THE EFFECT OF STRUCTURAL CARBOHYDRATES UPON SEASONAL DIGESTIBILITY OF TALLGRASS PRAIRIE VEGETATION

By

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Bachelor of Science

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1977

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1980

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SEASONAL DIGESTIBILITY OF TALLGRASS

PRAIRIE VEGETATION

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ACKNOWLEDGMENTS

I would like to express my deepest appreciation to Dr. Donald G. Wagner for his guidance, counsel and interest while serving as my major adviser during the course of this study. A special thanks is reserved for Dr. Wagner for his guidance and patience in the preparation of this final manuscript.

I wish to thank Dr. Jeff Powell and Dr. Richard R. Frahm for their aid and concern while serving on my guidance committee. A special thanks goes to Dr. Frank O. Thetford for his suggestions on my studies during Dr. Powell's absence.

Utmost is the appreciation of my parents, Mr. and Mrs. William Ball, whose unending love, support, and understanding has resulted in my attaining this ambition and making it meaningful.

I wish to thank Danny Belcher and Carla Chennette for their friendship upon my arrival in Stillwater and throughout my graduate work.

Thanks are due to Roger Fent, Chuck Hibberd, Tom Hoagland, Dave Mapes, Ernie Mintor, Colin Muncy, Louise Bulgerin, Jocelyn Kapp, and other graduate students for their assistance and friendship throughout the author's graduate program.

A special thanks goes to Natalie (Arizona) Lawrence and Jane Bartlett for their understanding and friendship throughout the year.

Special recognition is extended to the range crew for collection of data and friendship during my work at O.S.U. Thanks also to all the lab assistants that have worked on the project.

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CHAPTER I

INTRODUCTION

With the ever increasing human population, a greater demand will exist for animal products such as red meat, leather, medicine and pet foods. The United States has the present potential of producing approximately 213.1 million animal unit months (AUM) per year. The projection of AUMs needed to meet the demand for animal products is 320 million by the year 2000. This represents an increase of about 50.2 percent (106.9 million AUMs) (U.S. Forest Service 1972).

One means of increasing AUMs and meeting the demand on the same or less acreage is increased management intensity. Improved management will continually become a greater necessity due to decreases in land available for production resulting from various social pressures, such as highways or more rural housing.

To increase management and production, a better understanding of inputs is necessary. One major input into animal production and the major product of rangeland is forage. Increased understanding of the factors affecting quality and utilization of forages from rangeland will help increase animal productivity to satisfy demands for greater production.

More intensive management of native rangeland could be a major contribution to meeting the greater demands for animal products. Rangelands encompass approximately 49% (app. 1078 million acres) of the land area in the United States (Heady, 1975). This vast area of forage production and the increase in population on highly productive land near urban areas warrant the attention of producers and researchers. In addition to meeting the needs of society, the longevity of a natural resource, such as rangeland, will be maintained for future production.

The objectives of this study, therefore, were to determine: (1) the effects of range site and time of year (season) on range plant structural carbohydrate components of tallgrass prairie vegetation and (2) the _in vivo_ nylon bag dry matter digestibility (NBDMD) of rangeland forage as affected by structural carbohydrate and ash content, range site and time of year (season).

This thesis was written in the style and format for technical journals. The style manual followed is that of the Council of Biological Editors.

CHAPTER II

REVIEW OF LITERATURE

A substantial proportion of ruminant animal products are produced from forages. The chemical composition of forage influences the production of animal products. Cell-wall constituents, a chemical component of forages, appears to affect animal performance in two general ways: (1) digestibility and (2) intake.

Factors Affecting Diet Quality and Animal Performance

Quality of forage diets affect animal performance. Diet quality may be measured in a number of ways. Structural carbohydrates and digestibility have been used as indicators of diet quality. Variables that are not actually part of or within the forage may affect the indicators of diet quality. Examples of such variables may be maturity and soil type (site) where the forage is grown.

Fiber

Microbial organisms appear to be restricted in their utilization of cell-wall components. Fiber components have been shown to be inversely related to digestibility (Van Soest, 1963b; Johnson et al., 1971; Moir et al., 1975; Cogswell and Kamstra, 1976; Ward, 1979). With an increased understanding of the factors affecting fiber composition and content, digestibility of forages may be improved which will result in better animal performance. Chapman et al. (1972) and Burton et al. (1967) demonstrated an increase in 12.3% in bermudagrass digestibility may increase average daily gain by 30%.

Intake by ruminants appears to be restricted by the volume in the rumen occupied by a fibrous mass (Van Soest, 1965). The cell-wall and digested cell-wall content of forages has been shown to account for 58% of the voluntary intake variation in sheep (Moir et al., 1975). Van Soest (1965) stated that intake is inhibited by fiber mass in those forages with a high cell-wall content. The fiber mass appears to limit intake when cell-wall content lies between 50 and 60% of the forage dry matter (Van Soest, 1965).

Structural carbohydrates, digestibility, and/or intake are indicators of diet quality. Relationship exists between these indicators as to the effect each one has on animal performance (Van Soest, 1965; Ward et al. 1979; Rittenhouse et al., 1970). Other variables may affect these indicators of diet quality, such as forage maturity and soil type (site). A more thorough understanding of the variables affecting structural carbohydrates and their effect on digestibility should permit improvements in total animal productivity.

Maturity

Nutritive value and, therefore, animal performance are directly related to stage of plant maturity at the time of cutting or grazing (Cogswell and Kamstra, 1976). As fiber content increases over any particular time, digestibility decreases. It has been shown that the fiber component of forages increases with the advancement of maturity

(Johnson et al., 1971; Rao et al., 1973; Kautzsch, 1978). Change in crude fiber content of forages has been reported with progress of time (Neathery, 1972; Stoddard, 1941).

Site

Soil type and fertility of range sites may affect fiber components of forages. Acid detergent fiber content was greater in herbage on loamy prairie sites than shallow sites, although a greater percent of tallgrass species may have confounded these results (Kautzsch, 1978). Cook (1959) measured higher cellulose content in crested and intermediate wheatgrass grown on sagebrush sites (sandy loam) than on juniper sites (clay loam).

Cellulose and Lignin

The acid detergent fiber residue of forages represents a reasonably pure lignin-cellulose complex. Acid detergent fiber is of nutritional significance since both the carbon and lignin content are highly correlated with nutritive value when expressed on a whole forage basis (Van Soest, 1963). The lignin-cellulose composition of forages may have direct implications on the digestion and intake obtained by livestock.

An increase in lignin-cellulose has been linked with a decrease in forage digestibility (Moir, 1971; Van Soest, 1963; Ward et al., 1979). Lignin indigestibility appears to cause a reduction in total forage digestibility values. The indigestibility of lignin has been reported to be on the order of 93 to 108% (Rittenhouse et al., 1970; Crampton and Maynard, 1938). On the other hand, Wallace and Van Dyne (1970) observed digestibility values for lignin of 4 to 42% for native range forage.

They stated that lignin was more digestible in younger plants. Thus, ligninification and its effect on forage digestion may be influenced by forage maturity.

An increase in structural carbohydrates and a change (in regards to cellulose, lignin ratios) in their relative proportion may depress forage intake. Highly lignified forages have been shown to reduce intake due to increased rumen retention time (Rittenhouse et al., 1970). Moir (1972) stated that the amount of digestible cell walls appeared constant per 100 grams of forage organic matter. Hence, if there is a constant amount of cell walls which can be digested, lower quality, less digestible forages should be retained in the rumen longer. Fiber mass would inhibit intake in those forages with high cell-wall contents (Van Soest, 1965).

Digestibility and intake of forages, therefore, may be affected by cellulose and/or lignin and may be influenced by maturity and season of growth. Cellulose-lignin content has been shown to increase in range vegetation with advancement of maturity (Cook and Harris, 1950, 1952). Moreover, the lignin fraction has been shown to increase as the season progresses (Rao et al., 1973; Kamstra, 1973; Meyer et al., 1957). Cogswell and Kamstra (1976) observed increases in acid detergent lignin in four native species from June to September. With advance of maturity in sorghum silage, Johnson et al., (1971) also measured an increase in acid detergent lignin.

In summary, it appears that with advancing forage maturity cellulose and lignin increase. Moreover, as maturity increases very limited data suggest the digestibility of these two fractions may decrease. Such changes may cause a reduction in forage digestibility and also reduce intake due to increased rumen retention time.

Site

The range site may influence the cellulose-lignin content of the forage grown. Kautzsch (1978) stated that range sites significantly influence levels of fiber components. Cellulose was higher in live biomass on loamy sites of a tallgrass prairie (Kautzsch, 1978). Cook (1959) reported crested and intermediate wheatgrass to be higher in lignin and cellulose on the favorable sites (sandy-loam, sagebrush). In a study by Cook and Harrie (1950), aspen sites had a higher cellulose to lignin ratio than sagebrush sites. If range site affects cellulose and lignin content, site may, therefore, have an indirect bearing on forage fiber composition and digestibility.

Dry Matter Digestibility

Dry matter digestibility (DMD) is usually regarded as an important indicator of forage quality. Chapman et al. (1972) and Burton (1967) demonstrated this by showing that bermuda grass which was 12% higher in DMD increased average daily gain in cattle by 50 to 60%, hence, digestibility should be a useful indicator of animal performance. A better understanding of factors affecting DMD should be of benefit in enhancing animal performance. Factors, such as cellulose-lignin ratios, may be important during forage harvesting or in plant breeding programs. A better understanding of the effects of maturity, soil and range site on DMD should better aid harvesting or grazing recommendations. The effects of these factors on forage and livestock production should be of major economic importance.

Fiber, Cellulose, and Lignin

Digestibility has been used as an indicator of animal performance. Generally, digestibility decreases as structural carbohydrates increase over any particular time, decreasing animal performance. Digestibility has been shown to decrease with an increase in cell-wall content (Moir et al., 1975; Ward et al., 1979; Horn and Taliaferro, 1979). Moreover, researchers have shown a strong negative association between digestion and increasing acid detergent fiber and lignin levels (Moir, 1971; Van Soest, 1963, 1965; Ward et al., 1979). In general, acid detergent fiber and lignin components have been shown to be inversely related to digestibility of native range vegetation (Cogswell and Kamstra, 1976; Horn and Taliaferro, 1979; Rao et al., 1973). Kautzsch (1978) showed a decrease in DMD of 1.62% for each 1% increase in acid detergent fiber throughout the year for native vegetation.

Maturity (Season)

Cogswell and Kamstra (1976) stated nutritive value and, therefore, animal performance are directly related to stage of plant maturity at the time of cutting or grazing. Two recent studies demonstrated a decrease in DMD with advancement of maturity (Horn and Taliaferro, 1979; Johnson et al., 1971).

Site

There is a paucity of information relating DMD to soil type or site, particularly for native range vegetation. One study observed nylon bag dry matter digestibility (NBMDM) to be greater in live herbage from shallow sites than from loamy sites. Kautzsch (1978) believed this was due to a greater growth of tallgrass species on the loamy prairie sites.

Ash

Individual elements, such as calcium and nitrogen, have been studied extensively. Data on total ash content as affected by site and season of forage utilization are minimal. Ash content, expressed on dry matter basis, appears to decrease as season progresses (Cook and Harris, 1950; Stoddart, 1941). The total ash content appears to follow the same general direction as individual elements (Fleming and Murphy, 1968). Cook's (1959) research showed the ash content of the entire plant to be significantly higher on unfavorable sites (juniper site, clay loam soil). Stoddart (1941), however, showed no effect on ash content due to site, but soil type had a high influence upon ash content.

CHAPTER III

STUDY AREA

The study area is located 16 km northwest of Stillwater, Oklahoma, U.S.A. (lat. 38^{o}N, long. 97^{o}W, elevation 290-319 m). The average number of frostfree days is 206 from early April to late October. Average annual precipitation is 821 ± 250 mm with about 75% occurring during the growing season. The average monthly precipitation ranges from about 120 mm in May to 30 mm in January (Kautzoch, 1978).

Soils of very fine or fine-loamy, mixed thermic Vertic Haplustalfs occupy 70% of the watershed. The proportion of soil orders is 75% Alfisols, 16% Mollisols, and 6% Inceptisols. on a range site basis, the watershed is composed of 53% loamy prairie, 32% shallow prairie, 7% claypan prairie, 6% shallow savannah and 2% sandy savannah. In this thesis, the loamy and claypan prairie sites are referred to as loamy prairie and the shallow prairie, shallow savannah and sandy savannah sites are referred to as shallow prairie (Powell et al., 1978).

The average plant species class composition on loamy prairie sites during the growing season was 18% tallgrass, 24% *Schizachyrium scoparium*, 12% midgrass, 10% other grasses, 26% forbs, and 10% shrubs. On shallow prairie sites the average species class composition was 8% tallgrass, 19% *Schizachyrium scoparium*, 18% midgrasses, 18% other grasses, 35% forbs, and 3% shrubs. The major tallgrasses included *Andropogon gerardii*, *Panicum*, *Paspalum*, *Sporobalus*, other genera and *Bouteloua* curtipendula (Powell et al., 1978).

The watershed has been seasonally grazed with cows and calves for many years. It is generally not grazed during the last two weeks of April and during the 75 days between August 1 and October 15. The average grazing use for the total watershed was about 80 animal-unit-days (AUD)/ha in 1977 and about 85 AUD/ha in 1978.

Dry cows were supplemented with about 1 kg of 41% protein cottonseed meal per head per day from October 15 to December 31 when they were removed from the watershed. From late January to mid April, cows and calves were fed 2.7 kg of 20% protein soybean meal range cubes and 1.8 kg of prairie hay per cow per day. A dicalcium-phosphorus mineral supplement plus salt was provided free choice during all grazing periods.

CHAPTER IV

VEGETATION SAMPLE COLLECTION

Twenty-nine permanent locations were arbitrarily selected for monthly vegetation sampling. Vegetation at each location was hand clipped at ground level to obtain total above ground standing vegetation. A 0.5 m^2 circular quadrant was used for clipping the vegetation sample. Vegetation samples were sorted into grazed live(GL) and grazed dead (GD) standing vegetation during the growing season. During the non-growing season, when clear distinction could not be made between live and dead vegetation, samples were designated as standing dead vegetation (STDV). All forage samples were ground through a 2 mm Wiley mill.

CHAPTER V

THE EFFECT OF SEASON AND LOCATION (SITE) UPON STRUCTURAL CARBOHYDRATE CONTENT OF NATIVE RANGE FORAGES IN CENTRAL OKLAHOMS

Introduction

Changes in the structural carbohydrate (fiber, lignin, cellulose) content of forages may influence the nutritive value for animal production. Structural carbohydrates in low quality forages may affect animal performance by reducing digestibility and/or intake.

Fiber components have been shown to be inversely related to digestibility (Van Soest, 1963; Moir et al., 1975; Ward et al., 1979). Sorghum silage work by Johnson et al. (1971) showed an increased cell-wall content in leaves and stalks caused a decrease in dry matter digestibility. Cogswell and Kamstra (1976) observed an inverse relationship between digestion of four native range species and lignin content. Fiber mass appears to inhibit intake in those forages with a high cell-wall content (Van Soest, 1965). Depressed intake occurs with increased rumen retention of ligninified forages (Rittenhouse et al., 1970).

To date, only a very limited amount of research has dealt with the structural carbohydrate content of mixed native range vegetation as affected by seasonal factors. The research which has been conducted has been rather limited in terms of the sampling times over which the forage has been evaluated.

A major goal today should be improved producivity and longevity of rangeland production for improved efficiency of livestock production. Vegetation from lighter-grazed areas is lower in acid detergent fiber content and produces higher gains per head (Vavra et al., 1973). Moreover, with lighter-grazing intensity, rangelands will have less stress placed upon regrowth. At the same time, with management improved livestock production may by attained. Presently, little is known regarding the effect of factors such as range site (soil type) and season (months) upon the structural carbohydrate components of mixed native range vegetation.

The objective of this study was to determine the effect of time of year (season) and range site upon the structural carbohydrate content of a mixed native rangeland vegetation in Central Oklahoma.

Methods and Materials

Forage samples were taken as described in Chapter four. A 0.5 gram sample of vegetation collected from each of the twenty-nine locations monthly was analyzed for structural carbohydrate components in duplicate. The structural carbohydrate components studied were acid-detergent fiber (ADF), acid-detergent lignin (ADL), and cellulose (CELL). The permanganate oxidation procedure of Van Soest and Wine (1968) was used to determine ADF, ADL, and CELL.

The structural carbohydrate content was measured for grazed (range vegetation with livestock utilization) and caged (range vegetation with no livestock utilization) vegetation samples. The SAS 76 system was used to conduct statistical analyses. Analysis of variance was performed to determine the effect of season and location on forage composition.

Results and Discussion

Structural Carbohydrates

Acid-Detergent Fiber. Acid-detergent fiber (ADF) values (means±SE) for grazed live (GLV), grazed dead (GDV), and standing dead vegetation (GSTDV) by month and season are presented in Tables 1, 2, and 3, respectively. The ADF content (%) increased in GLV from ~~8~~37.9% to 44.3% during the period of May to July in 1977 and showed the same trend during 1978 (31.3% to 43.1%) (Figure 1). During the months of August, September, and October, a slight increase in ADF for GLV (Figure 1) was observed. The increase observed in ADF is similar to results noted by other researchers between fiber components and maturity of forages (Johnson et al., 1971; Rao et al., 1973; Kautzsch, 1978). An increase in ADF values, as in other studies, indicates a decrease in range vegetation quality as the year advances.

The ADF values obtained in this study for GLV were lower than values obtained by Rao et al. (1973) work with bluestems, but similar to values obtained by Horn and Taliaferro (1979) in work with old world bluestems. Moreover, ADF values in this research showed a smaller range (less variation) for GLV than Kautzsch's (1978) values obtained with native range vegetation during a drought stress year. Contrary to the values of grazed live, grazed dead ADF values in this research showed a larger variation than reported for Kautzsch's work with GDV.

ADF content (%) in GLV was 40.3, 42.4 to 42.6% during the spring-summer, summer, and late-summer 1977 seasons, respectively (Table 3,

Table 1. Average (± SE) fiber components (%) of grazed live and dead vegetation by month from April, 1977 through October, 1978.

Month	Acid-Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead
APRIL '77		47.1±.010 Z		9.0±.002 W		34.0±.008 Z
May	37.9±.005 D	53.1±.008 ABC	7.0±.002 E	10.5±.004 F	30.0±.004 CD	36.9±.006 BC
June	43.1±.003 AB	53.7±.011 AB	9.3±,002 BCD	10.8±.003 EF	31.5±.003 AB	37.5±.007 AB
July	44.3±.008 A	53.2±.003 AB	11.0±.004 A	13.6±.003 BC	32.3±.008 A	36.0±.003 BC
August	42.1±.008 B	53.9±.004 A	10.1±.003 AB	13.9±.004 B	30.5±.006 BC	35.9±.005 CB
September	42.6±.007 AB	51.5±.017 BCDE	9.2±.002 BCD	15.3±.010 A	31.6±.007 AB	33.4±.008 D
October		45.1±.008 W		12.7±.006 XY		34.1±.007 Z
November		50.1±.009 Y	9.5.	13.3±.005 X	31 2.	34.9±.007 YZ
December		53.0±.004 X		10.5±.005 ZW		39.3±.008 X
JANUARY '78		53.0±.00				
February		51.9±.004 XY		12.7±.011 XY		37.2±.007 XY
March		52.6±.005 X		11.4±.006 YZ		36.6±.015 XY
April	31.3±.010 E	49.0±.006 E	8.2±.004 D	12.7±.006 CD	24.1±.006 E	39.1±.006 A
May	38.8±.006 CD	51.0±.006 CDE	9.5±.003 BC	12.5±.004 CD	31.1±.004 ABC	37.3±.006 B
June	40.4±.006 C	50.4±.006 DE	10.9±.005 A	12.8±.004 CD	32.4±.005 A	36.6±.004 BC
July	39.4±.005 CD	50.8±.004 CDE	10.1±.003 AB	11.9±.003 DE	32.0±.004 AB	36.8±.004 BC
August	39.4±.005 CD	51.6±.004 BCD	8.9±.005 CD	11.4±.003 EF	30.9±.004 ABC	36.0±.005 CB
September	39.1±.007 CD	51.4±.009 BCDE	9.3±.003 BCD	11.0±.003 EF	28.9±.005 D	35.3±.004 C
October	43.1±.006 AB		11.0±.003 A		31.4±.006 AB	

[1]Means significantly (P<.05) different if they do not have at least one common suffix within columns.

[2]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences (P<.05).

Table 2. Average ($\pm$ SE) fiber components (%) of caged live and dead vegetation by month from April, 1977 through October, 1978.

Month	Acid-Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead
April '77		$48.4 \pm .007^{Y}$[2]		$10.6 \pm .005^{Y}$		$33.9 \pm .006^{X}$
July '77	$43.1 \pm .004^{A}$[1]	$54.0 \pm .003^{A}$	$7.5 \pm .002^{C}$	$13.7 \pm .004^{A}$	$33.9 \pm .004^{A}$	$36.3 \pm .004^{A}$
March '78		$51.1 \pm .004^{X}$		$12.3 \pm .006^{X}$		$35.6 \pm .008^{X}$
July '78	$40.2 \pm .005^{B}$	$48.9 \pm .005^{B}$	$8.5 \pm .003^{B}$	$11.8 \pm .005^{B}$	$32.1 \pm .005^{B}$	$36.9 \pm .004^{A}$
October '78	$42.4 \pm .005^{A}$		$9.7 \pm .004^{A}$		$31.3 \pm .005^{B}$	

[1]Means significantly ($P<.05$) different if followed by different letter suffixes within columns.

[2]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences ($P<.05$).

Table 3. Average (± SE) fiber components (%) of grazed live and dead vegetation by season for April, 1977 through October, 1978.

Season	Acid Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead
Winter '77		47.1±.010 Y[2]		9.0±.002 Y		34.0±.008 Y
Spr/Sum '77	40.3±.004 CD[1]	53.5±.008 A	8.2±.002 C	10.6±.003 E	30.7±.003 AB	37.4±.005 AB
Summer '77	42.4±.007 A	53.4±.003 A	10.2±.003 A	13.8±.003 B	30.9±.006 A	35.7±.003 C
Lat Sum '77	42.6±.007 AB	51.5±.017 AB	9.2±.002 B	15.3±.010 A	31.6±.007 A	33.4±.008 D
Fall '77		45.1±.008 Z		12.7±.006 X		34.1±.007 Y
Winter '78		51.9±.005 X		12.2±.005 Z		36.8±.008 Z
Spr/Sum '78	38.1±.005 E	50.1±.004 B	9.9±.003 B	12.7±.003 C	30.4±.004 B	37.1±.004 A
Summer '78	39.3±.004 D	51.1±.004 B	9.3±.002 B	11.6±.002 D	31.5±.003 A	36.3±.003 BC
Fall '78	41.1±.005 BC	51.4±.009 B	10.1±.002 AB	11.0±.002 DE	30.2±.004 AB	35.3±.004 C

[1] Means significantly (P<.05) different if followed by different letter suffixes within columns.

[2] Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences (P<.05).

[3] April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer '77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

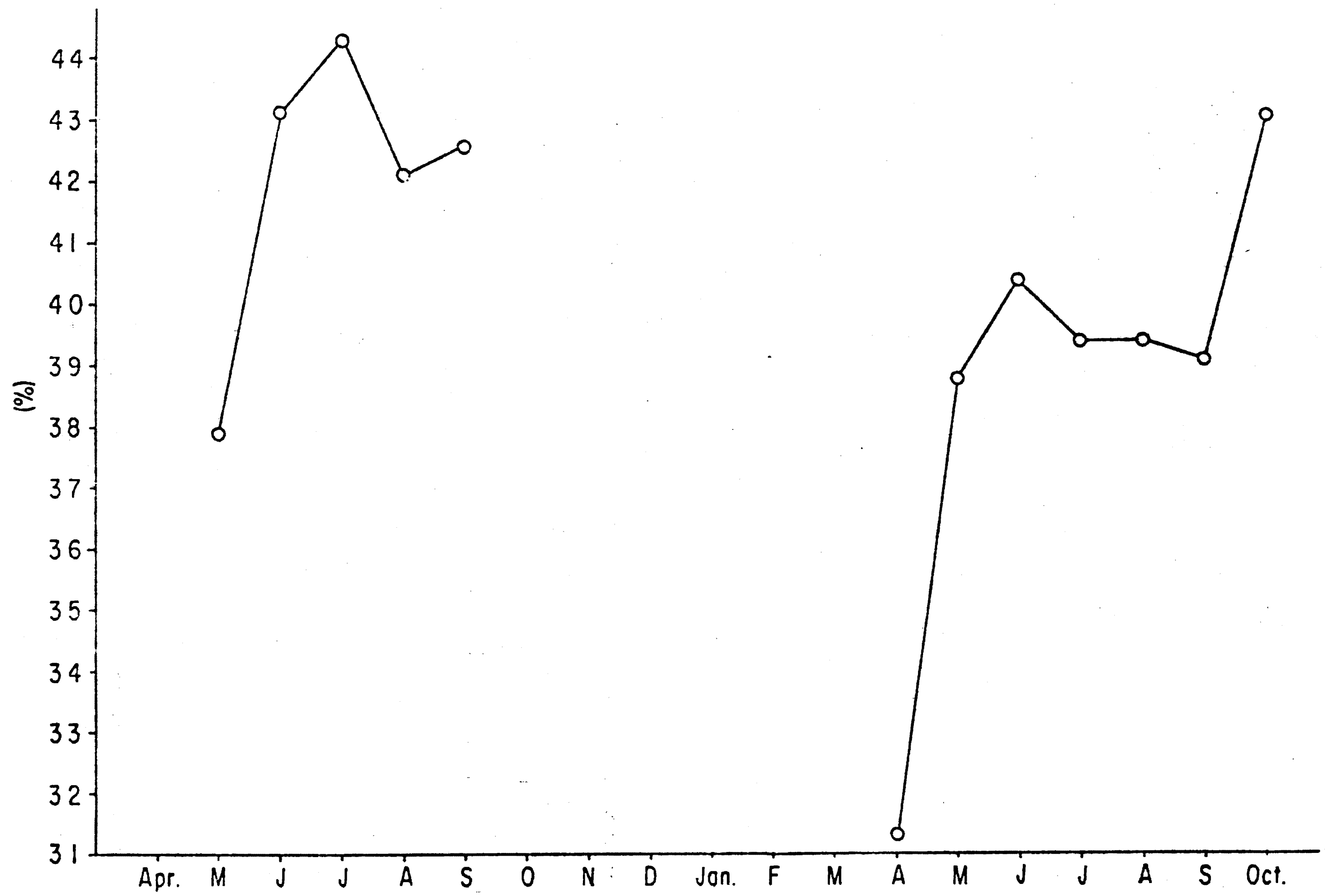


Figure 1. Acid-Detergent Fiber Content (%) in Grazed Live Vegetation from April, 1977 through October, 1978.

Figure 2). In 1978, the same trend was observed for ADF in GLV during the spring-summer, summer, and fall (38.1, 39.3 and 41.1%, respectively).

The trend noted for grazed live vegetation ADF values was not observed for grazed dead forage in either 1977 or 1978. A noticeable increase in ADF values could be seen, however, in grazed standing dead vegetation (GLV and GDV combined, no distinction), from October through December (45.1% to 53.1%, respectively). Such an increase in ADF of grazed standing dead vegetation might be attributed to a loss of soluble nutrients from the vegetation during the dormant (non-growing) season caused possibly by leaching. Selective grazing may also be a factor affecting the ADF content. Grazed dead forage (forage designated as no growth) ADF values ranged from 50.4% to 53.9% from May through September in 1977 and 1978. The slight decrease noted in the ADF values of GDV may possibly be due to a generation of some new material which was classified as dead.

Cellulose and Lignin

Cellulose, lignin, and ADF values of GLV each showed similar trends (Figures 3, 4, 5, and 6). Van Soest (1963) indicates that ADF fiber residue (laboratory fraction) increases for a forage, the composition of the residue probably changes as well. Since the ADF residue is primarily cellulose and lignin, the similarity of trends noted among the three parameters is logical.

Cellulose of GLV increased from 30.0% to 32.3% (1977) and 31.1% to 31.0% (1978) from May to July, respectively in each year (Table 1). The lignin content of GLV increased from 7.0% to 11.0% and 9.5% to 10.1% during the same time period (Table 1). The cellulose-lignin content in

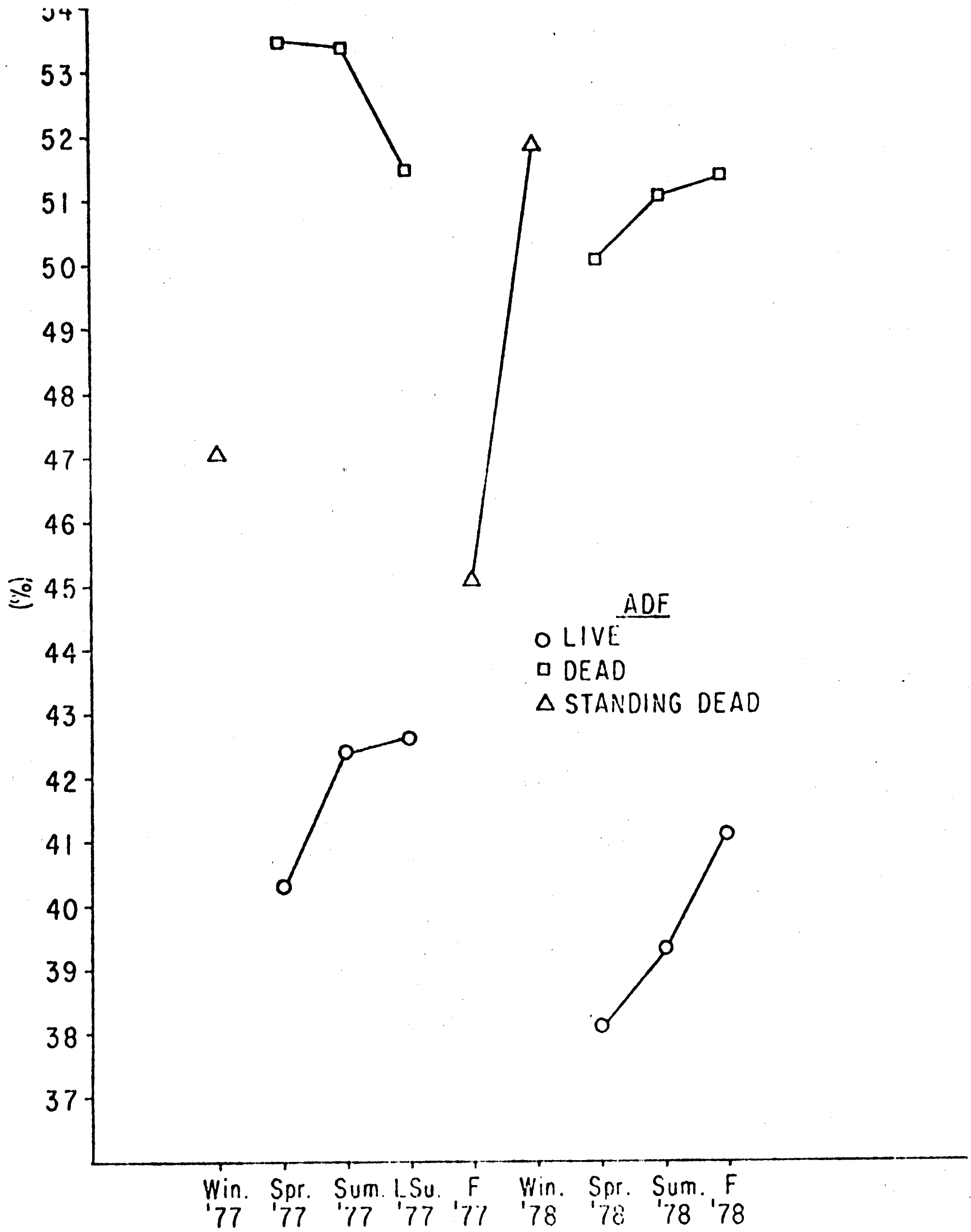


Figure 2. Acid-Detergent Fiber Content (%) in Grazed Live, Dead, and Standing Dead Vegetation by Season from April, 1977 through October, 1978.

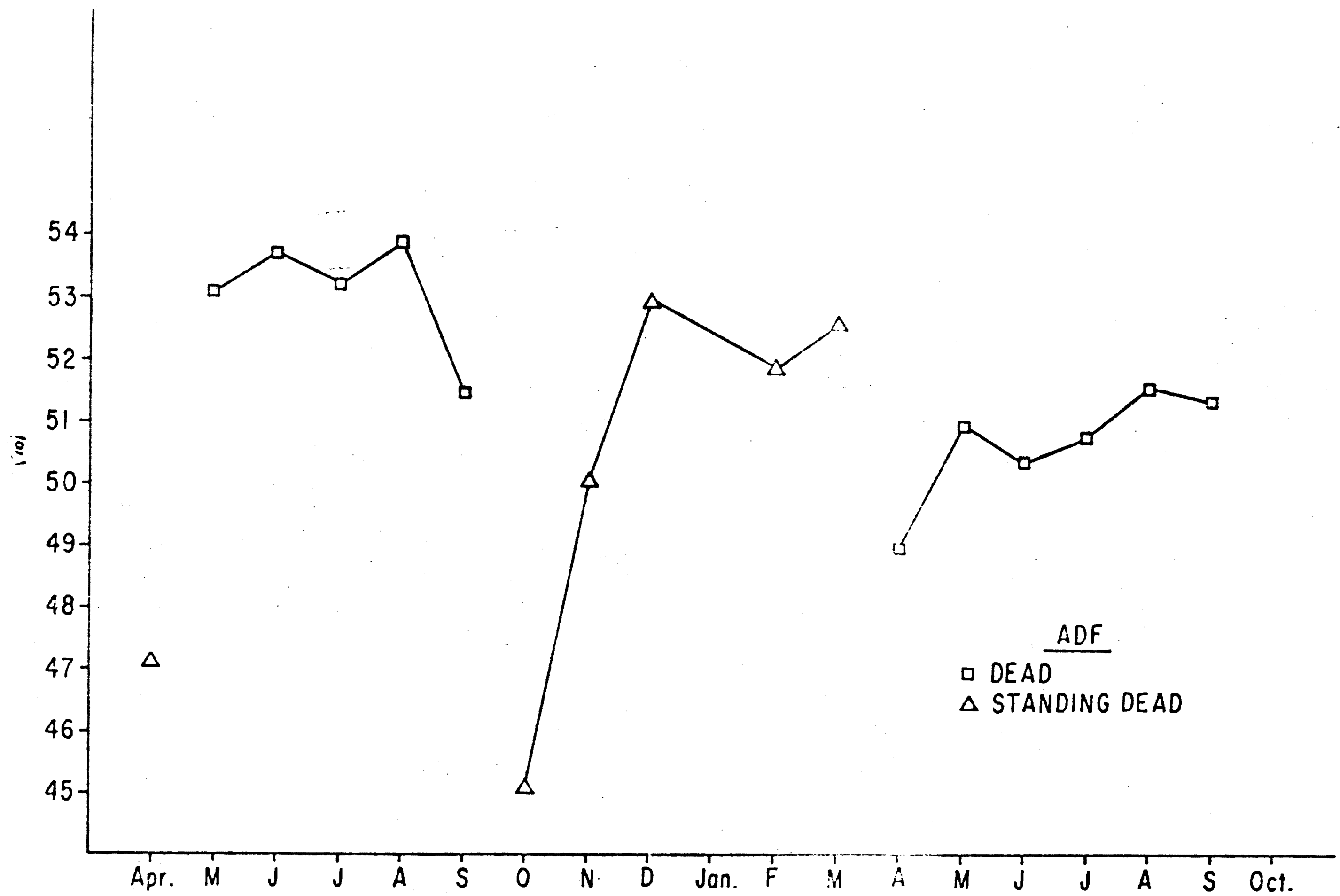


Figure 3. Acid-Detergent Fiber Content (%) in Grazed Dead and Standing Dead Vegetation from April, 1977 through October, 1978.

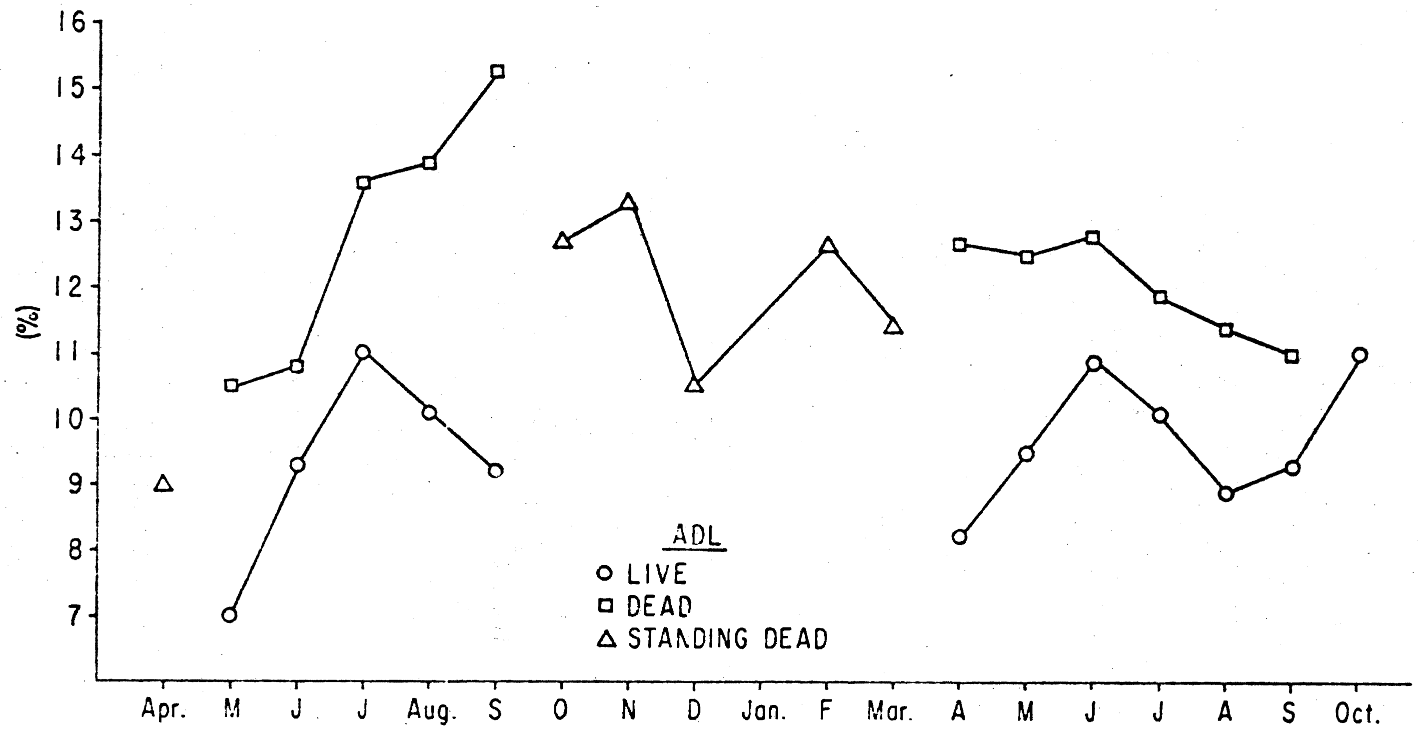


Figure 4. Acid-Detergent Lignin Content (%) in Grazed Live, Dead, and Standing Dead Vegetation from April, 1977 through October, 1978.

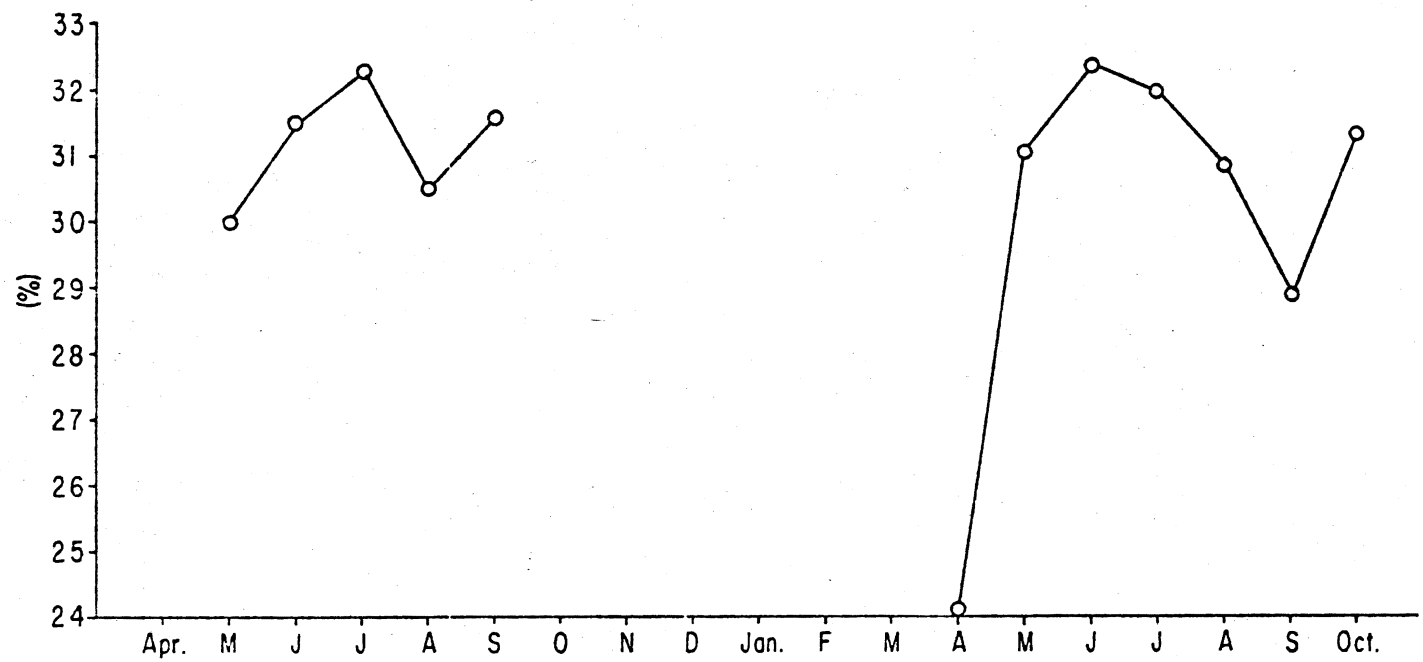


Figure 5. Cellulose Content (%) in Grazed Live Vegetation from April, 1977 through October, 1978.

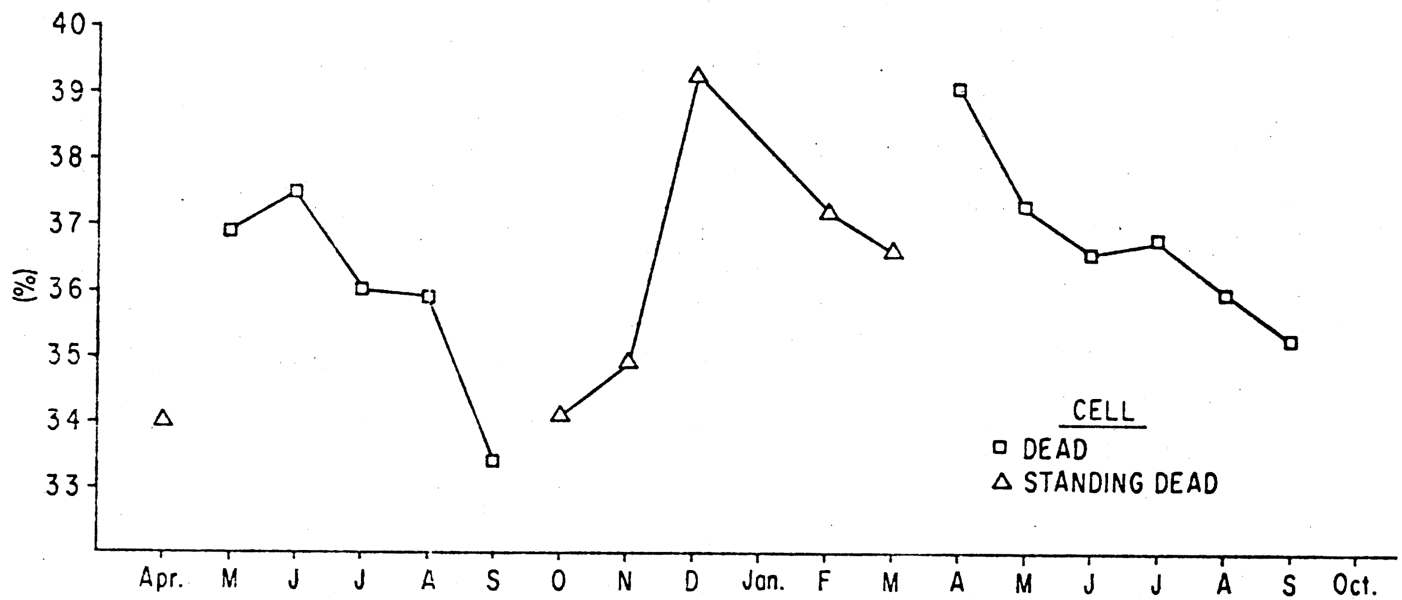


Figure 6. Cellulose Content (%) in Grazed Dead and Standing Dead Vegetation from April, 1977 through October, 1978.

range vegetation has been shown to increase with advancing maturity (Cook and Harris, 1950, 1952). Cogswell and Kamstra (1976) reported similar results for four native range species, showing an increase in ADL from June to September.

An increase in cellulose and lignin (Figures 7 and 8) was observed during the spring-summer, summer, and late-summer of 1977, much as with ADF. A similar trend between cellulose, lignin and ADF over seasons was not observed during 1978 as reported for the previous year. Differences in the directional change of cellulose and lignin between 1977 and 1978 may be caused by a difference in the time or amount of precipitation. The precipitation pattern during 1978 showed a greater frequency including a greater total precipitation. A greater frequency of precipitation should promote vegetative regrowth, which is younger and has a less advanced structural carbohydrate content for an extended period. Generally, results reported by other researchers showed the trend observed in 1977, with the lignin fraction increasing as the season progressed (Rao et al., 1973; Kamstra, 1973; and Meyer et al., 1957).

CLV samples were lower in acid-detergent lignin content than GLV for both month and season. The higher acid-detergent lignin values for GLV may be due to a larger proportion of the sample being stems. Vavra et al. (1973) reported ADF values to be lowered with lighter grazing pressure. The grazing pressure on grazed vegetation could increase the percent lignin due to livestock selectivity away from stems and in favor of leaves. If a lighter grazing pressure is maintained, a lower plant structural carbohydrate content might exist. This is evidenced or supported by the large differences noted in the caged (no grazing) samples. The lower structural carbohydrate content should indicate more desirable

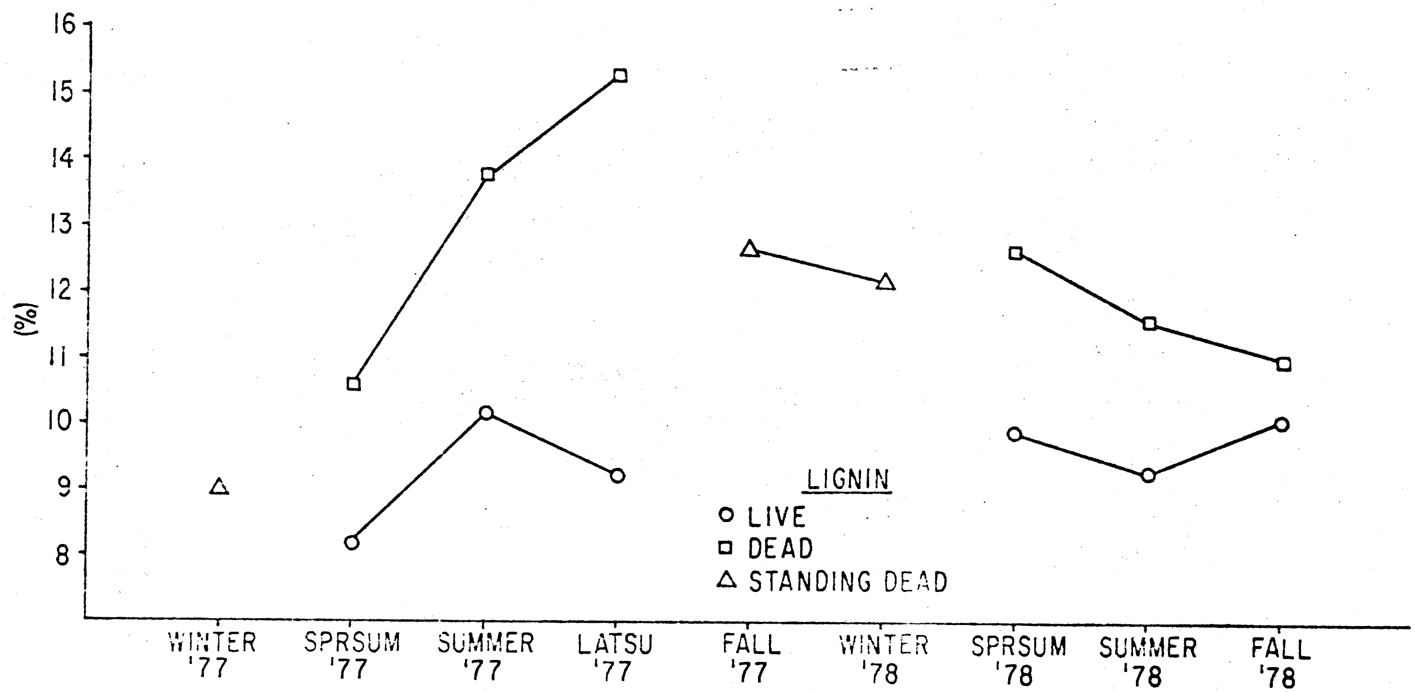


Figure 7. Lignin Content (%) in Grazed Live, Dead, and Standing Dead Vegetation by Season from April, 1977 through October, 1978.

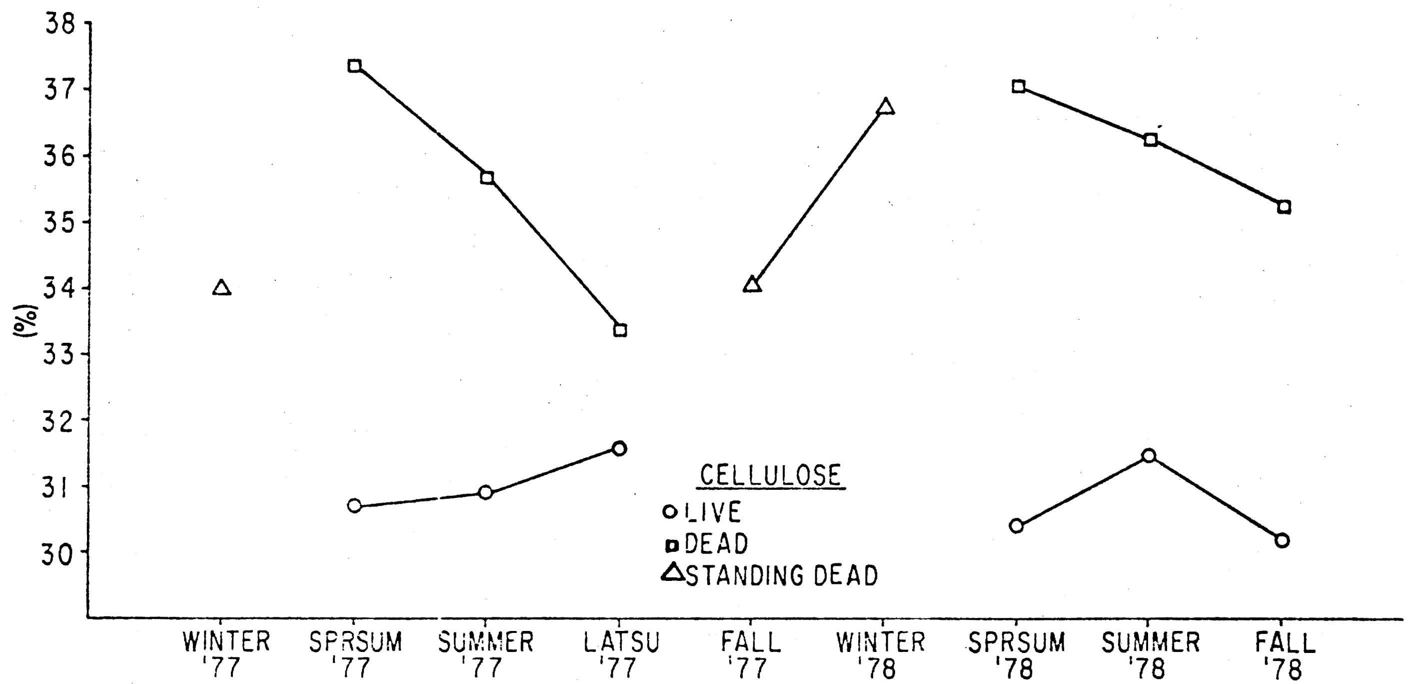


Figure 8. Cellulose Content (%) in Grazed Live, Dead, and Standing Dead Vegetation by Season from April, 1977 through October, 1978.

forage quality for animal production. Thus, grazing intensity by livestock may be manipulated for improvement of forage quality from a mixed native vegetation.

Both month and season of collection had a significant ($P<.05$) effect upon structural carbohydrate values (Tables 4 and 5). Seasons were a combination of months which were similar in climatic and anticipated plant growth (Appendix A).

Structural carbohydrate content increased significantly from approximately April through December. The increase of structural carbohydrate content could be due to: (1) a maturity of the vegetation, thus, increased cell wall, (2) a leaching of vegetation, (3) same shift from shortgrass to tallgrass composition or (4) a combination of the first three.

With advancing maturity, cell walls increase more than the cell content. An increase in structural carbohydrates is in agreement with Horn and Taliaferro (1979) and Rao et al. (1973) work with homogeneous vegetation (bluestems). This study points out that a heterogeneous vegetation (mixed native range) might be expected to increase approximately the same amount as single species (particularly bluestems) which have been studied.

Location and location within site had no measurable significant effect upon structural carbohydrate values. Although, locations were divided into two sites -- loamy and shallow -- site grouping had no measurable significant effect on structural carbohydrate in this study. Moreover, site by day and site by season interactions had no significant effect upon structural carbohydrate values.

Table 4. Analysis of variance for grazed live, dead, and standing dead ADF, ADL, and Cellulose from April, 1977 through October, 1978.

	PR>F				PR>F		Error Mean Square
	SITE[2]	LOC (SITE)[2]	MONTH (SEASON)**	DF	SITE*MONTH (SITE*SEASON)	DF	
GLADF[1]	.3872	.0126*	.0001	11	.0541÷	11	.00081
	.5743	.3728	(.0001)	5	(.0332)*	5	.00137
GLADL	.1200	.0118*	.0001	11	.6828	11	.00026
	.1757	.0722	(.0001)	5	(.5492)	5	.00033
GLCELL	.9923	.0232*	.0001	11	.1639	11	.00057
	.8184	.3809	(.0291)*	5	(.1009)	5	.00090
GDADF	.0374*	.7060	.0001	10	.5734	10	.00099
	.0347	.6356	(.0001)	5	(.3431)	5	.00098
GDADL	.2145	.0215*	.0001	10	.3656	10	.00030
	.1968	.0125*	(.0001)	5	(.2587)	5	.00029
GDCELL	.0209*	.1005	.0001	10	.9695	10	.00051
	.0236*	.0879	(.0001)	5	(.8956)	5	.00053
GSTADF	.0027**	.0005*	.0001	5	.6457	5	.00095
	.0025**	.0004*	(.0001)	2	(.2175)	2	.00097
GSTADL	.6397	.1834	.0001	5	.4895	5	.00072
	.6691	.1553	(.0001)	2	(.2026)	2	.00075
GSTCELL	.0005**	.0039**	.0028	5	.9497	5	.00143
	.0006**	.0020**	(.0031)	2	(.9982)	2	.00147

[1]GLADF = grazed live ADF; GLADL = grazed live ADL; GLCELL = grazed live cellulose; GDADF = grazed dead ADF; GDADL = grazed dead ADL; GDCELL = grazed dead cellulose; GSTADF = grazed standing dead ADF; GSTADL = grazed standing dead ADL; GSTCELL = grazed standing dead cellulose.

[2]Degree of Freedom for SITE = 1; LOC (SITE) = 27

[3]Means squares in Appendix C.

*P<.05; **P<.01; ÷P<.10.

Table 5. Analysis of variance for caged live, dead, and standing dead for ADF, ADL, and Cellulose from April, 1977 through October, 1978.

	PR>F							Error Mean Square
	SITE[2]	LOC (SITE)	DF	MONTH (SEASON)	DF	SITE*MONTH (SITE*SEASON)	DF	
CLADF[1]	.2803	.2395	23	.0001**	2	.3492	2	.00044
	.2803	.2395	23	(.0001)**	2	(.3492)	2	.00044
CLADL	.1452	.4509	23	.0001**	2	.9215	2	.00022
	.1452	.4509	23	(.0001)**	2	(.9215)	2	.00022
CLCELL	.6013	.1011	23	.0006**	2	.2914	2	.00045
	.6013	.1011	23	(.0006)**	2	(.2914)	2	.00045
CDADF	.0042**	.3742	23	.0001**	1	.3560	1	.00033
	.0042**	.3742	23	(.0001)**	1	(.3560)	1	.00033
CDADL	.3976	.5151	23	.0207*	1	.3267	1	.00051
	.3976	.5151	23	(.0207)*	1	(.3267)	1	.00051
CDCELL	.0663±	.5598	23	.4206	1	.4783	1	.00046
	.0663±	.5598	23	(.4206)	1	(.4783)	1	.00046
CSTADF	.0230*	.0665±	22	.0007**	1	.0308*	1	.00037
	.0230*	.0665±	22	(.0007)**	1	(.0308)*	1	.00037
CSTADL	.1447	.2639	22	.0230*	1	.3482	1	.00052
	.1447	.2639	22	(.0230)*	1	(.3482)	1	.00052
CSTCELL	.3249	.1388	22	.0275*	1	.9322	1	.00075
	.3249	.1388	22	(.0275)*	1	(.9322)	1	.00075

[1]CLADF = caged live ADF; CLADL = caged live ADL; CLCELL = caged live cellulose; CDADF = caged dead ADF; CDADL = caged dead ADL; CDCELL = caged dead Cellulose; CSTADF = caged standing dead ADF; CSTADL CSTADF = caged standing dead ADF; CSTADL = caged standing dead ADL; CSTCELL = caged standing dead Cellulose.

[2]Degree of Freedon for SITE = 1.

[3]Mean squares in Appendix C.

*P<.05; **P<.01; ±P<.10.

Conclusions

Time of forage harvesting maturity is one factor which appears to affect forage quality. Data in this study indicate that month or season of harvesting had a significant effect upon the structural carbohydrate content of rangeland forage. Advancement of forage maturity over months or seasons produced an increase in structural carbohydrate content, reducing the forage value for animal production. Hence, management of animals for efficient production would involve change as the composition and nutritive value of vegetation is altered over season. A very heavy grazing intensity will produce maximum production per hectare for a short period of time, but will reduce forage quality and range condition of the pasture over a longer period. Therefore, livestock production and range condition need to be co-managed.

Range site, contrary to other research, did not appear to have a significant effect upon the structural carbohydrate content of native range grass in this study. Moreover, location, subdivision used for site, did not have a measurable significant effect upon structural carbohydrate content. This non-significant effect of range site may be due to a diversity of species composition and/or ecosystems affecting this particular study area.

Measuring structural carbohydrate for differences in forage quality between range sites may be of limited value. This is one point that needs further development and research to aid in a better understanding of forage quality.

The main conclusion from this study is that a mixed tallgrass native vegetation appears to respond much as a monoculture does to seasonal change. Furthermore, structural carbohydrates values for a mixed tallgrass vegetation over an extended period and separated into different growing components is now available. Additional research on structural carbohydrate and range site effects by species composition needs to be conducted. Such research as the relationship of lignin-cellulose ratios effect on digestibility needs further research. As well, controlled precipitation research on structural carbohydrates needs further study. Research on an optimum species combination and properties deserves further attention as well.

Table 6. Average (± SE) fiber components (%) of caged live and dead vegetation by season from April, 1977 through October, 1978.

Season	Acid-Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead
Winter '77[3]		48.4±.007^{Y}[2]		10.6±.005^{Y}		33.9±.006^{X}
Summer '77	43.1±.004^{A}[1]	54.0±.003^{A}	7.5±.002^{C}	13.7±.004^{A}	33.9±.004^{A}	36.3±.004^{A}
Winter '78		51.1±.004^{X}		12.3±.005^{X}		35.6±.008^{X}
Summer '78	40.2±.005^{B}	48.9±.005^{B}	8.5±.003^{B}	11.8±.005^{B}	32.1±.005^{B}	36.9±.004^{A}
Fall '78	42.3±.005^{A}		9.7±.004^{A}		31.3±.005^{B}	

[1]Means significantly (P<.05) different if followed by different letter suffixes within columns.

[2]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences (P<.05).

[3]April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer '77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

CHAPTER VI

THE EFFECT OF SEASON AND LOCATION (SITE) UPON DRY MATTER AND ORGANIC MATTER DIGESTIBILITY OF NATIVE RANGE FORAGES IN CENTRAL OKLAHOMA

Introduction

Dry matter (DMD) and organic matter digestibility (OMD) have been used as relative indicators of forage quality. An increase in dry matter digestibility indicates a higher quality forage and has been associated with improved animal performance. A 12% increase in DMD of bermudagrass has been shown to enhance average daily gains of steers by 30 to 60% (Burton et al., 1967; Chapman et al., 1972).

¶ Generally, the more immature a forage at the time of harvest, the more digestible the forage is as indicated by two recent studies which showed a decrease in dry matter digestibility of bluestem and sorghum with advancing forage maturity (Horn and Taliaferro, 1979; Johnson et al., 1971, respectively). Moreover, Cogswell and Kamstra (1976) stated nutritive value and, therefore, animal performance were directly related to stage of plant maturity at the time of cutting or grazing. Most past studies have involved homogeneous types of vegetation. Native rangeland, however, consists of a heterogeneous vegetation when grazed by livestock. Data in the literature on the digestibility of heterogeneous native vegetation as affected by season is limited, particularly over an extended period of time. Moreover, research data on mixed tallgrass native forage which has been separated into live and dead vegetation is especially limited.

Forage dry matter, excluding ash, is generally classified organic matter. DMD and OMD have been shown to be highly correlated in some studies with homogeneous vegetation such as Rhodesgrass and tropical grasses (Milford and Minson, 1968; McLead and Minson, 1974). Wind contamination and therefore variable ash content may have a greater effect upon the relationship between DMD and OMD for a heterogeneous vegetation such as that on native rangeland. However, relationships between DMD and OMD have not been studied for such heterogeneous forage. Correlation coefficients between DMD and OMD need to be determined for native rangeland to better assess measures of vegetation quality are of interest to determine the possibility of forage quality results being affected by ash content from season to season of a heterogeneous native rangeland vegetation.

The objectives of this study, therefore, were to: (1) determine the effect which season and location (site) have on dry matter digestibility (DMD) and (2) to determine the relationship between dry matter and organic matter digestibility of mixed tallgrass native range over seasons.

Methods and Materials

Forage samples were taken as described in Chapter IV. Forage samples were analyzed for nylon bag dry matter digestibility (NBDMD) on a monthly basis corresponding with the month in which the forage sample was collected from the study area. A three gram sample of forage was placed in a 100 mesh nylon bag microscopically measured to have 32,400 pores per cm^2. The nylon bags were as described by Kautzsch (1978). Forage samples were incubated ruminally for 48 hours in three Holstein steers. Steers were maintained on a range similar in plant species composition to that of the study area where the forage samples were collected. After a 48-hour incubation period, nylon bags were removed and placed in a chest of ice water. In the laboratory, individual bags were washed thoroughly with cold tap water. The bags were then placed on drying trays and dried in an oven at 55°C for 48 hours. After the drying process, the bags were reweighed and the percent dry matter digestibility calculated. Nylon bag organic matter digestibility (OMD) was calculated as organic matter (ash free) disappearance during incubation. Organic matter was assumed to be dry matter in the sample minus ash (determined on samples before and after incubation).

The SAS 76 system was used to conduct statistical analyses. Analysis of variance (AOV) was performed to determine the effect of season and location. Significance level was considered at the $P<.05$, unless otherwise stated. Correlation coefficients were obtained to determine the relationship of DMD to OMD.

Results and Discussion

Digestibility

Dry matter (DMD) and organic matter (OMD) digestibility values of grazed live and dead vegetation (GLV and GDV, respectively) are presented in Table 7. DMD values of GLV in 1977 decreased from 48.1% to 38.8% from May to September (Figure 9) and OMD decreased from 50.6 to 41.5%

Table 7. Average (±SE) NBDMD and NBOMD of live and dead grazed vegetation by month from April, 1977 through October, 1978.

	Dry Matter Digestibility		Organic Matter Digestibility	
Month	Live	Dead	Live	Dead
April '77		29.0±.024[1]Y		28.8±.013
May	48.1±.009B	18.8±.013EF	50.6±.010	22.3±.010
June	46.9±.007BC	20.4±.010DEF	48.7±.008	22.7±.011
July	48.6±.008B	21.7±.014CDE	49.6±.008	25.4±.014
August	47.0±.010BC	22.9±.009CD	49.2±.013	25.8±.009
September	38.8±.007E	24.2±.006BC	41.5±.009	26.1±.008
October		42.0±.008X		43.5±.007
November		22.1±.009Z		23.8±.007
December		15.5±.008W		17.7±.008
January '78				
February		17.7±.008W		19.5±.008
March		15.3±.005W		15.8±.004
April	58.5±.011A	21.6±.008CDE	58.9±.026	23.4±.009
May	48.8±.011B	18.5±.010F	49.5±.011	19.1±.008
June	43.4±.006D	20.3±.011DEF	45.1±.006	22.4±.011
July	44.4±.012CD	25.5±.011B	46.3±.011	26.1±.011
August	50.1±.013B	20.8±.022DEF	51.6±.013	25.5±.023
September	47.2±.017BC	29.1±.009A	47.9±.027	30.0±.010
October	19.0±.021F			

[1]Standing dead vegetation is listed in the dead vegetation column. Live vegetation values are not given for those months when no live vegetation existed.

[2]Means significantly (P<.05) different if followed by different letter suffixes within columns.

[3]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences (P<.05).

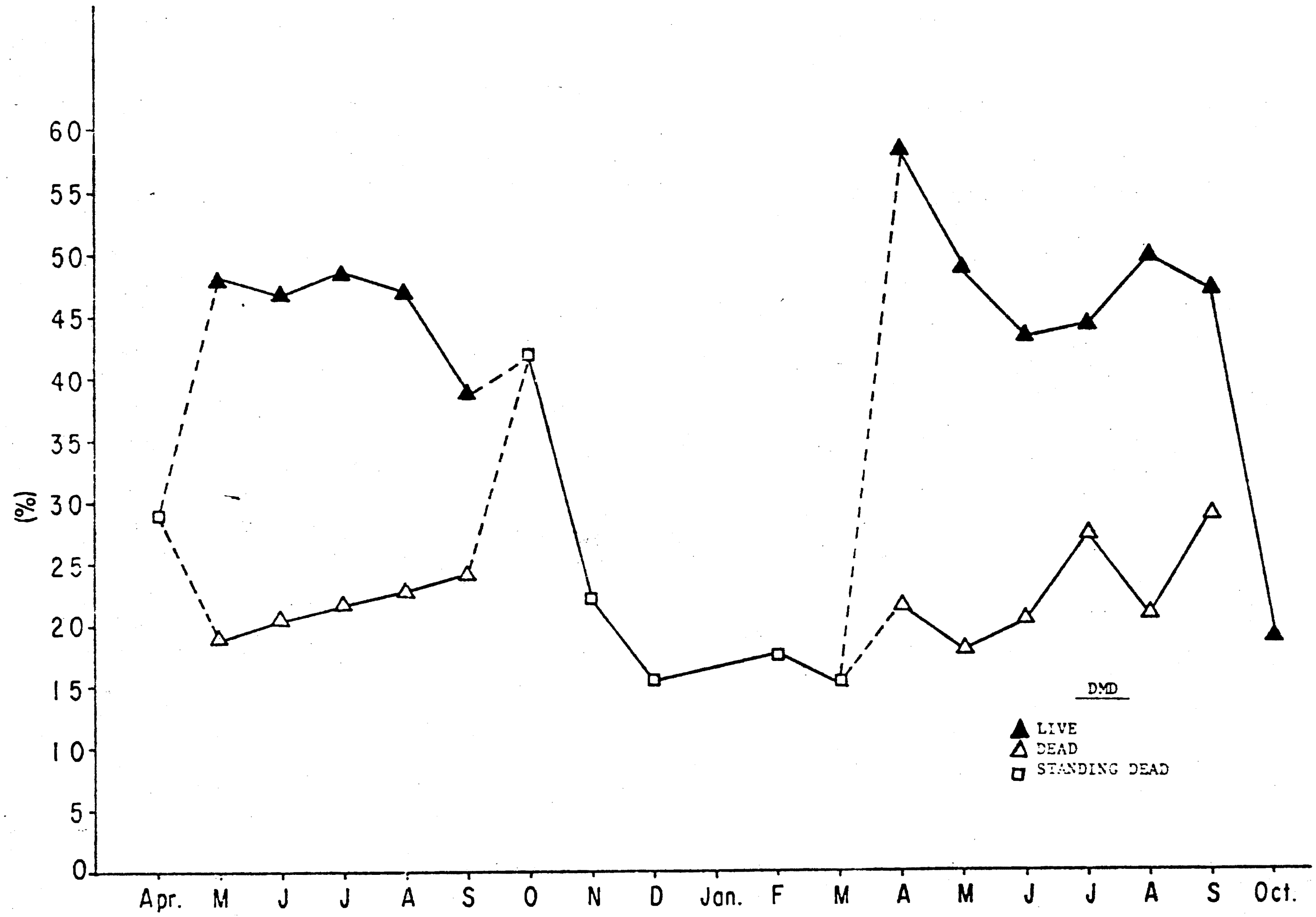


Figure 9. NBDMD (%) in Grazed Live and Dead Vegetation from April, 1977 through October, 1978.

(Figure 10) during this same time period. During 1978, DMD of GLV decreased from 58.5% to 43.4% from April to June, and then increased to 50.1% from June to August. OMD showed a similar trend. The higher DMD and OMD values in the early growing months of 1978 and the subsequent decline and rise in the DMD and OMD values may be related to more total precipitation prior to June, July, and August than in 1977.

The decrease in digestibility of GLV noted with advancing time (months) in this study is consistent with research findings with other forages - five old world bluestems (Horn and Taliaferro, 1979), sorghum (Johnson et al., 1972), oat hay (Meyer et al., 1957) and bermudagrass (Chapman et al., 1972). An increase in digestibility of warm season grasses during the fall was noted by Kamstra (1973) following an increase in rainfall. This was also observed in this study from July to August and September, 1978.

GDV showed an increase in DMD and OMD from May to September during both years. An increase in the digestibility of GDV may be noted when live vegetation discontinues photosynthesis and becomes dormant vegetation. An increased digestibility of the dead vegetation, as a whole, may be due to the lack of weathering upon the new dead vegetation.

Caged live (CLV) and caged dead (CDV) vegetation were more digestible than GLV and GDV. This is probably related to grazing selectivity in that the more digestible plant parts of the grazed vegetation was consumed by livestock. The caged (ungrazed) vegetation being more digestible is in agreement with results obtained by Vavra et al. (1973) in which cattle were grazing primarily blue grama. Variation observed in digestibilities between GV or CV in this study may also be caused by differences in species composition.

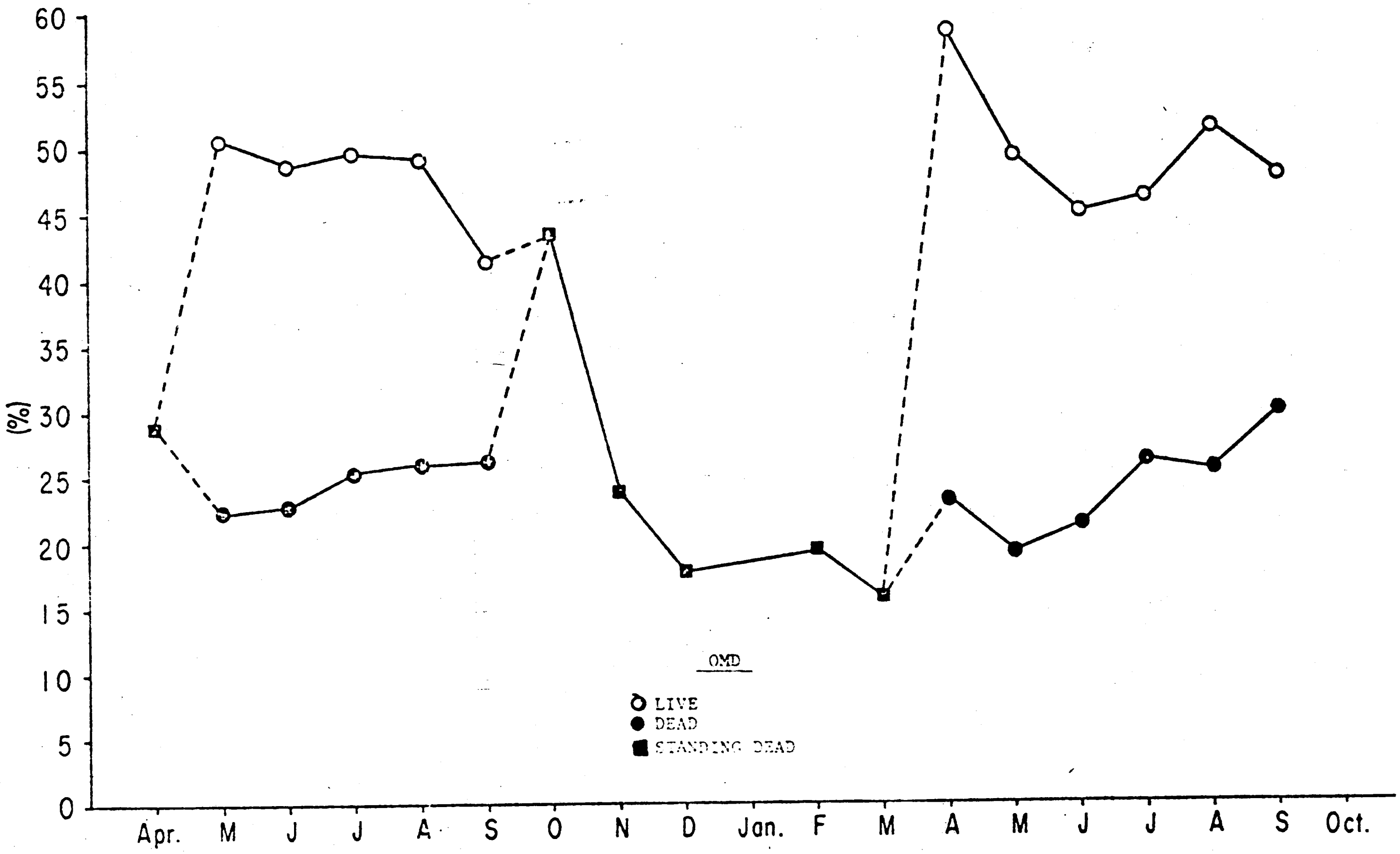


Figure 10. NBOMD (%) in Grazed Live and Dead Vegetation from April, 1977 through October, 1978.

Table 8. Average ($\pm$ SE) NBDMD and NBOMD of live and dead caged vegetation by month from April, 1977 through October, 1978.

Month	Dry Matter Digestibility		Organic Matter Digestibility	
	Live	Dead	Live	Dead
April '77		30.5$\pm$.010[1]		32.7$\pm$.010
July '77	43.5$\pm$.01	22.9$\pm$.008	44.1$\pm$.010	26.1$\pm$.010
March '78		23.5$\pm$.008		23.4$\pm$.007
July '78	46.0$\pm$.01	20.0$\pm$.010	48.2$\pm$.009	22.7$\pm$.010
October '78	37.3$\pm$.01		38.9$\pm$.010	

[1]Standing dead vegetation is listed in the dead vegetation column with live vegetation values being absent during months where no live vegetation existed.

DMD of GLV was 48.0, 47.8, and 38.7% during the spring-summer, summer, and late-summer period of 1977, respectively (Table 9). In 1978, GLV dry matter digestibility values during the spring-summer, summer, and fall decreased (49.7, 46.5, and 36.4%, respectively) in a similar manner. To obtain maximum livestock production from native rangeland, the range must be utilized to the greatest degree at the time of peak digestibility of the vegetation. A lower digestibility of rangeland vegetation may still permit economic gains, however, if total production of vegetation is increased. To increase total rangeland vegetation, some deferment from grazing may also be neccessary with some corresponding utilization at a time of lower digestibility to permit higher root reserves and greater stand preservation. Deferment would aid the vegetation in reseeding and maintenance of vigorous stand. Highest DMD may possibly coincide with the periods of lowest root reserves.

Month and Location

Two models were used in the statistical analysis of digestibility data. The first model evaluated the month effect and the second model the season effect (Tables 10 and 11). Both models accounted for site and location effects. Site by month and site by season interactions were determined. The two models were used due to certain seasons containing only one month.

Month and season of the year significantly affected digestibility of grazed rangeland vegetation. Range site was a significant factor affecting digestibility of both GLV and GDV for both dry matter and organic matter. Shallow range sites showed higher forage digestibility than loamy sites (Table 12). This is probably related to the type of

Table 9. Average (%) NBDMD and NBOMD of live and dead grazed vegetation by season from April, 1977 through October, 1978.

Season	Dry Matter Digestibility		Organic Matter Digestibility	
	Live	Dead	Live	Dead
Winter '77[2]		29.9[1]	49	28.8
Spring/Summer '77	48.0	19.7	19.6	22.5
Summer '77	47.8	22.3	49.4	25.6
Late Summer '77	38.7	24.2	41.5	26.1
Fall '77		42.0		43.5
Winter '78		18.0		19.7
Spring/Summer '78	49.7	20.1	48.2	21.6
Summer '78	46.5	24.0	48.2	25.9
Fall '78	36.4	29.1	47.9	30.0

[1] Standing dead vegetation is listed in the dead vegetation column.

[2] April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer '77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

Table 10. Analysis of variance for grazed live, dead, and standing dead DMD and OMD from April, 1977 through October, 1978.

	PR>F						
	SITE	LOC	DF	MONTH (SEASON)	DF	SITE*MONTH (SITE*SEASON)	DF
GLDMD[1]	.0001**	.0001**	27	.0001**	11	.0233*	11
	.0122*	.0018**	27	(.0001)**	5	(.4041)	5
GDDMD	.0015**	.0001**	27	.0001**	10	.2477	10
	.002**	.0001**	27	(.0001)**	5	(.3311)	5
GSTDMD	.0492*	.1461	27	.0001**	5	.0542†	5
	.0604†	.2327	27	(.0001)**	2	(.0102)*	2
GLOMD	.0046**	.0001**	27	.0001**	10	.0246*	10
	.0128*	.0018**	27	(.0001)**	5	(.0826)†	5
GDOMD	.0002**	.0001**	26	.0001**	10	.4926	10
	.0002**	.0001**	26	(.0001)**	5	(.4506)	5
GSTOMD	.4082	.0001**	27	.0001**	5	.6363	5
	.4771	.0016**	27	(.0001)**	2	(.4699)	2

[1]GLDMD = grazed live DMD; GDDMD = grazed dead DMD; GSTDMD = grazed standing dead DMD; GLOMD = grazed live OMD; GDOMD = grazed dead OMD; GSTOMD = grazed standing dead OMD.

[2]Degree of Freedom for SITE = 1.

*P<.05; **P<.01; †P<.10.

Table 11. Analysis of variance for caged live, dead, and standing dead DMD and OMD from April, 1977 through October, 1978.

	PR>F						
	SITE	LOC	DF	MONTH (SEASON)	DF	SITE*MONTH (SITE*SEASON)	DF
CLDMD[1]	.0001**	.0680†	23	.0001**	2	.6004	2
	.0001**	.0680†	23	(.0001)**	2	(.6004)	2
CDDMD	.0128*	.6384	23	.2250	1	.7356	1
	.0128*	.6384	23	(.2250)	1	(.7356)	1
CSTDMD	.1386	.1720	23	.0011**	1	.6739	1
	.1386	.1720	23	(.0011)**	1	(.6739)	1
CLOMD	.0004**	.1771	23	.0001**	2	.5488	2
	.0004**	.1771	23	(.0001)**	2	(.5488)	2
CDOMD	.0127**	.6722	22	.1323	1	.9311	1
	.0127**	.6722	22	(.1323)	1	(.9311)	1
CSTOMD	.3147	.2692	22	.0001**	1	.4535	1
	.3147	.2692	22	(.0001)**	1	(.4535)	1

[1]CLDMD = caged live DMD; CDDMD = caged dead DMD; CSTDMD = caged standing dead DMD; CLOMD = caged live OMD; CDOMD = caged dead OMD; CSTOMD = caged dead OMD.

[2]Degree of Freedom for SITE = 1.

*P<.05; **P<.01; †P<.10.

Table 12. Average (± SE) DMD and OMD values by season and site with differences presented by site for grazed vegetation.

	DMD - Range Site			OMD - Range Site		
	Loamy	Shallow	Difference[1]	Loamy	Shallow	Difference
Winter '77[2]						
G. Standing Dead	24.6±.010	30.8±.020	-6.2	29.1±.010	29.6± .010	-0.5
Spring-Summer '77						
G. Live	47.3±.008	48.7±.008	-1.4	49.0±.007	50.2±.007	-1.2
G. Dead	18.2±.008	21.6±.010	-3.4	21.3±.008	21.6±.010	-0.3
Summer '77						
G. Live	46.2±.006	49.6±.007	-3.4	47.5±.006	51.4±.007	-3.9
G. Dead	22.5±.009	22.2±.008	0.3	25.6±.008	25.8±.009	-0.2
Late-Summer '77						
G. Live	38.6±.010	38.9±.010	-0.3	40.7±.010	42.3±.010	-1.6
G. Dead	22.4±.009	25.7±.007	-3.3	24.4±.010	27.9±.008	-3.5
Fall '77						
G. Standing Dead	40.7±.006	43.4±.008	-2.7	42.3±.006	44.8±.007	-2.5
Winter '78						
G. Standing Dead	18.0±.006	18.6±.007	-0.6	19.8±.007	20.0±.008	-0.2
Spring-Summer '78						
G. Live	49.6±.008	48.9±.009	0.7	49.7±.008	47.5±.008	1.2
G. Dead	18.9±.007	21.3±.007	-2.4	20.4±.007	22.8±.007	-2.4
Summer '78						
G. Live	45.9±.010	47.2±.010	-1.3	47.8±.010	49.2±.010	-1.9
G. Dead	22.8±.010	25.2±.010	-2.4	23.5±.010	28.0±.020	-4.5
Fall '78						
G. Live	31.6±.020	36.5±.020	-4.9	45.2±.010	50.3±.020	-5.1
G. Dead	28.9±.010	28.9±.020	0	29.5±.010	29.9±.020	-0.4

[1]Difference = Loamy - Shallow.

[2]April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer ' 77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March,'78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

forage prevalent on shallow soil sites. Shallow range sites are more prevalent on hill tops and slopes. The hill tops and slopes from a mixed tallgrass range that has had extensive use by livestock generally consists mostly of short grasses. Short grass species are usually more digestible than tallgrass species (Kamstra, 1973). Thus, the difference measured between range site may be due to a species composition effect. Site by month and site by season interactions varied in level of significance ($P<.0233$ to $P<.6363$ and $P<.0102$ to $P<.4699$, respectively) for DMD and OMD of grazed vegetation. CLV and caged standing dead vegetation (CSTDV) digestibilities were also significantly affected by month and season of collection. CDV, DMD, and OMD were not significantly affected, however, by month and season of collection. CDV being in a dormant or dead state no longer performs photosynthesis as does CLV and CSTDV. Hence, the digestible nutrients should be in a somewhat more constant state except for perhaps weathering effect. The nutrients no longer would cycle from the root reserves to the vegetative part of the plant in CDV with changing climatic conditions.

Location of sample forage collection on the range had no significant effect upon digestibility values of caged vegetation -- live, dead, or standing dead. Range site had a significant effect upon the DMD and on OMD of CLV and CDV (Table 13). Range site, however, did not significantly affect digestibility values of caged standing vegetation for DMD and OMD. The significant effect of range site for caged live and dead vegetation may be due to a species difference - shallow sites consisting more of short grass species and loamy sites more tallgrass species. No measureable significant effect of range site on digestibility of CSTV

Table 13. Average (± SE) DMD and OMD values by season, and site with difference between sites presented for caged vegetation.

	DMD - Range Site			OMD - Range Site		
	Loamy	Shallow	Difference[1]	Loamy	Shallow	Difference
Winter '77[2]						
C. Standing Dead	29.2±.020	32.0±.010	-2.8	31.8±.020	34.0±.010	-2.2
Summer '77						
C. Live	41.3±.010	45.6±.009	-4.3	41.9±.010	46.4±.010	-4.5
C. Dead	21.2±.007	24.7±.010	-3.5	24.0±.008	28.4±.010	-4.4
Winter '78						
C. Standing Dead	22.7±.010	24.0±.010	-1.3	23.1±.008	23.3±.010	-0.2
Summer '78						
C. Live	43.7±.010	48.4±.010	-4.7	45.9±.010	50.7±.010	-4.8
C. Dead	17.8±.010	21.9±.020	-4.6	19.9±.010	24.7±.020	-4.8
Fall '78						
C. Live	36.3±.009	38.5±.010	-2.2	38.0±.009	40.0±.010	-2

[1]Difference = Loamy = Shallow.

[2]April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 - Summer '77; September '77 - Late Summer '77; October '77 - Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 - Spring/Summer '78; July, August '78 - Summer '78; September, October '78 = Fall '78.

may be due to the limited number of months sampled as CSTV - half as many months were measured for CSTV as for CLV and CDV.

Shallow sites should yield or provide more desirable livestock production than loamy sites if digestibility is used as an indicator of animal performance. However, total forage production is often lower on shallow range sites (Dalrymple, 1978). The greater forage digestibility noted on shallow sites may be offset by more total forage production on loamy sites. The higher total forage production on loamy sites, although lower in digestibility, may support more animal unit months. Therefore, range site-loamy or shallow - if encompassing a sufficient area, should be managed separately if at all practical. The management scheme should take into consideration digestibility and forage production. Differences in digestibility were not extremely large between range sites, but significant. Forage production of desirable vegetative species should be managed for if the range sites are scattered in small areas - as in this study - and show small differences in digestibility. The management scheme on range sites would depend upon individual operations.

Digestibility Correlations

It may be possible that nylon bag dry matter digestibility values may be effected by the ash content and particularly potential dust contamination, etc. of a mixed tallgrass prairie. Measuring organic matter digestibility, on the other hand, may eliminate any potential interference caused by ash contamination when measuring forage quality by nylon bag digestibility. However, measuring OMD is more time consuming and complex than DMD since samples must be ashed during the analysis procedure to obtain organic matter content. Correlation coefficients would identify if DMD and OMD give similar relative rankings of forage quality. If DMD and OMD are highly correlated then the same relative ranking of forages could be obtained by either procedure and little concern need be expressed for potential ash contamination. As of now, such research data is lacking in the literature on mixed tallgrass prairie. Considering the vastness of area encompassed by this class of land such information would be valuable.

Nylon bag dry matter (DMD) and organic matter (OMD) digestibility correlation coefficients are presented in Tables 14 and 15. In these studies, DMD and OMD were highly correlated, with correlations ranging from .667 to .998. Eighty-six percent of the correlations values were above .95 with all but 5.7% of the total correlations above .919. High correlations of DMD and OMD have been reported by other researchers studying homogeneous forages (five varieties of grass - McLead and Minson, 1974; Chloris gayana - Milford and Minson, 1968). It is interesting to note that the two lowest correlations between DMD and OMD (.667 for grazed dead and .805 for caged dead vegetation) were observed during March, generally regarded as one of the windiest months during the year. Perhaps, soil or dust contamination was greater at this time.

Heterogeneous live material decreased in digestibility with progression of seasons. On the other hand, heterogeneous dead or dormant vegetation showed either little change in digestibility or a slight increase during the growing season. Nevertheless, the DMD and OMD values for the dead forage were less than one-half of those for live forage. The slight increase in DMD and OMD values observed for dead forage over the growing season may be due to the fact that some forage

Table 14. Correlation coefficients of dry matter digestibility to organic matter digestibility by months from April, 1977 through October, 1978.

Month	Grazed Live	Grazed Dead	Caged Live	Caged Dead
April '77		.978[1]		.984
May	.990	.972		
June	.984	.932		
July	.992	.954	.982	.982
August	.989	.975		
September	.960	.951		
October		.994		
November		.934		
December		.969		
January '78				
February		.954		
March		.667		.805
April	.992	.987		
May	.996	.919		
June	.949	.984		
July	.991	.988	.985	.988
August	.978	.991		
September	.998	.985		
October			.987	

[1]Standing dead vegetation is listed in the dead vegetation column and recognized by live vegetation values absent.

Table 15. Correlation coefficients of dry matter digestibility to organic matter digestibility by Seasons from April, 1977 through October, 1978.

Season	Grazed Live	Grazed Dead	Caged Live	Caged Dead
Winter '77[2]		.978[1]		.984
Spring-Summer '77	.988	.938		
Summer '77	.987	.974	.954	.982
Late-Summer '77	.960	.951		
Fall '77		.994		
Winter '78		.957		.805
Spring-Summer '78	.990	.972		
Summer '78	.989	.973	.985	.988
Fall '78	.998	.985	.987	

[1]Standing dead vegetation is listed in the dead vegetation column and recognized by live vegetation values absent.

[2]April '77 - Winter '77; May, June '77 - Spring/Summer '77; July, August '77 - Summer '77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

appeared or was classified as dead which had actually grown during that growing season, in contrast to being produced in previous growing seasons. In general, the dry matter and organic matter digestibility data shown for different heterogeneous vegetation types - GL, GD, GST, CL, CD, or CST - throughout the year indicate digestibility is highest for rangeland vegetation from May to August or the spring-summer, summer seasons and, in favorable years, perhaps the fall.

Nylon bag DMD and OMD were highly correlated in a positive direction. Due to the high correlation, it would appear that DMD and OMD of a mixed tallgrass prairie give the same relative ranking of forage quality. Ash content and contamination does not appear to interfere with the relative rankings of forages with nylon bag dry matter digestibility, except perhaps during the late spring months (especially March).

Since plains grasslands account for about 21% of all ranges and forages and 62% of all grassland a greater understanding of this important natural resource is needed. Separation of sample material into vegetative types provides more definitive data. Proper utilization of rangeland vegetation should be in accordance with the laboratory indicators of forage quality, stand preservation, and nutrient requirements of animals.

CHAPTER VII

THE EFFECT OF STRUCTURAL CARBOHYDRATE AND ASH CONTENT UPON THE NYLON BAG DRY MATTER AND ORGANIC MATTER DIGESTIBILITY OF CENTRAL OKLAHOMA NATIVE RANGELAND GRASSES

Introduction

Improved animal performance is normally observed with an increase in forage quality. Dry matter (DMD) and organic matter (OMD) digestibility are relative indicators of forage quality. An increase in DMD value of a forage serves as a useful indicator of animal performance. An increase of approximately 12% DMD has been shown to increase average daily gain of steers by 30 to 60% (Barton et al., 1967; Chapman et al., 1972).

Digestibility of forages usually decreases as structural carbohydrates increase over any particular time. Thus, digestibility and animal performance may decrease with an increase of structural carbohydrates. Research has shown a strong negative relationship between forage digestion and acid detergent fiber and lignin levels (Moir, 1971; Van Soest, 1963, 1965; Ward et al., 1979). Acid detergent fiber and lignin have been shown to be inversely related to digestibility of native range vegetation (Cogswell and Kamstra, 1976; Horn and Taliaferro, 1979; Rao et al., 1973).

Previous studies conducted have not dealt specifically, however, with the effect of acid-detergent fiber and lignin of a mixed native range vegetation. Data on the effects of structural carbohydrates upon the digestibility of native rangeland vegetation in Central Oklahoma over seasons is particularly lacking. A change in structural carbohydrate causing DMD to increase or decrease may have a significant impact upon the economic situation of beef production in Oklahoma.

The objectives of this study were (1) to determine the effects of structural carbohydrates and ash content on nylon bag dry matter and organic matter digestibility and (2) to determine the effect of season.

Methods and Materials

The study area was that as described in Chapter III. Forage samples were obtained as previously presented in Chapter IV. Structural carbohydrates and dry matter digestibility determinations were conducted as presented in Chapters V and VI, respectively.

SAS 76 R-square analysis was used to determine the most significant independent variables on the dependent variable. Multiple regression equations were then determined on DMD by day and season.

Results and Discussion

Structural Carbohydrates

Grazed Live Vegetation. Grazed live vegetation (GLV) had a significant increase of acid-detergent fiber (ADF) by month from May to September, 1977 (37.9% to 42.6%) and April to September, 1978 (31.3% to

39.1%) (Table 16). A similar trend was noted by season for grazed live vegetation ADF. ADF significantly increased from spring-summer (Spr/Sum) to late summer (Lat Sum), 1977 and Spr/Sum to fall (Fall), 1978 of 40.3% to 52.6% and 38.1% to 41.1%, respectively (Table 17).

Cellulose and lignin of grazed live vegetation significantly increased by month as did ADF (Table 16). Lignin increased during the same period in 1977 as ADF, but for 1978 a shorter period of time (April to July) significantly increased (8.2% to 10.1%, respectively). Lignin increased significantly from Spr/Sum to Late Summer 1977 (8.2% to 9.2%) for GLV. The increase from Spr/Sum to Fall 1978 was not measured to be significant (9.9% to 10.1%). Cellulose did not significantly increase by season for either 1977 or 1978.

Grazed Dead Vegetation. An overlap of significant differences were measured by the Duncan's Multiple Range test for ADF for grazed dead vegetation (GDV) (Table 16). ADF of grazed dead vegetation increased in 1978, but was fairly constant for 1977 with a slight decrease. Seasonal trends for the ADF content of GDV showed no significant directional movement (Table 17).

Cellulose and lignin values of GDV varied with advancing months and seasons. Cellulose values of GDV significantly decreased from May to September, 1977 and April to September, 1978 (36.9% to 33.4% and 39.1% to 35.3%, respectively). Cellulose values of GDV seasonal change significantly decreased for both years, 1977 and 1978. Lignin values for GDV increased significantly in 1977 and decreased significantly in 1978 by both month and season.

The differences in lignin significance between years may be a reflection in precipitation. In 1978, the precipitation was more spread

Table 16. Average (± SE) fiber components (%) of grazed live and dead vegetation by month from April, 1977 through October, 1978.

Month	Acid-Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead
APRIL '77		47.1±.010 Z		9.0±.002 W		34.0±.008 Z
May	37.9±.005 D	53.1±.008 ABC	7.0±.002 E	10.5±.004 F	30.0±.004 CD	36.9±.006 BC
June	43.1±.003 AB	53.7±.011 AB	9.3±,002 BCD	10.8±.003 EF	31.5±.003 AB	37.5±.007 AB
July	44.3±.008 A	53.2±.003 AB	11.0±.004 A	13.6±.003 BC	32.3±.008 A	36.0±.003 BC
August	42.1±.008 B	53.9±.004 A	10.1±.003 AB	13.9±.004 B	30.5±.006 BC	35.9±.005 CB
September	42.6±.007 AB	51.5±.017 BCDE	9.2±.002 BCD	15.3±.010 A	31.6±.007 AB	33.4±.008 D
October		45.1±.008 W		12.7±.006 XY		34.1±.007 Z
November		50.1±.009 Y		13.3±.005 X		34.9±.007 YZ
December		53.0±.004 X		10.5±.005 ZW		39.3±.008 X
JANUARY '78		53.0±.00				
February		51.9±.004 XY		12.7±.011 XY		37.2±.007 XY
March		52.6±.005 X		11.4±.006 YZ		36.6±.015 XY
April	31.3±.010 E	49.0±.006 E	8.2±.004 D	12.7±.006 CD	24.1±.006 E	39.1±.006 A
May	38.8±.006 CD	51.0±.006 CDE	9.5±.003 BC	12.5±.004 CD	31.1±.004 ABC	37.3±.006 B
June	40.4±.006 C	50.4±.006 DE	10.9±.005 A	12.8±.004 CD	32.4±.005 A	36.6±.004 BC
July	39.4±.005 CD	50.8±.004 CDE	10.1±.003 AB	11.9±.003 DE	32.0±.004 AB	36.8±.004 BC
August	39.4±.005 CD	51.6±.004 BCD	8.9±.005 CD	11.4±.003 EF	30.9±.004 ABC	36.0±.005 CB
September	39.1±.007 CD	51.4±.009 BCDE	9.3±.003 BCD	11.0±.003 EF	28.9±.005 D	35.3±.004 C
October	43.1±.006 AB		11.0±.003 A		31.4±.006 AB	

[1]Means significantly (P<.05) different fi followed by different letter suffixes within columns.

[2]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, andWW letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine sugnificant differences (P<.05).

Table 17. Average (± SE) fiber components (%) of grazed live and dead vegetation by season for April, 1977 through October, 1978.

	Acid Detergent Fiber		Lignin		Cellulose	
Season	Live	Dead	Live	Dead	Live	Dead
Winter '77		47.1±.010 Y[2]		9.0±.002 Y		34.0±.008 Y
Spr/Sum '77	40.3±.004 CD[1]	53.5±.008 A	8.2±.002 C	10.6±.003 E	30.7±.003 AB	37.4±.005 AB
Summer '77	42.4±.007 A	53.4±.003 A	10.2±.003 A	13.8±.003 B	30.9±.006 A	35.7±.003 C
Lat Sum '77	42.6±.007 AB	51.5±.017 AB	9.2±.002 B	15.3±.010 A	31.6±.007 A	33.4±.008 D
Fall '77		45.1±.008 Z		12.7±.006 X		34.1±.007 Y
Winter '78		51.9±.005 X		12.2±.005 Z		36.8±.003 Z
Spr/Sum '78	38.1±.005 E	50.1±.004 B	9.9±.003 B	12.7±.003 C	30.4±.004 B	37.1±.004 A
Summer '78	39.3±.004 D	51.1±.004 B	9.3±.002 B	11.6±.002 D	31.5±.003 A	36.3±.003 BC
Fall '78	41.1±.005 BC	51.4±.009 B	10.1±.002 AB	11.0±.002 DE	30.2±.004 AB	35.3±.004 C

[1]Means significantly ($P<.05$) different if followed by different letter suffixes within columns.

[2]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences ($P<.05$).

[3]April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer '77; September '77 - Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July August '78 = Summer '78; September, October '78 = Fall '78.

out over the summer months, whereas 1977 was a more typical rainfall for Oklahoma.

Grazed Standing Vegetation. ADF content (Table 16) increased significantly for grazed standing vegetation (GSTDV) from October, 1977 to March, 1978 (45.1% to 52.6%, respectively). Moreover, seasonal values of ADF significantly increased from Fall, 1977 to Winter, 1978 (45.1% to 51.9%) in GSTDV (Table 17).

Cellulose, by month, showed a significant increase similar to ADF. Whereas, the Duncan's Multiple Range test performed on lignin values overlapped in significant differences by month. Significant differences in lignin content were noted for GSTDV by season from Winter 1977 to Winter 1978.

The grazed live vegetation reacted as would be expected in comparison to homogeneous vegetation. Whereas, the grazed dead vegetation, if using structural carbohydrates as a quality factor, actually improved with advancement of time. This improvement of GDV quality may be a reflection on the mechanics of separation. The differences in lignin content for GSTDV remains too small to measure objectively. For the most part, one should consider vegetation quality, as measured by structural carbohydrates, to decrease with advancement of time.

Dry Matter Digestibility

Dry Matter Digestibility (DMD) of GLV by month (Table 18) significantly decreased from May to September, 1977 and April to September, 1978 (49.1% to 38.8% and 58.5% to 47.2%, respectively). A significant decrease in DMD by season for GLV (Table 19) was also observed. The

Table 18. Average (± SE) NBDMD and NBOMD of live and dead grazed vegetation by month from April, 1977 through October, 1978.

	Dry Matter Digestibility		Organic Matter Digestibility	
Month	Live	Dead	Live	Dead
April '77		29.0±.024[1]Y		28.8±.013
May	49.1±.009B	18.8±.013EF	50.6±.010	22.3±.010
June	46.9±.007BC	20.4±.010DEF	48.7±.008	22.7±.011
July	48.6±.008B	21.7±.014CDE	49.6±.008	25.4±.014
August	47.0±.010BC	22.9±.009CD	49.2±.013	25.8±.009
September	38.8±.007E	24.2±.006BC	41.5±.009	26.1±.008
October		42.0±.008X		43.5±.007
November		22.5±.009Z		23.8±.007
December		15.5±.008W		17.7±.008
January '78				
February		17.7±.008W		19.5±.008
March		15.3±.005W		15.8±.004
April	58.5±.011A	21.6±.008CDE	58.9±.026	23.4±.009
May	48.8±.011B	18.5±.010F	49.5±.011	19.1±.008
June	43.4±.006D	20.3±.011DEF	45.1±.006	22.4±.011
July	44.4±.012CD	25.5±.011B	46.3±.011	26.1±.011
August	50.1±.013B	20.8±.022DEF	51.6±.013	25.5±.023
September	47.2±.017BC	29.1±.009A	47.9±.027	30.0±.010
October	19.0±.021F			

[1]Standing dead vegetation is listed in the dead vegetation column. Live vegetation values are not given for those months when no live vegetation existed.

[2]Means significantly ($P<.05$) different if followed by different letter suffixes within columns.

[3]Standing dead vegetation is listed in the dead vegetation column identified by X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences ($P<.05$).

Table 19. Average (%) NBDMD and NBOMD of live and dead grazed vegetation by season from April, 1977 through October, 1978.

	Dry Matter Digestibility		Organic Matter Digestibility	
Season	Live	Dead	Live	Dead
Winter '77[2]		29.9[1] Y	49	28.8
Spring/Summer '77	48.0 B	19.7 C	19.6	22.5
Summer '77	47.8 B	22.3 B	49.4	25.6
Late Summer '77	38.7 C	24.2 B	41.5	26.1
Fall '77		42.0 X		43.5
Winter '78		18.0 Z		19.7
Spring/Summer '78	49.7 A	20.1 C	48.2	21.6
Summer '78	46.5 B	24.0 B	48.2	25.9
Fall '78	36.4 C	29.1 A	47.9	30.0

[1]Standing dead vegetation is listed in the dead vegetation column.

[2]April '77 = Winter '77; May, June '77 = Spring/Summer '77; July, August '77 = Summer '77; September '77 = Late Summer '77; October '77 = Fall '77; November, December '77, January, February, March '78 = Winter '78; April, May, June '78 = Spring/Summer '78; July, August '78 = Summer '78; September, October '78 = Fall '78.

[3]Means significantly ($P<.05$) different if followed by different letter suffixes within columns.

[4]Standing dead vegetation is listed in the dead vegetation column identified X, Y, Z, and W letter suffixes. Duncan's multiple range test was performed separately for the standing dead vegetation to determine significant differences ($P<.05$).

decrease in DMD for grazed live vegetation with advancing time over months and/or seasons conforms to general beliefs or thinking regarding effects of plant maturity.

Grazed dead vegetation DMD showed opposite effects to GLV with the advancement of months and/or seasons (Table 18 and 19). Grazed dead vegetation DMD significantly increased over time by months (May to September, 1977 and April to September, 1978) and by seasons (Spr/Sum '77 to Lat Sum '77 and Spr/Sum '78 to Fall '78). The increase of DMD of grazed dead vegetation may be due to some regeneration or replacement of dead vegetation by new growth. As live vegetation reaches maturity and becomes dormant or dies, the vegetation was considered as dead vegetation. This so called new dead vegetation may have had less weathering; thus it may not have lost as many soluble nutrients as the vegetation which had been dead for a longer period of time.

Correlation Coefficients

Correlation coefficients of DMD to structural carbohydrates and ash content are presented in Tables 20 and 21 by month and season, respectively. The majority of the correlations by month were negative in value (Table 20). Correlations between DMD and structural carbohydrates by season for grazed live vegetation were all negative (Table 21). Eighty percent of the correlation coefficients for GDV structural carbohydrates to DMD showed negative values. Correlation coefficients of ash content to DMD fluctuated in sign by month and season, but appear to be mainly positive.

Correlation values between acid-detergent fiber (ADF) and DMD ranged from -.453 to -.649 for grazed live vegetation. Van Soest (1967)

Table 20. Correlation coefficients of DMD to structural carbohydrates and ash content for grazed vegetation of a mixed native range from April, 1977 through October, 1978.

Month	ADF and DMD		ADL and DMD		Cellulose and DMD		Ash and DMD	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
April '77 7160		-.927		-.568		-.912		.389
May 7192	-.405	-.305	-.450	-.375	-.007	-.207	.215	.121
June 7220	-.481	-.135	-.218	-.588	-.308	.008	.216	-.242
July 7250	-.515	-.588	-.070	.017	-.329	-.402	-.033	-.033
August 7275	-.758	-.297	-.408	-.198	-.707	.0003	-.154	-.104
September 7312	-.453	.196	-.262	.325	-.621	-.784	.440	.011
October 7349		-.539		-.215		-.475		-.161
November 8010		-.652		-.048		-.646		-.107
December 8045		-.155		-.044		.040		.315
January '78								
February 8120		-.361		-.132		-.444		.412
March 8148		-.060		-.233		-.472		.742
April 8175	-.083	-.507	.122	-.254	.193	-.113	.335	.118
May 8196	-.330	.112	-.117	.175	-.695	-.161	.128	.343
June 8225	-.205	-.346	-.301	.022	-.102	-.564	.322	-.136
July 8255	-.498	-.217	-.127	-.106	-.452	-.348	.370	-.256
August 8280	-.707	.118	-.466	-.022	-.681	.008	.386	-.290
September 8315	-.576	-.249	-.092	.150	-.826	-.071	.542	-.276
October 8345	-.646		.335		-.672			

Table 21. Correlation coefficients of DMD to structural carbohydrates and ash content for grazed vegetation of a mixed native range from April, 1977 through October, 1978.

Seasons	ADF and DMD		ADL and DMD		Cellulose and DMD		Ash and DMD	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Winter '77		-.927		-.568		-.912		.389
		.0001		.001		.0001		.054
Spring/ Summer '77	-.470	-.194	-.446	-.449	-.220	-.078	.187	-.119
	.0003	.331	.0006	.019	.104	.698	.171	.531
Summer '77	-.624	-.430	-.242	-.069	-.517	-.202	-.078	-.050
	.0001	.002	.132	.641	.0006	.168	.585	.738
Late Summer '77	-.453	.196	-.212	.325	-.621	-.784	.440	.011
	.059	.612	.398	.393	.006	.012	.022	.963
Fall '77		-.539		-.215		-.475		-.161
		.008		.325		.022		.421
Winter '78		-.626		.117		-.594		.017
		.0001		.3775		.0001		.885
Spring/ Summer '78	-.620	-.295	-.434	.006	-.686	-.308	.272	-.081
	.0001	.029	.0003	.963	.0001	.022	.036	.556
Summer '78	-.591	-.217	-.314	-.018	-.608	-.294	.380	-.298
	.0001	.217	.045	.919	.0001	.091	.012	.104
Fall '78	-.649	-.249	-.365	.150	-.673	-.071	.542	-.276
	.0001	.276	.028	.517	.0001	.761	.009	.238

reported a correlation of ADF to digestion of .50. The value by Van Soest is within the range obtained in this study but opposite in sign. Oh, Baumgardt, and Scholl (1966) reported the value of -.53 for a correlation of digestible dry matter to ADF. Findings by Oh, Baumgardt, and Scholl (1966) showed the same relation for both the sign and magnitude of correlations between DMD and ADF. Moreover, other research has reported correlation values of -.73 to -.88 (Van Soest, 1964, 1965).

Correlation values of ADL to DMD of the heterogenous vegetation ranged from -.070 to -.588. ADL to DMD correlation values are similar to past research on homogeneous vegetation (Van Soest, 1964, 1965; Oh, Baumgardt, and Scholl, 1966).

Correlation coefficients of structural carbohydrates to DMD obtained by this study are lower in value than past research. Most research to date has dealt with homogeneous vegetation. The quality of heterogenous vegetation as used in this study, does not appear to depend upon any one factor investigated in this study. Species composition of a mixed vegetation may alter the interpretation of structural carbohydrate data obtained, particularly when considering studies of forage quality over seasons. Moreover, range site difference used in this study may compound interpretation of results. Structural carbohydrates were not significantly affected by site differences, whereas DMD was significantly affected by site differences. The difference in response as to whether site had a significant effect upon forage quality values may indicate structural carbohydrates alone do not control as large a portion of DMD of a mixed native vegetation.

Correlation coefficients of structural carbohydrates, ash, and organic matter digestibility (OMD) have the same directional sign as

Table 22. Correlation coefficients of OMD to structural carbohydrates and ash content for grazed vegetation of a mixed native range from April, 1977 through October, 1978.

Month	ADF		ADL		Cellulose		Ash	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
April '77 (7160)		-.854		-.157		-.812		.240
May (7192)	-.367	-.380	-.401	-.475	.058	-.171	.192	.132
June (7220)	-.426	-.053	-.313	-.596	-.318	.153	.279	-.396
July (7250)	-.461	-.599	-.102	-.066	-.268	-.357	.003	-.069
August (7275)	-.768	-.327	-.525	-.143	-.698	-.167	-.171	-.172
September (7312)	-.385		-.283		-.672		.388	-.161
October (7347)		-.498		-.248		-.449		-.140
November (8010)		-.023		-.203		.071		-.241
December (8045)		-.251		-.056		.139		.248
January '78								
February (8120)		.295		-.650		.744		.243
March (8148)		-.192		-.646		-.128		.372
April (8175)		-.460		.266		-.133	.296	.174
May (8196)	-.354	.156	.003	-.001	-.729	.133	.112	.047
June (8225)	-.178	-.300	-.289	-.013	-.050	-.533	.145	-.141
July (8255)	-.471	-.221	-.185	-.095	-.422	-.111	.332	-.234
August (8280)	-.682	.106	-.467	-.187	-.665	.447	.338	-.378
September (8315)	-.607	-.260	-.105	.168	-.835	-.064	.525	-.402
October (8345)								

Table 23. Correlation coefficients of OMD to structural carbohydrates and ash content for grazed vegetation of a mixed native range from April, 1977 through October, 1978.

Seasons	ADF		ADL		Cellulose		Ash	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Winter '77		-.854		-.157		-.813		.240
Spring/ Summer '77	-.406	-.185	-.404	-.500	-.174	.012	.210	-.246
Summer '77	-.644	-.476	-.353	-.096	-.518	-.251	-.077	-.108
Late Summer '77		-.385		-.283		-.672	.388	-.161
Fall '77		-.498		-.248		-.449		-.140
Winter '78		-.450		-.020		-.356		-.050
Spring/ Summer '78	-.425	-.265	-.273	-.044	-.556	-.254	.206	-.165
Summer '78	-.573	-.191	-.344	-.093	-.592	.007	.345	.323
Fall '78	-.607	-.260	-.105	.168	-.835	-.064	.525	-.402

shown by DMD. The magnitude of the correlations for structural carbohydrates and ash to OMD appear to be higher than for DMD. Expressing the digestibility of vegetation on an organic matter basis may eliminate some of the ash contamination, both on and within the vegetation.

Regression Equations

A larger amount of variation was accounted for by the regression equation for grazed live vegetation than the grazed dead vegetation (range of .26 to .52) (Tables 24 and 25). The regression models for grazed live vegetation were significant ($P<.01$) with the exception of the models by range site. The level of significance for the regression models for grazed dead vegetation varied throughout the study.

Regression equations predicting dependent variables DMD and OMD by the independent variables acid-detergent fiber (ADF), acid-detergent lignin (ADL), cellulose and ash by year, season, and vegetation are presented in Tables 24, 25, 26, and 27. No one independent variable best depicts NBDMD or NBOMD. For 1978 cellulose seems to best predict DMD and OMD, whereas for 1977 ADF seems to be the one best independent variable. The fact that no one factor served as a best predictor of DMD or OMD agrees with the correlation coefficient findings.

In a further effort to increase the R^2 value for the prediction model of digestion, different combinations of time of year, range site and vegetation collected were tried. Since no one single factor was best, four independent variables were maintained to try and increase the prediction ability for digestion.

DMD and OMD prediction equation by seasons, combined for 1977 and 1978, for grazed live, dead, and standing dead vegetation are presented

Table 24. Regression equations for DMD content (%) of grazed live vegetation by season from April, 1977 through October, 1978 (DMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Spring/	.725	-.608				.0011	.1895
Summer '77	.642	-.595			1.014	.0019	.2221
	.630	-.449	-.500		.939	.0042	.2342
	.601	-.524	-.423	.161	.984	.0101	.2371
Summer '77	.872	-.905				.0001	.4135
	.926	-.863	-.683			.0001	.4517
	.930	-.730	-.787	-.161		.0003	.4526
	.946	-.650	-.857	-.237	-.284	.0009	.4539
Late	.602			-.647		.006	.3855
Summer '77	.498			-.685	1.596	.0002	.6700
	.548		-.428	-.695	1.494	.0007	.6901
	.515	.348	-.646	-.998	1.509	.0012	.7287
Spring/	.833			-1.180		.0001	.3270
Summer '78	.883		-.633	-1.133		.0001	.384
	.849		-.589	-1.122	.321	.0001	.3870
	.860	-.149	-.536	-1.009	.404	.0002	.3910
Summer '78	1.024			-1.767		.0001	.3699
	1.066		-.671	-1.691		.0001	.4338
	1.202	-.880	-.680	-1.018		.0001	.4882
	1.143	-.811	-.693	-.993	.328	.0001	.4800
Fall '78	1.339			-3.004		.0001	.6822
	1.100			-2.639	1.828	.0001	.7594
	1.103	.134		-2.823	1.798	.0001	.7612
	1.162	.282	-.393	-3.056	1.629	.0001	.7652

Table 25. Regression equations for DMD content (%) of grazed dead and standing dead vegetation by season from April, 1977 through October, 1978 (DMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Winter '77 GSTDV	1.267	-2.096				.0001	.8956
	1.234	-2.246	1.145			.0001	.9055
	1.287	-2.297	1.155		-.321	.0001	.9075
	1.348	-1.910	.729	-.513	-.641	.0001	.9096
Spring/ Summer '77	.3612		-1.594			.0161	.2182
	.470		-1.664	-.275		.0447	.2368
	.6711		-1.862	-.557	-.899	.0583	.2828
	.8055	.640	-2.725	-1.530	-1.174	.0608	.3368
Summer '77	.977	-1.404				.0045	.1848
	.985	-1.523	.412			.0146	.1948
	.973	-1.656	.506	.194		.0379	.1967
	.976	-1.647	.495	.182	-.022	.0806	.1967
Spring/ Summer '78	.411			-.569		.0340	.0885
	.553			-.793	-.686	.0369	.1284
	.586	-.176		-.658	-.633	.0748	.1354
	.609	-.187	-.124	-.663	-.633	.1376	.1378
Summer '78	.271				-.576	.3787	.0311
	.490	-.421			-.626	.4436	.0655
	.537	-.410	-.377		-.729	.6130	.0741
	.573	-.356	-.384	-.151	-.812	.7739	.0750
Fall '78	.348				-.677	.2388	.0762
	.891			-1.363	-1.392	.1175	.2227
	.861	-.089		-1.167	-1.309	.2258	.2321
	.854	-.087	.068	-1.176	-1.282	.3768	.2326
Winter '78 GSTDV	.866	-1.321				.0001	.4136
	.842	-.982		-.408		.0001	.4362
	.919	-.971	-.304	-.532		.0001	.4602
	.950	-.860	-.389	-.668	-.335	.0001	.4673

Table 26. Regression equations for OMD content (%) of grazed live vegetation by season from April, 1977 through October, 1978 (OMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Spring/ Summer '77	.731	-.578				.0026	.1647
	.636	-.563			1.165	.0031	.2062
	.618	-.361	-.689		1.062	.0050	.2283
	.595	-.421	-.628	.129	1.098	.0122	.2302
Summer '77	.901	-.940				.0001	.4148
	.975	-.881	-.938			.0001	.4803
	.984	-.624	-1.149	-.309		.0002	.4828
	.998	-.551	-1.212	-.378	-.267	.0005	.4839
Late Summer '77	.719			-.913		.0167	.4515
	.658			-1.081	1.541	.0021	.7454
	.727		-.548	-1.090	1.347	.0053	.7789
	.729	-.013	-.541	-1.085	1.350	.0189	.7789
Spring/ Summer '78	821			-1.099		.0001	.3087
	.865		-.564	-1.058		.0001	.3578
	.879	-.102	-.536	-.982		.0002	.3600
	.880	-.101	-.538	-.983	-.009	.0006	.3600
Summer '78	.986			-1.59		.0001	.3509
	1.030		-.699	-1.51		.0001	.4320
	1.151	-.783	-.707	-.914		.0001	.4823
	1.127	-.755	-.712	-.904	.130	.0001	.4827
Fall '78	1.318			-2.906		.0001	.6980
	1.107			-2.483	1.615	.0001	.7639
	1.137		-.214	-2.599	1.541	.0001	.7659
	1.164	.170	-.374	-2.844	1.448	.0001	.7679

Table 27. Regression equations for OMD content (%) of grazed dead and standing dead vegetation by season from April, 1977 through October, 1978 (OMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Winter '77	1.220	-1.908				.0001	.7300
GSTDV	1.187	-2.015	.914			.0001	.7484
	1.261	-2.097	.922		-.386	.0001	.7563
	1.297	-.968		-1.237	-1.095	.0001	.7844
	1.301	-.890	-.131	-1.313	-1.137	.0001	.7846
Spring/	.387		-1.570			.0110	.2497
Summer '77	.4606		-1.663		-.751	.0203	.2983
	.719		-1.863	-.516	-1.292	.0258	.3509
	.836	.477	-2.515	-1.265	-1.581	.0384	.3834
Summer '77	1.030	-1.438				.0017	.2265
	1.067	-1.447			-.410	.0063	.2342
	1.064	-1.495	.174		-.354	.0177	.2362
	1.067	-1.482	.162	-.019	-.367	.0411	.2362
Spring/	.435	-.440				.0522	.0748
Summer '78	.492	-.480			-.431	.0862	.0971
	.614	-.210		-.600	-.822	.0536	.1489
	.653	-.229	-.210	-.608	-.823	.0920	.1564
Summer '78	.301				-.615	.2986	.0431
	.525	-.430			-.665	.3364	.0868
	.598	-.413	-.586		-.825	.4244	.1122
	.618	-.382	-.590	-.087	-.873	.6018	.1125
Fall '78	.384				-.992	.0789	.1616
	.937			-1.387	-1.719	.0419	.3114
	.902	-.104		-1.159	-1.622	.0915	.3241
	.910	-.106	-.081	-1.147	-1.653	.1807	.3247
Fall '77	.681	-.528				.0157	.2476
GSTDV	.872	-.759	-.661			.0012	.4889
	.849	-.781	-.659		.460	.0038	.4988
	.843	-.743	-.634	-.056	.527	.0107	.5003

in Tables 28 and 29. A greater variation was accounted for by the prediction equations for grazed live than grazed dead when seasons are combined for the two years. No increase in R^2 values was noted when seasons were combined for both years together or for seasons within years.

DMD and OMD prediction equations by vegetation type disregarding time of year, is presented in Table 30. The variation accounted for in grazed standing vegetation is higher (R^2 = .6969 for DMD and .7101 for OMD). The variation accounted for in the grazed live and dead was not as great as the prediction equations by seasons. The grazed standing dead vegetation being in a more dormant stage, may account for the greater R^2 value than for GLV and GDV. Changing stages of maturity in grazed live and dead vegetation may account for the lower R^2 values.

DMD and OMD prediction equations by season and range site for grazed live, dead, and standing dead vegetation are presented in Tables 31, 32, and 33, respectively. Predictor equations by loamy range sites for grazed dead and standing dead vegetation seemed to account for a larger variation for DMD and OMD than shallow range sites. Although for grazed live vegetation no apparent advantage was noticeable between loamy or shallow range sites. The level of model significance is reduced when prediction equations are done by season and range site. This lower model significance could be due to a reduced sample size.

DMD and OMD were negatively correlated with ADF, lignin, and cellulose. Based on sign, DMD and OMD were positively correlated to ash content for grazed live vegetation, but negatively correlated for grazed dead and standing dead vegetation. The negative correlation for GDV and GSTDV ash content to DMD and OMD may be due to a contamination of nylon

Table 28. Regression equations for DMD and OMD content (%) of grazed live vegetation by seasons combined over 1977 and 1978.

Seasons		Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	R^2
Spring/ Summer	DMD	.771	-.232	-.657	-.605	.516	.0001	.2714
	OMD	.788	-.174	-.727	-.612	.307	.0001	.2595
Summer	DMD	.920	-.001	-.819	-1.19	.176	.0001	.3847
	OMD	.948	-.056	-.892	-1.095	.004	.0001	.3996
Fall	DMD	.801	-.205	.136	-1.502	2.199	.0001	.6687
	OMD	.912	-.244	-.037	-1.648	1.968	.0001	.7473

Table 29. Regression equations for DMD and OMD content (%) of grazed dead and standing dead vegetation by seasons combined over 1977 and 1978.

Seasons		Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Winter GDV								
	DMD	-.340	-.996	1.536	1.655	2.788	.2571	.6683
	OMD	-.293	-.759	1.484	1.248	3.052	.2864	.6466
Spring/ Summer GDV								
	DMD	.602	.041	-.249	-.932	-.655	.0249	.1600
	OMD	.652	.048	-.439	-.886	-.954	.0093	.1923
Summer GDV								
	DMD	.790	-.574	-.089	-.523	-.773	.1045	.1113
	OMD	.850	-.404	-.282	-.723	-1.021	.0609	.1313
Fall GDV								
	DMD	.770	-.199	-.760	-.530	-1.281	.3813	.2080
	OMD	.057	-.186	-.686	-.695	-1.669	.1625	.3053
Fall GSTDV								
	DMD	.868	-.809	-.640	-.063	.426	.0075	.5210
	OMD	.843	-.743	-.634	-.056	.527	.0107	.5003
Winter GSTDV								
	DMD	1.200	-1.354	-.481	-.632	-.279	.0001	.7768
	OMD	1.384	-1.281	-.764	-.898	-1.043	.0001	.6920

Table 30. Regression equations for DMD and OMD content (%) of grazed live, dead, and standing dead vegetation from April, 1977 through October, 1978, disregarding seasons.

Matter	Y Intercept	ADF	ADL	CELL	ASH	Model R^2	Model PROB>F
Dead DMD	.828	-.068	-.467	-1.141	-1.179	.1643	.0001
Dead OMD	.869	.011	-.513	-1.206	-1.523	.2119	.0001
Live DMD	.828	-.264	-.471	-.842	.689	.3175	.0001
Live OMD	.858	-.226	-.587	-.837	.437	.3186	.0001
STDV DMD	1.497	-2.203	-.307	-.072	-1.070	.6969	.0001
STDV OMD	1.687	-2.269	-.536	-.249	-1.573	.7101	.0001

Table 31. Regression equations for DMD content (%) of grazed live vegetation by season and site from April, 1977 through October, 1978 (DMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Spring/ Summer '77							
Shallow	.4440	-.9855	.3240	.8121	2.0212	.2998	.1993
Loamy	.7438	-.5022	-.6918	-.1776	.6670	.0733	.3111
Summer '77							
Shallow	.9393	-.2496	-.3120	-.7387	-.9765	.0221	.6181
Loamy	.6717	-1.1268	-.1202	.5732	1.6956	.3003	.2784
Late Summer '77							
Shallow	.3444	.7400	-.6593	-.9734	1.3448	.0558	.7967
Loamy	.4430	.6608	-.9732	-1.2935	2.4841	.1957	.8008
Spring/ Summer '78							
Shallow	.8666	-.1855	-.5541	-.7604	-.5052	.0593	.3656
Loamy	.8846	.3003	-.7256	-1.7423	.9734	.0220	.4370
Summer '78							
Shallow	1.2551	-1.4857	-.4701	-.7839	1.3530	.0067	.6402
Loamy	1.2699	-.4556	-1.1850	-1.5097	-.5239	.0061	.5328
Fall '78							
Shallow	.8104	-.0697	-1.0504	-1.7970	4.1561	.0048	.9594
Loamy	1.5534	1.0710	-1.3411	-4.5631	-.8104	.0263	.7125

Table 32. Regression equations for DMD content (%) of grazed dead vegetation by season and site from April, 1977 through October, 1978 (DMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Spring/ Summer '77							
Shallow	.912	.678	-2.835	-1.960	-.459	.0449	.7608
Loamy	.581	.508	-2.436	-.638	-2.183	.0888	.5236
Summer '77							
Shallow	.725	-1.254	.183	.465	-.175	.6654	.1474
Loamy	1.504	-1.583	-.315	-.945	-.666	.1435	.3038
Spring/ Summer '78							
Shallow	.881	-.324	-.356	-1.027	-1.000	.1915	.2754
Loamy	.345	-.243	-.095	-.080	.050	.9158	.0392
Summer '78							
Shallow	.708	-.070	.636	-1.158	-.880	.8388	.1341
Loamy	.228	-.676	-.931	1.371	-.954	.6491	.2423
Fall '78							
Shallow	.411	-2.243	2.360	1.669	1.749	.7986	.3505
Loamy	1.232	-.004	.077	-2.247	-1.736	.3004	.4610

Table 33. Regression equations for DMD content (%) of grazed standing dead vegetation by season and site from April, 1977 through October, 1978 (DMD = a + bx).

Seasons	Y Intercept	ADF	ADL	CELL	ASH	Model PROB>F	Model R^2
Winter '77							
Shallow	1.558	-1.530	-.391	-1.084	-1.594	.0007	.9434
Loamy	1.026	-1.808	2.183	-.498	.834	.0001	.9063
Fall '77							
Shallow	.776	-.341	-.033	-.231	-1.428	.2018	.6403
Loamy	.442	-.311	-.197	-.368	3.723	.0235	.7210
Winter '78							
Shallow	.864	-.332	-.437	-1.144	-.437	.0085	.5143
Loamy	1.463	-2.345	-.346	.048	-.523	.0032	.5683

bag residue with ruminal ash content. DMD and OMD showed the same relationship to structural carbohydrates and ash content, which is in support of the high correlation coefficients between DMD and OMD.

Conclusions

Structural carbohydrates significantly increased while digestibility decreased for grazed live vegetation for the same period of time. Grazed dead vegetation presented a somewhat similar relationship of structural carbohydrates to digestibility in reverse order.

It was found that the relationship between structural carbohydrates to DMD and OMD was quite variable. No one or two factors could be identified to be used for predicting DMD or OMD by season and/or range site.

The diversity of mixed tallgrass prairie may be one reason structural carbohydrates relation to digestion varies. As climatic factors change, vegetative species adapt that best survive. The shifting species composition makes the mixed prairie vegetation more adaptable to climatic changes, limiting the possibility of one or two factor prediction equations on DMD or OMD.

With the multitude of factors affecting a mixed native range vegetation, no one factor can practically be utilized for prediction equations. The practicality of a group of forage quality factors being used for digestion prediction equations is offset by the time required for lab analysis. The time required to perform approximate analysis, with a reasonable amount of variation accounted for, may be shortened. The shortened time, and improved variation accounted for, may be achieved with a direct analysis for digestion by *in vitro* or a nylon bag procedure.

Research on the effect of soil type and/or climatic conditions of a well-defined vegetative mixture (approx. 4 species) on structural carbohydrates still requires attention. Structural carbohydrates effect on livestock performance under a more strictly controlled climatic condition has merit for further research. Parallel to livestock performance grazing intensity interaction of structural carbohydrates needs further study.

LITERATURE CITED

Burton, G. W., R. H. Hart, and R. S. Lowrey. 1967. Improving forage quality in bermudagrass by breeding. Crop Sci. 7:329.

Chapman, H. D., W. H. Marchant, P. R. Utley, R. E. Hellwig, and W. G. Monson. 1972. Performance of steers on Pensacola bahiagrass, Coastal bermudagrass and Costcross - 1 bermudagrass pasture. J. An. Sci. 34:373-378.

Cogswell, C. and L. D. Kamstra. 1976. The stage of maturity and its effect upon the chemical composition of four native range species. J. Range Manage. 29:460-463.

Cook, C. W. 1959. The effect of site on the palatability and nutritive content of seeded wheatgrass. J. Range Manage. 12:289-292.

Cook, C. W. and L. E. Harris. 1952. Nutritive value of cheatgrass and crested wheatgrass on spring ranges in Utah. J. Range Manage. 5:331-337.

Cook, C. W. and L. E. Harris. 1950. The nutritive value of range forage as affected by vegetation type, site and state of maturity. Utah Agr. Exp. Station Tech. Bull. 344, p. 45.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feed. J. Nutr. 15:383.

Dalrymple, R. L. 1978. Summer and winter forages for beef cattle production. O-K Cattle Conference, Proceedings, Oct. 1978, 4th Annual, C-1.

Fleming, G. A. and W. E. Murphy. 1968. The uptake of some major and trace elements by grasses as affected by season and stage of maturity. J. British Grassland Society, 23:174-185.

Heady, H. F. 1975. Rangeland Management. McGraw Hill Book Co., New York, p. 3.

Horn, F. P. and C. M. Taliaferro. 1979. Seasonal changes in the nutritive value of five "Old World Bluestems." Agr. Exp. Sta., O.S.U. and U.S.D.A., p. 108.

Johnson, R. R., V. P. DeFaria, and K. E. McClure. 1971. Effects of maturity on chemical composition and digestibility of bird-resistant sorghum plants when fed to sheep as silage. J. An. Sci. 33: 1102.

Kamstra, L. D. 1973. Seasonal changes in quality of some important range grasses. J. Range Manage. 26:289-291.

Kautzsch, S. H. 1978. Plant, soil, and dung factors affecting tallgrass prairie vegetation during drought conditions on a north central Oklahoma rangeland watershed. M.S. Thesis, O.S.U.

McLead, M. N. and D. J. Minson. 1974. Predicting organic matter digestibility from _in vivo_ and _in vitro_ determinations of dry matter digestibility. J. Br. Grassland Soc. 29:17-21.

Meyer, J. H., W. C. Weir, L. G. Jones, and J. L. Hull. 1957. The influence of stage of maturity on the feeding value of oat hay. J. An. Sci. 16:623.

Milford, R. and D. J. Minson. 1968. The digestibility and intake of six varieties of Phodes grass (Chloris gayana). Aust. J. Exp. Agr. and An. Husbandry 8:413.

Moir, K. W. 1972. An assessment of the quality of forage from its cell-wall content and amount of cell wall digested. J. Agr. Sci., Cambridge 78:355-362.

Moir, K. W. 1971. _In vivo_ and _in vitro_ digestible fractions in forage. J. Sci. Food and Agr. 22;338-341.

Moir, K. W., L. Laws, and G. Bright. 1975. The relative importance of the total cell wall and quantity of digested cell wall in the regulation of the voluntary intake of grass hays by sheep. J. Agr. Sci., Cambridge, 85:39-43.

Neathery, M. W. 1972. Conventional digestion trials vs nylon bag technique for determining seasonal difference in quality of Midland Bermudagrass forage. J. An. Sci., 34:1075.

Oh, Hi Kon, B. R. Baumgardt, and J. M. Scholl. 1966. Evaluation of forages in the laboratory. V. Comparisons of chemical analyses, solubility tests, and _in vitro_ fermentation. J. Dairy Sci. 49:850.

Powell, J., F. R. Crow, and D. G. Wagner. 1978. Plant Biomass and nutrient cycling on a grazed, tallgrass prairie watershed. International Rangeland Congress.

Rao, M. R., L. H. Harbers, and E. F. Smith. 1973. Seasonal change in nutritive value of bluestem pastures. J. Range Manage. 26:419-422.

Rittenhouse, L. R., D. C. Clanton, and C. L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. An. Sci. 31:1215-1221.

Stoddart, L. A. 1941. Chemical composition of symphoricarpos rotundifolius as influenced by soil, site, and date of collection. J. Agr. Res. 63:727-739.

Forest-Range Task Force. 1972. The Nation's Range Resources--A Forest-Range Environmental Study. Forest Resource Report No. 19, USDA Forest Service, Washington, D.C., 147 pp., illus.

Van Soest, P. J. 1967. Development of a comprehensive system of feed analysis and its application to forages. J. An. Sci. 26:119.

Van Soest, P. J. 1965. Symposium of factors influencing the voluntary intake in relation to chemical composition and digestibility. J. An. Sci. 24:834-843.

Van Soest, P. J. 1964. Symposium on nutrition and forage and pastures: new chemical procedures for evaluating forages. J. An. Sci. 23:838.

Van Soest, P. J. 1963a. Use of detergents in the analysis of fibrous feeds. I. Preparation of fiber residues of low nitrogen content J. of the A.O.A.C., 46:825.

Van Soest, P. J. 1963b. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. of the A.O.A.C., 46:829-835.

Van Soest, P. J. and L. A. Moore. 1965. New chemical methods for analysis of forage for the purpose of predicting nutritive value. Proc. IX Int. Grassld. Congr., p. 785-789.

Van Soest, P. J. and R. H. Wine. 1968. Determination of lignin and cellulose in acid-detergent fiber and permanganate. J. of the A. O.A.C. 51:

Vavra, M., R. W. Rice, and R. E. Bement. 1973. Chemical composition of the diet, intake and gain of yearling cattle on different grazing intensities. J. An. Sci., 36:411-414.

Wallace, J. D. and G. M. VanDyne. 1970. Precision of indirect methods for estimating digestibility of forage consumed by grazing cattle. J. Range Manage. 23:424-430.

Ward, J. K., L. J. Perry, Jr., D. H. Smith, and J. T. Schmitz. 1979. Forage composition and utilization of grains sorghum residue by beef cows. J. An. Sci., 48:919.

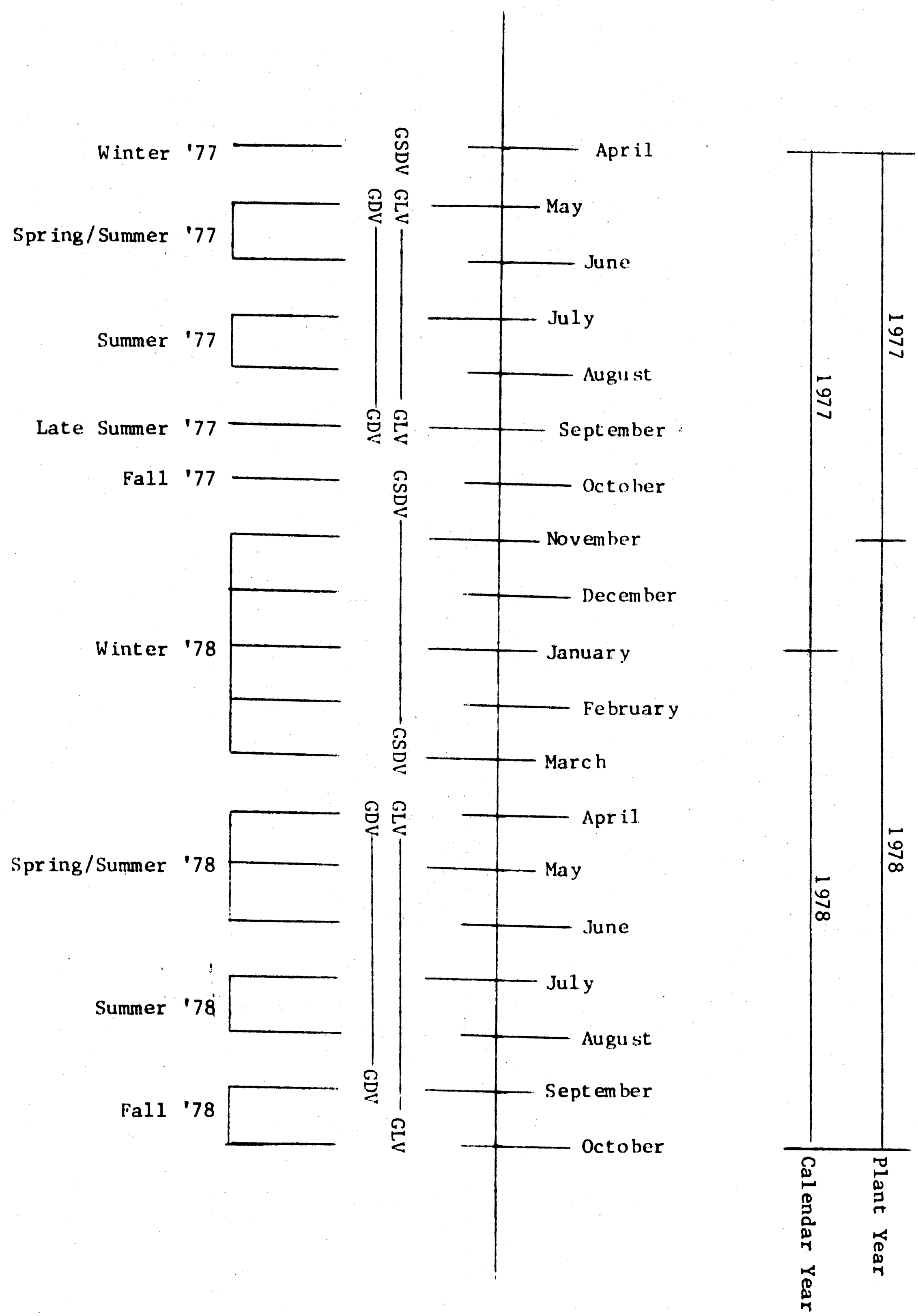
APPENDIXES

APPENDIX A

TIME AND VEGETATIVE MATERIAL STUDIED FOR A WATER-

SHED NORTH OF LAKE CARL BLACKWELL FROM

APRIL, 1977 THROUGH OCTOBER, 1978



Winter '77
Spring/Summer '77
Summer '77
Late Summer '77
Fall '77
Winter '78
Spring/Summer '78
Summer '78
Fall '78
GSDV
GLV
GDV
GLV
GDV
GSDV
GSDV
GLV
GDV
GDV
GLV
April
May
June
July
August
September
October
November
December
January
February
March
April
May
June
July
August
September
October
1977
1977
1978
1978
Calendar Year
Plant Year

APPENDIX B

REGRESSION EQUATIONS FOR THE DEPENDENT VARIABLE OMD FROM THE INDEPENDENT VARIABLE DMD, $OMD = b_0 + b_1\ DMD$

Table 34. Regression Equations for the Dependent Variable OMD by Month for Grazed Live and Dead OMD = Bo = b1 (DMD).

Month	Live				Dead			
	y-Int.	Slope	Model PR>F	R^2 Model	y-Int.	Slope	Model PR>F	R^2 Model
April '77					.0621	.9289	.0001	.957
May	.0172	1.0020	.0001	.980	.0744	.7914	.0001	.946
June	.01499	1.0061	.0001	.9684	.0289	.992	.0001	.868
July	.0235	.9759	.0001	.9838	.0680	.8787	.0001	.9646
August	.0064	1.0280	.0001	.9792	.0374	.9684	.0001	.951
September	.0385	.9815	.0001	.9218	.0469	.9017	.0001	.9040
October					.0371	.9484	.0001	.9883
November					.0646	.7693	.0001	.8720
December					.0564	.7762	.0001	.9393
January '78								
February					.0414	.8686	.0001	.9095
March					.0882	.4565	.0128	.4447
April	-.0308	1.0648	.0008	.9852	.0209	.9794	.0001	.9737
May	.0249	.9761	.0001	.9931	.0543	.7758	.0001	.8445
June	.0575	.9046	.0001	.9015	.0258	.9722	.0001	.9677
July	.0608	.9051	.0001	.9832	.0247	.9843	.0001	.975
August	.0491	.9324	.0001	.9561	.0564	.9463	.0001	.9825
September	.0286	.9548	.0001	.9965	.0117	.9919	.0001	.9712
October								

Table 35. Regression Equations for the Dependent Variable OMD by Season for Grazed Live and Dead. $OMD = b_o + b_1 (DMD)$.

	Live				Dead			
Season	y-Int.	Slope	Model PR>F	Model R^2	y-Int.	Slope	Model PR>F	Model R^2
Winter '77					.0621	.9289	.0001	.9574
Spring-Summer '77	.0160	1.0041	.0001	.9766	.0542	.8797	.0001	.8798
Summer '77	.0163	.9981	.0001	.9743	.0600	.8916	.0001	.9494
Late Summer '77	.0385	.9815	.0001	.9218	.0469	.0917	.0001	.9040
Fall '77					.0371	.9484	.0001	.9883
Winter '78					.0424	.8499	.0001	.9166
Spring-Summer '78	.0357	.9538	.0001	.9812	.0277	.9492	.0001	.9458
Summer '78	.0556	.9179	.0001	.9793	.0476	.9213	.0001	.9464
Fall '78	.0286	.9548	.0001	.9965	.0117	.9919	.0001	.9712

Table 36. Regression Equations for the Dependent Variable OMD by Month for Caged Live and Dead. $OMD = b_o + b_1 (DMD)$.

	Live				Dead			
Month	y-Int.	Slope	Model PR>F	R^2 Model	y-Int.	Slope	Model PR>F	R^2 Model
April '77					.0512	.9149	.0001	.9694
July '77	-.0195	1.0700	.0001	.9099	.0265	1.0137	.0001	.9647
March '78					.0812	.6504	.0001	.6484
July '78	.0416	.959	.0001	.971	.0412	.9293	.0001	.9766
October '78	.0225	.9809	.0001	.9735				

Table 37. Regression Equations for the Dependent Variable OMD by Season for Caged Live and Dead. $OMD = b_o + b_1 (DMD)$.

	Live				Dead			
Season	y-Int.	Slope	Model PR>F	Model R^2	y-Int.	Slope	Model PR>F	Model R^2
Winter '77					.0512	.9149	.0001	.9694
Spring-Summer '77								
Summer '77	-.0195	1.0700	.0001	.9099	.0265	1.0137	.0001	.9647
Late Summer '77								
Fall '77								
Winter '78					.0812	.6504	.0001	.6484
Spring-Summer '78								
Summer '78	.0416	.9590	.0001	.9710	.0412	.9293	.0001	.9766
Fall '78	.0225	.9809	.0001	.9735				

Table 38. Regression Equations for the Dependent Variable OMD Over All Months for Different Vegetation Type. $OMD = b_o + b_1 (DMD)$.

Material	y-Int.	Slope	Model PR>F	Model R^2
C Dead	.0347	.9682	.0001	.9901
G Dead	.0385	.9388	.0001	.9654
C Live	.0183	.9960	.0001	.9739
G Live	.0390	.9520	.0001	.9851
C STDV	.0168	.9814	.0001	.9269
G STDV	.0266	.9765	.0001	.9797

APPENDIX C

MEAN SQUARE VALUES FOR THE ANALYSIS OF VARIANCE OF GRAZED AND CAGED VEGETATION STRUCTURAL CARBOHYDRATES

Table 39. Mean square values for grazed live, dead, and standing dead ADF, ADL, and Cellulose from April, 1977 through October, 1978 for analysis of variance.

	MEAN SQUARE					
	SITE	LOC (SITE)	MONTH (SEASON)	DF	SITE*MONTH (SITE*SEASON)	DF
GLADF[1]	.00061	.00145	.02197	11	.00146	11
	.00043	.00147	(.01827)	5	(.00337)	5
GLADL	.00064	.00047	.00313	11	.00020	11
	.00062	.00049	(.00287)	5	(.00027)	5
GLCELL	.00000	.00096	.00922	11	.00081	11
	.00005	.00096	(.00229)	5	(.00168)	5
GDADF	.00435	.00082	.00434	10	.00085	10
	.00444	.00087	(.00762)	5	(.00111)	5
GDADL	.00047	.00051	.00305	10	.00033	10
	.00049	.00053	(.00602)	5	(.00039)	5
GDCELL	.00279	.00072	.00256	10	.00017	10
	.00274	.00075	(.00387)	5	(.00017)	5
GSTADF	.00919	.00247	.01959	5	.00065	5
	.00942	.00255	(.04559)	2	(.00151)	2
GSTADL	.00016	.00091	.00564	5	.00065	5
	.00014	.00100	(.01121)	2	(.00122)	2
GSTCELL	.01879	.00311	.00573	5	.00032	5
	.01870	.00336	(.00906)	2	(.00000)	2

[1]GLADF = grazed live ADF; GLADL = grazed live ADL; GLCELL = grazed live Cellulose; GDADF = grazed dead ADF; GDADL = grazed dead ADL; GDCELL = grazed dead Cellulose; GDSTADF = grazed standing dead ADF; GSTADL = grazed standing dead ADL; GSTCELL = grazed standing Cellulose.

[2]Degree of Freedom for SITE = 1; LOC (SITE) = 27.

Table 40. Mean square values for caged live, dead, and standing dead for ADF, ADL, and Cellulose from April, 1977 through October, 1978 for analysis of variance.

	MEAN SQUARE						
	SITE	LOC (SITE)	DF	MONTH (SEASON)	DF	SITE*MONTH (SITE*SEASON)	DF
CLADF[1]	.00053	.00057	23	.00544	2	.00048	2
	.00053	.00057	23	(.00544)	2	(.00048)	2
CLADL	.00049	.00023	23	.00280	2	.00002	2
	.00049	.00023	23	(.00280)	2	(.00002)	2
CLCELL	.00012	.00071	23	.00403	2	.00057	2
	.00012	.00071	23	(.00403)	2	(.00057)	2
CDADF	.00344	.00038	23	.03194	1	.00030	1
	.00344	.00038	23	(.03194)	1	(.00030)	1
CDADL	.00038	.00050	23	.00319	1	.00051	1
	.00038	.00050	23	(.00319)	1	(.00051)	1
CDCELL	.00173	.00043	23	.00031	1	.00024	1
	.00173	.00043	23	(.00031)	1	(.00024)	1
CSTADF	.00234	.00077	22	.00649	1	.00208	1
	.00234	.00077	22	(.00649)	1	(.00208)	1
CSTADL	.00123	.00072	22	.00331	1	.00041	1
	.00123	.00072	22	(.00331)	1	(.00049)	1
CSTCELL	.00077	.00128	22	.00442	1	.00000	1
	.00077	.00128	22	(.00442)	1	(.00000)	1

[1]CLADF = caged live ADF; CLADL = caged live ADL; CLCELL = caged live Cellulose; CDADF = caged dead ADF; CDADL = caged dead ADL; CDCELL = caged dead Cellulose; CSTADF = caged standing dead ADF; CSTADL = caged standing dead ADF; CSTADL = caged standing dead ADL; CSTCELL = caged standing dead Cellulose.

[2]Degree of Freedom for SITE = 1.

VITA 2

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Master of Science

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