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TALLGRASS PRAIRIE RANGE ASSESSMENT TECHNIQUES

by Sally A. Wilk and James M. Mayo*

ABSTRACT

A scorecard method for determining range condition was developed for the tallgrass prairie of east central Kansas. It was designed for use primarily by non-professional range managers. Data were collected by the step-loop method of determining vegetation composition and density. The step-loop data were entered into both a vegetation scorecard and a soil stability scorecard to determine overall condition classification of a range site. To assure the information obtained by the step-loop method was a reliable index to vegetation composition and density, plots were clipped by the frame-point method and estimates of basal density were made. It was shown that as the number of step-loop hits on decreaser species and increaser species increased, so did the lbs/acre dry-weight production and basal density. This indicated the step-loop method was a reliable index to vegetation composition and density.

Because range condition is closely related to range utilization, stubble height curves for determining the utilization of *Andropogon gerardi* Vitman., *A. scoparius* Michx., *Sorghastrum nutans* (L.) Nash., and *Panicum virgatum* L. were formulated. Since native grasses have two mature forms, those that produce seedstalks and those that do not produce seedstalks, two stubble height curves were formulated for each species. One curve was for use during a year in which seedstalks dominate (normal or favorable year) and the other curve was for use during a year in which seedstalks do not dominate (unfavorable year).

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INTRODUCTION

Range management as a science has existed only since the turn of the century. In the late 1800's, the disaster of long-term overgrazing struck the western and southwestern ranges of the United States forcing the initiation of research for the intelligent use of rangelands. Since its birth, range management has become a science rooted in the application of ecological principles (Stoddart et al. 1975).

Range Condition

Maximum productivity of native tallgrass prairie rangelands is best achieved by maintaining the climax or near climax vegetation. For a variety of reasons, many native tallgrass prairie rangelands have regressed from these optimum conditions. The ability to recognize the successional stage of a particular range site (i.e. its degree of departure from climax) is necessary for proper range management and analysis of range trend (i.e. the trend of range condition).

The current composition and productivity of the vegetation of a particular range site compared to its potential composition and productivity (i.e. climax) is referred to as range condition. Early in the history of range management, range condition was determined by reconnaissance surveys, i.e. a judgment based upon what the range examiner saw on a site and what the examiner knew from experience could potentially be there. Since those early days, a variety of methods has been developed to evaluate range condition more objectively based upon ecological principles (Humphrey 1947, Humphrey 1949, Humphrey and Lister 1941, Dyksterhuis 1949, Weaver and Hansen 1941, Parker 1950, Parker 1951, Parker 1954, Voight and Weaver 1951, and Evans and Love 1957, Stoddart 1935, Hutchings and Holmgren 1959).

In this study, a combination and modification of the methods of Parker (1950, 1951) and Evans and Love (1957) were chosen as the method for determining range condition. It was felt that such a combination would provide a simple, practical, fast and easy-to-learn method for determining range condition. Other methods were rejected because: (1) reconnaissance surveys provide no record of vegetation composition and range condition and require a high degree of training in order to obtain accurate results; (2) Humphrey's (1949) method relies on the often inaccurate forage production measurements rather than the more accurate ecological

measurements; and (3) Dyksterhuis' (1949) method is beyond the technical ability of the ordinary range manager.

Utilization

Range managers have long understood that proper stocking rates are necessary to maintain or improve range condition. The rate of stocking determines the degree of utilization (i.e. forage removal) of key forage species; in turn the pressures placed on key species play a major role in upward or downward trend in range condition. Ellison et al. (1951) state that utilization is the most sensitive indicator of trend in any given year. This means that utilization determined over several years gives a good indication of range trend. Thus, it is necessary to be able to accurately determine the utilization of key species.

Most range researchers recognize that grass plants do not have biomass or forage volume evenly distributed with height (i.e. there is more biomass/unit height near the base of the plant). Because of this, utilization measurements have been based upon height-weight or height-volume relationships (Crafts 1938, Lommasson and Jensen 1938, Reid and Pickford 1941, Lommasson and Jensen 1943, Heady 1949, 1950, Stoddart et al. 1975).

In this study, stubble height vs. weight removed curves were developed because of the interrelationship of range condition and range utilization. Range condition usually changes because of the intensity of utilization. In keeping with this study's objectives of being simple, practical, fast, and easy-to-learn; generalized stubble height curves for the tallgrass prairie were developed. The stubble height curves were used to determine the average per cent utilization, the per cent of plants grazed, and the per cent of plants grazed 50% or more for a key species. All three of these factors indicate whether or not a key area is being utilized at satisfactory levels.

Objectives of the Study

Concern for the long-term maintenance of native grasslands was the motivation behind this study. The major objective was to develop a tallgrass prairie range condition scorecard for use by both private and public range managers who have little training in range management, plant ecology, or plant taxonomy. The aim was to develop a simple, practical, fast, and easy-to-learn method for determining range condition that could be applied to the Flint Hills of east central Kansas. In addition, stubble height curves for determining utilization of the major forage grasses were developed.

The research designs utilized herein were a compromise between those necessary for the special needs of range studies and the requirements of scientific research. The study was based on the key species and key area concepts of range management. The key species concept involves the selection of a few important forage species from a heterogenous mixture of plants. The vigor, abundance, and use of these plants serve as the indicators for management decisions. The key area concept involves the selection of an area representative of the range and then basing management decisions upon how that area is utilized by livestock.

DESCRIPTION OF STUDY AREAS

Condition class studies were conducted in both Osage and Chase Counties in Kansas. Osage County is found in the Osage Cuestas subdivision of the Osage Plains physiographic region, while Chase County is in the Flint Hills Upland subdivision of the Osage Plains (Schoewe 1949, Küchler 1974). The boundaries of these two physiographic regions and the location of the two major study sites within them are shown in Figure 1.

The studies in Osage County were conducted on property owned by the U. S. Army Corps of Engineers, Kansas City District, at Melvern Lake. The first of these study areas (hereafter referred to as Melvern site 1) is Corps of Engineers tract 101, T18S, R15E, S15NW¼. This tract was purchased by the U. S. Government in January, 1968. The previous owner had uncontrolled access to the land until November, 1968.

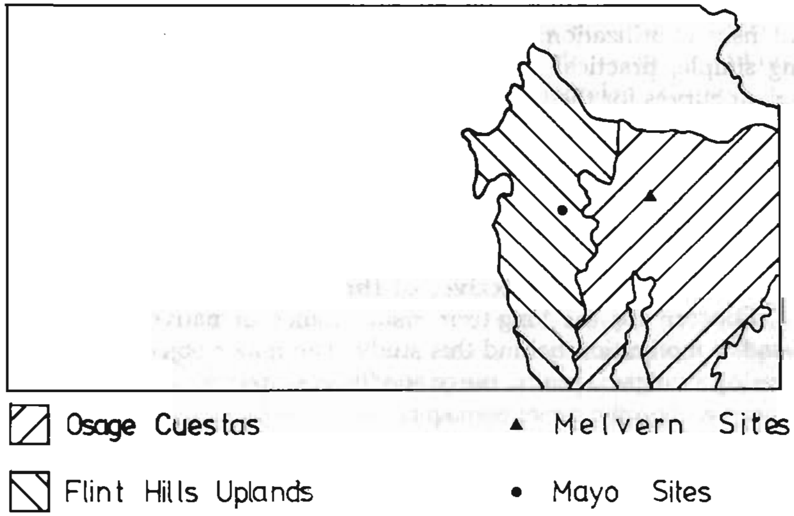

Figure 1. Location of the major study areas within the physiographic regions of Kansas (after Schoewe 1949).

From 1969 to 1972, Melvern site 1 was leased to private individuals for grazing. Haying leases were issued on this site from 1973 to 1982. The area was subjected to controlled spring burns in 1981 and 1982. Prior to that time, no regular controlled burns occurred. In 1983, the area was not burned or hayed. In 1979, the management of 395 acres of native prairie was leased by the Corps of Engineers to the Grassland Heritage Foundation of Shawnee Mission, Kansas. Melvern site 1 is on the extreme western end of this management lease (Hall 1984).

The second study area at Melvern Lake (hereafter referred to as Melvern site 2) is Corps of Engineers tract 100, T18S, R15E, S9SE1/4. This tract was purchased by the U. S. Government in May, 1968. The previous owner grazed the site until September, 1968. At that time both cattle and fences were removed. Since this study area is at the entrance to a camping and recreation area, it has been neither grazed nor hayed since September, 1968. The last controlled burn on the site was April, 1981 (Hall 1984). Currently the site supports native tallgrasses and a host of woody invaders.

The soil types of the Melvern sites are as follows: Melvern site 1 is an Eram-Lula soil type complex and a Loamy Upland range site. Melvern site 2 is a Clareson-Eram soil type complex and a Shallow Falts-Loamy Upland range site (USDA, unpublished).

Table 1 is a summary of the 1983 data for temperature and precipitation at Melvern Lake for the duration of the study. Weather data for the site for the last several years were not readily available.

Table 1. Temperature and precipitation data for May through October, 1983, at Melvern Lake (Schideler 1984).

	TEMPERATURE (°F)			PRECIPITATION (in.)		
MONTH	Average Maximum	Average Minimum	Average	Total	Greatest Day	Date
May	70.7	47.6	59.2	5.85	2.10	28
June	80.0	59.3	70.1	6.61	1.58	19
July	91.2	66.7	79.0	1.71	1.71	4
August	97.3	68.5	82.9	0.32	0.11	30
September	83.7	55.1	69.4	2.32	0.86	20
October	67.0	46.6	56.8	5.11	1.37	19

In Chase County, the studies were conducted on property owned by J. Mayo. The first of these sites (hereafter referred to as Mayo site 1) is T19, R6E, S12NW1/4. This site is located on a ridge top. The second site (hereafter referred to as Mayo site 2) is T19, R6E, S12SW1/4 and is located to the south of Mayo site 1.

Both Mayo sites have been used as part of a cow-calf operation for approximately the past 15 years. Prior to that time, these sites were primarily utilized in a steer operation. These sites are regularly subjected to controlled spring burns. In 1983, both sites were burned on April 24, but neither site carried the fire very well.

The soil types of Mayo sites 1 and 2 are a Clime-Sogn soil type complex and a Limy Upland-Shallow Limy range site (Neill 1974).

Table 2 is a summary of the precipitation data for May through September, 1983, at Elmdale, Kansas. This was the weather station nearest the study area. No other data were available.

Table 2. Precipitation data for May through September, 1983, at Elmdale, Kansas (Schideler 1984).

	PRECIPITATION (in.)		
MONTH	Total	Greatest Day	Date
May	4.12	1.85	21
June	4.46	1.85	3
July	1.25	1.05	4
August	1.63	0.80	21
September	3.13	0.90	20

A third study area was located in Lyon County adjacent to the northwest corner of Ross Natural History Reservation on the Jack Lefler property. This area was utilized in the range condition class study only. The site (hereafter referred to as the Lefler site) is utilized in steer operations and is regularly burned. The portion of the Lefler site studied is a Clime-Sogn soil type complex and a Limy Upland-Shallow Limy range site (Neill 1981).

MATERIALS AND METHODS

Range Condition

Studies of range condition were conducted in September, October, and November, 1983, at both Melvern sites, both Mayo sites, and at the Lefler site. These sites were selected because of their accessibility and because of their apparent differences in condition. It was not possible at the beginning of the study to determine precisely what the condition of each site was since the goal of the study was to determine just that. Thus, these sites were selected in hopes that by the conclusion of the study they would prove to represent a variety of condition classes. The objective, therefore, was to classify each site as excellent, good, fair, or poor based on the following critera: (1) soil stability, (2) species composition, and (3) per cent basal ground cover. Since these are quantitative measurements, assessment of range condition and trend due to environmental conditions and management practices would be possible (Cook 1962).

The sampling method used was a combination of the step-point method of Evans and Love (1957) and the ¾'' loop method of Parker (1950, 1951). A ¾'' diameter loop attached to a metal rod was the basic sampling tool. In addition, a ¼-m^2 plot frame was utilized for the ocular estimate and clipping portion of the study. This method was known as the step- loop/frame-point method.

As described by Evans and Love (1957), each transect consisted of 100 step-loops with ten frame-points. A table of random numbers (Freese 1962) was used to select the location of the ten frame-points within the 100 step-points. The location of each 100 step-point transect was determined chiefly by the contour of the soil-type as shown on the Soil Conservation Service soil type map (Neill 1974, 1981; USDA, unpublished). Features such as fence lines and hedge rows were avoided. This is the manner in which a range technician would select key areas.

Data were collected in the following manner. The 100 step-loops consisted of 100 paces. At the completion of each pace the ¾'' loop was placed at the toe of the examiner's boot as the foot was held at a 30° angle from the ground. This procedure is the same as that of Evans and Love (1957) who used pins rather than loops. The loop was lowered to the ground, perpendicular to the examiner's foot. The sample was considered a hit on vegetation if at least one-half the diameter of the loop was covered by the *crown* of the plant. The species hit was recorded. Hits such as rock, bareground, and litter also were recorded (Parker 1950, 1951).

When a step-loop was sampled that had also been randomly selected for sampling by the frame-point method, the following procedure was followed. After recording the hit of the loop, the ¼-m^2 frame was placed at the toe of the examiner's boot so that the side of the frame nearest the examiner was centered on the boot. The per cent of basal area within the frame covered by vegetation, litter, rock, and bareground was estimated by sight and recorded. All vegetation within the frame greater than one-inch in height was clipped at ground level and the plants were separated into individual, labelled, brown paper bags. Litter and vegetation from the previous season were not bagged. When working on grazed sites, care was taken to assure that the frame-points included only ungrazed vegetation since the object was to measure total production. The bagged samples were taken to the laboratory and oven-dried at 100°F for at least 48 hours. The samples were weighed on a Mettler H54AR balance to obtain oven-dry weight in $g/.25m^2$.

The weight of each species for all ten frame-points of each transect was totalled to obtain $g/2.5m^2$. These weights were converted to pounds per acre.

The production in pounds per acre for each transect was listed by species and the total production for each transect calculated. The per cent of total production for each species was also calculated. Total pounds of production and the per cent of total production for the categories of decreasers, increasers, and invaders were also calculated.

The step-loop hits were summarized by species and by the categories of decreasers, increasers, invaders, rock, litter, and bareground.

Data from two transects were collected at each of the five sites. The mean pounds of production, mean per cent of production, and mean number of step-loop hits by species were calculated for each site from the data of the two transects. Each transect took approximately 4-5 hours to complete.

The data obtained in the range condition studies and publications of previous researchers were utilized to formulate a range condition scorecard similar to that of Parker (1950, 1951). It was necessary to formulate two scorecards, i.e. a vegetation scorecard and a soil stability scorecard. The record sheet for recording data, the taxa list, the vegetation scorecard and the soil stability scorecard are shown in Appendices 1 through 4. The taxa list (Appendix 2) is a list of some of the most commonly encountered plants in the tallgrass prairie; many other species will also occur.

The vegetation scorecard that Parker (1950, 1951) developed consisted of three portions: forage density index, composition, and vigor of desirable species. Forage density index and composition were used in the tallgrass prairie scorecard but the vigor of desirable species was not.

The scorecard is designed chiefly for use by non-professional range managers and it is felt that a valid scorecard can be formulated without the difficult problems presented by yearly vigor measurements.

Forage density index is the number of hits on decreasers plus increasers. It was assumed that Melvern site 1 was in excellent condition due to its management history (see "Description of Study Area") and due to the overall nature of its vegetation composition. Thus, Melvern site 1 was used as the reference point from which to establish the four categories for the forage density index on the vegetation scorecard.

According to Humphrey (1949) and Neill (1974), a range is in excellent condition if it has 76-100 per cent of the climax vegetation; is in good condition if it has 51-75 per cent of the climax vegetation; is in fair condition if it has 26-50 per cent of the climax vegetation; and is in poor condition if it has less than 25 per cent of the climax vegetation.

At Melvern site 1, 81 of the step-loop hits were on decreasers and increasers with the remaining 19 hits occurring on litter. There were no hits on invaders, rock, or bareground. For the purpose of establishing the forage density index, the 81 actual hits will be rounded to 80. Based on the criteria of Humphrey (1949) and Neill (1974), let 80 hits equal 100 per cent of the climax vegetation and 61 hits equal 76 per cent of the climax vegetation (i.e. 76% of 80). This would represent the excellent category for forage density (i.e. 61 or more hits). Good, fair, and poor conditions for the forage density index were derived in a similar manner.

The composition portion of the vegetation scorecard was also designed after that of Parker (1950, 1951). The criteria established for each of the composition categories were based on field observations and supported by Voight and Weaver's (1951) work on these condition classes in the tallgrass prairie of eastern Nebraska.

The final portion of the vegetation scorecard is the overall classification of the vegetation score. To determine the vegetation condition, the points assigned for forage density index are added to the points for composition. The total score is used to determine vegetation condition.

The soil stability scorecard was constructed after the design of Parker (1951). It consists of two major portions, the erosion hazard index and the current erosion.

Erosion hazard index is a scale based on the ground cover index that was determined in the step-loop method. The erosion hazard index used in the tallgrass prairie soil stability scorecard is based on the guidelines proposed by Reid and Love (1951).

Criteria for the current erosion ratings were taken directly from Parker (1951). Although these criteria were established for southwestern ranges, it is felt that they are applicable to a wide variety of ranges, including the tallgrass prairie.

Soil stability condition is determined by totalling the points for erosion hazard index and current erosion. Overall range condition is the lower rating of vegetation condition and/or soil stability condition.

Utilization

Stubble height curves were prepared in both the fall 1982 and the fall 1983 for the four major range grasses of the tallgrass prairie: *Andropogon gerardi* Vitman., *A. scoparius* Michx., *Sorghastrum nutans* (L.) Nash., and *Panicum virgatum* L.

In 1982, samples were collected on September 29 and October 5 and 30 at Melvern site 1. Maturation of all species was essentially complete by September 29, so the different collection dates do not reflect different growth stages.

In 1983, all samples were collected on October 12. Again maturation was complete and growth had essentially ceased by this time. These collections were also made at Melvern site 1.

Since individual genets are difficult to distinguish in perennial grasses (Harper 1977), it was necessary at the onset of this study to specify distinguishable sampling units. The species involved in this study tend to grow in bunches; each one of these bunches was arbitrarily designated a colony for the purpose of collecting samples, although each bunch in reality probably represents only a small portion of an original zygote.

The colonies to be collected were located randomly by use of an X, Y coordinate system. A landmark served as the permanent 0, 0 Point, and in this case it was a corner hedge fence post. Values for X and Y were selected from a table of random numbers (Freese 1962). The species to correspond with each X, Y coordinate was randomly selected by drawing. The X, Y coordinate was located by pacing-off the randomly selected values from the permanent 0, 0 point. The colony of the corresponding species that was nearest the X, Y coordinate was collected in this manner both in 1982 and 1983.

The collection method for each colony was similar to that of Lommasson and Jensen (1943). These authors dug the plant, bound the vegetation with string, and clipped the plants at regular intervals. In this study, the colony was weeded of any stray species and/or litter. The vegetation was partially bound with string by holding the leaves in an upright position against the stems and culms. The entire colony was clipped at ground level and further secured with string. The result was a neat bundle of grass.

The bundled colonies were taken into the laboratory for sectioning. In 1982 the bundles were cut into 15 cm sections beginning at the botton of the bundle. The plants were considerably shorter in 1983 so these bundles were cut into 10 cm sections beginning at the bottom of the bundle. Each section was placed in an individual brown paper bag and labelled as to species, colony (bundle) number, and section of height. The bags were placed in a drying oven for at least 24 hours at approximately 100°F.

The dried sections were weighed on a Mettler H54AR balance to obtain oven-dry weights. The per cent of total volume (dry weight) for each section of each colony was calculated. These values for each of the five colonies of each species were averaged together by section height to obtain a mean per cent of volume (dry weight) by section. Variance, standard error of the mean, and 95 per cent confidence intervals were calculated for each section of each species. Mean per cent of dry weight remaining was plotted against actual height remaining in cm for each species for both 1982 and 1983 to achieve the stubble height curves. In addition, per cent of forage by section was plotted against height in cm to show the growth form of each species.

RESULTS AND DISCUSSION

Range Condition

The range/soil condition scorecards developed in this study are shown in Appendix 3 and Appendix 4.

Two transects were obtained at each of the five study sites. The data collected in the step-loop/frame-point method were summarized and the mean step-loop data were used to determine the condition classification for each site as shown in Table 3. In addition, the step-loop data for Melvern site 1 (excellent condition) were used to formulate portions of the vegetation scorecard.

Table 3. Vegetation and soil stability condition classification based on the scorecard method of range condition analysis for Melvern site 1 (ME 1), Melvern site 2 (ME 2), Mayo site 1 (MY 1), Mayo site 2 (MY 2), and the Lefler site (LEF).

	ME 1	ME 2	MY 1	MY 2	LEF
VEGETATION:					
Forage Density Index	8	5	7	7	5
Composition	7	4	7	5	5
Total	15	9	14	12	10
Condition Class	Exc.	Fair+	Exc.	Good+	Good−
SOIL STABILITY:					
Erosion Hazard Index	8	8	5	5	5
Current Erosion	15	13	11	12	10
Total	23	21	16	17	15
Condition Class	Exc.	Exc.	Good	Good	Good−

These specific sites were selected at the onset of this study because it was hoped that they would represent a variety of condition classes ranging from poor to excellent. Reconnaissance surveys or ocular estimates were the basis for these choices. Initially, it was thought that Melvern site 1 would be in excellent condition, Melvern site 2 would be in poor condition because of woody invasion, Mayo site 1 would be in good to excellent condition, Mayo site 2 would be in poor to fair condition, and the Lefler site would be in fair condition. When measurements were made by the scorecard method, it became apparent that ocular estimates are *not* a good method for judging range condition. In addition, the ocular estimates do not provide a record of vegetation composition and range condition; the scorecard method does.

Thus, it must be emphasized that in order to judge range condition accurately, actual measurements of the vegetation and soil conditions must be taken. Many range managers rely on clipping plots at the end of the season. Although clipping is a good measure of range condition, it is a very time-consuming task requiring as much as 3-4 hours per transect. Because of this, the number of plots clipped in any year by some range managers is not sufficient to give an accurate indication of vegetation composition and range condition. The step-loop method, however, was found to be an accurate yet quick and easy method for determining range condition in the

tallgrass prairie. The step-loop method requires about 30 minutes per transect. Parker (1950, 1951) had previously confirmed this to be true on western and southwestern ranges.

To confirm that the scorecard method would reflect the same trends in range condition as the clipping method, the frame-point method (which involved clipping) was incorporated into the design of the step-loop method. In Figure 2, the total pounds of production of decreasers and increasers (frame-point method) are plotted against the number of hits on decreasers and increasers (step-loop method). With the exception of one site (Lefler), as the number of hits increased so did the pounds of production. This would seem to indicate that the clipping method and the step-loop method are both sensitive to differences in vegetation composition. Because of this, it is felt that the step-loop method is a reliable index to vegetation composition and production for the tallgrass prairie.

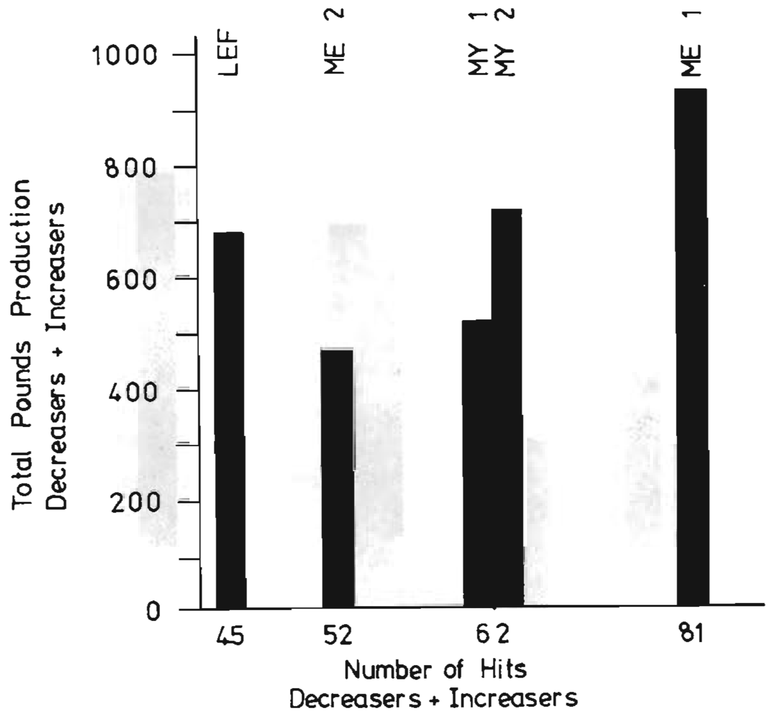

Figure 2. Mean total pounds of production of decreasers and increasers vs. the number of step-loop hits on decreasers and increasers. The data used in formulating this graph was the mean data for the two transects taken at each site. LEF = Lefler site; ME 2 = Melvern site 2; MY 1 = Mayo site 1; MY 2 = Mayo site 2; ME 1 = Melvern site 1.

It is possible that the data from the Lefler site may be erroneous since one of the two transects (transect B) was taken by students. For most of these students, it was their first exposure to this method and to field identification of often non-flowering native grasses. If transect A for the Lefler site is considered alone, it takes a more logical position in Figure 2 with 56 hits and 726 pounds per acre of production of decreasers and increasers.

Figure 3 shows the relationship between the mean per cent basal coverage (basal density) and the number of hits on decreasers and increasers. Again, the same *general* trends are evident, as the number of hits increases, so does the per cent basal coverage. The Lefler site still is an exception to the trend. However, if Lefler transect A is considered alone, once again it takes on a more logical position in Figure 3 with 56 hits and 55 per cent basal coverage. Because of these relationships, it is felt that the step-loop method is

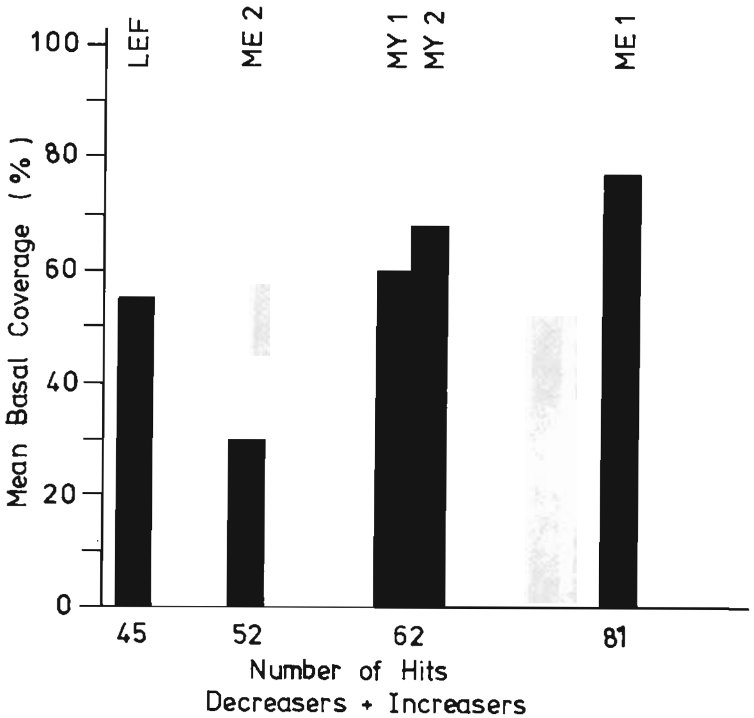

Figure 3. Mean per cent basal coverage vs. the number of step-loop hits on decreasers and increasers. The data used in formulating this graph was the mean data for the two transects taken at each site. LEF = Lefler site; ME 2 = Melvern site 2; MY 1 = Mayo site 1; MY 2 = Mayo site 2; ME 1 = Melvern site 1.

a reliable index to vegetation density as well as vegetation composition.

Condition classes for soil stability were as expected for all five sites. All sites have adequate cover (i.e. litter, rock, plant cover) for preventing erosion. The importance of litter in stabilizing soils and the impact of grazing animals on soil cannot be ignored. Melvern sites 1 and 2 have not been grazed for a number of years. Mayo sites 1 and 2 and the Lefler site have all been subjected to regular grazing. In Figure 4, differences between the grazed sites and the ungrazed sites can be seen in regard to the amount of bareground and litter; the grazed sites have more bareground and less litter than the ungrazed sites.

Plant density is probably the most important factor in preventing soil erosion. Melvern site 1, an ungrazed site, has a high percentage of plant density. Humphrey (1949) noted that grazing, especially overgrazing, reduces plant density. When Melvern site 1 is compared with both Mayo sites and the Lefler site in Figure 4, it can be seen that these three grazed sites do have a reduced percentage of plant density as compared to the ungrazed site.

Melvern site 2, although ungrazed, must be considered separately. It was initally thought that this site would be poor in vegetation condition because of a large number of woody invaders. Table 4 is a list of woody invaders found on this site during June, 1983. The list includes some plants not normally thought of as decreasers, e.g. lead plant, but they are included here because they were found in much greater abundance than in climax prairie.

Table 4. Woody invaders found on Melvern site 2 on June 27, 1983.

Common Name	Scientific Name
Lead plant	*Amorpha canescens* Pursh
Rough-leaved dogwood	*Cornus drummondii* Meyer
St. John's Wort	*Hypericum perforatum* L.
Smooth sumac	*Rhus glabra* L.
Rose	*Rosa* spp.
Buckbrush	*Symphoricarpos orbiculatus* Moench
Hawthorne	*Crataegus* spp.
Siberian elm	*Ulmus pumila* L.
Honey locust	*Gleditisia triacanthos* L.
Osage orange	*Maclura pomifera* (Raf.) Schneid.

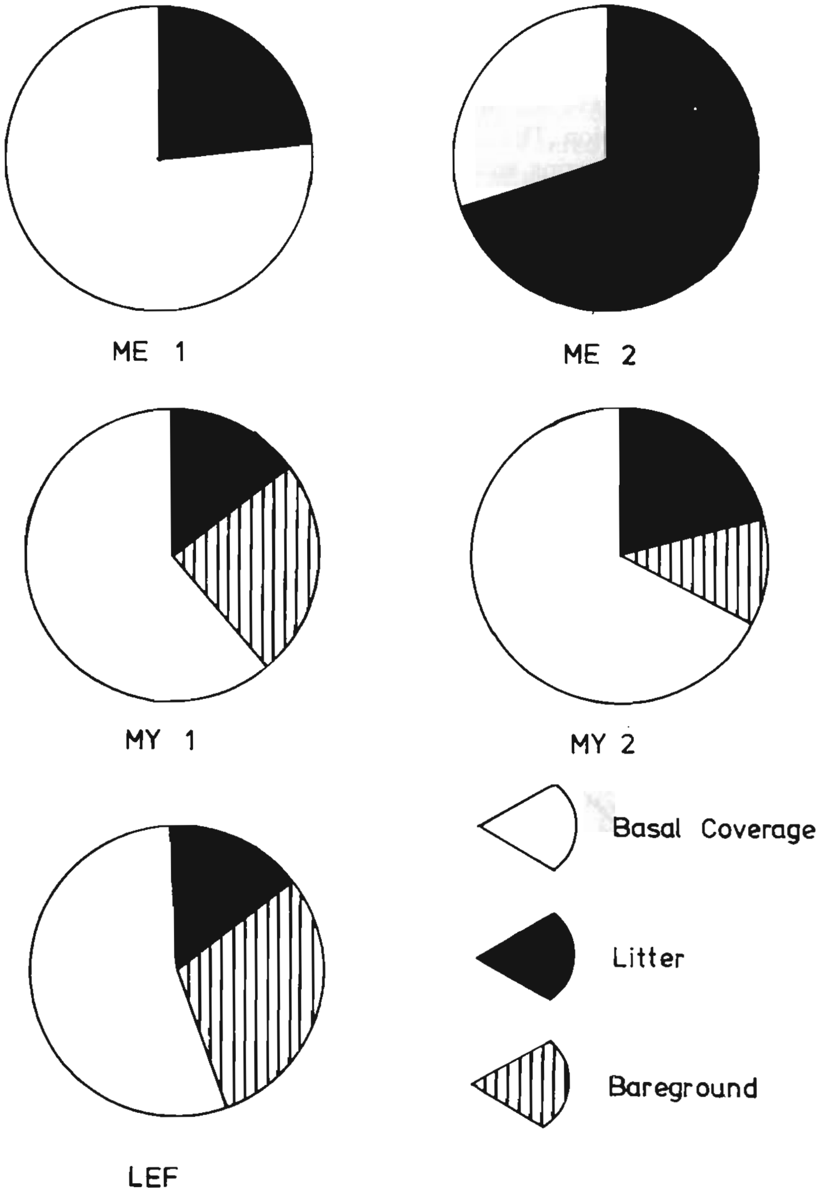

Figure 4. Ocular estimates within the ¼-m² plot frame of the per cent of basal plant coverage, litter, and bareground. The results shown are the means of 20 samples, except for the Lefler site where only 10 samples were taken. ME 1 = Melvern site 1; ME 2 = Melvern site 2; MY 1 = Mayo site 1; MY 2 = Mayo site 2; and LEF = the Lefler site.

When the results from the scorecard were tabulated, it was determined that Melvern site 2 was in a high fair condition. Melvern site 2 had a larger portion of invaders than any of the other sites (if transect B for the Lefler site is once again not considered).

It is felt that the scorecard accurately reflected the understory vegetation at Melvern site 2. There was a surprisingly large amount of native grass under the large colony of smooth sumac *(Rhus glabra)* on this site. When working inside this large sumac colony, the majority of the step-loop hits was on decreaser grasses or litter; only rarely did the step-loop hit the base of a sumac stem. For this reason, it is felt that in technical assessments a scorecard method where one records *both* understory and overstory plants for each hit be utilized on sites where there is a large degree of woody invasion. Parker's (1951) three-step method made allowances for recording both understory and overstory plants. However, in a simplified scorecard, notes concerning the woody invasion (i.e. the overstory) can be made on the record sheet and then considered when classifying the condition.

It should be noted that when the decreaser grasses are still present on a site undergoing woody invasion, e.g. Melvern site 2, (Figure 5) the potential for the site to return to a higher condition class is still present.

Thus, it is felt that when dealing with condition classes in the tallgrass prairie there are really two types of poor and fair condition classes—those that result from woody invasion and those that result from the impact of overgrazing on herbaceous vegetation. Woody plant invasion must be considered serious, perhaps this automatically lowers the vegetation condition at least one class.

The scorecard method presented in this study should be considered a first attempt at developing this method for the tallgrass prairie of east central Kansas. Further and more extensive use of this scorecard will undoubtedly bring forth a number of revisions and improvements. For example, it is felt that guidelines for the percentages of decreaser grasses and forbs in the various condition classes could be determined. Such guidelines would be particularly helpful for a plant such as lead plant *(Amorpha canescens)* which in most cases is a desirable decreaser forb, but which in great abundance can be considered a woody invader. In addition. carrying capacity estimates could be formulated for each of the four range condition classes. This would require further study of both condition and utilization.

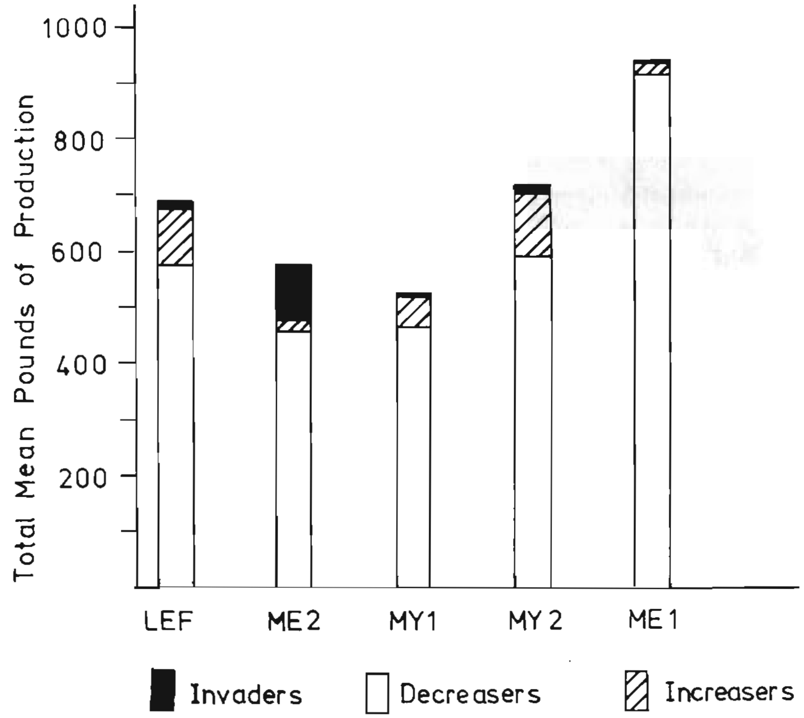

Figure 5. The proportions of invaders, decreasers, and increasers within the mean total production at the Lefler site (LEF), Melvern site 2 (ME 2), Mayo site 1 (MY 1), Mayo site 2 (MY 2), and Melvern site 1 (ME 1).

Utilization

Figures 6 through 9 show the stubble height curves for each of the four species studied for both 1982 and 1983. The curves are formulated after the work of Reid and Pickford (1941).

All colonies of each species collected in 1982 had produced seedstalks. The 1982 growing season was favorable in both temperature and precipitation for the growth of native grasses. The result was plants of vigorous stature with numerous seedstalks.

Nineteen eighty-three, however, presented a very dry growing season. The result was the lack of production of seedstalks in three of the four species studied, as well as an overall reduction of maximum height. Of the 1983 samples collected, *P. virgatum* was the only species which had produced fully mature well-developed seedstalks. *S. nutans* produced a few flowering stalks, but none were well-developed. *A. gerardi* showed an occasional, very poorly developed seedstalk and *A. scoparius* produced virtually no seedstalks.

The 1982 and 1983 stubble height curves for *P. virgatum* were rather similar, while those of *S. nutans, A. gerardi,* and *A. scoparius* were somewhat different for the two years due to the difference in total height.

Lommasson and Jensen (1943) recognized that individual mature heights varied within a species and this was often due to the presence or absence of seedstalks. The 1982 and 1983 studies vividly illustrate that there are two forms of mature grasses in the tallgrass prairie—those that produce seedstalks and those that do not produce seedstalks. Within any given year, one mature form or the other will probably be found to dominate a range site. Only one of the four species, *P. virgatum,* did not illustrate this, and it is thought that this is not unusual since *P. virgatum* tends to mature earlier than any of the other three grasses studied.

In a technical assessment of utilization, it is best to determine stubble height curves each year so as to account for seasonal variation much like the ones which occurred in this study. On the other hand, individual farmers and ranchers may not have the resources available (e.g. weighing instruments) which are necessary to determine a yearly stubble height curve. Since one goal of this research was to develop methods that could be used by the average farmer and rancher, the stubble height curves presented here can be standards for the east central Kansas native prairie. The 1982 curve would be used for utilization determination in a year in which seedstalks are produced (normal or favorable year) and the 1983 curve would be used in a year in which seedstalks are not produced (unfavorable year). In order to determine utilization by the stubble height method, the steps below are followed:

(1) Select key areas within a range management unit that are indicative of the unit in general.
(2) Choose one (or more) of the four key species for stubble height measurement.
(3) Walk a transect of 50 or 100 paces, stopping at each pace to record the total height of a plant of the specified species which is nearest the toe of the examiner. Record the data on a sheet (Appendix 5). If a plant is ungrazed, record its total height and 0 per cent use. Heights are measured by placing a meter stick beside the plant and holding the stems in an upright position against the meter stick. The end of the meter stick should be resting as nearly as possible on the soil surface.
(4) When 50 or 100 heights have been recorded on the data sheet, convert the stubble heights to per cent utilized by using the appropriate curve. Remember that some plants may have 0 per cent utilization. Determine the average per cent utilization, the per cent of plants grazed, and the per cent of plants grazed 50 per cent or more.
(5) Retain the data sheets so that utilization trends can be monitored.

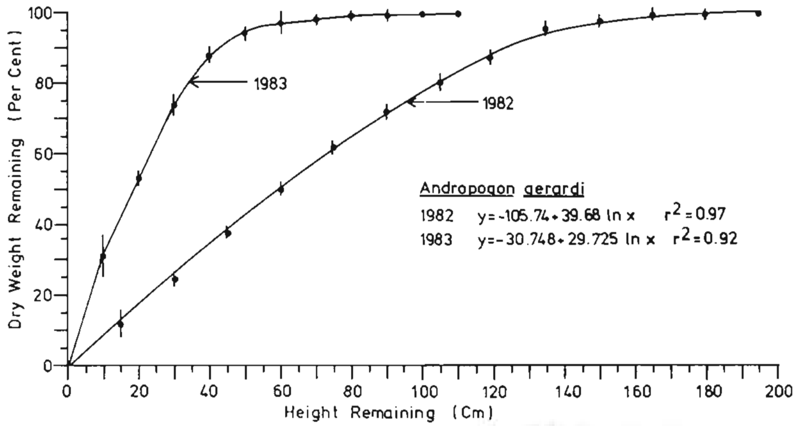

Figure 6. 1982 and 1983 stubble height curves for *Andropogon gerardi*. 95% confidence intervals are shown on both curves.

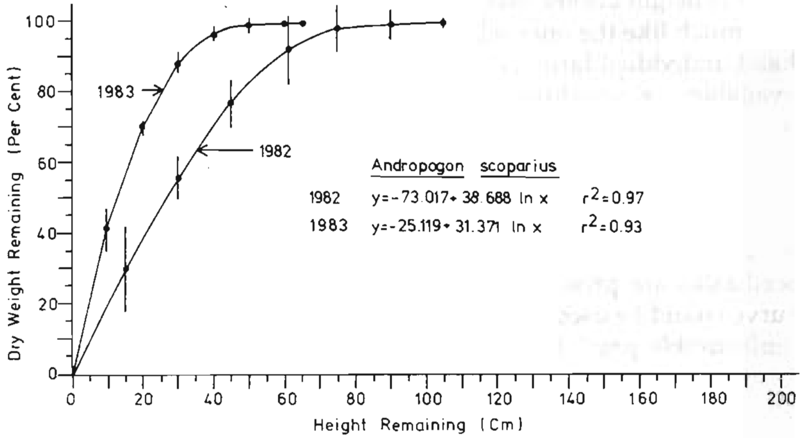

Figure 7. 1982 and 1983 stubble height curves for *Andropogon scoparius*. 95% confidence intervals are shown on both curves.

Once utilization information is accumulated, it must be interpreted to be of any practical value. Range managers have long used the rule-of-thumb of take half and leave half as a guide for acceptable levels of utilization. This adage may seem easy to follow, yet it poses several questions. Does this refer to one-half the total population of available forage or one-half of an individual plant? Some individual plants will be very closely grazed while others will be completely ungrazed. Livestock (and wildlife) do not necessarily graze a range unit uniformly; parts of the unit may be essentially untouched while other areas may be obviously overgrazed. The data obtained in the stubble height method provide the answers to

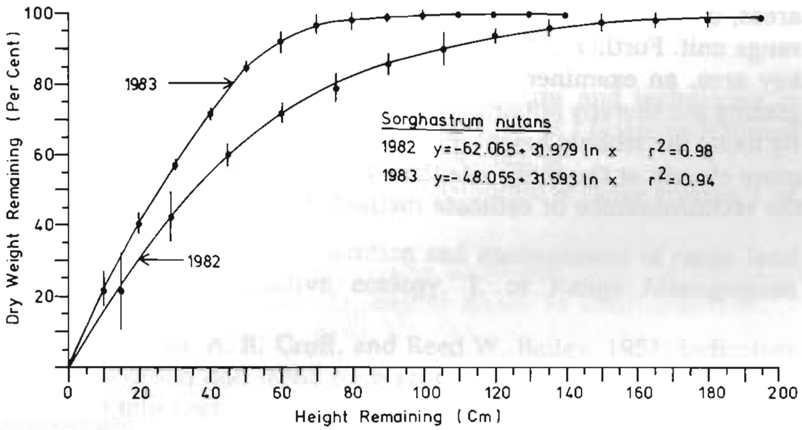

Figure 8. 1982 and 1983 stubble height curves for *Sorghastrum nutans*. 95% confidence intervals are shown on both curves.

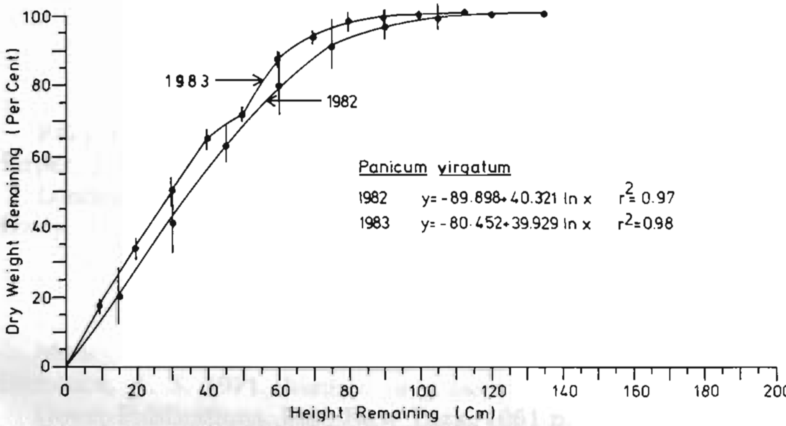

Figure 9. 1982 and 1983 stubble height curves for *Panicum virgatum*. 95% confidence intervals are shown on both curves.

these questions. From these data, the average utilization of a species can be determined as well as the per cent of plants grazed and the per cent of plants grazed 50% or more. Total utilization of a range is dependent upon all three of these features.

Therefore, above 50 per cent utilization is considered satisfactory and below 50 per cent is considered unsatisfactory when evaluated in terms of average per cent utilization of all plants measured and in terms of the per cent of the measured plants grazed 50 per cent or more.

The key area-key species concept is applied in the stubble height method. By measuring utilization of key species on key areas, one can get a fairly good idea of the utilization of the total range unit. Further, by walking a transect of 100 paces through the key area, an examiner may pass through several areas of varied grazing use thereby obtaining a good estimate of overall utilization. By using the stubble height method, the examiner is forced to look more closely at the range site than would be done by using any of the reconnaissance or estimate methods for utilization surveys.

LITERATURE CITED

Cook, C..W, chairman. 1962. Basic problems and techniques in range research. National Academy of Sciences-National Research Council, Washington, DC 342. p.

Crafts, E. C. 1938. Height-volume distribution in range grasses. J. of Forestry 36:1182-1185.

Dyksterhuis, E. J. 1949. Condition and management of range land based on quantitative ecology. J. of Range Management 2(2):104-115.

Ellison, Lincoln, A. R. Croft, and Reed W. Bailey. 1951. Indicators of condition and trend on high range-watersheds of the intermountain region. Ag. Handbook No. 19. USDA 66 p.

Evans, R. A. and R. M. Love. 1957. The step-point method of sampling—a practical tool in range research. J. of Range Management 10(5):208-212.

Freese, F. 1962. Elementary forest sampling. U. S. Dept. of Agriculture, Forest Service, Ag. Handbook N,. 232 p.

Hall, C. D. January 24, 1984. Personal communication. Park Ranger, U. S. Army, Corps of Engineers.

Harper, J. L. 1977. Population biology of plants. Academic Press, London. 892 p.

Heady, H. F. 1949. Methods of determining utilization of range forage. J. of Range Management 2(2):53-63.

__________. 1950. Studies on bluebunch wheatgrass in Montana and height-weight relationships of certain range grasses. Ecol. Monogr. 20:55-81.

Hitchcock, A. S. 1971. Manual of grasses of the United States. Dover Publications, Inc., New York. 1051 p.

Humphrey, R. R. 1947. Range forage evaluation by the range condition method. J. of Forestry 45(1):10-16.

__________. 1949. Field comments on the range condition method of forage survey. J. of Range Management 2(1):1-10.

__________. and P. B. Lister. 1941. Native vegetation as a criterion for determining correct range management and run-off characteristics of grazing lands. J. of Forestry 39(10):837-842.

Hutchings, S. S. and R. C. Holmgren. 1959. Interpretation of loop-frequency data as a measure of plant cover. Ecology 40(4:668-677.

Küchler, A. W. 1974. A new vegetation map of Kansas. Ecology 55:586-604.

Lommasson, T. and C. Jensen. 1938. Grass volume tables for determining range utilization. Science 87:444.

__________. 1943. Determining utilization of range grasses from height-weight tables. J. of Forestry 41(8):589-593.

Neill, J. T. 1974. Soil survey of Chase County, Kansas. U. S. Dept. of Agriculture, Soil Conservation Service.

__________. 1981. Soil survey of Lyon County, Kansas. U. S. Dept. of Agriculture, Soil Conservation Service.

Parker, K. W. 1950. Report on 3-step method for measuring condition and trend of forest ranges. U. S. Dept. of Agriculture, Forest Service, Washington, DC 68 p.

__________. 1951. A method for measuring trend in range condition on natural forest ranges. U. S. Dept. of Agriculture, Forest Service. (Multilithed.)

__________. 1954. Application of ecology in the determination of range condition and trend. J. of Range Management 7:14-23.

Reid, E. H. and L. D. Love. 1951. Range-watershed conditions and recommendations for management, Elk Ridge and Lower Elk Ridge Cattle Allotments, Roosevelt Natl. Forest, Colorado. U. S. Dept. of Agriculture. Forest Service. 123 p. (Proc.) *In* Parker, K. W. 1954. Application of ecology of range condition and trend. J. of Range Management 7(1):14-22.

__________. and G. O. Pickford. 1941. A comparison of the ocular-estimate-by-plot and the stubble-height methods of determining percentage utilization of range grasses. J. of Forestry 39:935-941.

Schoewe, W. H. 1949. The geography of Kansas. Trans. Kansas Acad. Sci. 52:261-331.

Schideler, P.E. 1984. Personal communication. Meteorologist in charge. U. S. Dept. of Commerce, National Weather Service Forecast Office, Topeka, Kansas.

Stoddart, L. A. 1935. Range capacity determinations. Ecology 16(3):531-533.

__________. A. D. Smith, and T. W. Box. 1975. Range management. McGraw-Hill Book Co., New York. 532 p.

U. S. Dept. of Agriculture, Soil Conservation Service. Unpublished. Soil Survey of Osage County, Kansas.

Voight, J. W. and J. E. Weaver. 1951. Range condition classes of native midwestern pasture: an ecological analysis. Ecol. Monogr. 21(1):39-60.

Weaver, J. E. and W. W. Hansen. 1941. Native midwestern pastures; their origin, composition, and degeneration. Univ. Neb. Conserv. and Surv. Div. Bull. 22.

Wilk, Sally A. (Kuykendall). 1984. Tallgrass Prairie Range Assessment Techniques. M.S. Thesis. Emporia State University. 165 p.

APPENDIX 1
RECORD OF STEP LOOPS AND CONDITION CLASS ANALYSIS

Date ______________ Examiner ______________

Transect No. ______________ Location ______________

Soil Type ______________ SCS Range Site ______________

Bareground _____

Rock _____

Litter _____

Plant Density Index _____

Total 100

Forage Density Index _____
(No. of decreasers + increasers)

Ground Cover Index _____
(100 - no. hits on bareground)

CONDITION CLASSIFICATION

VEGETATION:

Forage Density Index _____

Composition _____

Total _____

Condition Class ______________

SOIL:

Erosion Hazard Index _____

Current Erosion _____

Total _____

Condition Class ______________

OVERALL RANGE CONDITION:

____

NOTES:

ROCK

LITTER

BAREGROUND

APPENDIX 2
TAXA LIST FOR TALL GRASS PRAIRIE SCORECARD

DECREASERS

Symbol	**Scientific Name**	**Common Name**
Ange	Andropogon gerardi	Big bluestem
Ansc	Andropogon scoparius	Little bluestem
Pavi	Panicum virgatum	Switch grass
Sonu	Sorghastrum nutans	Indian grass
Trda	Tripsacum dactyloides	Eastern gamagrass
Kocr	Koeleria cristata	June grass
Sppe	Spartina pectinata	Prairie cordgrass
ELY	Elymus spp.	Wild-rye
Amca	Amorpha canescens	Lead plant
Deil	Desmanthus illinoensis	Illinois bundleflower
PET	Petalostemon spp.	Prairie clovers
ROS	Rosa spp.	Rose
Baau	Baptisia australis	Wild indigo

INCREASERS

Popr	Poa pratensis	Kentucky bluegrass
Bocu	Bouteloua curtipendula	Side-oats grama
Bogr	Bouteloua gracilis	Blue grama
Bohi	Bouteloua hirsuta	Hairy grama
Buda	Buchloe dactyloides	Buffalo grass
Pasc	Panicum scribnerianum	Scribner's panicum
Spas	Sporobolus asper	Tall dropseed
Agsm	Agropyron smithii	Western wheatgrass
Ersp	Eragrostis spectabilis	Purple lovegrass
CAR	Carex spp.	Sedges
Acmi	Achillea millefolium	Yarrow
Arlu	Artemisia ludoviciana	Sage
ERI	Erigeron spp.	Fleabane
Sila	Silphium laciniatum	Compass plant
Veba	Vernonia baldwinii	Baldwin's ironweed

INVADERS

ARI	Aristida spp.	Three-awn
BRO	Bromus spp.	Brome
Chve	Chloris verticillata	Windmill grass
DIG	Digitaria spp.	Crabgrass
Paca	Panicum capillare	Witchgrass
Spcr	Sporobolus cryptandrus	Sand dropseed
AMB	Ambrosia spp.	Ragweed
Vest	Verbena stricta	Vervain
Xadr	Xanthocephalum dracunculoides	Annual broomweed
Juvi	Juniperus virginiana	Red cedar
Syor	Symphoricarpos orbiculatus	Buckbrush
Rhgla	Rhus glabra	Smooth sumac
Codr	Cornus drummondii	Rough-leaved dogwood
PRU	Prunus spp.	Plum
Gltr	Gleditisia triacanthos	Honey locust
Canu	Carduus nutans	Musk thistle

The scientific names of the grasses follow the nomenclature of Hitchock (1971).

APPENDIX 3
TALLGRASS PRAIRIE VEGETATION SCORECARD FOR UPLAND SITES

Forage Density Index

This is the total number of hits on decreasers and increasers. Exclude the number of hits on invaders. Rate from 0 to 8.

61 or more hits	= 7-8	(Excellent)
41 to 60 hits	= 5-6	(Good)
21 to 40 hits	= 3-4	(Fair)
20 or less hits	= 0-2	(Poor)

Composition

Rate from 0 to 8 based on the following characteristics.

Desirable perennial grasses dominate, especially big bluestem and little bluestem. Desirable prairie forbs e.g. Illinois bundleflower, lead plant, New Jersey tea, and compass plant are found abundantly among the grasses.

7-8 (Excellent)

Desirable perennial grasses still abundant, but are on the decline. Only a moderate number of desirable prairie forbs remain. Invader forbs and weeds e.g. western yarrow, western ragweed, annual broomweed, snow-on-the-mountain, and ironweed occur occassionally.

5-6 (Good)

Desirable perennial grasses largely replaced and occur only in localized bunches. Dropseed, three-awn, and annual brome increase in abundance. Shorter grasses, e.g. blue grama and buffalo grass may also increase. Invader forbs and weeds common. On some sites, woody invaders e.g. red cedar, sumac, buckbrush, honey locust, etc. occur with an understory of desirable perennial grasses. Burning potential on these woody sites is still good.

3-4 (Fair)

Desirable perennial and forbs only relics. Invaders and weeds are much or most of the vegetation. A large variety of annual and weedy grasses (e.g. windmill grass, crabgrass, witchgrass, and foxtails) also dominate. On some sites, woody invaders. e.g. red cedar, sumac, buckbrush, honey locust, etc., occur with *no* understory of desirable perennial grasses. Burning potential on these woody sites is poor.

0-2 (Poor)

Classificiation of Vegetation Score

Total points assigned for forage density index and composition to determine the vegetation condition based on the scale below.

Excellent = 13-16	Fair = 6-9
Good = 10-12	Poor = 0-5

APPENDIX 4
TALLGRASS PRAIRIE SOIL STABILITY SCORECARD FOR UPLAND SITES

Erosion Hazard Index

Based on the ground cover index (100 - the number of hits on bareground). Rate from 0-8 points.

Ground Cover Index		Rating
93-100	no erosion hazard	7-8
76- 92	slight erosion hazard	5-6
50- 75	moderate erosion hazard	3-4
49 or less	severe erosion hazard	0-2

Current Erosion (Rate from 0-15)

No evidence of soil movement; plant and litter cover effective in protecting soil; runoff is clear; no piling up of litter behind plants; gullies if present completely stabilized and healed. 13-15

Soil movement slight; but difficult to recognize; may be evidence of past accelerated erosion but now fairly well stabilized; plant and litter cover appears effective in protecting soil; plant pedestals few or sloping sided and stabilized; rills, alluvial deposits and gullies if present are nearly healed; some litter may be dammed against vegetation, forming miniature alluvial fans; trampling displacement slight, not noticeable compaction; rodent activity normal. 10-12

Soil movement moderate; definitely discernible, may be accelerated in spots and stable elsewhere; plant cover and litter effectiveness doubtful in protecting soil; considerable bare soil; many plant pedestals, some steep sided; erosion pavement forming with occasional exposed pebbles; occasional alluvial deposits and rills present; gullies if present, not raw; trampling displacement and compaction noticeable, but not excessive; rodent activity may not be noticeable; runoff murky. 7-9

Soil movement advanced; plant cover and litter definitely not effective in preventing soil movement; considerable bare soil; steep sided plant pedestals numerous; stony soils with well formed erosion pavement; rills, and alluvial deposits common; gullies, if present, with raw sides; trampling displacement and compaction common; rodent activity may be excessive; runoff muddy. 4-6

Soil movement severe; plant cover inadequate, litter lacking; subsoils exposed in many places; pedestals of stronger perennials almost completely eroded away; erosion pavement complete on stony soils; rills and alluvial deposits numerous; gullies, if present, with raw sides; rodent activity generally severe; runoff from summer storms trashy and muddy often causing miniature mud flows. 0-3

Classification of Soil Score

Total the points assigned for erosion hazard index and current erosion to determine the soil stability condition based on the scale below.

Excellent	20-23
Good	15-19
Fair	10-14
Poor	0-19

Classification of Overall Range Condition

The condition class rating which is lowest is the overall range condition class. For example, if the vegetation condition is excellent and the soil stability condition is good, then the overall range condition class is good.

APPENDIX 5
DATA SHEET FOR RANGE UTILIZATION BY THE STUBBLE HEIGHT METHOD

Date ______________ Key Species ______________

Location ______________ Examiner ______________

Transect No. ______________

Stubble Height	Per Cent Use	Stubble Height	Per Cent Use	Stubble Height	Per Cent Use

Average Per Cent Utilization ______________

Per Cent of Plants Grazed ______________

Per Cent of Plants Grazed 50% or More ______________

Notes ______________

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