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AN ECONOMIC APPRAISAL OF DAIRY PASTURES IN SOUTHEASTERN MICHIGAN

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Warren Harding Vincent

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AN ECONOMIC APPRAISAL OF DAIRY PASTURES IN SOUTHEASTERN MICHIGAN

By

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A THESIS

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VITA

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CHAPTER I

STATEMENT OF THE PROBLEM AND DESCRIPTION OF THE STUDY

Introduction: Man, through the ages, has depended more on pasture than on any other single crop. It is recorded that without pasture there was famine in the days when grazing sheep and cattle provided most of man's food and clothing. The first Biblical reference to pasture is made in Genesis* at a time believe to be nearly 2000 years B.C. As long as man has made use of animals that graze the fields -- for the same period has he realized the economic importance of pasture. He has become especailly aware of its value during the past few hundred years when the area subject to pasturage has become smaller. The nomads of old moved their livestock with the seasons where they could always enjoy the best pasture available. The livestock husbandryman of today is limited to the confines of a specific area. The extent of this limitation varies widely, but in all cases the owner of livestock is interested in the maximum returns from the land on which his livestock graze.

Pasture evaluation and improvement is a general problem. Since pasture is usually interpreted as the food of livestock gained by grazing, it varies vegetatively from sagebrush to domestic legumes. There is practically no limit to the kinds of grazing livestock. This wide diversity

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*Genesis 47:7

of plants and animals under consideration has been a complicating element in the study of pasture values. Further complications come from wide variation in soil and climatic conditions. Even when these complications are met by limiting the problem to specific conditions, one is always faced with the lack of a suitable unit of measure for pasture.

In spite of the general obstacles in pasture research, the problem becomes very specific and important on the individual farm. On farms with a high percentage of tillable land, pasture is considered a specific crop and part of the crop rotation -- providing livestock is a major enterprise on the farm. On farms with nontillable land used as pasture the problem becomes one of increasing the productivity of the land by improving the pasture management practices used. In either case, the entrepreneur is faced with a specific management problem. The increasing emphasis placed on soil conservation adds impetus to the problem as do new developments in forage utilization.

The Need for the Study: The need for the study can be stated rather specifically as follows:

1. The cattle population in Michigan was estimated at more than 1.8 million head on January 1, 1949. (32) Over three-fourths of the farms of Michigan reported cows and heifers being milked in the 1945 Census of Agriculture. (33) In 1945, the cash farm receipts from the sale of dairy products amounted to more than 157 millions of dollars in Michigan, which was about a third of the total

cash farm receipts for the state. (31) This predominance of dairying in Michigan makes a widespread interest in and need for investigation in the fundamentals of cattle feeding. Pasture comprises a large portion of the feed consumed by dairy cattle. Thus, pasture research warrants strong consideration because it represents a phase of cattle feeding in which much information is lacking.

2. A systematic approach to the value of pastures is desired by farmers, teachers, and extension workers. They have been lacking specific and consistent information concerning pasture value. Uniformity in viewpoint is desired especially by Dairy Herd Improvement Associations and similar organizations where pasture evaluation is of major concern.

3. Farmers interested in dairy cost accounting in most cases have been forced to appraise pasture in terms of its rental value. Due to the immobility of pasture and to the imperfections of the pasture market, they have felt rental rates do not accurately reflect standards which are generally applicable. There is a need to establish more uniform rates, particularly for different species of pasture plants.

4. The need for pasture is generally recognized in the organization of the farm because of its soil conserving properties and because of the crop of hay which may be harvested from a field the same season it is pastured. On some farms these needs are considered primary, and the

contribution in the form of animal feed from grazing is undervalued. The complete evaluation of pasture in its relation to other crops involves a comparison of the inputs to the pasture in the form of labor, seed and materials with outputs in the form of nutriments to grazing livestock and its contribution to soil maintenance. Determining the value of pasture to dairy cattle is an important phase of the problem of complete pasture costs and returns.

The Scope of the Study: Investigations in pasture research include many phases of farm organization and operation. They overlap in agronomy, animal husbandry and animal nutrition, soil conservation, and farm management. This study is confined to pastures used by dairy cattle. More specifically, it is limited to the mature dairy herd excluding all young stock.

Objectives of the Study:

1. To review research in pasture evaluation to see if there exists a technique suitable for evaluating Michigan dairy pastures. If none is available; attempt to develop one.

2. To isolate and determine, if possible, the affects of the sundry variables on efficient utilization of dairy pasture. Such variables as amount of supplementary feed fed during the pasture season, length of pasture season, and season of freshening were considered.

3. To classify, if possible, the various combinations of crops and acreages used for pasture and determine

the most productive system in the observed sample.

4. To determine the value of pasture when used by cows in the production of milk.

Hypotheses:

1. A necessary part of the study has been to describe existing pastures used by dairy cattle. Hypothetically, it could be stated that there is wide variation in the amounts and kinds of pasture provided dairy cows.

2. The effects of several variables on pasture utilization can be measured statistically by multiple correlation. It was thought that from a mass of data containing complete costs and income the influence of a given variable on pasture utilization could be measured by holding other variables constant at their average values.

3. Since the values assigned pasture by the cooperators in this study were, for the most part, arbitrary, it seemed desirable to test their validity. It was asserted that if the yield of a given pasture could be measured, then a monetary value could be ascribed and the result compared with existing rental rates.

Conditions Under Which the Study was Conducted:

For background to some of the conditions existent during the time of this study a few economic and climatilogical situations were investigated.

The monthly milk-feed ratio is reviewed in figure 1. There was a seasonal widening of the ratio from June to November for the period 1935-39. One pound of milk would

buy over a pound more of ration in November than in June. In 1947, the amount of ration that a pound of milk would buy increased by less than a quarter of a pound from June until November. This condition of an unfavorable milk-feed ratio has relevance to the problem of pasture evaluation if it resulted in reduced quantities of feed fed. In practice, it was found that many herds were fed large quantities of grain in spite of their high prices. It is asserted that accurate pasture evaluation is aided when a minimum of supplementary feed is fed. Then it is possible to attribute the feeding responses to pasture without the question of how much is due to pasture and how much is due to other feed.

Since the feeding program in many herds did not seem to follow the pattern expected from an unfavorable milk-feed ratio, the significance of this condition is somewhat diminished.

The investigation of climatological conditions revealed a more suitable year for pasture growth in 1947 than the normal for the region. Although the average growing season was shorter (figure 2), the above average rainfall in August and September benefited pastures in 1947 (figure 3). The average rainfall was above average every month from May to November except in October and November. The aggregate rainfall was not only greater, but also fell during more days of the month than the average (figure 4). The distribution of rainfall over the region was not uniform, however. This is pointed out in figure 5 which illustrates

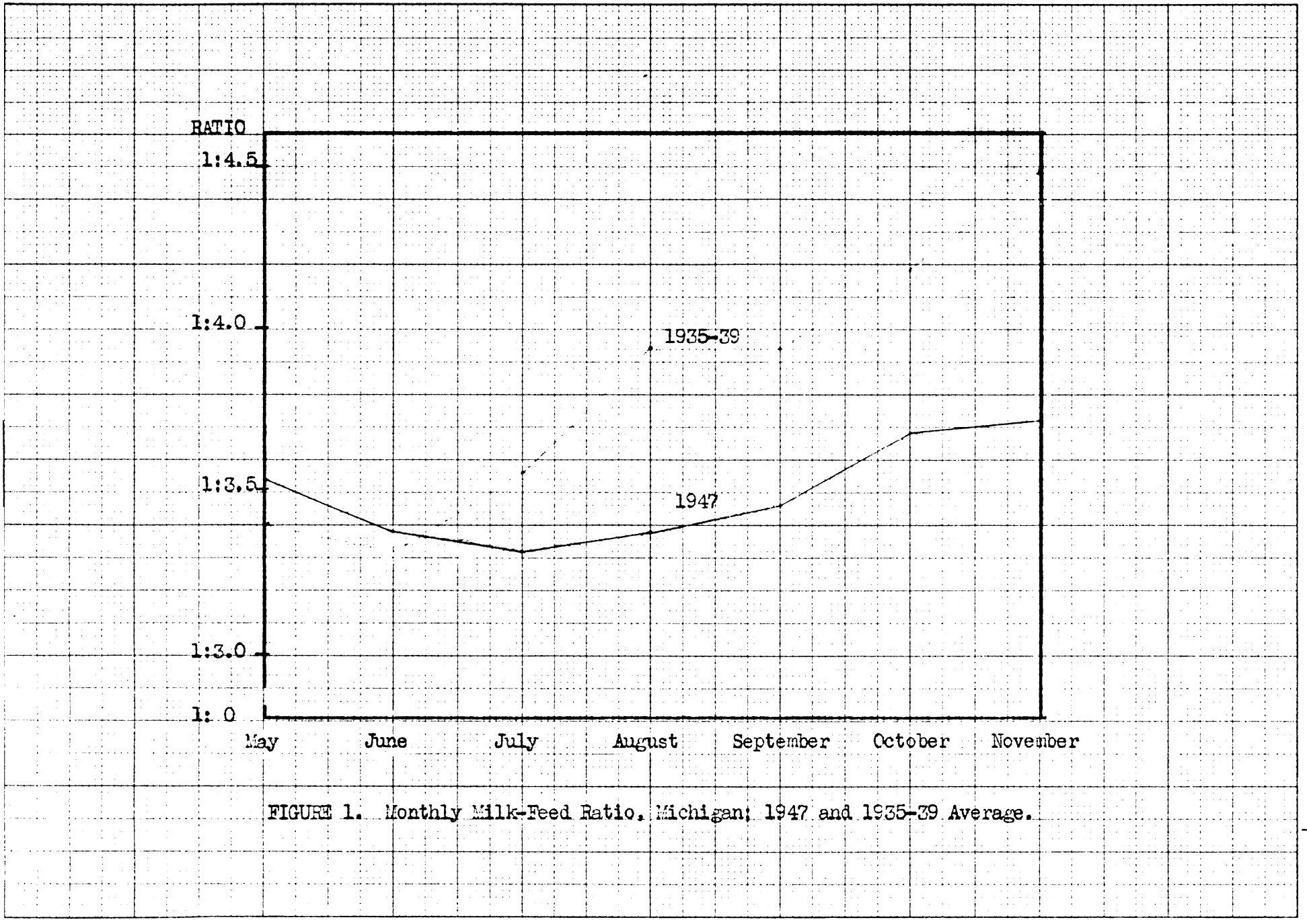


FIGURE 1. Monthly Milk-Feed Ratio, Michigan; 1947 and 1935-39 Average.

diagrammatically the standard deviations for monthly rainfall of selected stations in 1947 and of the all time averages for the same stations. This indicates that the month of least uniformity in rainfall was August.

The season of Spring and Fall were "late" in 1947 based on average monthly temperature (figure 6). The cold spring is related to this study if many farmers were forced to pasture more land than usual because of an inability to fit and sow for the usual spring crops.

It is recognized that weather and economic conditions affect pasture use. However, no attempt to measure their effects was made in this study. These conditions have been merely presented here to provide a background of conditions existing while the study was made.

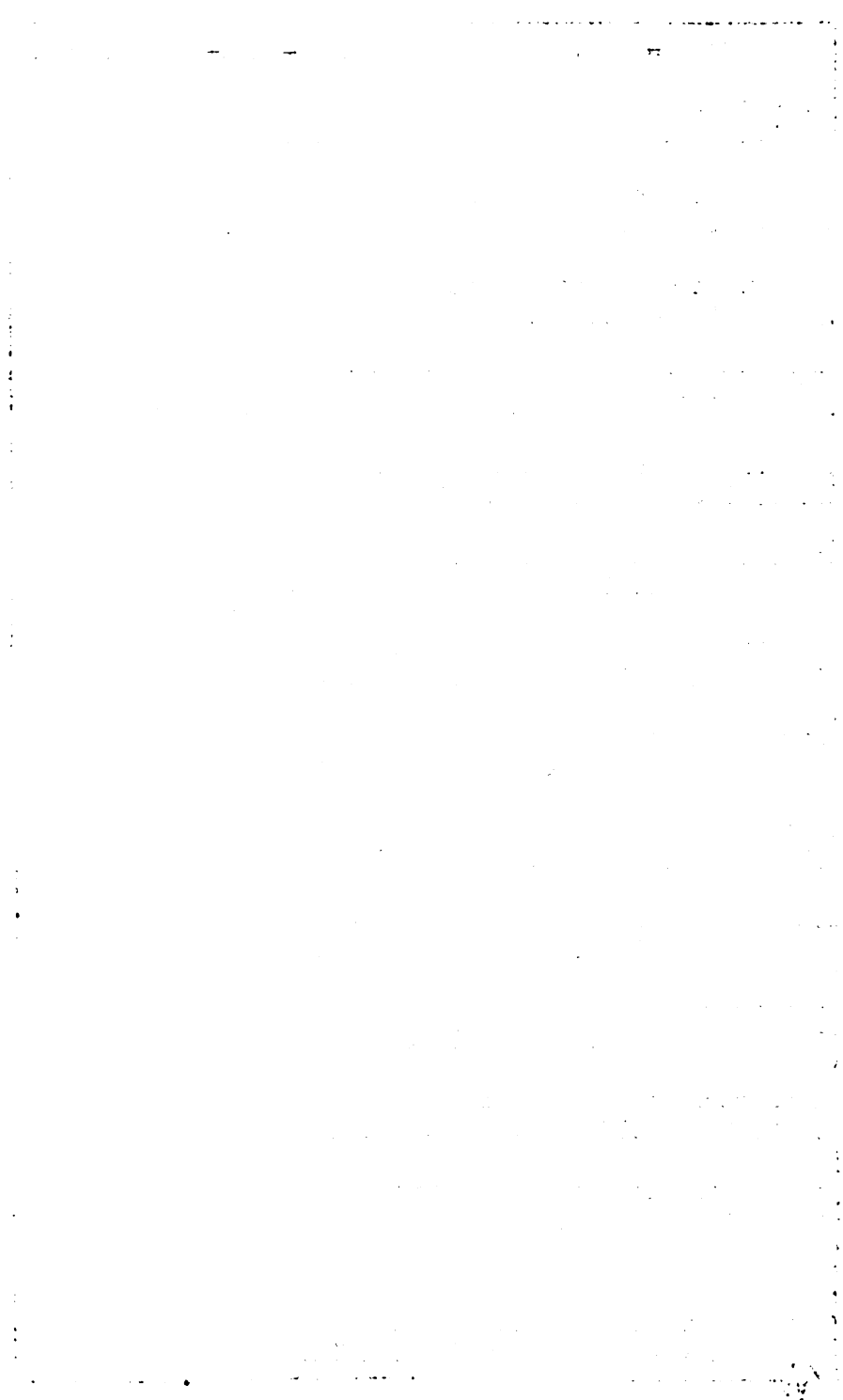
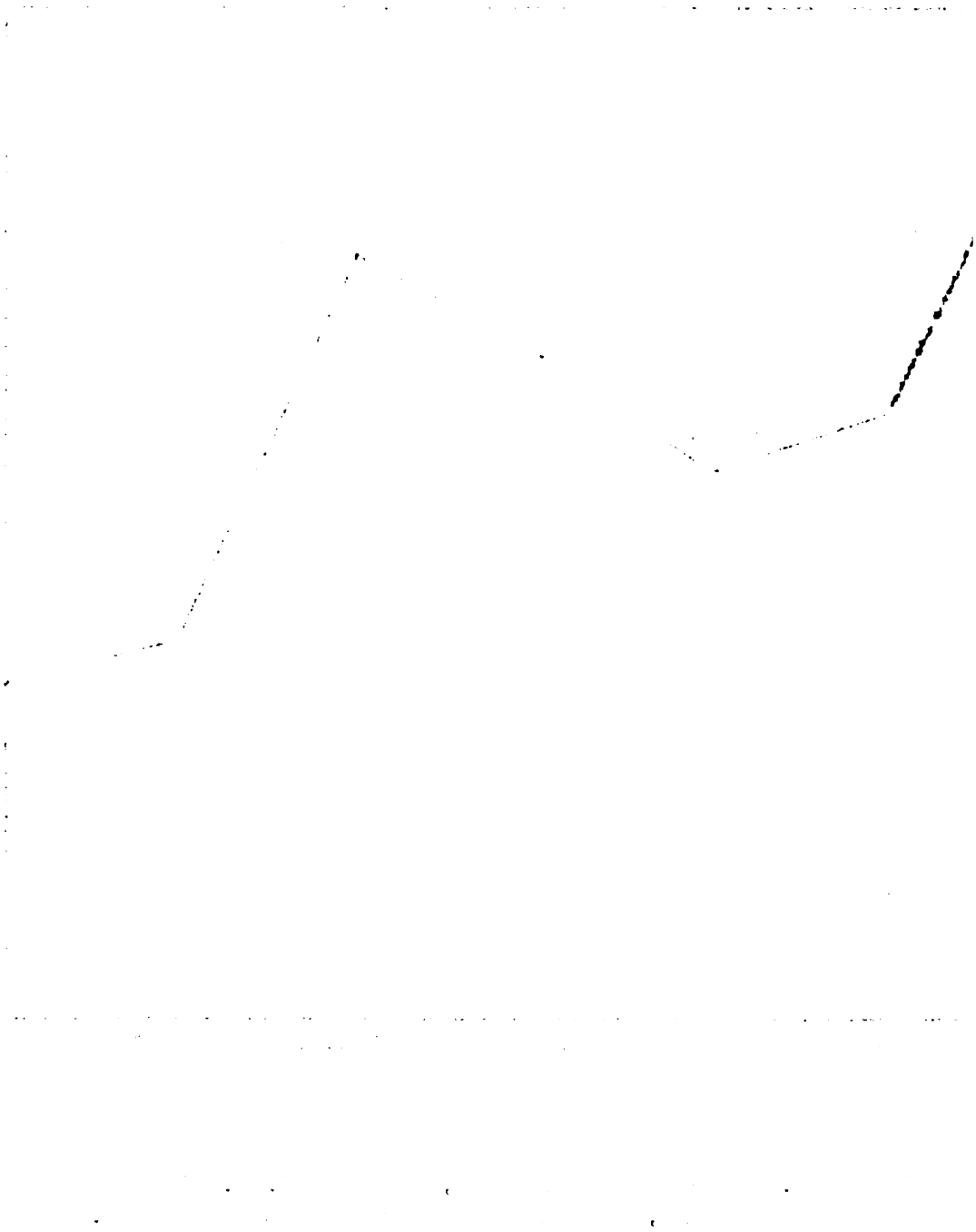


FIGURE 3. Inches Precipitation, Selected S. E. Michigan Stations, 1947 and Mean for All Recorded Years.



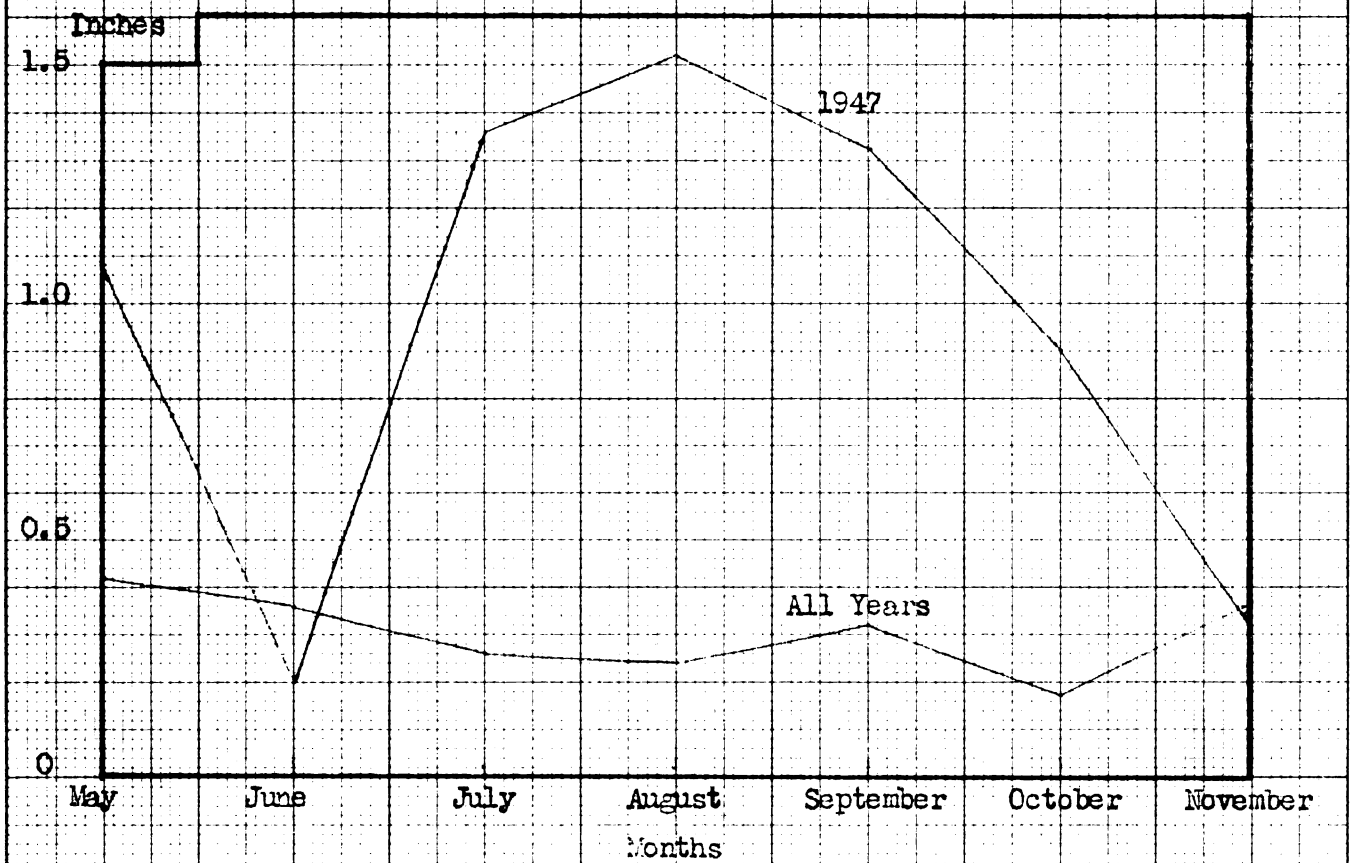
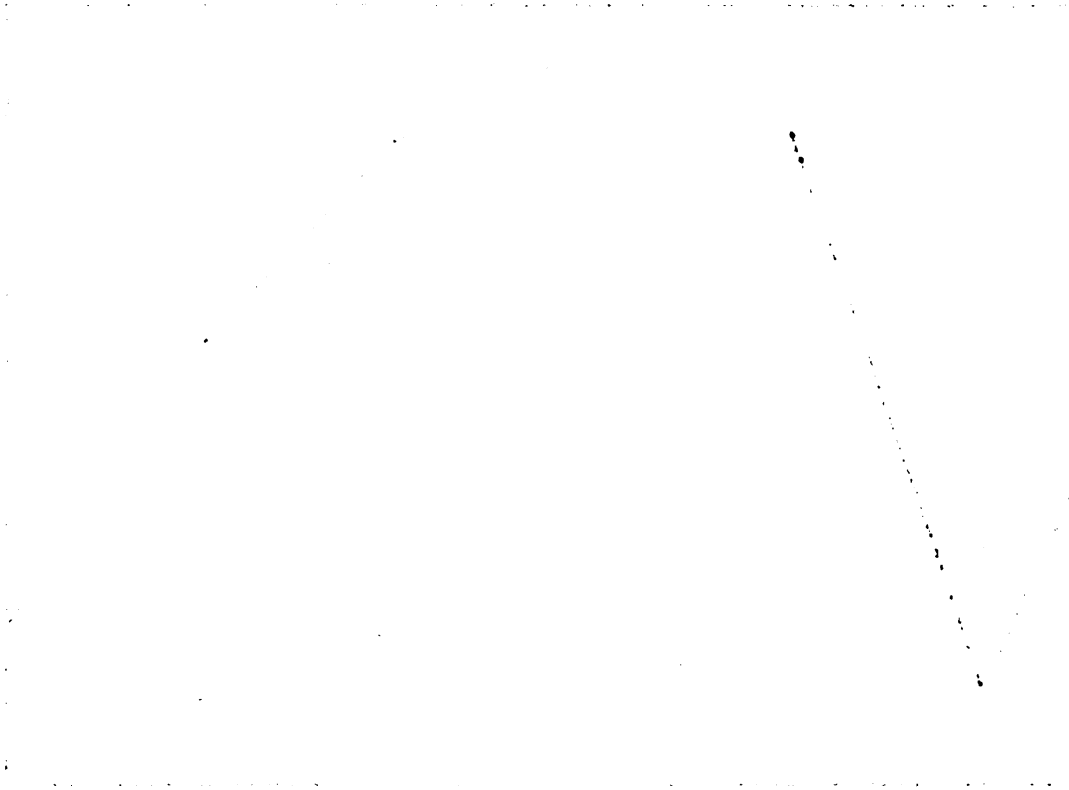


FIGURE 5. Average Monthly Rainfall, Standard Deviations by Selected S. E. Michigan Weather Stations, 1947 and All Recorded Years.



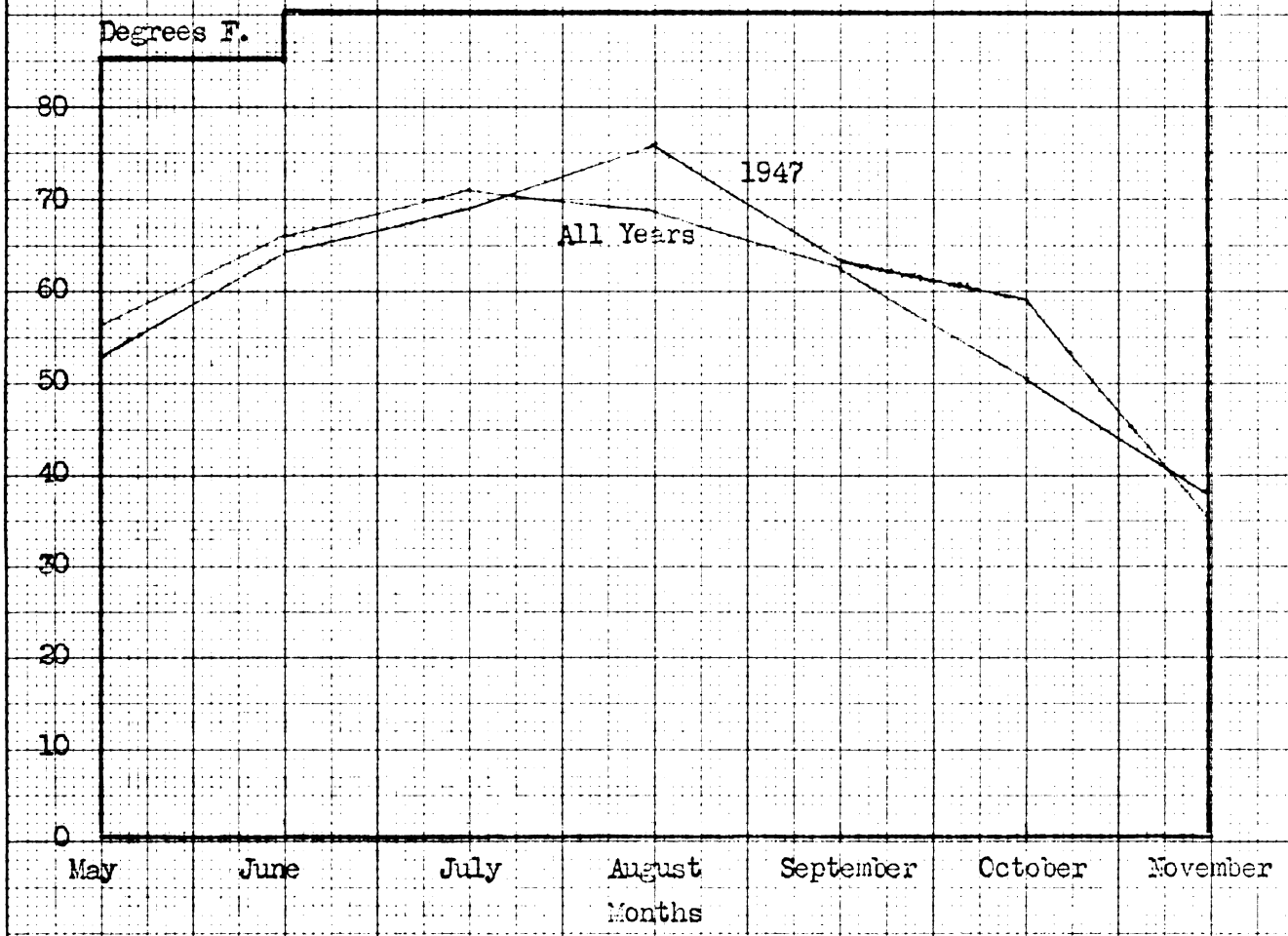


FIGURE 6. Average Monthly Temperature, Selected S. E. Michigan Weather Stations, 1947 and Mean for All Recorded Years.

CHAPTER II

A REVIEW OF THE LITERATURE

Matter pertaining to pasture culture and use has been written in abundance. While a sincere attempt was made to become thoroughly familiar with the problem, this review falls short of consideration for all written matter on the subject. The intent was to become familiar with the problem of pasture evaluation rather than to make a comprehensive digest of literature dealing with all phases of pasture culture and use. Material has been drawn chiefly from experiment station bulletins and articles from technical journels.

Characteristics of Pasture: Determining the characteristics of pasture was considered the first step in becoming familiar with the problem. The following questions suggest the type of information sought in the study of secondary data: What characteristics distinguish pasture from other crops in its culture, land use, method of harvest, measure of yield and utilization? Is its price consistent with the feeding value of pasture consumed? What difficulties in the measurement of yield are peculiar to pastures?

The problem of pasture evaluation as it effects the individual farm has been aptly stated by L'Hote (17) which adds emphasis to the purpose of this study:

> "Farmers have always had the problem of determining the amount to charge for the various classes of livestock for the pasture used during the year. Usually the amount charged has been an arbitrary

> figure. It often happens that a farmer actually has no basis for estimating the charge and consequently he may charge pasture to a particular class of livestock at too high or too low a rate. If he charges pasture at too high a rate, feeding efficiency with his class would appear low, and if he continues doing this, he may eventually decide to dispose of the enterprise. In reality, if the correct charge for pasture were made, the enterprise may be operating on a paying basis. If the pasture is charged at too low a rate, a livestock enterprise may be kept that actually is not paying for itself."

Hence the first characteristic of pasture to be considered is that of a non-uniform price from farm to farm.

Pasture is considered a cheap feed but explanations for its cheapness vary. L'Hote (17) attributes the cheapness to its immobility. It must be harvested by livestock and since there are usually few bidders in the market, the rental value is less than its real value. Bidders are limited because the prospective buyer must have livestock and they must be close enough to facilitate moving them economically from the home farm to the rented area. Beyond this, there must be a scarcity of pasture on the home farm to warrant moving the livestock to another area. The conditions of pasture scarcity and that of having several interested parties are not common so the prospective renters are few and the market is not competitive.

Another reason for pasture being considered a cheap feed is that the output is usually high for the amount of inputs expended. Semple (24) explains that even annual and other temporary pastures which may cost as much to produce as grain crops, are harvested by livestock with

practically no labor cost. There is, of course, much variation in the relative output of different pastures.

Basically, pasture is a cheap feed because acrewise it is a commodity of abundance. Most farms have more pasture than can be utilized by enterprises such as hogs and poultry. Bottom (5) carries this idea further to state that "since the marginal use of a product determines its value, pasture values do not get far out of line with the value of pasture in the great plains areas". An exception to this rule is cited in whole milk consumption areas. In these areas the importance of dairying limits the production of cattle and sheep and the marginal use becomes more intensive and the price of pasture becomes higher.

Young (34) asserts that because the contribution of pasturage to the total feed supply is difficult to measure it is therefore commonly underestimated.

None of these explanations satisfactorily answers the question of how to evaluate pasture if it is not being offered on the market. In this case, it is no longer a problem of what would a buyer be willing to pay, but what contributions does it make to the farm economy? According to Bottom (5) there are two main contributions of pasture: (1) to conserve and improve productivity of the soil and (2) to provide a source of livestock feed. Neither of these contributions have been satisfactorily measured.

The method of comparing pasture with non-pasture has been a common technique. This establishes comparative

values but the results are usually lacking in concrete statistics. In comparing crops in relation to their soil maintenance effects, Semple (24) states, "In addition to losing less soil by erosion than cultivated land, well managed grazing land loses less fertility because less is taken from the soil by pasture plants and part of that which is removed is restored directly through the excrement of grazing animals".

The problem of comparing quantities of feed produced by pasture with that of other crops becomes even more difficult than comparing their effects on the soil. Semple (24) attributes this difficulty to the fact that pastures are usually found on the poorer lands and to the lack of practicable means of determining the quantity or composition of the pasturage consumed.

It is essential to the farmer that a objective technique for comparing pasture and non-pasture crops be determined. It is through a comparative process that the farm operator makes his plans for farm organization. The crops will be selected that will contribute most to his particular farm economy.

One of the considerations taken by the entrepreneur in this process of comparison is that of the contribution of feed from a nutritive point of view. True evaluation is difficult, as pasture production in weight or volume may be low, but nutrient analysis may be such as to result in a high value.

It has been established by Woodward (30) and Semple (24) that when grown on fertile soil and harvested at the proper stage of growth, pasture contains most of the substances for perfect nutrition. So, a feed with high nutritive value may be listed as one important characteristic of pasture if it is grazed at a proper stage of growth. The nutritive value of pasture is clearly recognized by many but is prompting further research by technicians. Huffman of the Michigan Experiment Station is conducting extensive research along lines of pasture nutrition to determine more complete and satisfactory reasons for the tremendous response to pasture in the way of increased milk production by dairy cattle than have thus far been presented.

Summary: One phase of the review of literature was directed toward determining characteristics which had primary relevance to an economic appraisal of pasture. Botanical classification and descriptions of physical properties were not of major concern.

The primary characteristics considered are summarized as follows:

1. There has been non-uniformity in expressing the value of pasture.

2. Pasture, as compared to grain crops, is a product of abundance acre-wise and thus there is little competition in the market for it.

3. Pasture is immobile and must be utilized at the point of production which prohibits its utility to but a few.

4. Pasture has two primary functions, soil maintenance and improvement and to provide a source of livestock feed. Quantitative measurement of both functions has been difficult.

5. Pasture is considered a profitable crop because of a low input requirement and because the end product (a valuable feed) is consumed by the grazing animal at practically no cost to the cattle owner.

Methods Used in Pasture Research: Many problems connected with pasture research have already been discussed. It is not surprising that with a wide variety of conditions and problems involved that there would be numerous methods of pasture research. The lack of uniformity and the quest for still other methods by farmers and technicians are positive indications that none are completely acceptable. The wide range of variables affecting pasture culture and use suggest in themselves numerous research techniques in measuring pasture value.

Schuster (22) reports 13 different methods of pasture evaluation used by 12 stations and the U.S. Department of Agriculture. Each station reported one or more of the methods being used so that it was possible to determine the most commonly used technique. The methods followed

at the time of the survey was taken are as follows: profit, hay weights, clippings, cattle weights, sheep weights, photographs, surveys, carrying capacity, milk flow, plant population, chemical analysis, palatability, and duration of grasses. These and other methods will be considered in this review. Ahlgren (1) lists the following three prerequisities for a research method if it is to be most effective: "(1) Be relatively inexpensive, (2) be reliable and reasonably unbiased, and (3) provide results within a reasonable time. Methods of measurement must take into consideration the many variables occasioned by differences in species, relative palatability, stage of growth, management, fertility, and climate".

Profit: If profit is to be used as the measure of pasture value, it is necessary to consider increases in animal weight, increase in milk production and increase over investment and interest on investment, according to Schuster (23). In research of this type it becomes extremely difficult to control the many variables involved under farm conditions. The expense connected with conducting a controlled experiment when sufficient numbers of animals are used is almost prohibitive. The value of pasture for beef cattle is frequently credited as the increase in body weight times the price of market beef. It is analagous to multiplying the price of milk by the milk production during the summer and crediting the product to pasture. The fallacy of these plans lies in the failure to recognize the part the animals played in the end product. Age, stage of

production, inheritance, and health of the animals are factors effecting the production during the pasture season. Also, there are many other items such as building expense and interest on animal investment that are omitted from the profits analysis, but which effect the final result. One test of reliable research is to obtain the same results by duplicating the experiment. It would be difficult for the technique of profits to withstand this test because of the large number of variables involved.

Hay Weights and Clippings: These methods can be considered together because they involve manual cutting of the pasture plant. They involve little expense and are easily conducted. Schuster (23) and Ahlgren (1) have discredited the use of hay weights because they represent the growth and production of meadows for hay and not for pasture. It is assumed that the yield for a field is the same whether the forage is cut once or several times. Wiggans (28) and Stapledon (25) have shown that yield decreases with additional cutting (as would be the case under grazing conditions).

Nevins (18), on the other hand, has expressed satisfaction with clippings in the determination of pasture yield. However, on the basis of total digestible nutrients, Jones (15) has found higher yields under the clip plot method than under grazing conditions. This occurred even when allowances were made for gain in animal weight and a low digestibility for the pasturage. Similar results have

been experienced by Gardner, et al (11), Brown and Helm (9), Hodgson, et al (14), Brandt and Ewalt (6), and Ahlgren, et al (2). The clip plot method is, therefore, limited in use unless a definite grazing-mowing ratio can be determined. This plan has been suggested by Knott (16).

Cattle Weights and Sheep Weights: The methods of cattle and sheep weights will be considered together because they require similar analysis. They have the advantage of harvesting pasture by livestock under actual grazing conditions. However, the number of animals required for reliable statistics make it costly to conduct. This objection is more easily overcome by using sheep instead of cattle for larger numbers may be kept without excess expense. Ahlgren (1) points out that data obtained with one class of livestock are not readily applied to other classes of livestock. This means the kind of animal should be used for which the results are to apply. Grazing habits and tramping effects of sheep and beef cattle are entirely different and it is likely that their respective effects on the sward will differ.

The chief problems in using this method lie in the proper selection of animals, weighing of animals and the following of recommended practices relative to the feeding of supplementary feeds.

Photographs: Photography as a method of pasture evaluation is a means of portraying differences in the conditions of pastures. Photographs are ineffective when these differences are small. However, they are extremely valuable in supporting experimental data. Schuster (23)

has reported that it was impossible to distinguish accurate ratings for various grass mixtures and fertilizer treatment by use of photographs. He concluded that photographs were of little value in themselves.

Surveys: The survey method of pasture evaluation involves the gathering of primary data from the farm operator by means of a questionnaire. The survey method has limited use in pasture research because the data are ordinarily inaccurate and contain enough bias to reduce their reliability. They are valuable, however, in gaining general impressions of pasture conditions and in becoming familiar with the major areas to be investigated by other means.

Carrying Capacity: The term, carrying capacity, has common usage in describing the productive ability of pastures, but has certain limitations when carefully analyzed. These limitations have been summarized by Brown and White (8) as follows: "(1) No record of supplementary feed provided is supplied, (2) neither maintenance requirements nor gains and losses in weight are considered, and (3) no distinction is made in the requirements of high and low-producing milking cows". Because these limitations have considerable significance it is felt by Ahlgren (1) that the term carrying capacity has limited use. The "standard cow day" proposed by Knott, et al (16) eliminates the objectional features of the term carrying capacity.

From previous experimental data Knott concluded that if a 1350 pound cow consumed 16 pounds of TDN per day,

this would enable her to meet her body maintenance requirements and produce about 17 pounds of 3.5% milk. From this basic data the standard cow day was defined as a unit in which an animal obtains 16 pounds of TDN from pasture per day. This expression has gained wide acceptance and will undoubtedly grow in use as a means of describing the productivity of a pasture.

Milk Production: When the production of pasture is expressed in terms of milk production the same limitations are encountered that were discussed in the method of profits. The many variables affecting milk flow may obscure the results and lead to false interpretation. However, this technique is easily interpreted by farmers which is an attribute often lacking in more exact scientific procedures. It is possible that many of the variables can be controlled by recommended procedures for selection, allotment of animals, weighing of animals, and in the use of supplementary feeds. Experiments of this type, however, are relatively expensive and thus are somewhat limited in use.

Plant Population: Palatability: and Duration of Grasses: These three methods of pasture evaluation have been treated briefly by Schuster (23) as follows: "These are all contributing factors to some of the other factors that have been discussed. They furnish an explanation for some of the results that have been obtained and are very valuable".

Ahlgren (1) has concluded that even if palatability is established as a significant factor in the value of pasture forages it is only one of the many factors affecting their nutritive values. Because of this, he questions its use as a sole means of measuring the results of pasture research.

Evaluation on the basis of "duration of grasses" has been replaced by more specific and precise techniques. Information relating to the survival of species is important, according to Ahlgren (1), but must be combined with other data to be of most value.

Chemical Analysis: From Ahlgren's (1) review of the exhaustive critiques by Beeson (3) and Orr (19) on the chemical composition of forage it was learned that mineral content is an important factor in determining its feeding value. Its association with livestock growth, and protein content and succulence of plants has been determined by chemical analysis. When used with other methods it may help to explain difference in soil, plant and animal relationships which are not readily detected otherwise. It has helped solve problems of malnutrition and toxicity in certain regions. Other valuable data have been obtained by chemical analysis, but Ahlgren (1) has concluded that insufficient comparisons of these analyses and digestion trials have been made to accurately predict results to be expected by feeding forages. Therefore, the results as applied to livestock feeding are, inadequate by themselves.

Total Digestible Nutrients: During recent years the total digestible nutrient method of determining the productivity of pasture has gained prominence. It consists of calculating the total TDN requirements for body maintenance, change in body weight, and milk production for the cow while on pasture. The calculated TDN from supplementary feed is subtracted and the residual is assigned to pasture. This method has been used by Forbes, et al (10) and Knott, et al (16). Others, including Sprague (25), Ahlgren, et al (2), Nevens (18), Robinson, et al (21), Schaller, et al (22), Young (34), Gorton (12), and Warren and Williamson (28) have followed this procedure with minor changes. L'Hote (17) used net energy units expressed in therms instead of TDN.

Ahlgren (1) reviews this method as follows: "The total digestible nutrient method is considered by many to be the best available means of evaulating pasture practices on the basis of milk-producing dairy cattle." The merits of this method are given by Knott (16) as follows: "The factors of maintenance, amount of production, gain or loss in live weight and amount of supplementary feed all need to be considered in making pasture comparisons or evaluating pastures where producing dairy cows are the grazing animals. The calculation of the yield of pastures in terms of total digestible nutrients seems to be the only method that permits consideration of these factors". Further discussion

on this method is made in the text of Black, et al (4). "The most difficult estimate to make is that of the amount of feed obtained from pasture. The method of total digestible nutrient yield is the best available. It consists of calculating the amount of maintenance plus production required to produce the amount of milk produced while the cattle are on pasture, and subtracting the calculated TDN pounds in the supplementary feeds from the total and converting the remainder back to TDN's. One weakness of this method is that cattle frequently lose or gain weight in the late summer. Also, any feed wasted is credited to livestock and this reduces the imputed value of pasturage."

It is recognized that much of the reliability of this method rests in the acceptability of feeding standards, and the strength of assumptions dealing with changes in animal weights and the use of supplementary feeds.

Summary: This review of literature dealing with methods employed in pasture evaluation yielded the following conclusions:

1. The methods employed in pasture research are numerous. Those considered in this review were: profit, hay weights, clippings, cattle weights, sheep weights, photographs, surveys, carrying capacity, milk flow, plant population, chemical analysis, palatability, duration of grasses, and total digestible nutrients.

2. All methods employed have produced valuable results but, for the most part, have been inadequate in

themselves. There is an inter-dependence of one method on another for reliability.

3. Since this study deals with value of pasture to lactating animals, it was decided that the total digestible nutrient method would be most useful. Other methods give less regard for many factors effecting variations in milk flow, do not directly meet the objective of this study or are not suited to the collected data.

CHAPTER III

THE MEASUREMENT OF PASTURE VALUE

The Collection and Analysis of Primary Data: The primary data used in this report came from a cost of milk production study conducted in the Detroit milk shed. It has been a cooperative project between the Farm Management Department of Michigan State College and the Michigan Milk Producers Association since April, 1945. About 100 cooperating farmers each year have submitted detailed monthly reports showing actual cost and income figures on their respective dairy enterprises.

In addition to the monthly reports, data were also obtained by farm visits at the beginning and the end of the project year. At these times, inventories of cattle, buildings and equipment were taken and questionnaires were answered for information not included in the monthly reports. (See Appendix for forms used.)

The 85 herds whose records were summarized were located in 13 southeastern Michigan counties. Their distribution is shown in table 1. These herds averaged 16.5 cows and ranged in size from 6 to 43 cows. Milk production for all herds averaged 7,942 pounds per cow and ranged from 4,941 to 11,447 pounds per cow for the year in individual herds. Butterfat production averaged 301 pounds and ranged from 190 to 404 pounds per cow in individual herds.

Table 1. Location of 85 Herds in Dairy Cost of Production Study, 1947.

County	Number of Herds	County	Number of Herds
Genesee	3	Macomb	5
Hillsdale	6	Oakland	1
Ingham	5	Sanilac	6
Lapeer	5	Shiawassee	3
Lenawee	7	St. Clair	15
Livingston	13	Tuscola	2
		Washtenaw	13

Only 25 cooperators have participated for the entire three period of the study. This has a meant a change in sample each year by the addition of new cooperators.

It was decided to use the records for only 1947 because: (1) certain supplementary data necessary for complete analysis were lacking prior to 1947, (2) they were the most recent records available, and (3) the deviations were too great for reliable averages in the small sample of continuous cooperators.

The analysis procedure was as follows:

1. Tabulate significant physical quantities to be used in calculation. Those considered are:

a. The length of the pasture season. (Calculated as days between dates cows were turned on and removed from pasture.)

b. Total cow days of pasture.

c. Total value of pasture as charged by cooperators.

d. Pounds and value of grain, hay and silage fed the herd during the pasture season.

e. Number of calves born and month they were born.

f. Acres and kinds of pasture.

g. Pounds and butterfat test of milk produced on pasture.

h. Breed of cow.

2. From these tabulations the following statistics were computed: (All calculations were limited to the period the cows were on pasture.)

a. Average number of cows in the herd.

b. Average milk production per cow. Milk production was converted to a fat corrected (4%) basis according to the conversion standards calculated by Brody and Ragsdale (7) using Gaines' formula*.

c. Total requirements of the herd to maintain body weights. Cow weights were calculated using the standards for breeds calculated by Ragsdale (20). Mixed breeds were assumed to average 1000 pounds per cow. No consideration was made for gain or loss of weight during the pasture season.

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*FCM = .4M + 15F, where FCM (fat corrected milk) is gross energy value in terms of normal average cow's milk of 4% content, M is actual milk, and F is fat, all in the same unit of weight.

d. TDN requirements for the amount of milk produced during the season. Likewise, the TDN supplied from barn feeding was determined.

(See Appendix for assumptions used for these and other computations in this study.)

e. TDN requirements for maintenance and for milk production were totalled to represent the TDN requirement for the cow.

f. Yield of pasture per cow day. This was calculated as the residual left after the TDNs from barn feed was subtracted from the total daily requirements.

Table 2. Grain Fed Cows on Pasture and Its Relation to Production and Feed Cost Per Cwt. Milk, Detroit Milk Shed, May - September, 1947.

Month	Pounds Grain Fed Per Cow Daily on Pasture				
	0-2.9	3.0-5.9	6.0-8.9	9.0-11.9	12.0-14.9
	Grain Fed Per Cow (Pounds Monthly)				
May	52	138	226	342	412
June	24	130	200	315	430
July	38	149	234	271	450
August	31	135	224	304	384
September	30	126	213	297	380
	Hay Fed Per Cow (Pounds Monthly)				
May	119	244	426	234	304
June	41	26	42	53	133
July	38	13	26	88	0
August	31	23	51	113	48
September	111	110	194	89	141
	Silage Fed Per Cow (Pounds Monthly)				
May	0	187	351	156	304
June	0	48	26	0	0
July	0	24	16	0	0
August	0	16	102	51	0
September	95	55	276	0	0
	Milk Production Per Cow (Pounds Monthly)				
May	636	695	738	872	932
June	691	770	794	850	812
July	617	689	702	788	723
August	619	609	660	741	670
September	621	585	643	708	735
	Total Feed Cost Per Cwt Milk				
May	$1.14	$1.39	$2.13	$1.83	$2.07
June	.91	1.18	1.45	1.81	2.17
July	1.03	1.48	1.86	2.13	2.56
August	1.22	1.68	2.25	2.21	2.69
September	1.33	1.71	2.21	2.19	2.72

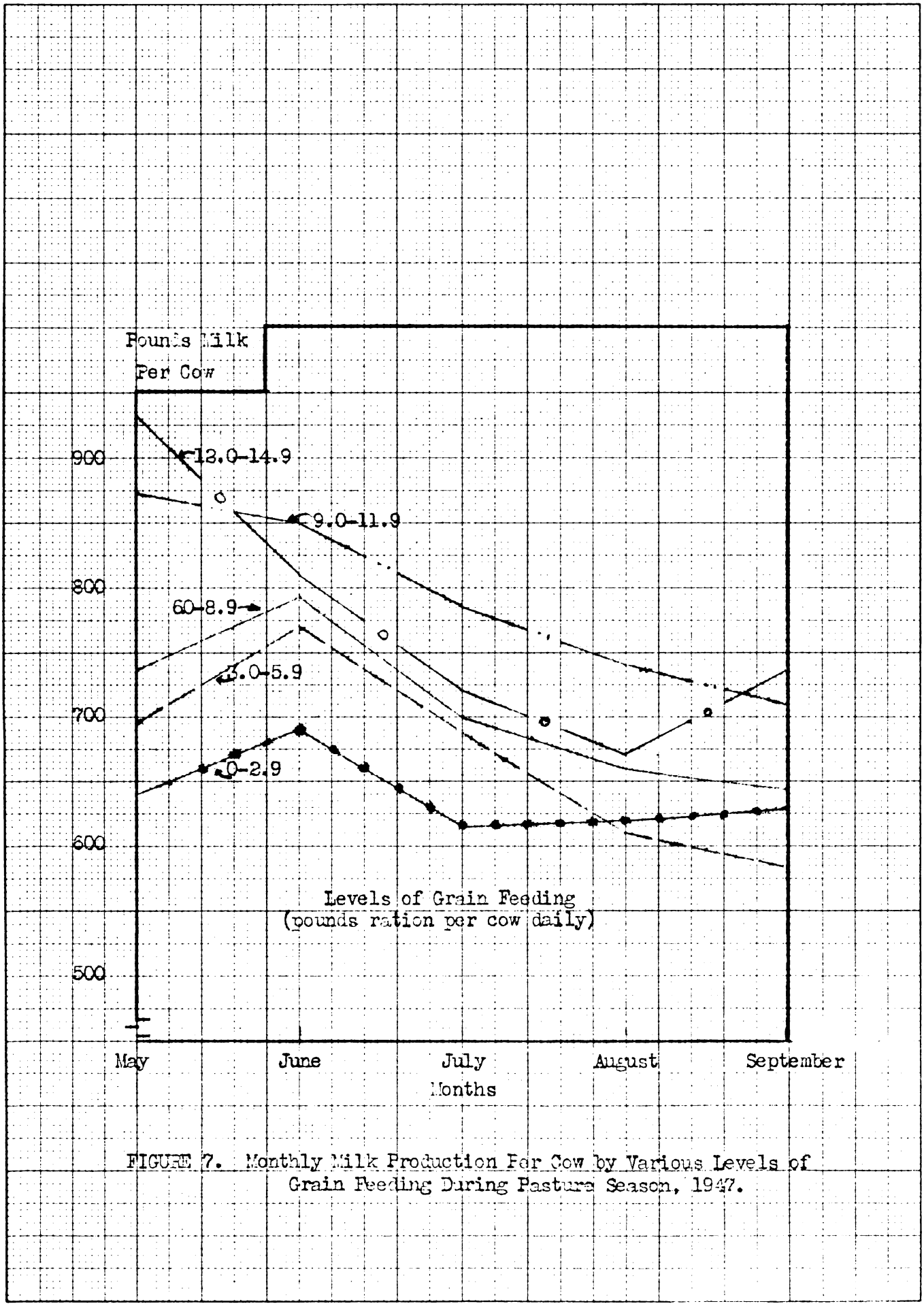
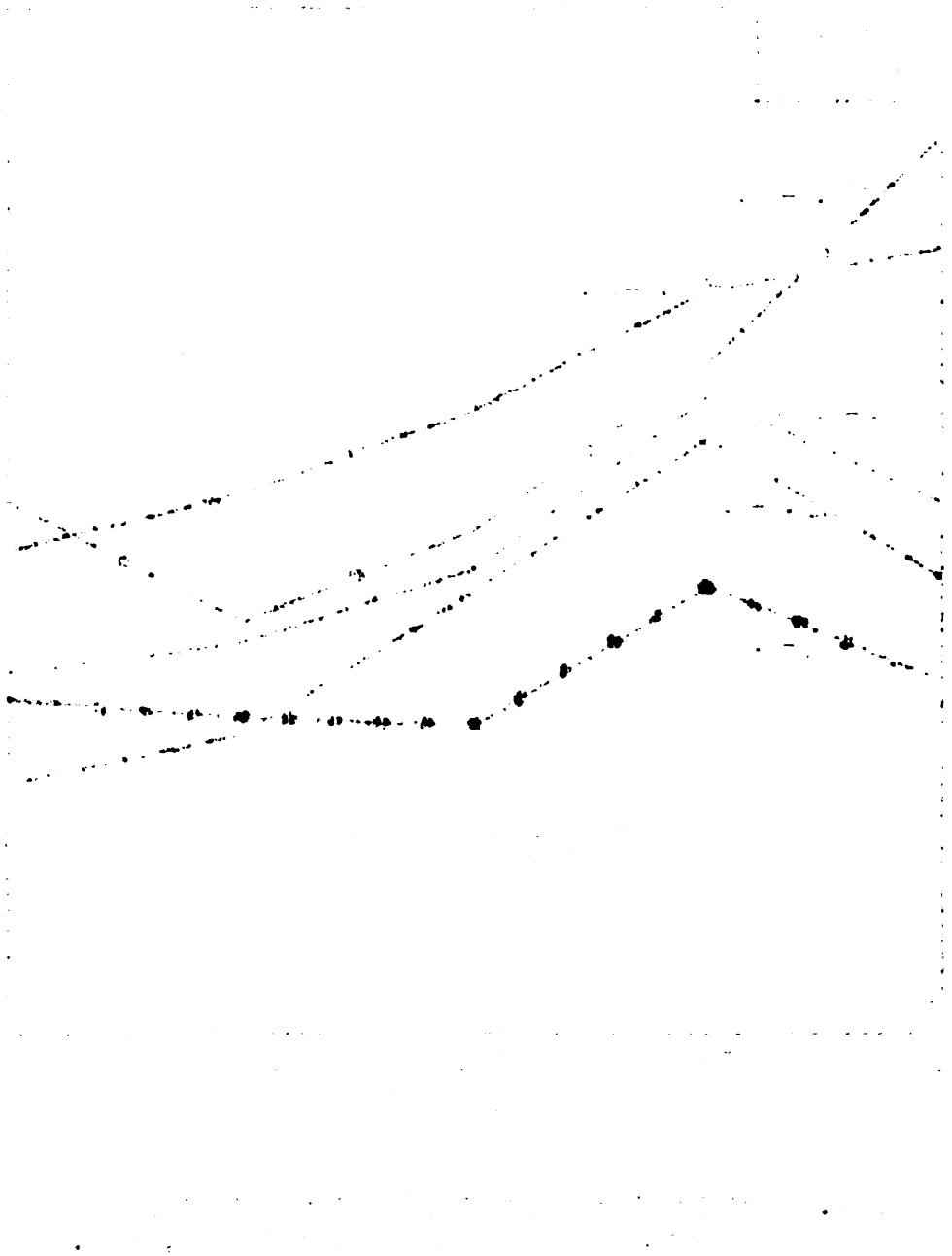


FIGURE 7. Monthly Milk Production Per Cow by Various Levels of Grain Feeding During Pasture Season, 1947.



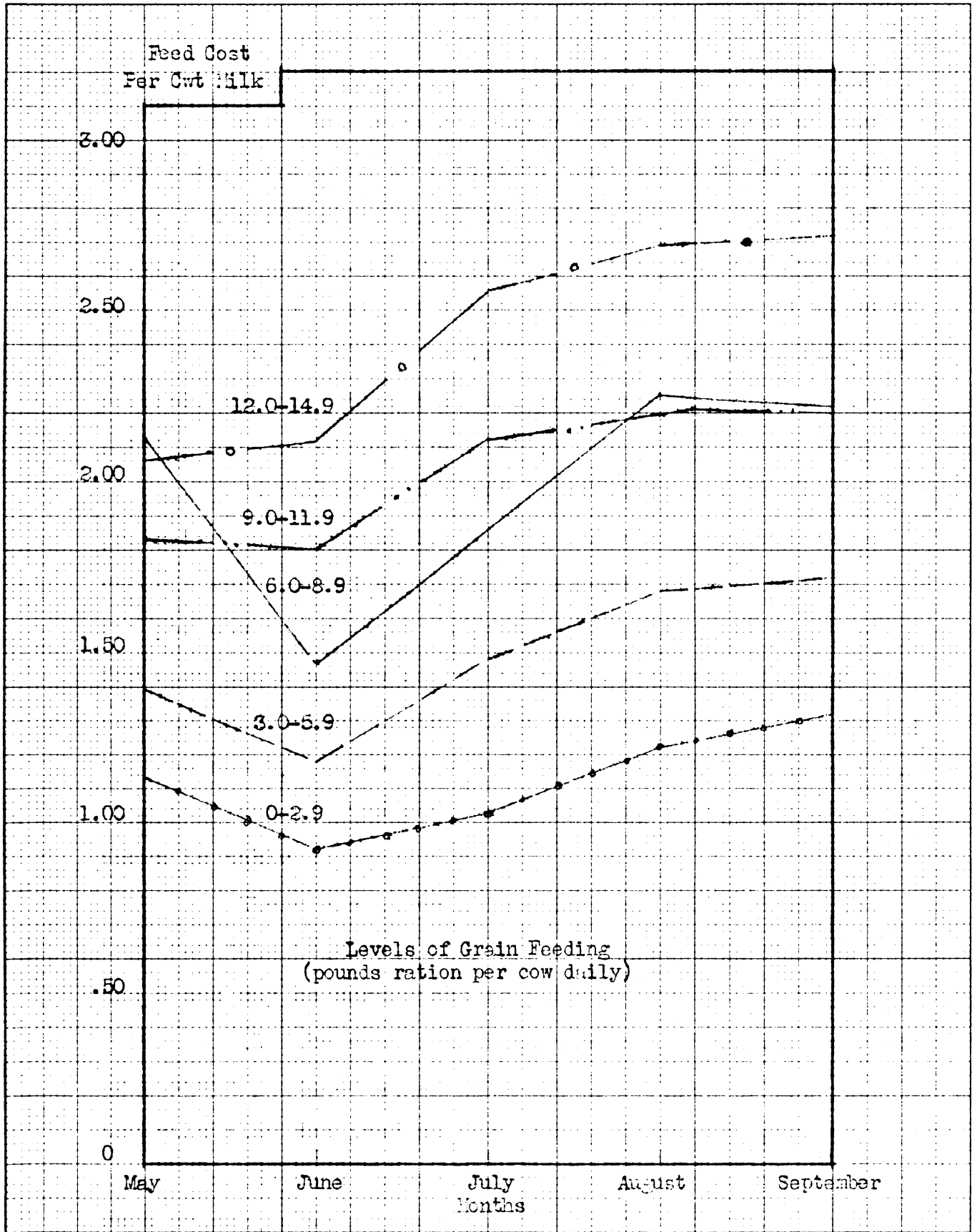
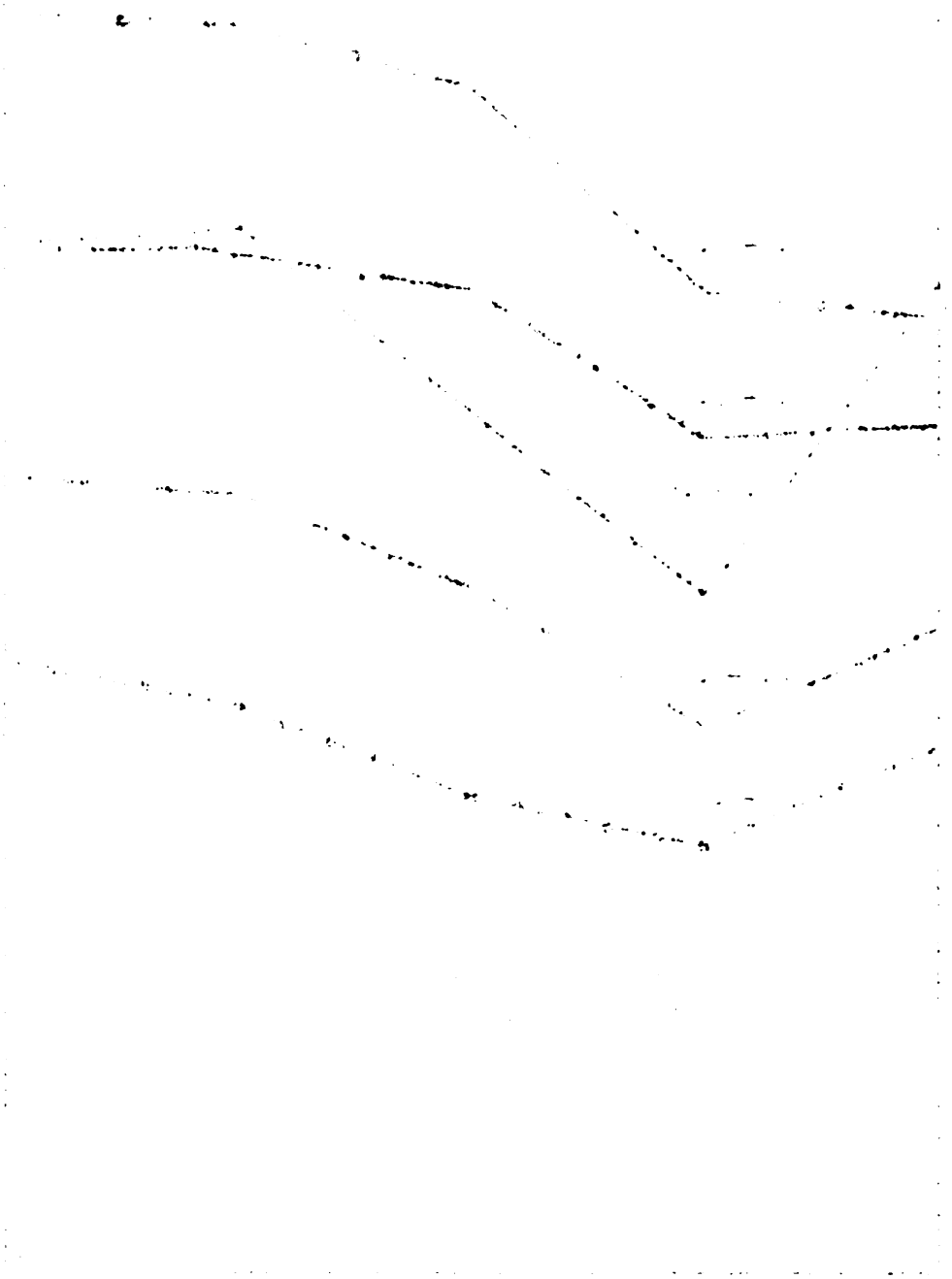


FIGURE 8. Total Feed Cost Per Cwt. Milk by Various Levels of Grain Feeding During Pasture Season, 1947.



Factors Affecting Results in Pasture Evaluation:

It became apparent early in the analysis of the data that there were many factors that could affect the results obtained by the total digestible nutrient method of pasture evaluation. For example, excessive grain feeding of cows on pasture could minimize or erase the imputed value of pasture. It seemed desirable to determine as accurately as possible the effect of this and other variables on the resulting measure of pasture yield.

To determine the effect of different levels of grain feeding on total feed costs and milk production the records were sorted according to amounts of grain ration fed per cow daily while on pasture. Sorting was repeated for each month so the farms did not necessarily fall in the same grouping every month. If a herd was not pasture during a given month, its records were not included in that particular tabulation. The results of this investigation are shown in table 2.

There are three main points of interest resulting from this inquiry. They are illustrated in figures 7 and 8 and may be summarized as follows:

(1) the cows receiving the largest amount of grain on pasture produced at a higher level of production, but the milk flow declined as the pasture season progressed,

(2) cows receiving the least supplementary feed were producing at a lower level of production but it was more level for the season, and

(3) the average total feed cost per 100 pounds of milk was higher in the herds receiving the most grain in spite of higher average production in these herds.

In the first case, there is the indication that the pastures were too inadequate to maintain a high flow of milk. On the other hand, as shown in the second case, the herds receiving the least supplementary feed maintained milk production at a more constant level. No visits to specific farms were made to see if the higher rates of barn feeding related to inadequacies of the pasture program.

In the matter of unit costs of production, as summarized in item 3, the highest unit costs were in the herds receiving the most supplementary feed. This does not necessarily mean a lower net profit for these herds. The extra production may have yielded a higher return even though the margin for each unit was smaller. However, it was impossible to answer this question by using only monthly data. Many of the costs of production, (e.g. interest and depreciation) cannot be calculated until the end of an entire year.

There were many ramifications to the problem of different levels of grain feeding as related to economical milk production that could not be dealt with in this study. It was concluded, however, that excessive supplementary feeding can obscure the results in pasture evaluation if production of the cow and quantities of feed inputs are involved. This is particularly true where much feed is wasted.

At this point, investigation was extended to see if the extent to which the results were effected by supplementary feeding could be determined. It was decided to do this by multiple correlation.* The imputed yield of pasture in terms of pounds of TDN per cow day was designated as the dependent variable (X_1). This yield was calculated according to the method outlined previously. The independent variables selected for the multiple correlation analysis were as follows: percent that the pasture yield was of the total TDN input (X_2), percent of the number of cows that were dry at some time during the pasture season were of the total herd (X_3)**, daily production per cow of fat corrected (4%) milk (X_4), and length of pasture season (X_5).

When the daily pasture TDN yield was calculated for individual farms it was found in a few cases there was little or no TDN residual left to be ascribed to as the value of pasture. This, of course, meant the entire input requirement was being met by non-pasture feeds. When the pasture yield was expressed as a percent of total feed needed to meet all that was required it was found that in 18 of the 85 herds less than 40 percent of the total feed intake was

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*Multiple correlation involves measuring the association of one dependent variable and two or more independent variables. See Appendix D for formulas used in calculating coefficients of gross correlation, coefficients of partial correlation, and the coefficient of multiple correlation.

**Determined from the date calves were born.

supplied by pasture. It was felt that the inclusion of the records of these 18 herds would impair the reliability of desired averages. Hence, further consideration was limited to the remaining 67 herds.

The pastures of these 67 herds yielded a daily average of 12.3 pounds of TDN per cow. The range in yield was 5.9 to 16.9 pounds and the standard deviation was 2.5 pounds. Since, according to Knott et al (16), it takes 16 pounds of TDN to meet body requirements and produce 17 pounds of 3.5% milk daily, the average pasture is unable to be the sole ration for the producing cow. Woodward (30) maintains that 25 percent of the value of pasture is lost in tramping, soiling and energy used in grazing. If the TDN yield were adjusted to compensate for these losses the result would be an average of 16.4 pounds per cow daily.

Although it is conceded that the yield according to this adjustment is probably more accurate, the original calculation was used in all of the multiple correlation analysis. A summary of the results of this analysis are shown in table 3.

The gross correlation coefficients indicate the linear relationship between pairs of variables without the effects of other variables included. It was found (as to be expected) that milk production and amount of supplementary feed fed were more closely associated with pasture yield than any of the other selected variables.

Table 3. Imputed Pasture Yield and Selected Variable Factors. (A summary of multiple correlation analysis.)

	Factors Influencing Pasture Yield				
	X_1 (lbs)	X_2 (%)	X_3 (%)	X_4 (lbs)	X_5 (days)
Mean	12.3	72.2	31.6	20.8	157
Standard Deviation	2.5	12.4	15.9	6.6	22

Gross Correlation Coefficients

$r_{12} = +.64$

$r_{13} = -.18$ $\quad r_{23} = -.014$

$r_{14} = +.31$ $\quad r_{24} = -.016$ $\quad r_{34} = -.14$

$r_{15} = +.04$ $\quad r_{25} = -.001$ $\quad r_{35} = +.13$ $\quad r_{45} = .018$

Coefficients of Partial Correlation

$r_{12.3} = +.65$ $\quad r_{13.4} = -.15$

$r_{12.4} = +.67$ $\quad r_{23.4} = -.01$

Coefficient of Multiple Correlation

$$R_{1.234} = +.75$$

Equations for Lines of Regression

$$X_{1.234} = 1.52 + .1276\ (X_2) - .0154\ (X_3) + .1242\ (X_4)$$

$$X_{1.24} = 2.31 + .1342\ (X_2) + .0123\ (X_4)$$

X_1 = The imputed yield of pasture in terms of pounds of TDN per cow per day.

X_2 = Percent that the pasture yield was of the total TDN input.

X_3 = Percent that dry cows were of the total herd.

X_4 = Daily production per cow of fat corrected (4%) milk.

X_5 = Length of pasture season

The correlation between length of pasture season and any other variable was highly insignificant. This may be interpreted to mean that adequacy of pasture cannot be expressed only in number of days. It is likely that many herds were being charged for pasture, especially at the end of the season, when the amount of available feed from pasture was small. Since these insignificant relationships occurred, it was decided to omit length of pasture season as a factor to be considered in the partial and multiple correlation calculations.

The effect of dry cows on the imputed pasture yield was apparently slight. A correlation coefficient of +.18 was computed for the relation of the percent of cows dry during the summer and pasture yield. This small coefficient was further reduced when milk production was held constant at its average value. When the percent of dry cows was held constant at its average value in relating pasture yield to the percent that pasture was of the total feed, the result was practically the same as when the variable of dry cows was omitted entirely.

The effect of holding both the variables of dry cows and daily milk production constant is shown in the multiple correlation coefficient where $R_{1.234} = + .75$. Thus the correlation between pasture yield and the percent that pasture was of the total ration was increased by including and holding constant the other variables.

A predicting equation was derived using three independent variables. The standard error of estimate for

this equation was 3.00 pounds of TDN daily. It was observed that the coefficient for the factor of dry cows (X_3) was very small. Therefore, that factor was omitted in the formulation of a second line of regression equation involving only daily milk production (X_4) and the factor of the relative importance of pasture in the ration (X_2). The standard error of estimate in this equation was 1.53 pounds of TDN. This makes a better equation for the purpose of prediction than the one involving three variables. The use of an equation of this type could be very valuable in predicting pasture yields on individual farms. However, the need for strengthening some of the assumptions used in formulating this equation necessitates caution in its use at this time. Some of the assumptions concerning the maintenance requirements of livestock and the relative nutritive values of different feeds will undoubtedly be changed as further research along these lines is made.

Computed Values of Pasture. It has been pointed out that the average daily yield of pasture was 12.3 pounds of TDN per cow. In order to express this as a dollar value it became necessary to use some price per pound of pasture TDN. It was decided to use the same average price as that for the TDN from other feeds. The total cost of all grains and roughages fed during the summer was divided by the total TDN yield of these feeds. The result was a price of 1.23 cents per pound. Applying this price to the yield makes an average daily value of pasture of 15.13 cents per

cow day. Coincidentally, the average charge for pasture made by the farmers was likewise, 15 cents per cow day. However, if the correction is made suggested by Woodward (30) for losses in tramping, soiling and energy used in grazing the resulting average daily value of pasture would be 20 cents per cow. These averages would amount to about $4.50 a month per cow if the lower rate were used and about $6.00 a month per cow if the higher rate were used.

These averages can be useful guides, but there is much variation in the kinds and conditions of pastures and the single rate cannot be used in all cases.

An attempt was made to classify the pastures and to calculate the yields of different types. The difficulty encountered in accomplishing this objective came in the wide range in pastures on single farms. In many cases it was a matter of starting the pasture season by pasturing a field of permanent pasture. Thereafter, as the need arose, gates to other fields were opened and before the season was closed, the cows were given free range of most of the farm. Since the cows were permitted to choose their own field it was impossible to tell from the data collected just what kind of pasture the cows were using at any given time. This condition destroyed the data for use in calculating the carrying capacities of different types of pastures and the values of these pastures on an acre basis. Thus, the solution of both of these problems were specific objectives of the study that could not be answered with the data

collected for analysis. An attempt to reduce the total yields of pasture TDN to an acre basis became ridiculous because so much of the land listed as pasture was not actually being grazed. This made the yield per acre in most cases extremely low.

An interesting comparison of yields of different forage crops has been presented by Semple et al (24). The manner in which these yields were derived was not explained but the results are shown in table 4 because they are closely related to this study. The price of 1.23 cents per pound of TDN as used above has been applied to the yields and an additional column on pasture value per acre has been included in the table.

Table 4. Value and Comparison of Yields per Acre for Selected Forage Crops.

Crop	Yield as Hay (T.)	TDN Yield when- Harvested (Pounds)	TDN Yield when- Grazed (Pounds)	Value per Acre Grazed
Alfalfa	2.07	2,252	1,666	$20.49
Sweetclover	1.19	1,226	907	11.16
Clover & Timothy	1.25	1,200	888	10.92
Grains cut green	1.05	1,029	761	9.36

For further comparison of the value of different pasture crops on an acre basis rates have been applied to the carrying capacities of various pastures suggested by Harrison and Bell (13). Both the 15.13 and 20 cent rates per cow day suggested on page 43 have been used to present

a possible range of reasonable values for each crop for the season. These results are presented in table 5, with figures rounded to the nearest dollar. These values are not necessarily intended to be the amounts that should be charged livestock for the use of the various forage crops. However, they represent interesting comparisons which, in general, are quite realistic. They are only suggestions based on research information presently available. It is the opinion of the author that farmers interested in dairy cost accounting are inclined to charge more than these suggested rates for pastures of lowest productive ability and less than the suggested rates for the pastures of highest productivity.

Table 5. Suggested Values per Acre for Selected Michigan Pasture Crops.

	Cow Days Per Acre	Range
June grass (good-permanent	50	$ 7.50 - $10.00
Alfalfa-brome (average 3 yrs)	120	18.00 - 24.00
2nd Yr. Sweet Clover (average)	90	14.00 - 18.00
2nd Yr. Red Clover - Timothy	95	14.00 - 19.00
Junegrass - whiteclover (permanent)	90	14.00 - 18.00
Reed canary grass (average-10 yrs)	200	30.00 - 40.00
Sudan grass (average)	115	17.00 - 23.00
Oats (average)	60	9.00 - 12.00

Many difficulties were encountered in arriving at a satisfactory expression of pasture yield by the method

employed with the data analyzed. Average yields and values have been presented, but their reliability for general use will be discussed in the next chapter where the entire study will be evaluated.

CHAPTER IV

SUMMARY AND EVALUATION OF THE STUDY

It was revealed early in conducting this study that while pasture research is not new, results dealing with pasture yields and value are not readily accepted by many technicians in the field. In many cases evidence is personal opinion and opinions are often easily changed. Opinions have been formed on the best information available but even the best information appears inadequate and sometimes inconsistent. It has been difficult for teachers in the field to make specific recommendations concerning the value of pasture. The difficulties to be encountered in pasture research were described in Chapter I. At the outset of the study objectives were set up with cognizance of these difficulties in mind. It will be possible to evaluate the study by considering how well these objectives were met.

The first objective was to search for an acceptable method of pasture evaluation that might be applied to the dairy enterprise using data which were already available. Many methods of pasture research have been used in the past but the wide selection did not insure an easy choice. Limitations were found in each. Some of them merely describe a condition or characteristic of pasture. Those falling in this category were: photographs, surveys, plant population, chemical analysis, palatability, and duration of grasses. These were considered as valuable methods providing they were

not used in themselves as methods of measurement of pasture value. They are excellent supplements to the techniques directly involved in measurement of yield.

The methods which did attempt to measure yield could be classified according to the manner of harvest. Pastures can either be harvested by man by mechanical means or by grazing livestock. In the case in which man does the harvesting it is assumed the resulting yields simulate the results obtained by animal grazing. The methods considered in the review of literature which involved harvesting mechanically or by hand were hay weights and clippings. From available results of research of this type it was found that neither method closely represents the yield which would have been consumed under animal grazing.

The methods of pasture measurement involving livestock have widespread use. They have been particularly popular with livestock farmers because the results could be expressed in familiar terms. Those considered in this study were: carrying capacity, profits, cattle weights, sheep weights, flow of milk, and yield of total digestible nutrients. In those methods in which livestock products or dollars are the end product, it is difficult to measure how much of the yield was directly caused by the pasture intake and how much was due to other factors affecting livestock production. Research involving the use of livestock requires extreme care in setting up conditions which will control the influence of other factors besides the

one which is being considered. The necessary precautionary measures are frequently overlooked in some of the methods of pasture evaluation requiring the use of livestock.

In spite of the many limitations of the method, it was decided to measure the pasture yield in terms of pounds of total digestible nutrients per cow daily. This involved the calculation of the contribution of pasture to the total feed consumption. The acceptance of this plan was based on the general approval of many authorities in the field and because it was well adapted to the data collected. It is granted that the reliability of the technique rests largely on the strength of assumptions made in connection with requirements for maintenance, milk production and growth, These assumptions were made with the aid of the best information available. The resulting pasture yield averaged 12.3 pounds of TDN per cow daily for the season. Hence, in the use of this technique of pasture evaluation, it was felt the first objective of the study was met.

The second objective of the study was to determine what factors common to dairy farms affected the use and yield of pasture. Climatological conditions and the availability of other feed during the period of study are matters of importance but whose affects could not be measured in this study.

Those selected for consideration were: (1) quantities of grains and roughages fed during the pasture

season, (2) number of dry cows on pasture, (3) production of milk and (4) length of pasture season. It was convenient to use these quantities in correlation analysis. By this process their significance was determined and the second objective of the study was met.

The third objective of the study was to classify and evaluate the various pasture crops used by the cooperating farmers. Failure was met in connection with this objective. The data did not lend themselves to classification because more than one kind of pasture was usually used at the same time.

The fourth objective of the study was to determine the "dollar value" of pasture. Since the yield had been expressed as pounds of TDN the problem was one of determining a reasonable price that could be assigned this yield. One possibility was to divide the total pasture charge for the season by the total TDN yield for the season. This plan was not followed because the actual pasture charge was made by farmers who themselves were not sure of the value of pasture. Another possibility, which was followed, was to divide the total value of all feed besides pasture by the total digestible nutrient content of those feeds. The result was 1.23 cents per pound. For converting yield to dollar value, this price was used. In principle, this means that a pound of TDN from pasture is equivalent to a pound of TDN from other feeds. In fact, it is quite likely they cause different responses and are not of equal value. It is probable that a

pound of TDN from pasture would be equal to or have greater value than a pound of TDN from other feeds. Hence, the price of 1.23 cents per pound becomes a minimum value. How much higher one could safely raise this price is not known.

When applied to the average daily TDN yield from pasture, the calculated value was 15.13 cents per cow day. This compares with 15 cents per cow day as the average actual charge made by farmers in the study. This answer was the desired end in the fourth objective. For further comparison, amounts of TDN yield and carrying capacities of different crops were obtained from other research to which the prices obtained from this study were applied. In this way it was possible to express pasture values in terms of value per acre.

In the methods described above the objectives of the study were met, with the exception of the third. Critical consideration of the data used in calculating the results of this study prompt suggestions for further research needed.

CHAPTER V

ADDITIONAL RESEARCH SUGGESTED

The new research that will be suggested is that which seems to be necessary to improve the results of this type of pasture investigation. It does not seem appropriate to necessarily propose new projects, but to simply state questions that arose as the study progressed. The field is broad and the limited experience and time of the writer prohibits complete mastery of the problem in all respects. These questions are raised only because they seem relevant to a complete treatment of the problem, but with no intent of being critical.

The following questions were brought to mind during the analysis phase of the study:

1. How long should a study of this type be conducted in order to measure the affect of weather on the productivity of pasture? It suggests a long-time study of identical farms. If generalizations are to be made relative to the yield of certain species of forage crops they must be made with certain qualifications concerning climatological conditions. How typical these generalizations can be with one year of data is uncertain.

2. The matter of representative conditions is also involved in ways besides the consideration of length of time needed. For example, the

size and dispersion of the sample are important. What is a proper size of sample for a study of this type? How large an area should be included? Should corrections be made for different type-of-farming areas? Are the answers to these questions necessarily the same for a study of pastures as one on the cost of milk production?

3. Still other matters relative to representative conditions have to do with variations of farms. Examples may be found in soil variations, variations in the quality of crops and livestock, and in the differences in managerial abilities of the operators. Some of these are difficult to measure, but they could be responsible for considerable bias in the final result. What are average conditions as far as soils are concerned? The sample used in this study was considered fairly typical from the standpoint of the organization of the dairy enterprise, but some of these other matters were not considered.

4. How can the value of specific pasture crops be studied under farm conditions when the general practice is to pasture several kinds of pasture at the same time? It would seem that the cows should be left on a single field throughout the period of the study if the yield of the field is to be measured. Therefore, a study in which this factor is controlled is suggested.

5. When the TDN method of pasture evaluation is employed, it is necessary to use in calculation many standards based on metabolic rates of the cow. The Morrison feeding standards, and likewise, the Haecker feeding standards are widely used but they are considered inadequate by many nutrition authorities. It would be well to know more about comparative requirements of pregnant, and lactating animals. It would be desirable to know more about the nutritional requirements for growth and weight loss under farm conditions. It would also be advisable, in connection with digestion trials, to know what unit could be developed that would be superior to TDNs for the purpose of comparing different feeds. Some current research reveals that there is not a direct relationship between TDN intake and production -- that the same production quantities are possible with different amounts of TDN being consumed. A unit that would more nearly describe productive capability of feeds is essential.

6. It has been emphasized at length that the influence of large quantities of feed besides pasture during the summer on the final imputed yield of pastures is great. It would be desirable to conduct a study of this type in which the supplementary feed was kept to a minimum and to standardize the grain ration as much as possible. It might

also be possible to measure the responses to pasture that would come to cows going on pasture in different degress of flesh condition. In other words, it would be well to know how the winter feeding program is related to the production response caused by pasture.

The above considerations were confronted in developing the problem. They bring out definite shortcomings in the analysis herewith presented. However, they help to focus attention on needed areas of investigation and help to stimulate thinking along lines of improvement. It was strikingly apparent throughout this study that people in fields related to pasture use are searching for an acceptable method of evaluation. Perhaps one solution to the problem is to refine the methods now in use rather than developing new techniques. It is not important which method is perfected so long as it overcomes the prime objections currently raised concerning each of them. It is felt by the writer, however, that the TDN approach or related techniques have many advantages and could be developed to a satisfactory point of acceptance for both farmers and technician alike.

This study has progressed much as an amateur naturalist nets a butterfly. In the distance he views his objective -- a new and valuable speciman -- and proceeds to capture it. The chase leads to land travelled before and occasionally on territory entirely foreign. Numerous

"passes" at the insect yields nothing. So it was with this study. Many times the answer seemed right in the net, but jumps to the conclusion, like the jumps of a butterfly chaser, were too hasty and the prize escaped. Sometimes the butterfly was lost from sight and the path had to be retraced to pick up the trail. When, after an arduous journey, the butterfly is finally in the net, a closer examination reveals the specimen is not so new and valuable after all, and the spoils of the victory are small.

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FORMS USED IN COLLECTING AND ANALYZING PRIMARY DATA

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SYMBOLS AND FORMULAS USED IN LINEAR MULTIPLE CORRELATION

APPENDIX A

TABLE I. Average Monthly Temperature, Selected Michigan Stations, 1947*

Station	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	55.2	66.7	70.7	78.1	65.0	59.0	35.9
Ann Arbor	52.8	64.0	68.6	75.6	62.8	59.5	35.8
Caro	53.4	64.8	70.0	75.5	63.2	59.6	34.8
Detroit	53.8	66.0	70.8	76.5	65.4	60.3	37.2
Flint	51.8	64.5	69.2	76.0	64.0	59.4	35.0
Hillsdale	54.6	65.1	69.0	77.4	64.3	59.0	35.2
Howell	51.6	64.0	68.0	74.6	62.8	58.6	34.1
Lansing	52.1	63.6	68.2	75.5	62.4	57.8	34.6
Lapeer	51.2	63.0	67.8	73.7	62.2	58.2	33.8
Mt. Clemens	53.2	65.2	70.4	75.6	65.0	59.8	37.2
Owosso	53.8	64.6	69.6	76.5	64.2	60.4	36.2
Pontiac	53.4	64.8	69.8	75.4	64.8	59.6	35.8
Port Huron	50.4	**	**	**	**	**	37.5
Sandusky	52.4	64.2	69.2	74.6	63.9	59.8	35.9
Average	52.5	64.6	69.3	75.8	63.8	59.3	35.6

*U. S. Dept. Commerce Weather Bureau, 1947 Climatological Data, 34: nos. 5-13

**Not available

APPENDIX A

TABLE II. Days with More Than .01 Inch Precipitation, Selected Stations, 1947.*

Stations	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	15	10	9	11	10	6	12
Ann Arbor	14	7	5	4	4	4	11
Caro	14	9	14	5	9	3	7
Detroit	19	11	10	11	11	6	12
Flint	21	9	11	10	12	6	12
Hillsdale	16	10	7	8	8	5	16
Howell	20	8	9	12	11	6	13
Lansing	22	11	12	12	10	7	14
Lapeer	16	9	12	9	10	5	11
Mt. Clemens	18	9	10	9	10	6	10
Owosso	16	9	8	11	10	5	11
Pontiac	17	8	14	10	10	6	11
Port Huron	18	**	**	**	**	**	12
Sandusky	18	8	14	7	10	3	8
Average	17	9	10	9	10	5	11

*U.S. Dept. Commerce Weather Bureau, 1947 Climatological Data, 34: nos. 5-13

**Not available

APPENDIX A

TABLE III. Average Monthly Precipitation (inches), Selected Stations, 1947*

Stations	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	4.95	3.72	1.51	3.56	3.06	2.69	2.17
Ann Arbor	5.56	2.49	1.13	4.10	1.10	3.40	1.88
Caro	3.46	2.78	2.70	1.83	3.94	0.97	1.35
Detroit	6.97	3.49	2.42	2.85	3.96	1.31	1.80
Flint	4.60	3.53	4.75	3.36	6.61	3.36	1.79
Hillsdale	6.80	4.05	0.85	4.90	4.39	1.56	2.70
Howell	5.84	4.09	4.43	7.46	5.63	3.24	2.20
Lansing	5.22	2.74	3.06	3.86	4.75	2.68	1.99
Lapeer	4.56	4.28	3.20	4.08	6.00	2.89	2.00
Mt. Clemens	5.54	2.57	4.74	6.03	4.39	0.58	1.21
Owosso	4.13	4.49	2.76	3.02	4.06	2.35	1.75
Pontiac	5.09	3.18	4.84	2.60	4.40	1.68	1.73
Port Huron	6.94	**	**	**	**	**	1.82
Sandusky	6.95	3.91	4.34	1.98	4.45	2.01	2.18
Average	4.75	4.93	1.33	3.82	4.36	2.19	1.97

*U.S. Dept. Commerce Weather Bureau, 1947 Climatological Data, 34: nos. 5-13

**Not available

APPENDIX A

TABLE IV. Dates of First and Last Killing Frost, Selected Stations, 1947*

Station	Date of First Killing Frost	Date of Last Killing Frost
Adrian	May 10	September 26
Ann Arbor	May 10	October 1
Caro	May 4	September 23
Detroit	May 9	October 1
Flint	May 10	September 25
Hillsdale	May 10	September 23
Howell	May 10	September 25
Lansing	May 10	September 26
Lapeer	June 4	September 25
Mt. Clemens	May 10	October 1
Owosso	May 10	September 25
Pontiac	May 10	September 25
Port Huron	**	**
Sandusky	May 10	September 26

*U. S. Dept. Commerce Weather Bureau, 1947 Climatological Data, 34: nos. 5-13

**Not available

APPENDIX A

TABLE V. Average Monthly Temperature, Selected Stations, All Recorded Years.

Stations	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	58.2	68.1	72.5	70.1	63.7	51.3	38.4
Ann Arbor	57.5	67.0	71.7	69.2	62.8	50.6	37.8
Arbela	56.0	65.3	70.3	68.3	61.6	50.0	37.4
Armada	55.2	65.4	70.0	68.2	61.5	49.5	36.9
Detroit	57.7	67.3	72.3	70.3	63.7	52.2	39.1
Durand	57.1	68.1	73.2	70.8	63.9	51.6	39.7
Eloise	57.4	67.1	72.4	70.0	63.7	52.2	39.2
Flint	56.3	66.0	70.6	67.6	61.6	50.0	37.3
Hillsdale	57.3	66.6	71.8	69.4	63.2	51.4	38.4
Howell	56.4	67.0	71.2	68.8	63.2	50.5	37.9
Lansing	56.5	66.7	71.0	68.4	61.3	49.2	36.5
Lapeer	56.5	65.8	71.8	68.9	62.9	51.3	38.1
Mt. Clemens	56.0	65.9	71.2	69.4	62.9	51.7	39.5
Owosso	58.0	67.0	72.4	65.7	63.4	51.4	38.4
Pontiac	56.5	66.2	71.0	68.4	62.5	50.5	37.8
Port Huron	53.9	64.0	69.3	67.8	61.8	50.3	37.8
Sandusky	53.5	62.9	68.8	66.7	60.7	49.1	37.5
Ypsilanti	57.3	66.4	71.1	69.0	62.4	50.5	37.9
Average	56.5	66.2	71.3	68.7	62.6	50.7	38.1

* U.S. Dept. of Agriculture Weather Bureau, Climatic Summary of the U.S., Section 63; Eastern Lower Michigan

APPENDIX A

TABLE VI. Days with More Than .01 Inch Precipitation, Selected Stations, All Recorded Years.*

Stations	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	10	8	7	7	8	8	9
Ann Arbor	12	10	8	8	9	9	10
Arbela	10	9	7	7	7	7	9
Armada	10	9	10	8	9	9	10
Detroit	13	11	9	9	10	10	12
Durand	9	9	6	6	7	7	6
Eloise	9	8	8	7	7	8	8
Flint	12	10	9	8	9	9	10
Hillsdale	11	9	8	8	8	9	10
Howell	10	9	8	8	8	9	8
Lansing	10	9	7	8	8	9	11
Lapeer	9	7	7	5	7	7	7
Mt. Clemens	9	8	7	7	8	8	9
Owosso	10	8	7	7	8	8	9
Pontiac	9	8	8	7	7	7	8
Port Huron	12	11	10	9	10	11	12
Sandusky	9	8	7	6	7	7	7
Ypsilanti	12	10	9	9	9	9	10
Average	10	9	8	7	8	9	9

*U. S. D. A., Weather Bureau, Climatic Summary of the U.S., Section 63; Eastern Lower Michigan

APPENDIX A

TABLE VII. Average Monthly Precipitation (inches), Selected Stations, All Recorded Years.*

Stations	Months						
	May	June	July	Aug.	Sept.	Oct.	Nov.
Adrian	3.93	3.75	3.15	3.08	3.37	2.65	2.92
Ann Arbor	3.52	3.40	2.94	2.70	2.95	2.64	2.49
Arbela	4.55	3.43	3.40	3.26	3.33	2.91	2.77
Armada	3.63	3.22	2.95	3.17	2.77	2.72	2.49
Detroit	3.26	3.56	3.27	2.74	2.76	2.39	2.41
Durand	3.19	2.90	2.14	2.67	2.39	2.18	1.60
Eloise	2.88	2.90	2.69	2.52	2.67	2.27	1.96
Flint	3.62	2.81	3.03	2.64	2.76	2.30	2.25
Hillsdale	3.99	3.68	3.07	2.81	3.01	2.70	2.87
Howell	3.24	2.82	2.76	2.83	2.62	2.52	2.35
Lansing	3.31	3.57	3.05	2.71	2.81	2.44	2.27
Lapeer	3.57	3.33	2.88	2.48	2.74	2.32	2.44
Mt. Clemens	3.01	2.93	3.24	2.55	3.05	2.21	2.22
Owosso	3.30	2.82	3.29	2.63	2.92	2.60	2.39
Pontiac	3.17	2.78	2.69	2.52	2.75	2.29	2.26
Port Huron	2.96	2.94	2.70	2.68	2.70	2.52	2.36
Sandusky	3.39	2.97	3.21	2.74	2.61	2.42	2.02
Ypsilanti	3.64	3.48	2.95	2.64	3.19	2.55	2.69

*U. S. D. A., Weather Bureau, Climatic Summary of the U. S., Section 63; Eastern Lower Michigan

APPENDIX A

TABLE VIII. Average Length of Growing Season, Selected Stations, All Recorded Years.*

Station	Days
Adrian	158
Ann Arbor	163
Arbela	137
Armada	144
Detroit	169
Durand	148
Eloise	153
Flint	131
Hillsdale	150
Howell	148
Lansing	158
Lapeer	150
Mt. Clemens	151
Owosso	143
Pontiac	151
Port Huron	143
Sandusky	131
Ypsilanti	154
Average	150

* U. S. D. A., Weather Bureau, Climatic Summary of the U.S., Section 63; Eastern Lower Michigan.

APPENDIX B

APPENDIX B

APPENDIX B

Farm Mgt. Dept., M. S. C. Mich. Milk Producers Ass'n

INVENTORIES

Name_____ Address_____ Date_____

County_____ Township_____ Section_____

DAIRY CATTLE

Name or number	Age	Beginning of year	End of year	Name or number	Age	Beginning of year	End of year
1.		$	$	19.		$	$
2.				20.			
3.				21.			
4.				22.			
5.				23.			
6.				24.			
7.				25.			
8.				26.			
9.				27.			
10.				28.			
11.				29.			
12.				30.			
13.				Total			
14.				Bulls			
15.							
16.				Heifers (over 1 year) No.			
17.				Calves (under 1 year) No.			
18.				Other cattle No.			

BUILDINGS

Description	Beginning of year	End of year
Dairy barn*	$	$
Milk house		
Bull shed or pen		
Separate calf pens		
Total		

EQUIPMENT

Description	Beginning of year	End of year
Milking machine	$	$
Milk cooler		
Milk cans		
Pails and strainer		
Cream separator		
Cooling tank		
Hot water heater		
Forks, shovels, stools		
Electric fencer		
Total		

*Share of floor space used by: Cows_____% Bulls_____% Young stock_____%

APPENDIX B

ANNUAL DAIRY COST SUMMARY

Name _____ Milk: Av. B.F. test ___ % Production per cow _____

County _____ Butterfat: Total production _____ per cow _____

COWS: Breed _____ Av. no. _____

COSTS	Total	Per Cow
Feed	$	$
Labor ____ hrs.		
Cow depreciation		
Interest on invest.		
Building use		
Equipment use		
Breeding cost		
Misc: Electricity		
Vet. and Med.		
Bedding		
Other		
Overhead (5%)		
Total	$	$
INCOME		
Milk sold	$	$
Milk used		
Total		
Subsidy		
Calf value		
Manure credit		
Cow appreciation		
Total	$	$
Net Return		
Return per hour		

YOUNGSTOCK: No. under 1 yr. ___ over 1 yr. ___

COSTS	Total	Per Head
Feed	$	$
Labor ____ hrs.		
Calf value		
Interest on invest.		
Building use		
Equipment use		
Breeding cost		
Misc: Electricity		
Vet. and Med.		
Bedding		
Other		
Overhead (5%)		
Total	$	$
INCOME		
Appreciation	$	$
Manure credit		
Total	$	$
Net Return		
Return per Hour		

BULLS: Average no. _____

Feed	$	$
Labor ____ hrs.		
Bull depreciation		
Interest on bull		
Building use		
Equipment use		
Misc: Bedding		
Other		
Overhead (5%)		
Total	$	$
Manure credit		
Other income		
Total	$	$
Net Cost for Year		
Cost per Service		

COSTS AND INCOME PER UNIT OF PRODUCT

Item	Milk (per cwt.)	Butterfat (per lb.)
Costs: Feed	$	$
Labor		
Other		
Total		
Income: Milk		
Other		
Total	$	$
Net Return		

FEED AND LABOR AMOUNTS AND VALUES

	COWS			BULLS			YOUNGSTOCK		
	Amount			Amount			Amount		
FEED	Per Head	Total	Value	Per Head	Total	Value	Per Head	Total	Value
Conc. mix.			$			$			$
Other grain									
Hay									
Silage									
Other rough.									
Pasture									
Milk to Y.S.									
Total									
LABOR									
Hired help									
Farmer									
Family									
Total									

CATTLE INVENTORIES, PURCHASES, SALES, AND APPRECIATION OR DEPRECIATION

Ending inventory	no.	$		no.	$		End. inv'ty.	$
Sales							Sales	
Total credits							Heifers, Bulls	
Beginning inventory							Total Cr.	
Purchases							Beg. inv'ty.	
Heifers freshening				Bulls kept			Purchases	
Total debits							Total Dr.	
Appreciation								
Depreciation								
Interest on av. investment at 5%		$			$			$

BUILDINGS AND EQUIPMENT INVENTORIES AND CHARGES

Item	Barn	Milkhouse			Equipment	Barn Usage:		
Beg. inv'ty.	$	$	$	$	$	Cows	%	%
End. inv'ty.						Bulls	%	%
Depreciation						Y.S.	%	%
Interest (5%)						Barn use charge:		
Taxes, ins.(2%)						Cows	$	$
Rep. and new						Bulls	$	$
Total cost						Y.S.	$	$

Farm Mgt. Dept., M. S. C. APPENDIX B Mich. Milk Producers Ass'n

MONTHLY DAIRY COSTS

Name_____ Address_____ Month of_____ 19____

1. CONCENTRATE MIX (*Only*)

Concentrate mix	Amount (lbs.)	Average price	Total value
Corn		$	$
Oats			
Barley			
Grinding			
Mineral			
Salt			
Total		XXXXXXXX	

Concentrate use		
Item	Amount	Value
On hand first of month		$
Mixed or bought		
Total		
On hand end of month		
Used		
Share to:		
Cows		
Bulls		
Young stock		
Other stock		

2. FEED SUMMARY (*Concentrate Mix, Other Grains, Roughage and Pasture*)

Kind	Average price	Cows		Bulls		Young stock	
		Amount	Value	Amount	Value	Amount	Value
Conc. mix lb.	$		$		$		$
Other grain lb.							
Hay T.							
Silage T.							
Pasture							
Total	XXXXXXXX	XXXXXXXX		XXXXXXXX		XXXXXXXX	

3. LABOR RECORD

Worker	Rate*	Cows		Bulls		Young stock	
		Hr. per mo.	Value	Hr. per mo.	Value	Hr. per mo.	Value
Hired help	$		$		$		$
Farmer							
Family							
Total	XXXXXXXX						

*For hired help rate per hour: Cash wages per month $_____ Value of items supplied (list them)_____ Total Wage $_____

Hours worked in a typical week-day_____ X _____ days in month = _____ hours

Hours worked in a typical Sunday _____ X _____ Sundays in month = _____ hours

Divide total monthly wage $_____ by total hours in month_____ for rate per hour_____.

Monthly wage for you $_____ Hours you worked in month_____ your rate per hour_____.

Average daily time spent on cows: Milking_____ minutes. Feeding_____ minutes.

4. PURCHASES AND SALES OF DAIRY CATTLE

Date	Cow purchases	No.	Value	Date	Cow sales	No.	Value
			$				$
	Heifers freshening				Cows butchered		
					Cows died		XXXXXXXX
	Total				Total		
Cows on farm at first of month			XXXXXXXX	Cows on farm at end of month			XXXXXXXX
	Total number		XXXXXXXX		Total number		XXXXXXXX
	Bull purchases				Bull sales		
	Calf purchases				Calf sales		

Average number of cows for month_____. Calves born during month_____. Number of dairy heifers at beginning of month over 1 year_____under 1 year_____. Number of bull calves at beginning of month over 1 year_____under 1 year_____

5. DAIRY PRODUCTS SOLD AND USED

Milk					Cream and skimmilk				
Sold Date	Pounds	Test	Net receipt*		Sold Date	Pounds	Test	Price	Net receipt*
			$					$	$
					Used: House				
					Fed				
Used: House		XXXXXX			Total		XXXXXX	XXXXXX	
Fed		XXXXXX			Calves at 5 days age				
Total		XXXXXX			Manure				
Subsidy payment (rate)					Total income				

*Hauling and fees are to be deducted. Enter other expense items below.

6. MISCELLANEOUS EXPENSES OF DAIRY CATTLE

Date	Item**	Cows	Bulls	Young stock
		$	$	$
	Bedding (price per ton $)			

**Dairy equipment repairs and supplies, expenses on barn, share of electric bill, veterinary, medicine, breeding fees, testing dues, and other dairy expenses.

APPENDIX C

ASSUMPTIONS USED IN CALCULATING PASTURE YIELD BY TDN METHOD

1. TDN content of feeds:*
   a. Usual grain ration to consist of 75 percent total digestible nutrients.
   b. Usual hay fed to consist of 41 percent total digestible nutrients.
   c. Silage (corn) to consists of 17.8 percent total digestible nutrients.
2. TDN required for maintenance of each 100 pounds of live weight:* .787 pounds.
3. TDN required for each pound of 4 percent fat corrected milk:* .3375
4. Standard weights of dairy cows by breeds as presented by Ragsdale.** Cows in mixed herds assumed to weigh 1000 pounds.
5. Milk converted to fat corrected basis according to the conversion tables of Brody and Ragsdale.***

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* Woodward, T. E., Feeding Dairy Cows. U. S. D. A., Farmers Bul. 1626, pp. 30-31

** Ragsdale, A. C., Growth Standards for Dairy Cattle. Mo Agr. Exp. Sta., Bul. 336

*** Brody, S., and Ragsdale, A. C., Evaluating the Efficiency of Dairy Cattle. U. of Mo. Col. Agr. Exp. Sta., Bul. 351, p. 4.

APPENDIX D

SYMBOLS AND FORMULAS USED IN LINEAR MULTIPLE CORRELATION

X_1 = the dependent factor or variable.

X_2, X_3, X_4, etc. = the independent factors or variables.

Σ = Total or summation, i.e. ΣX_1 = sum of X_1 values

N = The number of items in a given series

AX_1 = The average of the X_1 values = $\frac{X_1}{N}$

σ = The standard deviation

σ_1 = The standard deviation of X_1 = $\sqrt{A\Sigma(X_1)^2 - (AX_1)^2}$

P_{12} = The product moment of X_1 and X_2 = $\frac{\Sigma X_1 X_2}{N} - (AX_1)(AX_2)$

r_{12} = The coefficient of gross correlation = $\frac{P_{12}}{\sigma_1 \sigma_2}$

$b_{1.2}$ = The regression coefficient for X_1 on X_2 = $r_{12}\frac{\sigma_1}{\sigma_2}$

FIRST ORDER CORRELATION COEFFICIENTS

$r_{12.3}$ = Measure of correlation between X_1 and X_2 holding X_3 constant

$$12.3 = \frac{r_{12} - (r_{13})(r_{23})}{\sqrt{1-(r_{13})^2}\ \sqrt{1-(r_{23})^2}}$$

$$r_{12.4} = \frac{r_{12} - (r_{14})(r_{24})}{\sqrt{1-(r_{14})^2}\ \sqrt{1-(r_{24})^2}}$$

$$r_{23.4} = \frac{r_{23} - (r_{24})(r_{34})}{\sqrt{1-(r_{24})^2}\ \sqrt{1-(r_{34})^2}}$$

APPENDIX D

SECOND ORDER CORRELATIONS COEFFICIENTS

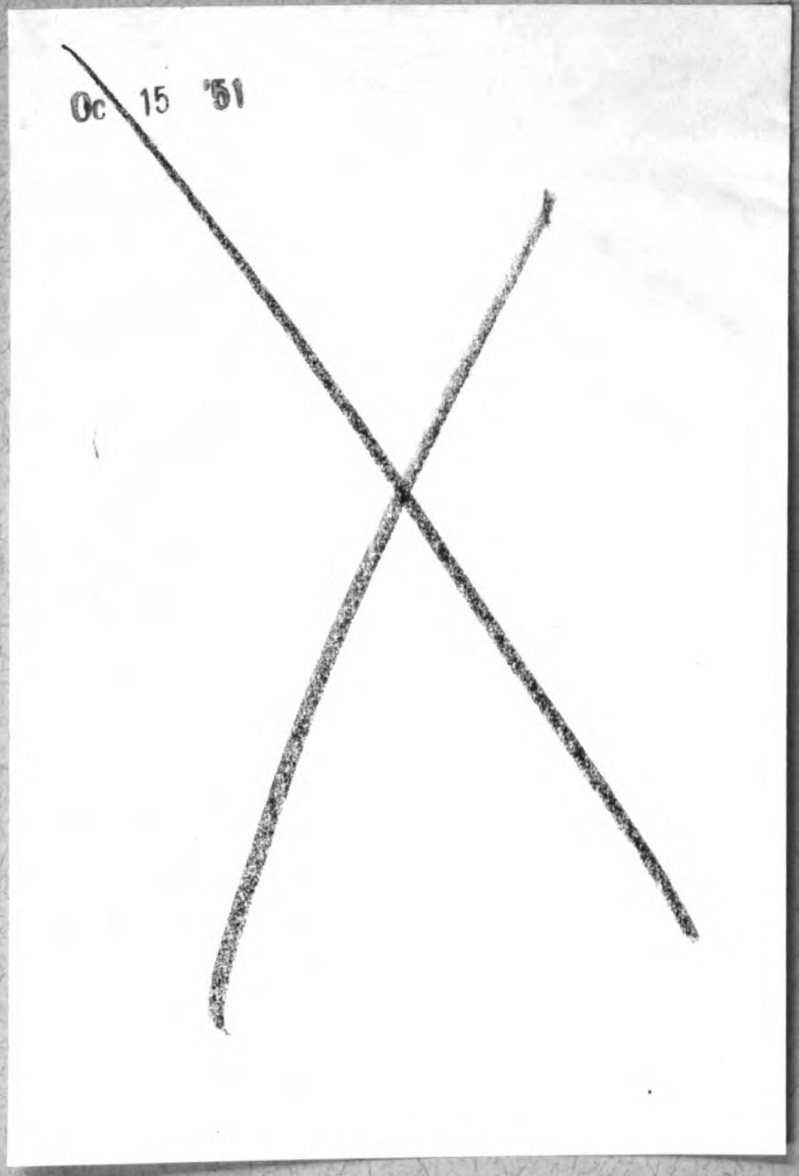
$r_{12.34}$ = Measure of correlation between X_1 X_2 holding X_3 and X_4 constant

$$r_{12.34} = \frac{r_{12.4} - (r_{13.4})\,(r_{23.4})}{\sqrt{1 - r^2_{13.4}}\ \sqrt{1 - r^2_{23.4}}}$$

COEFFICIENT OF MULTIPLE CORRELATION

$R_{1.234}$ = Measure of correlation of a X_1 and the series of X_2 , X_3 and X_4.

$$R_{1.234} = \sqrt{1 - (1-r^2_{14})\,(1-r^2_{13.4})\,(1-r^2_{12.34})}$$



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