A METHOD OF DETERMINING THE ECONOMIC PRODUCTION CAPACITY OF OKLAHOMA PASTURES

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Bachelor of Science

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Stillwater, Oklahoma

1935

Submitted to the Department of Agricultural Economics

Oklahoma Agricultural and Mechanical College

In partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

1943

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ACKNOWLEDGMENTS

Appreciation is expressed to Dr. Peter Nelson, Head of the Department of Agricultural Economics, Oklahoma Agricultural and Mechanical College for the guidance, encouragement, and inspiration which he provided in the development of this study.

Special mention is given to K.D. Blood, Agricultural Statistician, U.S. Department of Agriculture, and to Harley A. Daniels and Harry M. Elwell, Red Plains Experiment Station, Guthrie, Oklahoma, for providing necessary data.

Additional acknowledgment and appreciation are extended to members of the Oklahoma Society of Farm Managers and Rural Appraisers and to a large number of Oklahoma farmers and stockmen who supplied additional information and comments which contributed substantially to this investigation.

E.A.T.

PREFACE

PURPOSE OF THE STUDY

This study was undertaken to learn if data on pasture utilization as indicated by forage clippings of both grazed and ungrazed areas and resulting beef production, as shown by cattle weights, could be used, when supplemented with other related data, to indicate economic grazing practices for Oklahoma pastures.

The other related data, as defined for this purpose, include information on wild hay yields, pasture conditions, pasture utilization reports from individual farmers and estimates from a number of well-trained individuals on the relative forage yields of the more important types of pasture in all parts of the State as well as the many reports on pasture studies which have been made at numerous experiment stations.

By comparing the consumption of grass to the resulting beef production and by inquiring of the relative yields of pasture crops and wild hay it was hoped that a method could be developed which would be helpful in determining the physical production of different kinds and grades of pasture in such terms as pounds of beef and milk to which greater economic significance could be attached than is generally attached to acres of pasture with yield unknown.

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CHAPTER I

NEED FOR PASTURE YIELD DATA

Yield data are available by districts, areas, and in many cases by counties for practically all of the important crops of Oklahoma except pastures. The Division of Crop and Livestock Estimates, A.A.A., State Board of Agriculture, and other public, semi-public, and private organizations compile very satisfactory reports on crop yields for the current and for historical periods, yet the yield of pastures which make up more than 48 percent of the area of Oklahoma farms is unreported except by percentage expressions of the relative condition of pastures this year or this month with previous periods. As these reports are for pastures in general and on a state-wide basis their value for individual areas or particular kinds of pasture is not great. To report pasture yields in tons of forage, animal unit days of grazing, or in pounds of beef or milk production per acre is practically unheard of except in connection with formal experiments and since such experiments are limited in number and usually deal with only one or two kinds of pasture, little information has been gathered on relative yields of various pastures.[1] Hence, information on relative returns from various kinds of pasture or the production of pastures as compared to that of cultivated crops is far from plentiful. As a result, individual bargaining power must be resorted to in determining the sale, loan, or rental value of a particular tract of pasture land and no very

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[1] At this time there are at least three separate studies under way in Oklahoma which are providing valuable information of this type. In addition to the work of Taylor of Stillwater and Daniel and Elwell at Guthrie, which has been drawn on for this discussion, Professor Hi W. Staten of the Oklahoma Agricultural Experiment Station is testing forage yields of a number of small grain crops at Stillwater.

comprehensive data are available to guide or support the judgment of those individuals involved. In some areas of the State a stocking rate for native pasture has been rather generally agreed upon but in a large part of the State it is the number of animals a farmer owns that determines his stocking rate rather than the production capacity of the grass. This may result in over- or under-grasing, either of which reduces his returns to something below what he could expect under an optimum stocking rate. The results of over-grazing and under-grazing are generally known to stockmen though misused pastures can be found in practically all sections of the State.

Physical Studies Are Not Adequate

"A properly managed pasture should be stocked according to its grazing capacity in an average year," explained Aldous[2] in describing a desirable stocking rate for Kansas pastures. "This means," he continued, "that there may be a shortage of forage in the dry years and an excess in the favorable ones." Over-grazing, he contended, does decrease grass production, often changes the type of grass found in a pasture, and may substantially reduce the total production of forage if continued over a period of years.

While Aldous conducted extensive tests on the effects of various stocking rates and management practices and reported the results which are generally accepted, his publications do not contain a great deal of material of value to one attempting to predetermine optimum stocking rate. As indicated by his description of the grazing capacity of

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[2] A. E. Aldous, "Effect of Burning Kansas Bluestem Pastures," Kansas Agricultural Experiment Station, Technical Bulletin 38, p. 62.

a properly managed pasture, above, one would find need for the trial and error system in determining the capacity of a pasture which differed materially from those studied by Aldous.

From a review of the literature on this subject it appears that yield decreases resulting from over-grazing arise from a number of related causes; first, the most desirable species of vegetation are killed out and replaced by those which can tolerate closer grazing or which are not relished by the grazing animals, second, protective ground cover is eaten off which decreases the amount of moisture entering the soil, evaporation increases and erosion is accelerated, and third, with severe over-grazing the livestock fail to find enough forage above maintenance requirements to allow maximum gains in weight or milk production.

While little material has been assembled to indicate the economic effects of mismanagement on various kinds of pasture, much material has been gathered to show the physical effects. For example, experiments at Guthrie, Oklahoma, have shown that Bermuda grass and native grass when grown together lost 0.02 percent of the rainfall and no soil; Bermuda grass clipped lost 0.91 percent of the rainfall and 0.02 tons of soil per acre, while water losses from bare ground averaged 27.09 percent with an average annual soil loss of 21.86 tons per acre.[3] At the Fort Hays, Kansas, Branch Agricultural Experiment Station

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[3] Harley A. Daniel, Harry M. Elwell, and Maurice B. Cox, "Investigations in Erosion Control and Reclamation of Eroded Land at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma, 1930-40," United States Department of Agriculture, Technical Bulletin 837, p. 23.

moderately grazed buffalo grass pasture lost 1.2 percent of the rainfall and heavily grazed pastures 4.95 percent.[4] On moderately grazed plots vegetated with little bluestem the runoff was 0.52 percent compared with 3.1 percent on heavily grazed plots. Soil losses were 0.049 tons per acre on the heavily grazed buffalo and about one-tenth as much on the moderately grazed pasture. In this experiment erosion losses were about one-half as great on the bluestem as on the buffalo due to differences in soil. From the reports on these tests it appears that over-grazing is not the only factor responsible for the loss of soil and water from pasture lands. Slope, soil type, and kind of grass may be equally as important in determining how close the grass may be grazed without causing undue soil loss.

Stocking Rates and Management Practices Are Important

Since maintenance requirements for farm animals are rather constant for a given set of circumstances and gains can result only when the daily intake exceeds daily requirements it appears that greatest net production can be assured only by planning to keep that number of animals which can be provided with near maximum rations. Otherwise a large part of our feed supply might conceivably be dissipated in maintaining animals on rations inadequate to allow satisfactory gains.

Under-utilization of pastures is also undesirable for no gains are made from grass which is not used. With under-stocking animals are likely to spot graze, browsing around to secure only the choice portions of the grass, thus leaving much forage to interfere with grazing at a later date and create a fire hazard. As has been shown in a study

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[4] A. E. Aldous, "Management of Kansas Permanent Pastures," Kansas Agricultural Experiment Station Bulletin 272, p. 37.

of grazing practices in South Dakota, maximum gains per acre are not necessarily associated with maximum gains per steer.[5] These tests did show, however, that heavy grazing produced more beef per acre and per steer than was attained from light grazing though more forage was produced per acre on the lightly grazed pastures. This, they reported, indicated that the heavily grazed grass was more nutritious. "Heavy grazing" in these tests was not so heavy as to change the character of the native vegetation. Reports failed to indicate the effects of this "heavy grazing" on soil and water losses. That they were not referred to would suggest that soil and water losses were not materially greater with heavy than with light grazing. The purpose for which animals are being produced will necessarily influence the stocking rate. If slaughter cattle are desired, then livestock men will tend to control numbers so as to secure large gains per animal while in producing feeder cattle maximum gains per acre will be of increasing importance.

Many Circumstances Affect Desirable Rates and Practices

Under circumstances of emergency and especially when the practice of grain feeding of cattle from summer pastures may be curtailed there is a strong incentive for stockmen who produce chiefly from ranges and farm pastures to market as large a percentage of their animals in slaughter condition as possible. However, the demand for meat and milk cannot be met by animals produced on forage alone. Grain feeding cannot be discontinued if maximum utilization is made of our pasture

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[5] W. H. Black, V. J. Clark, and O. R. Matthews, "Effects of Different Methods of Grazing on Native Vegetation and Gains Per Steer in Northern Great Plains," United States Department of Agriculture, Technical Bulletin 547, p. 15.

resources.[6] Under such conditions the most desirable stocking rate will be a compromise as at other times, though the specific circumstances will undoubtedly alter the situation somewhat. Neither maximum production per acre nor per animal is to be desired necessarily, but rather the greatest contribution will be made if each acre of pasture produces as much food of as high a quality as possible. Such a statement is not intended to be as meaningless as it may appear. Areas growing grass which will put animals in a slaughter condition will continue to market slaughter cattle. Their goal will be to produce as many pounds of acceptable beef per acre as they can. Areas having pastures unsuited for producing beef in slaughter condition should also re-examine their stocking rate for their maximum output will be a compromise between quality and quantity. Their objective should be to produce as much per acre as they can consistent with the current demand situation.

While stocking rates and production policies have always been important to the individual producer and to society they are especially vital under conditions of pressure for maximum beef per acre. Here the economic principle of opportunity cost is involved. When cattle prices are high relative to the prices of feed grains and labor maximum gains per acre will be relatively more desirable than maximum gains per animal for feeding operations will be profitable and light weight feeder cattle will be in demand. Pastures and range lands will be carrying more cattle than when the beef-feed ratio discourages feeding. Hence, the question of whether maximum gains per acre or per steer are most desirable cannot be answered by determining the effects of heavy

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[6] "Wartime Agricultural Production Capacity in Oklahoma," 1943, Bureau of Agricultural Economics, United States Department of Agriculture, and Oklahoma Agricultural Experiment Station, Mimeographed, p. 17.

and moderate grazing on the character of the vegetation, on soil and water losses, and on the longtime production capacity of a pasture. There are external economic forces which must be fully considered if the stocking rate most satisfactory for a given situation is determined.

Re-examination of production possibilities would be profitable to individuals and to the public alike. In most cases farmers do not have the basic information necessary to make an adequate appraisal of either the productive capacity of pastures or of their monetary value. In areas where land is cheap and pastures are plentiful instances can be found of both hogs and workstock being maintained in dry lots from planting time in the spring until the crops have been gathered in the fall. These conditions exist, presumably, because some farmers are unaware of the relative costs and benefits to be derived from pastures.

Relative returns to land when in pasture and when in harvested crops are vigorously discussed in connection with proposals for retiring areas of crop land to pasture, but direct comparisons of the probable returns from the alternative uses of land are difficult when pasture yields are unknown.

A need exists for additional investigations of the value of pastures. It is not enough to determine the production of pastures in terms of total digestible nutrients per acre, the effects of various stocking rates and management practices on succession of grasses, or the effects of supplemental feeding of cattle on pastures. Oklahoma farmers need to know if they are stocking at a rate which will give them maximum economic returns. They know that neither over-grazing or under-grazing is as profitable as grazing at the correct rate.

However, in most cases, they have to resort to the trial and error method of determining the stocking rate which will be the most satisfactory under a given set of conditions.

Investigations which would indicate what restrictions a landlord might justly impose on a tenant in connection with pasture use and the rent which a tenant could afford to pay for various kinds of pasture would also be extremely valuable. Determining the carrying capacity of individual farm pastures by trial and error is a time-consuming and costly method. In many cases much of the grass has failed to survive this experiment. Certainly it is not a system adapted to rented land. Many tenants have reported that in order to secure a farm they were obliged to pay rent on a run-down pasture far beyond its value. The usual action of a tenant, who had paid as much for a depleted pasture as a good pasture would ordinarily command, would be to recover as much of his rent money as possible by securing maximum utilization of the pasture for the current season without any regard for the probable longtime effects of his current management system. This, it appears, would lead to further misuse of the grass and allow little chance for it to recover. It has likewise been reported by landlords that tenants showed but little respect for the welfare of existing grass. Perhaps both landlords and tenants could make good use of additional information on the yield and value of pastures under various conditions of management and stocking rate. It seems likely that owners who rent grass to others could make good use of additional information on the restrictions which they could reasonably impose on the use of pastures and the returns which they could expect from renting pastures in various conditions.

Various conservation practices have been found to increase pasture yields. In widely separated areas of the State mowing of native pastures was found to increase yields from 20 to 30 percent. Bermuda grass, sweet clover, and lespedeza pastures were generally found to produce two or three times as much grazing as did native, untreated pasture.[7] In a detailed study of the cost of establishing and improving pastures in Beckham County, it was found that such costs were relatively low when compared to the benefits attained.[8] Figure 1, "Distribution of Pastures in Oklahoma," indicates the rather uniform distribution of pastures over the State. This distribution is based on the Agricultural Census for 1935 and shows all pastures as they were reported for 1934. Pasture, other than plowable for 1934, which probably approximates native, permanent pasture is shown in Figure 2.

The Acreage of Oklahoma Pastures Is Increasing

Annual progress reports from Soil Conservation Districts in the State indicate that up to the first of 1943 23,429 acres of old pastures had been improved and 102,162 acres of new pastures established within the Districts. The same reports revealed that cooperating farmers had made plans for improving 36,626 additional acres of old pastures and for establishing 171,677 more acres of new pastures.[9] Naturally all improvement and establishment of pastures in Oklahoma

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[7] E. A. Tucker, "Conservation Increases Pasture Production," Current Farm Economics, Vol. 16, No. 4 (August, 1943), p. 134.

[8] E. A. Tucker, "Simple Conservation Practices are Weapons of War," Current Farm Economics, Vol. 15, No. 6 (December, 1942), p. 189.

[9] Annual Progress Reports for Soil Conservation Districts of Oklahoma, 1942.

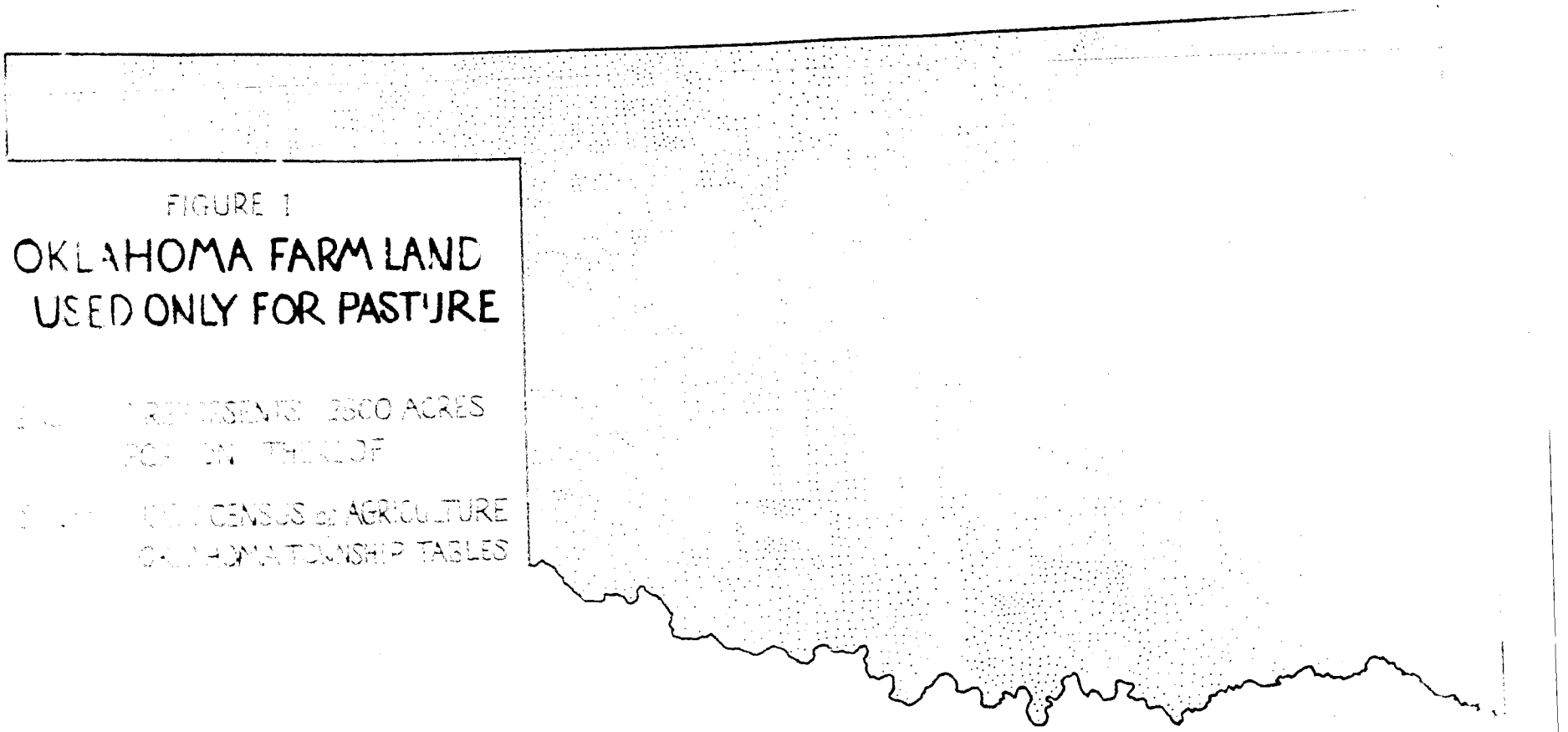

FIGURE 1

OKLAHOMA FARM LAND
USED ONLY FOR PASTURE

[illegible] REPRESENTS 2500 ACRES
[illegible] PORTION THEREOF

[illegible] U.S. CENSUS OF AGRICULTURE
[illegible] OKLAHOMA TOWNSHIP TABLES

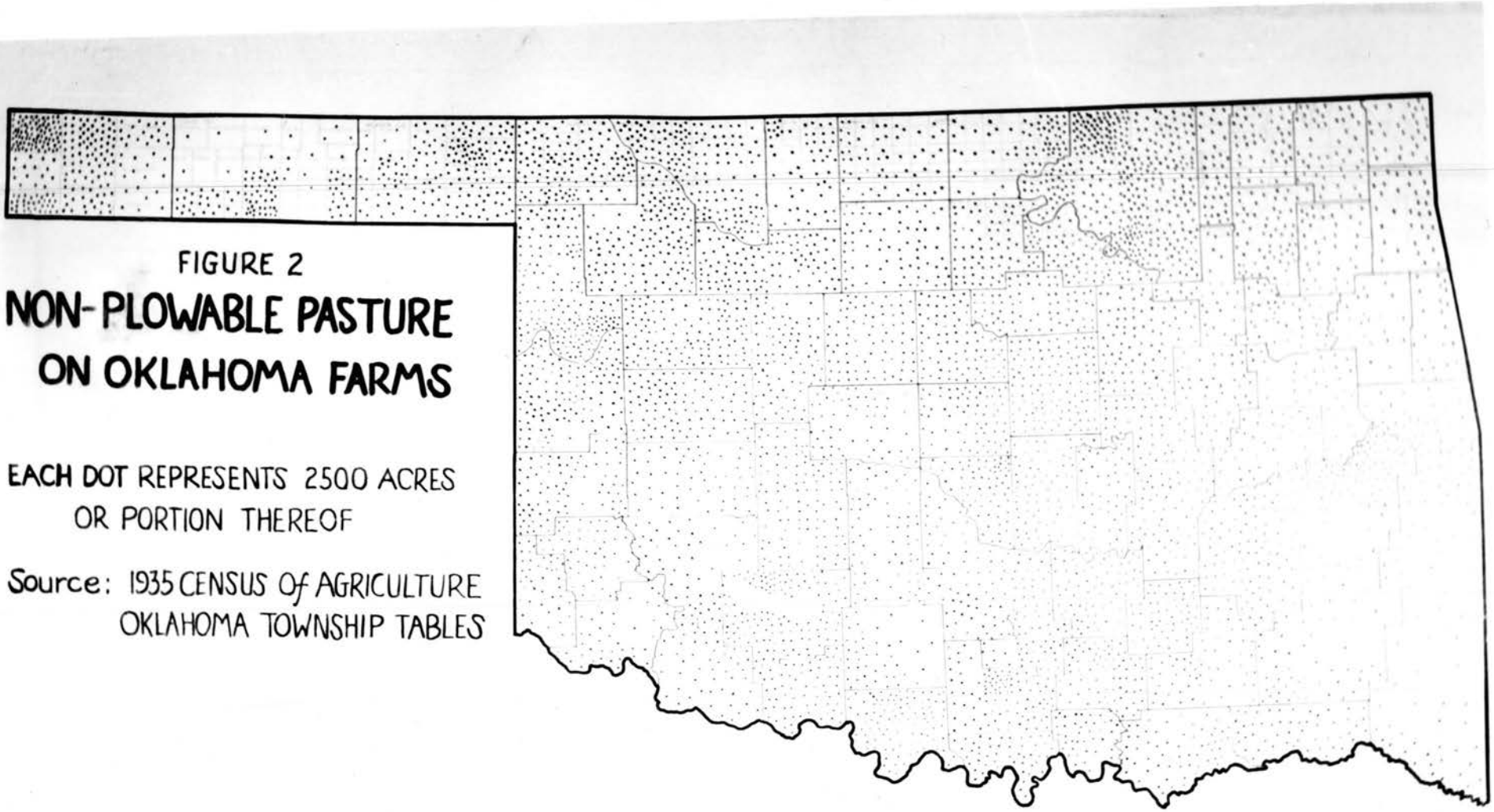

FIGURE 2

NON-PLOWABLE PASTURE ON OKLAHOMA FARMS

EACH DOT REPRESENTS 2500 ACRES OR PORTION THEREOF

Source: 1935 CENSUS *Of* AGRICULTURE OKLAHOMA TOWNSHIP TABLES

has not been done by Soil Conservation District cooperators, but in the absence of reports on the accomplishments of all farmers their reports are cited to indicate the trend toward greater emphasis on pastures. The distribution of this pasture improving and establishment work by the 14,634 Oklahoma farmers who were cooperating with Soil Conservation Districts on December 31, 1942 is shown in Table I.

Table I. Acres of Pasture Plantings to December 31, 1943, By 14,634 Farmers, In Soil Conservation Districts, By Type of Farming Areas of Oklahoma

Type of Farming Areas	Planned		Accomplished	
	Old Pastures	New Pastures	Old Pastures	New Pastures
1	—	739	—	127
2	2,622	4,056	800	684
3	32	2,959	—	1,336
4	217	719	2	136
5	2,974	3,267	212	424
6	—	13,291	—	4,280
7	2,103	11,806	115	1,894
8	31,779	57,057	14,936	29,505
9	11,572	15,168	3,884	5,402
10	3,071	6,479	—	346
11	1,980	15,680	1,377	5,820
12	719	18,823	524	7,763
13	—	6,376	—	2,469
14	1,326	70,463	1,326	23,424
15	1,092	15,428	172	5,016
16	568	31,528	81	13,536
Total	60,055	273,839	23,429	102,162

Under the 1940 Agricultural Conservation Programs Oklahoma farmers are reported to have established333,054 acres of new grass and legume by seeding, of which 115,059 acres were alfalfa. Deferred grazing was practiced on 938,377 acres of pasture and range land so as to allow reseeding while 134,809 additional acres were reseeded by artificial

methods.[10] Increasing the acreage of winter wheat in the State by two million acres should add materially to the total pasture resources.

The importance of pastures, including native, improved, and annual, in Oklahoma is attested by the acres devoted to this use. While a detailed picture of pasture resources is not available from the Agricultural Census it appears from the 1940 volume when used in connection with the 1935 report that there were 16,330,640 acres of Oklahoma farm land used only for pastures in 1939. Further study of these two most recent Census volumes indicates that land use in Oklahoma was distributed approximately as indicated in Table II.

These figures and tabulations which portray the distribution and relative importance of pastures in Oklahoma also show the current trend toward expanding the total pasture acreage by converting formerly cultivated areas to pasture crops. Further, they emphasize the need for added information on the economic grazing capacity of pastures under various stocking rates and with alternative management systems. The following pages call attention to the dearth of factual information required for making appraisals of the relative income producing ability of various grades of land when in grass and when used for cultivated crops.

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[10] Agricultural Statistics, 1942. United States Department of Agriculture, p. 753.

Table II. Approximate Distribution of Oklahoma Farm Land

	Years		
	1939	1934	1929
Pasture:			
Plowable pasture, permanent	2,600,000 1/	2,500,000 1/	3,000,000 1/
Plowable pasture, annual	1,230,147 1/	62,122 1/	248,518 1/
Woodland pasture	4,270,650 2/	4,270,650 2/	3,566,972 2/
Other pasture	8,729,843 3/	9,309,740 2/	7,824,022 2/
Total land used only for pasture	16,830,640	16,142,512	14,639,512
Total land used for harvested crops, failure, idle, and fallow	15,831,216	17,050,897	17,333,174
Woodland	576,105 2/	576,105 2/	492,521 2/
Other land in farms	1,565,356 2/	1,565,356 2/	1,325,610 2/
Total land in farms	34,803,317	35,334,870	33,790,817

SOURCE: Census of Agriculture for Oklahoma, 1940, Volume 1, Part 5, County Table 1, except when indicated otherwise.

1/ These are necessarily estimated figures since plowable pasture as given in the Census includes both permanent and annual pastures.

2/ Census of Agriculture for Oklahoma, 1935, Volume 1, Part 2, County Table I.

3/ Residual: The total of plowable pasture, cropland harvested, crop failure, and cropland idle or fallow as reported in the 1940 Census, plus woodland pasture and other land in farms as reported for 1934 in the 1935 Census was subtracted from all land in farms as reported in the 1940 Census to arrive at this figure.

CHAPTER II

PASTURE STUDIES SELDOM INDICATE ECONOMIC GRAZING PRACTICES

Physical Considerations The Basis of Most Work

No work of the type attempted in this manuscript has been reported in the literature available. While many pasture studies have been made covering a number of years, reports of their findings indicate that the chief interest of pasture investigators lies in some field foreign to economics. Of the large number of reports on pasture studies inspected only one or two publications were found which gave the data necessary for determining the relationship between grass consumption and beef production. In these studies no variations in stocking rates or utilization were reported. Points most frequently emphasized were; relative returns in pounds of beef from various grazing systems or stocking rates, yield determinations in terms of total digestible nutrients through production of beef or milk with the use of standards, developing or perfecting standards, or studies of grass behavior under various use intensities.

A review of the literature on pasture and grazing experiments indicates that much work has been undertaken, but trying to use these reports to determine economic grazing practices emphasizes the need for additional investigations which will bridge the existing gap between the physical and economic fields. For instance, it is not enough to know that one grazing system produced more gain per steer than another, or that beef production per acre varied by some particular amount under different circumstances. Neither maximum gains per acre or per steer are necessarily indicative of a good or bad grazing system. Before the merits of the alternative systems can be determined in an economic way

information on values of beef produced in the alternative systems must be known. Much work has been done to develop standards useful in measuring pasture yields and in anticipating the beef or milk production which would result from the feeding of a particular amount of grain or forage.

Examples of the standards developed from numerous feeding and grazing tests follow.

According to Savage's[1] standard maintenance of a 1,000 pound dairy cow requires approximately 7.92 pounds of total digestible nutrients daily plus an additional .35 pounds for each pound of milk produced containing four percent butterfat. Gullickson and Eckles[2] reported that daily total digestible nutrient requirements for maintaining a 500 pound heifer were 5.45 pounds. To produce one pound of gain on a 500 pound Holstein heifer, they indicated, an additional 1.04 pounds would be required while one pound of gain on a Jersey heifer, they report, requires slightly more or 1.55 pounds and for maintaining a 1,000 pound dairy animal, they continued, 7.95 pounds of total digestible nutrients would be required while a pound of gain in body weight would be secured from 1.98 pounds of digestible nutrients with the Holstein heifer and from 1.896 pounds with the Jersey. Brody[3]

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[1] E. S. Savage, "A Study of Feeding Standards for Milk Production," Cornell Agricultural Experiment Station, Bulletin 323, pp. 58-123.

[2] T. W. Gullickson and C. H. Eckles, "Nutrients Used for Maintenance By Growing Dairy Cattle," Journal of Agricultural Research, 42:593-601. 603-618

[3] Samuel Brody, Robert C. Proctor, and Ural S. Ashworth, "Growth and Development With Special References to Domestic Animals," Missouri Agricultural Experiment Station, Research Bulletin 220, p. 27.

indicated that total digestible nutrients required for maintaining a 500 pound calf would be 4.07 and for a 1,000 pound animal 6.75 pounds. Morrison[4] suggested that daily requirements of total digestible nutrients for growing and fattening cattle should be within the following ranges; at 100 pounds live weight 1.2 to 2 pounds, at 300 pounds 5.2 to 5.9, at 500 pounds 7.6 to 8.5, at 800 pounds 10.0 to 11.8 and for a 1,000 pound beef animal from 11.4 to 13.9 pounds. Moseley[5] concluded that 4.3 pounds of total digestible nutrients were required to produce one pound of beef on fattening animals while Knott and associates[6] assumed that to produce a pound of gain in live weight on growing animals or dairy cows required 3.53 pounds of total digestible nutrients or 10.36 times as much as to produce one pound of milk containing 4 percent butterfat. They suggested that a credit 3.53 pounds of digestible nutrients be made to the pasture for each pound of gain in weight of the cows and that the pasture be debited 2.73 pounds for each pound of weight lost.

A comparison of these standards suggests that the exact relationship between the consumption of feed and the production anticipated has not altogether been agreed upon. Variations in the size, age, and type of animals used in the different tests account, no doubt, for a part of this variation. When these standards are applied to a 1,000 pound animal it appears that daily maintenance would require from 6.75

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[4] F. B. Morrison, Feeds and Feeding, A Handbook for the Student and Stockmen, p. 1005.

[5] Moseley, Stewart, and Graves, "Dairy Work at The Huntley Field Station," Huntly, Montana, United States Department of Agriculture, Technical Bulletin 116, p. 3.

[6] J. C. Knott, R. E. Hodgson, and E. V. Ellington, "Methods of Measuring Pasture Yields with Dairy Cattle," Washington Agricultural Experiment Station, Bulletin 295, p. 8.

to 7.95 pounds of digestible nutrients. Additional nutrients would be required to produce gains in weight. The exact amount required per pound of gain on this 1,000 pound animal would apparently depend somewhat on the type of animal, and somewhat on which standard was used for Moseley[7] used 4.3 to fatten steers, Knott[8] used 3.53 with his dairy cows, and Gullickson and Eckles[9] contended that 1.896 pounds of total digestible nutrients would produce a weight gain of one pound on a Jersey or that with a Holstein 1.98 pounds would be required.

Cattlemen in Iowa, Illinois, and Missouri, according to Walters[10] who interviewed several hundred of them, average daily gains of 1.55 pounds in weight with yearling steers on summer pasture and just under 1.75 pounds with 2-year olds. Taylor[11] secured an average daily gain of 2.28 pounds on 2-year old steers on Bluestem pasture during the summer of 1943 with no supplement other than salt. The pounds of forage consumed to produce these gains has seldom been reported. From the work of Morrison[12] and others[13] on total digestible nutrients of various feeds it appears that total digestible nutrients in Oklahoma

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[7] Moseley. Loc. cit.

[8] Knott. Loc. cit.

[9] Gullickson. Loc. cit.

[10] H. J. Walters, "Beef Production on High Priced Land," Missouri Agricultural Experiment Station, Circular 24, p. 25.

[11] Bruce R. Taylor and Charles S. Hobbs, "Supplements for Fattening 2-Year Old Steers on Bluestem Grass," Oklahoma Agricultural Experiment Station, Mimeographed Circular M-102, p. 2.

[12] Morrison. Op. cit.

[13] Food and Life, United States Department of Agriculture, Yearbook, 1939, Table 2, p. 1073.

pasture grasses can be expected to amount to approximately 50 percent of the weight of the air-dry grasses. From the standards just enumerated on requirements for maintenance and for growth it should be possible to calculate daily needs for a particular animal under almost any set of circumstances, but due to the variations in these standards the results of such calculations could be expected to cover quite a wide range. To illustrate, a 1,000 pound steer gaining two pounds in weight per day would require somewhere between 10.54 and 16.55 pounds of total digestible nutrients, depending on which standards were used. This would be from 21 to 33 pounds of air-dry grass daily. Maintenance would require from 6.75 to 7.95 pounds of nutrients while weight gained might be expected to use from under four to 8.6 pounds of nutrients. Thus maintenance would require from 44 to 68 percent of the total intake. Black,[14] in reporting on his investigations wrote "For maintaining their weight, average 2-year old steers on pasture will require from about one-third to one-half of all the feed they consume." Thus a review of the literature reveals that pasture investigators have found daily requirements for steers on pasture to range from one-third to above two-thirds of their daily intake which appears to be quite a wide range in view of the numerous experiments which have been aimed at shedding light on this point.

The ratio between total intake utilization for maintenance and for gains in weight is important since maintenance requirements have a prior claim on total intake which must be met before gains in weight

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[14] W. H. Black, V. J. Clark, and O. R. Matthews, "Effects of Different Methods of Grazing on Native Vegetation and Gains Per Steer in Northern Great Plains," United States Department of Agriculture, Technical Bulletin 547, p. 15.

can be made. True, a dairy cow may produce at a rate in excess of that justified by her daily feed intake but this is for short periods only and results from her drawing on her body reserves. Actually her excess production results from feed fed during an earlier period.

The Economic Picture Is Seldom Complete

In the literature reporting on and discussing the many grazing experiments undertaken, one can find references to all of the material needed for determining the economic capacity of pastures, but seldom does an individual report contain more than a part of the essential information. The major faults to be found with pasture studies, as such, are that they stress a few of the important items and neglect others which are equally important from an economic viewpoint. For instance, it is not enough to know what the yields in pounds of beef per acre were under given stocking rates and management practices if the rates and practices did not produce maximum returns, and without some variations in rates and practices it is impossible to know that the system used did result in maximum production. Even though maximum production in a physical sense is attained by some particular grazing system it does not necessarily follow that this is the most desirable system economically for in determining economic desirability production must be measured in value, which is physical production times price and production costs must be taken into account.

It is rather remarkable that so much work has been done on the requirements for maintenance and for growth and so little done on the yield of nutrients per acre of land under varying circumstances. That variations continue to exist between standards proposed by different

investigators for nutrients required is, no doubt, sufficient reason for continuing this type of investigation, but should exact requirements be determined for the numerous types and sizes of animals produced it would still be necessary to determine stocking rates by trial and error for to date little emphasis has been placed on the yield of nutrients from pastures with different stocking rates and with various management practices. Complete knowledge of requirements could not lead to predetermining stocking rates if forage yields were unknown. With a reasonable amount of knowledge on the ratio between the intake of forage and resulting beef or milk production, predetermining desirable stocking rates would not be difficult for situations in which expected forage yields were also available. This suggests that additional investigations might well be undertaken to provide the additional information essential to determining in advance the probable yields of various kinds of pasture in terms of beef or milk.

CHAPTER III

THE DATA AND THE METHOD

The nature and extent of available background materials have been previously indicated. With the help of these basic investigations an attempt has been made to draw from a number of studies in Oklahoma the information necessary for developing a method of determining the economic production capacity of pastures in this State.

The Specific Data

The particular data used in this study include; (1) pasture utilization information secured in connection with farm business reports from farmers in Payne and Muskogee counties for the years 1939 and 1940, (2) supplemental data secured from farm account book keepers in Garfield County between 1932 and 1941, (3) pasture utilization reports from farmers in Beckham, Garvin, Murray, Tulsa, and Wagoner counties for 1941, (4) both published and unpublished data from both the Red Plains Conservation Experiment Station at Guthrie, Oklahoma, and the Animal Husbandry Department of the Oklahoma Agricultural Experiment Station at Stillwater, Oklahoma, (5) monthly rainfall data from Climatological Bulletins, Weather Bureau, United States Department of Commerce, (6) Pasture Condition reports and yield figures from both the office of K. D. Blood, Agricultural Statistician, United States Department of Agriculture, and (7) observations of both technicians of the Soil Conservation Service trained in the establishment and management of pastures and members of the Oklahoma Society of Farm Managers and Rural Appraisers whose profession keeps them in close touch with all phases of the farm business.

The Proposed Method

While no study identical to this one has been found, many investigations have been undertaken to measure pasture production, animal requirements, and the effects of various systems of grazing on pasture and beef production. As Schuster[1] pointed out, there are at least 13 methods of measurements used in determining the productivity of pastures. Methods he enumerated were; "profit, hay weight, clippings, cattle weights, sheep weights, photographs, surveys, carrying capacity, milk flow, plant population, chemical analysis, palatibility and duration of grasses." The literature contains numerous accounts of the results attained by the use of these measuring devices.

Assumptions on which this study is based include: (1) That in general there is a rather stable relationship between yields of wild hay, native pasture, and other pasture within a given area, (2) That rainfall is the one variable responsible for a large part of the year-to-year variation in yields of hay and pasture within a given area, and (3) That the work done on the requirements of livestock for maintenance and for production in terms of total digestible nutrients as well as the total digestible nutrients of various forage crops would be applicable for this study.

Hay yields and monthly precipitation data are generally available. The data in Table III gives a basis for the first and second assumptions referred to above. Their relationships are portrayed graphically in Figure 3. The digestible nutrient yields of various

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[1] G. L. Schuster, "Methods of Research in Pasture Investigation," Journal of the American Society of Agronomy, 21:666-673.

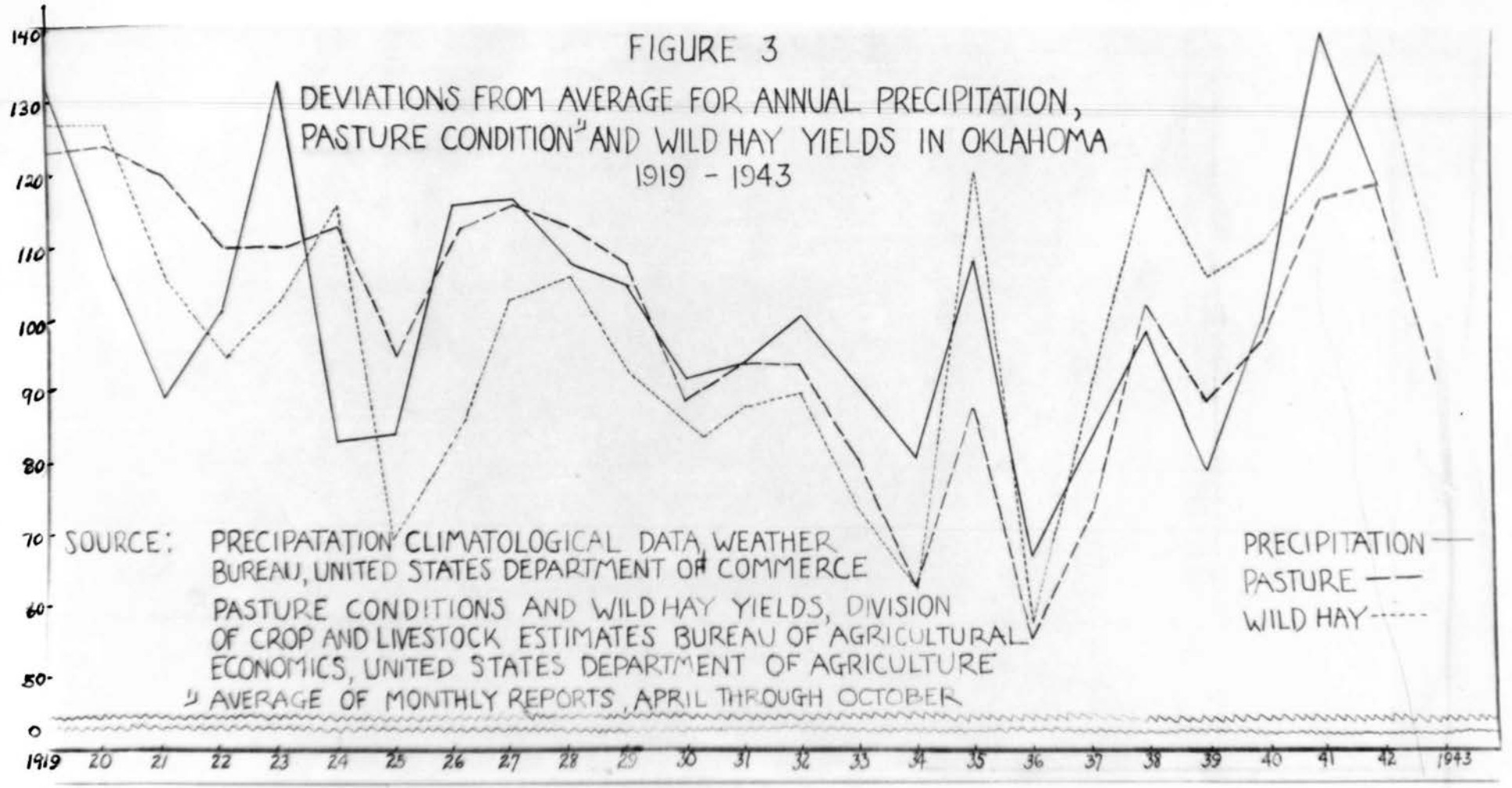
FIGURE 3
DEVIATIONS FROM AVERAGE FOR ANNUAL PRECIPITATION, PASTURE CONDITION 1/ AND WILD HAY YIELDS IN OKLAHOMA
1919 - 1943
140
130
120
110
100
90
80
70
60
50
0
1919 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 1943
SOURCE: PRECIPATATION CLIMATOLOGICAL DATA, WEATHER BUREAU, UNITED STATES DEPARTMENT OF COMMERCE
PASTURE CONDITIONS AND WILD HAY YIELDS, DIVISION OF CROP AND LIVESTOCK ESTIMATES BUREAU OF AGRICULTURAL ECONOMICS, UNITED STATES DEPARTMENT OF AGRICULTURE
1/ AVERAGE OF MONTHLY REPORTS, APRIL THROUGH OCTOBER
PRECIPITATION
PASTURE
WILD HAY

plants is generally agreed upon and much work has been done on the relationships between animal requirements for maintenance and for growth. Probably the most ellusive factor is the relative yield of wild hay and various kinds of pasture. Reports from trained observers have been relied upon to supply this. While generalizations of this type might conceivably lead to grave errors in individual cases this does not appear to be necessary as each individual case may be considered on its own merit. To illustrate, native pastures in a particular area may, in general, yield about 60 percent as much forage as do meadows which have a normal yield of one ton, but carrying capacity of an individual pasture which appeared to be 90 percent as productive as meadow would be assumed to be not at the level of all pastures, but 50 percent above the area average or at 90 percent of meadows.

Farmers' reports of pasture utilization cannot be used as indicators of carrying capacity for no check on the percentage of forage actually utilized was made. Their reports have not indicated if pastures were under-grazed, over-grazed, or properly utilized. The ratio of pasture to grazing animals and the supply of supplemental feed does, in many cases, determine the intensity of pasture use. Farmers' reports should, however, offer a satisfactory measure of the relative yields of different kinds of pasture.

The experimental data of Taylor,[2] Daniel,[3] and Elwell[4] both published and unpublished have been relied upon to indicate the relationship between the yields of hay and of beef. It is true that in some communities so little wild hay is harvested that farmers may not be familiar with yields. In such cases it may be necessary to use another hay crop for a basis for estimating pasture production. Figure 4 indicates the distribution of wild hay harvested as reported in the 1940 Agricultural Census of Oklahoma for the year 1939.

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[2] Bruce R. Taylor, W. L. Blizzard, and Charles S. Hobbs, "Feeding and Grazing Tests with Beef Cattle 17th Annual Feeders' Day Report," April, 1943, Oklahoma Agricultural Experiment Station, Mimeographed.

[3] Harley A. Daniel, Harry M. Elwell, and Maurice B. Cox, "Summary of Research Findings at the Red Plains Conservation Experiment Station," Oklahoma Agricultural Experiment Station, Mimeographed Circular M-99.

[4] Harry M. Elwell, "Progress Report of Land Reclamation and Pasture Investigations on Abandoned and Scrubby Oak Areas of Central Oklahoma," Oklahoma Agricultural Experiment Station, Mimeographed Circular M-86.

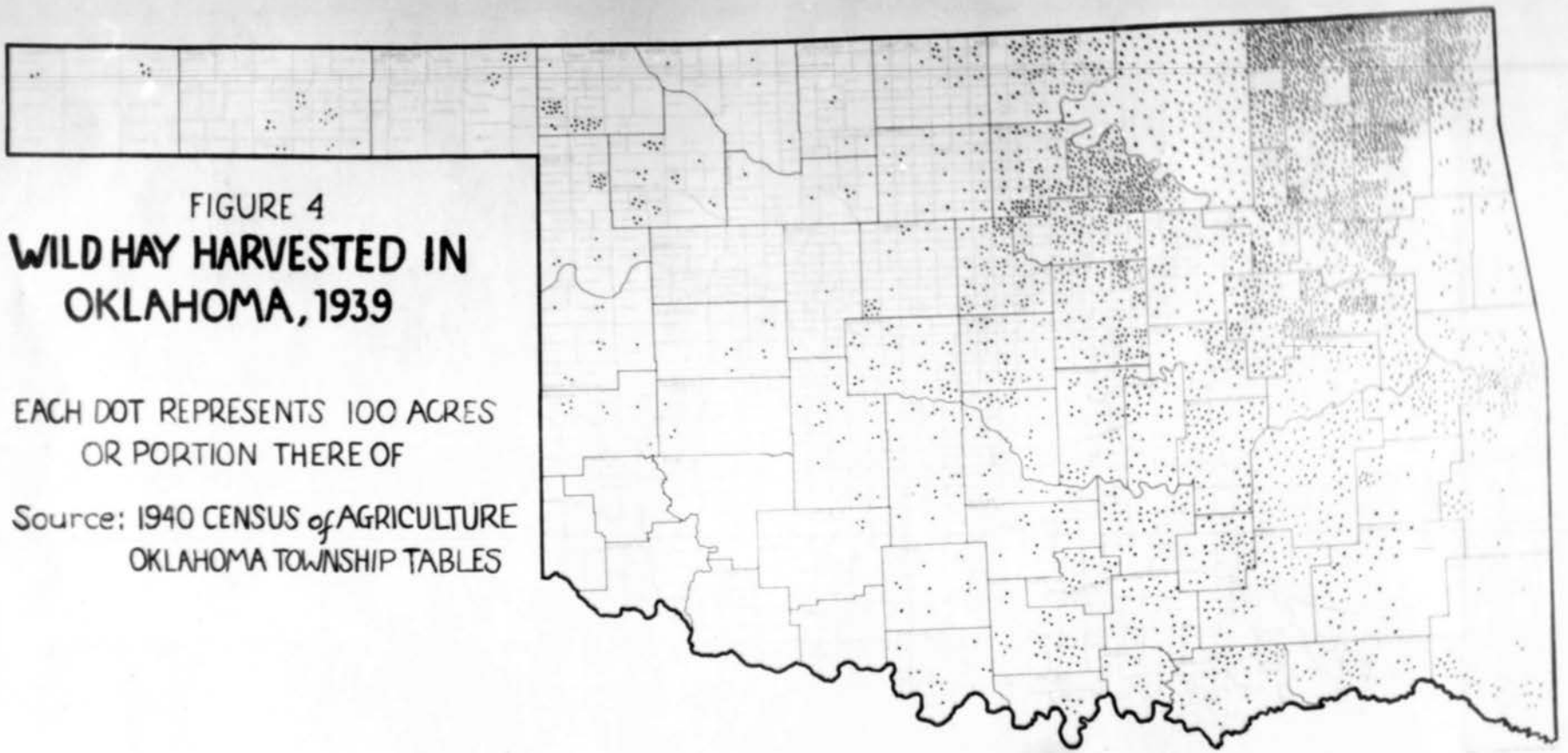


FIGURE 4

WILD HAY HARVESTED IN OKLAHOMA, 1939

EACH DOT REPRESENTS 100 ACRES OR PORTION THERE OF

Source: 1940 CENSUS of AGRICULTURE OKLAHOMA TOWNSHIP TABLES

CHAPTER IV

PASTURE YIELDS IN OKLAHOMA

Yields Vary From Year To Year

Yields of most crops in Oklahoma fluctuate rather widely from year to year, see Table III. This is not surprising in view of the variation in annual precipitation also shown in this table. It is to be expected that yields of perennial grasses and self-seeded annual pasture crops would be much more stable than would yields of crops which are seeded annually for they are not affected by many of the forces which influence the yields of most crops. For instance, the method of seed bed preparation, seeding date, variety of seed used, and frequency of cultivation are variabilities which do not affect native grasses. Then, too, they escape damage from most of the diseases and insects which may reduce yields of other crops. Thus moisture and temperature variations appear to be responsible for a much greater proportion of the total variation in yields of native vegetation than is the case with other crops. Naturally mean annual precipitation and mean annual temperature do not indicate the adequacy or inadequacy of these factors for yearly means may cover up periods when both available moisture and daily temperatures are so unusual as to cause crop damage. When temperature deviates noticeably from normal during the growing season crop yields are likely to be affected.

Annual mean precipitation and temperatures, average pasture conditions in percentages of normal as reported at the first of each month from April through October, and average yields of wild hay, wheat, oats, corn, barley, sorghums for grain, and cotton are shown in Table III for Oklahoma for the 25-year period, 1919-1943. The coefficient of

Table III. Average Annual Precipitation, Temperature, Pasture Condition, and Crop Yields in Oklahoma, 1919-1943

Year	Precipitation (Inches)	Temperature °F	Pasture Condition Percent of Normal 1/	Wild Hay Tons	Wheat (Bu.)	Corn (Bu.)	Oats (Bu.)	Barley (Bu.)	Sorghum Grain (Bu.)	Cotton Pounds Lint
1943			66	1.00	9.5	11.0	18.0	9.5	8.0	118
1942	39.96	60.2	85	1.30	16.5	18.5	19.0	17.0	12.9	190
1941	47.02	61.0	84	1.15	9.7	17.5	18.5	18.0	11.5	208
1940	33.78	59.4	70	1.05	14.5	21.5	23.0	17.0	11.0	211
1939	26.71	62.7	64	1.00	14.0	14.5	17.0	16.0	8.0	141
1938	33.21	62.8	73	1.15	11.0	20.0	21.0	16.3	10.5	163
1937	28.21	60.2	52	.85	14.2	18.0	20.5	17.5	10.0	156
1936	22.69	61.8	40	.55	8.0	7.0	16.0	10.0	5.0	62
1935	36.71	60.8	63	1.15	10.0	14.0	25.0	16.5	8.0	117
1934	27.46	63.0	45	.60	10.5	5.5	15.5	11.5	6.0	56
1933	30.56	63.0	58	.70	10.2	7.5	18.5	9.0	8.5	208
1932	33.99	60.6	67	.85	12.0	20.0	18.0	12.5	9.5	167
1931	31.59	62.1	67	.83	17.0	15.6	28.5	21.0	10.0	178
1930	30.70	61.0	64	.80	9.5	11.2	24.5	12.5	6.0	102
1929	35.39	59.4	77	.88	11.2	15.0	21.0	16.0	11.0	128
1928	36.48	60.8	81	1.00	13.5	23.0	22.0	16.5	12.0	136
1927	39.55	61.4	83	.98	9.0	26.5	16.5	11.0	12.5	138
1926	39.04	60.1	81	.80	17.5	26.0	22.0	20.0	12.5	181
1925	28.31	61.7	68	.66	8.2	7.5	23.0	14.0	12.5	155
1924	27.86	59.2	81	1.10	16.0	19.0	25.0	23.0	18.0	187
1923	44.98	60.9	79	.98	11.0	11.5	20.0	22.0	12.0	98
1922	33.89	61.6	79	.90	9.5	18.0	20.0	17.0	13.5	103
1921	30.02	62.9	86	1.00	12.5	25.0	20.0	22.0	21.0	104
1920	36.35	59.6	89	1.20	16.0	28.0	33.0	24.0	26.0	230
1919	34.41	59.4	88	1.20	14.0	24.0	32.0	30.0	23.0	195
Average	33.70	61.1	72	.95	12.2	17.0	21.5	16.8	12.0	149.0
Coefficient of Variation	16.8	2.0	18.1	20.2	23.3	37.6	20.8	38.4	42.2	30.8

SOURCE: Precipitation and temperatures; "Annual Reports," Weather Bureau, United States Department of Commerce, Data for 1943 not available.

Yields; Agricultural Statistics, 1942, United States Department of Agriculture, except for 1942 and 1943, which are from Oklahoma Crop Report, Division of Crop and Livestock Estimates, Bureau of Agricultural Economics, United States Department of Agriculture. The 1943 data are as indicated September 1.

1/ Average of reports for first of each month, April through October.

variation, last line of figures in this table, indicates that, of all items listed, mean annual temperature is the most stable. Next in order of stability are precipitation, pasture, wild hay, oats, and wheat. Deviation from normal for these four crops during the past 25 years has been only slightly greater than the deviations from rainfall. The crops indicated as having much more erratic yield tendencies are corn, barley, cotton, and sorghums for grain.

Deviations from normal, Table IV, were computed by dividing each of these annual figures by the long time average. With such an arrangement simple inspection of the data is sufficient to determine both the frequency and the extent of deviations to be expected from each crop. The last line of this table shows average deviations, which is another check on the frequency and extent of deviations from normal. Average deviations from normal were lowest for pastures and for meadows while corn and grain sorghums showed the greatest average deviations.

Annual production of meadow land is probably even less erratic than these yield figures indicate for in years of high yields it appears that hay-makers tend to cut fewer acres than in years when yields are low. A plausible explanation for this is that since feed requirements are more constant than are feed yields farmers attempt during poor years to make up for the deficit in the production of all feed crops by harvesting greater than normal acreages of wild hay. Conceivably, they might cut all available hay when yields are very low and only the best when production is above normal which would have the effects of magnifying all variations. Actually during the past 25 years wild hay yields for the State have averaged less than one ton 13

Table VI. Relationship Between Rainfall, Forage Production, Utilization, and Beef Production from Summer Grazing of Yearling Steers on Cleared Woodland and Abandoned Cropland Now Supporting Native Grasses at the Conservation Experiment Station, Guthrie, Oklahoma

Size of Pasture and Former Land Use	Rainfall March-August	Acres	Pounds of Air-Dry Forage Per Acre: Produced	Residue	Utilized	Percent Utilized	Acres Per Steer	Animal Grazing Days Per Steer	Pounds of Beef Produced: Per Acre	Per Steer	Pounds of Grass Utilized: Per Animal Grazing Day	Per Pound of Beef Produced	Pounds of Forage Available Per Steer
The 110-acre pasture													
1940													
Cleared woodland		35	2,679	881	1,798	67	1.75						4,688
Abandon cropland		75	1,255	945	310	25	3.75						4,706
Total	18.30	110	1,708	925	783	46	5.50	27.8	50	276	28.17	15.60	9,394
1941													
Cleared woodland		35	2,633	1,225	1,408	53	2.06						5,421
Abandon cropland		75	1,226	903	323	26	4.41						5,409
Total	17.84	110	1,674	1,005	669	40	6.47	23.5	35	226	28.47	19.15	10,830
1942													
Cleared woodland		35	3,225	1,608	1,617	50	1.75						5,644
Abandon cropland		75	1,708	1,259	449	26	3.75						6,405
Total	22.20	110	2,191	1,370	821	37	5.50	28.0	38	209	29.32	21.61	12,049
The 34-acre pasture:													
1941													
Cleared woodland		5.3	2,217	1,011	1,206	54	1.06						2,350
Abandon cropland		29.0	1,161	587	583	50	5.80						6,731
Total	17.84	34.3	1,324	645	679	51	6.86	22.2	40	272	30.64	17.21	9,081
1942													
Cleared woodland		5.3	3,510	1,979	1,531	47	1.06						3,721
Abandon cropland		29.0	2,066	1,439	627	30	5.80						11,984
Total	22.20	34.3	2,289	1,522	767	34	6.86	22.4	34	234	34.17	23.88	15,705

SOURCE: Arranged from data secured from Daniel and Elwell.

Table IV. Deviations From Average for Precipitation, Temperature, Pasture Conditions and Crop Yields in Oklahoma, 1919-1943

Year	Precipitation	Temperature	Pasture Condition	Wild Hay	Wheat	Corn	Oats	Barley	Sorghum for Grain	Cotton Lint
1943			92	106	78	65	84	57	67	79
1942	119	99	119	137	135	109	88	101	108	127
1941	140	100	117	121	80	103	86	107	96	139
1940	100	97	98	111	119	126	107	101	92	141
1939	79	103	89	106	115	85	79	95	67	94
1938	99	103	102	121	90	118	98	97	88	109
1937	84	99	73	90	116	106	95	104	84	105
1936	67	101	56	58	66	41	74	60	42	42
1935	109	100	88	121	82	82	116	98	67	78
1934	81	103	63	63	86	32	72	68	50	38
1933	91	103	81	74	84	44	86	54	71	139
1932	101	99	94	90	98	118	84	74	79	112
1931	94	102	94	88	139	92	133	125	84	119
1930	92	100	89	84	78	66	114	74	50	68
1929	105	97	108	93	92	88	98	95	92	86
1928	108	100	113	106	111	135	102	98	100	91
1927	117	101	116	103	74	156	77	66	105	92
1926	116	98	113	84	143	153	102	119	105	121
1925	84	101	95	70	67	44	107	83	105	104
1924	83	97	113	116	131	112	116	137	151	125
1923	133	100	110	103	90	68	93	131	100	66
1922	101	101	110	95	78	106	93	101	113	69
1921	89	103	120	106	102	147	93	131	176	70
1920	108	98	124	127	131	165	153	143	217	154
1919	102	97	123	127	115	141	149	179	192	131
Average Deviation	13.2	1.7	15.0	16.9	20.6	31.5	16.0	22.4	29.7	26.1

SOURCE: Table III.

times and a ton or more in 12 years. When yields were under one ton, they cut an average of 490,615 acres, but when yields were a ton or more they averaged 487,902 acres per year. During all of the past six years hay yields have been one ton or more. The average acreage cut during 1938, 1941, and 1942 when yields were 1.15, 1.15, and 1.30 tons was 439,000 acres while in 1939, 1940, and 1943 with yields of 1.00, 1.05, and 1.00 tons an average of 443,000 acres of wild hay were harvested. It is granted that this variation in acres of hay harvested is relatively slight, but since it appears to have a constant relationship to yields it may be worth mentioning.

This matter of yield stability is dwelt upon at length because year-to-year variations in yields are important in making comparisons of the relative desirability of two or more crops. There are circumstances when stable yields with a relatively low average may be more desirable than yields having a much higher average with wide annual fluctuations for prices tend to be higher during poor crop years. This is especially true with bulky crops as they can seldom be moved from areas of plenty to distant areas where such crops are scarce. This matter of year-to-year fluctuation appears to be doubly important when considering livestock feeds which are to be fed on the farm where grown such as hay and pasture for failure will not only mean that there will be no crop to market as is the case with growers of cash crops, but in addition failure to produce the necessary feed will often make necessary the purchasing of high priced feeds or the liquidation of livestock on depressed markets. Insurance in the form of feed reserves does, of course, take some of the risk out of this type of farming, but silage and hay reserves can seldom be used in place of pasture.

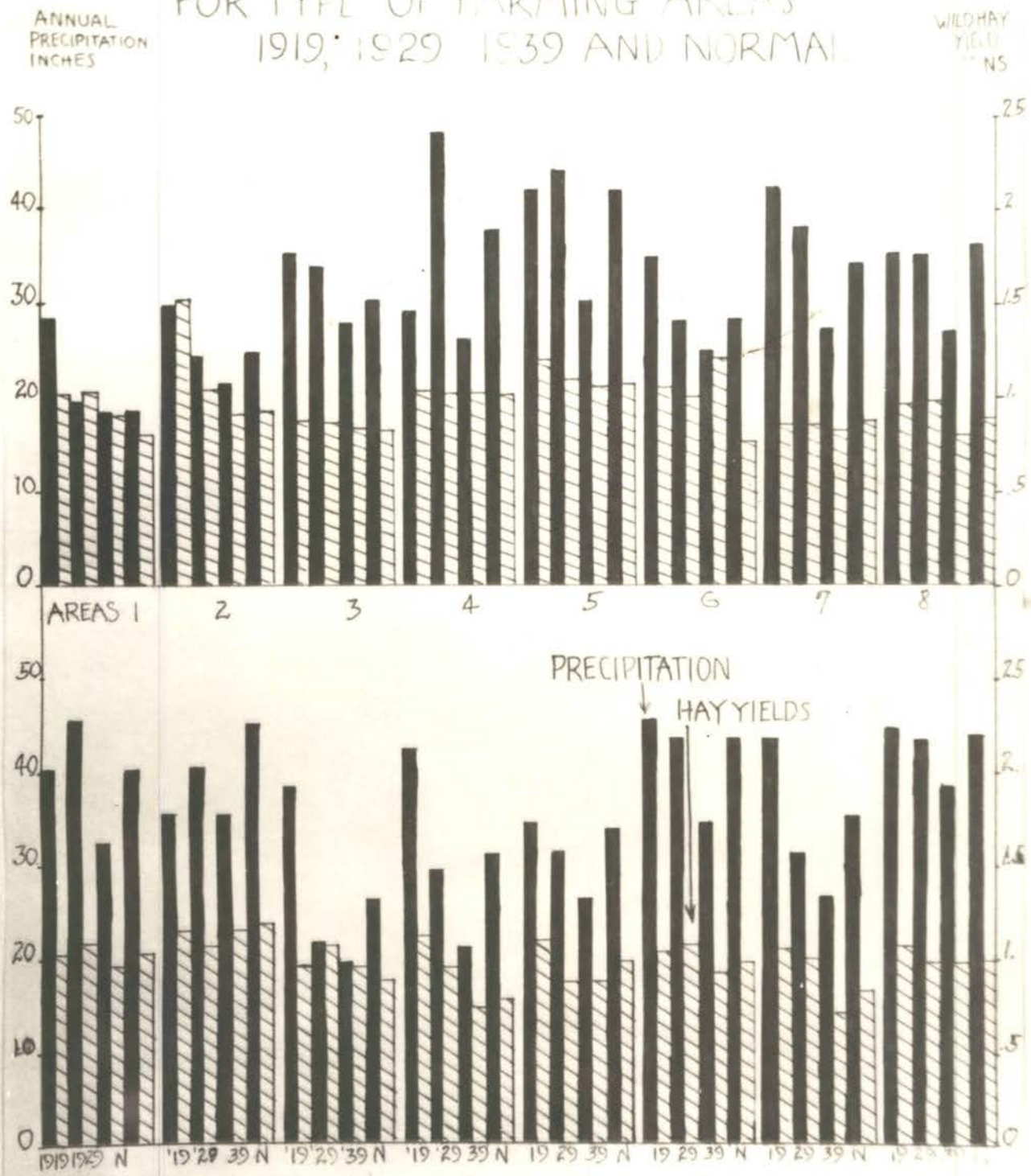
The data indicate that those who grow pasture, wild hay, wheat, and oats will enjoy whatever advantages there are in growing crops with minimum yield variations from year to year. These crops are shown to be almost as stable as rainfall when viewed for the State as a whole. Hay yields for type of farming areas appear to be even more dependable than precipitation, see Figure 5. The bars, which represent both moisture and hay yield for Census years and for the longtime period, suggest that wild hay can be counted on to yield about one ton per acre and that for this production moisture in excess of 20 to 25 inches is unnecessary. This would explain why it is difficult, if not impossible, to relate precipitation received in any selected group of months with hay yields. It would also lend much support to the contention that hay and pasture crops are among the most reliable producers grown in the State.

That data on monthly precipitation are inadequate for explaining yields of wild hay is suggested in Table V. On the surface it might appear possible to add together the precipitation received in different series of months to determine during which months precipitation had a marked influence on wild hay yields and months when moisture was not important. Such a study would be extremely valuable if definite results could be obtained for this could possibly lead to forecasting when pastures would be adequate and when they would be short. This would allow the stockman some advance notice which would aid in determining current grazing practices. The table suggests, however, that monthly data are not satisfactory for such a study and show that normal rainfall is not necessary for normal yields of wild hay.

The data for Area 2 suggest that a close relationship between

FIGURE 5

ANNUAL PRECIPITATION AND WILD HAY YIELDS FOR TYPE OF FARMING AREAS 1919, 1929 1939 AND NORMAL



SOURCE: PRECIPITATION, CLIMATOLOGICAL DATA, WEATHER BUREAU, UNITED STATES DEPARTMENT OF COMMERCE
HAY YIELDS, DIVISION OF CROP AND LIVESTOCK ESTIMATES, BUREAU OF AGRICULTURAL ECONOMICS, UNITED STATES DEPARTMENT OF AGRICULTURE.

Table V. Wild Hay Yields and Monthly Precipitation 1/ In Selected Type of Farming Areas for Census Years

	Year	Wild Hay Yields	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Area 2:	1918-19	1.54	1.54	4.65	1.37	3.89	.07	1.71	1.89	4.02	4.61	3.33	1.08	1.92	30.02
	1928-29	1.05	1.05	3.38	4.53	1.42	1.15	.85	2.11	.82	3.83	1.38	2.89	1.57	24.98
	1938-39	.92	1.33	.26	.84	.42	2.64	.89	1.59	3.78	1.41	5.08	2.15	1.51	21.90
	Normal	.94 2/	2.78	1.98	1.59	.86	.83	.77	1.57	2.41	3.49	3.37	2.70	2.73	25.08
Area 4:	1918-19	1.05	3/	4.19	4.24	2.80	.25	1.81	1.15	5.38	4.79	3/	.60	4.27	29.53 4/
	1928-29	1.04	.36	3.61	3.41	3.50	1.92	2.32	3.60	7.26	7.86	9.66	4.87	.27	48.64
	1938-39	1.04	.93	.52	3.41	.06	1.44	1.16	3.14	.57	4.82	6.05	.32	3.81	26.23
	Normal	1.04	3.87	3.25	2.14	1.52	1.81	1.63	2.62	3.94	5.13	5.21	3.81	3.50	38.13

SOURCE: Yields; arranged from data secured from the Census of Agriculture for Oklahoma, 1920, 1930, and 1940, and the Division of Crop and Livestock Estimates, Bureau of Agricultural Economics, United States Department of Agriculture.

Precipitation; Climatological Data, Weather Bureau, United States Department of Commerce.

1/ Simple average of all stations reporting within each area.

2/ Average of 1937-1941 for the area adjusted by the 1919-1943 average for the State, as data by type of farming areas are not available for this longer period.

3/ Data not reported.

4/ Total of those months reported.

total precipitation and hay yields might be expected. However, in Area 4 yields were quite constant while annual moisture varied from 26 to 48 inches.

For Area 2 there is a positive relationship between the moisture received from September through May and yields; 23.69, 19.14, and 13.14 inches coupled with yields of 1.54, 1.05, and .92 tons. Yields in Area 4 were practically identical while the September-May precipitation ranged from 16.05 to 33.84 inches.

The precipitation of a particular group of months may appear to be associated with yields in one area and not on others. Details on precipitation and yields for all type of farming areas are shown in Appendix A. Areas 3, 4, and 7 had yields almost identical for the three years yet total moisture ranged from 68 to 127 percent of normal. These data also suggest that normal rainfall in most areas is considerably above that required to produce a normal crop of hay and that monthly data are inadequate to indicate either the adequacy or inadequacy of the available moisture. Obviously, a particular month with normal total rainfall may be too wet or too dry for a period long enough to adversely affect yields. Likewise, when moisture distribution is desirable, satisfactory crop production may be the result when both monthly and annual precipitation are noticeably below normal.

Relationship Between Beef Production and Wild Hay Yields

Grazing experiments designed to determine the yield of beef obtainable from pastures established on abandoned cropland and land cleared of scrub oak timber are being conducted at the Red Plains

Conservation Experiment Station by Daniel[1] and Elwell[2]. In 1939 tests were started on a 110-acre pasture consisting of 75 acres of abandoned cropland and 35 acres of cleared woodland. In this pasture revegetation was accomplished by seeding about 10 acres of gullied land to native grasses and allowing the existing native grasses to continue spreading on the balance of the area. Clippings of grazed and ungrazed areas have been made annually to determine the amount of grass utilized. Initial and final weights on the yearling steers grazed have provided beef production figures. Similar tests on a small pasture made up of 5.3 acres of cleared woodland and 29.0 acres of abandoned cropland were started in 1941. Practically all of this area was seeded to native grasses in the spring of 1939. Both pure stands and mixed seedings of Buffalo, Blue Grama and Little Bluestem grass were established.

In addition to providing the information for which the experiments were designed these trials have also provided information on: (1) Daily forage requirements for steers, and (2) An indication of the possible range in the beef-grass ratio with different degrees of forage utilization. Details of this particular phase of their results are summarized in Table VI.

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[1] Harley A. Daniel, Harry M. Elwell, and Maurice B. Cox, "Summary of Research Findings at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma," Oklahoma Agricultural Experiment Station, Mimeographed Circular M-99, pp. 7-9.

[2] Harry M. Elwell, "Progress Report on Land Reclamation and Pasture Investigations on Abandoned and Scrubby Oak Areas in Central Oklahoma," Oklahoma Agricultural Experiment Station, Mimeographed Circular M-86, pp. 1-8.

From this study it appears that daily forage requirements for yearling steers making satisfactory gains from native pastures during the summer season may range from 30 to 35 pounds of air-dry forage equivalents. The percent of utilization appears to be an important factor in determining daily requirements per steer as well as influencing the beef-grass ratio. With higher utilization gains per steer and per acre were increased. Apparently these relationships held when ratios of grass to steers were altered either by climatic conditions which stimulated growth of the grass or when the ratio was changed due to variations in the stocking rate. Note "percent of utilization" and "pounds of grass per pound of beef produced" for the three years for which figures are available on the 110-acre pasture, Table VI. As the percent utilized declined, gains per steer and per acre also went down. Data on the 110-acre pasture shows that when the average steer had access to 9,394 pounds of grass in 1940 he ate 46 percent of it and produced maximum gains both per acre and per steer. The next year 40 percent of the 10,829 pounds of grass available per steer was utilized to produce 35 pounds of beef per acre and 226 pounds per steer. With 12,049 pounds of grass per steer in 1942, 37 percent was utilized to produce 38 pounds of beef per acre which was slightly above the 1941 yield of beef per acre but gains per steer dropped to 209 pounds, lowest for either pasture to date. Figures in the column headed "Pounds of Grass Utilized" indicate that closer grazing as shown by "Percent Utilized" produces more nutritious grass if the two pastures are considered separately. As percentage utilized decreased it took more and more grass to produce a pound of beef. How far utilization could be

increased without adversely affecting the yield of beef per acre or per steer cannot be determined from this study.

Results obtained on the 34-acre pasture also indicate that greater utilization results in increased beef production per acre and per steer and per pound of grass used. Note that with 50 percent of the grass used in 1941 the beef yield was 40 pounds per acre compared with 34 pounds in 1942 when 34 percent of the grass was used. A comparison of the two pastures for 1941 reveals the same tendency--utilizing a greater percentage of the available grass meant increasing the production of beef--both per acre and per steer. It appears significant that in 1942 the beef-grass ratio for both pastures was materially higher than for previous years--utilization was lower in 1942 than for previous years. Stockmen have been heard to remark that the grass "lacked strength" when referring to a situation in which luxurious grass was produced by abundant rainfall but the cattle appeared to be making unsatisfactory gains. No doubt they would have commented that in 1942 the grass "lacked the strength" it had during the previous year and that this would satisfactorially account for the higher beef-grass ratio in 1942, but from the data it appears also that grass in the 34-acre pasture "lacked the strength" of the grass in the 110-acre pasture during 1942. Further TableVI shows that utilization was slightly higher in the larger pasture. Perhaps heavier grazing can be counted on to "give strength to the grass." The work of Sarvis[3] appears to be in agreement with this thought. During a 25-year study in

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[3] J. T. Sarvis, "Grazing Investigations on The Northern Great Plains," North Dakota Agricultural Experiment Station, Bulletin 309, p. 43.

North Dakota he reported that the average removal from a 70-acre pasture was 77 percent. Since the pasture normally carried the cattle with practically maximum gains it was concluded that 20 to 25 percent of the forage should remain standing at the end of a grazing season in order to prevent over-grazing. In discussing degrees of intensity of grazing Sarvis wrote:

> Lightly grazed pastures are those wherein the vegetation has remained in more or less of a normal condition throughout the course of the experiment. Normally grazed areas are those that have furnished plenty of feed to allow cattle to put on maximum gains under normal conditions, without injury to the vegetation. Severely grazed pastures are those that are grazed so heavily that they cannot provide enough feed for the cattle to put on normal gains, yet the vegetation is able to return to near a normal condition with rest periods. By overgrazing is meant that areas have been grazed with too many cattle on too few acres so that some of the desirable species have been driven out. [4]

The experiences of Black[5] in South Dakota are particularly interesting as he was working with a similar problem. In reporting on the relative production of an 80-acre and a 150-acre pasture he wrote:

> It is particularly significant that, from 1919 to 1930, the pastures which were the more intensively grazed--the 80 acres with an average of 11 head and the first 80-acre section of the 160--acre alternatively grazed pasture with an average of 20 head--produced almost two and three times, respectively, as much gain per acre from May 21 to July 31, as well as greater gains per acre for the season, than the pasture which was less intensively grazed, averaging 11 head to 150 acres.
>
> The greater gains per acre along with carrying capacity indicate that the forage consumed on the more intensively grazed pasture must have had considerably more feeding value, inasmuch as the feed on the least intensively grazed pasture, the 150-acre pasture, was practically all consumed by the end of the grazing season.
>
> Even though the more mature forage should yield more digestible nutrients on account of its much higher grass yield, the less mature forage may produce more pounds of gain in weight because less energy is required to digest each unit of digestible nutrients.

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[4] Sarvis. Op. cit. p. 42.

[5] W. H. Black, V. J. Clark, and O. R. Matthews, "Effects of Different Methods of Grazing on Native Vegetation and Gain Per Steer In Northern Great Plains," United States Department of Agriculture, Technical Bulletin 547, p. 16.

Here it should be pointed out that tests at Guthrie were not intended to determine maximum stocking rates. Rather they were undertaken to learn how much grazing could be provided by cleared woodland and abandoned cropland while establishing and improving the stand of desirable plants. The directors of this experiment concluded that the grazing intensity practiced did not prevent the grasses from becoming better established.

Grazing tests by Taylor[6] in which 2-year-old steers were pastured on good Bluestem grass during the summer of 1943 revealed that it required 25.07 pounds of grass to produce a pound of beef. His stocking rate was 5.4 acres per steer, with 60 percent utilization. Hay on similar land produced .85 tons per acre. His gains were 54 pounds per acre or 293 pounds per steer on that group of animals grazed with no supplement other than salt.

These tests indicate that the normal beef-grass ratio in Oklahoma may be between 1 to 15 or 20 with moderate stocking rates. With greater utilization the narrower ratio appears likely. Daily requirements in terms of air-dry grass per animal are also indicated in these studies as being around 30 pounds for yearlings and 40 pounds for 2-year olds. During the summer grazing season of 1942 stock cows on good pastures were maintained for 198 days on an average daily ration of 56 pounds of air-dry grass at the Oklahoma Agricultural Experiment

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[6] Bruce R. Taylor and Charles S. Hobbs, "Supplements for Fattening 2-Year-Old Steers on Bluestem Grass," Oklahoma Agricultural Experiment Station, Mimeographed Circular, M-102, p. 2.

Station.[7] That group of cows grazed during the winter season consumed 34 pounds of grass daily in addition to two pounds of cottonseed cake.

The investigations referred to earlier also provide a basis for calculating these yields. From the standards referred to heretofore it appears reasonable to assume that six pounds of total digestive nutrients are required for the daily maintenance of yearling steers or seven pounds for 2-year olds. Knott's[8] figure of 3.53 pounds of total digestible nutrients per pound of gain appears to have been acceptable for it has been used by Woodward, Shepherd, and Hein,[9] by Faires, Dawson, La Master and Wise,[10] and by others. Morrison[11] has indicated that the total digestible nutrients of native grasses runs approximately 50 percent of their dry weight. The United States Department of Agriculture has also made available data on this subject assembled from various sources which should be applicable to Oklahoma.[12] Total

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[7] Bruce R. Taylor, W. L. Blizzard, and Charles S. Hobbs, "Feeding and Grazing Tests with Beef Cattle 17th Annual Feeders' Day Report," April, 1943, Oklahoma Agricultural Experiment Station, Mimeographed.

[8] J. C. Knott, R. E. Hodgson, and E. V. Ellington, "Methods of Measuring Pasture Yields With Dairy Cattle," Washington Agricultural Experiment Station, Bulletin 295, p. 8.

[9] T. E. Woodward, J. B. Shepherd, and E. A. Hein, "The Hohenheim System in the Management of Permanent Pasture for Dairy Cattle," United States Department of Agriculture, Technical Bulletin 660, p. 12.

[10] E. W. Faires, J. R. Dawson, and J. P. La Master, and G. H. Wise, "Experiments with Annual Crops and Permanent Pastures to Provide Grazing for Dairy Cows In the Sandhill Region of the Southeast," United States Department of Agriculture, Technical Bulletin 805, p.12.

[11] Henry P. Morrison, Foods and Feeding, A Handbook for The Student and Stockman, p. 960.

[12] Food and Life, United States Department of Agriculture, Yearbook, 1939, p. 1073.

digestible nutrients of Buffalo grass hay as determined by feeding tests to cattle, they report, is 53.2 percent, and for prairie hay in Kansas and Oklahoma 50.3 percent.

A comparison of the production actually secured with that computed by using results of other investigations, Table VII indicates that to assume a beef-grass ratio of 1 to 15 or 20 is quite conservative as the beef-grass ratio calculated with the aid of investigations of total digestible nutrients required for maintenance and for growth indicates that a lower ratio could be expected. The computed gains per steer exceed those which livestock men usually expect to make and in some instances are so great as to appear impossible. Year-to-year variations in computed gains are about as great as are the actual variations though the range in the computed beef-grass ratio is considerably narrower than is the actual ratio between pounds of beef produced and pounds of grass consumed.

This method of estimating pasture carrying capacity from hay yields appears somewhat crude and may be subject to correction for the number of trials available are quite limited, but at its worst it appears to be about as accurate as some other methods of measuring production which have been given a great deal of attention.

Lastly it should be emphasized that this beef-grass ratio is of value only for animals which are making satisfactory gains. If approximately 64 percent of the average daily intake of yearling steers on good grass is required for body maintenance and around 67 percent in the case of 2-year olds it is apparent that to place an animal on a ration substantially below his maximum capacity would materially decrease his rate of gain. Apparently little gain could be expected

Table VII. Actual Gains Per Steer From Grazing Tests In Oklahoma With Computed Gains Based on Standards of Total Digestible Nutrients Required for Maintenance and For Growth

Year	Number of Animals	Number of Days	Average Weight 1/	Pounds of T.D.N. Required Per Day For Maintenance 2/	Total Intake Grass (Air-Dry) Pounds	Total Intake T. D. N. 3/ Pounds	T. D. N. for Maintenance	T. D. N. Available For Grain	Pounds of Beef Produced Actual	Pounds of Beef Produced Computed 4/	Beef-Grass Ratio Actual	Beef-Grass Ratio Computed
Experiments on the 110-acre pasture at Guthrie:												
1940	20	153	697	6.87	4,306	2,153	1,051	1,102	276	312	15.60	13.80
1941	17	152	635	6.50	4,328	2,164	988	1,176	226	333	19.15	13.00
1942	20	154	701	6.90	4,516	2,258	1,063	1,195	209	339	21.61	13.32
Experiments on the 34-acre pasture at Guthrie:												
1941	5	152	684	6.85	4,658	2,329	1,041	1,288	272	365	17.21	12.76
1942	5	154	710	6.95	5,263	2,631	1,070	1,561	234	442	23.88	11.91
Experiments by Taylor at Stillwater:												
1943	22	128	880	7.70	7,344	3,672	986	2,686	293	761	25.07	9.65

SOURCE: Arranged from data secured from Daniel, Elwell, and Taylor.

1/ Average weight as shown here has been computed as initial weight plus three-quarters of the gain as tests have shown that steers on pasture make the largest gains early in the season.

2/ As indicated in Food and Life, United States Department of Agriculture Yearbook, 1939, p. 627, Table 9, "Total digestible nutrients per head daily required for growth of dairy cattle, calculated from the Gullickson-Eckles data, and compared with the Morrison feeding Standard." Maintenance requirements for dairy cattle were selected for use here as they are somewhat more liveral than those of Brody for beef and general purpose cattle.

3/ Assuming that total digestible nutrients equal 50 percent of the air-dry weight of the grass consumed.

4/ This computation is based on the assumption that one pound gain in body weight will result from the consumption of 3.53 pounds of total digestible nutrients above daily maintenance requirements.

from a ration which was two-thirds of maximum requirements. This is important in considering the degree to which pastures are to be utilized. Granting that 100 percent utilization would provide more forage than would 60 percent it does not necessarily follow that complete utilization would produce the most beef, for a stocking rate sufficient to force 100 percent utilization might require such an increase in the number of cattle grazed that a large part of this additional forage would be dissipated in maintenance. Then, too, in stocking so as to secure more complete utilization it seems logical to assume that during a part of the grazing season individual animals would encounter difficulty in finding the forage required for a complete fill. These difficulties plus the damage done to the vegetation by over-grazing were considered by Sarvis[13] when he suggested that most desirable results would be secured with 75 to 80 percent utilization.

It appears from the evidence available that pastures can be grazed so as to remove about the same percent of their total forage production as would be removed by mowing in July for it has been observed that native meadows cut annually, not later than July, are generally able to make sufficient growth after that to regain a satisfactory amount of their normal vigor and remain at a near maximum production level indefinitely. Hence, for purposes of this discussion it will be assumed that pasture yields in terms of air-dry forage approximate that of meadows providing that both type and density of the vegetative cover are similar. In making estimates of forage production expected from pastures downward adjustments will

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[13] Sarvis. Op. cit. p. 43.

be necessary to allow for variations between the density of plants in pasture and in meadows but the degree of utilization can safely be assumed to be identical.

Value of A Beef-Grass Ratio

Normal and anticipated wild hay yields are generally known. Pasture yields in terms of beef per acre are not so generally known nor are they recorded in documents available to all as are hay yields. However, if a normal relationship exists between feed consumed by a particular type of animal and production in terms of a gain in weight or in milk yield then it would appear possible to anticipate yields of meat or milk about as accurately as pounds of forage or grain. Naturally such calculations will include some assumptions or estimates in addition to the beef-grass ratio. Most important of these are, first, an estimate of the relative yields of forage to be expected from pastures and from meadows, and, second, some assumption as to the degree to which all forage is to be utilized.

The relationship of these various factors is indicated in the following illustration. On a meadow yielding .95 tons of hay, which has been the average yield of the State during the past 25 years expected beef yield would apparently be 105 pounds per acre, or between 65 and 127 pounds depending on the beef-grass ratio assumed and the completeness with which available forage is to be used. The calculations are 1,900 pounds of forage divided by the pounds of grass which it is expected will be required to produce a pound of beef, in this case 15, 18 or 20 to determine expected beef yield. An assumption

necessary for reaching this conclusion is that the same amount of forage will be harvested by animals as by a mower. Problems apparently circumvented by the beef-grass ratio method of yield determination which have plagued many investigators of pasture yields are: (1) The question of whether grasses produce as much forage when grazed frequently as when mowed annually, and (2) The relative nutrients of frequently grazed forage and that cut only at the end of the growing season. Black[14] referred to this problem in reporting on his studies of grazing intensity in South Dakota when he reported:

> Considering the lower yields of air-dry forage from the more frequently clipped quadrants, which corresponded to the more intensively grazed pastures, it is evident that the forage consumed on such pastures was much more nutritious since it produced not only greater gain per acre but also carries considerably more cattle per acre.

True the tests at Guthrie do indicate that a narrower ratio 1-12 or even 1-10 might be possible with greater utilization, but since forage yields would likely decline with utilization beyond 75 percent it would seem safer to assume about 75 percent utilization and a beef-grass ratio of 1 to 15 or 20.

As grasses in pastures seldom grow as dense as in meadows it is necessary to make an adjustment of the reported hay yield to compensate for this. Estimates of farm managers and pasture technicians of this relationship are shown in Table IX for different areas of the State. It appears from a study of their reports that for the State as a whole pastures may be expected to yield about one-half as much forage as native meadows or 950 pounds as compared with 1,900 pounds which has been the average wild hay yield for the past 25 years. In

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[14] Black. Op. cit. p. 18.

determining the carrying capacity of an individual pasture the accuracy of this estimate cannot be over-emphasized.

The expected beef production from a 100-acre native grass pasture yielding 750 pounds of air-dry forage per acre with a beef-grass ratio of 1 to 18 would be 750 pounds times 100 acres divided by 18, the beef-grass ratio, or 4,333 pounds of beef or 43.3 pounds per acre. In order to determine the stocking rate for this pasture which would normally allow each steer to put on 300 pounds of gain during the summer grazing season the calculations would be: 18 times 300 or 5,400, the pounds of grass necessary to produce 300 pounds of beef per steer with a 1-18 beef-grass ratio divided by 750 which is the pounds of grass actually consumed from the pasture. This calculation, 5,400 divided by 750, indicates that the stocking rates would need to be 7.2 acres per steer.

To illustrate how either over-grazing or under-grazing may decrease yields of beef from a given area Table VIII is presented. Whether maximum gains would be attained when utilization was forced beyond 79 percent is open to question. It is quite possible that in securing greater utilization gains per animal may be reduced substantially below those shown here. The effects of over-stocking on subsequent grass production and the variation in price between different grades of beef are considerations not shown in this table which are extremely important in determining the economic stocking rate. The 6,600 pounds of beef produced on 22 steers is worth the same amount at $12.00 per hundred as is the 7,166 pounds produced by 26 steers at $11.05 per hundred or the 7,666 pounds from 30 steers at $10.33. Cattle on moderately stocked pastures do not suffer so quickly from drouth as

when maximum utilization is planned. The advantages of having some grass in reserve during below normal years would also appear to be important in determining the most profitable rate of stocking.

Table VIII. Beef Production Anticipated from Summer Grazing A 100 Acre Native Pasture Yielding 1,500 Pounds of Air-Dry Forage Per Acre With Various Rates of Stocking and Degrees of Utilization 1/

Number of Steers	Air-Dry Forage Produced (Pounds)	Air-Dry Forage Utilized (Pounds)	Air-Dry Forage Utilized (Percent)	Pounds of Beef Produced Total	Pounds of Beef Produced Per Steer	Pounds of Beef Produced Per Acre
18	150,000	97,200	65	5,400	300	54
22	150,000	118,800	79	6,600	300	66
26	150,000	129,000	86	7,166	276	72
30	150,000	138,000	92	7,666	256	77
34	150,000	142,500	95	7,917	233	79

1/ A beef-grass ratio of 1 to 18 is assumed for purposes of this illustration. Other assumptions are; (1) that 300 pounds gain per steer represents approximately the maximum gain anticipated from summer grazing, and (2) that the cattle would fail to fill completely as utilization approached 100 percent and as a result would fail to make maximum gains. Experimental data are not available to show exactly how far utilization may go before decreased gains per head result.

Beef and Milk Yields of Oklahoma Pastures

The material presented in the preceding pages indicates that: (1) A beef-grass ratio of 1 to 15 or 20 may generally be expected with optimum utilization of pastures, (2) In those cases where experimental data have been available daily requirements for making satisfactory gains on steers have been about 30 pounds of air-dry grass for yearlings, 40 pounds for 2-year olds, 56 pounds for maintaining stock cows with calves, and 34 pounds for stock cows on winter pasture when supplemented with two pounds of cottonseed cake, and (3) For determining

pasture yields with the aid of this beef-grass ratio it can be assumed that forage production of pastures will approximate that of meadows with similar density and kinds of grass. In clipping tests at Guthrie for the period 1940 through 1942 Blue Grama produced 65 percent as much forage as Little Bluestem and Buffalo 65 percent as much. Whether beef gains to be expected from these different kinds of pasture would show this same amount of variation appears doubtful as analysis of grasses at Stillwater has shown affalo to contain less moisture and crude fiber than Bluestem at various times during the grazing season while being higher in ash, crude protein, calcium, and phosphorus.[15] This agrees with reported digestible nutrient content of the two grasses.[16] Then, too, clipping tests at other stations have indicated that the yield of forage from shorter grasses is affected less by frequent clippings than are the taller ones. When stocked so as to insure adequate utilization there may be but little variation between beef yields from short and tall grasses.

Reports from farm managers and pasture technicians failed to indicate any variations between forage yields of short and tall grasses in Oklahoma. Their reports, summarized by areas in Table IX, suggest that, in general, native pastures may be expected to produce about one-half as much forage as wild hay meadows, that wheat for grain may be grazed to supply about as much forage as a meadow, and that improved pastures may be expected to provide from three-quarters to twice as as much forage as wild hay meadows. This wide range in yields

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[15] Taylor. Op. cit. p. 3.

[16] Morrison. Loc. cit.

Table IX. Estimates of Forage Production of Native Pastures, Wheat for Grain, and Improved Pastures Relative to Wild Hay Meadows by Type of Farming Areas of Oklahoma

Area	Percent			
	Wild Hay	Native Pasture	Wheat	Improved Pasture
1	100	45	72	72
2	100	50	75	75
3	100	60	100	90
4	100	75	1/	1/
5	100	40	100	175
6	100	45	72	144
7	100	50	90	100
8	100	40	140	175
9	100	40	120	200
10	100	45	100	150
11	100	40	80	70
12	100	50	100	80
13	100	45	70	75
14	100	45	130	175
15	100	50	100	175
16	100	40	1/	150

1/ No report.

reported for improved pasture results from both ranges in rainfall within the State and from differences in kinds of improved pasture considered. Wheat pasture yields as reported here appear unusually high in relation to other pastures. The reports indicated that an acre of wheat could be expected to produce twice as much pasture as native grass, which is not in agreement with reports secured from farmers. It is possible that in these reports the years when wheat provided little or no pasture may have been omitted and that the reported yield is in reality an average of only those years when wheat pasture was important.

A beef-grass ratio of 1 to 20 has been applied to the data in Table IX to construct Table X which emphasizes the high regard of farm managers and pasture technicians for improved pastures. This table

shows expected yields of beef per acre for wild hay, native pasture, wheat pasture, and improved pasture for each type of farming area. Note also that wheat pasture yields have been used as reported and that high rating of this pasture may be due, in a large measure, to a misunderstanding of the exact type of information desired.

The investigators already referred to have generally agreed that 10.4 pounds of milk containing .4 pounds of butterfat may be produced with the nutrients required to produce one pound of beef. Knott[17] converted total digestible nutrients to milk at the rate of .35 pounds of nutrients to beef at the rate of 3.33 pounds of nutrients per pound of beef. While it is true that individual investigators have reported requirements for the maintenance of 1,000 pound dairy cows ranging from 5,635 to 8,200 pounds of total digestible nutrients[18] and requirements for the production of one pound of milk containing 4 percent butterfat ranging from .285 to .343 pounds of total digestible nutrients[19] it appears that for practical purposes a rate of one to 10 can be used for converting beef yields to milk yields. Hence, the beef yields given in Table X can be converted to pounds of 4 percent milk by adding zero to the figures shown.

Reports secured from farmers in the State on the use which they have made of their pastures, Table XI, indicate the relative importance of principle pastures, length of grazing season, and relative

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[17] Knott. Loc. cit.

[18] Food and Life, Yearbook of Agriculture. Op. cit. p. 655.

[19] Food and Life, Yearbook of Agriculture. Op. cit. p. 656.

Table X. Pounds of Beef Per Acre From Principle Kinds of Pasture With A Beef-Grass Ratio of 1:20 and the Meadow-Pasture Relationships As Shown in Table IX

Type of Farming Areas	Wild Hay Yield (Tons per Acre)	Pounds of Beef Per Acre			
		Wild Hay	Native Pasture	Wheat	Improved Pasture
1	.81	81	36	58	58
2	.94	94	47	70	70
3	.84	84	50	84	76
4	1.04	104	78	--	--
5	1.09	109	44	109	190
6	.77	77	35	55	111
7	.88	88	44	79	88
8	.88	88	35	123	154
9	1.03	103	41	124	206
10	1.19	119	54	119	178
11	.88	88	35	70	62
12	.77	77	38	77	62
13	.98	98	44	69	74
14	.98	98	44	127	172
15	.84	84	42	84	147
16	.99	99	40	--	148

yields within limits. Farmers reported the time each kind of pasture was used and the number of animals grazed, but since no check on utilization was made their reported "Animal Unit Months of Grazing Per Acre" reflect not grazing capacity, but rather their need for pasture at the time a particular pasture was available. This situation is illustrated by the reported yield of wheat pasture in various areas. Where the acreage of wheat was large as in Garfield County the use of it was low compared to the use reported in Muskogee and Payne counties where the acreage of winter pasture was limited. It appears unlikely that in Garfield County the actual grazing capacity of wheat grown for grain and pasture would be 75 percent of native grass, 150 percent in Payne County, and 163 percent in Muskogee County. A better

explanation is that in Garfield County livestock numbers were not large enough to graze the available acres of wheat at near capacity and that reports on the use of wheat pasture from other areas indicate more nearly the actual grazing capacity of wheat grown for grain.

An indication of both the degree of utilization of native pastures in different parts of the State and the practice of supplemental feeding on grass are indicated in Table XII. Grazing rates as reported by farmers, that is their reported use of native pastures, have been applied to estimated forage yields of pastures, assuming 75 percent utilization, in estimating the pounds of forage available per animal unit daily. When the daily rations per animal unit go lower than 20 or 25 pounds of forage it is very likely that either the cattle were fed while on grass or they utilized more than 75 percent of the grass. Note that in Garfield County the air-dry forage available per animal unit ranged from 13 to 58 pounds per day during the grazing season. In only one year, 1938, does it appear that pastures were adequate to feed the animals. That year high forage yields were accompanied by low livestock inventories. The data indicate that in Garfield, Muskogee, Tulsa, and Wagoner counties it is the usual practice to feed the livestock while they are on pasture. The last column in this table "Pounds of Beef Per Acre" indicates potential yield, a figure calculated to show the yield of beef which could be expected from the forage produced with a moderate stocking rate. Should a beef-grass ratio of 1 to 15 or 16 be assumed this figure would have been increased accordingly. As it is it indicates yield variations between areas and year-to-year fluctuation within areas.

Table XI. Use and Distribution of Major Kinds of Pasture in Selected Areas of Oklahoma

Location, Year, and Type of Pasture	Percent of Total Pasture Area	Percent of Total Pasture Provided	Length of Grazing Season In Months	Animal Unit Months of Grazing Per Acre
Garfield County, average of 1932, 1933, 1935, 1937, 1938, 1940, and 1941				
Native	39	57	5.5	1.6
Wheat for grain	55	34	3.8	1.2
Sudan	2	5	2.1	3.3
Legumes	2	3	2.5	2.0
Crop residue	2	1	1.6	.4
Wild hay yield, tons 0.80				
Muskogee County, Average of 1939 and 1940				
Native	66	60	5.6	1.2
Perennial, improved	4	7	5.0	2.0
Wheat for grain	4	8	3.0	2.2
Other annuals	3	8	2.4	3.6
Crop residues	23	17	2.8	1.0
Wild hay yield, tons 0.68				
Payne County, Average of 1939 and 1940				
Native	79	72	6.8	1.0
Perennial, improved	1	2	6.0	1.3
Wheat for grain	6	6	2.8	1.5
Other annuals	3	6	2.3	2.5
Crop residues	11	14	2.7	1.7
Wild hay yield, tons 0.75				
Beckham County, 1941				
Native	35	25	5.4	2.0
Perennial, improved	13	13	5.4	4.8
Wheat for grain	14	23	3.1	2.3
Other annuals	12	18	4.3	3.4
Crop residues	26	19	1.8	1.7
Wild hay yield, tons 1.45				

(Continued)

Table XI (Continued)

Location, Year, and Type of Pasture	Percent of Total Pasture Area	Percent of Total Pasture Provided	Length of Grazing Season In Months	Animal Unit Months of Grazing Per Acre
Garvin and Murray Counties, 1941				
Native	64	47	6.6	1.4
Native, mowed	14	17	6.9	1.7
Perennial, improved	6	24	6.8	6.3
Annual	3	4	4.1	2.0
Crop residues	13	8	1.8	.8
Wild hay yield, tons 1.25				
Tulsa and Wagoner counties, 1941				
Native	9	5	5.4	2.0
Native, mowed	28	28	5.0	2.6
Perennial, improved	16	34	6.8	6.3
Wheat for grain	2	2	2.1	2.7
Other annuals	15	24	4.6	5.2
Crop residue	30	7	.9	.7

SOURCE: Unpublished data from Projects 285 and 293, Department of Agricultural Economics, Oklahoma Agricultural Experiment Station.

Table XII. Estimated Pounds of Air-Dry Grass Available Per Day For Each Animal Unit Grazed on Native Pastures and Resulting Beef Yields In Selected Counties of Oklahoma

County	Year	Animal Units Months of Grazing Reported Per Acre	Wild Hay Yield	Pasture-Meadow Ratio	Pounds of Grass Per Animal Unit Per Pasture Day	Pounds of Beef Per Acre with A 1:20 Ratio
Garfield County:	1941	2.1	.86	60	16.4	52
	1940	1.7	.57	60	13.4	34
	1938	.8	1.16	60	58.0	70
	1937	1.1	.36	60	13.1	22
	1935	1.5	.95	60	25.3	57
	1933	1.8	1.00	60	22.2	60
	1932	2.1	1.02	60	19.4	61
Muskogee County:	1940	1.3	.63	40	12.9	25
	1939	1.2	.74	40	16.4	30
Payne County:	1940	.9	.76	50	28.1	38
	1939	1.2	.73	50	20.3	36
Beckham County:	1941	2.0	1.45	50	24.2	72
Garvin and Murray Counties:	1941	1.4	1.25	50	29.8	62
Tulsa and Wagoner Counties:	1941	2.0	1.12	40	14.9	45

SOURCE: Unpublished data from Projects 285 and 293, Department of Agricultural Economics, Oklahoma Agricultural Experiment Station.

CHAPTER V

RELATIVE RETURNS FROM CROPS AND PASTURES

Making estimates of probable returns to particular tracts of land when in pasture and when in harvested crops is certainly nothing new. Undoubtedly one or more people have made such an estimate for every parcel of land in Oklahoma. Until recently the trend has been toward cultivating more acres of land. Early settlers took stock of their new surroundings, made estimates of returns to be expected from these two alternatives and broke up the sod. Recently the trend has been reversed so that formerly cultivated land is now in pasture. The magnitude of the present trend is indicated in Table I. That land was first in grass, then in cultivation and again in grass does not necessarily indicate that the one who broke the native sod was in error for circumstances change from year to year and that which is economically feasible today may have been economically impossible a few years earlier.

In determining the most desirable use for a particular piece of land some of the points which should be considered are: relative returns, the labor supply, available equipment, credit facilities, the markets and transportation available, experience of the farmer, his personal preferences, the effects of alternative uses on the present farm organization and upon the security of the capital investment. This list is not complete but it serves to illustrate that to determine relative returns to land when in alternative uses is quite a different problem than to determine the most desirable land use.

Yields, Costs, and Prices Affect Returns

The principle factors involved in determining the relative returns to land when in harvested crops and when in pasture are yields, costs, and prices.

Data are not available in sufficient volume to indicate how pasture yields compare with yields of harvested crops on similar land. This is unfortunate as yields are of prime importance in determining relative returns to land with alternative uses. To gather factual information of this type would appear to be a wise investment of public funds. In the absence of actual data it will be necessary to assume some yield relationships in order that the relationship of yields to other factors may be shown in determining under what circumstances land should or should not be in pasture.

Production costs which need to be considered in estimating probable returns to land when in pasture and when in harvested crops are those which will be affected by the proposed land use. For example, if the alternatives are; (1) harvest a small grain crop, and (2) pasture it if it is obvious that the cost items involved are those connected with harvesting, storing, and marketing the grain as compared to the costs connected with using it for pasture. That is to say, only operating costs will be involved; fixed costs which will not be affected by changes in land use will not need be considered. However, in the long run no costs are fixed, which means that costs involved in a proposed change in land use may include such items as taxes, building repairs, fences as well as the usual labor, power, seed, and machinery for a change of long duration may influence the need for buildings, fences, and public services though they may not enter into making

decisions covering operations for a single year.

The price relationships selected for use in estimating returns from different enterprises should be considered very carefully for prices alone may easily outweigh the effects of both yields and costs. Fortunately the chances for being mislead by the unwise selection of prices decreases as the length of time to be covered by the proposed change increases. The reason for this is that actual prices for wheat and beef for the past 20 or 30 years offer a more satisfactory basis for estimating their probable relationship during the next 10 years than for the coming year. It would probably be safe to assume that the normal price relationship would exist for most of the time during the next dozen years for principal farm products than to assume a normal price relationship for the next year or two. The producer who emphasized beef production in 1943 because 1942 beef prices compared favorably with crop prices may not have fared so well as the producer who continued with his usual farm organization.

In making an estimate of the effects which prices would have on the relative returns to be expected from harvesting a small grain crop or from using it as pasture it would be necessary to forecast both the price of wheat and of beef at the time these products would be ready for market. In this connection it might be well to point out that the price of stocker and feeder cattle in the spring is not necessarily an indication of the price which stockers and feeders will sell for in the fall. Records are available to show the price of stockers and feeder cattle at Oklahoma City for the past eight years. During four of these years August prices were below April prices though in August, 1943 prices for medium 500-1000 pound steers were $5.46 per hundred higher

than in August, 1936.[1] April quotations on this class of steer averaged 3 percent higher during the eight year period than in August. In 1943 they were 15 percent higher or $12.25 in April and $10.67 in August.

Oklahoma farm prices of all cattle are available for a much longer period of time as this series was started in 1910 and has been reported monthly since that date,[2] but these raw data are probably no more helpful in indicating future stocker and feeder prices than are the data covering only eight years. The Oklahoma farm prices of all cattle on April 15 averaged 4 percent higher than for August 15 during the eight year period which is approximately the price trend reported for stockers and feeders on the Oklahoma City market. Average farm prices for April 15 for the whole 33 year period were 8 percent above the average prices for August 15.

The implications to be drawn from this discussion are that future prices, which have much to do with returns from land, are almost if not altogether unpredictable. While the above discussion has treated only cattle prices the same unpredictable situation applies with equal force to prices to be received for crops.

How Relative Returns May Be Estimated

It would be pointless to attempt comparisons of returns to average crop land with returns to average pasture land for there are wide variations in quality of these two classes of land, crop land, in

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[1] Compiled by the Department of Agricultural Economics, Oklahoma Agricultural Experiment Station from Daily Livestock Market Reports, War Food Distribution Administration.

[2] Agricultural Prices, Bureau of Agricultural Economics, United States Department of Agriculture.

general, being considerably more productive than pasture. The real purpose of this discussion is to look at some cases somewhere near the margin and see how the principles enumerated above apply.

An elementary illustration should be helpful in indicating the interlocking nature of yield, costs, and prices. An acre of land producing 12 bushels of wheat selling for $1.20 with total operating costs of $7.00 would make a return of $7.40 per acre. If when used as pasture this land produced 60 pounds of beef at $11.00 per hundred with operating costs of $2.00 per acre the return would be $4.60. Obviously under these circumstances this land would remain in wheat. If this land could be expected to produce only nine bushels of wheat, and all other conditions remained the same as outlined above, returns would be reduced to $3.80 or $0.80 below returns from beef. If prices were $0.90 for wheat and $13.00 for beef the 12 bushel wheat crop would return $3.80 as compared to $5.80 when used for pasture.

This illustration could be extended to include an endless number of variations all emphasizing the fact that returns to both harvested crops and pasture are dependent upon a number of factors of which yields, costs, and prices are by far the most important.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary. The acreage of Oklahoma farm land used only for pastures has increased during each of the last two decades until in 1939 it exceeded the total acres used for harvested crops, failed, idle, and fallow cropland. Establishing and improving pastures is one of the more popular phases of the conservation program being carried out by Oklahoma farmers. Under the 1940 A.A.A. program alone 333,054 acres were seeded to grasses and legumes. In addition to this deferred grazing was practiced on 938,377 acres so as to allow reseeding and 184,809 acres of existing pastures were reseeded by artificial methods.

Notwithstanding the relative importance of pastures in Oklahoma agriculture the yield of pastures is still unavailable except for the reports on pasture conditions which is a simple expression of the condition of pastures for the current month in relation to normal. Consequently those wishing to determine the sale or rental value of pasture land or the conditions under which pasture land should be cultivated or cultivated land should be returned to pasture have very little information on which to base their judgment.

A review of the literature on pasture investigations reveals that few pasture studies have been made for the purpose of determining economic grazing practices. While much work has been undertaken to learn of the nutrients required to produce a pound of beef or a pound of milk much less attention has been given to determining the yields of various kinds and grades of pasture with various stocking rates and management practices.

The literature indicates that a great many individuals have been working on the nutritional requirements for maintaining cattle and for producing beef and milk and that these studies have been carried on for a great many years. That they continue to differ as to standard requirements may indicate that they have not yet completed their job and may also suggest that some other approach might be worthwhile for even if they reached complete agreement on requirements they would not be in a position to determine the economic production capacity of pastures for which the yields of nutrients was unknown without resorting to the trial and error method, and little work has been done on the yields of nutrients per acre of land under the various conditions of pasture stocking and management.

By clipping areas of both grazed and ungrazed grass in pastures it has been possible to determine the amount of forage consumed by the animals on pasture. In those cases where both amount of forage consumed and the weight gained were known it has been a simple matter to calculate a beef-grass ratio. The pounds of air-dry grass utilized were divided by the pounds of beef produced to find the number of pounds of grass required to produce a pound of beef. As was to be expected the ratio was not the same in all cases. Actually it ranged from 15 to 25 pounds of grass per pound of beef in the relatively few tests made. From these studies it appeared that a ratio of 1:15, 1:18 or 1:20 could normally be expected with moderate stocking. The data suggested that a narrower ratio could be expected with heavier stocking, which is in agreement with the experience of some other investigators. Studies of nutrient requirements indicate that a ratio of 1:10 or 1:12 would not be at all unreasonable.

Estimates of professional farm managers and pasture specialists were relied upon to provide information on the relative yields of wild hay meadows and various kinds of pastures throughout the State. Their combined report showed that they expected native pastures to produce about one-half as much forage as would be expected from wild hay meadows. Since yields of wild hay are generally known it would appear to be rather a simple matter to calculate pasture yields, in pounds of beef per acre, from this kind of information.

In a community where wild hay meadows normally produce about one ton of hay per acre a pasture which appeared to be able to produce one-half this much forage would be expected to yield 50 pounds of beef per acre under a grazing system where a 1:20 beef-grass ratio would be expected. With a beef-grass ratio of 1:15 66 pounds of beef would be the normal yield of such a pasture. If it is agreed that 10 pounds of milk can be produced with the feed needed to make one pound of beef then this pasture would have a milk yield of 500 or 660 pounds per acre.

While this method of yield determination is really quite simple and may be somewhat faulty because it has not been tested in a large number of cases it appears to be at least as accurate as the methods which have been developed as a result of a great deal of investigation. Naturally it could not be expected to work in those cases where the stocking rate was too heavy for all of the forage could conceivably be used to maintain animals. Likewise without enough animals to use the available grass maximum gains could not be expected for no production could result when the grass was not used. In these studies yearlings ate about 30 pounds of grass per day, 2-year-olds 40 pounds,

and mature cows with calves on summer pasture ate, on an average, 56 pounds of grass per day during the one summer for which these figures were available. When the cows were on winter pasture they ate 34 pounds of grass per day plus two pounds of cottonseed cake. These figures indicate that with pasture producing 1,000 pounds of forage per acre a yearling would need four and one-half acres to provide five months of pasture or a 2-year-old would have to have six acres to furnish him with 40 pounds of grass per day.

Naturally there will be a shortage of grass in the dry years if the stocking rate is set up on the basis of average yields, and there will also be surplus grass during the better years. Just how much consideration this matter should receive is hard to determine for the study of yields showed that wild hay and pastures were among the most dependable crops.

Conclusions. The beef-grass ratio appears to have considerable value as a tool for estimating the economic grazing capacity of Oklahoma pastures. The accuracy of estimates made with the use of a beef-grass ratio will depend chiefly on the accuracy with which forage yields of pastures are estimated and by the applicability of the ratio selected. As found in these studies beef-grass ratios may range from 1:15 to 1:25. At the present stage of investigations the exact reasons for this are not clear. It is apparent that the degree of utilization is one of the more important factors. The type and age of animals used and the growing rate of the grass are probably also important in determining whether a wide or narrow ratio should be expected. These studies failed to indicate what kind of a ratio could be expected from grass stocked so as to secure 75 or 80 percent utilization. The data

did suggest that it would run somewhat narrower than 1:15. Perhaps with more complete utilization the 1:10 or 1:12 ratio as indicated by the use of standard nutritional requirements might be realized. Probably little significance should be attached to those cases in which ratios of 1:20 or wider were found. It appears very likely that it was the abundance of grass available which caused these wide ratios.

If it is known that a pound of beef can be produced from each 15 or 20 pounds of grass and some reasonable estimate of forage yields are available it should be much easier to arrive at the sale or rental value of a pasture than when such information is not available.

Recommendations. The beef-grass ratio as a tool to be used in estimating pasture production in terms of beef and milk appears to be worthy of further study. Much of the needed information could be assembled in connection with the regular pasture studies now being carried on. About all the additional information required would be clippings to determine the pounds of forage actually consumed. It would be fortunate indeed if clipping information were available in connection with some of the excellent pasture studies which have been assembling data for years on beef production and grass behavior under various stocking rates and management practices. Data which would show the pounds of forage actually utilized with heavy and moderate stocking would make it possible to determine how narrow a beef-grass ratio one could expect under various circumstances.

Many of the pasture studies reviewed could have been improved by subjecting the physical results to an economic analysis. The relative merits of alternative grazing systems cannot be adequately explained by reporting that with one system maximum gains per animal were

obtained and that another system produced maximum gains per acre. The value of the products of the alternative systems are needed in order that the more desirable system can be identified.

Additional investigations designed to learn more about the effects of variations in stocking rates on the quantity and quality of beef produced appear desirable.

Since agricultural production in Oklahoma is often limited by drouth it might be desirable to make some tests which would indicate how much allowance should be made for the hazard. Specifically, would it be more profitable to stock pastures at their normal capacity and expect to sell the animals when drouth came, or is the practice of stocking at something below capacity in order that there will be a reserve of grass when the dry years come desirable? Should a pasture be stocked with the number of animals which can be carried from May through September or would it be more profitable to stock enough cattle to consume all available grass by July 15?

Some rather definite information on the seasonal movement of prices to be expected under various circumstances would be of great value to stockmen.

Studies which would determine the yields which could be expected from particular grades of land when in pastures and when in harvested crops would be helpful in determining economic land use.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aldous, A. E. "Effects of Burning Kansas Bluestem Pastures." Kansas Agricultural Experiment Station, Technical Bulletin 38.

2. _____ "Management of Kansas Permanent Pastures." Kansas Agricultural Experiment Station, Bulletin 272, 1935.

3. Black, W. H., Clark V. J., and Matthews, O. R. "Effects of Different Methods of Grazing on Native Vegetation and Gains Per Steer In Norther Great Plains." United States Department of Agriculture, Technical Bulletin 547, 1937.

4. Brody, Samuel, Proctor, Robert C., and Ashworth, Ural S. "Growth and Development With Special References to Domestic Animals." Missouri Agricultural Experiment Station, Research Bulletin 220, 1934.

5. Daniel, Harley A., Elwell, Harry M., and Cox, Maurice B. Investigations in Erosion Control and Reclamation of Eroded Land At The Red Plains Conservation Experiment Station, Guthrie, Oklahoma, 1930-40." United States Department of Agriculture, Technical Bulletin 837, 1943.

6. _____ "Summary of Research Findings At The Red Plains Conservation Experiment Station." Oklahoma Agricultural Experiment Station, Mimeographed Circular M-99, 1943.

7. Elwell, Harry M. "Progress Report of Land Reclamation and Pasture Investigations on Abandoned and Scrubby Oak Areas of Central Oklahoma." Oklahoma Agricultural Experiment Station, Mimeographed Circular M-86, 1942.

8. Faires, E. W., Dawson, J. R., LaMaster, J. P., and Wise, G. H. "Experiments With Annual Crops and Permanent Pastures to Provide Grazing for Dairy Cows In The Sandhill Region of the Southeast." United States Department of Agriculture, Technical Bulletin 805, 1941.

9. Gullickson, T. W., and Eckles, C. H. "Nutrients Used For Maintenance By Growing Dairy Cattle." Journal of Agricultural Research 42:593-601.

10. Knott, J. C., Hodgson, R. E., and Ellington, E. V. "Methods of Measuring Pasture Yields With Dairy Cattle." Washington Agricultural Experiment Station, Bulletin 295, 1934.

11. Morrison, F. B. Feeds and Feeding. A Handbook for Students and Stockmen. Edition 20. Ithaca, New York; The Morrison Publishing Co., 1939.

12. Moseley, Stewart, and Graves. "Dairy Work at The Huntley Field Station, Huntly, Montana." United States Department of Agriculture, Technical Bulletin 116, 1929.

13. Sarvis, J. T. "Grazing Investigations on the Northern Great Plains." North Dakota Agricultural Experiment Station, Bulletin 308, 1941.

14. Savage, E. S. "A Study of Feeding Standards for Milk Production." Ithaca, New York; Cornell Agricultural Experiment Station, Bulletin 323, 1912.

15. Schuster, G. L. "Methods of Research In Pasture Investigation." Journal of The American Society of Agronomy, 21:666-673, 1929.

16. Taylor, Bruce R., and Hobbs, Charles S. "Supplements for Fattening 2-Year-Old Steers on Bluestem Grass." Oklahoma Agricultural Experiment Station, Mimeographed Circular M-102, 1943.

17. Taylor, Bruce R., Blizzard, W. L., and Hobbs, Charles S. "Feeding and Grazing Tests With Beef Cattle." 17th Annual Feeders' Day Report, April, 1943. Oklahoma Agricultural Experiment Station, Mimeographed.

18. Tucker, E. A. "Conservation Increases Pasture Production." Current Farm Economics, Vol. 16, No. 4, August, 1943. Oklahoma Agricultural Experiment Station.

19. _____ "Simple Conservation Practices Are Weapons of War." Current Farm Economics, Vol. 15, No. 6, December, 1942. Oklahoma Agricultural Experiment Station.

20. Walters, H. J., "Beef Production on High Priced Land." Missouri Agricultural Experiment Station, Circular 24,

21. Woodward, T. E., Shepherd, J. B., and Hein, M. A. "The Hohenheim System in the Management of Permanent Pastures For Dairy Cattle." United States Department of Agriculture, Technical Bulletin 660, 1938.

22. State Soil Conservation Districts of Oklahoma. "Annual Progress Reports."

23. United States Department of Agriculture, Bureau of Agricultural Economics. Agricultural Prices, 1942.

24. _____ Food and Life, Yearbook of Agriculture, 1939, Washington, D. C.; United States Government printing Office, 1939.

25. United States Department of Agriculture, Bureau of Agricultural Economics and Oklahoma Agricultural Experiment Station. "Wartime Agricultural Production Capacity In Oklahoma," 1943.

26. War Food Administration. "Daily Livestock Market Reports."

APPENDIX A

APPENDIX

Wild Hay Yields and Monthly Precipitation by Census Years
By Type of Farming Areas 1/

	Year	Wild Hay Yields	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Area 1:	1918-19	1.01	3.58	2.65	.81	2.74	.10	1.56	2.65	3.79	2.59	2.44	3.03	2.55	28.49
	1928-29	1.03	.64	3.20	2.66	.69	.29	.56	1.33	.37	2.53	1.46	3.56	2.46	19.75
	1938-39	.91	3.28	1.45	1.06	.57	1.42	.59	1.21	1.67	1.55	3.11	1.73	.99	18.63
	Normal	.81 2/	1.68	1.52	.81	.55	.30	.66	.85	1.59	2.54	2.46	3.48	2.29	18.73
Area 2:	1918-19	1.54	1.54	4.65	1.37	3.89	.07	1.71	1.83	4.02	4.61	3.33	1.08	1.92	30.02
	1928-29	1.05	1.05	3.38	4.53	1.42	1.15	.85	2.11	.82	3.83	1.38	2.89	1.57	24.98
	1938-39	.92	1.33	.26	.84	.42	2.64	.89	1.59	3.78	1.41	5.08	2.15	1.51	21.90
	Normal	.94 2/	2.78	1.98	1.59	.86	.83	.77	1.57	2.41	3.49	3.37	2.70	2.73	25.08
Area 3:	1918-19	.88	2.14	7.15	2.64	3.35	.51	2.17	1.61	4.10	3.81	5.75	.29	2.31	35.83
	1928-29	.87	.90	2.87	4.60	2.62	1.22	1.37	2.84	3.59	8.12	3.34	2.39	.46	34.32
	1938-39	.84	3.45	.16	2.52	.36	2.82	.53	1.57	2.48	3.81	5.63	2.13	2.80	28.26
	Normal	.84 2/	3.09	2.87	1.79	1.25	1.05	1.24	1.77	3.33	4.48	4.15	2.80	3.14	30.96
Area 4:	1918-19	1.05	3/	4.19	4.34	2.80	.25	1.81	1.15	5.38	4.79	3/	.60	4.27	29.58 4/
	1928-29	1.04	.36	3.61	3.41	3.50	1.92	2.32	3.60	7.26	7.86	9.66	4.87	.27	48.64
	1938-39	1.04	.93	.52	3.41	.06	1.44	1.16	3.14	.57	4.82	6.05	.32	3.81	26.23
	Normal	1.04 2/	3.87	3.25	2.14	1.52	1.51	1.63	2.62	3.94	5.13	5.21	3.81	3.50	38.13
Area 5:	1918-19	1.22	4.63	4.85	6.21	3.88	.27	2.02	2.26	3.72	4.07	5.12	1.19	4.12	42.34
	1928-29	1.13	.85	4.58	3.06	2.48	2.42	1.64	3.05	7.20	7.92	6.57	3.76	.82	44.35
	1938-39	1.08	1.02	.55	2.59	.76	2.26	1.54	1.72	1.40	7.83	6.36	1.92	2.93	30.88
	Normal	1.09 2/	4.07	4.06	2.76	2.14	2.32	1.75	3.05	4.14	5.25	5.26	3.64	3.73	42.17

(Continued)

APPENDIX A (Continued)

	Year	Wild Hay Yields	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Area 6:	1918-19	1.06	2.09	6.53	1.46	3.43	.24	1.51	1.54	3.90	5.28	5.14	2.19	1.76	35.07
	1928-29	1.02	.85	2.59	3.60	2.05	1.12	1.00	4.02	1.63	6.59	2.04	2.02	.84	28.35
	1938-39	1.22	2.33	.58	2.09	.29	3.13	.19	1.80	1.43	2.68	5.87	2.07	2.56	25.02
	Normal	.77 2/	3.03	2.53	1.71		.88	1.07	1.56	3.16	4.20	3.71	3.31	2.44	28.84
Area 7:	1918-19	.87	4.24	5.48	4.11	3.32	.46	1.76	1.97	4.04	5.09	4.08	5.48	2.69	42.72
	1928-29	.87	1.35	3.02	3.82	2.45	2.01	1.41	4.95	3.89	9.34	2.84	2.90	.53	38.51
	1938-39	.83	1.77	.50	2.30	.70	3.44	.60	1.55	1.56	3.72	6.18	2.17	3.47	27.96
	Normal	.88 2/	3.27	3.25	2.25	1.56	1.45	1.30	2.40	3.83	5.20	4.10	2.87	3.00	34.48
Area 8:	1918-19	.96	4.70	4.36	2.85	3.90	.46	1.67	1.37	4.02	4.51	3.46	.24	3.96	35.50
	1928-29	.98	.63	4.66	3.18	2.05	2.68	1.36	3.75	2.44	8.48	3.55	2.21	.36	35.35
	1938-39	.80	1.45	1.32	1.77	.49	2.81	1.23	1.66	1.84	4.17	5.56	2.32	2.65	27.27
	Normal	.88 2/	3.62	3.80	2.50	1.99	2.15	1.51	1.98	3.93	4.97	3.92	3.01	3.13	36.51
Area 9:	1918-19	1.02	4.31	4.44	3.24	4.54	1.04	2.16	1.72	3.80	4.43	4.94	.97	4.66	40.25
	1928-29	1.09	.82	5.01	3.48	2.23	4.23	2.81	4.20	3.58	10.00	5.32	3.20	.78	45.66
	1938-39	.96	1.43	.77	3.81	1.10	2.63	3.64	1.59	3.68	5.24	5.03	1.43	2.59	32.94
	Normal	1.03 2/	3.33	3.85	2.60	2.22	2.50	1.94	3.00	4.30	5.48	4.26	3.34	3.32	40.14 4/
Area 10:	1918-19	1.20	5.06	4.00	2.61	4.36	.16	2.85	3.18	2.57	4.28	3/	3/	6.84	35.91
	1928-29	1.08	.58	4.08	4.00	1.56	2.85	3.57	1.98	4.55	7.82	4.40	4.72	.55	40.66
	1938-39	1.15	1.50	.70	3.72	.93	2.69	4.36	1.79	2.89	7.16	6.05	1.17	2.82	35.78
	Normal	1.19 2/	4.28	4.24	3.08	2.60	2.86	2.18	3.38	4.92	4.77	5.89	3.52	3.62	45.32
Area 11:	1918-19	.94	2.75	6.84	1.07	4.31	.33	1.52	2.50	5.20	5.30	3.31	4.03	1.42	38.58
	1928-29	1.07	.80	2.43	2.87	.63	.48	.68	4.58	.57	4.43	2.06	1.38	1.01	21.92
	1938-39	.95	1.31	.68	1.36	.16	3.25	.19	1.92	.80	2.90	3.81	.59	3.00	19.97
	Normal	.88 2/	2.75	2.88	1.62	1.24	.74	.87	1.54	2.80	4.01	3.36	2.45	2.29	26.55

(Continued)

APPENDIX (Continued)

	Year	Wild Hay Yields	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Area 12:	1918-19	1.12	3.52	7.52	1.43	3.52	.60	1.60	2.27	5.54	5.41	4.78	4.26	1.93	42.38
	1928-29	.95	.95	2.81	2.22	1.53	.92	1.17	4.19	1.64	7.90	3.04	2.97	.58	29.92
	1938-39	.74	1.79	.39	2.02	.36	3.17	.27	1.97	.70	1.72	5.39	.77	2.70	21.25
	Normal	.77 2/	3.18	3.25	2.01	1.44	1.09	1.07	1.78	3.56	4.63	3.98	2.61	2.56	31.16
Area 13:	1918-19	1.10	3.63	3.90	2.54	3.22	.85	1.38	1.90	3.35	2.27	3.35	2.15	6.36	34.90
	1928-29	.87	1.90	2.48	2.48	2.06	2.63	1.32	4.24	1.12	9.36	2.37	1.68	.14	31.78
	1938-39	.88	1.75	.28	2.55	.61	2.90	.64	2.42	.92	3.68	5.58	1.62	3.28	26.23
	Normal	.98 2/	3.11	3.31	2.32	1.66	1.59	1.50	2.10	3.35	5.20	4.31	2.83	2.72	34.00
Area 14:	1918-19	1.04	2.77	4.64	5.73	5.46	2.19	2.61	1.22	4.32	5.86	4.84	.12	6.01	45.77
	1928-29	1.07	.55	5.58	3.80	2.61	4.27	3.14	2.74	1.53	12.10	4.18	2.50	.58	43.58
	1938-39	.92	1.82	.14	1.41	1.76	2.34	5.29	2.44	4.79	3.45	5.45	2.69	3.14	34.72
	Normal	.98 2/	3.00	4.24	3.07	2.94	2.90	2.46	3.34	4.87	6.25	4.08	3.42	3.37	43.94
Area 15:	1918-19	1.05	5.35	4.76	2.79	4.09	1.63	2.14	2.33	2.87	5.33	3.46	4.79	4.12	43.86
	1928-29	1.00	.30	2.00	2.99	2.12	2.34	1.27	2.51	1.82	9.40	2.96	2.71	.62	31.04
	1938-39	.71	1.54	.65	1.96	.81	3.01	2.20	2.44	2.90	2.97	4.68	1.02	2.55	26.73
	Normal	.84 2/	3.08	3.58	2.39	2.16	1.80	1.76	2.14	3.77	4.74	3.99	3.02	2.67	35.10
Area 16:	1918-19	1.06	4.43	3.46	6.31	4.88	2.93	2.97	1.57	2.95	4.42	2.48	2.41	5.87	44.68
	1928-29	.98	.51	4.03	4.10	4.92	5.02	3.47	2.60	3.16	9.60	3.10	2.27	.32	43.10
	1938-39	.97	1.84	.22	2.74	1.90	2.82	6.02	3.46	6.64	3.69	3.60	1.61	3.50	38.04
	Normal	.99 2/	3.18	3.91	2.55	3.74	3.40	2.98	3.46	4.71	6.16	4.13	3.34	2.36	43.92

(Continued)

APPENDIX (Continued)

SOURCE: Yields; arranged from data secured from the Census of Agriculture for Oklahoma, 1920, 1930, and 1940, and the Division of Crop and Livestock Estimates, Bureau of Agricultural Economics, United States Department of Agriculture.

Precipitation; Climatological Data, Weather Bureau, United States Department of Commerce.

1/ Simple average of all stations reporting within each area.

2/ Average of 1937-41 adjusted by the 1919-1943 average, as data by type of farming areas are not available for this longer period.

3/ Data not reported.

4/ Total of those months reported.