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An evaluation of a subjective pasture scoring system based on animal performance

Robert L. White

To the Graduate Council:

I am submitting herewith a thesis written by Robert L. White entitled "An evaluation of a subjective pasture scoring system based on animal performance." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C.S. Hobbs, Major Professor

We have read this thesis and recommend its acceptance:

R.J. Cooper, Harold J. Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 1, 1960

To the Graduate Council:

I am submitting herewith a thesis written by Robert L. White entitled "An Evaluation of a Subjective Pasture Scoring System Based on Animal Performance." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Charles A. Hobbs
Major Professor

We have read this thesis
and recommend its acceptance:

W. J. Smith

R. J. Cooper

Accepted for the Council:

W. E. Spivey
Acting Dean of the Graduate School

AN EVALUATION OF A SUBJECTIVE PASTURE SCORING SYSTEM BASED ON ANIMAL PERFORMANCE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Robert L. White

December 1960

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CHAPTER I

INTRODUCTION

Pastures supply a major portion of the total feed used in producing beef in the Southeast. The importance of productive and nutritious pastures to the beef cattle industry for many years to come is inevitable. Therefore, economical and profitable production of beef will be greatly dependent on the type of pasture used. Because of this dependence the beef producer needs to know which pastures will produce the greatest returns for his labors.

In Tennessee there is a critical need for the evaluation of the established pastures more commonly used for beef production, such as orchardgrass-Ladino clover pastures. If accurate evaluations are to be made, information is needed regarding the relative importance of the various characteristics included in pasture analysis such as species percentage, height of the various species, stage of maturity, color and carrying capacity.

Evaluating or scoring pastures accurately has been one of the most difficult problems confronting researchers. Members of the University of Tennessee Animal Husbandry-Veterinary Science Department developed a pasture scoring system whereby important pasture information could be systematically recorded. The system was used to score the pastures on all of the University of Tennessee Agricultural Experiment Stations where pasture work was conducted: namely, Highland Rim Experiment Station, Springfield; Middle Tennessee Experiment Station, Spring Hill; Tobacco

Experiment Station, Greeneville; and the Main Experiment Station, Knoxville, Tennessee.

This thesis will be a report of the findings obtained when correlations were made between the various factors used in scoring orchardgrass-Ladino clover pastures and average daily gain, total grazing days per acre and total beef gain per acre. The data used were obtained at the experiment stations located at Springfield, Greeneville and Knoxville and were collected from the period 1953-1959 with the following objectives:

1. To evaluate the relationships of the various items scored to the animals' performance.
2. To determine which pasture characteristics are most closely related to the performance of the animals.

CHAPTER II

LITERATURE REVIEW

There are numerous publications available regarding management of pastures, however relatively few studies have been made involving the scoring or rating of pastures when botanical compositions, species height, stage of growth, color and other factors are all considered in the evaluation. This review includes only those references that deal directly with the conditions involved in this study.

Black and Savage (1948) asserted that beef cattle led all classes of American livestock in the consumption of grass and grassland crops. This class of livestock utilized about one-third of the permanent pastures, three-fourths of the range grasses, and a high percentage of the harvested crops. Seemingly then, grass represents the principle and cheapest feed for beef cattle.

A report of Castle (1955) showed that an increasing amount of grassland research was focused on selecting suitable and accurate methods for evaluating grassland productivity. Techniques based on botanical composition give only a relative assessment of the potential production from the grassland, but they are valuable yardsticks for measuring the fertility of the land and the efficiency of grazing management.

In discussing the problems involved in evaluating pasture, Ahlgren et al. (1938) reported that the true carrying capacity of any pasture was determined by the amount of feed produced and utilized rather than by the total grazing days obtained or the number of livestock units supported. A measure of the efficiency of any pasture could be determined

only in terms of the livestock and livestock products that were ultimately produced.

Jones (1937) found that the provision of animal foods was best studied by comparison of production in terms of grazing animals. The yield of animal products from a pasture sown with a given grass may be increased by as much as 30-50 per cent if the sward contains a high proportion of clover. Clover, then has an important bearing upon yield and makes a comparison of the relative values of any two grasses difficult if they are growing in association with different quantities of clover.

A review of pasture evaluation methods by Ahlgren (1947) pointed out sixteen methods for measuring the results of pasture research. Seven of these; namely, hay weights, yields of dry matter of immature forages, photographs, surveys, botanical composition, chemical composition, and duration of grasses did not involve the use of livestock. The other nine methods which included profit, production of milk, cattle and sheep weights, pilot plots, total digestible nutrients, carrying capacity, palatability, digestion trials, and biological assays with small animals were based on animal results. Ahlgren further stated that carefully designed and executed trials that involved the use of livestock provided the most accurate results not only from the standpoint of the effect of the forage on the livestock but also from the equally important viewpoint of the effect of the livestock on the forage.

A corn equivalent method of measuring the productive value of pastures was studied by L'Hote (1942). The yields were measured by converting the gains in weights or production of the products into a common

unit, such as corn equivalent. One important fact noted was that pasture production under farm conditions was materially less than that secured under highly controlled experimental conditions because farmers were not usually in a position to procure complete utilization of the pastures without overgrazing them.

An investigation by Pasto (1957) was conducted to determine whether ground cover and sward height could be used to estimate forage production on permanent bluegrass and renovated orchardgrass-Ladino clover pastures. Test areas on both types of pastures were caged and evaluated in terms of ground cover, height of sward and yield. A tabular analysis of these factors showed an impressive relationship of cover to yield for both pastures. Within ranges of cover, however, the standard errors of the average production were large. On the bluegrass pastures the yield of forage was very small when the cover was less than seventy per cent. Conclusions were drawn that cover could be used to delineate bluegrass pasture areas that have insignificant potential for forage production. On orchardgrass-Ladino clover pastures such a delineation was not possible because the average production and standard errors represented large amounts of forage. Multiple correlation coefficients showed that most of the variations in yield were explained by variations in height and cover.

Brown (1954), in a comprehensive review of the methods used in pasture research, reported that the line intercept method for botanical analysis was accepted as a numerical value representing the ground surface occupied by plants. This method consisted of horizontal and linear measurements of plants along the course of a line. Satisfactory proof

of the method was presented by Canfield (1941) when the system was used on the semi-arid type of vegetation found in the Southwestern region of the United States. It was satisfactory not only for botanical analysis but also for measuring utilization of the pastures.

Levy and Madden (1933), investigating dairy cattle pastures in New Zealand, developed the "point quadrat" method of botanical analysis. This method was a logical outcome of thinking concerning a quadrat that becomes smaller and smaller until it is a point - hence the term "point quadrat". It is essentially a method for expressing botanical composition in terms of ground cover.

Comparisons between the permanent quadrat and the randomized line-transect method of sampling pasture vegetation were made by Anderson (1942). Native tall grass pastures were used to determine if the line-transect method would be as satisfactory as the permanent quadrat method in determining composition and density of vegetation. Results showed that the line-transect method was much more rapid and easier, therefore less costly. Both methods gave comparable results but showed some discrepancies in certain species due to failure of the quadrats to sample the vegetation adequately. The transects appeared to give estimates of the pasture population as good as or better than the quadrats.

In their statistical study of methods used in determining the botanical composition of swards, Van Kewren and Ahlgren (1957) reported that the point quadrat method, developed by Levy and Madden (1933), had been widely used first with the pins set in a vertical position and later with the pins set at an angle of forty-five degrees. This "inclined point quadrat" method was shown by Tinney et al. (1937) to

have some advantages: the accuracy was increased because of the larger path through the vegetation, and it was easier to use particularly in taller growth. Goodall (1952) suggested that the pins be as fine as possible and also demonstrated differences due to observers.

A further study by Van Kewren and Ahlgren (1957) of several methods used in determining the botanical composition of swards showed that the "inclined point quadrat" method and visual estimates, based on the standing forage, provided satisfactory measures of the percentage composition of swards when compared with separating a sample of forage by hand. Of the visual estimates of percentage composition, the estimate based on the standing forage appeared to be more satisfactory than the estimate based on the green harvested forage. However, the reliability of both methods was influenced by the experience of the estimator. Estimates based on the standing crop could be made more rapidly where management treatments on the same forage (or pasture) were concerned. There was a tendency in this system to overestimate the percentage of clover, but all plots of the same mixture were overestimated approximately the same amount. Visual estimates of percentage composition permitted an increase in the number of samples, and good agreement between visual estimates and estimates based on hand separation methods were reported by Leasure (1949), Klapp (1935), and Nowosad (1947).

Tanner et al. (1960) studied the visual estimation and the hand separation methods of determining botanical composition of two component mixtures. Positive significant correlations were found between the per cent legume values obtained by the two methods. Visual estimates were less variable than hand separations and the precision was greater. The

differences between per cent legume values obtained by the two methods were influenced by the stage of maturity of the components (medium or late hay) and the cut (hay or aftermath) as the differences were significant only in the medium aftermath cut. Individually, three observers showed some inconsistencies between estimates on the medium and late maturing groups and between the hay and the aftermath cut. Both methods were more precise in the aftermath cut than in the hay. An additional observer increased the precision of the visual estimate more than an additional sample increased the precision of an estimate based on hand separation. Under the conditions of this experiment, the visual estimation method was superior to the hand separation method as a means of determining botanical composition.

At present two methods are used in making estimates of carrying capacity of range areas. The first of these is the point observation plot method or the square foot density method developed by Stewart and Hutchings (1936). This method utilizes a series of replicated plots from which the kind and amount of vegetation on a smaller area at a particular point are recorded. The plot usually contains one hundred square feet and for convenience is circular. It is marked off by drawing a circle around a point located mechanically and in no way selected. Satisfactory results were obtained from use of this method for depletion surveys, forage inventories, and for permanent plots; also for studies in range and pasture management, erosion control and in ecological observations.

The second of these methods is the ocular observation method. According to Shipley, et al. (1942) both of these methods make use of

the following factors in estimating carrying capacity: (1) forage density of the ground covered to 10/10 density by each plant species, (2) degree to which a plant should be grazed when the range is properly utilized, and (3) forage acre allowance expressed in forage acres needed to satisfy the daily grazing requirements of a mature animal for a specified time without injury to the range source. Forage acre allowance reflects only the amount of feed available from the plant composition on the area for which the forage acre is determined and connot be carried over from one range to another with any degree of accuracy. This Nevada work proved that estimates of carrying capacity were highly accurate provided they were based on the amount of forage the different plants were capable of contributing per square foot of density and when the forage-acre allowances were expressed in pounds of dry matter instead of in forage acres. Further investigation established that the forage allowance could be transferred from one locality to another with a measurable degree of accuracy regardless of the plant composition provided it is expressed in pounds required of air-dry forage per animal day (or month) instead of forage acres per animal day (or month).

A shortcut method of computing carrying capacity ratings was described by Harris (1941) in which many detailed computations were eliminated. The shortcut method was found applicable to the point observation plot and ocular reconnaissance methods of range survey, requiring no changes in the field procedure. A reduction in the time required to compute carrying capacity ratings from estimates of forage density was accomplished by the prearrangement of the coded products of density times the proper use factor (forage factor) on the write-up sheet.

Sums of these small whole numbers were converted to carrying capacity ratings by reference to tables found as a part of the write-up sheet.

CHAPTER III

EXPERIMENTAL PROCEDURE

The data for this investigation were obtained as a part of a long term pasture experiment entitled, "The Evaluation of Different Pasture Species in Various Combinations and at Varying Rates of Nitrogen Fertilization as Reflected in Beef Cattle Gains and Forage Yields", conducted by the University of Tennessee Animal Husbandry-Veterinary Science Department. Pastures in this experiment included various combinations of orchardgrass, Ladino clover, fescue, bluegrass, and other grasses and legumes. Varying amounts of nitrogen were applied to these pastures.

Each pasture was scored for twelve characteristics at two-week intervals during the winter and summer grazing seasons. Evaluation of the pastures in terms of animal performance was done by the "put and take" system. In this system certain steers were designated as test steers and they remained on their respective pastures for the entire grazing season. The forage in excess of that used by the test steers was removed by extra steers that were put on or taken off the pastures to control the height of the forage.

The scores and animal performance figures obtained during the summer grazing season on seven orchardgrass and Ladino clover pastures with similar seeding and management were selected to use in this study because of the value of orchardgrass and Ladino clover pastures to efficient beef cattle production in Tennessee. None of these plots received any nitrogen during the period of this study. The location and size of the plots and the years for which pasture scores and animal

performance measures were studied are given in Table I.

Scores for each plot were recorded on the Pasture Report Sheet as shown in Figure 1. The following twelve pasture characteristics were scored: orchardgrass percentage, legume percentage, orchardgrass average height, legume average height, orchardgrass stage of growth, legume stage of growth, condition of pasture, color, carrying capacity, thickness of sod, footing and grade. The data concerning weather and moisture conditions were not used in this work. The terms on the report sheet to explain the pasture characteristics are discussed in the following paragraphs.

Per cent of stand was a visual estimate of the per cent that each species made of the total forage available, both edible and non-edible, and not necessarily the per cent of ground cover. Three of the pastures contained small percentages of alfalfa but this was averaged with the Ladino clover giving legume percentage.

An estimated average height of each species, made from several locations in each plot was used for this investigation. However, estimates of the maximum and minimum height of each species were also made.

Stage of growth of the individual species referred to the growth period of the plant at the time of scoring. These stages were seasonal except after clipping. As new growth developed after clipping, the stage of growth cycle began anew. Each pasture was clipped once or twice each summer grazing season to control weeds.

Condition of the pasture was an overall rating of the pasture quality with respect to its feeding value. This condition was directly related to the stage of growth of each species. Prime was believed to

TABLE I

SOURCE OF DATA

Location	Year	No. of Test Plots	Size of Test Plots (Acres)	No. of Test Steers	28-day Periods
Springfield	1953	2	3	2	5
	1954	2	3	2	5
	1955	2	3	2	5
	1956	2	3	2	5
	1957	2	3	2	4
Greeneville	1956	3	2.5	3	5
	1957	3	2.5	3	5
	1958	3	2.5	2	5
	1959	3	2.5	2	5
Knoxville	1956	2	3	2	5
	1957	2	3	2	5
	1958	2	3	2	5
	1959	2	3	2	5

UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
ANIMAL HUSBANDRY - VETERINARY SCIENCE DEPARTMENT

Pasture Report

Station_____ Project_____ Date of Period_____

Lot No.	No.	SUB PERIOD 1 Date: Days on Regular Pasture	SUB PERIOD 1 No. Days: Days on Buffer Pasture	SUB PERIOD 2 Date: Days on Regular Pasture	SUB PERIOD 2 No. Days: Days on Buffer Pasture
Regular Animals					
Extra Animals					

SPECIES IN PASTURE

Common Name	% Total Stand	Height	Stage of Growth
			Young - Pre-bloom - Bloom - Seed-Dormant
			Young - Pre-bloom - Bloom - Seed-Dormant
			Young - Pre-bloom - Bloom - Seed-Dormant
			Young - Pre-bloom - Bloom - Seed-Dormant
			Young - Pre-bloom - Bloom - Seed-Dormant
			Young - Pre-bloom - Bloom - Seed-Dormant

GENERAL CONSIDERATIONS

1. Condition of Pasture: Prime - Washy - Succulent - Dry - Tough - Dead
2. Color: Very Green - Green - Brown - Drab
3. Carrying Capacity: Excess - Sufficient - Short - Insufficient
4. Thickness of Sod: Very Dense - Dense - Moderate - Thin
5. Footing: Firm - Soft - Very Soft
6. Grade: Excellent - Very Good - Good - Fair - Poor - Very Poor

WEATHER AND MOISTURE CONDITIONS

Date	Temperature Max.	Temperature Min.	Snow Inches	Rain Inches	Soil Moisture	Water Added

FIGURE 1

PASTURE REPORT FORM

be the most desirable stage of growth from the standpoint of palatability and beef gains. Washy was a term that usually referred to young, watery vegetation found early in the spring or summer. Succulent included young, tender growth that was not scored prime or washy. This usually included the new growth made after clipping. The term dry was used when the vegetation began turning brown from lack of moisture. A tough pasture was one that had become stemy and dry with insufficient edible forage for acceptable cattle gains. The lowest classification for condition of pasture was for pastures that were predominately dead.

The terms describing color of the pastures were very green, green, drab, and brown; with drab color appearing before brown.

Carrying capacity, the crux of the put and take system, was an estimate of how many animals the pasture would carry for the next two weeks based on the number of cattle in the pasture at the time of rating, season of the year, amount of soil moisture, composition of the pasture, stage of growth and average height of the pasture species.

The rating for thickness of the sod depended primarily on the amount of ground cover present.

Soft and very soft ratings for the footing of the pastures were used primarily in the wet winter period and the firm rating was used during the summer grazing season.

The grade of the pasture was an overall estimate of the grazing potential of the pasture, and all the other factors previously scored were considered. Percentage composition, height, and carrying capacity influenced the final grade more than did some of the other factors.

The summer grazing season usually began about April 1 and continued until approximately September 1. The average beginning and ending dates of the grazing seasons are shown in Table II. These dates varied from year to year due to various weather conditions. The starting dates at each station were different to allow time for travel. Once the experiment had started, scoring at fourteen-day intervals was followed.

The scoring was performed by a member of the Animal Husbandry-Veterinary Science staff with considerable experience in scoring pastures, assisted by the writer the last eighteen months of the evaluation. Close observation and study were required in evaluating each plot before a final score was recorded. Previous scores were not referred to, and a conscientious effort was made to score each plot as accurately as possible.

The experimental animals used were steer calves that weighed approximately 525-575 pounds and graded good to choice as stockers. Care was taken in the initial selection to obtain, as nearly as possible, calves similar in age, weight, type and condition. Two steers were used as test steers on each plot located at Springfield, Knoxville, and for the last two years at Greeneville; however, three steers were used as test steers for the first two years at Greeneville. The individual test steers were weighed at the beginning of the summer grazing season and at 28-day intervals throughout the experiment.

The forage in excess of that used by the test steers in each pasture was removed by extra steers put on or taken off the pastures to control the height of the forage. These changes were normally made at the regular two-week scoring times. Grazing days for the test and extra

TABLE II

RANGE OF BEGINNING AND ENDING DATES
BY SUMMER GRAZING PERIODS

Period	Beginning Dates Range Mo. Day to Mo. Day	Average Mo. Day	Ending Dates Range Mo. Day to Mo. Day	Average Mo. Day	Average Days in Period
1	3-26 to 5-1	4-5	4-23 to 5-15	5-2	27
2	4-6 to 5-15	4-29	5-4 to 6-12	5-28	29
3	5-19 to 6-12	5-30	6-16 to 7-10	6-27	28
4	6-16 to 7-10	6-27	7-14 to 8-7	7-25	28
5	7-14 to 8-7	7-25	8-11 to 9-4	8-22	28

steers were recorded on the pasture report at each two-week interval. Grazing days per acre by 28-day periods were obtained by adding the number of days the test steers and the extra steers were on the pastures. The estimated beef gains per acre for each 28-day period were then calculated by multiplying the daily gain of the test steers by the grazing days per acre for the period. The total beef gain per acre was an accumulation of the beef gain for each of the 28-day periods.

Correlations were computed between the twelve pasture characteristics and the three measures of the animal's performance. In order to make the computions using the scores a numerical coding system as shown in Table III was employed on the descriptive terms used on the Pasture Report Sheet. No coding was necessary for average height and percentage composition as the actual figures recorded were used. Averages of the two scores at the beginning and the midpoint of each 28-day period were used.

Correlations were computed using the data from the entire grazing season. Also correlations were computed separately for three of the 28-day periods, the first, the third, and the fifth or last period. At the Springfield station in the year 1957 only four 28-day periods were recorded. However, these fourth period figures were used with the last period figures in computing the correlations for the last period group. All other stations had a total of five 28-day periods during each summer grazing season. Location and year differences were removed by analysis of variance techniques. Correlations between each of the pasture measurements and average daily gain and total grazing days for the entire

TABLE III

CODE USED FOR DESCRIPTIVE TERMS ON PASTURE REPORT

Factor	Adjective	Numerical Code
1. Stage of growth	Young	5
	Prebloom	4
	Bloom	3
	Seed	2
	Dormant	1
2. Condition of pasture	Prime	6
	Washy	5
	Succulent	4
	Dry	3
	Tough	2
	Dead	1
3. Color	Very green	4
	Green	3
	Drab	2
	Brown	1
4. Carrying capacity	Excess	4
	Sufficient	3
	Short	2
	Insufficient	1
5. Thickness of sod	Very dense	4
	Dense	3
	Moderate	2
	Thin	1
6. Footing	Firm	3
	Soft	2
	Very soft	1
7. Grade	Excellent	6
	Very good	5
	Good	4
	Fair	3
	Poor	2
	Very poor	1

grazing season were also computed without removing location and year differences.

CHAPTER IV

RESULTS AND DISCUSSION

The individual periods and the entire grazing season presented different results when analyzed. With one hundred and thirty-five degrees of freedom, the correlations obtained for the entire grazing season were much more reliable than those obtained for the individual periods based on seventeen degrees of freedom. However, the correlations for the entire grazing season could be influenced by seasonal trends occurring both in the pasture characteristics and the measures of animal performance. Any resulting correlation might or might not indicate a direct relationship between the two items considered. The correlations computed for the individual periods would be influenced much less by such seasonal trends. Also the correlations for the individual periods could indicate seasonal changes in the relationship between any of the pasture characteristics and the measures of animal performance. In order to more adequately describe the populations studied, averages and standard deviations for the variables were computed for each 28-day period and for the entire grazing season.

I. AVERAGES FOR INDIVIDUAL PERIODS AND ENTIRE GRAZING SEASON

Averages and standard deviations of the variables studied for each 28-day period as well as those for the entire grazing season are given in Table IV. Additional information concerning individual station yearly averages of the variables studied is found in Appendix Tables X, XI, and XII.

TABLE IV

AVERAGES AND STANDARD DEVIATIONS OF VARIABLES STUDIED

Variable	Entire Grazing Season		First Period		Second Period		Third Period		Fourth Period		Fifth Period	
	$\bar{X}$	s*	$\bar{X}$	s*	$\bar{X}$	s*	$\bar{X}$	s*	$\bar{X}$	s*	$\bar{X}$	s*
Orchardgrass percentage	45.6	13.6	43.0	16.4	43.5	16.8	45.5	15.4	46.0	16.6	48.6	14.9
Orchardgrass average height	5.1	2.3	4.6	1.0	6.6	1.2	5.9	1.4	4.4	1.5	4.0	.8
Orchardgrass stage of growth	3.3	1.3	4.6	.9	3.5	.6	3.0	.7	2.6	.6	2.7	.5
Legume percentage	45.3	13.2	46.4	14.0	45.4	13.0	46.9	13.4	47.0	15.6	43.3	14.0
Legume average height	3.9	1.5	3.4	.7	5.0	.8	4.6	.8	3.8	.8	2.9	.6
Legume stage of growth	3.5	1.0	4.8	.0	4.0	.1	3.0	.2	2.8	.4	2.9	.3
Condition of pasture	4.1	.7	4.6	.2	4.4	.3	4.2	.4	3.9	.4	3.6	.4
Color	3.0	.7	3.2	.3	3.3	.2	3.1	.2	2.8	.3	2.5	.4
Carrying capacity	3.0	.7	3.2	.3	3.3	.3	3.0	.3	3.0	.2	2.8	.3
Thickness of sod	2.8	.7	2.8	.4	2.9	.4	3.0	.5	2.7	.3	2.5	.4
Footing	2.9	.3	2.7	.2	2.8	.0	3.0	.0	3.0	.0	3.0	.0
Grade	4.3	.9	4.2	.4	4.8	.6	4.6	.5	4.4	.4	3.7	.5
Average daily gain	1.54	1.0	1.48	.6	2.22	.7	1.57	.5	1.07	.4	1.38	.5
Total grazing days	34.9	14.2	36.4	9.3	45.4	19.8	38.9	7.6	31.0	7.8	23.3	5.2
Total beef gain	56.5	39.0	53.5	27.2	95.0	29.5	59.4	26.2	37.8	11.4	36.8	14.9

*Based on the within year-station subgroup mean squares.

The average percentage of orchardgrass and average percentage of the legumes for the total grazing season were similar being 45.6 per cent and 45.3 per cent respectively. While the percentage of orchardgrass ranged from 43.0 per cent in the first period to 48.6 per cent in the fifth period, the legume percentage was consistently around 46.0 per cent through the fourth period, then it dropped to 43.3 per cent in the fifth period. Although this drop was not large, it indicates that the legume percentage may decline as the grazing season nears the end and dry weather conditions are more pronounced. The percentage of species remaining, which consisted of other grasses and weeds, ranged from a high of 11.1 per cent in the second period to a low of 7.0 per cent in the fourth period.

Both the orchardgrass and the legume reached their maximum average height during the second period. Dates for this period usually were during the month of May. Stage of growth averages for each species steadily declined as the grazing season progressed.

The average score for condition of the pasture was 4.1 or succulent. Succulent was the average rating for the individual periods until the latter portion of the grazing season when moisture was becoming scarce.

Color scores were green until approximately July 1 or the beginning of the fourth period. After that average scores for each period were just under the green rating or between drab and green.

Carrying capacity scores averaged 3.0 or sufficient for the entire grazing season. Each individual period except the fifth averaged 3.0 or higher for carrying capacity. Since most of the pastures contained three acres each, carrying capacity ratings did not go below the sufficient

rating during the part of the grazing season when moisture was present. Because the Greeneville pastures contained two and one-half acres each, the rating did drop somewhat during the fifth period when pastures normally became shorter.

Thickness of sod scores ranged from a high of 3.0 in the third period to a low of 2.5 in the fifth period which indicated that the maximum ground cover was evidenced in the second and third periods (May and June). The average height of the two species reached a maximum during the second and third periods also.

Footing scores were lower in the beginning of the season and reached a peak of 3.0 or firm in the third period. By June 1 the excess moisture had vanished and the maximum rating, firm, continued throughout the grazing season. No variation from the mean occurred from the second period through the fifth period as scores for all plots at each station in a given year were the same.

Slightly higher grade scores were observed in the second period than in the first. Following the rise the scores steadily declined in each succeeding period. This same trend was observed in average scores for orchardgrass average height, legume average height, color, and carrying capacity. Similarity in these characteristics would seem to indicate that height of species, color, and carrying capacity were considered when scoring for final grade.

The averages for average daily gain were very irregular throughout the grazing season.

Total grazing days averages presented the same trend seen in the grade averages. Probably these trends were due to the same basic reasons.

Usually the test steers were started on the test plots in the beginning of the grazing season. Then as more pasture was available during the second period, extra steers were added to the pastures; therefore, more grazing days per acre were recorded. After a high of 45.4 grazing days per acre was reached in the second period, the grazing days declined each period ending with 23.3 grazing days per acre for the fifth period. Even though the pasture may have become short in the latter part of the grazing season, the test steers remained on the pastures.

Total beef gain per acre, determined by obtaining the product of average daily gain for test steers and total grazing days per acre, presented the same trend seen in the trends for its components (average daily gain and total grazing days).

II. CORRELATIONS OF VARIABLES STUDIED WITH AVERAGE DAILY GAIN

The correlations obtained between average daily gain and the pasture characteristics are found in Table V.

A majority of the correlations obtained represented only small portions of the variation in average daily gain. The highest correlations between a pasture characteristic and average daily gain for the entire grazing season were .18 between legume average height and average daily gain and .17 between condition of pasture and average daily gain. These correlations, even though they were statistically significant, indicated that only two or three per cent of the variation in average daily gain was linearily associated with variations in legume average height and condition of pasture.

TABLE V

CORRELATIONS OF AVERAGE DAILY GAIN WITH TWELVE PASTURE CHARACTERISTICS (STATION AND YEAR DIFFERENCES REMOVED)

Variable	Entire Grazing Season	First Period	Third Period	Fifth Period
Orchardgrass percentage	-.12	.38	.01	-.47*
Orchardgrass average height	.03	.07	.07	-.20
Orchardgrass stage of growth	.05	.13	-.25	-.28
Legume percentage	.12	-.36	.20	.43
Legume average height	.18*	.12	.41	.08
Legume stage of growth	.13	.00	.06	-.04
Condition of pasture	.17*	.12	-.04	.20
Color	.13	-.35	.13	.16
Carrying capacity	.08	.15	.34	-.08
Thickness of sod	.06	.07	.61**	.30
Footing	.06	.02	.00	.00
Grade	.15	.27	.67**	.14

*P = 0.05 or less.

**P = 0.01 or less.

As mentioned earlier, the correlations may have been lowered by removing the variation between stations and years before making the calculations. Therefore, correlations were also computed between the twelve pasture characteristics and average daily gain for the entire grazing season ignoring station and year differences. The correlations shown in Table VI were very similar to those obtained when station and year differences were removed.

Correlations for the individual periods were different from the correlations for the entire grazing season in many instances. The following paragraphs will contain a discussion of the correlations for each pasture characteristic and average daily gain.

The correlation between orchardgrass percentage and average daily gain was statistically significant only during the fifth period. This relationship was negative indicating that a higher percentage of orchardgrass was not conducive to higher average daily gains during the latter part of the grazing season. This retardation in daily gain could have been caused by the grass being dryer and less palatable. Although the coefficient for the first period was not significant, it was moderately high and positive. Thus it tended to counteract the high negative relationship that occurred in the fifth period when the data from the entire grazing season were considered.

The association of orchardgrass average height and average daily gain was not too high but it was higher in the fifth period than in any other period. Again this negative relationship was probably due to the quality of the grass during the hot, dry summer days of the fifth period.

TABLE VI

CORRELATIONS OF AVERAGE DAILY GAIN WITH TWELVE PASTURE CHARACTERISTICS (STATION AND YEAR DIFFERENCES INCLUDED)

Variable	Correlation for Entire Grazing Season
Orchardgrass percentage	-.08
Orchardgrass average height	.02
Orchardgrass stage of growth	.06
Legume percentage	.08
Legume average height	.13
Legume stage of growth	.11
Condition of pasture	.20*
Color	.14
Carrying capacity	.08
Thickness of sod	.09
Footing	.04
Grade	.14

*P = 0.05 or less.

Differences in the stage of maturity seemed to have little relationship with average daily gain over the entire grazing season. However, within individual periods the relationship changed from a positive to a negative one as the season progressed.

Correlations between legume percentage and average daily gain were not statistically significant, although they were relatively high. These correlations were practically the reverse of the correlations obtained for orchardgrass percentage. As the relationship for one species went up or down, its counterpart moved in the opposite direction. A vivid fact borne out by these figures is that a companionship of the two primary species involved may be the key to a good pasture mixture. During the early part of the grazing season when legumes are young and full of moisture making them not conducive to good cattle gains, a higher percentage of orchardgrass increases the daily gains. Likewise, in the latter part of the season the reverse of this is true with a higher percentage of legume being conducive to higher gains.

Average height of the legumes for the entire grazing season was significantly correlated with average daily gain. This correlation of .18 suggested that as the height of the legume increased, so did the daily gain. The reason for the correlation being lower in the fifth period than in the other periods was not readily known. It would seem that since the correlation of average daily gain with per cent legume was high in the same period that the correlation of average daily gain with legume height would likewise be high.

The stage of growth of the legume for the entire grazing season was positively correlated with average daily gain, although not

significantly. In any one period this relationship was not strong but for the entire grazing season it proved to be moderately strong. A correlation of zero was observed between the two variables during the first period because there was no variation in the stage of growth of legumes at that time.

Condition of the pasture proved to be significantly correlated with average daily gain when the entire grazing season was considered. Individual periods' correlations showed no definite trends.

A positive relationship of color to average daily gain was obtained for the entire grazing season but again this was not statistically significant. These correlations between color and average daily gain presented the same general pattern as seen between legume percentage and average daily gain.

Carrying capacity was only slightly related to average daily gain.

A highly significant correlation obtained in the third period between thickness of sod and average daily gain was not explainable. All other correlations were not statistically significant.

Final grade was highly correlated ($r=.67$) with average daily gain for the third period. One explanation for this correlation being higher in the third period than in the other periods is that one person scored a majority of the pastures. The scoring habits and relative values placed on the characteristics involved in determining the final grade were probably relatively constant throughout all scorings. It would seem logical that the importance of these characteristics involved in forming a grade would be changing throughout the grazing season;

therefore, the scorer was doing a better job in predicting average daily gain in the third period than he was in other periods.

III. CORRELATIONS OF VARIABLES STUDIED WITH TOTAL GRAZING DAYS

In determining whether or not extra steers were to be added to a respective lot, several factors such as average height of the primary species, stage of growth of the species, number of steers on the plot the previous two weeks, and predicted weather conditions were considered. Therefore, if too many or too few steers were added to the plots, the correlations for that period would be influenced by the error in the scorer's judgement. Too many steers added would raise the total grazing days and would tend to bias upward the correlations of total grazing days with those characteristics employed in determining carrying capacity. Also adding too many steers would lower the average daily gain and possibly the total beef gain.

A summarization of the findings concerning correlations between the pasture characteristics and total grazing days per acre is given in Table VII and will be discussed in the following paragraphs.

Several of the individual pasture characteristics were much more highly correlated with total grazing days than with average daily gain for the entire grazing season. Four of the variables, orchardgrass average height, legume average height, color, and grade, were individually associated with one-third or more of the variation in total grazing days for the entire grazing season. The correlations between each of these variables and total grazing days were as follows: orchardgrass average height, .58; legume average height, .68; color, .60; and

TABLE VII

CORRELATIONS OF TOTAL GRAZING DAYS WITH TWELVE PASTURE CHARACTERISTICS AND AVERAGE DAILY GAIN (STATION AND YEAR DIFFERENCES REMOVED)

Variable	Entire Grazing Season	First Period	Third Period	Fifth Period
Orchardgrass percentage	-.17*	-.15	.13	.15
Orchardgrass average height	.58**	.54*	.09	-.16
Orchardgrass stage of growth	.10	-.05	-.12	-.21
Legume percentage	.08	.29	.08	-.19
Legume average height	.68**	.33	.43	-.12
Legume stage of growth	.24**	.00	.09	-.09
Condition of pasture	.42**	.09	.25	.18
Color	.60**	.70**	-.26	-.11
Carrying capacity	.38**	.63**	.18	-.25
Thickness of sod	.46**	.47*	.52*	-.19
Footing	-.27**	-.02	.00	.00
Grade	.63**	.66**	.31	-.05
Average daily gain	.13	-.27	.26	.09

*P = 0.05 or less.

**P = 0.01 or less.

and grade, .63. Three other characteristics, thickness of sod, condition of pasture, and carrying capacity, were linearily associated with from fourteen to twenty-one per cent of the variation in total grazing days. The correlations were also computed for the entire grazing season ignoring station and year differences (Table VIII). These correlations between the pasture characteristics and total grazing days were lower in most cases when the station and year differences were included than they were when these differences were removed.

For a number of characteristics the relationship with total grazing days was considerably different for the entire grazing season than it was for the individual periods.

Significant results ($P < .05$) were obtained in correlating orchardgrass percentage with total grazing days for the entire grazing season. This correlation of -.17 was indicative of a higher orchardgrass percentage being associated with fewer total grazing days. This relationship was partially due to the fact that orchardgrass percentage increased during the grazing season while total grazing days decreased in the latter periods. In the third and last periods the relationship was positive which indicated that as orchardgrass percentage increased the grazing days increased.

The correlations between orchardgrass average height and total grazing days were significant both for the entire grazing season and for the first period. The relationship was such that as average height increased, total grazing days increased. Significant results were not obtained in the other two periods.

TABLE VIII

CORRELATIONS OF TOTAL GRAZING DAYS WITH TWELVE PASTURE CHARACTERISTICS AND AVERAGE DAILY GAIN (STATION AND YEAR DIFFERENCES INCLUDED)

Variable	Correlation for Entire Grazing Season
Orchardgrass percentage	-.05
Orchardgrass average height	.17*
Orchardgrass stage of growth	.05
Legume percentage	.01
Legume average height	.19*
Legume stage of growth	.09
Condition of pasture	.14
Color	.23**
Carrying capacity	.13
Thickness of sod	.25**
Footing	-.09
Grade	.24**
Average daily gain	.04

*P = 0.05 or less.

**P = 0.01 or less.

Orchardgrass stage of growth and total grazing days were correlated negatively for each individual period but positively correlated for the entire grazing season. This positive correlation was probably due to the fact that over the entire grazing season stage of growth scores decreased as total grazing days decreased.

Correlations for legume percentage with total grazing days were positive except in the fifth period. These correlations were not very high. However, the figure for the first period was greater than for any period for orchardgrass percentage.

Average height of legume was correlated significantly ($P < .01$) with total grazing days for the entire grazing season. The relationship changed from positive to negative between the third and last periods.

Although no individual period correlations between stage of growth of legumes and total grazing days were significant, the entire grazing season correlation was significant at the one per cent level of probability due to the accumulative effect when measured over the entire grazing season. The correlation was zero in the first period and essentially zero for each of the other individual periods because the stage of growth was fairly uniform within each of the periods.

Correlations for condition of pasture with total grazing days presented the same trend as that seen for the correlations between stage of growth of the legumes and total grazing days, with only the entire grazing season correlation being significant. As the condition of the pasture increased, the total grazing days increased. Only a very few of the pastures were scored prime or washy and a majority of them were rated succulent.

Color was highly correlated with total grazing days for the entire season and for the first period. As color became greener, the total grazing days increased. Causes for the abrupt change observed in this relationship in the third and last period were not readily known.

Significant positive correlations between carrying capacity and total grazing days for the entire grazing season and the first period were obtained. Individual period correlations changed from positive to negative from the first of the grazing season to the last. Other factors considered when scoring the pastures for this characteristic such as species composition and average height could have had an indirect effect on these correlations.

For the entire grazing season and for the first and third periods, thickness of sod was significantly correlated with total grazing days. As thickness of sod increased, the total grazing days increased.

Over the entire grazing season, the correlation between footing and total grazing days was significant ($P < .01$). However, correlations for the individual periods were low with those obtained in the third and last periods being zero, because all pastures within each station-year group were scored the same for footing.

Statistically significant correlations ($P < .01$) were obtained between pasture grade and total grazing days for the entire grazing season and for the first period. In the fifth period a negative relationship existed between grade and total grazing days due to the factors that were considered in determining grade being negatively correlated with total grazing days in that period.

The relationship between average daily gain and total grazing days for the entire grazing season was positive although not very large. In the first period as total grazing days increased, average daily gain decreased. For this first period plots that were below the average of their respective station-year group for average daily gain, tended more often than not to be above the average for total grazing days. Correlations between average daily gain and total grazing days were positive but insignificant in the third and fifth periods.

IV. CORRELATIONS OF VARIABLES STUDIED WITH TOTAL BEEF GAIN

Total beef gain was a calculated figure obtained by multiplying average daily gain times total grazing days; therefore, the previous discussion for the two animal performance measures will apply for beef gain correlations. More detailed information concerning these correlations is found in Table IX.

Orchardgrass percentage and orchardgrass average height presented statistically significant correlations with total beef gain when the total grazing season was analyzed. None of the other correlations involving orchardgrass and total beef gain was significant. For any one period or for the entire grazing season orchardgrass percentage and orchardgrass average height were not particularly good measures of total beef gain. However, for the entire grazing period these two characteristics did prove to be significant.

Legume average height was correlated significantly with total beef gain for the entire grazing season and for the third period. As average height increased, the total beef gain increased. The entire grazing

TABLE IX

CORRELATIONS OF TOTAL BEEF GAIN WITH TWELVE PASTURE CHARACTERISTICS, AVERAGE DAILY GAIN, AND TOTAL GRAZING DAYS (STATION AND YEAR DIFFERENCES REMOVED)

Variable	Entire Grazing Season	First Period	Third Period	Fifth Period
Orchardgrass percentage	-.26**	.23	.05	-.36
Orchardgrass average height	.28**	.33	.16	-.26
Orchardgrass stage of growth	.07	.08	-.29	.15
Legume percentage	.16	-.11	.24	.19
Legume average height	.47**	.25	.53*	-.03
Legume stage of growth	.21*	.00	.16	-.14
Condition of pasture	.32**	-.07	.09	-.07
Color	.39**	.05	-.01	-.02
Carrying capacity	.23**	.20	.31	-.25
Thickness of sod	.27**	.26	.63**	-.17
Footing	-.10	.01	.00	.00
Grade	.42**	.14	.62**	.00
Average daily gain	.78**	.68**	.90**	.17
Total grazing days	.59**	.51*	.60**	.41

*P = 0.05 or less.

**P = 0.01 or less.

season correlation between legume stage of growth and total beef gain was significant ($P < .05$) indicating that the younger the legume, the higher the total beef gain.

Condition of pasture, color and carrying capacity were all significantly correlated ($P < .01$) with total beef gain when computed for the entire grazing season. Correlations between these three characteristics and total beef gain were not significant for each of the individual periods.

Total beef gain and thickness of sod were correlated significantly ($P < .01$) for the entire grazing season and for the third period. The highly significant correlation of .63 in the third period was due probably to the high correlations for average daily gain and total grazing days with thickness of sod.

There was little relationship between footing and total beef gain and the correlations were practically zero in all cases.

The association of grade with total beef gain proved to be significant ($P < .01$) for the entire grazing season and for the third period.

Average daily gain and total grazing days were correlated significantly with total beef gain for the entire grazing season, first, and third periods. The correlations were much smaller in the last period. The total beef gain was more closely related to average daily gain than to total grazing days in all cases except the fifth period.

V. APPLICATION

In the Tennessee system of beef production, where pastures play such a vital role, a greater dollar return from each acre of pasture is desired. This increase in pasture returns will depend on how efficiently the total grazing days per acre is increased without decreasing the average daily gain. Since total beef gain is a product of average daily gain and total grazing days, total beef gain is the logical guide to increasing acre returns from pasture.

The benefits of the pasture scoring system depend on whether it is to be used for research or for practical purposes. One of its greatest benefits is that of providing a system for keeping pasture records. This valuable information should be useful to the farm manager or land use planner in making allotments of beef cattle to orchardgrass-Ladino clover pastures in Tennessee. Another benefit, applicable for farm or for research purposes, would be that certain animal and pasture management problems could possibly be avoided because the scorer would observe the cattle and the pastures in detail at least every two weeks.

The results of this investigation show that individually none of the pasture characteristics was very closely related to average daily gain, whereas many of the pasture characteristics were fairly closely related to total grazing days per acre. Therefore, total grazing days can be predicted more accurately from the visual observations studied in this work.

If the pasture scoring system is to be continued, certain measures should be taken to shorten the scoring procedure. The most important pasture characteristics should continue to be scored and the scoring of

the pasture characteristics having the least value should be discontinued. The inclusion of unimportant pasture characteristics increases not only the time required for scoring the pastures but also the work required to summarize the research data.

On the basis of the correlations of the individual characteristics with total beef gain per acre for the entire grazing season, orchardgrass stage of growth and footing could be eliminated from the scoring sheet. If any one period of the summer grazing season was studied, using correlations of the pasture characteristics with total beef gain as the basis of evaluating the pasture data, legume stage of growth, condition of pasture, color, and footing could be eliminated from the scoring sheet. However, indications were that the relations of the variables studied with total beef gain changed from period to period within the summer grazing season.

Some of the pasture characteristics suggested for elimination from the pasture scoring system might actually be interrelated in such a way that they would not be independent predictors of total beef gain. A multiple regression analysis would be the only way to determine what the optimum combination of the variables might be.

CHAPTER V

SUMMARY

A statistical study was made on a group of pasture subjective scores for the purpose of evaluating a pasture scoring system. Animal performance was used as the basis of the evaluation.

Seven established pastures primarily composed of orchardgrass and Ladino clover and located at three different locations were scored twice each twenty-eight day grazing period during the summer grazing season. A numerical coding system was applied to the terms used in scoring the pasture characteristics which included orchardgrass percentage, legume percentage, orchardgrass average height, legume average height, orchardgrass stage of growth, legume stage of growth, condition of pasture, color, carrying capacity, thickness of sod, footing and grade. Averages for the two scores made each period were obtained.

Test steers were assigned each plot with additional steers being added as needed according to the "put and take" system. Records were kept concerning their performance with the weights of the steers recorded every twenty-eight days. Average daily gain of the test steers, total grazing days per acre, and total beef gain per acre were computed and used as the animal performance measures.

Correlations were made between each of the pasture characteristics and each of the animal performance measures for all of the twenty-eight day periods in the entire summer grazing season and also for each of the first, third, and last period groups.

Legume average height and condition of pasture when correlated with average daily gain for the entire grazing season were .18 and .17 respectively and were significant. These figures accounted for only approximately three per cent of the variation in average daily gain.

Although no significant correlations were obtained in the first period, orchardgrass percentage, legume percentage and color were more highly related with average daily gain than any of the other characteristics and were responsible for from twelve to fourteen per cent of the variation in average daily gain in the first period.

In the third period thickness of sod and grade correlations were .61 and .67 respectively. These significant correlations ($P < .01$) were two of the highest obtained in the evaluation and each accounted for approximately forty per cent of the variation in average daily gain. Legume average height, when correlated with average daily gain, approached the significant level with a correlation of .41.

Orchardgrass percentage correlated significantly ($P < .05$) with average daily gain in the fifth period with a correlation of .47. The legume percentage and average daily gain correlation of .43 was relatively high but insignificant.

All pasture characteristics except orchardgrass stage of growth and legume percentage correlated significantly with total grazing days for the entire grazing season. Those correlations between total grazing days and orchardgrass average height, legume average height, color, thickness of sod, and grade, were .58, .68, .60, .46, and .63 respectively. Each of these traits was associated with more than twenty per cent of the variation in total grazing days.

In the first period when correlated with total grazing days per acre, orchardgrass average height, color, carrying capacity, thickness of sod, and grade correlated significantly. Each of these correlations accounted for better than twenty per cent of the variation in total grazing days during the first period.

Legume stage of growth and footing, when correlated with total grazing days, were relatively high in the third period with the latter characteristic's correlation being significant ($P < .05$).

None of the pasture characteristics explained more than six per cent of the variation in total grazing days in the fifth period, nor were they significant when correlated with total grazing days in the fifth period.

During the entire grazing season total beef gain correlated significantly with each of the pasture characteristics except orchardgrass stage of growth, legume percentage and footing. Most of these significant correlations were relatively low and each accounted for only twenty per cent or less of the variation in total beef gain in the entire grazing season.

No significant correlations were obtained between any of the pasture characteristics and total beef gain per acre in the first period and none of the correlations were relatively high.

Legume average height, thickness of sod, and grade correlations (.53, .63, and .62 respectively) were significant when correlated with total beef gain per acre in the third period. Better than twenty-eight per cent of the variation in total beef gain in the third period was explained by each of these characteristics.

None of the pasture characteristics, when correlated with total beef gain in the fifth period, were relatively high and none were statistically significant.

The correlations between average daily gain and total grazing days per acre were insignificant and relatively low for the entire grazing season and for each individual period.

Total grazing days per acre and average daily gain correlated significantly with total beef gain for the entire grazing season and for the first and third periods. These significant correlations were relatively high with average daily gain accounting for approximately eighty-one per cent of the variation in total beef gain in the third period.

LITERATURE CITATIONS

LITERATURE CITED

Ahlgren, H. L., G. Bohstedt, and O. S. Aamodt. 1938. Problems in evaluating pastures in relation to other crops. J. of Am. Soc. of Agronomy 30:1020.

Ahlgren, A. H. 1947. A comparison of methods used in evaluating the results of research. J. of Am. Soc. of Agronomy 39:240.

Anderson, K. L. 1942. Comparison of line transects and permanent quadrats in evaluating composition and density of pasture vegetation of tall prairie grass type. J. of Am. Soc. of Agronomy 34:805.

Black, W. H. and D. A. Savage. 1948. Grass for the production of beef. U.S.D.A. Yearbook of Agr. 103.

Brown, D. 1954. Methods of surveying and measuring vegetation. Bradley and Son, Ltd., The Crown Press. Reading, England.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. Forages 39:388.

Castle, M. E. 1955. Methods of evaluating grassland production in temperate zones. Herbage Abstr. 25:1.

Goodall, D. W. 1952. Some considerations in the use of point quadrats for the analysis of vegetation. Australian J. Sci. Res., Series B, Vol. 5.

Harris, F. B. 1941. A shortcut method of computing grazing capacity ratings from range survey forage estimates. Nev. Agr. Exp. Sta. Bul. 155.

Jones, I. 1937. The comparative value of pastures as measured by the grazing animal. Proc. Fourth Inter. Grasslands Cong. 386.

Klapp, E. 1935. Methods of studying grassland stands. Herbage Rev. 3:1.

Leasure, J. K. 1949. Determining the species composition of swards. Agronomy J. 41:204.

Levy, E. B. and E. A. Madden. 1933. The point method of pasture analysis. New Zealand J. Agr. 46:267.

L'Hote, H. T. 1942. Measuring the productive value of pastures. Mo. Agr. Exp. Sta. Bul. 443.

Nowosad, F. S., and T. M. Stevenson. 1947. The relative value of certain grass-legume mixtures for hay and pastures in short-term rotations. Sci. Agr. 27:86.

Pasto, J. K., J. R. Allison, and J. B. Washko. 1957. Ground cover and height of a sward as a means of estimating pasture production. Agronomy J. 49:407.

Shipley, M. A., C. E. Fleming, and B. S. Martineau. 1942. Estimating the value of forage for grazing use by means of an animal unit-month factor table. Nev. Agr. Exp. Sta. Bul. 160.

Stewart, G., and S. S. Hutchings. 1936. The point-observation-plot (square-foot density) method of vegetation survey. J. of Am. Soc. of Agronomy. 28:714.

Tanner, J. W., E. E. Gamble, and W. E. Tossell. 1960. Determination of botanical composition of two-component forage mixtures. Canadian J. of Plant Sci. 40:225.

Tinney, F. W., O. S. Aamodt, and H. L. Ahlgren. 1937. Preliminary report of a study on methods used in botanical analyses of pasture swards. J. of Am. Soc. of Agronomy 29:835.

Van Kewren, R. W., and H. L. Ahlgren. 1957. A statistical study of several methods used in determining the botanical composition of a sward: I. Study of established pastures. Agronomy J. 49:532.

Van Kewren, R. W., and H. L. Ahlgren. 1957. A statistical study of several methods used in determining the botanical composition of a sward: II. A study of several forage mixtures. Agronomy J. 49:581.

Wagner, R. E. 1952. Weight estimation and other procedures for measuring the botanical composition of pastures. Proc. Sixth Inter. Grasslands Cong. 2:1315.

APPENDIX

TABLE X

YEARLY AVERAGES OF VARIABLES STUDIED AT SPRINGFIELD

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Orchardgrass percentage	1953	43.1	43.5	45.2	41.8	46.2	38.8
	1954	29.8	31.0	32.5	28.8	25.0	31.2
	1955	11.1	11.2	12.5	11.8	10.0	10.0
	1956	9.6	7.5	11.5	13.0	10.8	5.8
	1957	21.6	23.8	22.5	17.0	22.5	
Orchardgrass average height	1953	7.0	7.5	10.0	8.8	4.5	4.2
	1954	5.0	4.0	7.0	6.2	4.2	3.4
	1955	2.3	1.8	2.0	2.5	3.8	1.6
	1956	3.0	1.8	4.2	3.8	3.1	2.4
	1957	3.9	2.1	5.2	4.1	4.0	
Orchardgrass stage of growth	1953	2.7	5.0	3.2	3.2	1.0	1.0
	1954	2.9	5.0	3.9	2.7	1.8	1.6
	1955	2.1	5.0	1.5	1.4	1.5	1.0
	1956	2.8	2.5	5.0	3.2	1.5	1.5
	1957	3.6	5.0	4.0	3.8	1.7	
Legume percentage	1953	48.0	45.5	36.2	51.2	45.8	61.2
	1954	55.9	49.5	42.2	55.0	61.2	66.5
	1955	76.6	77.2	69.0	71.0	82.2	83.5
	1956	88.4	86.5	85.0	82.0	84.0	94.8
	1957	67.4	50.0	68.8	78.5	72.5	
Legume average height	1953	6.8	6.8	9.2	9.2	4.2	4.8
	1954	5.2	3.6	6.5	7.2	5.5	3.2
	1955	5.2	2.5	5.5	6.5	7.8	3.6
	1956	3.9	3.1	6.2	4.5	3.1	2.4
	1957	4.0	1.6	5.2	4.2	5.0	
Legume stage of growth	1953	3.3	5.0	3.5	3.0	2.0	3.2
	1954	3.4	5.0	4.2	3.0	3.0	2.0
	1955	3.5	5.0	4.0	3.0	2.8	2.6
	1956	3.6	5.0	5.0	3.5	2.5	2.0
	1957	4.0	5.0	5.0	3.2	2.6	

TABLE X (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Condition of pasture	1953	4.1	5.0	5.0	4.5	2.5	3.7
	1954	3.6	4.5	4.0	4.0	3.5	1.9
	1955	3.7	2.5	4.5	4.5	4.0	3.2
	1956	4.1	5.0	5.0	4.0	3.5	3.0
	1957	4.6	4.8	5.0	4.5	4.0	
Color	1953	2.7	3.0	3.2	3.0	1.2	3.0
	1954	2.6	3.0	3.0	3.2	2.0	1.5
	1955	3.2	2.5	3.8	4.0	4.0	2.0
	1956	3.4	3.8	4.0	4.0	3.0	2.0
	1957	3.4	3.0	3.0	4.0	3.8	
Carrying capacity	1953	3.4	4.0	3.8	4.0	2.2	3.0
	1954	3.2	3.0	3.8	4.0	3.5	2.0
	1955	3.2	2.5	3.8	3.2	4.0	2.5
	1956	2.9	3.5	3.5	2.0	3.0	2.5
	1957	3.0	2.5	3.5	3.2	3.0	
Thickness of sod	1953	2.6	2.5	2.8	3.8	1.8	2.8
	1954	2.4	2.0	2.5	3.0	2.5	1.8
	1955	3.0	2.2	3.2	3.5	3.8	2.2
	1956	3.0	3.8	4.0	3.0	2.5	1.5
	1957	2.8	2.0	2.8	3.2	3.0	
Footing	1953	2.7	3.0	1.5	3.0	3.0	3.0
	1954	3.0	3.0	3.0	3.0	3.0	3.0
	1955	2.8	2.2	3.0	3.0	3.0	3.0
	1956	3.0	3.0	3.0	3.0	3.0	3.0
	1957	2.9	2.5	3.0	3.0	3.0	
Grade	1953	4.6	5.5	5.0	4.8	3.5	4.0
	1954	4.6	3.5	5.5	5.8	5.5	2.5
	1955	4.8	3.2	5.0	6.0	6.0	3.8
	1956	4.4	5.5	5.0	4.8	4.0	2.8
	1957	5.0	3.0	5.5	5.5	6.0	

TABLE X (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Average daily gain	1953	1.71	2.83	1.60	1.66	-.09	2.54
	1954	1.13	-.36	2.99	.62	1.83	.56
	1955	1.45	.59	2.81	1.43	1.52	.89
	1956	1.60	.90	1.83	1.47	1.56	2.23
	1957	1.40	1.04	1.96	1.07	1.52	
Total grazing days	1953	31.7	21.5	58.0	38.7	20.5	19.7
	1954	28.1	21.5	30.6	46.4	28.4	13.7
	1955	36.3	22.6	46.5	42.0	50.1	20.2
	1956	39.7	35.4	67.2	53.3	29.0	13.7
	1957	34.4	23.3	38.5	37.8	38.5	
Total beef gain	1953	53.5	61.3	91.9	67.0	-2.7	50.0
	1954	34.8	-8.2	88.4	28.7	51.0	13.8
	1955	59.4	13.4	128.6	60.0	76.4	18.3
	1956	62.5	31.5	120.0	74.4	45.2	41.6
	1957	48.6	24.2	73.7	40.0	57.0	

TABLE XI

YEARLY AVERAGES OF VARIABLES STUDIED AT GREENEVILLE

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Orchardgrass percentage	1956	43.1	34.3	31.3	46.7	48.0	55.2
	1957	47.1	43.3	44.5	42.7	48.8	56.3
	1958	64.0	67.8	63.8	62.2	64.0	62.0
	1959	79.1	70.0	82.8	83.2	80.3	79.3
Orchardgrass average height	1956	4.6	6.7	5.0	4.2	4.2	3.0
	1957	4.7	6.4	3.4	5.8	4.4	3.4
	1958	6.3	7.0	9.0	3.8	6.2	5.5
	1959	5.7	6.2	10.7	4.8	3.3	3.7
Orchardgrass stage of growth	1956	4.0	4.0	3.5	4.5	4.0	4.0
	1957	3.8	4.0	3.2	4.8	3.1	4.0
	1958	3.8	5.0	3.0	2.3	4.0	4.5
	1959	3.1	4.5	3.0	1.7	2.5	4.0
Legume percentage	1956	39.8	34.7	41.0	40.0	45.3	38.2
	1957	44.0	50.7	47.0	48.2	41.3	32.8
	1958	30.8	27.0	30.3	33.2	31.2	32.3
	1959	13.3	24.0	9.5	9.3	12.2	11.3
Legume average height	1956	4.2	5.7	4.7	3.6	4.0	3.0
	1957	3.9	4.5	3.4	5.7	3.2	2.7
	1958	4.0	3.3	5.7	2.6	4.7	3.8
	1959	2.5	2.7	2.8	2.8	2.1	2.1
Legume stage of growth	1956	3.5	4.0	3.5	3.2	3.2	3.3
	1957	3.9	4.5	3.5	4.2	3.2	4.0
	1958	3.6	5.0	4.5	2.0	3.0	3.7
	1959	3.3	4.5	3.0	2.2	2.7	4.0

TABLE XI (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Condition of pasture	1956	4.0	4.0	4.0	4.3	4.0	3.6
	1957	4.7	5.0	4.3	5.3	4.7	4.0
	1958	4.0	5.0	3.7	3.5	4.0	4.0
	1959	3.9	4.5	4.0	3.3	4.0	3.5
Color	1956	2.9	3.3	3.0	3.0	3.2	2.2
	1957	3.3	3.7	3.2	4.0	2.8	2.9
	1958	3.1	3.8	3.5	2.0	3.2	3.0
	1959	2.8	3.3	3.0	2.0	3.0	2.5
Carrying capacity	1956	2.9	3.7	2.3	3.0	2.8	2.5
	1957	3.0	3.5	2.5	3.5	2.8	2.7
	1958	3.1	3.5	3.2	2.3	3.7	2.7
	1959	2.9	3.5	2.5	2.3	3.2	3.0
Thickness of sod	1956	2.9	3.7	2.3	2.8	2.8	3.0
	1957	3.5	3.7	3.3	4.0	3.7	2.8
	1958	3.0	3.0	3.2	3.0	3.0	3.0
	1959	2.8	3.0	2.8	2.7	2.5	3.2
Footing	1956	2.7	2.0	3.0	3.0	3.0	2.5
	1957	3.0	3.0	3.0	3.0	3.0	3.0
	1958	2.8	2.5	2.5	3.0	3.0	3.0
	1959	3.0	3.0	3.0	3.0	3.0	3.0
Grade	1956	4.1	4.3	3.8	4.3	4.5	3.7
	1957	4.9	5.5	5.0	5.7	4.3	4.0
	1958	4.6	4.8	4.8	3.7	5.0	4.5
	1959	3.9	4.5	4.3	3.3	4.0	3.5

TABLE XI (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Average daily gain	1956	1.67	1.50	3.38	1.83	.54	1.13
	1957	1.88	1.41	3.31	1.68	1.69	1.29
	1958	1.48	1.58	1.61	1.37	1.13	1.71
	1959	1.23	1.91	.69	1.67	1.73	.15
Total grazing days	1956	33.8	59.6	42.9	33.6	20.7	12.3
	1957	40.5	46.7	44.8	44.8	37.3	28.9
	1958	45.1	49.9	59.7	33.6	45.1	37.3
	1959	41.3	59.6	54.1	29.9	31.7	31.2
Total beef gain	1956	72.7	91.5	137.8	66.2	18.8	49.2
	1957	77.5	57.6	153.1	78.0	62.2	36.7
	1958	66.8	77.8	95.3	42.7	49.6	68.6
	1959	52.2	113.5	37.4	50.7	53.8	5.6

TABLE XII

YEARLY AVERAGES OF VARIABLES STUDIED AT KNOXVILLE

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Orchardgrass percentage	1956	43.2	41.2	39.5	40.0	50.0	45.0
	1957	51.8	39.0	44.0	57.8	48.2	70.2
	1958	61.3	55.8	56.8	54.2	65.0	74.8
	1959	58.0	68.8	54.0	65.2	49.8	52.5
Orchardgrass average height	1956	5.8	4.5	9.2	6.5	4.1	4.8
	1957	4.8	3.1	6.5	4.9	6.0	3.8
	1958	7.6	1.9	8.2	15.2	4.6	8.2
	1959	4.8	2.8	4.9	8.0	3.9	4.6
Orchardgrass stage of growth	1956	3.4	5.0	3.5	2.8	3.0	3.0
	1957	3.2	5.0	3.5	2.2	4.2	1.0
	1958	3.8	5.0	4.5	2.5	2.2	5.0
	1959	2.8	5.0	4.5	2.5	1.2	1.0
Legume percentage	1956	54.7	53.5	60.0	60.0	50.0	50.0
	1957	44.0	58.0	53.8	41.2	49.5	17.2
	1958	34.8	39.8	37.8	42.8	31.2	22.5
	1959	22.8	31.2	30.8	21.0	22.0	9.2
Legume average height	1956	4.4	3.9	7.5	4.2	3.0	3.5
	1957	3.0	2.1	4.5	2.9	4.2	1.2
	1958	2.7	1.3	3.2	5.0	2.0	1.8
	1959	1.6	1.0	2.2	2.2	1.6	1.0
Legume stage of growth	1956	3.2	5.0	3.5	2.8	2.5	2.0
	1957	3.0	5.0	3.5	2.5	3.2	1.0
	1958	3.9	5.0	5.0	3.5	2.5	3.5
	1959	3.2	5.0	4.5	3.0	2.0	1.2

TABLE XII (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Condition of pasture	1956	4.3	5.0	4.8	5.0	3.5	3.3
	1957	4.2	5.0	4.5	4.0	5.0	2.6
	1958	4.4	5.0	4.5	4.0	3.5	5.0
	1959	4.1	4.0	4.5	4.0	4.0	4.0
Color	1956	2.8	3.2	3.5	3.0	2.0	2.0
	1957	2.6	3.0	3.5	2.5	3.0	1.0
	1958	2.8	3.0	3.2	3.2	1.7	3.0
	1959	3.0	3.0	3.0	3.0	3.0	3.0
Carrying capacity	1956	3.2	3.5	4.0	2.5	2.5	3.5
	1957	3.2	3.2	3.5	3.2	3.0	2.8
	1958	2.9	2.0	4.0	3.5	2.0	3.0
	1959	2.8	2.2	3.5	2.8	2.8	3.0
Thickness of sod	1956	2.7	2.8	3.2	2.8	2.2	2.5
	1957	2.8	2.8	3.2	3.0	3.0	2.0
	1958	2.8	2.5	2.8	3.2	2.8	2.5
	1959	1.6	1.5	2.0	1.5	1.5	1.5
Footing	1956	3.0	3.0	3.0	3.0	3.0	3.0
	1957	3.0	3.0	3.0	3.0	3.0	3.0
	1958	2.8	2.5	3.0	2.5	3.0	3.0
	1959	3.0	3.0	3.0	3.0	3.0	3.0
Grade	1956	4.4	4.2	5.2	4.8	3.5	4.0
	1957	4.4	4.2	5.5	4.2	5.2	2.8
	1958	3.6	2.5	4.2	5.0	2.8	3.8
	1959	3.2	3.2	3.5	3.2	3.2	3.0

TABLE XII (continued)

Variable	Year	Entire Grazing Season	First Period	Second Period	Third Period	Fourth Period	Fifth Period
Average daily gain	1956	1.59	.74	1.65	2.10	.71	2.76
	1957	1.72	2.22	2.50	1.42	1.42	1.02
	1958	1.44	2.65	1.29	1.04	1.64	.58
	1959	1.67	2.01	3.22	2.86	-1.74	1.99
Total grazing days	1956	30.1	25.6	38.6	44.4	18.7	23.2
	1957	33.4	30.4	45.5	32.7	39.7	18.7
	1958	28.5	18.0	31.0	56.0	18.7	18.7
	1959	20.4	18.7	22.5	23.4	18.7	18.7
Total beef gain	1956	50.6	18.6	63.9	92.6	13.3	64.4
	1957	59.1	65.8	108.3	45.8	56.5	19.7
	1958	36.8	47.5	42.0	57.0	26.4	10.8
	1959	36.9	37.5	72.6	70.0	-32.5	37.2