: this can be a relatively inexpensive flail-type forage harvester. Thus the only differences in investments between the three systems are in the choppers, and in the fencing. Total investment in fencing is \$2,500 for the grazing system, as compared to \$500 for the other two. The total investment for grazing is \$64,780, for green chopping it is \$64,280,

and for storage feeding it is \$62,780. The annual costs are \$5,906, \$5,961, and \$5,706, respectively.

D. Changes in costs and net income .

The net incomes obtained from the three systems are: grazing, \$9,354, green chopping, \$10,535, and storage feeding, \$10,730. Green chopping and storage feeding show increases over grazing of \$1,181 and \$1,376, respectively. Thus storage feeding is the most profitable system, as it was at the 60 cow level, and its advantage over grazing is increased. The increase in income resulting from expanding the herd size from 60 to 100 cows, using a storage feeding system, is \$2,232, and the increase in income over that obtained under the most profitable system, grazing, at the 30 cow level, is \$3,158.

The advantage for green chopping and storage feeding lies in the reduced amount of hay and grain which must be purchased. In all systems great reliance is placed on bought feed: no hay at all is produced on the farm, and no grain either under the grazing system. As at the 60 cow level, the increased costs involved in green chopping and storage feeding are mainly caused by the extra seed, fertilizers, and fuel which are required, and they can be explained in the same way.

8. Changes in costs with increase in herd size.

It is possible to construct cost curves from the data in the budgets. The production functions on which these curves are based are

determined by the assumptions of the budgets. The output is measured in terms of milk sales and sales of calves and cull cows. The variable inputs are the hired labor, feed, seed, and fertilizers, machinery and fuel, and increases in investment used in each pasture system. The fixed factors are the 200 acres of land, the labor and management of the operator and his son, and the capital investment for the grazing system at the 30 cow level. Figure C shows total cost curves for the three pasture systems, constructed from the expenses at each herd size. These cost curves are not therefore strictly valid except at the three outputs for which budgets were made. They do show, however, that the relationships between the systems alter with increasing size of herd, and that storage feeding becomes more profitable than the other two systems between outputs of 300, 000 and 588, 000 gallons of milk.

In figure D, the changes in costs when the most profitable system or technology is used at each level of output is shown. The inputs are grouped into four categories, as follows:

1. Feed costs less corn sales, seeds, fertilizers, bedding, D. H. I. A. and miscellaneous dairy costs, and real estate tax.
2. Machinery depreciation, repair, and insurance; fuel, oil and grease.
3. Custom hire of machinery and hired labor.

4. Interest on added investment.

As the herd is expanded from 30 to 60 cows, the category 1. costs increase faster than any of the others. With this change, it becomes no longer possible to sell any corn off the farm, and it becomes necessary to buy bedding, as oats are no longer grown.

With further expansion from 60 to 100 cows, the category 1. costs increase at an increasing rate. At the 100 cow level, large quantities of corn and hay must be bought. Land has become limiting in feed production, and the question is raised whether it would be more profitable to rent or buy more land, or to buy standing hay, if any of these become possible.

Fuller¹, budgeting alternative dairying plans in 1957, compared a farm of 228 tillable acres and two full-time men with one of 456 tillable acres and three full-time men, both supporting 120 cows, and found that the latter had a greater profit by \$3,082. However, Fuller used a price of \$1.25 as compared to the selling price of \$1.00 used in this study for corn. Hoglund² has also considered the effects of buying

¹ E.I. Fuller, Some Labor Efficient Dairy Farm Organizations, Department of Agricultural Economics, Michigan State University, Ag. Econ. No. 690, July 1957.

² C.R. Hoglund, Economics of Feed Production in South-central Michigan, Michigan Agricultural Experiment Station Special Bulletin 420, Sept. 1958.

versus producing feed for the larger dairy herd. For a herd of 65 cows on a 180 acre farm, for which extra feed had to be bought, he compared renting 62 acres of moderately productive cropland with renting 80 acres of less productive cropland. The increase in net income was nearly \$500 in the first case, and only \$200 in the second. As well as the productivity, the location of the rented land is also important, although green chopping and storage feeding increase the possibility of using awkwardly located land for the pasture period. Nevertheless, the difficulty of renting productive and conveniently located land often necessitates buying feed.

Increases in costs in categories 2., 3., and 4. occur at a decreasing rate, showing that some economies of scale are encountered. Labor requirements per cow are reduced with the introduction of a milking parlor and loose housing system. Once investment has been made in a milking parlor, little or no extra investment is needed as more cows are milked, and so depreciation and interest costs are little altered. Costs of seed and fertilizers remain nearly constant regardless of herd size.

The net effect of all these cost increases is that total cost increases at a slightly decreasing rate. This is shown by what can be termed the marginal cost, which, when calculated as an average per 100,000 gallons and associated livestock sales, was \$4,031 over the range 300,000 to 588,000 gallons, and dropped to \$3,677 over the

range 588, 000 to 950, 000 gallons. It would therefore seem that further expansion with the same fixed factors would be profitable, but since any further increase in herd size above 100 cows would involve buying silage, or going over to a ration composed largely of bought hay, it is likely that the marginal cost would begin to rise, or become an inapplicable concept. Buying or contracting for standing forage is likely to be a better alternative.

9. Substitution of inputs.

It is also possible to express the relationship between the three systems in terms of a substitution between acres of forage, and the expenses involved in feeding during the summer. Green chopping and storage feeding use less pasture, but involve greater expenses. This is not a true substitution between inputs because different technologies, and therefore production functions, are involved. However, a useful analysis can be made by superimposing the inputs required for each pasture system onto one graph. The combinations of acres of forage with cash expenses which are required by each system to supply the forage needs of 30, 60, and 100 cows during the pasture season are shown in figure E.

It was necessary to adjust the acres of alfalfa-brome grass for three reasons. First, pasture may be used all season, or for first cut or second cut only, the remainder of its production being used in the winter. In accordance with the T.D.N. produced by all season, by first cut, and by second cut grazing, chopping, haying, and ensilage

an acre used all season was given the value 1, an acre used for first cut was given the value $2/3$, and an acre used for second cut was given a value of $1/3$. The second reason that an adjustment had to be made is that for green chopping, some sudan grass is used as well as alfalfa-brome grass. An acre of sudan grass was given a value equal to an acre of alfalfa-brome grass, as they substitute for each other in land requirement in the ratio one to one. The third reason is that the pasture system lasts for 150 days in the grazing and green chopping systems, but for only 130 days in the storage feeding system. In order to make the systems comparable, the acreage requirement for the storage feeding system was multiplied by a factor of 1.154.

On the expense side, the costs of feeding the standing forage were computed. These costs consist of custom charges for baling hay and chopping silage fed in the summer period, fuel costs for green chopping and making silage which is fed in the summer, the extra labor costs for storage feeding, the cost of differences in investment between the systems directly attributable to the summer pasture program, and, for the green chopping system, the extra cost of growing sudan grass over the cost of growing an equal acreage of alfalfa-brome grass.

In order to bring a price line into the analysis, it was necessary to compute the cost of seed, lime, fertilizer, and fuel needed annually to produce an acre of alfalfa-brome grass which is kept down for three

years. This came to a total of \$12.90, and corresponding price lines are shown in figure E. The most profitable system is the one which produces a given output with the least cost. At the 30 cow level this is the grazing system. The total cost at this point is \$681.00, or \$22.70 per cow. The most profitable system at the 60 cow level is storage feeding: at this point the total cost is \$1,281.00, or \$21.36 per cow. At the 100 cow level the most profitable system is again storage feeding, the total cost is \$2,082.00, and the cost per cow \$20.82. It is interesting to note that these costs per cow are similar to those which have previously been used by research workers in Michigan. A usual charge has been \$0.15 per cow per day, which for a 150 day period totals \$22.50. This method of choosing the optimum system at each level provides the same results as are obtained in the budgets, as would be expected, and also points out some other relationships.

At increasing levels of output, the iso-quants tilt toward the right, showing that the acreage requirement increases more rapidly than the cash expenses for grazing relative to storage feeding. Although at the 30-cow level green chopping is the next most profitable, it becomes less profitable than storage feeding at higher levels due to a relatively greater increase in costs. An important part of these costs come from the necessity to seed and fertilize the sudan grass, and from the increased expenses for fuel and oil involved in daily

chopping.

In summary, it can be said that technologies which allow substitution of labor, machinery, and fuel for land tend to become profitable as herd size is increased since the machinery can be more fully utilized, and its cost spread over a larger output, and that this substitution is more efficient in the case of storage feeding than in the case of green chopping.

CHAPTER FIVE

THE ADOPTION OF NEW PRACTICES

1. The application of research results.

Research results based on experimental data suffer from two kinds of drawbacks. First, they may be difficult to arrive at due to the shortcomings of the data for economic analysis, and second, once arrived at, they may be difficult to apply. Swanson¹, discussing the latter problem, has said that farmers frequently remark that although results reported by agricultural experiment stations show adoption of a given practice to be profitable, conditions on the farm are sufficiently different from experimental conditions to render the results unreliable for planning operations on the farm.

These drawbacks can be ameliorated by obtaining the data necessary for the economic analysis from farms representing a homogenous group to which the results will be applied. In deciding on the size of the group, two factors must be balanced against each other, for as the size is increased, the study becomes wider in scope, but at the same time the homogeneity of the group decreases and the results become less reliable in application. Prices tend to be the same over a relatively large area, but not the physical resources of farms.

¹ E. R. Swanson, Problems of applying experimental results to commercial practice, Journal of Farm Economics, 39: 382, 1957.

Duckham¹, reporting on the different techniques used by extension workers in the United States and in the United Kingdom, said that in the United States:

"...in many cases, every farmer for 100 miles north, south, east, or west of any one point may have similar technical and economic problems, (and) may live on farms broadly similar in size and held on the same systems of land tenure."

This is only true, however, of parts of the United States, and relative to the great variability found in the United Kingdom.

In south-central Michigan, the physical resources of farms vary a great amount, especially in regard to size and topography. The farms in the survey ranged in size from 80 to 398 acres, and had significantly different amounts of land which could only be used for row crops occasionally. For the purposes of this study, a farm size near the mode of those in the survey was chosen, and other explicit assumptions were made. Although no separate rotations were worked out for land with different use capabilities, no more than 70 percent of the tillable acreage was in row crops in any of the budgets.

In applying the results of budgets to individual farms, account must be taken of differences between the situation on each farm and that assumed in the budgets. It is therefore very necessary that the

¹ A. N. Duckham, American Agriculture, Her Majesty's Stationery Office, London, 1952.

budgetary assumptions be made explicit, and the budgets presented in such a way that the results can be modified as required. Account must also be taken of factors other than physical resources, such as the age and composition of the labor force, management, and the equity position. Wheeler and Black¹ have discussed the need for the operating unit approach in budgeting in the following terms:

"In almost any agricultural county there are groups of farms with comparable physical characteristics... Optimum adjustments vary from farm to farm, but ordinarily they form patterns which are repeated through groups of farms with similar physical characteristics... But within any group of farms where physical resources are closely similar, widely divergent solutions are likely to occur... The explanation is to be found in the diversity of human resources existing on groups of farms where physical resources are similar."

A budgetary analysis is essentially a static one, and accordingly suffers from some additional disadvantages. One of these is that perfect knowledge of production functions and prices is assumed, and yet does not exist in the real world. It is therefore very unwise to predict the exact incomes to be expected from farm plans; but since there is often a reasonable degree of correlation between the yields of different crops, and between the prices of different products, the relative outcome of different plans will tend to remain the same although their absolute level changes.

¹ R. G. Wheeler and J. D. Black, Planning for Successful Dairying in New England, Harvard University Press, Boston, 1955.

Another disadvantage of a static analysis is that the inter-relation of production and consumption is not considered, and the subjective values of the farm family do not enter into the analysis. Among the values which have a profound effect on decisions are those concerned with risk aversion, desire for innovation and expansion, and the relative importance of present consumption and the potential future consumption made possible by present investment. It is as if the researcher assumes that the goal of the farm family is to maximize profit, and then proceeds to discover ways in which this goal may be obtained. But since his analysis makes this explicit, and shows what inputs, investments, and enterprises are involved, the farm family can modify the budget so that it fits their own physical and human resources more nearly, and can also discover what degree of initiative, management ability, and risk is involved in the different plans, so that a decision in line with their values can be made. It is probably true to say that a farmer is more likely to make a success of his operation using a plan in the efficacy of which he believes, than a plan which he dislikes, even though the latter may be potentially more profitable.

2. The adoption of the alternative pasture systems.

Despite these difficulties in the application of research results and in the use of generalized budgets in the planning of individual farms, it is interesting to find that the results of the budgets in this study can be used to explain some of the adjustments which took place on the farms

in the survey, from 1954 to 1958.

As was stated in section 3 of chapter four, the average size of the farms in the survey increased from 188 acres in 1954 to 210 acres in 1958, and the average herd size increased from 30.7 cows in 1954 to 44.5 cows in 1958. The farms in the survey were classified as following predominantly improved grazing, strip grazing, green chopping, and storage feeding systems. In 1954 nearly 65 percent of the farms were practising improved grazing; in 1958 the majority of farms were either practising green chopping or storage feeding. The complete changes are shown in table 13. Most of the changes were from improved grazing to green chopping and storage feeding. Three farms changed from green chopping to storage feeding during the 5 year period; storage feeding had the largest increase in numbers. There were no "retrograde" changes, that is, changes from right to left in the table.

A second way of looking at the changes which have been occurring, which relates them more directly to the effect of herd size and farm acreage, is to calculate the average number of tillable acres per cow for farms following each of the three pasture systems, and for the farm in the budgets. In order of decreasing number of tillable acres per cow, these are as follows:

1. Budget farm, 30 cow herd . . .	6.67	acres per cow
2. Improved grazing farms . . .	6.20	"
3. Green chopping farms . . .	4.50	"
4. Storage feeding farms . . .	4.38	"
5. Budget farm, 60 cow herd . .	3.33	"
6. Budget farm, 100 cow herd . .	2.00	"

These figures represent the pressure of herd size on available land.

As herd size is increased with little or no increase in farm acreage, the pressure is increased, and it becomes profitable to adopt green chopping or storage feeding which allow more intensive use of the pasture acreage.

These changes fit in with the changes suggested by the budgets, except that green chopping was never found to be the most profitable system, although it was more profitable than storage feeding for the 30 cow herd. This can be explained in two ways. First, budgets made for about a 45 cow herd may show that green chopping is the most profitable system, and second, subjective factors may enter into the farmers' decisions which were not allowed for in the budgets. These are particularly important when the money difference is not great. In particular, green chopping is a less radical change from grazing than is storage feeding, since in the former the cows are fed fresh forage, and a change can be made back to grazing with relative ease. Once the silage has been made for a storage feeding program, however, it is necessary to feed it at least until the grass has made considerable regrowth, and it must be fed eventually.

It should be made clear that the distinction made previously between the pasture systems used by farmers is not clear cut in many cases. Farmers following an improved grazing program may feed varying amounts of supplementary silage; farmers following a green chopping program may also have silage available in the summer for emergencies; and farmers following a storage feeding program may feed green chopped forage especially while they are chopping grass for silage. All this results in some welcome flexibility and also allows farmers to gain experience of using alternative systems without committing themselves to them completely.

3. Pattern of decisions made by farmers.

Johnson¹ has defined five tasks of management as follows:

1. Observation
2. Analysis
3. Decision
4. Action
5. Acceptance of responsibility

These comprise a complete act of management, but before they can be put into operation it is necessary that the manager should have some felt difficulty and should isolate a problem area to which he can apply his management ability. In discussing the identification of management

¹ G. L. Johnson, Managerial Concepts for Agriculturalists, Kentucky Agricultural Experiment Station Bulletin 619, July 1954.

alternatives, Overley¹ listed five stages as follows:

1. Discontent
2. Consideration of alternatives
3. Initial selection and verification
4. Tentative action and review
5. Full commitment.

The flexibility without full commitment mentioned in the previous section comes under stage five of this classification, which is very relevant to the actions of a farmer who operates in an uncertain world, and is usually unwilling to commit all his resources to a new plan without first trying it out on his own farm on a small scale.

In the survey, farmers were given an opportunity to discuss their attitudes towards the different pasture systems, and the reasons which had led them to adopt one rather than another. They were also asked some specific questions which it was thought might have relevance in this area. The information obtained in these ways is here discussed in relation to concepts which have been developed in the theory of management.

A. Definition of a problem.

The problem of changing from one pasture system to another is closely tied in with the whole question of innovation and increase in size of operation, and with the discontent discussed by Overley.

A considerable number of the farmers in the survey had increased the size of their dairy herds by more than 25 percent from 1954 to 1958. This sort of change is likely to become a central problem

¹ F. L. Overley, Identifying Management Alternatives in Extension Work with Farmers, unpublished M. S. Thesis, Department of Agricultural Economics, Michigan State University, 1957.

of their farm planning. Of the farmers who were following an improved grazing program in 1958, only 43 percent had increased their herd size by more than a fourth, as compared to 65 percent of those following a green chopping program, and 87 percent of those following a storage feeding program.

A farmer is always looking for ways to increase his income, but is more likely to make adjustments to his farming system if there is some particular need to be reckoned with, such as the expectation of a long life in farming before retirement, or, in the case of an older man, the expectation that his son will follow him in operating the farm. The average age of all the farmers in the survey, including the age of all partners if the younger partner was over 30 but otherwise only the age of the older partner, was 42.5 years. The average ages of the farmers using the alternative pasture systems were not very different from each other. The farmers in the survey averaged considerably younger than all dairy farmers in south-central Michigan taken as a group, and for this reason were probably more willing to adopt new technologies than the average.

Differences were found, however, in the number of farms under each pasture system on which a son was expected to take over the operation of the farm or to come in as a partner, or on which a son was already a partner, but under 35 years old. Of the grazing farms, only 57 percent could be described in these terms, as compared to 71

percent of the green chopping farms and 73 percent of the storage feeding farms.

As a more direct check on whether a problem had been defined in terms of alternative pasture systems, the farmers in the survey were asked if they were pleased with their present pasture systems. Of the farmers following an improved grazing program, 43 percent said that they were dissatisfied with their pasture system; of those following a green chopping program, only 12 percent; and of those following a storage feeding program, only 13 percent. One of the latter farmers was not dissatisfied with storage feeding as such, but was planning to make all corn silage in place of grass silage.

This analysis would seem to show, therefore, that a majority of the farmers in the survey were dissatisfied with grazing as a pasture system, or had been dissatisfied earlier and had since changed to green chopping or storage feeding.

B. Observation of data.

The farmers in the survey were asked from what sources they had obtained information about green chopping and storage feeding. They mentioned farm magazines, the research and extension publications of Experiment Stations, county agents and other representatives of agriculture colleges, and neighbors the most number of times, as being important sources of information. Other sources were numerous but were not mentioned so frequently. Table 14 shows the order of frequency

in which the five most important sources of information were mentioned. Johnson¹ has tabulated the communicative sources of information used by 1,075 selected midwestern farmers in 1954, by type of information. The relative importance of the same five sources in his whole list, for information about new technologies, is also shown in table 14.

In Johnson's tabulation, the third most important source of information was newspapers. This source was only mentioned four times in the survey. The major differences between these two lists lie in the relative importance of the publications of Experiment Stations, and of dealers, salesmen, and buyers. One conclusion of Johnson's study was that some opportunity existed for the agricultural colleges to expand their production and distribution of information on new technology. From this small survey, it would seem as if development along these lines has occurred since 1954, though it should be noted that the farmers in the survey were selected partly for the reason that they did make good use of the services of county agents and Experiment Station publications.

Dealers, salesmen, and buyers were not found to be very important sources of information in the survey. This may be because although it becomes essential or profitable to own a forage chopper

¹ G. L. Johnson, New Knowledge of the Decision-making Process, Journal of Farm Economics, 40: 1393, Dec. 1958.

with a green chopping or storage feeding program, it is not a completely new or specialized piece of equipment such as a bulk tank or a milking parlor, nor a newly developed input such as a certified seed or compound fertilizer, which a salesman would be keen to bring to the notice of farmers.

C. Analysis of data.

The farmers in the survey were asked whether they had ever figured the effect of a change in their pasture system on their expenses and income, and if they had done so, whether it was in their head or on paper. The replies are shown in table 15, tabulated according to whether the farmers changed their pasture system after the analysis, or if not whether they expected to do so in the future or not.

A majority of the farmers had done some figuring, but few had put it down on paper. It was not common for analysis of this sort to be done, and then for no change to be made or planned. More farmers analyzed one system only than analyzed both a green chopping and a storage feeding system. In discussions with farmers, the author obtained a strong impression that a farmer tends to sense that a particular system will suit him, then to find out more about it, do a little figuring, and try it out. If he does not sense that it will suit him, he will not bother to find out more about it or to analyze it. The initial acceptance or rejection is therefore rather subconscious, and depends on factors which are not strictly economical.

Farmers mentioned a large number of reasons why they had chosen or rejected the different pasture systems. These reasons were similar to the advantages and disadvantages listed in section D. of chapter two, which were those typically mentioned by research workers, although they varied greatly in the degree of importance given them.

An attempt was made to classify farmers' reasons for and against adopting green chopping or storage feeding into those concerned with economic, technical, and value aspects of the analysis. Since, however, the economic aspects depend largely on technical considerations, and are influenced directly by values, this classification is somewhat arbitrary. Reasons were classified as economic when they were concerned with costs, returns, and profit, with fixed costs, capital requirements, and with the overall organization and allocation of resources. Reasons were classified as technical when they were concerned with farmers' resources of land, labor, and management ability: with the effect for instance of topography, shortage of labor, or bad weather. Values are concerned with farmers' personal likes and dislikes, with what they think ought to be. Reasons were classified as having to do with values when they were concerned with what a farmer thinks is right and proper in a farming system, and with what he expects from himself and others in management and physical labor. The results are shown in table 16.

Among the most common reasons in favor of green chopping which were classified as economic was the greater output per unit of input, or specifically, the production of more feed per acre. The elimination of fencing costs was also mentioned. In the case of storage feeding, the former was again a common reason, and also the statement that storage feeding was "best for a large herd". It was also stated that storage feeding fitted well into an annual plan. An economic consideration frequently mentioned by farmers with a small dairy herd which they milked in a stanchion barn was the capital required for adoption of a storage feeding program.

The majority of the reasons given by farmers were classified as technical. Most of these technical considerations were concerned with the disadvantages of green chopping. Among these were the difficulties of maintaining the quality of the feed, the labor load involved in daily chopping, and the effect of adverse weather conditions. The technical reasons given in favor of storage feeding were mostly concerned with the relative certainty of the production of a good quality feed, and the resulting evenness of the production of milk.

It was not possible to isolate many reasons specifically concerned with the values of the farmers. All such reasons but one were reasons against adopting the systems, and were based on a desire to see the cows out of the dry lot and grazing, as soon as the grass had grown sufficiently in the spring, because that is "where they ought to be", and because

it provides a break from routine, especially on Sundays. The values concerned in such decisions can be related to those which treat anything habitual or traditional as inherently good.

D. Decision, action, and consequences.

Nearly all the farmers who had done some figuring changed their pasture systems, as was shown with reference to table 15. To many farmers who were increasing the size of their herds, it seemed the right or natural thing to change to green chopping or storage feeding. The process through which these farmers went might be described as a change in their image, as defined by Boulding¹, brought about by the influence of outside factors on their previous image. The most important of these factors were farm magazines and the publications of Experiment Stations, several of which during the period under consideration had discussed the alternative pasture systems and had suggested that they might be profitable under certain conditions. That this conception of the process is at least partly true is verified by the fact that two of the farmers, who said that they had done no figuring at all and who had nevertheless changed their pasture systems, stated that they had accepted published figures, one from a farming magazine and one from a research bulletin.

¹ K. E. Boulding, The Image, University of Michigan Press, Ann Arbor, 1956.

The execution of a decision to change from one pasture system to another usually took place after a trial or gradually, since it is possible to feed green chopped forage or grass silage in the summer without being completely committed to one system or another. As a result, the suggestion by Overley¹ that there is a stage of tentative action in identifying management alternatives is reinforced.

The farmers who made decisions about alternative pasture systems faced the possibility of making two kinds of error. One was to decide not to change when it would have been better to have changed, the other was to have decided to change when it would have been better not to have done so. That the latter occurred seldom is shown by the small number of farmers following a green chopping or storage feeding program who said that they were dissatisfied with their pasture system, and by the fact that during the five year period covered by the survey no farmers who were green chopping or storage feeding went back to a grazing program. This would probably have not been the case in a group of farmers with less management ability.

4. Relevance of the results to extension work.

This study has shown that farmers assimilate information from their environment, and build up an idea of how a new technique applies to their own farm situation. Budgeting is an approach which can provide

¹ F. L. Overley, op. cit.

information on the effect of new technologies subject to specific assumptions which limit the range of application of the results. Budgeting can also be used on an operating unit or individual farm to produce results more relevant to that particular unit.

The results of the budgets developed in this study were found to tally with changes which occurred on actual farms, to a considerable degree, even though the assumptions do not fit in all cases, and consideration of values has been omitted. This would suggest that budgeting is one useful method of explaining the possible effects of new technologies on a large group of farms.

There is, however, an acknowledged difficulty in going from the general budget to its application on individual farms. It is possible for farm management extension workers to assist farmers in making budgets and reaching decisions based on them, but this involves the expenditure of a great deal of time. It also suffers from the drawback that the same man does not execute and bear the responsibility for the decision as the man who makes the decision. Since these different tasks of management are inter-related and also loaded with values, the result is that a correct decision may not be made, and the farmer may become dissatisfied, fail to carry out the decision as well as he might, and possibly bear a grudge against the extension worker. These dangers will be lessened if the extension worker, as well as making good technical and economic recommendations, takes into

account all the likes and dislikes of the farm family, their values, and their goals. Nevertheless, it is the farmer who will have to live with the decision, and it would perhaps be better if he made it himself. Although an extension worker may be more effective if he does make more definite statements than would appear to be proper according to this argument, he would still be wise to make it clear that the actual decision rests with the farmer and is the latter's responsibility.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

1. Summary, and conclusions for south-central Michigan.

In this study, previous research on green chopping and storage feeding was investigated, and nine budgets were developed comparing improved grazing, green chopping, and storage feeding systems when used on a 200 acre farm with herd sizes of 30, 60, and 100 cows, under certain specific assumptions.

For the 30 cow herd, it was found that improved grazing was the most profitable system, with green chopping second and storage feeding third. For the 60 cow herd, the relationships were found to be different, and storage feeding was found to be the most profitable system, with green chopping again second, and improved grazing third. The three systems had the same order of profitability for the 100 cow herd as for the 60 cow herd.

A survey of dairy farms in south-central Michigan was described, and the data obtained from them were presented to show the changes which occurred from 1954 to 1958 in farm acreage, labor force, size of dairy herds, and in the pasture systems used by farmers. The results of the budgets were in line with these changes.

From 1954 to 1958, the average acreage of the farms in the survey increased from 188 to 210 acres, and the average size of dairy herd increased from 31 to 45 cows. The average size of herd estimated by farmers five years in the future was 57 cows. There was a small

increase in labor force between 1954 and 1958. Of the 44 farmers from whom data were obtained, 28 were following an improved grazing program in 1954; of these, only nine were following the same program in 1958. In 1958 the majority of farmers were green chopping or storage feeding, 16 using the former system and 14 the latter.

The preparation of budgets with assumed conditions similar to those on farms to which the results of the budgets will be applied, even though their physical and human resources differ considerably from those assumed in the budgets, appears to be a useful technique for research and extension. The budgetary analysis of individual farms is an additional refinement in that it allows for the consideration of the resources peculiar to those farms.

2. Tentative conclusions for the United Kingdom.

South-central Michigan provides a very different physical, biological, and institutional environment from that of any part of the United Kingdom, although the differences are not so extreme as in other parts of the United States. Duckham¹ has reached some important conclusions as a result of five years' experience of American Agriculture, as follows:

¹ A. N. Duckham, op. cit.

"There is no part of the United States where either the ecological conditions or the farming systems or the social structure has an exact counterpart in the United Kingdom. This means that only in rare instances can an improved variety of crop or grass . . . (or) a new cultivation practice . . . be successfully transplanted without modification. The most successful "transplants" are generally those which are least subject to ecological or social factors, e. g., advances in pure and applied science, in livestock production methods and in farm machinery.

Large dairy herds in loose housing are becoming increasingly popular in the United Kingdom, and it is possible that relationships similar to those discovered in the budgets will hold, but with modifications made necessary particularly by the different forage crops grown and the different weather conditions met with in the pasture season, and by differences in buildings, machinery, and labor force between the two countries. Difficulties may also be raised by the different values placed on traditional practices, especially as regards the grazing cow. The lowing herd winding slowly o'er the lea¹ is less likely to be replaced by Cynddylan on a tractor, away out of the farmyard scattering hens², in the United Kingdom than in the United States.

¹ T. Gray, Elegy written in a Country Churchyard, Oxford Book of English Verse, Oxford University Press, Oxford, 1900.

² R. S. Thomas, Cynddylan on a Tractor, Song at the Year's Turning, Hart-Davis, London, 1956.

The adoption of green chopping has been reported on British farms in recent years, ^{1, 2} and it appears that this can be done successfully. The interest in this technique is illustrated by the fact that it is being tested experimentally at Edinburgh University³.

There have been no published reports on storage feeding. Although it is too early to say to what extent green chopping and storage feeding will be adopted in the United Kingdom, it is likely that interest in them will increase, if larger herds become more common, and as advances are made in mechanization and in the productivity of labor, changes similar to those which have been occurring in south-central Michigan.

¹ A. Calder, op. cit.

² R. Wellesley, Zero grazing on a Berkshire farm, Agriculture, 65: 332, 1958.

³ K. V. Runcie, op. cit.

TABLE 1a

NUMBERS OF FARMS, DAIRY COWS,
AND ACRES PASTURED ¹

Year	Number of farms with dairy cows	Number of cows	Number of farms with pasture	Acres pastured
1944	132,627	951,276	143,152	6,348,150
1954	82,534	777,645	99,225	4,591,500

TABLE 1b

NUMBERS OF DAIRY COWS, TILLABLE ACRES,
AND MEN PER FARM ²

Year	Number of dairy cows per farm	Number of tillable acres per farm	Number of men per farm
1950	16.0	171	1.7
1958	29.6	211	1.7

¹ U.S. Department of Commerce, 1954 Census of Agriculture, Michigan, Vol. 1 Pt. 6.

² Michigan State University Cooperative Extension Service Farm Accounting Project, Area 5 Reports, South-Central Michigan.

TABLE 2
ESTIMATED NET DIFFERENCES IN RECEIPTS AND EXPENSES FOR THREE SIZES OF DAIRY HERD
WHEN THE FIELD CHOPPER, GRASS SILAGE FORAGE HARVESTING METHOD
REPLACES THE FIELD CURING, BAILING METHOD¹

	10 cow dairy herd	20 cow dairy herd	40 cow dairy herd
Total additional receipts and reduced expenses	<u>Dollars</u> 311	<u>Dollars</u> 623	<u>Dollars</u> 1,196
Total additional expenses	330	340	395
Net difference	-19	+283	+801

¹ C.R.Hoglund, Ag. Econ. No. 620, Michigan State University.

TABLE 3
EXPERIMENTAL RESULTS SHOWING ACRES PER DAIRY COW AND MILK YIELD PER ACRE

Location (references as in text)	Year	Plant species	Treatment	Number of dairy cows	Number of days	Acres per cow	% increase over grazing	Yield per acre lb.	% increase over grazing
Utah	1957	High producing pasture	Graze Green chop	20	159 136			8602 8601	0%
Minnesota	1953	Alfalfa-brome grass, oats, sudan grass,	Graze	35	74.5	1.46		1525	
		orchard grass, ladino	Green chop	35	74.5	0.38	68%	2538	68%
	1954	Alfalfa-brome grass	Graze	8	94	2.10		1343	
		only	Green chop	8	84	2.15	-2%	1406	2%
Rhode Island	1955	Alfalfa-brome grass, sudan grass, oats	Graze	25.5	94	1.14		3483	
		Ladino, brome-grass, orchard grass, sudan grass	Green chop	25.5	94	0.62	84%	6271	81%
			Graze	12	103	1.21		2792	
			Green chop	12	103	0.84	44%	3945	42%
Cornell		Alfalfa-brome grass, ladino	Strip graze	8	74	2.0		6160 ¹	
			Rotation graze	8	74	2.0		6230 ²	1%
			Green chop	8	74	2.0		5980 ³	-3%
Wisconsin	1955-6	Grass-legume stand	Rotation graze	12	115	1.14		2411	
			Green chop	12	115	0.69	67%	5190	115%
			Storage feed	12	115	0.49	122%	6056	150%
Scotland		Pasture grasses	Strip graze	38	197	0.87			
			Green chop	38	197	0.77	11%		
			Green chop	38	247			4752	
Michigan ⁴	1954- 1958	Alfalfa-brome grass, sudan grass, pre- predominantly	Graze	30	150	1.26			
			Green chop	38	150	0.99	27%		
			Storage feed	51	130	0.84			

4 Pasture study;
figures are averages.

1 Plus 1510 lb. Dry matter forage
2 Plus 1550 lb. " " "
3 Plus 2890 lb. " " "

TABLE 4

EXPERIMENTAL RESULTS SHOWING AVERAGE DAILY GAIN
AND MEAT PRODUCTION PER ACRE

Location (references as in text)	Plant species	Treatment	Number of animals	Animal	Number of days	Average daily gain	% increase over grazing	Production per acre lb.	% increase over grazing
California	Alfalfa	Graze Green chop	10 10	Feeder steer "	108 108	1.66 1.50	-9.5%	447 563	26%
"	Trefoil	Graze Green chop	10 10	Feeder steer "	108 108	1.75 1.76	0%	359 444	25%
California	Alfalfa	Graze Strip graze Green chop	10 10 10	Yearling steer " "	168 168 168	1.80 1.90 1.92	6% 7%	417 580 704	39% 69%
California	Alfalfa	Graze Green chop	10 10	Yearling steer "	155 155	1.94 1.80	-7%	525 678	29%
		Graze Green chop	9 10	Feeder steer "	132 132	1.79 1.73	-3%	689 1080	57%
Michigan	Alfalfa-brome grass	Graze Strip graze Green chop	10 10 10	Feeder steer " "	83 83 83	1.94 1.84 1.97	-5% 1%	200 380 400	91% 100%
California	Alfalfa	Graze Green chop	20 20	Feeder lamb "	108 108	0.34 0.21	-38%	440 463	6%
	Trefoil	Graze Green chop	20 20	" "	108 108	0.31 0.24	-23%	388 417	8%

TABLE 5

EXPERIMENTAL RESULTS SHOWING TIME TAKEN TO FEED COWS

Location (references as in text)	Details	Number of cows	Average daily requirement, man hours and minutes	Minutes per cow
Utah Minnesota Scotland ¹ Michigan ¹	GRAZING			
	Including clipping and raking	20	0:48	2.4
	Fence moving and clipping	25	0:15	0.6
	Including moving electric fence	38	1:30	2.4
	Driving cows, only	52		1.1
Utah Minnesota ² Minnesota ² Rhode Island Illinois ⁴ " " Scotland Michigan ¹	GREEN CHOPPING			
	Chopping, hauling, bedding down, and manure removal	20	1:56	5.8
	Side delivery wagon	25	0:40	1.6
	Cut once a day usually; side delivery wagon	30	1:50	2.8 ³
	Self-feeding wagon	13	1:55	8.8
	Chop once daily	41		1.4
	Chop twice daily	41		2.3 ⁵
	Two loads per day, average one mile to fields	38	2:30	4.0
	Chopping, only	42		1.8
Minnesota ² Michigan	STORAGE FEEDING			
	Feeding silage, only	30	0:54	1.4 ³
	Feeding silage, only	57		1.6

¹ Pasture study; averages.

² Minnesota Farm Business Notes No. 381, 1957

³ Including 20 heifers = 10 cow equivalents.

⁴ J.G.Cash and R.M.Finley, op. cit.; averages.

⁵ Use of a self-feeding wagon saved 0.13 minutes per cow per day.

TABLE 6
ESTIMATED DAILY LABOR REQUIREMENT FOR GREEN CHOPPING,
WITH VARYING HERD SIZE AND DISTANCE TO FIELD,
IN HOURS¹

	Distance to field in miles		
	0.4	1.0	2.5
Herd size			
20	1.57	1.82	2.45
40	2.98	3.23	3.86

¹ B.W.Henderson, J.W.Cobble, and H.J.Cook, op. cit.

Feeding 146 lb. forage per cow per day, unloading by hand.

TABLE 7

MACHINERY AND EQUIPMENT
FOUND IN THE STUDY

	Improved grazing	Green chopping	Storage feeding
Number of cows per farm	30.0	38.1	50.8
Percent of farms owning :			
Baler	82	70	87
Field chopper and blower	53	100	100
Chopper wagon	100	100	100
Self-feeding wagon	-	100	-
Silo unloader	-	30	63
Mechanical bunk feeder	-	-	63
Investment per cow	\$164	\$193	\$189

TABLE 8a

PRICES USED			
<u>Prices paid</u>		<u>Prices received</u>	
Corn	\$1.10 per bushel	Corn	\$1.00 per bushel
Hay	\$20 per ton	Milk	\$3.80 per cwt., net.
Soybean oil meal	\$80 per ton	Livestock	\$70 per cow in herd
Bedding	\$12 per cow		

COSTS

D.H.I.A. and other dairy costs.....	\$25.00 per cow
Electricity and telephone	\$10.00 per cow (30 cow herd)
	\$ 6.00 per cow (60, 100 cow herd)
Depreciation, repairs, and insurance	From .04 to .19% per annum
Custom hire	\$ 4.50 per ton, baled hay
	\$10.00 per acre, silage chopper
Labor	\$15.00 per day [and blower
	\$300 per month, part of year
	\$275 per month, whole year
Real estate tax	\$600
Interest on investment	6% of half the additional investment
	in buildings, machinery, and equipment,
	6% of additional investment in cows.
Hauling manure	\$2.00 per cow, grazing
	\$3.00 per cow, green chop or storage feed

MILK PRODUCTION

For 30 cows:	10,000 lb. milk per cow per year
For 60 cows:	9,800 lb. milk " " " "
For 100 cows:	9,500 lb. milk " " " "

TABLE 8b
CROP INPUTS, OUTPUTS, AND COSTS

Crop	Seed cost per acre	Lime cost per acre	Fertilizer per acre, lb.		Fuel per acre, gal.		Yield per acre
			6-24-12 ¹	0-20-20 ²	N ³	Regular	Custom
Corn grain	3.00	-	200	-	5 6 40; 80	12	-
Corn silage	3.00	-	200	-	5 6 40; 80	17	10
Oats grain	4.00	-	350	-	-	10	-
Alfalfa-brome seeding	5.00	10.00	-	200	-	6	-
Hay, 1st. cut	-	-	-	-	-	9	2.0 tons
2nd. cut	-	-	-	-	-	6	1.2 tons
Silage 1st. cut	-	-	-	-	-	14	7.2 tons
2nd. cut	-	-	-	-	-	10	3.6 tons
Green chopping all season	-	-	-	-	-	20	15.8 tons
2nd. cut	-	-	-	-	-	8	5.4 tons
Sudan grass, green chopping, 2 cuts	4.00	-	500	-	-	30	12.1 tons
Rye	2.50	-	150	-	-	6	-

1. Cost \$78.00 per ton
2. Cost \$64.00 per ton
3. Cost \$ 0.13 per lb.
4. Cost \$ 0.25 per gal., +10% for oil and grease
5. After sod crop or rye
6. After corn
7. 40-inch rows
8. 60-inch rows

TABLE 8 c
DAILY FEED INPUTS PER COW AND REPLACEMENTS

Feed	Improved grazing		Green chopping		Storage feeding	
	Days	Pounds per cow	Days	Pounds per cow	Days	Pounds per cow
Pasture period						
Alfalfa-brome grass pasture	150	200				
Alfalfa-brome grass green chop			130	200		
Sudan grass green chop			20	200		
Alfalfa-brome grass silage					130	140
Supplementary hay, OR	120	6	130	6	130	6
Supplementary silage	120	16	130	16	130	16
Barn period						
Hay	215	1		1		1
Silage	215	20	215	20	235	20
		1001	215	1001	235	1001
Whole year						
Bushels corn equivalent	45		45		45	
Pounds protein supplement						
Fairly heavy corn silage	500		500		500	
Medium corn silage	350		350		350	
Low silage, heavy hay	250		250		250	

1. Or equivalent with medium or heavy hay feeding.

TABLE 10
ESTIMATED INVESTMENTS REQUIRED FOR THREE PASTURE SYSTEMS
AND THREE SIZES OF DAIRY HERD, 200 ACRE FARM

	30 COWS			60 COWS			100 COWS		
	Graze	Green chop	Storage feed	Graze	Green chop	Storage feed	Graze	Green chop	Storage feed
Cows	9,000	9,000	9,000	18,000	18,000	18,000	30,000	30,000	30,000
Buildings and equipment	21,830	23,130	23,180	38,430	38,430	38,430	48,780	48,780	48,780
Fences	1,200	400	400	2,000	400	400	2,500	500	500
Power and machinery	10,480	12,080	11,680	14,780	15,380	14,780	13,500	15,000	13,500
TOTAL	42,510	44,660	44,260	73,210	72,210	71,610	94,780	94,280	92,780

TABLE 11
ESTIMATED RECEIPTS AND EXPENSES FOR THREE PASTURE SYSTEMS
AND THREE SIZES OF DAIRY HERD, 200 ACRE FARM

	30 COWS				60 COWS				100 COWS			
	Graze	Green chop	Storage feed	Graze	Green chop	Storage feed	Graze	Green chop	Storage feed	Graze	Green chop	Storage feed
RECEIPTS												
Milk	11,400	11,400	11,400	22,324	22,324	22,324	43,950	43,950	43,950	43,950	43,950	43,950
Livestock	2,100	2,100	2,100	4,200	4,200	4,200	8,400	8,400	8,400	8,400	8,400	8,400
Corn	5,034	5,889	5,779	-	-	-	-	-	-	-	-	-
Total	18,534	19,389	19,279	26,524	26,524	26,524	52,350	52,350	52,350	52,350	52,350	52,350
EXPENSES												
Corn	-	-	-	1,650	265	55	4,950	4,224	55	4,950	4,224	3,828
Supplement	420	420	420	1,200	1,200	1,200	1,800	2,000	1,200	1,800	2,000	2,000
Hay	-	-	-	-	-	-	7,520	5,080	-	7,520	5,080	5,480
Bedding	-	-	-	720	720	720	1,200	1,200	720	1,200	1,200	1,200
Building, equipment, and machinery costs	3,395	3,678	3,615	5,252	5,204	5,102	5,906	5,961	5,102	5,906	5,961	5,706
Miscellaneous dairy costs	750	750	750	1,500	1,500	1,500	2,500	2,500	1,500	2,500	2,500	2,500
Real estate tax	600	600	600	600	600	600	600	600	600	600	600	600
Electricity, telephone	300	300	300	360	360	360	600	600	360	600	600	600
Seeds	578	593	592	515	614	618	412	693	618	412	693	708
Fertilizers	2,809	2,989	2,940	2,410	2,697	2,680	2,139	2,876	2,680	2,139	2,876	2,840
Fuel, oil, and grease	670	801	780	928	1,525	1,550	621	1,409	1,550	621	1,409	1,342
Custom hire	240	493	536	-	-	-	-	-	-	-	-	-
Hired labor	1,200	1,200	1,320	2,400	2,400	2,550	3,300	3,300	2,550	3,300	3,300	3,480
Interest on investment	-	65	53	1,191	1,100	1,091	2,198	2,122	1,091	2,198	2,122	2,086
Total	10,962	11,889	11,906	18,726	18,185	18,026	33,746	32,565	18,026	33,746	32,565	32,370
NET INCOME	7,572	7,500	7,373	7,798	8,339	8,498	9,354	10,535	8,498	9,354	10,535	10,730

TABLE 12
PARTIAL BUDGETS

	30 COWS		60 COWS		100 COWS	
	Green chop	Storage feed	Green chop	Storage feed	Green chop	Storage feed
Added receipts						
Corn	855	745	-	-	-	-
Expenses saved						
Corn	-	-	1385	1595	726	1122
Hay	-	-	-	-	2440	2040
Machinery depreciation, etc.	-	-	48	150	-	200
Interest on investment	-	-	91	100	76	112
TOTAL	855	745	1524	1845	3242	3474
Added expenses						
Seed	15	14	99	103	281	296
Fertilizers	180	131	287	270	737	701
Fuel, oil, grease	131	110	597	622	788	721
Custom hire	253	296	-	-	-	-
Seasonal labor	-	120	-	150	-	180
Machinery depreciation, etc.	283	220	-	-	55	-
Protein supplement	-	-	-	-	200	200
Interest on investment	65	53	-	-	-	-
TOTAL	927	944	983	1145	2061	2098
DIFFERENCE	-72	-199	+541	+700	+1181	+1376

TABLE 13

CHANGES IN PASTURE SYSTEMS FOUND IN THE SURVEY

		Systems in 1958				Totals in 1954
		Improved grazing	Strip grazing	Green chopping	Storage feeding	
Systems in 1954	Improved grazing	9	1	8	10*	28
	Strip grazing	-	4	1	1	6
	Green chopping	-	-	7	2	9
	Storage feeding	-	-	-	1	1
Totals in 1958		9	5	16	14	44

* One farm was green chopping in 3 intermediate years.

TABLE 14

RELATIVE IMPORTANCE OF SOURCES OF INFORMATION

	Farm magazines	Publications of Experiment Stations	County Agent, Agricultural College Rep- resentatives	Neighbors and Relatives	Dealers Salesmen & Buyers
Survey	1	2	3*	3*	5
Midwestern farmers	1	6	4	5	2

* Equal third.

TABLE 15

NUMBERS OF FARMERS FIGURING ALTERNATIVES
ON PAPER, IN THEIR HEADS, OR NOT AT ALL

	For One System Only			For Both Systems			Total
	Changed	Expect to	No	Changed	Expect to	No	
On paper	3	1	1	1	-	-	6
In head	10	3	1	11	-	1	26
Neither				5	-	6	11

TABLE 16

THE NUMBERS OF DIFFERENT TYPES OF REASONS GIVEN BY FARMERS
FOR AND AGAINST ADOPTING GREEN CHOPPING AND STORAGE FEEDING SYSTEMS

		Economic	Technical	Values	TOTAL
Green chooping	For	12	7	0	19
	Against	1	39	4	44
Storage feeding	For	12	23	1	36
	Against	8	10	3	21
TOTAL		33	79	8	120

FIGURE A i
TWO VARIABLE INPUT PRODUCTION SURFACE

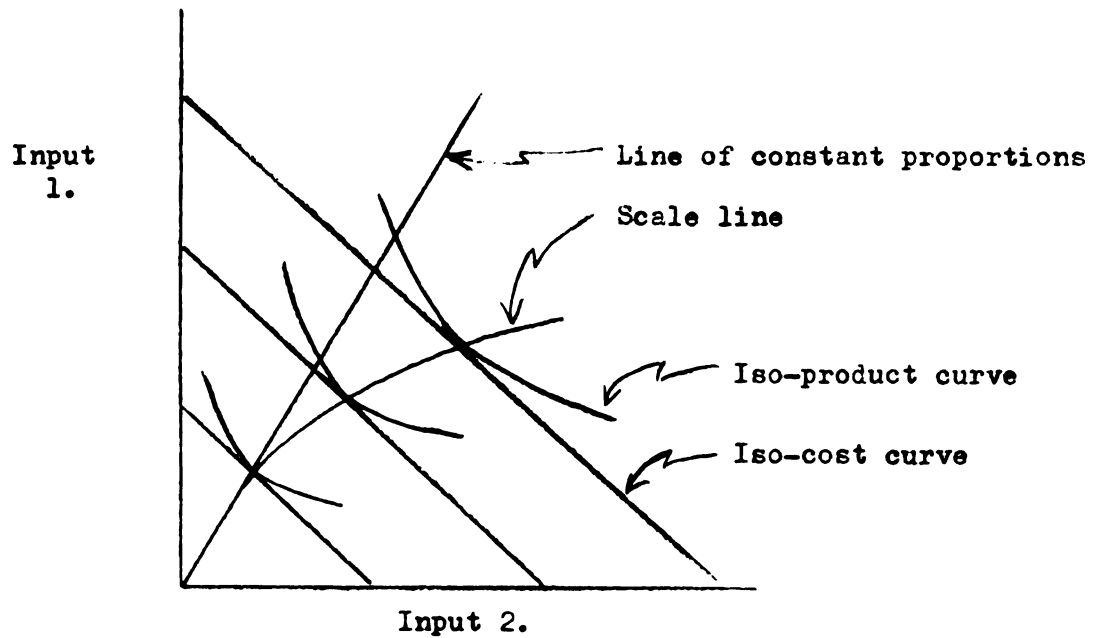


FIGURE A 11
PRODUCTION FUNCTIONS
CORRESPONDING TO DIFFERENT TECHNOLOGIES

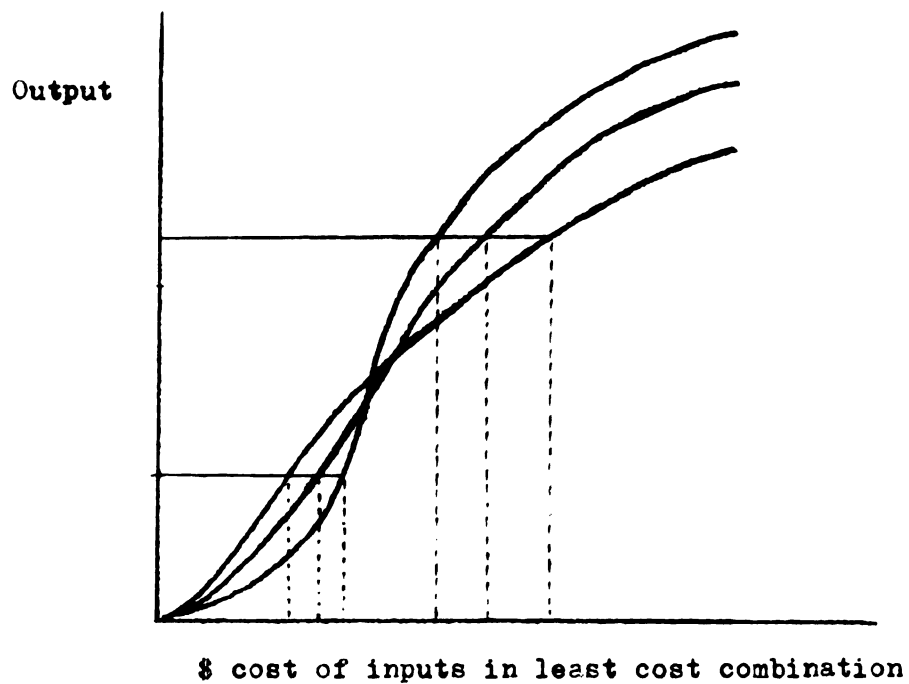


FIGURE B

Hours per two
week period

LABOR REQUIREMENT, 60 COW HERD

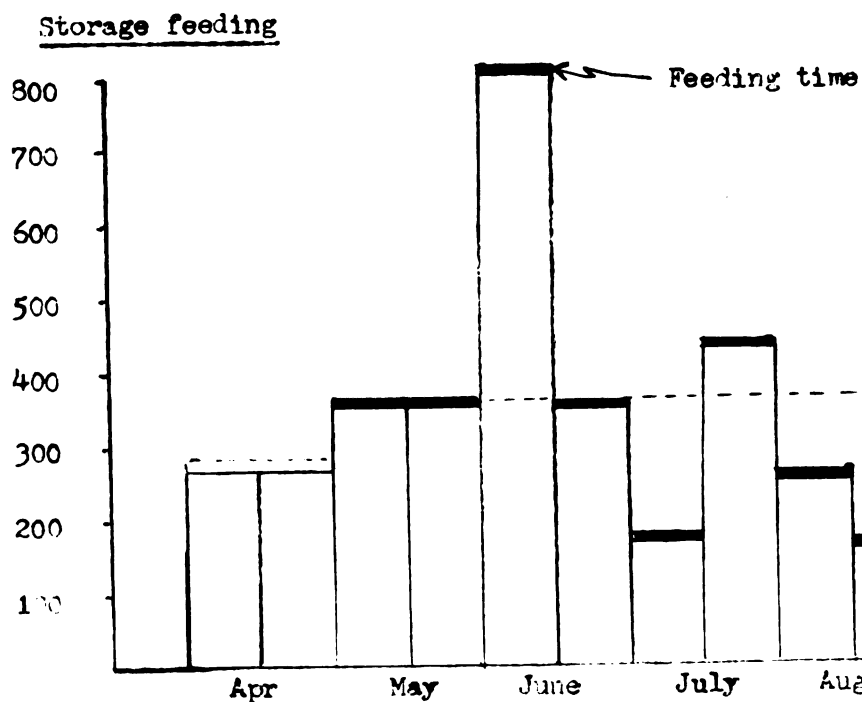
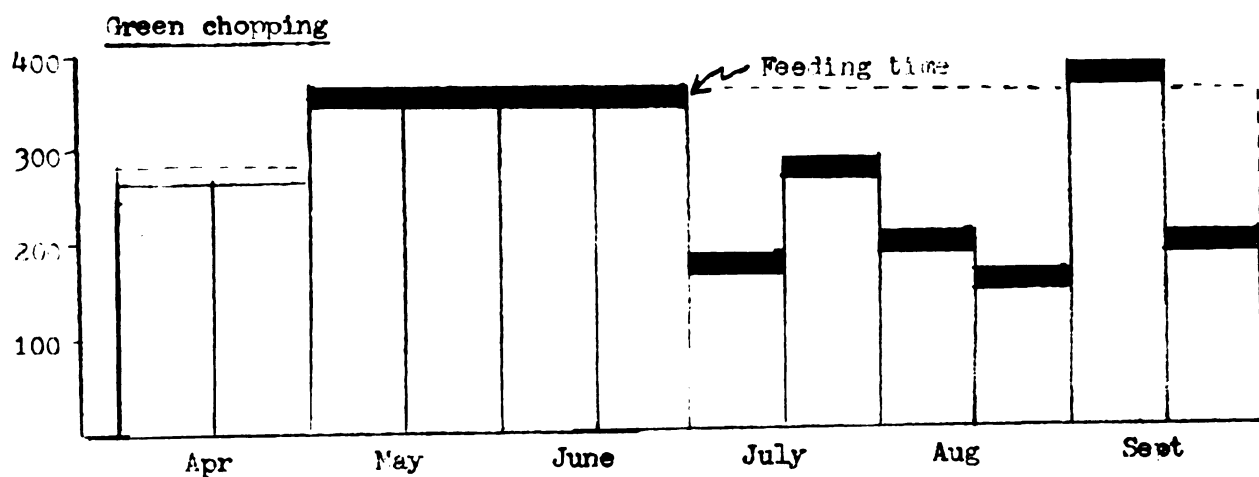
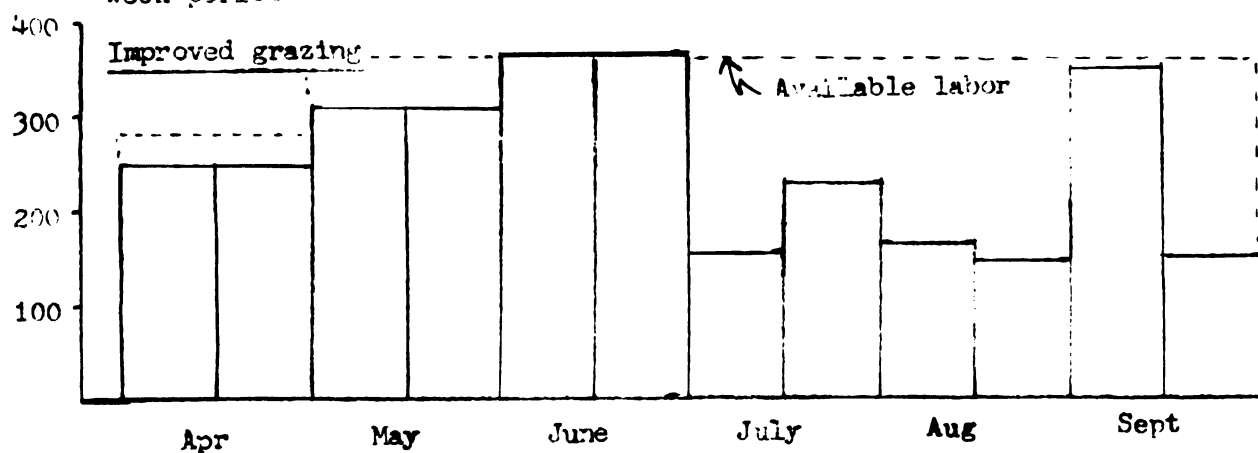


FIGURE C
TOTAL COST CURVES, THREE PASTURE SYSTEMS

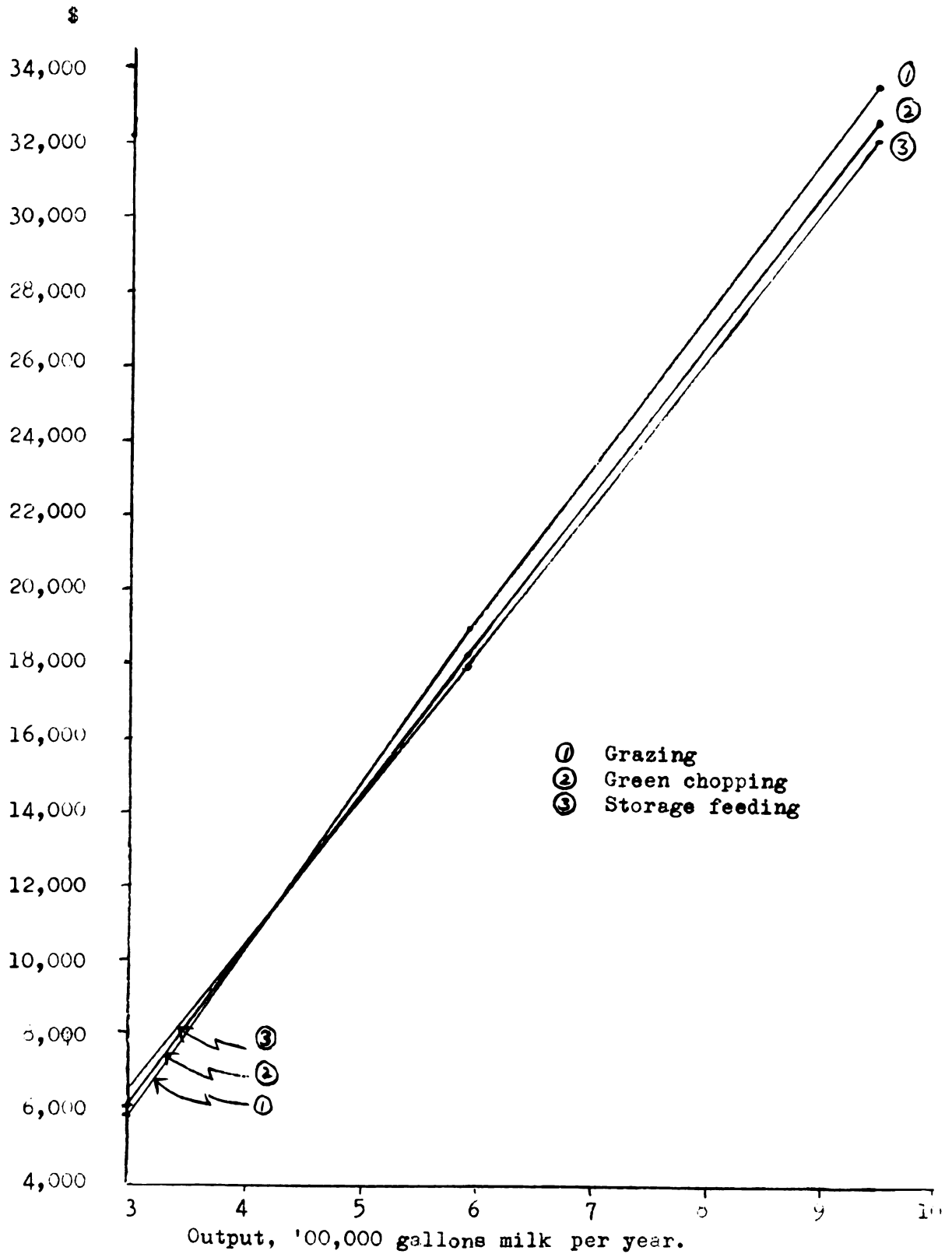
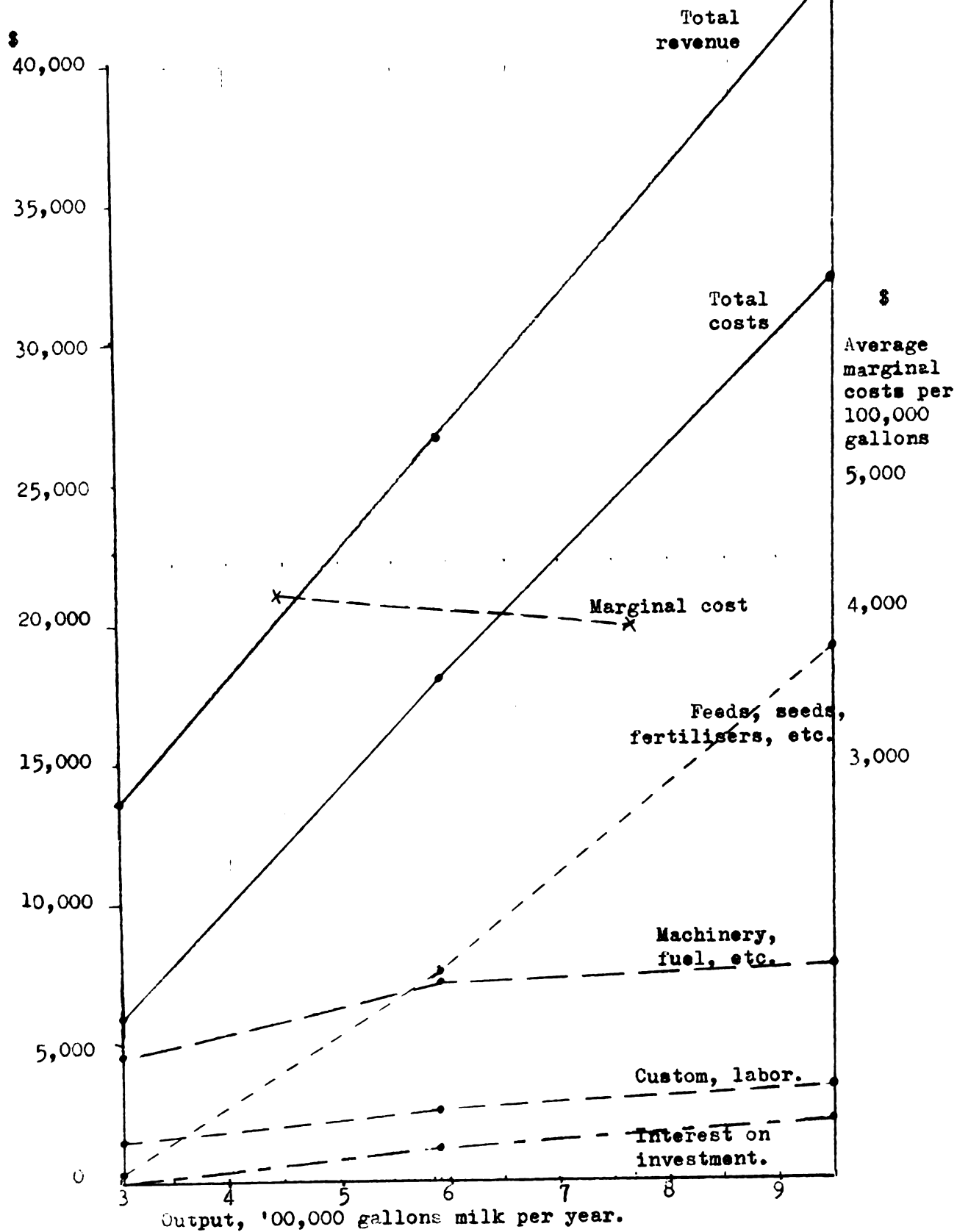
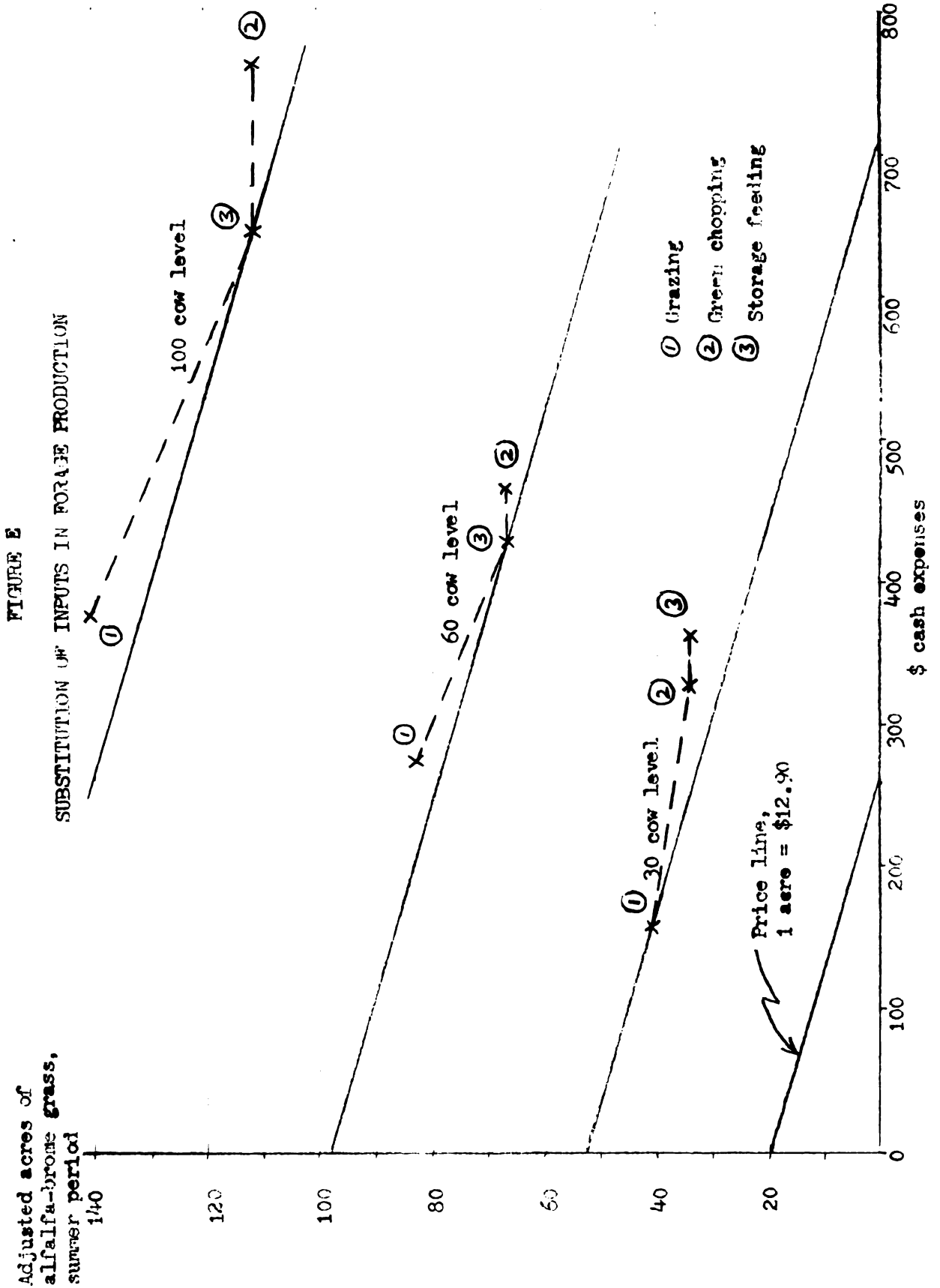


FIGURE D

CHANGES IN COSTS
WITH INCREASE IN HERD SIZE





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