PLANT, SOIL AND DUNG FACTORS AFFECTING TALLGRASS PRAIRIE VEGETATION DURING DROUGHT CONDITIONS ON A NORTH CENTRAL OKLAHOMA RANGELAND WATERSHED

By

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CHAPTER I

INTRODUCTION

There has been much interest in recent years in animal waste pollution. Most of the interest has been directed at point sources of pollution (e.g., feedlots) or nonpoint sources such as cropland or intensively managed pasture land.

With high grain prices and a greater demand for grain abroad for human consumption, more emphasis in the future will likely be placed upon greater forage utilization in beef production systems. Much of the additional forage will have to come from rangeland, requiring more efficient rangeland forage production. Consequently, there will be a need for greater understanding of range ecosystems.

Recently, larger numbers of cattle, particularly growing animals, have been maintained on rangeland for longer periods of time because of the economic situation in the beef cattle industry. If proper management is not practiced, high stocking rates and overgrazing might lead to greater water pollution from animal wastes produced by livestock grazing rangeland.

The objectives of this study were to determine (1) the effects of range site and plant species composition on plant fiber components and *in vivo* nylon bag dry matter digestibility (NBDMD) of tallgrass prairie vegetation, (2) effects of range site and plant species composition on plant chemical composition of tallgrass prairie vegetation, and (3) the chemical and fiber composition of all-age dung throughout the year and change in composition over time of recently deposited dung.

This thesis was written in the style and format for technical journals. The style and format adhered to in this thesis is that of the Journal of Range Management. Results of this study are presented in three different papers.

CHAPTER II

REVIEW OF LITERATURE

In the last decade considerable work has been conducted in the area of animal waste pollution. Recently, a comprehensive review by Ramsey (1974) included 1264 references to journal articles, conference proceedings, university and government publications. There was not one reference, however, that was directly related to the potential pollution from rangeland watersheds grazed by cattle.

Factors Influencing Plant Chemical Composition

A knowledge of plant chemical composition is essential and significant to better understand the relationships involved between plant and dung chemical composition. There are many factors affecting the maturity and consequently the chemical composition of rangeland herbage.

Soil Water Content

Soil moisture affects both the chemical composition and yield of plants. Early in the growing season soil water content is usually abundant. Plants are green and growing rapidly. Moisture, crude protein (CP) and phosphorus (P) content are high; whereas, crude fiber (CF) is low. As the growing season progresses soil water content decreases in temperate regions and plants mature and become dry. Throughout the growing season different changes occur in the plants: (1) CP and P decrease

(Oelberg 1956); (2) CF increases (Savage and Heller 1947); and (3) digestibility of most plant components decreases (Cook et al. 1961). Plant maturity causes most of these effects, with a decrease in soil water content indirectly affecting the resultant changes. Calcium (Ca) content is affected by soil water content and stage of growth, depending on species and location.

Precipitation

The amount and distribution of precipitation will affect plant chemical composition both directly and indirectly. Leaching of nutrients is the direct effect while variations in the amount of soil water content available for plant growth is the indirect effect.

Exposure to rain results in leaching and causes decreases in CP, P and ash of mature dry plants. Crude fiber is a plant component that resists leaching, thus proportionately increasing as leaching progresses. All species do not react in the same way. Crude protein of native grasses in New Mexico greatly declined with leaching incuring losses of 37 to 73% between October and March (Watkins 1943). Calcium and P contents were significantly reduced by heavy winter precipitation between October and March (Watkins 1943). Savage and Heller (1947) observed little influence of leaching on Ca content of grasses in Oklahoma. Guilbert et al. (1931) indicated that Ca content in bur clover and alfilaria is not affected greatly but P content is lowered, thus widening the Ca:P ratio. Dry mature grasses are in general lower in Ca content and since the P content is also reduced by leaching, the Ca:P ratio remained practically unchanged (Guilbert et al. 1931).

Soil Characteristics

Plant chemical composition is affected by different aspects related to soil such as soil depth and nutrient content of the soil.

Soil depth has been studied with seeded grasses on deep, sandy loam and shallow, rocky clay loam soils. Plants on shallow soil contained higher percentages of CP and less CF (Cook 1959). They were also found to be more palatable to livestock than those on deeper soil. Soil depth effect was indirectly responsible for this difference. Plants on shallow soil were more leafy and had smaller stems. Leafy characteristics would explain the greater palatability (Cook 1959). Stoddart (1941) however, found plants on deeper soils to have more ash and P than those on shallower soils. All other nutrients remained about the same. Site differences in soil nutrients or soil water content could be factors responsible for contradictory results.

Nitrogen generally has been the only fertilizer nutrient to affect the quality of grass herbage in the plains and mountains of the United States (Cook 1965). However, the relationship between soil fertility and plant chemical composition has not been established for all soils and species, and the effect of nutrient status of the soil can be altered by other factors.

Plant Species Composition

There are infinite variations in forage value among species. Range grasses in general have a higher CP and P content early in the growing season. Energy in the form of CF, cellulose, is low in the early growing season. As the plants mature there is a reverse relationship between nutrients that were high at the start of the growing season versus those that were low (Oelberg 1956).

Forbs do not generally cure well. Consequently, they are inferior as forage to both grass and browse during the non-growing season. Actively growing forbs, especially legumes, are consistently higher in Ca than grasses. Forbs are most nutritious early in the growing season due to a high CP content (Oelberg 1956).

Browse species more nearly maintain their peak nutrient values throughout the growing season. Generally, browse plants are more deep-rooted and tend to store food reserves in stems rather than roots (Stoddart and Smith 1955). They do not decrease in CP and energy during dry periods or during the winter as much as grasses (Stoddart and Smith 1955). Reductions in CP and P with increase in CF occur. Browse species in New Mexico contain more than three times as much Ca and 61% more P than grasses in the fall (Watkins 1937).

Stage of Maturity

Stage of maturity seems to be the most important factor affecting plant chemical composition and digestibility (Oelberg 1956). In the spring there is usually a higher soil water content and more favorable temperatures to initiate the start of rapid plant growth. Whitman et al. (1951) reported native and tame grasses of western North Dakota lost on an average 71% of their CP content by the end of September. Forage plants in Utah showed grass species had an average CP content of 8.2%, 7.2% and 4.5% in early, mid and late season, respectively (Cook and Harris 1950).

Phosphorus content normally parallels that of CP in regard to stage of maturity. Losses of from 49 to 83% P, over the growing season, were found in range grasses in New Mexico.

Range site also has an effect on plant chemical composition in relation to stage of maturity. Protein content (10.8% to 9.6%) on unfavorable sites was significantly higher than on favorable sites (Cook 1959). The difference was largely due to differences in stem-leaf ratio. Leaves and stems were higher in lignin content (6.5% to 6.0%) on the favorable sites. Cellulose content in the entire plant was significantly higher (31.2% to 28.7%) on favorable sites than on unfavorable sites.

Factors Affecting Diet Quality and Digestibility of Forage

For many years forage yield was the main criterion for forage value. In recent years relationships between forage yield, quality and animal response have been studied. Forage quality is an indicator of plant chemical composition. A high-quality forage for a ruminant animal will possess certain characteristics: (1) high palatability to the animal, with increased feed intake, (2) optimum levels of various nutrient components in proper ratios during animal use, (3) high apparent digestibility of nutrients with optimum ratio of nitrogenous to non-nitrogenous components, (4) optimum proportions of volatile fatty acids (VFA) for efficient energy production, (5) adequate amounts of minerals, vitamins and trace elements and (6) efficient convertability of components needed for the animal body over sustained periods of time (Dietz 1970). The plant chemical composition of the animal diet selected is not necessarily the same as that of forage (Laycock and Price 1970).

The declines in digestibility are not due just to changes in chemical composition. The digestibility of all chemical components declines. Unfavorable climatic conditions are a cause of poor digestibility (Minson and Meleod 1970) and lower mineral contents of forage (Patil and Jones 1970).

Dung Chemical Composition

The consistency of dung (physical characteristics and/or chemical composition) varies greatly depending upon the time of year cattle are grazing as it influences the type of forage being consumed. The content of the structural carbohydrates in dung is inversely related to the digestibility of the grazed forage, while the N content of dung is directly related to the N content in the forage (Raymond 1966). Direct counts of 250-3000 million bacteria/gm of cattle dung have been reported (Witzel et al. 1966). Various forms of dead and living organisms including protozoa and eggs, larvae and adults of parasitic nematodes, cestodes and trematodes are also present in dung composition.

Chemical composition analyses of dung and urine on a percentage net weight basis suggest that most voided P occurred in the feces, while N and K occurred in the urine (Heady 1975). The amount of N and sulfur (S) mineralized is closely related to the N and S content of the dung (Barrow 1961). There is no evidence that fecal excretion of N, S or organic P is affected by the level of feed intake (Barrow and Lambourne 1962). There is a very high recovery of N through the excreta on grazed pasture against the ungrazed area when pasture was fertilized (Brockman et al. 1971).

Dung of sheep grazing fertilized pastures contained a consistently higher P content than dung of sheep grazing unfertilized pastures. When comparing both fertilized and unfertilized pastures, total inorganic P content varied widely, 0.18 to 1.7%, while organic P content changes were small, 0.15 to 0.4% (Bromfield 1961). Inorganic P is readily soluble in acid but not in water and is readily available to the plant; whereas, organic P is not readily available to the plant nor rapidly mineralized to inorganic P (Bromfield 1961).

Degradation of Dung

Degradation Process

There are many factors involved in degradation of dung and their effects and interrelationships with various other components. The process dung degradation is a complex one beginning as soon as it is deposited. It is primarily the result of microbial activity that leads to the production of CO_2, NH_3, H_2O, nitrate and nitrites. This in turn is accompanied by synthesis of humic compounds of higher molecular weight (Marsh and Campling 1970).

Disappearance Rate

This aspect of dung degradation is influenced primarily by two factors: (1) formation of hard crust which decreases the eroding effect of rain and retards decomposition and (2) consistency of dung in relation to seasonal changes. Weeda (1967) reported dung deposited in the fall disappeared in one-two months and dung deposited in late spring or early summer disappeared in four-six months. Dung will tend to start decomposing on the margins first, and then the central area will decompose rather slowly from the underside upward. After the patch is broken into several pieces it will disappear rather rapidly (Weeda 1967). Dung decomposition of N fertilized pastures of two different levels, 500 or 125 kg/ha/yr. had a mean area of dung patches of .06 m^2 with no difference between patches on the two N treatments (Castle and MacDaid 1972). The dung patches on high and low N treatments crumbled in 63 and 55 days and disappeared in 115 and 113 days, respectively.

CHAPTER III

STUDY AREA

The study area, part of the Lake Carl Blackwell watershed, is located 16 km northwest of Stillwater, Oklahoma, USA (Lat. 38°N, Long. 97°W, elevation 290-318 m) in the NW¼, Section 32, T20N, R1E of the Indian Meridian (Fig. 1). The remainder of the watershed is located in the SW¼, Section 32 and the eastern edge of Section 31, Noble County.

Climate

The climate is continental, with hot summers and variable winters. The average annual temperature is 16°C. The average absolute maximum temperature is 44°C in either July or August. The average absolute minimum temperature is -26°C in January. Average wind speed varies from 15 km/hr in August to 25 km/hr in March. The mean relative humidity varies from 62% in July and August to 71% in December and January. The average number of frost-free days is 206 from early April to late October. Average annual precipitation is 820 mm with about 75% occurring during the growing season. The average monthly precipitation ranges from about 120 mm in May to 30 to 35 mm in December, January and February.

Topography

The watershed, 57.5 ha in size, is rolling with 3 to 5% slopes on

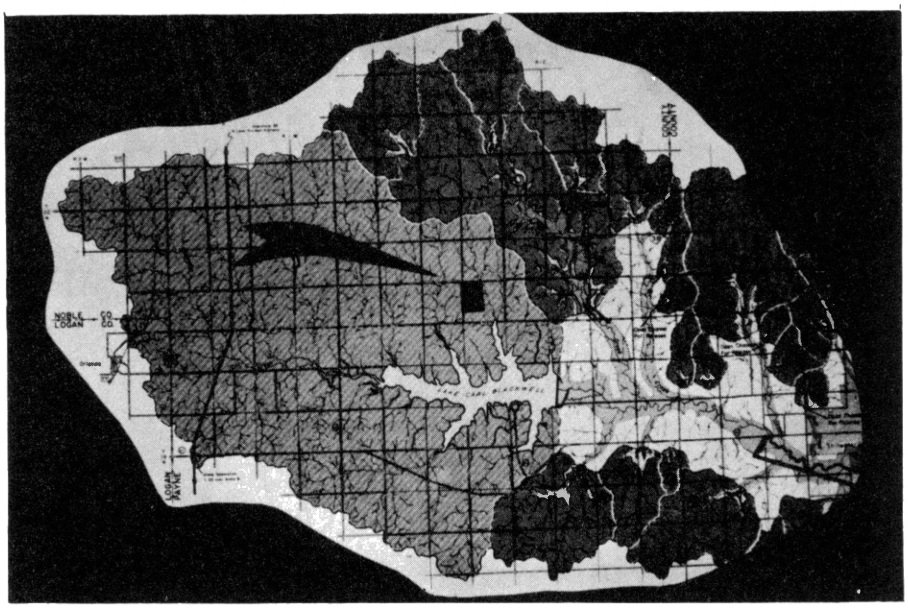

Fig. 1. Map showing location of watershed in relation to Lake Carl Blackwell.

the ridges and upland areas. The land adjacent to the drainageways has slopes of 5 to 10% or more but there are no active gulleys. The watershed is composed of two major drainageways which merge about 90 m upstream from a weir. The north drainageway has a watershed area of 20 ha. A stock water pond lies in the upper end with a watershed area of 6.1 ha. The north drainageway has a fall of 26 m over a distance of 760 m. The watershed area of the south drainageways is 30 ha. The fall is 26 m over a distance of 1060 m. The watershed has an eastwardly fall and a triangular shape.

Soils

There are eight soil series (Appendix A) with soils of very-fine or fine-loamy, mixed thermic Vertic Haplustalfs occupying 70% of the watershed (Fig. 2). The proportion of soil orders is 78% 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. The loamy and claypan prairie sites are combined as loamy prairie and the shallow prairie, shallow savannah and sandy savannah sites are combined as shallow prairie.

Vegetation

Many of the plant species present on the watershed (Fig. 3) are those tallgrass prairie climax species described by Bruner (1931) and Carpenter (1940). Other existing grassland species common to lower successional stages of the tallgrass prairie have been described by Sims and Dwyer (1965). About 80 to 85% of the watershed is grassland

Fig. 2. Soil survey map.

Fig. 3. General view of watershed vegetation.

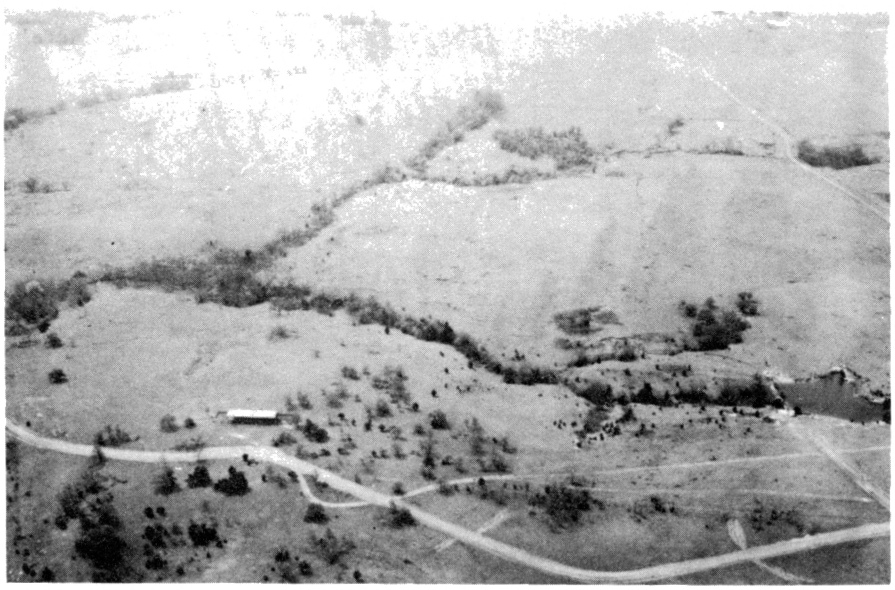

Fig. 4. Aerial view of watershed.

(Fig. 4). The average plant species class composition (Fig. 5) on loamy prairie sites during the growing season was 20% tallgrasses, 25% little bluestem (Schizachyrium scoporium), 13% midgrasses, 2% shortgrasses, 7% other grasses, 25% forbs and 8% shrubs (Powell et al. 1978). On shallow prairie sites the average species class composition was 8% tallgrasses, 20% little bluestem, 17% midgrasses, 7% shortgrasses, 13% other grasses, 33% forbs and 2% shrubs. The major tallgrasses included big bluestem (Andropogon gerardii), switchgrass (Panicum virgatum) and Indiangrass (Sorghastrum nutans). Midgrasses included various species of Andropogon, Panicum, Paspalum, dropseed (Sporobolus spp.), other genera and sideoats grama (Bouteloua curtipendula). Shortgrasses included buffalograss (Buchloe dactyloides) and other Bouteloua species. The major shrubs were buckbrush (Symphoricarpos orbiculatus) and smooth sumac (Rhus glabra). Post oak (Quercus stellata) and blackjack oak (Q. marilandica) were the dominant trees on the savannah sites. Elm (Ulmus), hackberry (Celtis), ash (Fraxinus) and persimmon (Diospyros) species were most common along drainageways.

Livestock

The watershed is grazed by Oklahoma State University cattle under a yearlong grazing, cow-calf management system. 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 70 animal-unit-days (AUD)/ha in 1976. Dry cows were supplemented with about 1 kg of cottonseed meal (41% protein) per head per day from October 15 to December 31 when they were removed from the watershed. From latter January to mid April cows and calves were fed

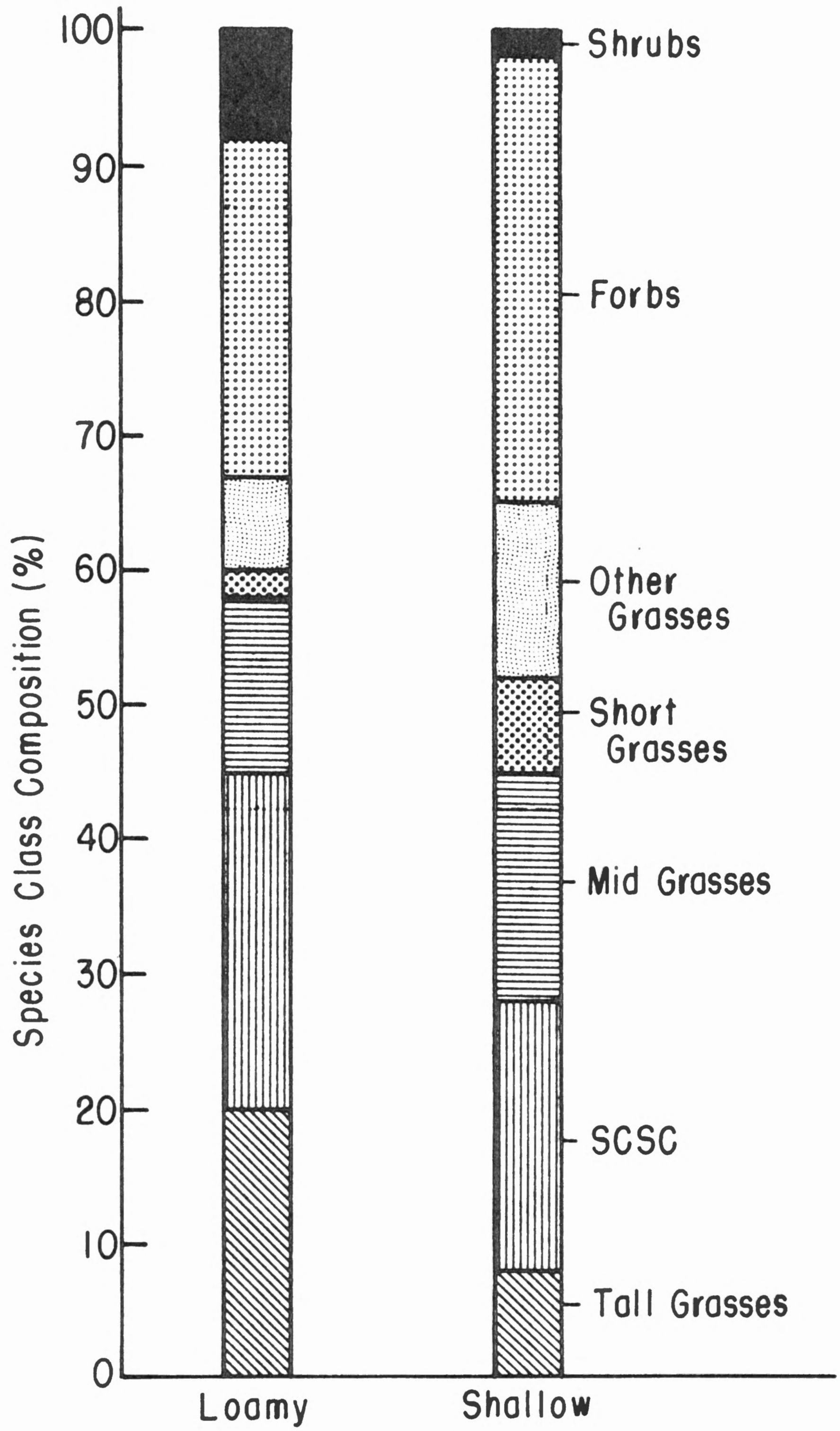

Fig. 5. Species composition (%) of herbage on loamy and shallow prairie sites (SCSC = _Schizachyrium scoparium_) (from Powell, et al. 1978).

2.7 kg of soybean meal range cubes (20% protein) 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

TALLGRASS PRAIRIE VEGETATION ON A RANGELAND WATERSHED: THE EFFECT OF RANGE SITES AND PLANT SPECIES COMPOSITION ON *IN VIVO* NYLON BAG DRY MATTER DIGESTIBILITY AND PLANT FIBER COMPONENTS DURING DROUGHT CONDITIONS

Abstract

The effects of range sites and plant species composition on plant fiber components and *in vivo* nylon bag dry matter digestibility (NBDMD) were studied on a tallgrass prairie watershed in north central Oklahoma. Drought stress was evident in herbage because of lack of precipitation and soil water. In general, cellulose content was inversely related to lignin content between May and July. Acid-detergent fiber (ADF) content was increased by the relative percentage of total warm season grasses ($P < .10$) and by percentage of tallgrasses plus *Schizachyrium scoparium* ($P < .01$). NBDMD was correlated with ADF ($r = -0.77$) ($P < .01$) and declined 1.62% for each 1% increase in ADF. Differences in mean cellulose content and NBDMD on different sites differed significantly ($P < .01$) across months. Differences in NBDMD on different sites were correlated with ADF ($r = -0.80$) ($P < .01$) and declined 1.73% for each 1% increase in ADF.

Introduction

For many years forage yield was the main criterion for forage value. In recent years relationships between forage yield, quality and animal response have been studied. The diet of the animal consists of plant parts and species selected by the animal and the plant chemical composition of the diet selected is not necessarily the same as that of forage (Laycock and Price 1970). Plant species composition affects nutrient quality of herbage. As plants mature there is a reverse relationship between nutrients that were high at the start of the growing season and those that were low (Oelberg 1956).

Range site affects plant chemical composition during different phenological stages of plant development. Plant chemical composition influences palatability and range site influences chemical composition of the plant tissues; therefore, range site influences palatability of plants (Watkins 1940 and Plice 1952).

There is also a difference in selection of diet due to animal species (Van Dyne and Heady 1965). Where forage is plentiful, selectivity enables animals to maintain nutrient levels of their diet even though the nutrient value of the plants decreases with maturity (Cook and Harris 1952 and Edelfen et al. 1960). Sheep fitted with esophageal fistulas, grazing California annual range, consistently consumed forage that was higher in protein and lower in crude fiber than samples clipped from the same area (Weir and Torell 1959).

The purpose of this study was to determine the effect of range site and plant species composition on plant fiber components and *in vivo* nylon bag dry matter digestibility of tallgrass prairie vegetation.

Methods and Materials

Forage Collection

Twenty-nine permanent locations were arbitrarily selected for monthly vegetation sampling. The number and distribution of locations provided a range in site conditions for regression analyses and replications on the major soil types in proportion to their percentage of occurrence throughout the watershed. Fourteen of the locations were on loamy sites and 15 were on shallow sites.

Sampling areas (Fig. 1) consisted of an area around each permanent location as indicated by a neutron probe access tube. The tube was the pivot point of the circle with a radius of 15 m. The circle was marked off in 20° increments beginning with 10° and ending at 350°. The circle was divided into thirds with boundaries falling on the compass bearings of 0°, 120° and 240°. Bearings 1, 3, 5, 7, 9 and 11 (corresponds to the degree readings of 10°, 30°, 50°, 70°, 90° and 110°) are in transect #1. Bearings 13, 15, 17, 19, 21 and 23 are in transect #2 and transect #3 consists of bearings 25, 27, 29, 31, 33 and 35.

Each bearing had six points beginning at 5 m from the center and occurring at 7, 9, 11, 13 and 15 m. The plots to be sampled were predetermined on a master copy of the location diagram.

Species composition and forage production were determined at each location using three estimated samples. Vegetation at one of the three sampling points was clipped at each location. Clipping was at ground level to determine total top growth. All estimates and clippings were from 0.5 m^2 circular quadrats.

Soil water content was determined monthly at each location. At

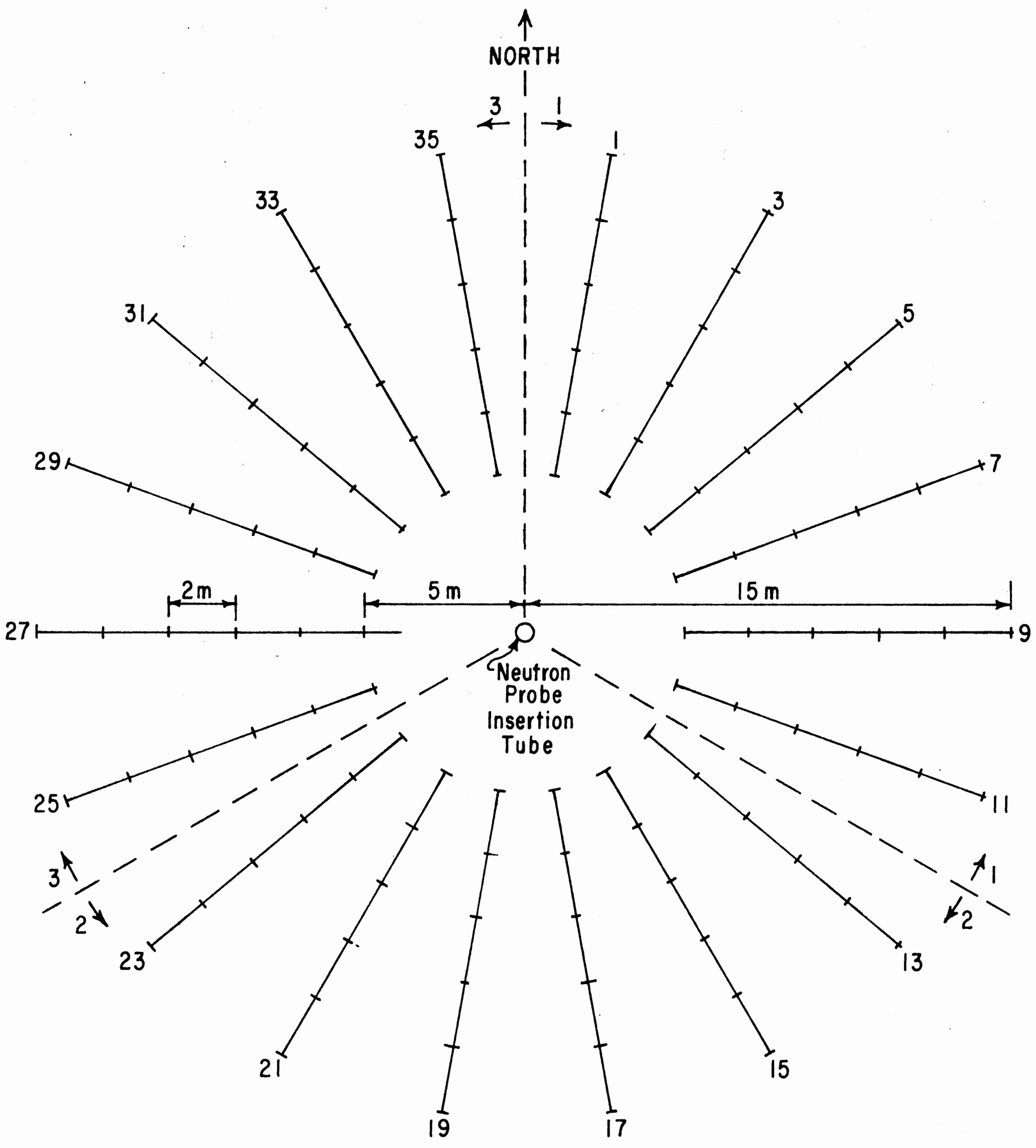

Fig. 1. Schematic used to randomly select plot locations at each site.

each location, a neutron probe access tube was driven into the soil to the maximum depth possible. Access tube depths ranged from 22 to 137 cm which, in most cases, coincided with the solum thickness. Soil water content was determined at several depths. From the soil surface to 50 cm soil water content was determined at 10 cm increments and depths greater than 50 cm determined at 20 cm increments. Soil water content was determined using a portable neutron scattering moisture meter (Stone et al. 1955), d/m-GAUGE Model 2800 portable scaler.

Laboratory Analyses

Clipped vegetation samples were separated into live and standing dead components, and ground through a 2 mm screen in a Wiley mill. Samples were analyzed for <u>in vivo</u> nylon bag dry matter digestibility (NBDMD) by a nylon bag technique (Johnson 1969), acid-detergent fiber (ADF), lignin and cellulose. ADF and lignin were determined by the permanganate oxidation procedure of Van Soest and Wine (1968). Samples consisted of 3 gm aliquot for DMD and a 0.5 gm aliquot for ADF and lignin. NBDMD analysis was triplicated while all other laboratory analyses were duplicated.

NBDMD

Three Holstein steers (408 kg mean weight) fitted with permanent rumen cannulae on May 5 for NBDMD trials were put on 9.5 ha of rangeland on May 20, 1976. This grazing area was composed of nearly the same plant species composition as the study area.

On November 1, hay from the same paddock in which the steers grazed was cut and baled in order to continue the NBDMD trials through the winter months. On November 3, the hay was transported to a barn and stored. The steers (427 kg mean weight) were put in a drylot paddock on November 10, 1976. Four samples from both the supplement and hay were analyzed for CP. The supplement and hay averaged 22% and 5.5% CP, respectively. Steers were fed 7 kg hay/hd/day, 1.12 kg supplement/hd/day, salt and water ad libitum. On April 14, 1977, the steers (510 kg mean weight) were taken back to the same paddock on rangeland to continue the NBDMD trial through May, 1977.

Nylon Bag Technique

Nylon bags were made from 100 mesh nylon. The bags were 5.0 by 7.6 cm with rounded corners to prevent the sample from collecting in the corners. A nylon thread was used for sewing the bags together. A set of six soft braided nylon lines (29 kg test), each 0.91 m in length were cut. A rubber stopper was tied at one end and a beveled stainless steel weight (76 gm) attached at the other end. A set of six lines (29 kg test) were also assembled without a weight on the end. Three small loops were made in the line. The first loop was 20 cm from the weight. The remaining two loops were spaced at 5 cm intervals above the first loop. Attached to each loop was a #3, brass swivel. A line (16 kg test) 23 cm long was attached with five loops in the line and a #3, brass swivel attached to each loop. After putting forage samples in the nylon bags, the bags were closed and tied with a line (16 kg test). The nylon bags were attached to each of the five loops. There were 15 samples per primary line and two lines per steer for a total of 30 samples per steer per analysis. A line of less than 24 kg test was not strong enough for the 0.91 m primary line and would break. The 76 gm stainless steel weight was found to be unnecessary when test animals were on an all-forage diet.

NBDMD Field and Laboratory Technique

Forage samples were analyzed for NBDMD on a monthly basis to correspond to the monthly collection period of the forage from the study area. NBDMD was determined for 48-hr incubation periods. After 48 hr, samples were taken from the steers, washed in ice water, placed in a chest of ice water, and transported to the laboratory. In the laboratory individual bags were washed thoroughly with cold tap water. The bags were then placed on drying trays and put into an oven at 55^{o}C for 48 hr. Twenty-four hours after beginning the drying process, bags were removed and ties removed to allow more thorough drying the next 24 hr. Following the drying procedure, samples were placed in desicators immediately upon removal from the oven. Samples were then reweighed and the percent NBDMD calculated.

Data Compilation and Statistical Analyses

Measurements of species, herbage weights, and laboratory data were recorded directly on data forms prepared to facilitate key-punching data cards directly from data forms. Examples of the data forms, input programs and procedures are printed in Appendices I, J, K, L, N, O, P, Q, and R. Data were stored and processed by the Oklahoma State University IBM 370/158 computer. Statistical analyses were performed using the procedures of the Statistical Analysis System, SA572, (Barr and Goodnight 1972). Regression and analyses of variance tables are shown in Appendices O, P, Q and R. All differences discussed were significant at the (P < .05) level unless otherwise specified.

Results and Discussion

Precipitation and Soil Water Content

Precipitation during the growing season of 1976 was below the longterm average for that period of time (Fig. 2). March, 1977 was the only month in which the amount of precipitation exceeded the long-term average. Soil water content declined rapidly from a high of 34.2 cm in May to a low of 18.1 cm in August. Rapid growth rates of the vegetation occurred during the sharpest decline of soil water content in May and June. Infrequent rains that provided additional soil water between June and October were rapidly depleted during the hot summer months.

Drought stress was very evident by July. Cook and Harris (1950) indicated that environmental factors and soil water content are more important in determining the nutrient content of range forage plants under various site conditions. Drought stress appeared to occur earlier and to a greater degree for the same species on shallow prairie sites than on loamy prairie sites.

Fiber Components and NBDMD

Cellulose and Lignin

Cellulose content (%), in live and dead biomass declined between April and May (Fig. 3). As cellulose content declined from 31.9% to 22.7% in live herbage and 38.9% to 34.1% in standing dead litter during the above period, lignin content increased in live herbage from 11.3%

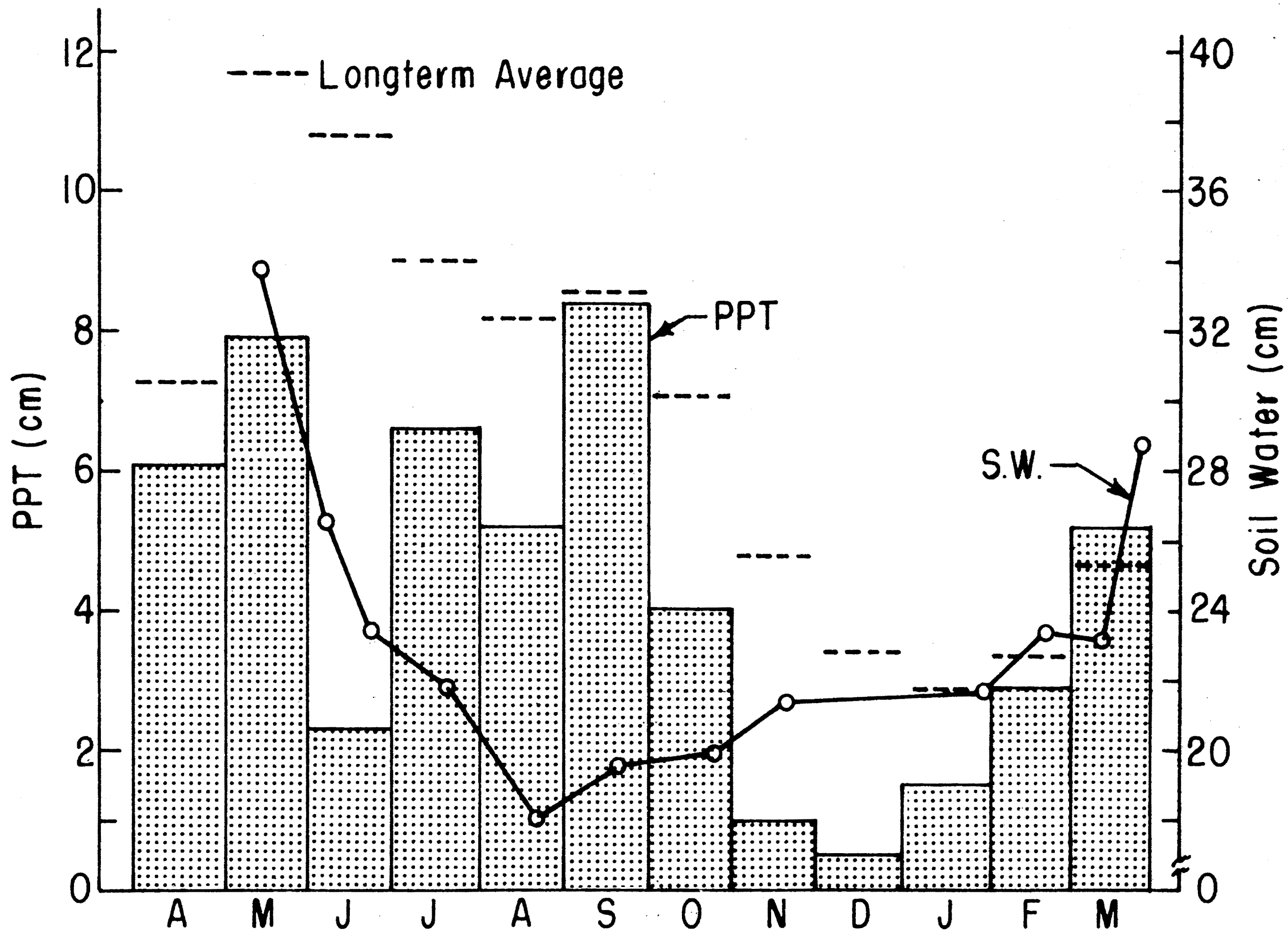

Fig. 2. Longterm average monthly precipitation (cm), actual monthly precipitation (cm) and monthly soil water (cm) content.

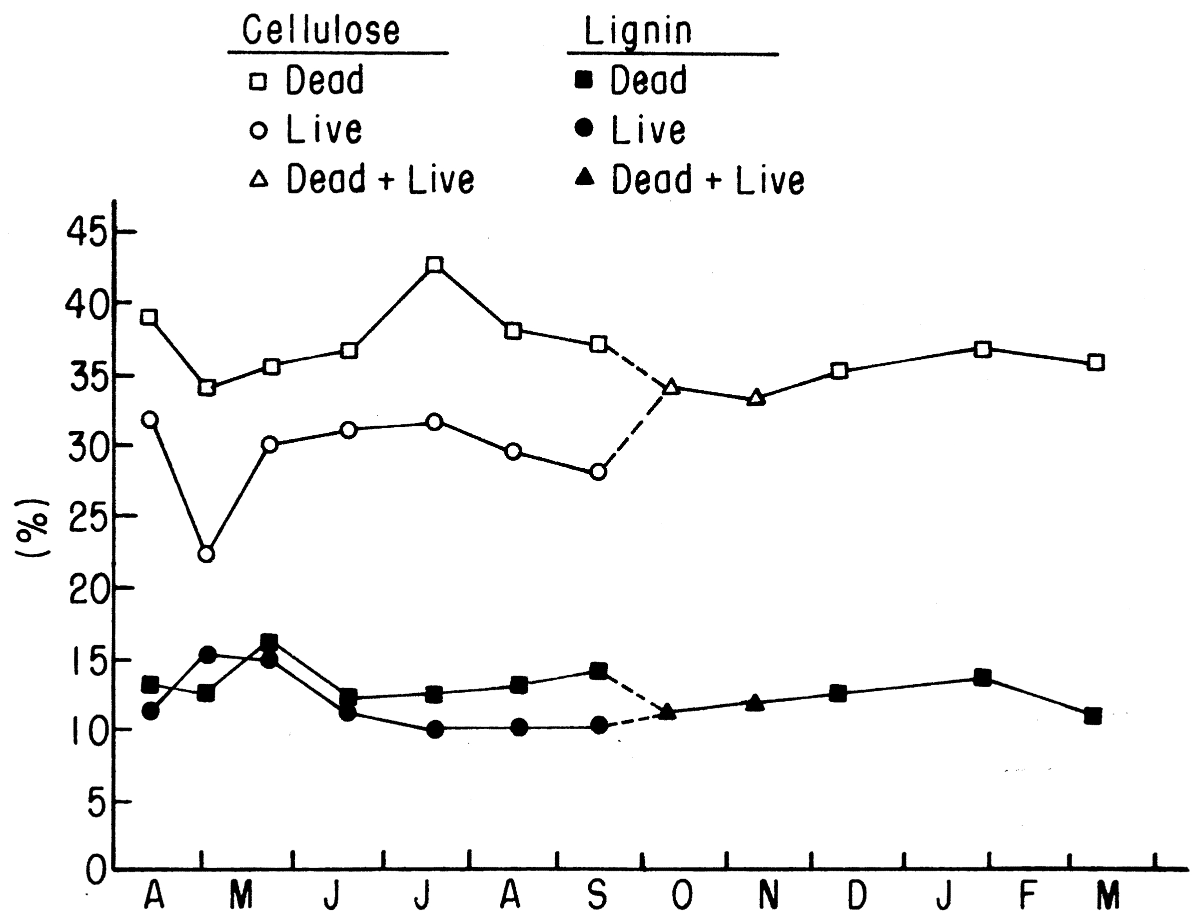

Fig. 3. Cellulose and lignin contents (%) in plant biomass from April, 1976 through March, 1977.

to 15.4%. This was related to the increased maturity of cool season annual grasses and spring forbs in May. In general, cellulose content was inversely related to lignin content between May and July (Fig. 3). The decline in lignin content from 15.1% to 10.2% between May and July may have resulted from an increase in the percentage of growing tallgrasses and a decrease in percentage of mature cool season annual grasses. Broyles (1978) reported the period of peak production in the tallgrass prairie varies from June to August depending on species composition, site factors such as soil water content and external factors such as grazing intensity. The difference in lignin content ranged from 10.2% to 15.4% in live herbage and from 11.0% to 16.1% in dead biomass. Grasses in Montana showed increases in lignin content of 5% in May to 18% in September (Patton and Gieseker 1942). Cellulose and lignin content in dead biomass was relatively stable throughout the winter months (Fig. 3). Specific mean values (± SE) for cellulose, lignin, ADF and NBDMD in live and dead biomass are shown in Appendix B.

ADF

Changes in ADF content in live herbage, generally reflected the change in species composition and different stages of maturity of the species (Fig. 4). ADF content was correlated ($r = -.23$) ($P < .10$) to percent warm season annual grasses in April. As the warm season annual grasses matured ADF content declined and upon reaching maturation ADF content increased 1% for every 8.6% increase in warm season annual grasses. Differences in ADF content were negatively correlated ($r = -.26$) ($P < .10$) to total warm season grasses in August. ADF content (%) was increased 1% for every 0.22% increase in tallgrasses plus

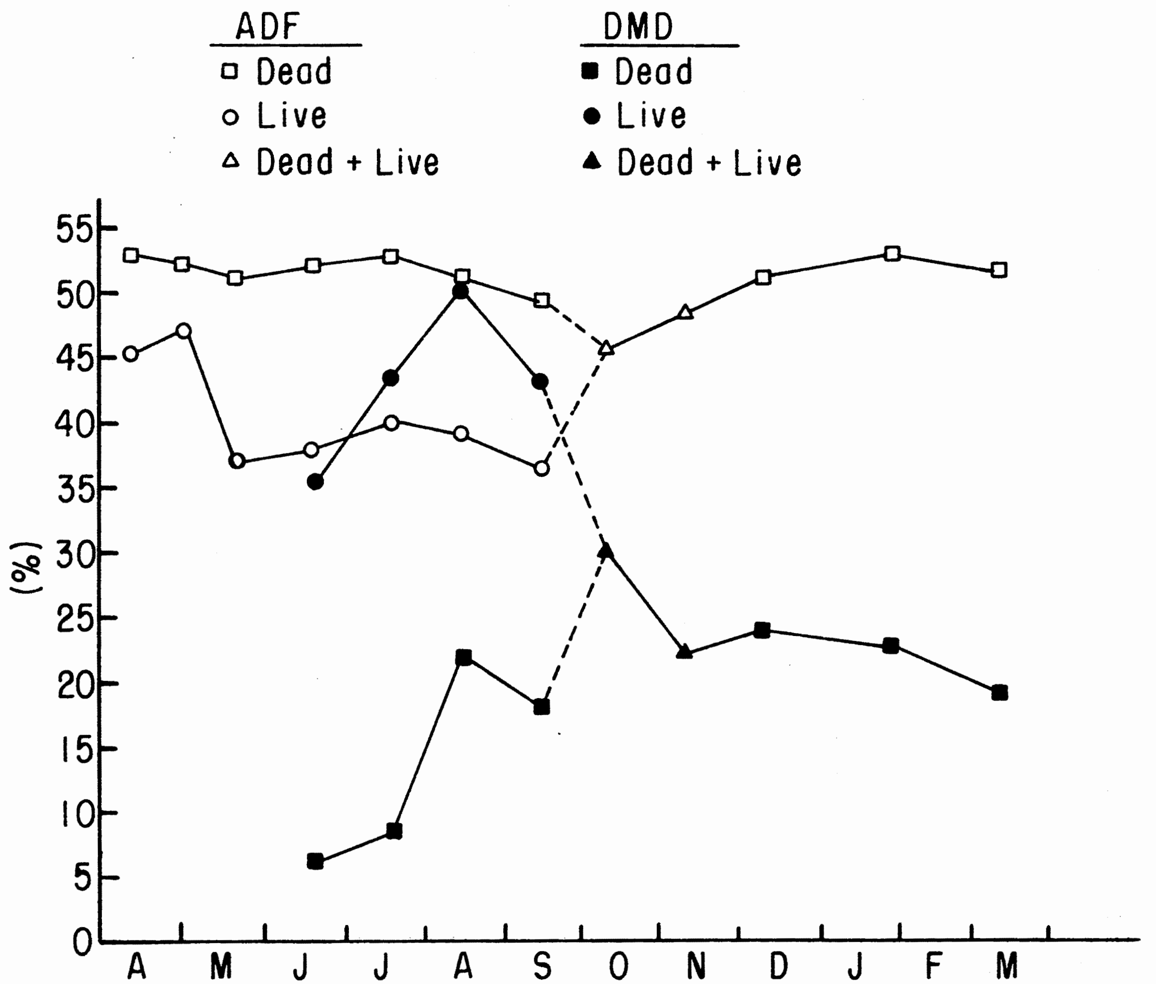

Fig. 4. ADF content (%) in plant biomass from April, 1976 through March, 1977 and NBDMD (%) from June, 1976 through March, 1977.

little bluestem in August ($P < .01$). The ADF content in dead biomass was the previous year's growth in the spring. After July, a greater percentage of the dead biomass was the current year's growth. Changes in ADF content in dead biomass were closely associated with different stages of plant phenology for different species. The ADF content of dead biomass in March, 1977 (51.3%) was at about the same level as in April, 1976 (52.7%).

NBDMD

NBDMD in June (35.7%) was much lower than generally reported for live vegetation in the literature (Fig. 4). Burzlaff (1971) reported DMD values of growing range grasses to be 40 to 70%, declining sharply as the growing period advances. Annual grasses in California were found to be 47% digestible in midsummer when they were dry (Van Dyne 1965). Tallgrasses were at peak production in June and the herbage was clipped at ground level.

As actively growing shortgrasses and summer forbs increased in percent composition of the herbage, the NBDMD increased until all species reached peak production (Fig. 4). Arnold (1962) found digestibility of herbage selected by grazing sheep in Australia did not decline until almost three weeks after a substantial decline in digestibility of the same species clipped and fed to penned sheep. NBDMD increased rapidly from 35.7% in June to 50.4% in August and at the same time there is a rapid growth in shortgrasses and late summer forbs. Dry matter digestibility of the dead plus live and dead biomass was relatively constant between November and March, declining from 30.0% to 18.8%. Dry matter digestibility of the live plus dead biomass throughout the year was highly correlated ($r = -0.78$) ($P < .01$) with ADF and declined 1.62% for each 1% increase in ADF.

Effect of Range Site on Fiber Components and NBDMD

Cellulose and Lignin

The cellulose content in live biomass on loamy sites was higher than that on shallow sites on all sampling dates except early May (Fig. 5). Cellulose content in the entire plant was significantly higher on favorable sites (31.2%) than on unfavorable sites (28.7%) (Cook 1959). Results from this study would agree with other studies that loamy prairie sites produced vegetation with a higher percentage of cellulose content in live herbage than did shallow prairie sites. There were no significant differences in cellulose content of dead biomass nor in lignin content of live herbage. Differences in lignin content of dead biomass were significant at less than the 10% level only in April.

ADF

ADF content of live herbage was greater ($P < .10$) in herbage on loamy prairie sites than that on shallow prairie sites in June, August and September (Fig. 6). The monthly average ADF content was also greater ($P < .02$) in herbage on loamy prairie sites. The higher ADF content in the herbage from the loamy prairie sites can be attributed to the greater percentage of tallgrass species on these sites. Cook (1959) also found that herbage on loamy prairie sites contained a higher ADF content compared to that on shallow prairie sites. Differ-

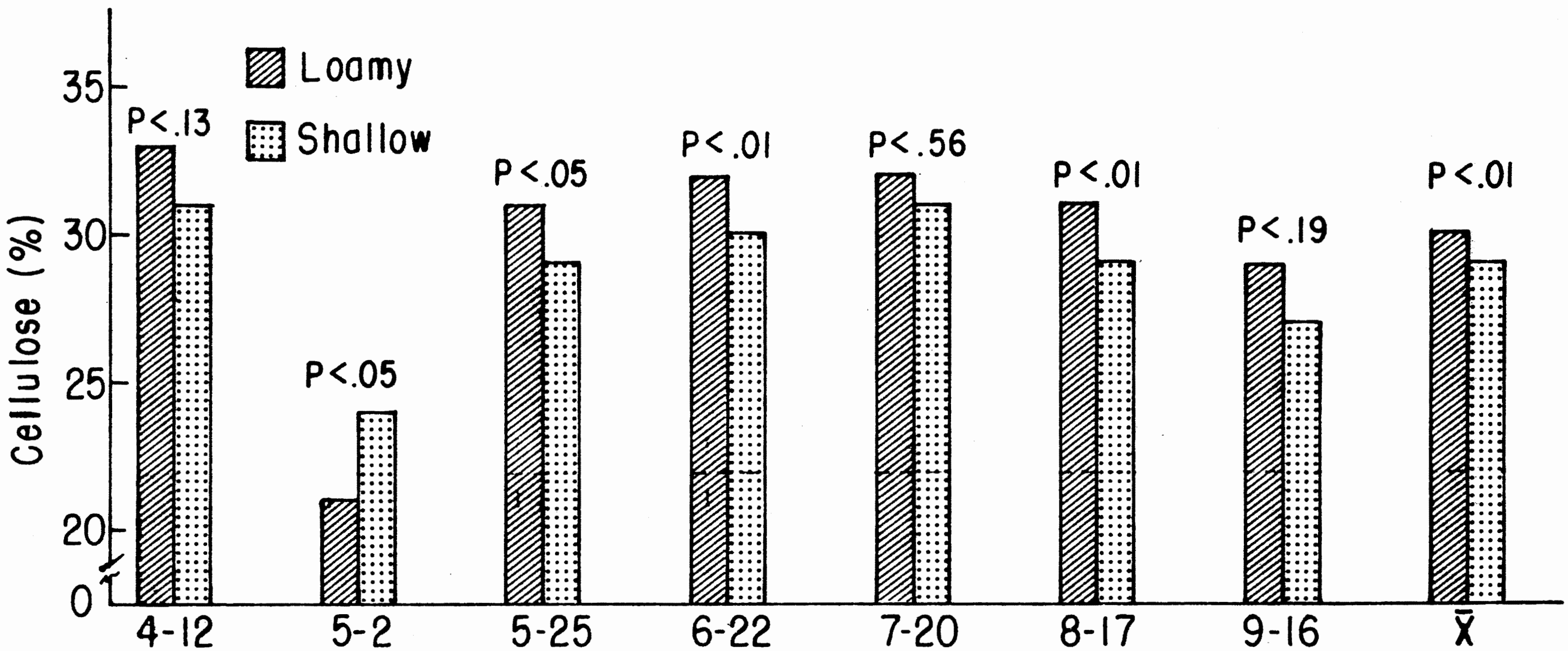

Fig. 5. Cellulose (%) of live herbage on loamy and shallow prairie range sites.

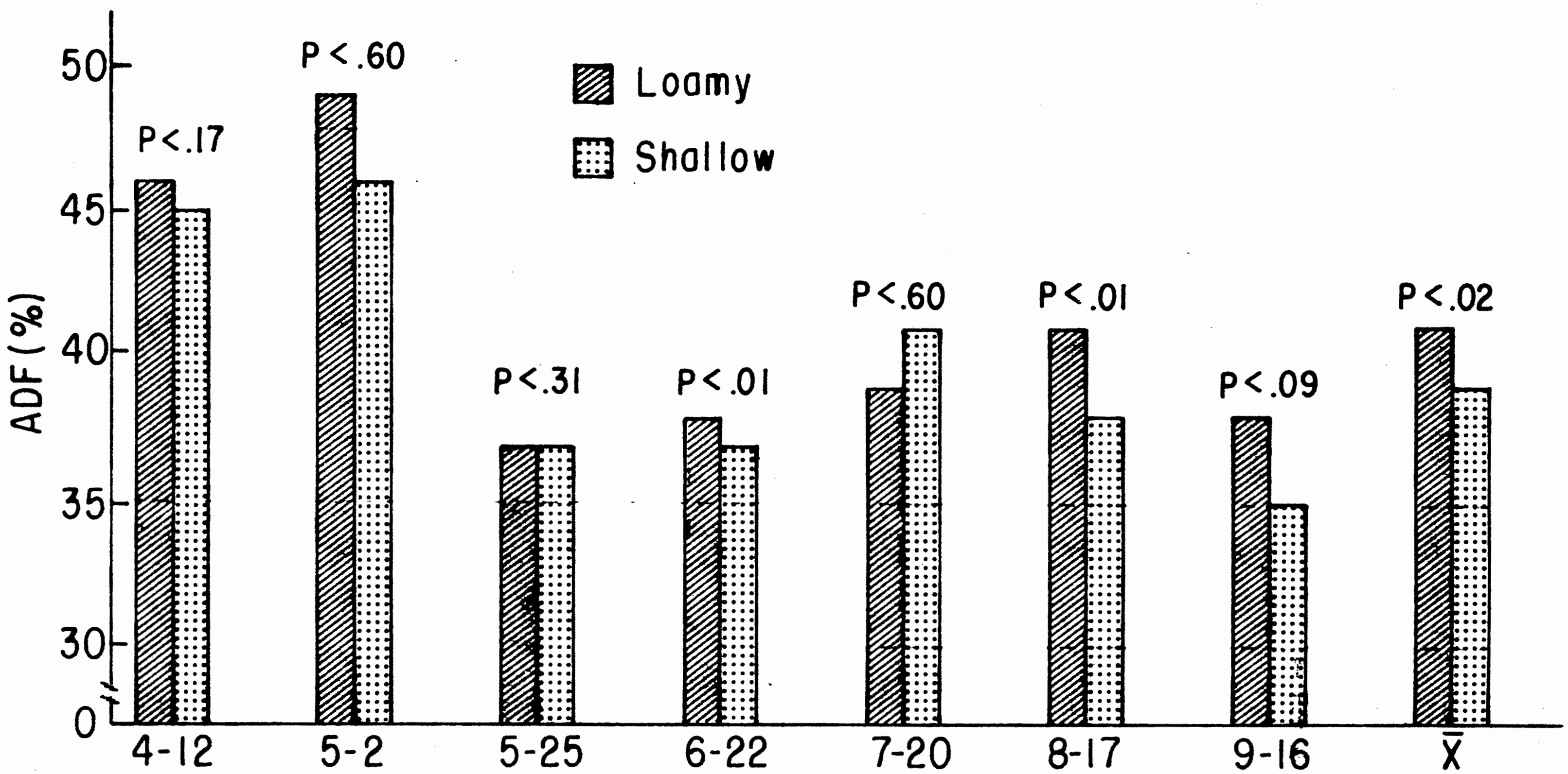

Fig. 6. ADF (%) of live herbage on loamy and shallow prairie range sites.

ences in ADF content of dead biomass due to range site were significant ($P < .10$) only in June and September (Table 4). Specific mean values (± SE) for ADF, cellulose and lignin, in live and dead biomass and NBDMD on both sites are shown in Appendices C and D.

NBDMD

NBDMD was consistently greater in live herbage from shallow sites although probability levels ranged from 1% in August to 25% in July (Fig. 7). This could be because of the growth of the tallgrass species on the loamy prairie sites. Cook (1959) reported an average percent utilization was significantly greater on unfavorable sites (81%) compared to favorable sites (43%). Differences in NBDMD of dead biomass on different range sites were small and significant at the 10% or less level only in October and March. Dry matter digestibility was highly correlated ($r = -0.80$) with ADF ($P < .01$) on loamy prairie sites and declined 1.73% for each 1% increase in ADF.

Conclusions

Soil water content influenced the nutrient content of range forage plants under various site conditions. Changes in ADF content in live herbage, generally reflected the change in species composition and different stages of maturity of the species. Dry matter digestibility was lower than generally reported in the literature, possibly because of the advanced stage of growth of tallgrasses and the fact herbage was clipped at ground level. Range sites and the species composition on different sites significantly influence levels of fiber components and NBDMD.

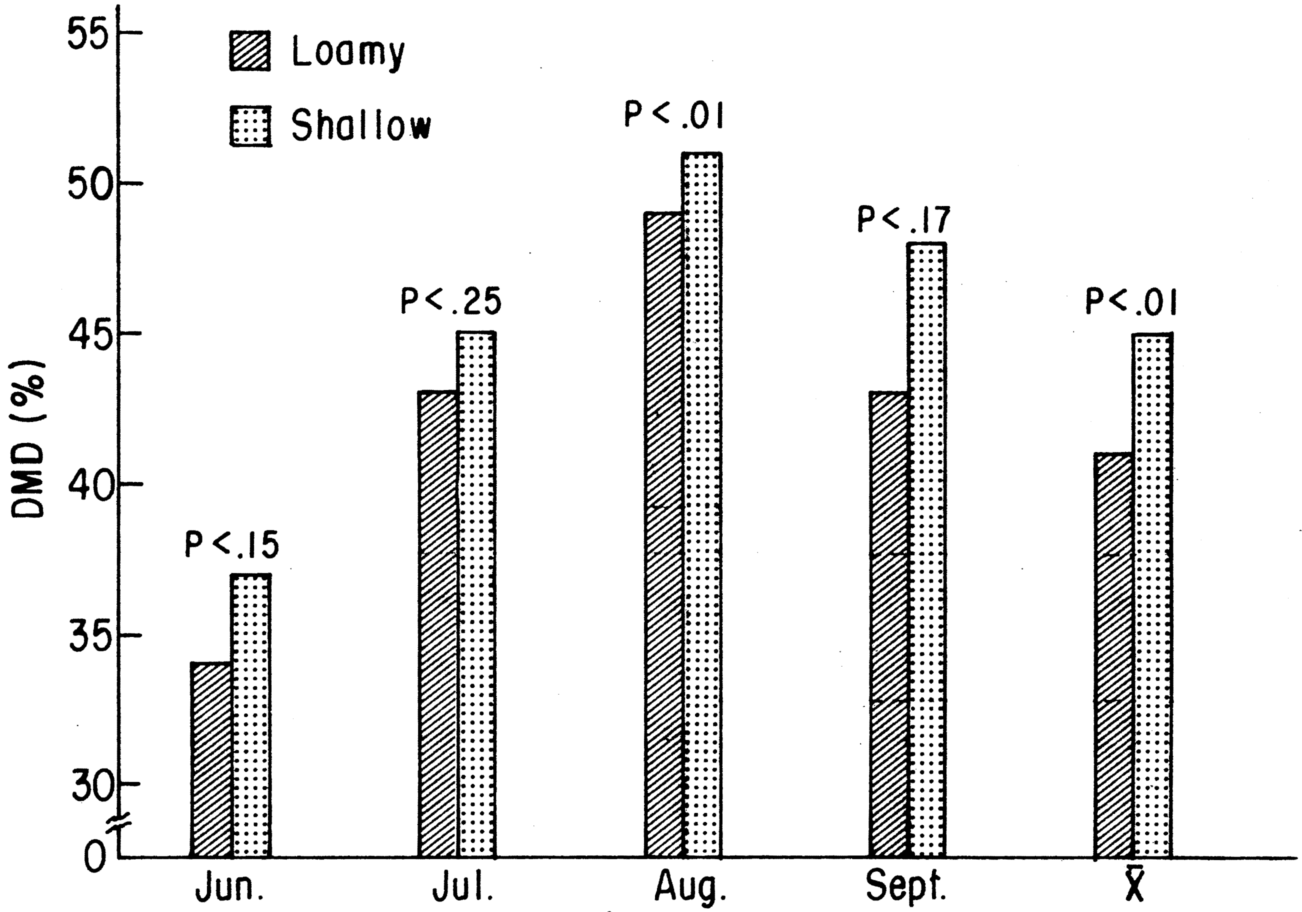

Fig. 7. NBDMD (%) of live herbage on loamy and shallow prairie range sites.

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CHAPTER V

TALLGRASS PRAIRIE VEGETATION ON A RANGELAND WATERSHED: THE EFFECT OF RANGE SITES AND PLANT SPECIES COMPOSITION ON PLANT CHEMICAL COMPONENTS DURING DROUGHT CONDITIONS

Abstract

The effects of range sites and plant species composition on plant chemical composition were studied on a tallgrass prairie watershed in north central Oklahoma. Plant species composition affected ($P < .10$) N, K and P contents of live herbage. Chemical composition of the live and dead biomass was significantly influenced by range site differences. Chemical components of N, P and K in live herbage decreased from a high in early spring to a low in summer at a rate that closely paralleled the decrease in soil water content.

Introduction

Stage of maturity seems to be the most important factor affecting plant chemical composition (Oelberg 1956). A decrease in soil water content indirectly affects the resultant changes in plant chemical composition (Laycock and Price 1970). Cook and Harris (1950) indicated environmental factors and soil water content are more important in determining nutrient content of range forage plants, under various site conditions than the chemical content of the soil as determined by standard methods.

Plants on shallow soil were found to be higher in certain nutrients (Cook 1959) because of the more leafy characteristics. Stoddart (1941) however, found plants on deeper soils to have more ash and phosphorus than those on shallower soils. Site differences in soil nutrients or soil water content could be factors responsible for contradictory results.

Nitrogen generally has been the only fertilizer nutrient to affect the quality of grass herbage in the plains and mountains of the United States (Cook 1965). However, the relationship between soil fertility and plant chemical composition has not been established for all soils and species, and the effect of nutrient status of the soil can be altered by other factors.

Plant species composition also affects chemical composition of the herbage on a site. Actively growing forbs, especially legumes, are consistently higher in calcium than grasses (Oelberg 1956). Browse species generally are more deep rooted and tend to store nutrients in stems rather than in roots and maintain their nutrient value during periods of drought and winter (Stoddart et al. 1975). Browse species in New Mexico contained more than three times as much Ca and 61% more P than grasses in the fall (Watkins 1937). Watkins (1943) reported decreases of Ca up to 23%, over the growing season, in range grasses in New Mexico. Pritchard et al. (1964) found decreases in Ca content when analyzing the plant biomass above ground.

The purpose of this study was to determine the effects of range site and plant species composition on plant chemical composition of tall-grass prairie vegetation.

Methods and Materials

Forage Collection

Twenty-nine permanent locations were arbitrarily selected for monthly vegetation sampling. The number and distribution of locations provided a range in site conditions for regression analyses and replications on the major soil types in proportion to their percentage of occurrence throughout the watershed. Fourteen of the locations were on loamy sites and 15 were on shallow sites.

Species composition and forage production were determined at each location using three estimated samples. Vegetation at one of the three sampling points was clipped at each location. Clipping was at ground level to determine total growth. All estimates and clippings were from 0.5 m^2 circular quadrats.

Laboratory Analyses

Clipped vegetation samples were hand separated into live and standing dead biomass during the growing season, air-dried and ground through a 2 mm screen in a Wiley mill. Samples were analyzed for nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca). Nitrogen was determined by the micro-Kjeldahl procedure using 0.5 gm samples. Phosphorus, K and Ca were analyzed by procedures adapted by the Soil and Water Testing Laboratory at Oklahoma State University.

Data Compilation and Statistical Analyses

Measurements of species, herbage weights, and laboratory data were recorded directly on data forms prepared to facilitate key-punching data cards directly from data forms. Examples of the data forms, input programs and procedures are printed in Appendices I, J, K, L, N, O, Q, S and T. Data were stored and processed by the Oklahoma State University IBM 370/158 computer. Statistical analyses were performed using the procedures of the Statistical Analysis System, SA572, (Barr and Goodnight 1972). Regression and analysis of variance tables are shown in the Appendices O, Q, S and T. All differences discussed were significant at the ($P < .05$) level unless otherwise specified.

Results and Discussion

Seasonal Differences

Nitrogen

The N content in live herbage declined ($P < .01$) from 2.38% in April to 1.27% in August (Fig. 1). Nitrogen tends to decrease with advancing maturity; however, the rapid decline indicates some drought stress on the live herbage and the early maturing of certain plant species. The increase ($P < .01$) in N content from 1.27% in August to 1.39% in September appeared to be in response to regrowth and an increased number of late summer forbs. Nitrogen content of live herbage was significantly ($P < .10$) affected by plant species composition in April, June and September. July and August N content of live herbage was significantly influenced by plant species composition at the

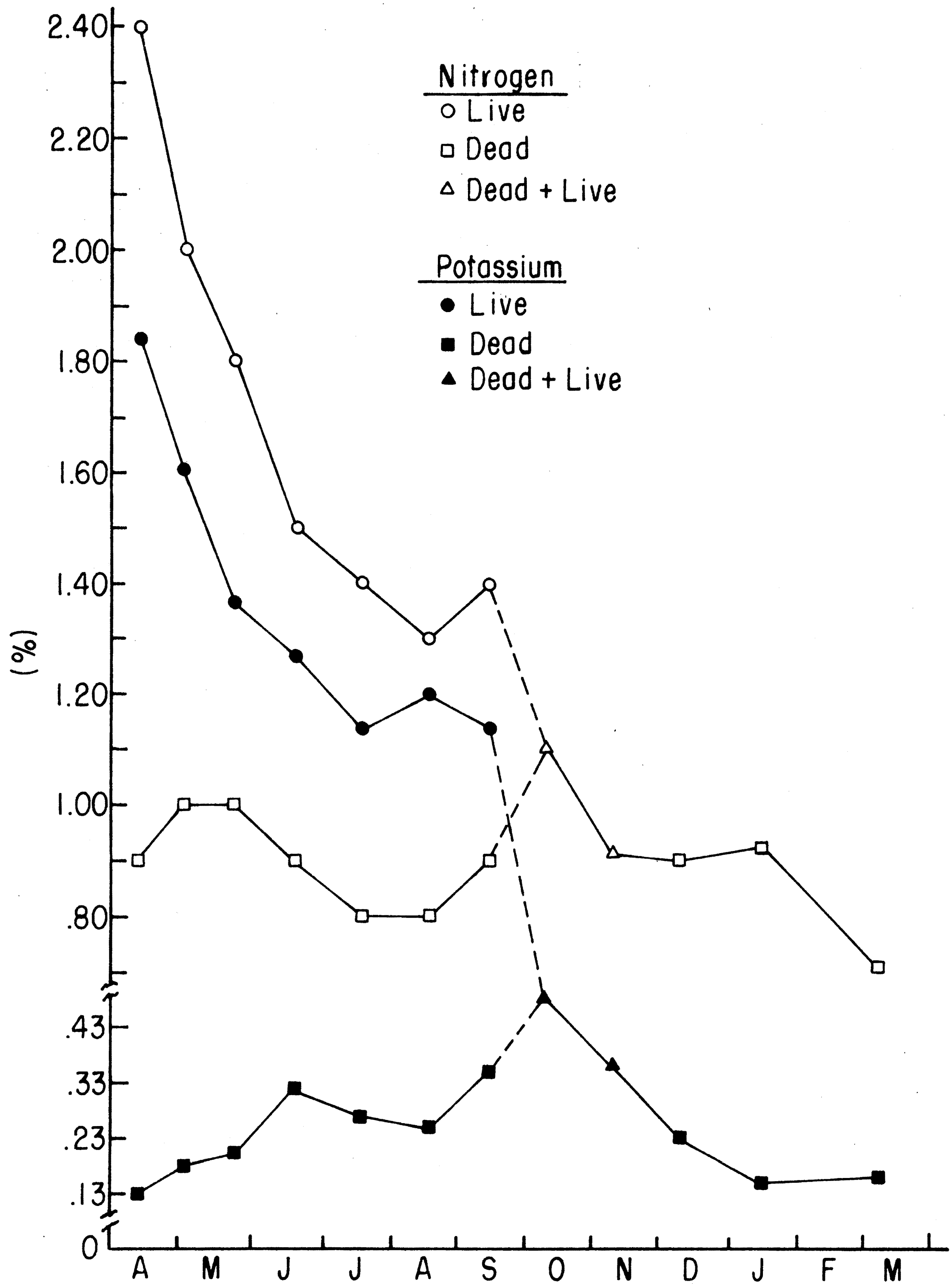

Fig. 1. Nitrogen and potassium contents (%) in plant biomass from April, 1976 through March, 1977.

($P < .05$, $P < .01$) levels, respectively.

Nitrogen content of dead biomass peaked in June at 1% before following the same trend as N content in live herbage (Fig. 14). The higher N content in June dead biomass was probably due to the death of the cool season annual grasses and forbs. Differences in N content of dead biomass between many sampling periods were significant ($P < .01$).

Potassium

Changes in K content of live herbage paralleled those of N content (Fig. 1). The average K content of live herbage was much greater than other chemical components during the same periods. Potassium is readily transported from older leaves to younger leaves to aid in growth (Barrow 1967). This indicates the high degree of mobility of potassium. When K is not active in live biomass, it is easily leached from dead biomass (White 1973). Potassium content of live herbage declined rapidly from a high of 1.84% in April to 1.14% in September (Appendix E). The higher values for K content in October and November standing dead biomass were due to the live herbage in these samples. Potassium contents of both live and dead biomass were significantly ($P < .01$) different between sampling dates.

Calcium

Unfavorable climatic conditions can cause changes in mineral contents of forages (Patil and Jones 1970). Calcium content in live herbage was more erratic than other nutrients in live herbage (Fig. 2). Calcium content did not follow the seasonal patterns of the other nutrients. At this time there is no apparent reason why Ca content fluc-

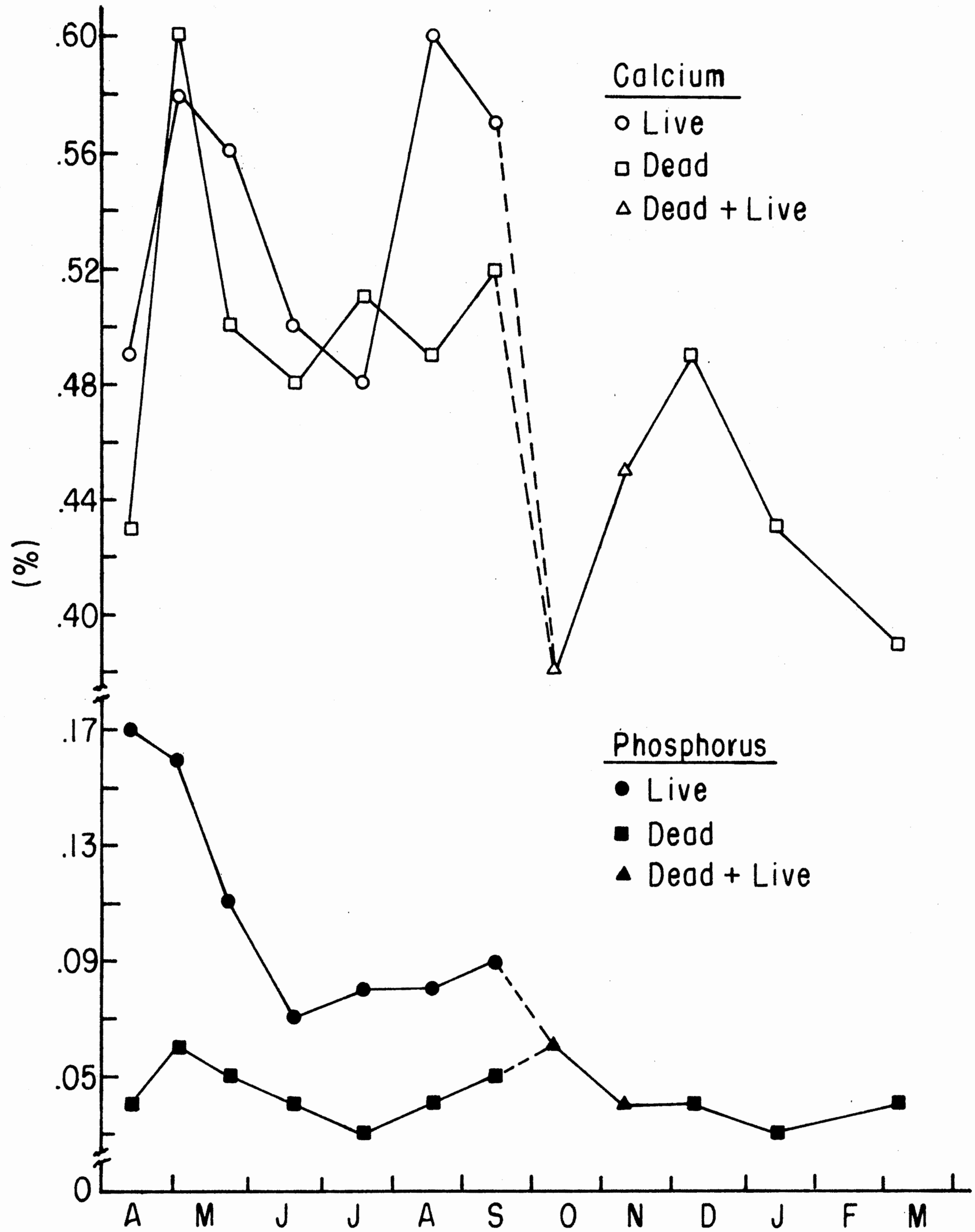

Fig. 2. Calcium and phosphorus contents (%) in plant biomass from April, 1976 through March, 1977.

tuated greatly. Savage and Heller (1947) observed little influence of leaching on Ca content of grasses in Oklahoma. Precipitation during the year was below the long-term average. The increase in Ca content of 0.49% in April to 0.58% in May appeared to be related to increased ($P < .01$) maturity of the cool-season grasses and a greater percentage of spring forbs, many of which were legumes. The highest Ca content (0.60%) appeared to be due to the peak production and a higher percentage of midgrasses, shortgrasses and late summer forbs.

Calcium content of the dead biomass was also quite variable, following a pattern similar to that of live herbage (Fig. 2). Calcium content in dead biomass was lowest (0.43%) in April and highest (0.60%) in early May.

Phosphorus

Changes in P content of both the live and dead biomass were similar to changes in N content (Fig. 2). Phosphorus content normally parallels that of N in regard to stage of maturity. However, the lowest P content in live herbage occurred in June at peak production rather than at the end of the growing season. This indicates the importance of soil water stress, early maturity and species composition on P content in rangeland vegetation. Phosphorus losses of from 49 to 83% during the growing season, were found in range grasses in New Mexico (Watkins 1943).

Phosphorus content of the dead biomass had lower values than other chemical components. Dead biomass had the narrowest range of values from a high of 0.06% in May to a low of 0.03% in July. The relative values of P content in dead biomass for different sampling periods tended to lag one month later than those in live biomass.

Range Site Differences

Live Biomass

The average N content in live biomass during the growing season on shallow sites (1.74%) was 0.15% greater ($P < .05$) than that (1.59%) on loamy sites (Table 1). The greater N content in live biomass on shallow sites was consistent for every sampling period except April. In general differences due to range sites were greater as the season progressed. In late summer tallgrasses and little bluestem were relatively more abundant on loamy sites and shortgrasses and late summer forbs were relatively more abundant on shallow sites.

The average P content in live biomass during the growing season on shallow sites (0.11%) was 0.01% greater ($P < .10$) than that (0.10%) on loamy sites (Table 1). The greater P content in live biomass on shallow sites was consistent in the summer and fall. The differences were increased as the season progressed. The differences in P content between loamy and shallow sites were significant ($P < .05$) during August and September.

The average K content in live biomass during the growing season on shallow sites (1.38%) was 0.03% greater than that (1.35%) on loamy sites, but significant at only the ($P < .55$) level (Table 1). The K content was generally greater on loamy sites in the spring and significantly ($P < .05$) higher in April. Throughout the summer and fall months the K content was consistently higher on shallow sites.

The average Ca content in live biomass during the growing season on shallow sites (0.58%) was 0.08% greater ($P < .01$) than that (0.50%) on loamy sites (Table 1). The Ca content was higher on shallow sites

Table 1. Chemical composition (%) of live herbage on loamy and shallow prairie range sites. (N = 29 for each sampling period).

	Nitrogen			Phosphorus			Potassium			Calcium		
Date	Loamy	Shallow	Diff.[1]	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.
4-12	2.46	2.31	0.15*	0.18	0.17	0.01	2.00	1.69	0.31**	0.51	0.48	0.03
5-2	1.91	2.06	0.15	0.15	0.16	0.01	1.67	1.53	0.14	0.55	0.61	0.06
5-25	1.70	1.89	0.19	0.11	0.11	0.0	1.33	1.38	0.05	0.50	0.62	0.12***
6-22	1.47	1.51	0.04	0.06	0.08	0.02*	1.20	1.33	0.13	0.13	0.52	0.04
7-20	1.21	1.49	0.28**	0.07	0.08	0.01	1.03	1.25	0.22	0.47	0.48	0.01
8-17	1.10	1.42	0.32*	0.07	0.10	0.03**	1.12	1.28	0.16	0.49	0.70	0.39*
9-16	1.27	1.50	0.23	0.08	0.10	0.02**	1.07	1.20	0.13	0.51	0.63	0.12
Mean	1.59	1.74	0.15**	0.10	0.11	0.01*	1.35	1.38	0.03	0.50	0.58	0.08***

[1]Level of significance (*P < .10; **P < .05; ***P < .01).

every month except April. The differences in magnitude between sites was erratic throughout the season with differences in Ca content in June significant at the ($P < .01$) level.

Standing Dead Biomass

The average N content in standing dead biomass throughout the year on shallow sites (0.97%) was 0.14% greater ($P < .01$) than that (0.83%) on loamy sites (Table 2). The N content in standing dead biomass on shallow sites was consistently higher throughout the year. Nitrogen content in standing dead biomass on loamy sites exhibited peaks in late spring and fall, with lows in July and March. Nitrogen content in standing dead biomass on shallow sites was erratic throughout the year with a peak occurring in October.

The average P content in standing dead biomass throughout the year on shallow sites (0.05%) was 0.01% greater ($P < .01$) than that (0.04%) on loamy sites (Table 2). Between days on both loamy and shallow sites there was not a definite pattern established. Differences in P content on loamy and shallow sites were significant ($P < .05$) on several days.

The average K content in standing dead biomass throughout the year on shallow sites (0.29%) was 0.07% greater ($P < .01$) than that (0.22%) on loamy sites (Table 2). Potassium content in standing dead biomass followed concurrent seasonal trends on loamy and shallow sites, each reaching peaks in June and October and declining to lows in August and March. The K content in standing dead biomass was consistently higher on shallow sites.

The average Ca content in standing dead biomass throughout the year on shallow sites (0.51%) was 0.07% greater ($P < .01$) than that

Table 2. Chemical composition (%) of dead biomass on loamy and shallow prairie range sites. (N = 29 for each sampling period).

Date	Nitrogen			Phosphorus			Potassium			Calcium		
	Loamy	Shallow	Diff.[1]	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.
4-12	0.72	0.99	0.27**	0.04	0.05	0.01*	0.10	0.16	0.06**	0.38	0.48	0.10*
5-2	0.89	1.02	0.13	0.05	0.07	0.02	0.15	0.21	0.06	0.53	0.67	0.14
5-25	1.02	0.99	0.03	0.05	0.05	0	0.20	0.20	0	0.45	0.54	0.09*
6-22	0.85	0.99	0.14*	0.03	0.05	0.02**	0.27	0.37	0.10**	0.44	0.52	0.08*
7-20	0.77	0.83	0.14	0.03	0.04	0.01	0.25	0.28	0.03	0.46	0.55	0.09**
8-17	0.78	0.90	0.12**	0.04	0.05	0.01**	0.23	0.26	0.03	0.46	0.52	0.06*
9-16	0.84	1.01	0.17*	0.04	0.05	0.01	0.33	0.37	0.04	0.47	0.57	0.10**
10-12	0.97	1.17	0.20**	0.05	0.07	0.02**	0.41	0.55	0.14*	0.36	0.40	0.04*
11-10	0.81	1.01	0.20	0.04	0.04	0	0.32	0.39	0.07	0.43	0.46	0.03
12-10	0.83	0.97	0.14	0.03	0.04	0.01*	0.21	0.25	0.04	0.49	0.49	0
1-29	0.86	1.01	0.15*	0.03	0.04	0.01**	0.12	0.19	0.07	0.42	0.45	0.03
3-10	0.65	0.78	0.13	0.03	0.05	0.02	0.10	0.22	0.12	0.36	0.42	0.06
Mean	0.83	0.97	0.14***	0.04	0.05	0.01***	0.22	0.29	0.07***	0.44	0.51	0.07***

[1]Level of significance (*P < .10; **P < .05; ***P < .01).

(0.44%) on loamy sites (Table 2). Calcium content in standing dead biomass was consistently and significantly ($P < .10$) higher on shallow sites during the growing season. Although there were no significant differences in Ca content in standing dead biomass during the winter months, Ca content was slightly higher on shallow sites.

Effects of Plant Species Composition

Nitrogen

The average N content in live biomass was significantly ($P < .10$) affected by plant species composition in April, June and September (Fig. 1). July and August N content in live biomass was significantly influenced by plant species composition at the ($P < .05$, $P < .01$) levels, respectively. Nitrogen content was highest in April (Table 4) when there was a relative abundance of forb species. As the growing season progressed there was an increase in percentage of midgrasses with a decrease in cool season grasses and spring forbs. There was a gradual decline of N content in live biomass through August when it reaches 1.27%. In September there was an increase of N content in live biomass due to the decline in the percentage tallgrasses plus little bluestem and an increase of late summer forbs plus shrubs. The R-squared value of 91% in August indicates that most of the variation in N content due to species composition was due to the plant species indicated.

Phosphorus

The average P content in live biomass was highest in April (0.17%) and declined to (0.07%) in June before becoming more constant (Table 5). The regression equations used were all significant ($P < .05$) except for

Table 3. Regression equations and species classes for herbage nitrogen content (%) by day (N = 29 for each sampling period).

MONTH-DAY	bo	b_1X_1	b_2X_2	b_3X_3	b_4X_4	b_5X_5	b_6X_6	R^2 [1/]	P [2/]	$\bar{Y}$±S.D. [3/]
4-12	0.022	- 0.047* [4/] MIDG [7/]	+ 0.020* SPFB	+ 0.031* LSUFS	+ 0.107* $MIDG^2$	+ 0.038* $LSUFS^2$		40	0.03	2.38 ± .21
5-2	0.021	- 0.073* MIDG	+ 0.019* SPFB	- 0.019† [5/] LSUFS	+ 0.192* $MIDG^2$	+ 0.034* $ESUF^2$		63	0.01	1.99 ± .28
5-25	0.012	+ 0.008* MIDG	+ 0.018* SPFB	+ 0.012* ESUF	+ 0.013∇ [6/] CSG^2			58	0.01	1.80 ± .26
6-22	0.007	+ 0.022* MIDG	+ 0.047* CSG	+ 0.025* SPFB	+ 0.010* ESUF	- 0.197* CSG^2	- 0.038* $SPFB^2$	54	0.01	1.49 ± .22
7-20	0.020	- 0.025* TSCSC	+ 0.011* MISCG	- 1.360* $SPFB^2$	+ 0.019* $TSCSC^2$			75	0.01	1.35 ± .19
8-17	0.008	+ 0.010* MISCG	+ 0.027* $MIDG^2$	+ 0.869* CSG^2	+ 0.028* $LSUFS^2$			91	0.01	1.27 ± .15
9-16	0.017	- 0.042* MIDG	+ 0.151* CSG	- 0.005* TSCSC	+ 0.104* $MIDG^2$	- 1.351* CSG^2	+ 0.014* $LSUFS^2$	63	0.01	1.39 ± .28

[1] Coefficient of determination.

[2] Probability level for regression equation.

[3] Means ± S.D. for herbage nitrogen content (%).

4/ * -(P < .1).

5/ † -(.1 < P < .2).

6/ ∇ -(P > .2).

7/ MIDG = Midgrasses; CSG = Cool Season Grasses; SPFB = Spring Forbs; ESUF = Early Summer Forbs; LSUFS = Late Summer Forbs Plus Shrubs; TSCSC = Tallgrasses Plus <u>Schizachyrium</u> <u>scoparium</u>; MISCG = Miscellaneous Grasses.

Table 4. Regression equations and species classes for herbage phosphorus content (%) by day (N = 29 for each sampling period).

MONTH-DAY	bo	b_1X_2	b_2X_2	b_3X_3	b_4X_4	b_5X_5	R^2 [1]	P [2]	$\bar{Y}$ ± S.D. [3]
4-12	0.002	- 0.005*[4] MIDG[6]	+ 0.007* $MIDG^2$	+ 0.002* $TSCSC^2$			68	0.01	0.17 ± .01
5-2	0.002	- 0.003† SPFB	- 0.006†[5] LSUFS	+ 0.010* $SPFB^2$	+ 0.034† $LSUFS^2$		19	0.25	0.16 ± .03
5-25	0.001	- 0.001* CSG	- 0.001* ESUF	- 0.004* TSCSC	+ 0.005* CSG^2		69	0.01	0.11 ± .01
6-22	0.001	+ 0.007* CSG^2	+ 0.002* $SPFB^2$	+ 0.003* $MISCG^2$			75	0.01	0.07 ± .01
7-20	0.001	- 0.004† SPFB	- 0.001* TSCSC	+ 0.013* CSG^2	+ 0.002* $LSUFS^2$	+ 0.002* $TSCSC^2$	62	0.01	0.08 ± .02
8-17	0.001	+ 0.003* $MIDG^2$	+ 0.002* $LSUFS^2$	+ 0.001* $MISCG^2$			64	0.01	0.08 ± .02
9-16	0.001	- 0.003† MIDG	+ 0.010* CSG	- 0.001* TSCSC	+ 0.006* $MIDG^2$	- 0.099* CSG^2	42	0.02	0.09 ± .02

[1] Coefficient of determination.

[2] Probability level for regression equation.

[3] Means ± S.D. for herbage phosphorus content (%).

[4] *-(P < .1).

[5] †-(.1 < P < .2).

[6] MIDG = Midgrasses; CSG = Cool Season Grasses; SPFB = Spring Forbs; ESUF = Early Summer Forbs; LSUFS = Late Summer Forbs Plus Shrubs; TSCSC = Tallgrasses Plus _Schizachyrium scoparium_; MISCG = Miscellaneous Grasses.

the month of May. In May the R-square value indicating the relative significance of the equation showing which species classes were involved was only 19%. The P content in live biomass followed a trend of increasing when grasses were in abundance and decreasing slightly when forbs and shrubs were predominant.

Potassium

The average K content in live biomass was significantly ($P < .01$) affected by plant species composition in April, May, June and July. In August and September plant species composition affected K content in live biomass at the ($P < .05$) level of significance (Fig. 1). Potassium content was at a high in April (1.84%) and declined throughout the growing season to a low of 1.14% in September (Table 6). All regression equations were significant at the ($P < .05$) level. As the forb species declined in abundance from early spring through the summer there was a decline in K content and at the same time an increase in the percentage of grass species.

Calcium

The average Ca content in live biomass was significantly ($P < .05$) affected, except for April, across days by plant species composition (Table 7). The mean values of Ca content in live biomass was erratic throughout the growing season. The R-squared values were not very high in most of the equations used. Throughout the growing season there was an indication that forbs and shrubs were the dominant species involved.

Table 5. Regression equations and species classes for herbage potassium content (%) by day (N = 29 for each sampling period).

DAY MONTH	bo	b_1X_1	b_2X_2	b_3X_3	b_4X_4	b_5X_5	R^2 [1]	P [2]	$\bar{Y}$ ± S.D. [3]
4-12	0.021	- 0.126*[4] ESUF	+ 0.016* TSCSC	- 0.019* MISCG	+ 0.856* $ESUF^2$		75	0.01	1.84 ± .22
5-2	0.010	+ 0.025* SPFB	+ 0.018* CSG^2	+ 0.014* $TSCSC^2$			43	0.01	1.60 ± .30
5-25	0.013	- 0.012†[5] CSG	+ 0.012† SPFB	+ 0.038* CSG^2	- 0.021∇[6] $SPFB^2$		32	0.04	1.36 ± .17
6-22	0.011	+ 0.085* CSG^2	+ 0.019* $SPFB^2$	+ 0.026* $MISCG^2$			75	0.01	1.27 ± .14
7-20	0.013	- 0.022* TSCSC	+ 0.174* CSG^2	+ 0.029* $LSUFS^2$	+ 0.024* $TSCSC^2$		75	0.01	1.14 ± .22
8-17	0.011	- 0.016* MIDG[7]	+ 0.015* SPFB	+ 0.049* $MIDG^2$	+ 0.023* $LSUFS^2$		92	0.01	1.20 ± .08
9-16	0.011	- 0.032* MIDG	+ 0.127* CSG	+ 0.086* $MIDG^2$	- 0.952* CSG^2	+ 0.015* $LSUFS^2$	61	0.01	1.14 ± .22

[1] Coefficient of determination.

[2] Probability level for regression equation.

[3] Means ± S.D. for herbage potassium content (%).

[4] * -($P < .1$).

[5] † -($.1 < P < .2$).

[6] ∇ -($P > .2$).

[7] MIDG = Midgrasses; CSG = Cool Season Grasses; SPFB = Spring Forbs; ESUF = Early Summer Forbs; LSUFS = Late Summer Forbs Plus Shrubs; TSCSC = Tallgrasses Plus _Schizachyrium scoparium_; MISCG = Miscellaneous Grasses.

Table 6. Regression equations and species classes for herbage calcium content (%) by day (N = 29 for each sampling period).

MONTH-DAY	bo	b_1X_1	b_2X_2	b_3X_3	b_4X_4	R^2 [1/]	P [2/]	$\bar{Y} \pm$ S.D. [3/]
4-12	0.002	+ 0.029* [4/] SPFB [6/]	+ 0.004* LSUFS	- 0.079† [5/] $SPFB^2$		18	0.16	0.49 ± .10
5-2	0.003	+ 0.007* ESUF	+ 0.036† LSUFS	+ 0.022* $SPFB^2$	- 0.183† $LSUFS^2$	46	0.01	0.58 ± .15
5-25	0.008	- 0.004* CSG	- 0.005* TSCSC	- 0.010* $MIDG^2$		53	0.01	0.56 ± .10
6-22	0.007	- 0.006* MISCG	- 0.009* $SPFB^2$	- 0.007* $TSCSC^2$		47	0.01	0.50 ± .11
7-20	0.006	+ 0.102* SPFB	- 0.003* TSCSC	- 2.970* $SPFB^2$		31	0.02	0.48 ± .13
8-17	0.003	+ 0.024* ESUF	+ 0.528* CSG^2	- 0.042* $ESUF^2$	+ 0.026* $LSUFS^2$	82	0.01	0.60 ± .16
9-16	0.010	- 0.010* MIDG	- 0.006* TSCSC	- 0.015* $MISCG^2$		32	0.02	0.55 ± .22

[1] Coefficient of determination.

[2] Probability level for regression equation.

[3] Means ± S.D. for herbage calcium content (%).

4/ * -(P < .1).

5/ † -(.1 < P < .2).

6/ MIDG = Midgrasses; CSG = Cool Season Grasses; SPFB = Spring Forbs; ESUF = Early Summer Forbs; LSUFS = Late Summer Forbs Plus Shrubs; TSCSC = Tallgrasses Plus *Schizachyrium scoparium*; MISCG = Miscellaneous Grasses.

Conclusions

Nitrogen content declined rapidly with increased maturity of plant species; however, the rapid rate of decrease is indicative of drought stress on live plants and the early maturing of certain species. Phosphorus content paralleled N content in both live and dead biomass. Potassium content indicated a high degree of mobility in live herbage. Calcium content was very erratic in both live and dead biomass. There is no apparent explanation at this time. Range site differences and plant species composition affected plant chemical composition of both the live and dead biomass significantly.

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CHAPTER VI

TALLGRASS PRAIRIE VEGETATION ON A RANGELAND WATERSHED: DUNG CHEMICAL COMPOSITION AND RATE OF DEGRADATION ON RANGELAND DURING DROUGHT CONDITIONS

Abstract

Dung (0-240 days), all-age dung and ground litter biomass on a tallgrass prairie watershed grazed by cattle in Central Oklahoma were analyzed for fiber, nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) contents. There were significant differences between days for all fiber components of dung (0-240 days). Differences in all-age dung N content from June through September were relatively large. Changes in N content between sampling dates were erratic. Phosphorus content of all-age dung was higher between July and late January. Chemical composition of dung deposited in July, 1976 followed a similar trend as that in dung accumulated over several seasons on the watershed. Unlike the other nutrients K content of all-age dung was less than that of ground litter during the grazing season. Calcium content of all-age dung and ground litter biomass followed similar trends, declining from early spring to July and increasing in August. Generally, ground litter content of N, P, K and Ca was lower than that of dung and was relatively stable in all instances.

Introduction

Dung is complex material composed of water, undigested forage residues, endogeneous animal products and a large and varied population of microorganisms and products of their metabolism (Marsh and Compling 1970). Dung dry matter contains about 0.8% K, 0.36% Na, 2.4% Ca, 0.7% P and 0.8% Mg, representing 12, 33, 78, 66 and 80% of the dietary intakes of these elements, respectively (Hutton et al. 1967).

There are many factors involved in degradation of dung and interrelationships with various other components. The process of dung degradation is complex beginning as soon as dung is deposited. Dung is primarily the result of microbial activity that leads to production of CO_2, NH_3, CH_3, H_2O, NO_3 and NO_2. This in turn is accompanied by synthesis of humic compounds of higher molecular weight (Marsh and Campling 1970).

The purpose of this study was to determine the chemical and fiber composition of all-age dung throughout the year and change in composition over time of recently deposited dung.

Methods and Materials

Dung Collection

Three replications of ungrazed conditions were established by constructing a 50 m x 100 m exclosure in late winter, 1975, at each of three different locations along the upper boundary of the watershed. Dung pats were removed from within each exclosure in early spring, 1976, to provide three dung-free areas. The dung was collected and weighed to establish an estimate of dung biomass per hectare.

Twenty-nine permanent locations were arbitrarily selected for monthly ground litter and dung sampling. The number and distribution of locations provided a range in site conditions for regression analyses and replications on the major soil types in proportion to their percentage of occurrence throughout the watershed.

Sampling areas consisted of an area 30 m in diameter around each permanent location marker. Each of 6 bearings in each third of the area radiated out from the center point and were used as sample transects. Dung samples were collected monthly in an area 2 m x 10 m along three bearings at each location. The total number of dung pats were counted along three bearings at each location. Ground litter biomass was estimated in each of three, 0.5 m^2 quadrats randomly located along dung sample transects. Ground litter was collected and weighed for one of the estimated samples using the weight-estimate method (Pechanec and Pickford 1937).

Dung Degradation

Fifty dung pats were located and marked on the day deposited, July 1, 1976. Twenty-five of the samples were marked in approximately a 4-hour period one morning with the remainder marked the next morning in approximately the same amount of time. Samples were located near five of the permanent locations used for collection of ground litter and all-age dung. The locating and marking of the dung occurred only one time during the study.

Six dung samples were collected on July 1, 1976 (Day 0). Six more samples were collected on day 30 with 5 samples being collected on days 60, 120, 180 and 240.

Laboratory Analyses

Dung and ground litter samples were air-dried and ground through a 2 mm screen in a Wiley mill. Samples were analyzed for acid-detergent fiber (ADF), lignin, cellulose, N, P, K and Ca. ADF and lignin were determined by the permanganate oxidation procedure of Van Soest and Wine (1968). Nitrogen was determined by the micro-Kjeldahl procedure. Phosphorus, K and Ca were analyzed by procedures adopted by the Soil and Water Testing Laboratory at Oklahoma State University.

Data Compilation and Statistical Analyses

Measurements of weather, soil factors, ground litter and dung weights, and laboratory data were recorded directly on data forms prepared to facilitate key-punching data cards directly from data forms. Examples of the data forms, input programs and procedures are printed in Appendices M, N, T and U. Data were stored and processed by the Oklahoma State University IBM 370/158 computer. Statistical analyses were performed using the procedures of the Statistical Analysis System, SA572, (Barr and Goodnight 1972). Data were analyzed using regression and analysis of variance procedures (Steel and Torrie 1960). All differences discussed were significant at the ($P < .05$) level unless otherwise specified.

Results and Discussion

Dung Removed From Exclosures

An average of 235 kg dung/ha was removed from the three exclosures in the spring, 1976. The dung removed was those pats readily found on or in the ground litter. An unknown amount of small, disintegrated pieces were undoubtedly overlooked. In 1976, the watershed had an average annual stocking rate of 70 animal-unit-days (AUD)/ha. If an average daily intake of 12.0 kg/AUD and an average DMD of 50% are assumed, the dung added each year would be about 420 kg/ha. A comparison of the weights of ground litter samples without dung and those samples with dung indicated an average of 460 kg dung/ha between April, 1976 and March, 1977. Based on these assumptions and results the amount of dung decomposed or naturally removed from the watershed appears to be approximately the same as the dung added each year.

In the spring and early summer it was observed that dung pats invaded by beetles were rapidly disintegrated within 2-3 months. Dung without beetle influence persisted over several seasons mainly because of crust formation. Weeda (1967) reported dung deposited in the fall disappeared more rapidly than dung deposited in the spring or early summer. Castle and MacDaid (1972) found dung deposited on N fertilized pastures disappeared significantly faster in July than that deposited in May.

Dung Degradation

Fiber Components of Dung

ADF and lignin content increased from 46.8% to 53.9% and 18.1% to 21.7% from day 0 to day 240, respectively (Table 1). With an increase in ADF through Day 120 and then a decrease through day 240 cellulose content decreased from 23.0% on day 0 to 18.0% on day 120 and then increased slightly to 19.4% by day 240. Differences in all-age dung for all fiber components did not exhibit any trends throughout the sampling

Table 1. Average (± SE) fiber components (%) of dung (0-240 days).

Day	Acid-Detergent Fiber (%)	Lignin (%)	Cellulose (%)
0[1/] N=6	46.8 ± .004	18.1 ± .005	23.0 ± .003
30 N=6	47.5 ± .004	17.3 ± .005	21.8 ± .008
60 N=5	50.7 ± .008	21.2 ± .011	20.8 ± .003
120 N=5	55.0 ± .024	19.0 ± .011	18.0 ± .013
180 N=5	54.4 ± .009	20.5 ± .006	18.7 ± .005
240 N=6	53.9 ± .007	21.7 ± .004	19.4 ± .004
$LSD_{.01}$	0.04	0.03	0.02

[1/] Day O = July 1, 1976.

period (Table 2).

Ground litter collected in April and August, 1976 was analyzed for ADF, lignin and cellulose content and no significant differences were found. Analyses of ground litter were then discontinued.

Chemical Composition of Dung and Ground Litter

Differences in all-age dung N content (Fig. 1) from June through September were relatively large and erratic. Cattle did not graze on the watershed during all of this period, so the explanation for these differences is not apparent at this time. The N content in all-age dung was relatively stable from November through March, averaging 1.75% (Fig. 1). Dung deposited in July, 1976 showed a slight increase from 1.91% in August to 2.15% in September in N content before declining to 1.65% in December. There is no apparent reason for the sharp increase in N content between December and late February. Gillard (1967) reported that most N in dung occurs in the form of undigested protein which is mineralized by bacteria and is lost by volatilization of NH_3. Ground litter over the year was very consistent in regard to N content (Fig. 1). Nitrogen content varied only 0.2% and was slightly lower in the winter months than the summer months.

Seasonal changes in all-age dung P content (Fig. 2) were less erratic than those for all-age dung N content (Fig. 1). Increased concentration during digestion (Bromfield and Jones 1970), relatively low mobility and free-choice intake of P mineral may have caused the higher and more consistent change in all-age dung P content between July and late January (Fig. 2). During this period P content increased from 0.21% to 0.27%. Bromfield (1961) reported dung P content to be highest in the

Table 2. Average (± SE) fiber components (%) of all-age dung.

Date	Acid-Detergent Fiber	Lignin	Cellulose
4-12	54.8 ± .004	25.1 ± .008	18.9 ± .002
5-2	54.9 ± .008	27.0 ± .007	19.4 ± .004
5-25	54.2 ± .003	24.0 ± .005	19.6 ± .008
6-22	57.0 ± .006	20.0 ± .004	19.5 ± .004
7-20	54.5 ± .004	19.1 ± .004	20.6 ± .003
8-17	54.7 ± .004	19.4 ± .005	23.2 ± .003
9-16	56.1 ± .004	24.0 ± .039	19.8 ± .004
10-12	56.7 ± .004	21.1 ± .003	18.7 ± .002
11-10	56.4 ± .006	20.7 ± .011	18.6 ± .004
12-10	53.5 ± .004	18.7 ± .003	19.2 ± .003
1-29	57.1 ± .026	22.9 ± .027	26.9 ± .063
3-10	54.8 ± .008	19.9 ± .013	19.7 ± .004

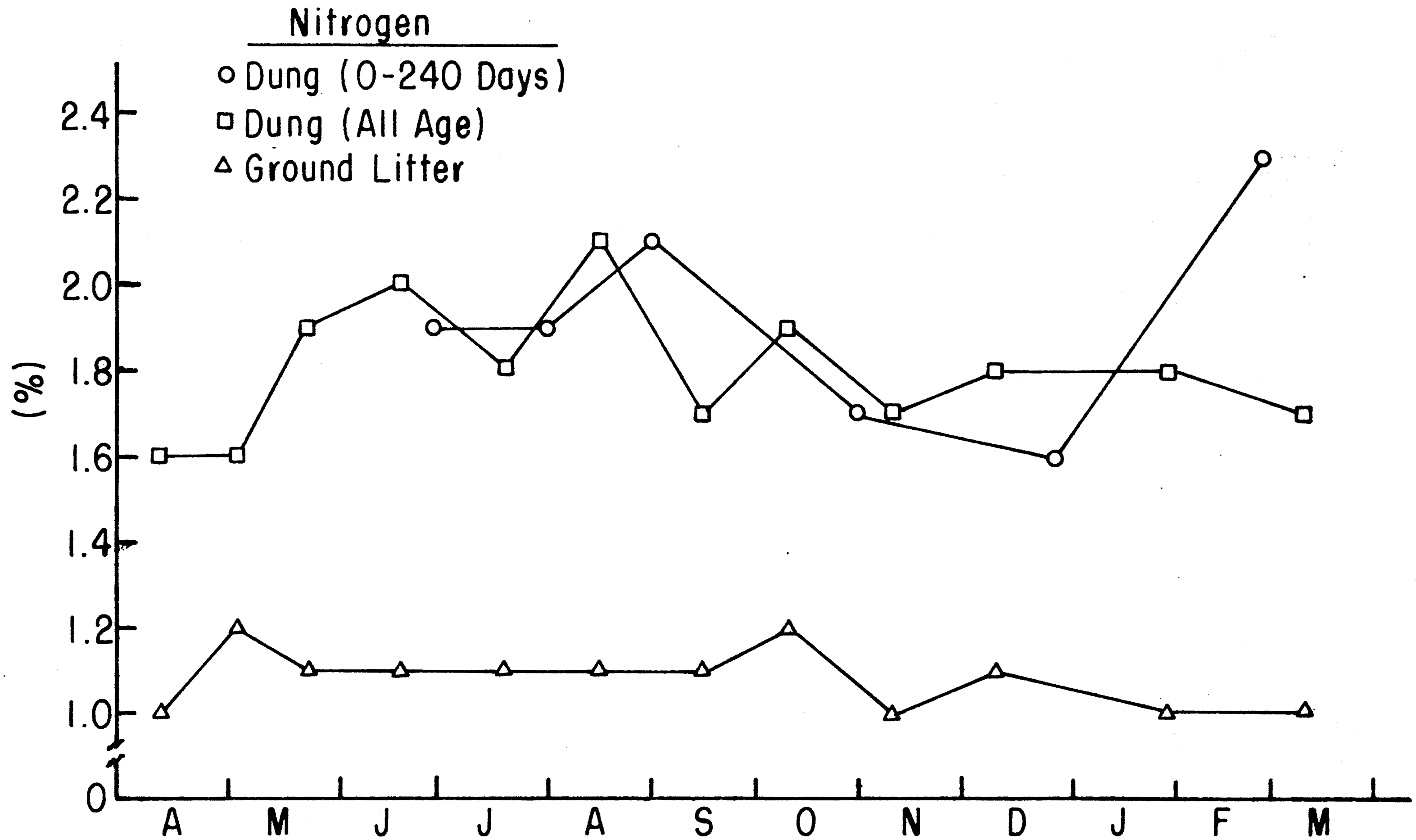

Fig. 1. Nitrogen content (%) of dung (0-240 days) from July, 1976 through March, 1977; dung (all-age) and ground litter from April, 1976 through March, 1977.

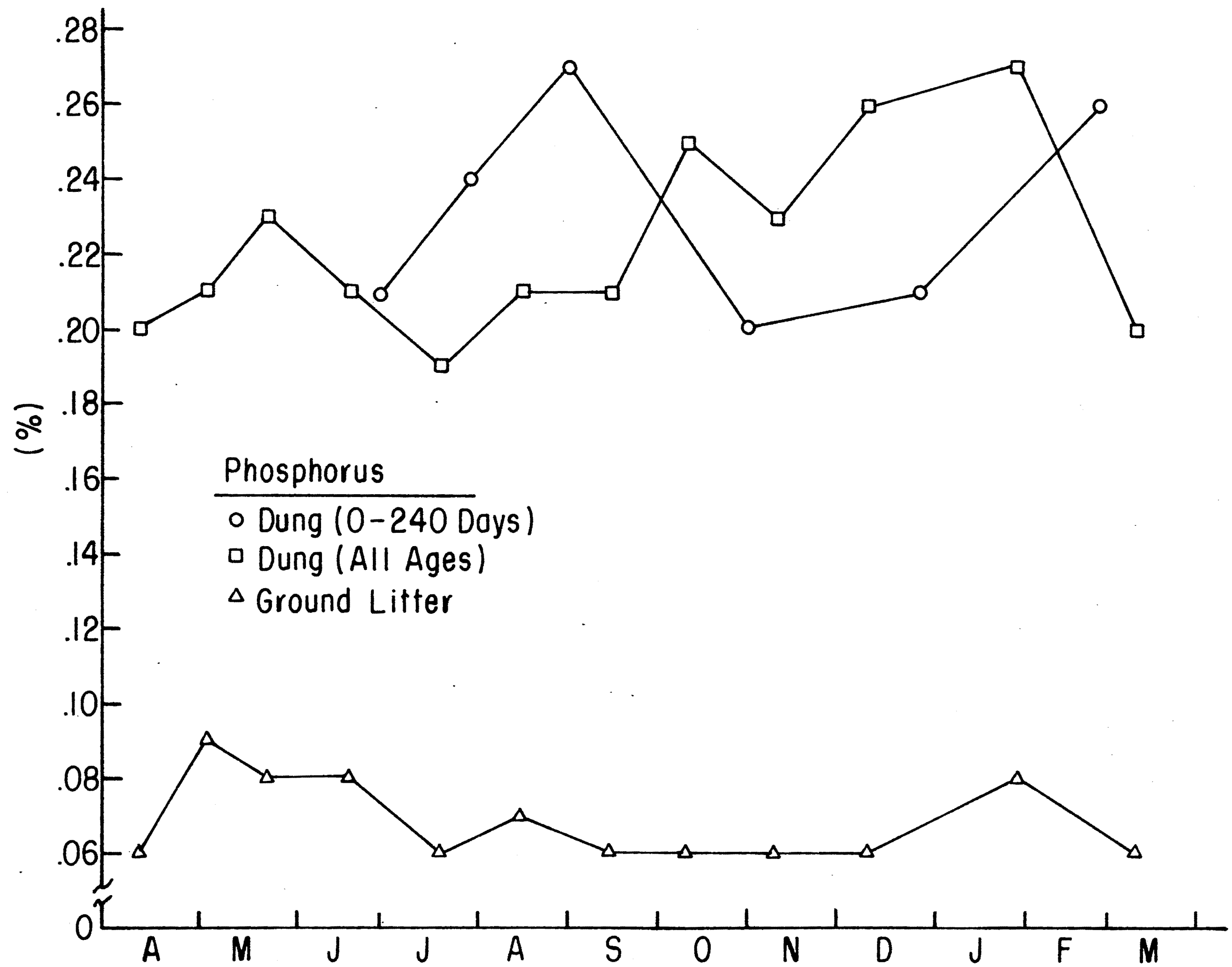

Fig. 2. Phosphorus content (%) of dung (0-240 days) from July, 1976 through March, 1977; dung (all-age) and ground litter from April, 1976 through March, 1977.

spring and autumn and lowest in midsummer and winter. Results from this study indicate all-age dung P content was highest in midwinter and lowest in midsummer with spring values in between those in midsummer and autumn (Fig. 2). Dung (0-240 days) P content increased from 0.21% on day 0 (July 1) to 0.27% in August before declining sharply to 0.20% in October. Between December and late February there was an increase from 0.22% to 0.26%.

Phosphorus content of ground litter peaked in early spring and January and was relatively uniform in the summer and autumn (Fig. 2). Peak values in P content of ground litter in early spring and January were 0.09% and 0.08%, respectively, with summer and autumn values averaging 0.065% (Table 3).

Unlike N, P and Ca, K content of all-age dung was generally below that of ground litter and 0-240 day dung (Fig. 3). Higher K content of all-age dung in summer than in early spring indicates less leaching during the dry summer months. In October K content of all-age dung increased from a low in October of 0.17% to a high of 0.32% in January (Table 3). This increase through the winter may have been due to the supplements and hay fed to livestock. Potassium, when not active in live plant material is easily leached (White 1973). The rapid decrease in K content of dung (0-240 days) between July and November illustrates the mobility of K (Fig. 3). The greatest decrease occurred in the first 30 days after deposition. Ground litter had a relatively constant K content (Fig. 3). There is a peak of 0.25% K in early May with a low of 0.17% K in late winter or early spring (Table 3).

Calcium content in all-age dung and ground litter declined from early spring to July before increasing in August (Fig. 4). Calcium

Table 3. Average (± SE) chemical composition (%) of ground liter and all-age dung. (N = 29 for each sampling period).

Date	Nitrogen		Phosphorus		Potassium		Calcium	
	Ground Litter	Dung	Ground Litter	Dung	Ground Litter	Dung	Ground Litter	Dung
4-12	1.02±.045	1.61±.026	0.06±.006	0.20±.009	0.16±.006	0.16±.011	0.56±.032	0.84±.042
5-2	1.23±.052	1.57±.042	0.09±.009	0.22±.015	0.25±.007	0.18±.011	0.68±.032	0.86±.042
5-25	1.11±.066	1.87±.016	0.08±.011	0.23±.018	0.22±.007	0.19±.032	0.64±.041	0.97±.037
6-22	1.14±.064	2.02±.037	0.08±.012	0.21±.011	0.22±.007	0.21±.018	0.63±.032	0.86±.032
7-20	1.10±.037	1.78±.050	0.06±.006	0.19±.014	0.20±.007	0.19±.020	0.56±.032	0.82±.061
8-17	1.14±.064	2.14±.044	0.07±.007	0.21±.010	0.21±.009	0.20±.140	0.65±.032	0.89±.028
9-16	1.10±.052	1.71±.028	0.06±.006	0.21±.010	0.21±.010	0.20±.018	0.64±.040	0.96±.020
10-12	1.22±.058	1.94±.060	0.06±.008	0.26±.034	0.23±.013	0.17±.012	0.61±.037	1.05±.063
11-10	0.98±.058	1.74±.045	0.06±.006	0.23±.010	0.21±.018	0.25±.020	0.52±.045	0.68±.040
12-10	1.10±.078	1.77±.048	0.06±.009	0.26±.020	0.25±.018	0.30±.020	0.50±.045	0.85±.028
1-29	0.97±.076	1.83±.056	0.08±.009	0.27±.021	0.21±.009	0.32±.021	0.35±.026	0.88±.047
3-10	0.98±.049	1.65±.052	0.06±.006	0.21±.009	0.17±.011	0.31±.021	0.51±.045	0.90±.021

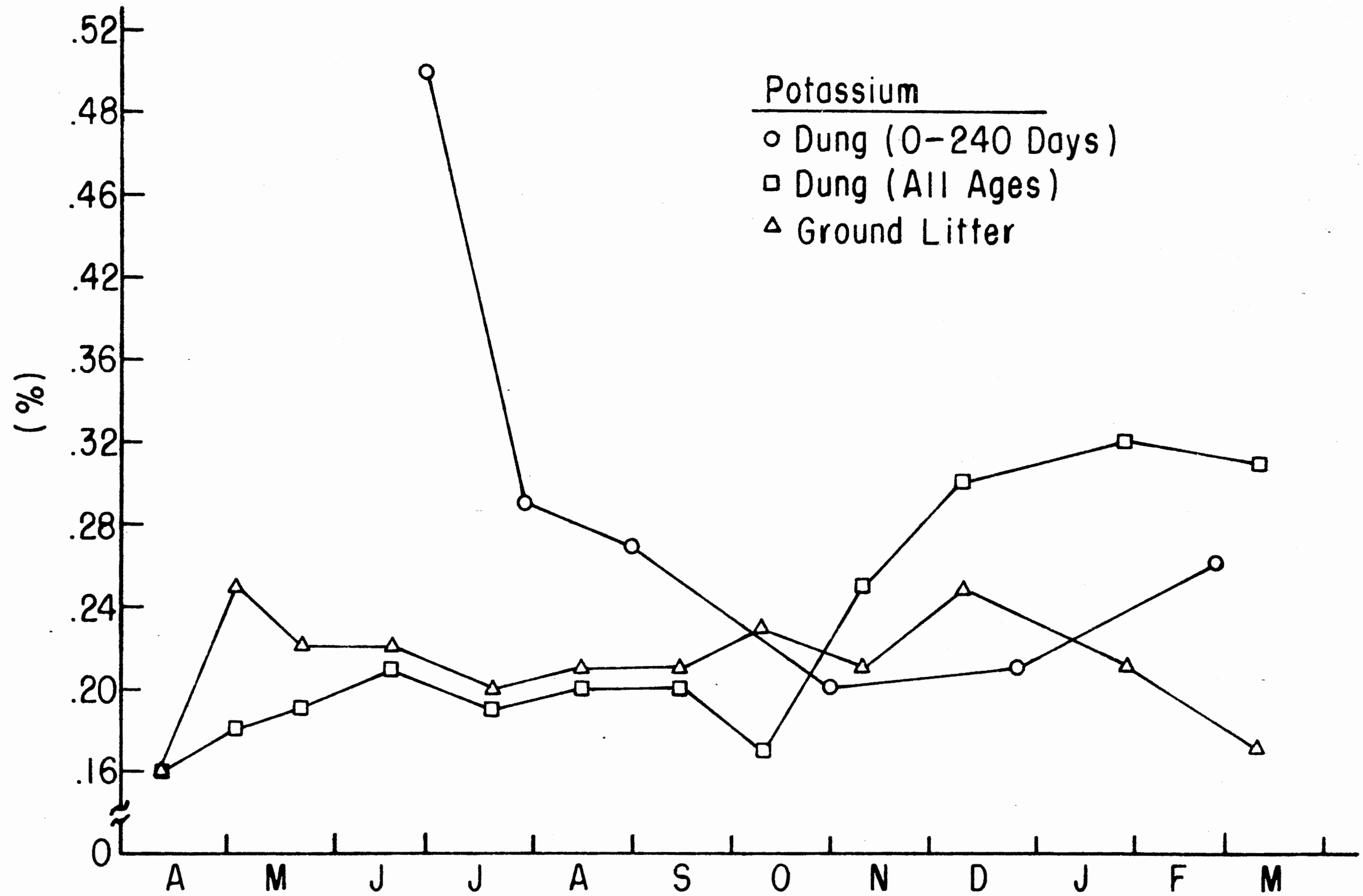

Fig. 3. Potassium content (%) of dung (0-240 days) from July, 1976 through March, 1977; all-age dung and ground litter from April, 1976 through March, 1977.

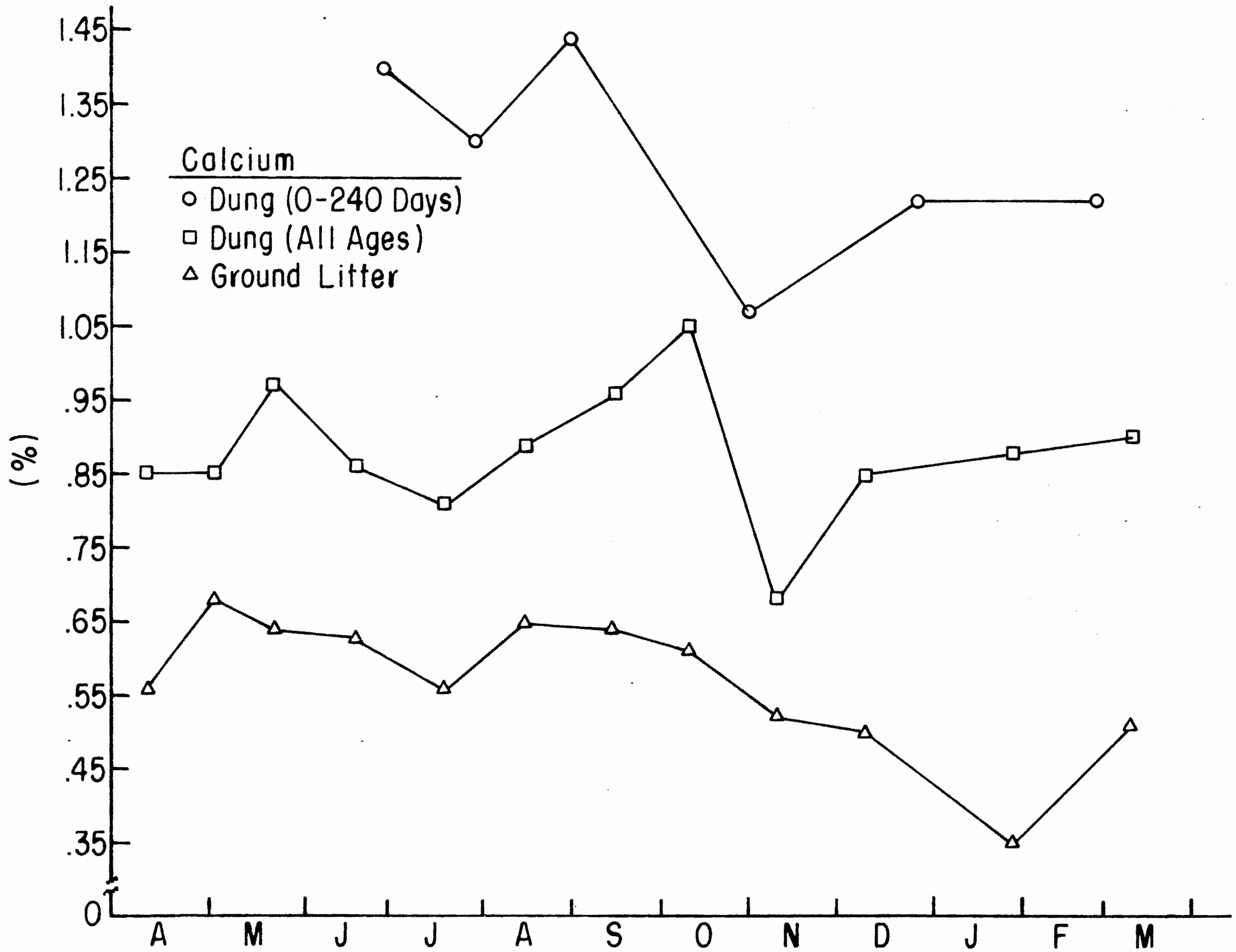

Fig. 4. Calcium content (%) of dung (0-240 days) from July, 1976 through March, 1977; all-age dung and ground litter from April, 1976 through March, 1977.

content of dung (0-240 days) was highest (1.44%) on day 60 and lowest (1.07%) on day 120. Calcium content of all-age dung declined most rapidly from 1.05% in October to 0.68% in November. Calcium content of ground litter biomass peaked in midspring and August and then decrease to a low of 0.35% in late winter.

Affect of Range Site on Chemical Composition

All-Age Dung

Differences between all-age dung fiber and chemical composition on loamy and shallow sites were very similar. This indicates diet may have more influence on dung composition than environmental effects of sites.

Ground Litter Biomass

Mean values for N, P and Ca content of ground litter were consistently higher on shallow sites (Table 4), except for 10-12 when N, P, K and Ca were all higher on loamy sites. There were no differences in K content of ground litter between loamy and shallow sites. This would indicate that leaching of K content occurred on both sites. Differences in overall mean values for N, P and Ca content were small, but highly significant.

In the summer and late fall differences in N, P and Ca content of ground litter were significant. Except for 5-25 P and Ca content differed significantly between loamy and shallow sites whenever N content differed. Most differences between loamy and shallow sites that were significant occurred in N content.

In the spring differences in Ca content of ground litter were highly significant. This difference may be attributed to the higher population

Table 4. Chemical composition (%) of ground litter on loamy and shallow prairie range sites. (N = 29 for each sampling period).

	Nitrogen			Phosphorus			Potassium			Calcium		
Date	Loamy	Shallow	Diff.[1]	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.
4-12	0.96	1.07	0.11	0.06	0.06	0	0.16	0.17	0.01	0.53	0.58	0.05
5-2	1.18	1.28	0.10	0.10	0.09	0.01	0.25	0.25	0	0.68	0.68	0
5-25	1.04	1.17	0.13	0.06	0.09	0.03	0.21	0.22	0.01	0.56	0.71	0.15**
6-22	1.05	1.22	0.17	0.08	0.09	0.01	0.23	0.21	0.02	0.61	0.64	0.03
7-20	0.99	1.21	0.22***	0.05	0.07	0.02**	0.19	0.21	0.02	0.50	0.61	0.11*
8-17	1.02	1.25	0.23*	0.06	0.08	0.02	0.20	0.21	0.01	0.60	0.69	0.09
9-16	1.06	1.13	0.07	0.06	0.07	0.01	0.20	0.22	0.02	0.63	0.65	0.02
10-12	1.24	1.21	0.03	0.07	0.06	0.01	0.24	0.23	0.01	0.65	0.58	0.07
11-10	0.83	1.14	0.31***	0.04	0.07	0.03**	0.20	0.22	0.02	0.38	0.64	0.26***
12-10	0.89	1.29	0.40***	0.05	0.07	0.02	0.27	0.22	0.05	0.52	0.49	0.03
1-29	0.93	1.00	0.07	0.07	0.09	0.02	0.20	0.02	0.02	0.31	0.39	0.08
3-10	0.80	1.06	0.17*	0.05	0.07	0.02*	0.17	0.16	0.01	0.48	0.54	0.06
Mean	1.01	1.17	0.16***	0.06	0.08	0.02***	0.21	0.21	0.00	0.54	0.60	0.06***

[1]Level of significance (*P < .10; **P < .05; ***P < .01).

of late spring and early summer forbs on the shallow sites. Differences in N and P content of ground litter in late winter may be due to the growth of the cool season annual grasses.

Conclusions

Based on the assumptions and results of this study the amount of dung decomposed or naturally removed from the watershed appears to be approximately the same as the dung added each year. Increased concentration during digestion, realtively low mobility and free choice of P mineral may have caused the higher and more consistent change in all-age dung P content between July and late January. Higher K content of all-age dung in summer than in early spring indicates less leaching during the dry summer months. Increases in K content through the winter may have been due to the supplements and hay fed to livestock. Differences in dung composition on loamy and shallow range sites were very similar indicating diet may have more influence than environmental effects of sites.

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APPENDIX A

CLASSIFICAITON OF SOIL SERIES

Table 1. Classification of soil series within each range site on the watershed and a description of each soil series.

SITES	Series	Percent	"A" Horizon (cm)	Depth (cm)	Family	Subgroup	Order
LOAMY	Aydelotte	7.0	0-13	102-152	Fine, mixed, thermic	Udertic Paleustalfs	Alfisols
LOAMY	Renfrow	0.1	0-38	> 150	Fine, mixed, thermic	Udertic Paleustolls	Mollisols
LOAMY	Stoneburg*	45.6	0-15	51-102	Fine-loomy, mixed, thermic	Vertic Haplustalfs	Alfisols
LOAMY	Zaneis*	7.5	0-23	> 100	Fine-loamy, mixed, thermic	Vertic Haplustalfs	Alfisols
SHALLOW	Darnell	6.0	0-15	25-50	Loamy, siliceous, thermic, shallow	Udic Ustochrepts	Inceptisols
SHALLOW	Grainola	17.3	0-12	50-102	Very-fine, mixed, thermic	Vertic Haplustalfs	Alfisols
SHALLOW	Lucien	14.3	0-12	8-51	Loamy, mixed, thermic, shallow	Typic Haplustolls	Mollisols
SHALLOW	Stephenville	2.2	0-30	51-102	Fine-loamy, siliceous, thermic	Ultic Haplustalfs	Alfisols

*This soil series is normally classified Vertic Argiustolls (Mollisols).

APPENDIX B

MEAN VALUES (± SE) FOR NBDMD, ADF, LIGNIN AND CELLULOSE IN LIVE AND DEAD BIOMASS

Table 1. Average (± SE) NBDMD (%) and fiber components (%) of live and dead herbage. (N = 29 for each sampling period).

Date	Dry Matter Digestibility		Acid-Detergent Fiber		Lignin		Cellulose	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
4-12			45.4±.007	52.7±.004	11.3±.003	13.2±.002	31.9±.009	38.9±.005
5-2			47.3±.02	52.3±.01	15.4±.012	12.9±.007	22.7±.009	34.1±.015
5-25			36.9±.004	51.3±.005	15.1±.01	16.1±.008	30.1±.004	35.3±.011
6-22	35.7±.014	6.0±.012	37.5±.005	51.5±.004	11.5±.005	11.9±.003	31.0±.005	36.4±.004
7-20	43.6±.009	8.4±.008	40.2±.011	52.5±.003	10.2±.009	12.3±.003	31.5±.006	42.5±.048
8-17	50.4±.01	22.0±.01	39.0±.006	51.0±.004	10.2±.004	13.0±.006	29.9±.006	38.0±.005
9-16	44.8±.016	18.1±.008	36.3±.007	49.3±.005	10.3±.007	14.1±.005	28.0±.007	37.0±.005
10-12		30.0±.015		45.7±.005		11.3±.006		34.3±.007
11-10		21.9±.01		48.3±.005		11.7±.003		33.5±.006
12-10		23.9±.013		51.5±.005		12.6±.004		35.1±.005
1-29		23.0±.007		52.5±.004		13.3±.005		36.6±.004
3-10		18.8±.008		51.3±.005		11.0±.003		35.8±.006

APPENDIX C

MEAN VALUES (± SE) FOR NBDMD, ADF, LIGNIN AND CELLULOSE IN LIVE HERBAGE ON DIFFERENT RANGE SITE

Table 1. NBDMD (%) and fiber components (%) of live herbage on loamy and shallow prairie range sites. (N = 29 for each sampling period).

	Dry Matter Digestibility			Acid-Detergent Fiber			Lignin			Cellulose		
Date	Loamy	Shallow	Diff.[1]	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.
4-12				46.4	44.5	1.9	11.0	11.6	0.6	33.3	30.6	2.7
5-2				49.1	45.6	3.5	17.1	13.7	3.4	21.0	24.3	3.3*
5-25				37.4	36.6	0.8	16.0	14.3	1.7	31.1	29.3	1.8**
6-22	35.9	38.7	2.8	38.9	36.6	2.3***	11.4	10.8	0.6	31.6	29.6	2.0***
7-20	42.7	44.8	2.1	39.2	41.1	1.9	9.1	11.2	2.1	31.9	31.0	0.9
8-17	46.2	52.6	6.4***	40.1	36.6	3.5***	10.2	10.7	0.5	31.5	27.9	3.6***
9-16	43.1	47.7	4.6	37.5	35.0	2.5*	9.7	10.9	1.2	28.8	27.0	1.8
Mean	41.4	45.0	3.6***	40.9	39.1	1.8**	11.8	11.7	0.1	30.2	28.6	1.6***

[1]Level of significance (*P < .10; **P < .05; ***P < .01).

APPENDIX D

MEAN VALUES (± SE) FOR NBDMD, ADF, LIGNIN AND

CELLULOSE IN DEAD BIOMASS ON

DIFFERENT RANGE SITES

Table 1. NBDMD (%) and fiber components (%) of dead biomass on loamy and shallow prairie range sites. (N = 29 for each sampling period).

	Dry Matter Digestibility			Acid-Detergent Fiber			Lignin			Cellulose		
Date	Loamy	Shallow	Diff.[1]	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.	Loamy	Shallow	Diff.
4-12				52.7	52.7	0.0	12.9	13.6	0.7*	39.0	38.9	0.1
5-2				51.1	53.4	2.3	12.1	13.6	1.5	34.2	34.0	0.2
5-25				51.5	51.1	0.4	15.9	16.4	0.5	33.9	37.1	3.2
6-22	15.8	16.8	1.0	52.2	51.2	1.0**	12.0	12.7	0.7	36.4	35.7	0.7
7-20	8.7	8.0	0.7	52.1	52.9	0.8	12.2	12.4	0.2	37.4	47.2	9.8
8-17	20.7	21.7	1.0	50.8	51.3	0.5	15.9	15.4	0.5	37.7	37.9	0.2
9-16	17.6	19.0	1.4	50.2	48.5	1.7*	14.0	14.2	0.2	37.4	36.6	0.8
10-12	27.6	32.4	4.8*	46.2	45.1	1.1	12.1	10.6	1.5	34.5	34.1	0.4
11-10	21.5	22.4	0.9	48.5	48.1	0.4	11.4	12.0	1.4	33.9	33.0	0.9
12-10	22.1	25.9	3.8	52.0	51.1	0.9**	12.4	12.8	0.4	34.7	35.5	0.8
1-29	23.3	22.6	0.7	52.0	52.9	0.9	13.1	13.5	0.4	36.9	36.2	0.7
3-10	17.0	20.4	3.4**	52.1	50.6	1.5	11.4	10.7	0.7	36.4	35.2	1.2
Mean	16.5	16.6	0.1	51.5	51.4	0.1	13.7	14.0	0.3	36.6	38.0	2.6

[1]Level of Significance (*P <,10; **P <.05).

APPENDIX E

MEAN VALUES (± SE) FOR CHEMICAL COMPONENTS

OF LIVE AND DEAD BIOMASS

Table 1. Average (± SE) chemical composition (%) of live and dead biomass. (N = 29 for each sampling period).

Date	Nitrogen		Phosphorus		Potassium		Calcium	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
4-12	2.38±.045	0.86±.066	0.17±.004	0.04±.002	1.84±.076	0.13±.018	0.49±.018	0.43±.026
5-2	1.99±.076	0.95±.084	0.16±.007	0.06±.006	1.60±.069	0.18±.018	0.58±.037	0.60±.050
5-25	1.80±.069	1.00±.037	0.11±.004	0.05±.004	1.36±.037	0.20±.018	0.56±.026	0.50±.026
6-22	1.49±.052	0.92±.041	0.07±.006	0.04±.004	1.27±.052	0.32±.026	0.32±.026	0.48±.018
7-20	1.35±.066	0.80±.032	0.08±.006	0.03±.018	1.14±.076	0.27±.018	0.48±.026	0.51±.018
8-17	1.27±.085	0.85±.026	0.08±.006	0.04±.004	1.20±.049	0.25±.002	0.60±.064	0.49±.002
9-16	1.39±.074	0.93±.045	0.09±.004	0.05±.004	1.14±.055	0.35±.037	0.57±.042	0.52±.018
10-12		1.07±.049		0.06±.004		0.48±.037		0.38±.011
11-10		0.91±.066		0.04±.004		0.36±.026		0.45±.026
12-10		0.90±.043		0.04±.004		0.23±.019		0.49±.033
1-29		0.93±.043		0.03±.004		0.15±.026		0.43±.026
3-10		0.71±.069		0.04±.006		0.16±.049		0.39±.026

APPENDIX F

MEAN VALUES (± SE) FOR CHEMICAL COMPONENTS OF

DUNG (0-240 DAYS) AND FIBER AND

CHEMICAL CONTENT OF ALL-AGE

DUNG ON RANGE SITES

Table 1. Average (± SD) chemical composition (%) of dung (0-240 days).

Day	Nitrogen	Phosphorus	Potassium	Calcium
0[1/] N=6	1.92±.13	0.21±.02	0.50±.08	1.39±.14
30 N=6	1.91±.11	0.24±.02	0.29±.04	1.27±.08
60 N=5	2.15±.14	0.27±.03	0.27±.06	1.44±.11
120 N=5	1.72±.27	0.20±.03	0.20±.04	1.07±.15
180 N=5	1.65±.13	0.22±.01	0.17±.01	1.23±.13
240 N=5	2.23±.04	0.26±.02	0.21±.03	1.24±.04

[1/] Day 0 = July 1, 1976.

Table 2. Average[1] fiber and chemical content (%) of all-age dung on shallow and loamy prairie range sites.

Component	Range Site Loamy (N=14)	Range Site Shallow (n=15)	Diff.	Probab. Level
Acid-Detergent Fiber	55.4	55.3	0.10	.87
Lignin	21.6	22.2	0.60	.52
Cellulose	20.5	20.1	0.40	.69
Nitrogen	1.83	1.78	0.05	.22
Phosphorus	0.23	0.21	0.02	.18
Potassium	0.21	0.23	0.02	.25
Calcium	0.89	0.88	0.01	.68

[1]Average of 10-15 samples collected on each of 12 different sampling dates during the year.

APPENDIX G

GLOSSARY OF TERMS

GLOSSARY OF TERMS[1]

Air-dry weight--The weight of a substance after it has been allowed to dry to equilibrium with the atmosphere.

Biomass--The sum total of living plants and animals above and below ground in area at a given time.

Climax--The highest ecological development of a plant community capable of perpetuation under the prevailing climatic and edaphic conditions.

Cool-season plant--A plant which generally makes the major portion of its growth during the winter and early spring.

Ecosystem--Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space.

Exclosure--An area fenced to exclude animals.

Forb--Any herbaceous plant other than those in the *Gramineae* (or *Poaceae*), *Cyperaceae* and *Juncacea* families.

Grass--A member of the family *Gramineae* (*Poaceae*).

Grasslike plant--A plant of the *Cyperaceae* or *Juncaceae* families which vegetatively resembles a true grass of the *Gramineae* family.

Herb--Any flowering plant except those developing persistent woody stems above ground.

Herbage--Herbs taken collectively.

Phenology--The study of periodic biological phenomenon such as flowering, seeding, etc., especially as related to climate.

Rangeland--Land on which the native vegetation (climax or natural potential) is predominately grasses, grass-like plants, forbs or shrubs suitable for grazing or browsing use. Includes lands revegetated naturally or artifically to provide a forage cover that is managed like native vegetation. Rangelands include natural grasslands, savannahs, shrublands, most deserts, tundra, alpine communities, coastal marshes and wet meadows.

Range site--A distinctive kind of rangeland, which in the absence of abnormal disturbance and physical site deterioration, has the potential to support a native plant community typified by an association of species different from that of other sites. This differentiation is based upon significantly differences in kind or proportion of species, or total productivity.

Shrub--A plant that has persistent, woody stems and a relatively low growth habit, and that generally produces several basal shoots instead of a single bole. It differs from a tree by its low stature and nonarborescent form.

Species composition--The proportions of various plant species in relation to the total on a given area. It may be expressed in terms of cover, density, weight, etc.

Succession, plant--The process of vegetational development whereby an area becomes successively occupied by different plant communities of higher ecological order.

Warm-season plant--A plant which makes most or all of its growth during the spring, summer or fall and is usually dormant in winter.

Watershed--(1) A total area of land above a given point on a waterway that contributes runoff water to the flow at that point. (2) A major subdivision of a drainage basin.

[1]Society for Range Management. 1974. A glossary of terms used in Range Management. 36 pp.

APPENDIX H

COMMENT STATEMENTS FOR RANGE NUTRITION STUDY

COMMENT

STUDY AREA LOCATION IN NORTH-CENTRAL OKLAHOMA NORTHWEST OF STILLWATER. THE STUDY AREA IS PART OF THE LAKE CARL BLACKWELL WATERSHED IN THE NORTHWEST ONE-QUARTER OF SECTION 32, TOWNSHIP 20 NORTH, RANGE 1 EAST OF THE INDIAN MERIDIAN. THE REMAINDER OF THE WATERSHED IS LOCATED IN THE SOUTHWEST ONE-QUATER OF SECTION 32 AND THE EASTERN EDGE OF SECTION 31, NOBLE COUNTY.

STUDY NUMBER - G1607.
STUDY NAME - PLANT, SOIL AND DUNG FACTORS AFFECTING TALLGRASS PRAIRIE VEGETATION DURING DROUGHT CONDITIONS ON A CENTRAL OKLAHOMA RANGELAND WATERSHED.
INITIATED IN THE SPRING OF 1975.

TREATMENTS

THREE REPLICATES OF UNGRAZED CONDITIONS WERE ESTABLISHED BY CONSTRUCTING A 50 METER BY 100 METER EXCLOSURE IN LATE WINTER, 1975, AT EACH OF THREE DIFFERENT LOCATIONS ALONG THE UPPER BOUNDARY OF THE WATERSHED.

VEGETATION SAMPLING

TWENTY-NINE PERMANENT LOCATIONS WERE ARBITARILY SELECTED FOR MONTHLY SOIL, VEGETATION AND DUNG SAMPLING. THE NUMBER AND DISTRIBUTION OF LOCATIONS PROVIDED A RANGE IN SITE CONDITIONS FOR REGRESSION ANALYSES AND REPLICATIONS ON THE MAJOR SOIL TYPES IN PROPORTION TO THEIR PERCENTAGE OF OCCURRENCE THROUGHOUT THE WATER SHED. ONE LOCATION WAS SELECTED INSIDE EACH EXCLOSURE WITH AN ADJACENT LOCATION OUTSIDE THE EXCLOSURE ON THE SAME SOIL TYPE. FORAGE SAMPLES WERE COLLECTED WITHIN A ONE-HALF METER SQUARED CIRCULAR HOOP. SPECIES COMPOSITION AND FORAGE PRODUCTION WERE DETERMINED ON BOTH CAGED AND GRAZED SAMPLING POINTS. ON GRAZED AREAS COVER, GROUND LITTER AND SURFACE SOIL TEMPERATURE WERE DETERMINED. VEGETATION AT ONE SAMPLING POINT WAS CLIPPED AT ONE LOCATION, AND ALL THREE SAMPLING POINTS WITHIN EACH LOCATION WAS ESTIMATED. CLIPPING WAS AT GROUND LEVEL.

IN VIVO DRY MATTER DIGESTIBILITY

THREE HOLSTEIN STEERS FITTED WITH PERMANENT RUMEN CANNULAE WERE PUT ON RANGELAND. THIS GRAZING AREA WAS COMPOSED OF NEARLY THE SAME PLANT SPECIES COMPOSITION AS THE GRAZED WATERSHED HAUING THE 29 PERMANENT LOCATIONS. STEERS WERE PUT IN A DRYLOT PADDOCK THROUGH THE WINTER. STEERS WERE THEN FED HAY FROM THE SAME PADDOCK IN WHICH THEY GRAZED. THEY WERE ALSO FED A PROTEIN SUPPLEMENT AND RETURNED TO THE RANGELAND PADDOCK IN THE SPRING.

DUNG SAMPLING

DUNG PATS WERE REMOVED FROM WITHIN EACH EXCLOSURE IN EARLY SPRING, 1976, TO PROVIDE THREE DUNG FREE AREAS. THE DUNG WAS WEIGHED TO ESTABLISH AN ESTIMATE OF DUNG BIOMASS PER HECTARE. DUNG SAMPLES WERE COLLECTED IN AN AREA TWO BY TEN METERS ALONG THE BEARING AT WHICH THE CLIPPED FORAGE SAMPLE WAS TAKEN AND THE NUMBER OF DUNG PATS ESTIMATED ALONG ALL THREE BEARINS AT EACH LOCATION. ALIQUOTS OF DUNG PATS. ALONG THE BEARING OF THE CLIPPED FORAGE SAMPLE, WERE TAKEN AND COMBINED INTO ONE SAMPLE.

DUNG DEGRADATION SAMPLING

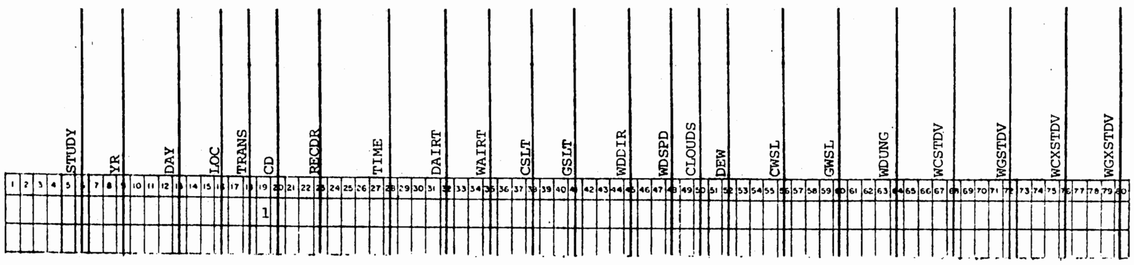
FIFTY DUNG PATS WERE LOCATED AND MARKED ON THE DAY DEPOSITED, JULY 1, 1976. THE LOCATING AND MARKING OF THE DUNG OCCURRED ONLY ONE TIME DURING THE STUDY. SIX DUNG SAMPLES WERE COLLECTED ON JULY 1, 1976 (DAY 0). SIX MORE SAMPLES WERE COLLECTED ON DAY 30 WITH 5 SAMPLES BEING COLLECTED ON DAYS 60, 120, 180 AND 240. DATA RECORDED AT THE TIME OF COLLECTION INCLUDED TIME OF DROP, SOIL TEMPERATURE AT 2 CM DEEP, DRY-BULB AIR TEMPERATURE, PERCENT BARE GROUND, PLANT SPECIES COMPOSITION, CLIPPED STANDING VEGETATION, GROUND LITTER, SOIL SAMPLE COLLECTED AT 0-10 CM DEEP AND WET WEIGHT.

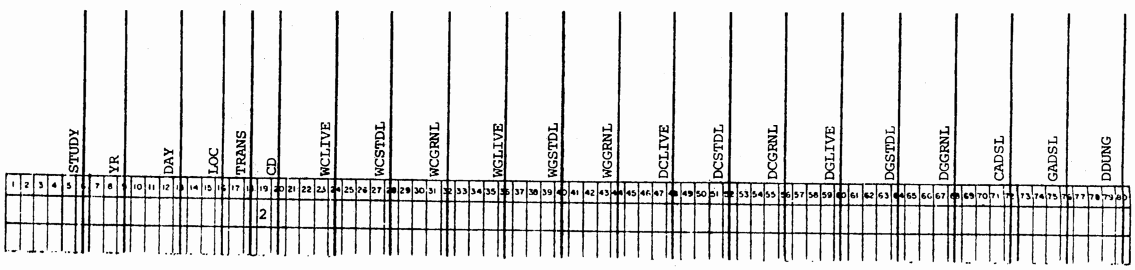
LABORATORY ANALYSES

CLIPPED VEGETATION AND DUNG SAMPLES WERE AIR-DRIED AND GROUND THROUGH A 2MM SCREEN IN A WILEY MILL. VEGETATION SAMPLES WERE ANALYZED FOR IN VIVO DRY MATTER DIGESTIBILITY, BY A NYLON BAG TECHNIQUE. VEGETATION AND DUNG SAMPLES WERE ANALYZED FOR DRY MATTER, CRUDE PROTEIN BY THE MICRO-KJELDAHL PROCEDURE, ACID-DETERGENT FIBER, LIGNIN AND CELLULOSE BY THE PERMANGANATE OXIDATION PROCEDURE OF VAN SOEST AND WINE. PHOSPHORUS, POTASSIUM AND CALCIUM WERE ANALYZED BY PROCEDURES ADOPTED BY THE SOIL AND WATER TESTING LABORATORY AT OKLAHOMA STATE UNIVERSITY. SAMPLES CONSISTED OF 3, 2 AND 0.5 GM ALIQUOTS FOR DMD; DM, CP; ADF AND LIGNIN, RESPECTIVELY. DMD ANALYSIS WAS TRIPLICATED WHILE ALL OTHER LABORATORY ANALYSES WERE DUPLICATED.

APPENDIX I

FIELD DATA WORKSHEETS FOR RANGE WEATHER AND FIELD WEIGHT





DATA SHEETS-RANGE WEATHER AND FIELD WEIGHT

STUDY - STUDY NUMBER.
YR - YEAR.
DAY - JULIAN DAY WITH 1 NOBEMBER CONSIDERED THE START OF A NEW PLANT YEAR.
LOC - LOCATION DESIGNATED AS 1-29 PERMANENT LOCATIONS ON THE WATERSHED
TRANS - TRANSEXT DESIGNATES
TRANS - TRANSECT DESIGNATED AS 1-3 WHICH WAS A 360 DEGREE CIRCLE AROUND THE PERMANENT LOCATION DIVIDED INTO THIRDS. EACH TRANSECT WAS 120 DEGREES.
CD - DATA SHEET CARD NUMBER.
RECDR - INITIALS OF INDIVIDUAL RECORDING DATA.
TIME - TIME OF SAMPLING
DAIRT - DRY AIR TEMPERATURE AT TIME OF SAMPLING.
WAIRT - WET AIR TEMPERATURE READING ON SLING PSYCHROMETER AT TIME OF SAMPLING.
CSLT - CAGED SOIL TEMPERATURE AT TIME OF SAMPLING.
GSLT - GRAZED SOIL TEMPERATURE AT TIME OF SAMPLING.
WDDIR - DIRECTION OF WIND-1 TO 360 DEGREES.
WDSPD - SPEED OF WIND MOVEMENT.
CLOUDS - CLOUD COVER, 1-CLEAR 2-BROKEN 3-SCATTERED 4-OVERCAST 5-HEAVY OVERCAST.
DEW - WETNESS OF VEGETATION, 1-DRY 2-DAMP 3-WET.
CWSL - CAGED WET WEIGHT OF SOIL SAMPLE-0 TO 10 CM.
GWSL - GRAZED WET WEIGHT OF SOIL SAMPLE-0 TO 10 CM.
WDUNG - WET WEIGHT OF DUNG SAMPLE.
WCSTDV - WET WEIGHT OF CAGED STANDING VEGETATION IN .5 SQ. METER-FRAME AS CLIPPED IN FIELD.
WGSTDV - WET WEIGHT OF GRAZED STANDING VEGETATION.
WCXSTDV - WET WEIGHT OF CAGED EXTRA STANDING VEGETATION.
WGXSTDV - WET WEIGHT OF GRAZED EXTRA STANDING VEGETATION.
WCLIVE - WET WEIGHT OF CAGED LIVE VEGETATION.
WCSTDL - WET WEIGHT OF CAGED STANDING LITTER.
WCGRNL - WET WEIGHT OF CAGED GROUND LITTER.
WGLIVE - WET WEIGHT OF GRAZED LIVE VEGETATION.
WGSTDL - WET WEIGHT OF GRAZED STANDING LITTER.
WGGRNL - WET WEIGHT OF GRAZED GROUND LITTER.
DCLIVE - DRY WEIGHT OF CAGED LIVE VEGETATION AFTER AIR-DRYING 10-14 DAYS.
DCSTDL - DRY WEIGHT OF CAGED STANDING LITTER AFTER AIR-DRYING 10-14 DAYS.
DCGRNL - DRY WEIGHT OF GROUND LITTER AFTER AIR-DRYING 10-14 DAYS.
DGLIVE - DRY WEIGHT OF GRAZED LIVE VEGETATION AFTER AIR-DRYING 10-14 DAYS.
DGSTDL - DRY WEIGHT OF GRAZED STANDING LITTER AFTER AIR-DRYING 10-14 DAYS.
DGGTNL - DRY WEIGHT OF GRAZED GROUND LITTER AFTER AIR-DRYING 10-14 DAYS.
CADSL - DRY WEIGHT OF CAGED SOIL SAMPLE AFTER AIR-DRYING 10-14 DAYS.
GADSL - DRY WEIGHT OF GRAZED SOIL SAMPLE AFTER AIR-DRYING 10-14 DAYS.
DDUNG - DRY WEIGHT OF DUNG SAMPLE AFTER AIR-DRYING 10-14 DAYS.

APPENDIX J

FIELD DATA WORKSHEETS FOR SPECIES COMPOSITION

STUDY	YR	DAY	LOC	TRANS	CD	CLIP	GESTMR	EGLIVE	EGSTDL	EGGRNL	GANGE	GANVI	GANTE	GARI	GBOCU	GBOGR	GBOHI	GBOSA	GBUDA	GBRJA	GCARX	GCYDA	GLECO	GPASC
					4																			

STUDY	YR	DAY	LOC	TRANS	CD	GPASP	GPAVI	GSET	GSPO	GSONU	GSCSC	GSCAG	GCSPG	GWSAG	GWSPG	GACLA	GAMPS	GARLU	GASER	GCAFA	GCIR	GERCA	GERST	GGUDR
					5																			

STUDY	YR	DAY	LOC	TRANS	CD	GHEL	GLESP	GPLA	GSAPI	GSCUN	GSOLA	GSOLI	GANFB	GPRFB	GWOOD	GSP1	GSP2	GSP3	GSP4	GSP5	PCBG	NODUNG
					6																	

DATA SHEETS-SPECIES COMPOSITION

CLIP - SAMPLE WAS CLIPPED (C) OR ESTIMATED (E).
GESTMR - ESTIMATED WEIGHT OF TOTAL GRAZED STANDING MATERIAL WITHIN A .5 SQ METER-FRAME.
EGLIVE - ESTIMATED WEIGHT OF TOTAL GRAZED LIVE VEGETATION WITHIN A .5 SQ METER-FRAME.
EGSTDL - ESTIMATED WEIGHT OF TOTAL GRAZED STANDING LITTER WITHIN A .5 SQ METER-FRAME.
EGGRNL - ESTIMATED WEIGHT OF TOTAL GRAZED GROUND LITTER WITHIN A .5 SQ METER-FRAME.
GSP1-GSP5 - PLANT SPECIES THAT CAN BE LISTED THAT ARE NOT OTHERWISE IDENTIFIED BY A SPECIES SYMBOL.
PCBG - ESTIMATED PERCENT BARE GROUND WITHIN A .5 SQ METER-FRAME.
NODUNG - NUMBER OF DUNG COUNTED WITHIN A TWO BY TEN METER AREA ALONG THE BEARINGS AT WHICH THE CLIPPED AND ESTIMATED VEGETATION SAMPLES WERE TAKEN.

SPECIES ABBREVIATIONS USED ARE LISTED SEPERATELY BY SCIENTIFIC NAME, COMMON NAME AND SPECIES SYMBOL.

APPENDIX K

PLANT SPECIES KEY TO FIELD DATA WORKSHEETS

Computer Species Abbreviation	Scientific Name	Common Name	Species Symbol
Grasses and grass-like			
ANGE	*Andropogon gerardi*	big bluestem	ANGE
ANTE	*Andropogon ternarius*	split-beard bluestem	ANTE
ANVI	*Andropogon virginicus*	broomsedge bluestem	ANVI
ARI	*Aristida* spp.	threeawn	ARIST
BOCU	*Bouteloua curtipendula*	sideoats grama	BOCU
BOGR	*Bouteloua gracilis*	blue grama	BOGR
BOHI	*Bouteloua hirsuta*	hairy grama	BOHI
BOSA	*Bothriochloa scchariodes*	silver bluestem	BOSA
BUDA	*Buchloe dactyloides*	common buffalograss	BUCHL
BRJA	*Bromus japonicus*	Japanese brome	BRJA
CARX	*Carex* spp.	sedge	CAREX
CYDA	*Cynodon dactylon*	common bermudagrass	CYDA
LECO	*Leptoloma cognatum*	fall witch	LECO
PASC	*Panicum scribnerianum*	scribners	PASC5
PASP	*Paspalum* spp.	paspalum	PASPA
PAVI	*Panicum vigratum*	switchgrass	PAV12
SET	*Setaria* spp.	bristlegrass	SETAR
SPO	*Sporobolus* spp.	dropseed	SPORO
SONU	*Sorghastrum nutans*	yellow indiangrass	SONU2
SCSC	*Schizachyrium scoparium*	little bluestem	SCSC
CSAG		cool season annual grass	
CSPG		cool season perennial grass	
WSAG		warm season annual grass	
WSPG		warm season perennial grass	
Forbs			
ACLA	*Achillea lanulosa*	yarrow	ACLA
AMPS	*Ambrosia artemisiifolia*	common ragweed	AMAR2

ARLU	*Artemisia frigida*	fringed sagewort	ARFR4
ASER	*Aster* spp.	aster	ASTER
CAFA	*Cassia fasciculata*	showy partridge pea	CAFA
CIR	*Cirsium* spp.	thistle	CIRSI
ERCA	*Erigeron canadensis*	mare's tail	ERCA3
ERST	*Erigeron strigosus*	daisy fleabane	ERST3
GUDR	*Gutierrezia dracunculoides*	annual broomweed	GUDR
HEL	*Helianthus annuus*	sunflower	HEAN3
LESP	*Lespedeza* spp.	lespedeza	LESPE
PLA	*Plantago* spp.	plaintain	PLANT
SAPI	*Salvia pitcheri*	pitcher sage	SAPI3
SCUN	*Schrankia uncinata*	cat's claw	SCUN
SOLA	*Solanum* spp.	horse nettle	SOLAN
SOLI	*Solidago* spp.	goldenrod	SOLID
ANFB		annual forb	
PRFB		perennial forb	
WOOD		woody species	

APPENDIX L

OTHER PLANT SPECIES RECORDED ON LAKE

CARL BLACKWELL STUDY AREA

Scientific Name[1]	Common Name	Species Symbol[2]
Grass and Grass-like		
Agrostis spp.	bentgrass	AGRO52
Chloris verticillata	windmill grass	CHVE2
Elymus spp.	wildrye	ELYMU
Eragrostis spp.	lovegrass	ERAGR
Hordeum pusillum	little barley	HOPU
Manisurus cylindrica	Carolina jointtail	MACY
Panicum spp.	panic	PANIC
Poa spp.	bluegrass	POA
Schedonnardus paniculatus	tumblegrass	SCPA
Sphenopholis obtusata	wedge grass	SPOB
Festuca octoflora	six-week fescue	FEOC2
Forbs		
Antennaria spp.	pussytoes	ANTEN
Asclepias spp.	milkweed	ASCLE
Baptisia australis	blue wildindigo	BAAU
Croton texensis	Texas croton	CRTE4
Daucus carota	wild carrot	CACA6
Geranium spp.	geranium	GERAN
Kuhnia eupatoroides	falseboneset	KUEU
Lepidium virginicum	Virginia pepperweed	LEVI3
Linus spp.	flax	LINUS
Liatris punctata	dotted gayfeather	LIPU
Monarda pectinata	plains beebalm	MOPE
Oenothera serrulata	half-shrub sundrop	OESE
Oxalis spp.	woodsorrel	OXALI
Petalostemon spp.	prairie clover	PETAL2
Prunus angustifolia	wild plum	PRAN2
Psoralea tenuiflora	scruf-pea	PSTE3
Ratibida columnaris	prairie cone-flower	RATIB
Rhus glabra	smooth sumac	RHGL
Ruellia ciliosa	fringeleaf ruellia	RUCI
Rudbeckia hirta	black-eyed susan	RUHI2
Specularia perfoliata	Venus looking-glass	SPPE
Ceanothus spp.	buckbrush	CEANO
Vernonia spp.	ironweed	VERNO

[1]Scientific names from Waterfall, U.T. 1972. Keys to the flora of Oklahoma, Okla. State Univ. Student Union Bookstore. Stillwater, 246 pp.

[2]Species symbols from National list of scientific plant names. 1971. U.S. Dep. Agr. Soil Conserv. Serv. 281 pp.

APPENDIX M

FIELD DATA WORKSHEETS FOR DUNG DEGRADATION STUDY

STUDY	SORT	YR	DAY OF COL	DEGR DATE	START MONTH	POSITION	MATR	REP	TIME	SAMP NO	DRY BULB	SL TEMP	DEW	SL TYPE NO	VEG TYPE	% BARE GND	EST STD VEG	EST GND LIT	WET WT	DRY WT
	F																			

DATA SHEETS - DUNG DEGRADATION

STUDY - STUDY NUMBER.
SORT - SORT AS TO CARD TYPE, F-DUNG D-DRY MATTER A-ACID-DETERGENT FIBER I-IN VIVO DRY MATTER DIGESTIBILITY.
YR - YEAR.
DAY OF COL - JULIAN DAY WITH 1 NOVEMBER CONSIDERED THE START OF A NEW PLANT YEAR.
DEGR DATE - THE NUMBER OF DAYS AFTER DEPOSITION SAMPLES WERE COLLECTED. DAYS 0, 30, 60, 120, 180 AND 240 ARE SAMPLING PERIODS.
START MONTH - THE MONTH DAY 0 OCCURRED-IN THIS STUDY JULY.
POSITION - AREA WITHIN A .5 SQ METER-FRAME-SAMPLE TAKEN I-IN OR O-OUT.
MATR - KIND OF SAMPLE TAKEN WITHIN A .5 SQ METER-FRAME-DUNG,SOIL, VEGETATION AND GROUND LITTER.
REP - REPLICATION SAMPLED DURING A SAMPLING PERIOD-1, 2, 3, 4 OR 5.
TIME - TIME OF SAMPLING.
SAMP NO - NUMBER OF THE SAMPLE
DRY BULB - AIR TEMPERATURE AT THE TIME OF SAMPLING.
SL TEMP - TEMPERATURE OF SOIL AT TIME OF ESTIMATE.
DEW - WETNESS OF VEGETATION,1-DRY 2-DAMP 3-WET.
SL TYPE NO - SOIL SERIES NUMBER.
VEG TYPE - TYPE OF VEGETATION-TALLGRASS MODGRASS SHORTGRASS.
% BARE GND - AMOUNT OF GROUND WITH NO VEGETATION COVER.
EST STD VEG - TOTAL ESTIMATED STANDING VEGETATION WITHIN A .5 SQ METER-FRAME.
EST GND LIT - TOTAL ESTIMATED GROUND LITTER WITHIN A .5 SQ METER-FRAME.
WET WT - ACTUAL WEIGHT OF MATERIAL IN .5 SQ METER-FRAME AS CLIPPED IN FIELD.
DRY WT - ACTUAL WEIGHT OF MATERIAL AFTER AIR-DRYING 10-14 DAYS.

APPENDIX N

LAB DATA WORKSHEETS FOR LABORATORY ANALYSES

STUDY	SORT	YR	DAY	LOC	TRANS	CD	TYPE	MATR	REP	ENV NO	XBLE NO	XBLE WT X.XXXX	XSAMP WT X.XXXX	SAM NET WT X.XX	TOT DRY WT X.XXXX	HND CAL DM XX.XXXX
	D					1										

STUDY	SORT	YR	DAY	LOC	TRANS	CD	TYPE	MATR	REP	ENV NO	BAG NO	DRY BAG WT X.XXXX	TARE WT X.XXXX	TARE SAM WT X.XXXX	NET SAM WT X.XX	BAG SAM WT X.XXXX
	I					1										

STUDY	SORT	YR	DAY	LOC	TRANS	CD	TYPE	MATR	REP	ENV NO	XRBL NO	BEAK NO	TAR WT .XXXX	TAR SPL WT .XXXX	XRBL DR WT XX.XXXX	XRBL ADF XX.XXXX	XRBL ADLR XX.XXXX	XRBL ASH XX.XXXX
	A					2												

DATA SHEETS-LABORATORY ANALYSES

TYPE - C-CAGED VEGETATION G-GRAZED RESIDUE.
MATR - KIND OF SAMPLE TAKEN WITHIN A .5 SQ METER-FRAME, VEGETATION-LIVE DEAD OR STANDING LITTER.
REP - REPLICATION SAMPLED DURING A SAMPLING PERIOD-1 OR 2.
ENVNO = ENVELOPE NUMBER
XBLENO = CRUCIBLE NUMBER
XBLEWT = CRUCIBLE WEIGHT
XSAMPWT = CRUCIBLE PLUS SAMPLE WEIGHT
SAMNETWT = SAMPLE NET WEIGHT (WITHOUT CRUCIBLE) FOR DRY MATTER
TOTDRYWT = COMBINED WEIGHT OF DRIED SAMPLE PLUS CRUCIBLE
HNDCALDM = HAND CALCULATED DRY MATTER
BAGNO = NUMBER ON NYLON RUMEN BAG
DRYBAGWT = DRY BAG WEIGHT
TAREWT = TARE WEIGHT OF CRUCIBLE (TIN BOAT) DRY
TARSAMWT = TARE PLUS SAMPLE WEIGHT (WET)
NETSAMWT = NET WEIGHT OF SAMPLE PLACED IN NYLON BAG
BAGSAMWT = COMBINED DRY WEIGHT OF SAMPLE AND NYLON BAG AFTER DIGESTION
XRBLNO = CRUCIBLE NO USED TO DETERMINE ACID-DETERGENT FIBER(ADF).
BEAKNO = BEAKER USED FOR ADF
TARWT = NET WEIGHT OF CRUCIBLES USED FOR ADF
TARSPLWT = CRUCIBLE PLUS SAMPLE WEIGHT FOR ADF (WET SAMPLE)
XRBLDRWT = DRY WEIGHT OF CRUCIBLE PLUS SAMPLE
XRBLADF = CRUCIBLE ADF
XRBLADLR = CRUCIBLE RESIDUE
XRBLASH = CRUCIBLE ASH

STUDY	YR	DAY	LOC	TRANS	CD	ENV NO GL	GN LIVE X.XX %	GP LIVE .XXX %	GK LIVE X.XX %	GCA LIVE .XXX %	GASH LIVE XX.X %	ENV NO GS	GN STDL X.XX %	GP STDL .XXX %	GK STDL X.XX %	GCA STDL .XXX %	GASH STDL XX.X %
					1												

STUDY	YR	DAY	LOC	TRANS	CD	ENV NO GG	GN GRNL X.XX %	GP GRNL .XXX %	GK GRNL X.XX %	GCA GRNL .XXX %	GASH GRNL XX.X %	ENV NO D	N DUNG X.XX %	P DUNG .XXX %	K DUNG X.XX %	CA DUNG .XXX %	ASH DUNG XX.X %
					2												

ENVNOGL - ENVELOPE NUMBER OF GRAZED LIVE RESIDUE SAMPLE.
GNLIVE - NITROGEN CONTENT (%) IN GRAZED LIVE RESIDUE SAMPLE.
GPLIVE - PHOSPHORUS CONTENT (%) IN GRAZED LIVE RESIDUE SAMPLE.
GKLIVE - POTASSIUM CONTENT (%) IN GRAZED LIVE RESIDUE SAMPLE.
GCALIVE - CALCIUM CONTENT (%) IN GRAZED LIVE RESIDUE SAMPLE.
GASHLIVE - ASH CONTENT (%) IN GRAZED LIVE RESIDUE SAMPLE.
ENVNOGS - ENVELOPE NUMBER OF GRAZED STANDING LITTER SAMPLE.
GNSTDL - NITROGEN CONTENT (%) IN GRAZED STANDING LITTER SAMPLE.
GPSTDL - PHOSPHORUS CONTENT (%) IN GRAZED STANDING LITTER SAMPLE.
GKSTDL - POTASSIUM CONTENT (%) IN GRAZED STANDING LITTER SAMPLE.
GASHSTDL - ASH CONTENT (%) IN GRAZED STANDING LITTER SAMPLE.
ENVNOGG - ENEVELOPE NUMBER OF GRAZED GROUND LITTER SAMPLE.
GNGRNL - NITROGEN CONTENT (%) IN GRAZED GROUND LITTER SAMPLE.
GPGRNL - PHOSPHORUS CONTENT (%) IN GRAZED GROUND LITTER SAMPLE.
GKGRNL - POTASSIUM CONTENT (%) IN GRAZED GROUND LITTER SAMPLE.
GCAGRNL - CALCIUM CONTENT (%) IN GRAZED GROUND LITTER SAMPLE.
ENVNOD - ENVELOPE NUMBER OF DUNG SAMPLE.
NDUNG - NITROGEN CONTENT (%) IN DUNG SAMPLE.
PDUNG - PHOSPHORUS CONTENT (%) IN DUNG SAMPLE.
KDUNG - POTASSIUM CONTENT (%) IN DUNG SAMPLE.
CADUNG - CALCIUM CONTENT (%) IN DUNG SAMPLE.
ASH DUNG - ASH CONTENT (%) IN DUNG SAMPLE.

APPENDIX O

COMPUTER CARD INPUT, PROCEDURES AND ANALYSES FOR NBDMD, CHEMICAL AND FIBER COMPONENTS

```
TITLE 'RANGE NUTRITION - INVIVO';

DATA STEERS; INPUT
  NAME $ 1-5 YR 7-8 DAT 10-12 LOC 14-15 TRANS 17 CD 19 TYPE $21 MATR $ 23-26
    REP 28 ENVNO 30-33 BAGNO 35-37 DRYBAGWT 39-41 2 TAREWT 45-49 4
    TARSAMWT 51-55 4 NETSAMWT 57-59 2 BAGSAMWT 61-63 2;

NETWT = BAGSAMWT-DRYBAGWT;
IF NETSAMWT = 0 THEN NETSAMWT = (TARSAMWT - TAREWT);
IF MATR = 'STVG' THEN MATR = 'STDV';
IF MATR = 'STND' THEN MATR = 'STDV';
  IF YR = 77 AND DAT >   5 AND DAT <  15 THEN DAY = 7010;
  IF YR = 77 AND DAT >  35 AND DAT <  50 THEN DAY = 7040;
  IF YR = 77 AND DAT >  85 AND DAT < 100 THEN DAY = 7090;
  IF YR = 77 AND DAT > 125 AND DAT < 135 THEN DAY = 7130;
  IF DAY = 7010 AND MATR = 'STDV' AND TYPE = 'G' THEN PU = 0.06;
  IF DAY = 7040 AND MATR = 'STDV' AND TYPE = 'G' THEN PU = 0.05;
  IF DAY = 7090 AND MATR = 'STDV' AND TYPE = 'G' THEN PU = 0.07;
  IF DAY = 7130 AND MATR = 'STDV' AND TYPE = 'G' THEN PU = 0.08;
SAMWT = NETWT-PU;
CARDS;

PROC SORT DATA=STEERS; BY DAY TYPE MATR LOC;
PROC PRINT DATA=STEERS; BY YR DAY TYPE MATR LOC;
 VAR BAGSAMWT DRYBAGWT NETWT SAMWT PU NETSAMWT;
```

```
TITLE 'RANGE NUTRITION MINERAL COMPONENT ANALYSIS';

DATA CHEMALS; INPUT
  NAME $ 1-5 YR 7-8 DAT 10-12 LOC 14-15 TRANS 17 CD 19 ENLIVE 21-23
  GNLIVE 25-27 2 GPLIVE 29-31 2 GKLIVE 33-35 2 GCLIVE 37-39 2 ENVDEAD 45-47
  GNDEAD 49-51 2 GPDEAD 53-55 2 GKDEAD 57-59 2 GCADEAD 61-63 2
    YR2 #2 7-8 DAT2 #2 10-11 LOC2 #2 14-15 TRANS2 #2 17 CD2 #2 19
    ENVGGRN #2 21-23 GNGRN #2 25-27 2 GPGRN #2 29-31 2 GKGRN #2 33-35 2
    GCAGRN #2 37-39 2 ENVDUNG #2 45-47 GNDUNG #2 49-51 2 GPDUNG #2 53-55 2
    GKDUNG #2 57-59 2 GCADUNG #2 61-63 2;

  IF YR = 77 AND DAT >   5 AND DAT <  15 THEN DAY = 7010;
  IF YR = 77 AND DAT >  35 AND DAT <  50 THEN DAY = 7040;
  IF YR = 77 AND DAT >  85 AND DAT < 100 THEN DAY = 7090;
  IF YR = 77 AND DAT > 125 AND DAT < 135 THEN DAY = 7130;
CARDS;

PROC SORT OUT= CHEMSORT DATA=CHEMALYS; BY YR DAY LOC;
PROC PRINT DATA=CHEMSORT; BY YR DAY; ID LOC;
  VAR GNLIVE GPLIVE GKLIVE GCALIVE GNDEAD GPDEAD GKDEAD GCADEAD;
PROC PRINT DATA=CHEMSORT; BY YR DAY; ID LOC;
  VAR GNGRN GPGRN GKGRN GCAGRN GNDUNG GPDUNG GKDUNG GCADUNG;
PROC MEANS OUT=CHEMAVG DATA=CHEMSORT; BY YR DAY;
  VAR GNLIVE GPLIVE GKLIVE GCALIVE GNDEAD GPDEAD GKDEAD GCADEAD
      GNGRN GPGRN GKGRN GCAGRN GNDUNG GPDUNG GKDUNG GCADUNG;
```

```
TITLE 'RANGE NUTRITION STUDY';

DATA ANSLAB; INPUT NREC = 2
  NAME $ 1-5 YR 7-8 DAT 10-12 LOC 14-15 TRANS 17 CD 19 TYPE $ 21 MATR $ 23-26
    REP 23 ENVNO 30-33 XBLENO $ 35-37 XBLEWT 39-41 2 XSAMPWT 45-47 2
    SAMNETWT 51-53 2 TOTDRYWT 55-57 2 HNDCALDM 61-66 4
      CD2 #2 19 ENVNO2 #2 30-33 XRBLNO #2 $ 35-37 BEAKNO #2 $ 39-41
      TARWT #2 43-46 4 TARSPLWT #2 48-52 4 XRBLDRWT #2 53-58 4
      XRBLADF #2 60-65 4 XRBLADLR #2 67-72 4 XRBLASH #2 74-79 4;

IF SAMNETWT < 0.1 THEN SAMNETWT = XSAMPWT - XBLEWT;
IF SAMNETWT > 0.2 THEN SAMNETWT = SAMNETWT;
DMP = DIV((TOTDRYWT-XBLEWT),SAMNETWT);
TDW = (TARSPLWT - TARWT) * DMP;
ADFP = DIV((XRBLADF-XRBLDRWT),TDW);
ADLP = DIV((XRBLADF-XRBLADLR),TDW);
CELLP = DIV((XRBLADLR-XRBLASH),TDW);
ADF = (XRBLADF - XRBLDRWT);
ADL = (XRBLADF - XRBLADLR);
CELL = (XRBLADLR - XRBLASH);
DRYWT = (TARSPLWT - TARWT);
IF TDW ¬> 0 THEN TDW = MISS(TDW);
IF ADF ¬> 0 THEN ADF = MISS(ADF);
IF ADL ¬> 0 THEN ADL = MISS(ADL);
IF CELL ¬> 0 THEN CELL = MISS(CELL);
IF DRYWT ¬> 0 THEN DRYWT = MISS(DRYWT);
  IF YR=75 AND DAT > 150 AND DAT < 170 THEN DAY=6163;
  IF YR = 76 AND DAT > 175 AND DAT < 190 THEN DAY = 6183;
  IF YR = 76 AND DAT > 205 AND DAT < 210 THEN DAY = 6206;
  IF YR = 76 AND DAT > 230 AND DAT < 240 THEN DAY = 6234;
  IF YR = 76 AND DAT > 255 AND DAT < 265 THEN DAY = 6262;
  IF YR = 76 AND DAT > 285 AND DAT < 295 THEN DAY = 6290;
  IF YR = 76 AND DAT > 310 AND DAT < 325 THEN DAY = 6320;
  IF YR = 76 AND DAT > 340 AND DAT < 350 THEN DAY = 6346;
  IF YR = 77 AND DAT >   5 AND DAT <  15 THEN DAY = 7010;
  IF YR = 77 AND DAT >  35 AND DAT <  50 THEN DAY = 7040;
  IF YR = 77 AND DAT >  85 AND DAT < 100 THEN DAY = 7090;
  IF YR = 77 AND DAT > 125 AND DAT < 135 THEN DAY = 7130;
  IF LOC=1 OR LOC=3 OR LOC=4 OR LOC=10 OR LOC=13 OR LOC=14 OR LOC=16
  OR LOC=17 OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23
  OR LOC=28 THEN SITE = 'LPRG';
  IF LOC=2 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=8 OR LOC=9 OR LOC=11 OR LOC=12
  OR LOC=15 OR LOC=18 OR LOC=24 OR LOC=25 OR LOC=26 OR LOC=27
  OR LOC=29 THEN SITE = 'SHPRG';
OUTPUT; CARDS


 604 OBSERVATIONS IN DATA SET ANSLAB        37  VARIABLES

PROC SORT OUT=ANSILABS DATA=ANSLAB; BY DAY SITE;
```

RANGE NUTRITION STUDY

```
PROC ANOVA DATA=ANSILABS;
CLASSES DAY SITE;   MEANS DAY|SITE;
MODEL DMP ADFP ADLP CELLP=DAY;
POOL 'E' RESIDUAL/DAY;
TEST DAY BY 'E';
```

DATA SET ANSILABS

CLASSES	VALUES
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130
SITE	LPRG SHPR

```
PROC SORT OUT=LABSANSI DATA=ANSILABS; BY SITE DAY;
```

```
PROC ANOVA DATA=LABSANSI;
CLASSES SITE DAY;   MEANS SITE|DAY;
MODEL DMP ADFP ADLP CELLP=SITE;
POOL 'E' RESIDUAL/SITE;
TEST SITE BY 'E';
```

DATA SET LABSANSI

CLASSES	VALUES
SITE	LPRG SHPR
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130

RANGE NUTRITION STUDY

ANALYSIS OF VARIANCE FOR VARIABLE DMP   MEAN 0.925371435   C.V. 2.38497249 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.047356850	0.00430516818			
E	592	0.288350450	0.00048707846	0.0114062838	0.00866907462	50
RESIDUAL	592	0.288350450	0.00048707846			
CORRECTED TOTAL	603	0.335707300	0.00055672852			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.047356850	0.00430516818	8.83876	0.0001
DENOMINATOR:	E	592	0.288350450	0.00048707846		

ANALYSIS OF VARIANCE FOR VARIABLE ADFP   MEAN 0.553565162   C.V. 10.6541536 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.07753132	0.00704830202			
E	575	2.00006107	0.00347836709	0.0307936333	0.0234031454	49
RESIDUAL	575	2.00006107	0.00347836709			
CORRECTED TOTAL	586	2.07759240	0.00354537952			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.07753132	0.00704830202	2.02632	0.0239
DENOMINATOR:	E	575	2.00006107	0.00347836709		

RANGE NUTRITION STUDY

ANALYSIS OF VARIANCE FOR VARIABLE ADLP MEAN 0.361517178 C.V. 953.832885 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	143.99156	13.0901419			
E	575	6837.07435	11.8905641	1.80042267	1.36832047	49
RESIDUAL	575	6837.07435	11.8905641			
CORRECTED TOTAL	586	6981.06591	11.9130818			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	143.99156	13.0901419	1.10088	0.3575
DENOMINATOR:	E	575	6837.07435	11.8905641		

ANALYSIS OF VARIANCE FOR VARIABLE CELLP MEAN 0.198090329 C.V. 79.1811541 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.0884933	0.0080448453			
E	575	14.1461430	0.0246019878	0.0818951726	0.0622403063	49
RESIDUAL	575	14.1461430	0.0246019878			
CORRECTED TOTAL	586	14.2346363	0.0242911882			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.0884933	0.0080448453	0.32700	0.9794
DENOMINATOR:	E	575	14.1461430	0.0246019878		

RANGE NUTRITION STUDY

ANALYSIS OF VARIANCE FOR VARIABLE DMP MEAN 0.925371435 C.V. 2.55135668 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.000146652	0.00014665208			
E	602	0.335560647	0.00055740971	0.00496466830	0.00377335399	302
RESIDUAL	602	0.335560647	0.00055740971			
CORRECTED TOTAL	603	0.335707300	0.00055672852			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.000146652	0.00014665208	0.26310	0.6146
DENOMINATOR:	E	602	0.335560647	0.00055740971		

ANALYSIS OF VARIANCE FOR VARIABLE ADFP MEAN 0.553565162 C.V. 10.7652542 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.00008803	0.00008802573			
E	585	2.07750437	0.00355128952	0.0127018206	0.00965357944	294
RESIDUAL	585	2.07750437	0.00355128952			
CORRECTED TOTAL	586	2.07759240	0.00354537952			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.00008803	0.00008802573	0.02479	0.8695
DENOMINATOR:	E	585	2.07750437	0.00355128952		

ANALYSIS OF VARIANCE FOR VARIABLE ADLP MEAN 0.361517178 C.V. 954.745248 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	11.77244	11.7724381			
E	585	6969.29347	11.9133222	0.735680759	0.559128642	294
RESIDUAL	585	6969.29347	11.9133222			
CORRECTED TOTAL	586	6981.06591	11.9130818			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	11.77244	11.7724381	0.98817	0.6787
DENOMINATOR:	E	585	6969.29347	11.9133222		

ANALYSIS OF VARIANCE FOR VARIABLE CELLP MEAN 0.198090329 C.V. 78.7393758 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.0026228	0.0026228193			
E	585	14.2320135	0.0243282282	0.0332451463	0.0252668224	294
RESIDUAL	585	14.2320135	0.0243282282			
CORRECTED TOTAL	586	14.2346363	0.0242911882			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.0026228	0.0026228193	0.10781	0.7420
DENOMINATOR:	E	585	14.2320135	0.0243282282		

APPENDIX P

COMPUTER PRINT PROCEDURE FROM DISK PROGRAM

FOR FIBER COMPONENT ANALYSES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
//XXSHK@3   JOB (XXXXX,503-56-0971),'KAUTZSCH',TIME=1,CLASS=A,
//    TYPRUN=HOLD
***ROUTE PRINT LOCAL
***JOBPARM FORMS=9001
// EXEC SAS,REGION.GO=200K
XXSAS        PROC   SORT=60,VER=7404
XXGO         EXEC PGM=SAS,REGION=127K
XXSTEPLIB     DD   DSN=SYS1.USERLIB.SAS&VER,DISP=SHR
XX            DD   DSN=SYS1.USERLIB.SASS&VER,DISP=SHR
XX            DD   DSN=SYS3.LINKLIB,DISP=SHR
XXMACRO       DD   UNIT=SYSDA,SPACE=(TRK,20,,CONTIG),DCB=BLKSIZE=1600
XXSASDATA     DD   UNIT=SYSDA,SPACE=(TRK,(80,40,8))
XXSYSPRINT DD   SYSOUT=*
XXFT02F001 DD   SYSOUT=B,DCB=(BLKSIZE=80,RECFM=F) PUNCH OUTPUT
XXFT03F001 DD   SYSOUT=*,DCB=(BLKSIZE=133,LRECL=133,RECFM=FBA)
XXFT05F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT06F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT07F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT08F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT09F001 DD   UNIT=SYSDA,SPACE=(TRK,(2,2)),
XX              DCB=(BLKSIZE=080,LRECL=80,RECFM=FB)
XXSYSOUT    DD SYSOUT=*,DCB=BUFNO=1
XXSORTLIB   DD DSN=SYS1.SORTLIB,DISP=SHR
XXSORTWK01 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK02 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK03 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK04 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
//GO.STEERDMD DD DSN=A8.YR7677.STEER.ADF.DMD,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.SYSIN DD *


  PROC PRINT DATA=STEERDMD; BY DAY TYPE MATR; ID LOC;
    VAR DMP ADFP ADLP CELLP DMD;


  PROC MEANS NOPRINT OUT=STDMDX DATA=STEERDMD; BY DAY TYPE MATR;
    VAR DMP ADFP ADLP CELLP DMD;


  PROC PRINT DATA=STDMDX; BY TYPE MATR; ID DAY;
    VAR DMP ADFP ADLP CELLP DMD;
```

APPENDIX Q

COMPUTER INPUT, PROCEDURES AND ANALYSES FROM DISK PROGRAM FOR FIBER COMPONENTS, SPECIES COMPOSITION AND CHEMICAL COMPONENTS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
//ZSHK8A@3 JOB (XXXXX,5?3-56-?971),'KAUTZSCH',TIME=5,CLASS=A,
//    TYPRUN=HCLD
***ROUTE PRINT LOCAL
***JOBPARM FORMS=9001
// EXEC SAS,REGION.GO=380K
XXSAS       PROC  SORT=60,VER=7404
XXGO        EXEC PGM=SAS,REGION=127K
XXSTEPLIB   DD   DSN=SYS1.USERLIB.SAS&VER,DISP=SHR
XX          DD   DSN=SYS1.USERLIB.SASS&VER,DISP=SHR
XX          DD   DSN=SYS3.LINKLIB,DISP=SHR
XXMACRO     DD   UNIT=SYSDA,SPACE=(TRK,20,,CONTIG),DCB=BLKSIZE=1600
XXSASDATA   DD   UNIT=SYSDA,SPACE=(TRK,(80,40,8))
XXSYSPRINT DD    SYSOUT=*
XXFT02F001 DD    SYSOUT=B,DCB=(BLKSIZE=80,RECFM=F) PUNCH OUTPUT
XXFT03F001 DD    SYSOUT=*,DCB=(BLKSIZE=133,LRECL=133,RECFM=FBA)
XXFT05F001 DD    UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT06F001 DD    UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT07F001 DD    UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT08F001 DD    UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT09F001 DD    UNIT=SYSDA,SPACE=(TRK,(2,2)),
XX               DCB=(BLKSIZE=080,LRECL=80,RECFM=FB)
XXSYSOUT    DD SYSOUT=*,DCB=BUFNO=1
XXSORTLIB   DD DSN=SYS1.SORTLIB,DISP=SHR
XXSORTWK01 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK02 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK03 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK04 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
//GO.FDALL DD DSN=A8.YR76.TO77,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.ALLGRAZE DD DSN=A8.YR7677.GRAZEST,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.CHEM DD DSN=A8.YR76.CH6163.TO6346,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.STEERDMD DD DSN=A8.YR7677.STEER.ADF.DMD,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.SYSIN DD *


PROC SORT OUT=GRAZEVEG DATA=ALLGRAZE; BY DAY LOC;


PROC SORT OUT=FLOWT DATA=FDALL; BY DAY LOC;


DATA FIELD; SET FLOWT;
IF DAY = 6163 OR DAY = 6183 OR DAY = 6206 OR DAY = 6234 OR
   DAY = 6262 OR DAY = 6290 OR DAY = 6320;
IF DAY = 7180 THEN DELETE;
IF LOC>11 AND LOC<19 THEN UNIT = 'SOUTH';
IF LOC <= 11 OR LOC >= 19 THEN UNIT = 'NORTH';
IF LOC=1 OR LOC=2 OR LOC=3 OR LOC=4 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=9
OR LOC=10 OR LOC=11 OR LOC=12 OR LOC=13 OR LOC=14 OR LOC=15 OR LOC=16 OR LOC=18
OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23 OR LOC=24 OR LOC=27 OR LOC=28
OR LOC=29 THEN ACCESS = 'GRAZED';
IF LOC = 8 OR LOC = 17 OR LOC=25 OR LOC=26 THEN ACCESS = 'EXCLOS';


 203 OBSERVATIONS IN DATA SET FIELD         49  VARIABLES


DATA EXCLFLD; SET FIELD; IF ACCESS = 'EXCLOS';
  WGSTDV = WCSTDV;
  WGGRNL = WCGRNL;
  DGLIVE = DCLIVE;
  DGSTDL = DCSTDL;
  DGGRNL = DCGRNL;
  GWSL = CWSL;
  GADSL = CADSL;
  GSLT = CSLT;


  28 OBSERVATIONS IN DATA SET EXCLFLD       49  VARIABLES


PROC SORT OUT=EXCS DATA=EXCLFLD; BY DAY LOC;
```

```
PROC SORT OUT=FLDS DATA=FIELD; BY DAY LOC;

DATA FLDEX; MERGE EXCS FLDS; BY DAY LOC;

 203 OBSERVATIONS IN DATA SET FLDEX          49  VARIABLES

DATA GRVEG; SET GRAZEVEG;
IF DAY = 6163 OR DAY = 6183 OR DAY = 6206 OR DAY = 6234 OR
   DAY = 6262 OR DAY = 6290 OR DAY = 6320;
IF DAY = 7180 THEN DELETE;
IF CLIP = 'C';
IF DAY = 6234 AND LOC = 3 AND TRANS = 1 THEN EGSTDL = 60;
IF DAY = 6234 AND LOC = 3 AND TRANS = 1 THEN EGGRNL = 220;

 203 OBSERVATIONS IN DATA SET GRVEG          59  VARIABLES

PROC SORT OUT=GRAZE DATA=GRVEG; BY DAY LOC;

PROC SORT OUT=WEIGH DATA=FLDEX; BY DAY LOC;

DATA GRAZEWT; MERGE WEIGH GRAZE; BY DAY LOC;
WGLIVE = EGLIVE * (WGSTDV/(EGLIVE + EGSTDL));
WGSTDL = EGSTDL * (WGSTDV/(EGLIVE + EGSTDL));
IF LOC=1 OR LOC=2 OR LOC=3 OR LOC=4 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=9
OR LOC=10 OR LOC=11 OR LOC=12 OR LOC=13 OR LOC=14 OR LOC=15 OR LOC=16 OR LOC=18
OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23 OR LOC=24 OR LOC=27 OR LOC=28
OR LOC=29 THEN ACCESS = 'GRAZED';
IF LOC = 8 OR LOC = 17 OR LOC=25 OR LOC=26 THEN ACCESS = 'EXCLOS';
IF LOC>11 AND LOC<19 THEN UNIT = 'SOUTH';
IF LOC <= 11 OR LOC >= 19 THEN UNIT = 'NORTH';
EGSTDL = EGSTDL + 0;
EGGRNL = EGGRNL + 0;
  GPCLIVE = DIV(EGLIVE,(EGLIVE + EGSTDL));
GPCSTDL = 1.0 - GPCLIVE;
GRAWSPP = GANGE+GANVI+GPAVI+GSONU+GANTE+GBOSA+GLECO+GPASC+GPASP+GSPO+GSET+GBOCU
+GBUDA+GBOGR+GBOHI+GCYDA+GARI+GWSAG+GBRJA+GCSAG+GCARX+GCSPG+GSCSC+GWSPG+GCAFA+
GCIR+GERCA+GERST+GGUDR+GPLA+GANFB+GACLA+GAMPS+GARLU+GASER+GHEL+GLESP+GSAPI
+GSCLA+GSOLI+GPRFB+GWOOD;
IF DGLIVE > 1 THEN GLIVFTR1 = DIV(DGLIVE,GRAWSPP) * 20;
IF DGLIVE ¬> 1 THEN GLIVFTR2 = 0;
GLIVFTR = (GLIVFTR2 = 0) * GLIVFTR1;
GANGE=GANGE*GLIVFTR; GANVI=GANVI*GLIVFTR; GPAVI=GPAVI*GLIVFTR;
GSONU=GSONU*GLIVFTR; GANTE=GANTE*GLIVFTR; GBOSA=GBOSA*GLIVFTR;
GLECO=GLECO*GLIVFTR; GPASC=GPASC*GLIVFTR; GPASP=GPASP*GLIVFTR;
GSPO =GSPO *GLIVFTR; GSET =GSET *GLIVFTR; GBOCU=GBOCU*GLIVFTR;
GBUDA=GBUDA*GLIVFTR; GBOGR=GBOGR*GLIVFTR; GBOHI=GBOHI*GLIVFTR;
GCYDA=GCYDA*GLIVFTR; GARI =GARI *GLIVFTR; GWSAG=GWSAG*GLIVFTR;
GBRJA=GBRJA*GLIVFTR; GCSAG=GCSAG*GLIVFTR; GCARX=GCARX*GLIVFTR;
GSCSC=GSCSC*GLIVFTR; GCSPG=GCSPG*GLIVFTR; GACLA=GACLA*GLIVFTR;
GARLU=GARLU*GLIVFTR; GASER=GASER*GLIVFTR; GCAFA=GCAFA*GLIVFTR;
GCIR =GCIR *GLIVFTR; GERCA=GERCA*GLIVFTR; GERST=GERST*GLIVFTR;
GGUDR=GGUDR*GLIVFTR; GAMPS=GAMPS*GLIVFTR; GHEL =GHEL *GLIVFTR;
GLESP=GLESP*GLIVFTR; GPLA =GPLA *GLIVFTR; GSAPI=GSAPI*GLIVFTR;
GSCUN=GSCUN*GLIVFTR; GSOLA=GSOLA*GLIVFTR; GSOLI=GSOLI*GLIVFTR;
GANFB=GANFB*GLIVFTR; GPRFB=GPRFB*GLIVFTR; GSHRUBS=GWOOD * GLIVFTR;
GWSPG = GWSPG * GLIVFTR;
GTALLGRS = GANGE + GANVI + GPAVI + GSONU;
GMIDGRS  = GANTE + GBOSA + GLECO + GPASC + GPASP + GSPO + GSET + GBOCU;
GSHRTGRS = GBUDA + GBOGR + GBOHI + GCYDA;
GWSAGRS = GARI + GWSAG;
GCSGRS = GBRJA + GCSAG + GCARX + GCSPG;
GWSGRS = GTALLGRS + GMIDGRS + GSHRTGRS + GWSAGRS + GSCSC;
GANFBS = GCAFA + GCIR + GERCA + GERST + GGUDR + GPLA + GANFB;
GPRFBS = GACLA + GAMPS + GARLU + GASER + GHEL + GLESP + GSAPI +
         GSOLA + GSOLI + GPRFB;
GSPFBS = GACLA + GCIR + GERCA + GERST + GPLA + GANFB;
GESUFBS = GHEL + GLESP + GSAPI + GSCUN + GSOLA + GPRFB;
GLSUFBS = GAMPS + GARLU + GASER + GCAFA + GGUDR + GSOLI;
GLSUSPP = GLSUFBS + GSHRUBS;
GMISCGRS = GSHRTGRS + GWSAGRS + GWSPG;
GGRASS = GTALLGRS + GSCSC + GMIDGRS + GCSGRS + GMISCGRS;
GFORBS = GSPFBS + GESUFBS + GLSUFBS;
GALLSPP = GGRASS + GFORBS + GSHRUBS;
PCTALL = DIV(GTALLGRS,GALLSPP);
PCMID = DIV(GMIDGRS,GALLSPP);
PCSHRT = DIV(GSHRTGRS,GALLSPP);
PCWSAG = DIV(GWSAGRS,GALLSPP);
PCCSGRS = DIV(GCSGRS,GALLSPP);
```

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
PCWSGRS = DIV(GWSGRS,GALLSPP);
PCFORBS = DIV(GFORBS,GALLSPP);
PCGRASS = DIV(GGRASS,GALLSPP);
PCSCSC = DIV(GSCSC,GALLSPP);
PCSPFBS = DIV(GSPFBS,GALLSPP);
PCESUFBS = DIV(GESUFBS,GALLSPP);
PCLSUFBS = DIV(GLSUFBS,GALLSPP);
PCLSUSPP = DIV(GLSUSPP,GALLSPP);
PCTLSCSC = DIV((GTALLGRS + GSCSC),GALLSPP);
PCMISCGS = DIV((GSHRTGRS + GWSAGRS + GWSPG),GALLSPP);

 203 OBSERVATIONS IN DATA SET GRAZEWT      142  VARIABLES

PROC SORT OUT=CHEMS DATA=CHEM; BY DAY LOC;

PROC SORT OUT=GRAZEWTS DATA=GRAZEWT; BY DAY LOC;

DATA CLIPCHEM; MERGE CHEMS GRAZEWTS; BY DAY LOC;
IF DAY=6163 OR DAY=6183 OR DAY=6206 OR DAY=6234 OR DAY=6262 OR DAY=6290
OR DAY=6320;
GNLIVE = GNLIVE * 0.01;
GPLIVE = GPLIVE * 0.01;
GKLIVE = GKLIVE * 0.01;
GCALIVE = GCALIVE * 0.01;
PCM2=PCMID*PCMID;
PCC2=PCCSGRS*PCCSGRS;
PCS2=PCSPFBS*PCSPFBS;
PCE2=PCESUFBS*PCESUFBS;
PCL2=PCLSUSPP*PCLSUSPP;
PCT2=PCTLSCSC*PCTLSCSC;
PCMI2=PCMISCGS*PCMISCGS;

 203 OBSERVATIONS IN DATA SET CLIPCHEM     177  VARIABLES

DATA CLPCH163;SET CLIPCHEM;IF DAY=6163;

  29 OBSERVATIONS IN DATA SET CLPCH163     177  VARIABLES

PROC SORT OUT=STEERX DATA=STEERDMD;   BY DAY LOC;

PROC SORT OUT=CHEMCLIP DATA=CLIPCHEM; BY DAY LOC;

DATA CHEMSTRX; MERGE STEERX CHEMCLIP; BY DAY LOC;
IF DAY=6163;
PCTALL2=PCTALL*PCTALL;
PCWSAG2=PCWSAG*PCWSAG;

  68 OBSERVATIONS IN DATA SET CHEMSTRX     229  VARIABLES

PROC REGR S CORR DATA=CHEMSTRX;
MODEL ADFP=PCTALL PCTALL2;
MODEL ADFP=PCWSAG PCWSAG2;
```

```
*******************************************************************************************
*                                                                                         *
*  PROC REGR    :  RANGE NUTRITION - EFFECT OF SPECIES COMP ON ADF & NBDMD                *
*                                                                                         *
*  DATA SET     :  CHEMSTRX       NUMBER OF VARIABLES =  5      NUMBER OF CLASSES =  0    *
*                                                                                         *
*  VARIABLES    :  ADFP PCTALL PCWSAG PCTALL2 PCWSAG2                                     *
*                                                                                         *
*******************************************************************************************
```

N = 27   CORRELATION COEFFICIENTS / PROB > |R| UNDER HO: RHO=0

	ADFP	PCTALL	PCWSAG	PCTALL2	PCWSAG2
ADFP	1.000000 0.0000	0.307672 0.1185	-0.233708 0.2407	0.229575 0.2494	-0.084918 0.6737
PCTALL	0.307672 0.1185	1.000000 0.0000	-0.328759 0.0941	0.960935 0.0001	-0.272793 0.1686
PCWSAG	-0.233708 0.2407	-0.328759 0.0941	1.000000 0.0000	-0.347713 0.0755	0.926527 0.0001
PCTALL2	0.229575 0.2494	0.960935 0.0001	-0.347713 0.0755	1.000000 0.0000	-0.264148 0.1831
PCWSAG2	-0.084918 0.6737	-0.272793 0.1686	0.926527 0.0001	-0.264148 0.1831	1.000000 0.0000

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE ADFP

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	2	0.00541520	0.00270760	2.14530	0.1374	0.15166167	6.99245 %
ERROR	24	0.03029060	0.00126211			STD DEV	ADFP MEAN
CORRECTED TOTAL	26	0.03570580				0.03552616	0.50806

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
PCTALL	1	0.00337999	2.67805	0.1148	0.00353334	2.79956	0.1073
PCTALL2	1	0.00203521	1.61255	0.2163	0.00203521	1.61255	0.2163

SOURCE	B VALUES	T FOR H0:B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	0.49502377	53.05337	0.0001	0.00933032	0.0
PCTALL	0.66364245	1.67319	0.1073	0.39663366	1.13658083
PCTALL2	-3.15188271	-1.26986	0.2163	2.48206569	-0.86260607

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE ADFP

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	2	0.00632016	0.00316008	2.58092	0.0950	0.17700647	6.88721 %
ERROR	24	0.02938564	0.00122440			STD DEV	ADFP MEAN
CORRECTED TOTAL	26	0.03570580				0.03499145	0.50806

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
PCWSAG	1	0.00195024	1.59281	0.2191	0.00606268	4.95155	0.0357
PCWSAG2	1	0.00436992	3.56903	0.0710	0.00436992	3.56903	0.0710

SOURCE	B VALUES	T FOR H0: B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	0.52401379	51.52578	0.0001	0.01016993	0.0
PCWSAG	-1.09228904	-2.22521	0.0357	0.49087071	-1.09524297
PCWSAG2	8.61950943	1.88919	0.0710	4.56255105	0.92985414

```
                    FOUR- AND FIVE- AND SIX-VARIABLE MODELS

        DATA CLPCH206; SET CLIPCHEM; IF DAY=6206;

          29 OBSERVATIONS IN DATA SET CLPCH206      177  VARIABLES

        PROC RSQUARE START = 4 STOP = 6 PRINT = 5 DATA = CLPCH206;
        VAR PCMID PCCSGRS PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC PCMISCGS GNLIVE;

N=   29                              FOUR- AND FIVE- AND SIX-VARIABLE MODELS

                          ALL POSSIBLE REGRESSION MODELS FOR DEPENDENT VARIABLE GNLIVE

NUMBER IN     R-SQUARE    VARIABLES IN MODEL
  MODEL

    4        0.56925146   PCMID PCSPFBS PCESUFBS PCMISCGS
    4        0.57006008   PCMID PCCSGRS PCSPFBS PCESUFBS
    4        0.57125688   PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC
    4        0.57254224   PCCSGRS PCSPFBS PCLSUSPP PCTLSCSC
    4        0.57375085   PCMID PCSPFBS PCESUFBS PCTLSCSC
 -------------------------------------------------------------------
    5        0.57754218   PCMID PCCSGRS PCSPFBS PCLSUSPP PCTLSCSC
    5        0.57818153   PCMID PCSPFBS PCESUFBS PCTLSCSC PCMISCGS
    5        0.58052182   PCMID PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC
    5        0.58136787   PCMID PCCSGRS PCSPFBS PCESUFBS PCMISCGS
    5        0.58146706   PCCSGRS PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC
 -------------------------------------------------------------------
    6        0.58177017   PCCSGRS PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC PCMISCGS
    6        0.58177017   PCMID PCCSGRS PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC
    6        0.58177017   PCMID PCSPFBS PCESUFBS PCLSUSPP PCTLSCSC PCMISCGS
    6        0.58177017   PCMID PCCSGRS PCSPFBS PCESUFBS PCTLSCSC PCMISCGS
    6        0.58177017   PCMID PCCSGRS PCSPFBS PCESUFBS PCLSUSPP PCMISCGS
 -------------------------------------------------------------------

   RANGE NUTRITION-EFFECT OF SPECIES COMP ON CHEMICAL COMPONENTS

                    DATA CLPCH183; SET CLIPCHEM; IF DAY=6183;

                      29 OBSERVATIONS IN DATA SET CLPCH183      177  VARIABLES

                    PROC REGR S DATA=CLPCH183;
                    MODEL GNLIVE=PCMID PCSPFBS PCLSUSPP PCM2 PCE2;

********************************************************************************
*                                                                              *
*  PROC REGR    :  RANGE NUTRITION-EFFECT OF SPECIES COMP ON CHEMICAL COMPONENTS *
*                                                                              *
*  DATA SET     :  CLPCH183     NUMBER OF VARIABLES =  6    NUMBER OF CLASSES = 0 *
*                                                                              *
*  VARIABLES    :  GNLIVE PCMID PCSPFBS PCLSUSPP PCM2 PCE2                     *
*                                                                              *
********************************************************************************
```

RANGE NUTRITION-EFFECT OF SPECIES COMP ON CHEMICAL COMPONENTS

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE GNLIVE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	5	0.00030604	0.00006121	7.73029	0.0004	0.62693510	14.16706 %
ERROR	23	0.00018211	0.00000792			STD DEV	GNLIVE MEAN
CORRECTED TOTAL	28	0.00048815				0.00281387	0.01986

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
PCMID	1	0.00003660	4.62274	0.0423	0.00008212	10.37120	0.0038
PCSPFBS	1	0.00002920	3.68842	0.0673	0.00009322	11.77393	0.0023
PCLSUSPP	1	0.00006810	8.60079	0.0075	0.00001795	2.26733	0.1457
PCM2	1	0.00003305	4.17354	0.0527	0.00006550	8.27284	0.0085
PCE2	1	0.00013909	17.56599	0.0003	0.00013909	17.56599	0.0003

SOURCE	B VALUES	T FOR H0:B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	0.02141469	12.34911	0.0001	0.00173411	0.0
PCMID	-0.07292456	-3.22043	0.0038	0.02264433	-1.75807483
PCSPFBS	0.01872268	3.43132	0.0023	0.00545641	0.51796065
PCLSUSPP	-0.01913051	-1.50576	0.1457	0.01270486	-0.21108503
PCM2	0.19248683	2.87625	0.0085	0.06692275	1.59263921
PCE2	0.03432939	4.19118	0.0003	0.00819087	0.60099290

APPENDIX R

COMPUTER INPUT, PROCEDURES AND ANALYSES FROM DISK PROGRAM FOR FIBER COMPONENTS ON RANGE SITES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
//ZZSHK03   JOB (XXXXX,503-56-0971),'KAUTZSCH',TIME=1,CLASS=A,
//     TYPRUN=HOLD
***ROUTE PRINT LOCAL
***JOBPARM FORMS=0001
// EXEC SAS,REGION.GO=390K
XXSAS       PROC   SORT=60,VER=7404
XXGO        EXEC PGM=SAS,REGION=127K
XXSTEPLIB   DD   DSN=SYS1.USERLIB.SAS&VER,DISP=SHR
XX          DD   DSN=SYS1.USERLIB.SASS&VER,DISP=SHR
XX          DD   DSN=SYS3.LINKLIB,DISP=SHR
XXMACRO     DD   UNIT=SYSDA,SPACE=(TRK,20,,CONTIG),DCB=BLKSIZE=1600
XXSASDATA   DD   UNIT=SYSDA,SPACE=(TRK,(80,40,8))
XXSYSPRINT  DD   SYSOUT=*
XXFT02F001  DD   SYSOUT=B,DCB=(BLKSIZE=80,RECFM=F) PUNCH OUTPUT
XXFT03F001  DD   SYSOUT=*,DCB=(BLKSIZE=133,LRECL=133,RECFM=FBA)
XXFT05F001  DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT06F001  DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT07F001  DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT08F001  DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX               DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT09F001  DD   UNIT=SYSDA,SPACE=(TRK,(2,2)),
XX               DCB=(BLKSIZE=080,LRECL=80,RECFM=FB)
XXSYSOUT    DD  SYSOUT=*,DCB=BUFNO=1
XXSORTLIB   DD  DSN=SYS1.SORTLIB,DISP=SHR
XXSORTWK01  DD  SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK02  DD  SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK03  DD  SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK04  DD  SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
//GO.STEERDMD DD DSN=AB.YR7677.STEER.ADF.DMD,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.SYSIN DD *

DATA STEERDAY; SET STEERDMD;
  IF DAY < 6365 THEN DAYS = DAY;
  IF DAY > 6365 THEN DAYS = DAY-635;
  IF LOC=1 OR LOC=3 OR LOC=4 OR LOC=10 OR LOC=13 OR LOC=14 OR LOC=16
  OR LOC=17 OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23
  OR LOC=28 THEN SITE = 'LPRG';
  IF LOC=2 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=8 OR LOC=9 OR LOC=11 OR LOC=12
  OR LOC=15 OR LOC=18 OR LOC=24 OR LOC=25 OR LOC=26 OR LOC=27
  OR LOC=29 THEN SITE = 'SHPRG';

 649 OBSERVATIONS IN DATA SET STEERDAY       59  VARIABLES

PROC REGR S C DATA=STEERDAY;
MODEL DMD = ADFP ADLP CELLP;
MODEL DMD = ADLP CELLP;
MODEL DMD = ADFP CELLP;
MODEL DMD = ADFP;
MODEL DMD = CELLP;

PROC SORT DATA=STEERDAY; BY SITE;

PROC REGR S C DATA=STEERDAY;    BY SITE;
MODEL DMD = ADFP ADLP CELLP;
MODEL DMD = ADLP CELLP;
MODEL DMD = ADFP CELLP;
MODEL DMD = ADFP;
MODEL DMD = CELLP;
```

```
****************************************************************************************
*                                                                                      *
*  PROC REGR    :  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M               *
*                                                                                      *
*  DATA SET     :  STEERDAY      NUMBER OF VARIABLES =  4      NUMBER OF CLASSES =  0  *
*                                                                                      *
*  VARIABLES    :  ADFP ADLP CELLP DMD                                                 *
*                                                                                      *
****************************************************************************************
```

N = 396 CORRELATION COEFFICIENTS / PROB > |R| UNDER HO: RHO=0

	ADFP	ADLP	CELLP	DMD
ADFP	1.000000 0.0000	0.334031 0.0001	0.828821 0.0001	-0.775983 0.0001
ADLP	0.334031 0.0001	1.000000 0.0000	0.175705 0.0004	-0.254947 0.0001
CELLP	0.828821 0.0001	0.175705 0.0004	1.000000 0.0000	-0.726029 0.0001
DMD	-0.775983 0.0001	-0.254947 0.0001	-0.726029 0.0001	1.000000 0.0000

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE DMD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	1	4.47048391	4.47048391	596.32203	0.0001	0.60214962	30.99560 %
ERROR	394	2.95372395	0.00749676			STD DEV	DMD MEAN
CORRECTED TOTAL	395	7.42420786				0.08658384	0.27934

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
ADFP	1	4.47048391	596.32203	0.0001	4.47048391	596.32203	0.0001

SOURCE	B VALUES	T FOR HO:B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	1.03767411	33.09182	0.0001	0.03135742	0.0
ADFP	-1.62479620	-24.41971	0.0001	0.06653627	-0.77598300

```
*************************************************************************************************************
*                                                                                                           *
*  PROC REGR    :  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                    *
*                                                                                                           *
*                     SITE=LPRG                                                                             *
*                                                                                                           *
*  DATA SET     :  STEERDAY   .  NUMBER OF VARIABLES =  4      NUMBER OF CLASSES =  0                       *
*                                                                                                           *
*  VARIABLES    :  ADEP ADLP CELLP DMD                                                                      *
*                                                                                                           *
*************************************************************************************************************
```

SITE=LPRG

N = 212 CORRELATION COEFFICIENTS / PROB > |R| UNDER HO: RHO=0

	ADEP	ADLP	CELLP	DMD
ADEP	1.000000 0.0000	0.261296 0.0001	0.771972 0.0001	-0.795195 0.0001
ADLP	0.261296 0.0001	1.000000 0.0000	0.108192 0.1163	-0.243126 0.0004
CELLP	0.771972 0.0001	0.108192 0.1163	1.000000 0.0000	-0.710427 0.0001
DMD	-0.795195 0.0001	-0.243126 0.0004	-0.710427 0.0001	1.000000 0.0000

SITE=LPRG

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE DMD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	1	2.24032308	2.24032308	361.17344	0.0001	0.63233585	29.24457 %
ERROR	210	1.30260919	0.00620290			STD DEV	DMD MEAN
CORRECTED TOTAL	211	3.54293228				0.07875850	0.26931

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
ADEP	1	2.24032308	361.17344	0.0001	2.24032308	361.17344	0.0001

SOURCE	B VALUES	T FOR HO:B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	1.07944519	25.11712	0.0001	0.04299638	0.0
ADEP	-1.72515291	-19.00456	0.0001	0.09077624	-0.79519548

```
*************************************************************************************************
*                                                                                               *
*  PROC REG    :  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                         *
*                                                                                               *
*                 SITE=SHPR                                                                     *
*                                                                                               *
*  DATA ...    :  STEERDAY       NUMBER OF VARIABLES =  4       NUMBER OF CLASSES =  0          *
*                                                                                               *
*  VARIABLES   :  ADFP ADLP CELLP DMD                                                           *
*                                                                                               *
*************************************************************************************************
```

SITE=SHPR

N = 184 CORRELATION COEFFICIENTS / PROB > |R| UNDER H0: RHO=0

	ADFP	ADLP	CELLP	DMD
ADFP	1.000000	0.426790	0.876738	-0.759094
	0.0000	0.0001	0.0001	0.0001
ADLP	0.426790	1.000000	0.252411	-0.271547
	0.0001	0.0000	0.0005	0.0002
CELLP	0.876738	0.252411	1.000000	-0.737240
	0.0001	0.0005	0.0000	0.0001
DMD	-0.759094	-0.271547	-0.737240	1.000000
	0.0001	0.0002	0.0001	0.0000

SITE=SHPR

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR DEPENDENT VARIABLE DMD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F	R-SQUARE	C.V.
REGRESSION	1	2.21002129	2.21002129	247.47210	0.0001	0.57622393	32.48545 %
ERROR	182	1.62533018	0.00893039			STD DEV	DMD MEAN
CORRECTED TOTAL	183	3.83535147				0.09450072	0.29090

SOURCE	DF	SEQUENTIAL SS	F VALUE	PROB > F	PARTIAL SS	F VALUE	PROB > F
ADFP	1	2.21002129	247.47210	0.0001	2.21002129	247.47210	0.0001

SOURCE	B VALUES	T FOR H0:B=0	PROB > |T|	STD ERR B	STD B VALUES
INTERCEPT	1.00243958	21.90443	0.0001	0.04576424	0.0
ADFP	-1.53654134	-15.73125	0.0001	0.09767448	-0.75909415

APPENDIX S

COMPUTER INPUT, PROCEDURES AND ANALYSES FROM

DISK PROGRAM FOR CHEMICAL COMPONENTS

ON RANGE SITES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
//ZZSHK@3   JOB (XXXXX,503-56-0971),'KAUTZSCH',TIME=1,CLASS=A,
//    TYPRUN=HOLD
***ROUTE PRINT LOCAL
***JOBPARM FORMS=9001
// EXEC SAS,REGION.GO=380K
XXSAS        PROC   SORT=60,VER=7404
XXGO         EXEC PGM=SAS,REGION=127K
XXSTEPLIB    DD   DSN=SYS1.USERLIB.SAS&VER,DISP=SHR
XX           DD   DSN=SYS1.USERLIB.SASS&VER,DISP=SHR
XX           DD   DSN=SYS3.LINKLIB,DISP=SHR
XXMACRO      DD   UNIT=SYSDA,SPACE=(TRK,20,,CONTIG),DCB=BLKSIZE=1600
XXSASDATA    DD   UNIT=SYSDA,SPACE=(TRK,(80,40,8))
XXSYSPRINT DD   SYSOUT=*
XXFT02F001 DD   SYSOUT=B,DCB=(BLKSIZE=80,RECFM=F) PUNCH OUTPUT
XXFT03F001 DD   SYSOUT=*,DCB=(BLKSIZE=133,LRECL=133,RECFM=FBA)
XXFT05F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT06F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT07F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT08F001 DD   UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX              DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT09F001 DD   UNIT=SYSDA,SPACE=(TRK,(2,2)),
XX              DCB=(BLKSIZE=080,LRECL=80,RECFM=FB)
XXSYSOUT     DD SYSOUT=*,DCB=BUFNO=1
XXSORTLIB    DD DSN=SYS1.SORTLIB,DISP=SHR
XXSORTWK01 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK02 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK03 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK04 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
//GO.CHEMALYS DD DSN=A8.YR7677.CH6163.T07130,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.SYSIN DD *

  DATA CHEMSITE; SET CHEMALYS;
    IF LOC=1 OR LOC=3 OR LOC=4 OR LOC=10 OR LOC=13 OR LOC=14 OR LOC=16
    OR LOC=17 OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23
    OR LOC=28 THEN SITE = 'LPRG';
    IF LOC=2 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=8 OR LOC=9 OR LOC=11 OR LOC=12
    OR LOC=15 OR LOC=18 OR LOC=24 OR LOC=25 OR LOC=26 OR LOC=27
    OR LOC=29 THEN SITE = 'SHPRG';

   348 OBSERVATIONS IN DATA SET CHEMSITE       33  VARIABLES

  PROC SORT OUT=CHEMSORT DATA=CHEMSITE; BY DAY SITE;

  PROC ANOVA DATA=CHEMSORT; BY DAY;
    CLASSES SITE; MEANS SITE;
    MODEL GNLIVE GPLIVE GKLIVE GCALIVE = SITE;
      POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';

                                                  DAY=6163

   DATA SET CHEMSORT

   CLASSES        VALUES

   SITE           LPRG SHPR
```

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
PROC ANOVA DATA=CHEMSORT; BY DAY;
  CLASSES SITE; MEANS SITE;
  MODEL GNDEAD GPDEAD GKDEAD GCADEAD = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';
```

DAY=6163

DATA SET CHEMSORT

CLASSES	VALUES
SITE	LPRG SHPR

```
PROC ANOVA DATA=CHEMSORT; BY DAY;
  CLASSES SITE; MEANS SITE;
  MODEL GNDUNG GPDUNG GKDUNG GCADUNG = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';
```

DAY=6163

DATA SET CHEMSORT

CLASSES	VALUES
SITE	LPRG SHPR

```
PROC ANOVA DATA=CHEMSORT; BY DAY;
  CLASSES SITE; MEANS SITE;
  MODEL GNGRN GPGRN GKGRN GCAGRN = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';
```

DAY=6163

DATA SET CHEMSORT

CLASSES	VALUES
SITE	LPRG SHPR

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

DAY=6163

ANALYSIS OF VARIANCE FOR VARIABLE GNLIVE   MEAN 2.37896552   C.V. 10.0794504 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.15943278	0.159432775			
E	27	1.55243619	0.057497637	0.242595792	0.179651976	15
RESIDUAL	27	1.55243619	0.057497637			
CORRECTED TOTAL	28	1.71186897	0.061138177			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.15943278	0.159432775	2.77286	0.1039
DENOMINATOR:	E	27	1.55243619	0.057497637		

ANALYSIS OF VARIANCE FOR VARIABLE GNDEAD   MEAN 0.859310345   C.V. 38.6223967 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.54157716	0.541577159			
E	27	2.97400905	0.110148483	0.335774422	0.248654485	15
RESIDUAL	27	2.97400905	0.110148483			
CORRECTED TOTAL	28	3.51558621	0.125556650			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.54157716	0.541577159	4.91679	0.0332
DENOMINATOR:	E	27	2.97400905	0.110148483		

STATISTICAL ANALYSIS SYSTEM
DAY=6163

ANALYSIS OF VARIANCE FOR VARIABLE GNDUNG MEAN 1.61250000 C.V. 9.24382832 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.011459359	0.0114593590			
E	26	0.577665641	0.0222179093	0.156548619	0.115803719	14
RESIDUAL	26	0.577665641	0.0222179093			
CORRECTED TOTAL	27	0.589125000	0.0218194444			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.011459359	0.0114593590	0.51577	0.5143
DENOMINATOR:	E	26	0.577665641	0.0222179093		

ANALYSIS OF VARIANCE FOR VARIABLE GNGRN MEAN 1.01793103 C.V. 23.8042649 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.07998110	0.0799811002			
E	27	1.58529476	0.0587146208	0.245149791	0.181543291	15
RESIDUAL	27	1.58529476	0.0587146208			
CORRECTED TOTAL	28	1.66527586	0.0594741379			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.07998110	0.0799811002	1.36220	0.2522
DENOMINATOR:	E	27	1.58529476	0.0587146208		

APPENDIX T

COMPUTER INPUT PROCEDURES AND ANALYSES FROM DISK PROGRAM FOR CHEMICAL COMPONENTS OF LIVE, DEAD, GROUND LITTER AND DUNG BIOMASS ON RANGE SITES

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
//ZSHK@3   JOB (XXXXX,503-56-0971),'KAUTZSCH',TIME=1,CLASS=A,
//    TYPRUN=HOLD
***ROUTE PRINT LOCAL
***JOBPARM FORMS=9001
// EXEC SAS,REGION.GO=380K
XXSAS        PROC   SORT=60,VER=7404
XXGO         EXEC  PGM=SAS,REGION=127K
XXSTEPLIB    DD   DSN=SYS1.USERLIB.SAS&VER,DISP=SHR
XX           DD   DSN=SYS1.USERLIB.SASS&VER,DISP=SHR
XX           DD   DSN=SYS3.LINKLIB,DISP=SHR
XXMACRO      DD   UNIT=SYSDA,SPACE=(TRK,20,,CONTIG),DCB=BLKSIZE=1600
XXSASDATA    DD   UNIT=SYSDA,SPACE=(TRK,(80,40,8))
XXSYSPRINT DD     SYSOUT=*
XXFT02F001 DD     SYSOUT=B,DCB=(BLKSIZE=80,RECFM=F) PUNCH OUTPUT
XXFT03F001 DD     SYSOUT=*,DCB=(BLKSIZE=133,LRECL=133,RECFM=FBA)
XXFT05F001 DD     UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX                DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT06F001 DD     UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX                DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT07F001 DD     UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX                DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT08F001 DD     UNIT=SYSDA,SPACE=(TRK,(10,40)),
XX                DCB=(BLKSIZE=0404,RECFM=VBS,LRECL=32000)
XXFT09F001 DD     UNIT=SYSDA,SPACE=(TRK,(2,2)),
XX                DCB=(BLKSIZE=080,LRECL=80,RECFM=FB)
XXSYSOUT     DD SYSOUT=*,DCB=BUFNO=1
XXSORTLIB    DD DSN=SYS1.SORTLIB,DISP=SHR
XXSORTWK01 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK02 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK03 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
XXSORTWK04 DD SPACE=(TRK,(&SORT),,CONTIG),UNIT=SYSDA
//GO.CHEMALYS DD DSN=A3.YR7677.CH6163.T07130,UNIT=2314,VOL=SER=DISK87,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=2000,RECFM=FB)
//GO.SYSIN DD *
''
```

```
PROC SORT OUT=CHEMAOVS DATA=CHEMALYS; BY DAY LOC;
```

```
PROC ANOVA DATA=CHEMAOVS; CLASSES DAY; MEANS DAY;
  MODEL GNLIVE GPLIVE GKLIVE GCALIVE = DAY;
    POOL 'E' RESIDUAL/DAY; TEST DAY BY 'E';
```

DATA SET CHEMAOVS

CLASSES	VALUES
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
PROC ANOVA DATA=CHEMAOVS; CLASSES DAY; MEANS DAY;
  MODEL GNDEAD GPDEAD GKDEAD GCADEAD = DAY;
    POOL 'E' RESIDUAL/DAY; TEST DAY BY 'E';
```

DATA SET CHEMAOVS

CLASSES	VALUES
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130

```
PROC ANOVA DATA=CHEMAOVS; CLASSES DAY; MEANS DAY;
  MODEL GNGRN GPGRN GKGRN GCAGRN = DAY;
    POOL 'E' RESIDUAL/DAY; TEST DAY BY 'E';
```

DATA SET CHEMAOVS

CLASSES	VALUES
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130

```
PROC ANOVA DATA=CHEMAOVS; CLASSES DAY; MEANS DAY;
  MODEL GNDUNG GPDUNG GKDUNG GCADUNG = DAY;
    POOL 'E' RESIDUAL/DAY; TEST DAY BY 'E';
```

DATA SET CHEMAOVS

CLASSES	VALUES
DAY	6163 6183 6206 6234 6262 6290 6320 6346 7010 7040 7090 7130

ANALYSIS OF VARIANCE FOR VARIABLE GVLIVE   MEAN 1.66596059   C.V. 22.3311707 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	6	28.8568670	4.80947783			
E	196	27.1274207	0.13840521	0.254128397	0.192678988	29
RESIDUAL	196	27.1274207	0.13840521			
CORRECTED TOTAL	202	55.9842877	0.27714994			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	6	28.8568670	4.80947783	34.74925	0.0001
DENOMINATOR:	E	196	27.1274207	0.13840521		

ANALYSIS OF VARIANCE FOR VARIABLE GPLIVE   MEAN 0.103620690   C.V. 27.0500728 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	6	0.289006897	0.0481678161			
E	196	0.169206897	0.0008633005	0.0200704820	0.0152173489	29
RESIDUAL	196	0.169206897	0.0008633005			
CORRECTED TOTAL	202	0.458213793	0.0022683851			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	6	0.289006897	0.0481678161	55.79496	0.0001
DENOMINATOR:	E	196	0.169206897	0.0008633005		

ANALYSIS OF VARIANCE FOR VARIABLE GKLIVE MEAN 1.36497537 C.V. 24.2001481 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	6	12.1348749	2.02247915			
E	196	21.3866000	0.10911531	0.225641787	0.171080589	29
RESIDUAL	196	21.3866000	0.10911531			
CORRECTED TOTAL	202	33.5214749	0.16594790			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	6	12.1348749	2.02247915	18.53525	0.0001
DENOMINATOR:	E	196	21.3866000	0.10911531		

ANALYSIS OF VARIANCE FOR VARIABLE GCALIVE MEAN 0.540247525 C.V. 37.2207538 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	6	0.41409070	0.0690151171			
E	195	7.88479692	0.0404348560	0.137365162	0.104147732	29
RESIDUAL	195	7.88479692	0.0404348560			
CORRECTED TOTAL	201	8.29888762	0.0412879981			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	6	0.41409070	0.0690151171	1.70682	0.1205
DENOMINATOR:	E	195	7.88479692	0.0404348560		

ANALYSIS OF VARIANCE FOR VARIABLE GNDEAD MEAN 0.903971014 C.V. 32.0171238 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	2.7432051	0.249382285			
E	333	27.8944546	0.083767131	0.196907043	0.149515986	29
RESIDUAL	333	27.8944546	0.083767131			
CORRECTED TOTAL	344	30.6376597	0.089062964			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	2.7432051	0.249382285	2.97709	0.0011
DENOMINATOR:	E	333	27.8944546	0.083767131		

ANALYSIS OF VARIANCE FOR VARIABLE GPDEAD MEAN 0.0444767442 C.V. 49.0552939 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.020262610	0.00184205547			
E	332	0.158043204	0.00047603375	0.0148440041	0.0112713128	29
RESIDUAL	332	0.158043204	0.00047603375			
CORRECTED TOTAL	343	0.178305814	0.00051984202			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.020262610	0.00184205547	3.86959	0.0001
DENOMINATOR:	E	332	0.158043204	0.00047603375		

ANALYSIS OF VARIANCE FOR VARIABLE GKDEAD   MEAN 0.257151163   C.V. 59.0265688 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	3.5121115	0.319282868			
E	332	7.6490966	0.023039448	0.103268564	0.0784136057	29
RESIDUAL	332	7.6490966	0.023039448			
CORRECTED TOTAL	343	11.1612081	0.032539965			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	3.5121115	0.319282868	13.85810	0.0001
DENOMINATOR:	E	332	7.6490966	0.023039448		

ANALYSIS OF VARIANCE FOR VARIABLE GCADEAD   MEAN 0.472645349   C.V. 31.2359568 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	1.15916067	0.105378242			
E	332	7.23633207	0.021796181	0.100443602	0.0762686133	29
RESIDUAL	332	7.23633207	0.021796181			
CORRECTED TOTAL	343	8.39549273	0.024476655			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	1.15916067	0.105378242	4.83471	0.0001
DENOMINATOR:	E	332	7.23633207	0.021796181		

ANALYSIS OF VARIANCE FOR VARIABLE GNGRN MEAN 1.09066092 C.V. 30.0192347 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	2.5228790	0.229352638			
E	336	36.0178690	0.107196039	0.222736537	0.169132173	29
RESIDUAL	336	36.0178690	0.107196039			
CORRECTED TOTAL	347	38.5407480	0.111068438			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	2.5228790	0.229352638	2.13956	0.0173
DENOMINATOR:	E	336	36.0178690	0.107196039		

ANALYSIS OF VARIANCE FOR VARIABLE GPGRN MEAN 0.0686781609 C.V. 68.4877518 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.047026437	0.00427513062			
E	336	0.743365517	0.00221239737	0.0319988094	0.0242978856	29
RESIDUAL	336	0.743365517	0.00221239737			
CORRECTED TOTAL	347	0.790391954	0.00227778661			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.047026437	0.00427513062	1.93235	0.0343
DENOMINATOR:	E	336	0.743365517	0.00221239737		

ANALYSIS OF VARIANCE FOR VARIABLE GKGRN MEAN 0.211034483 C.V. 26.7911667 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.22256552	0.0202332288			
E	336	1.07406207	0.0031966133	0.0384633653	0.0292066671	29
RESIDUAL	336	1.07406207	0.0031966133			
CORRECTED TOTAL	347	1.29662759	0.0037366789			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.22256552	0.0202332288	6.32958	0.0001
DENOMINATOR:	E	336	1.07406207	0.0031966133		

ANALYSIS OF VARIANCE FOR VARIABLE GCAGRN MEAN 0.569712644 C.V. 35.9566723 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	2.6710678	0.242824347			
E	336	14.0997034	0.041963403	0.139359832	0.105821073	29
RESIDUAL	336	14.0997034	0.041963403			
CORRECTED TOTAL	347	16.7707713	0.048330753			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	2.6710678	0.242824347	5.78657	0.0001
DENOMINATOR:	E	336	14.0997034	0.041963403		

ANALYSIS OF VARIANCE FOR VARIABLE GNDUNG MEAN 1.80488525 C.V. 13.3628487 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	8.0832805	0.734843678			
E	293	17.0437405	0.058169763	0.176865935	0.134259343	25
RESIDUAL	293	17.0437405	0.058169763			
CORRECTED TOTAL	304	25.1270210	0.082654674			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	8.0832805	0.734843678	12.63274	0.0001
DENOMINATOR:	E	293	17.0437405	0.058169763		

ANALYSIS OF VARIANCE FOR VARIABLE GPDUNG MEAN 0.224934211 C.V. 37.2766568 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.17029871	0.0154817013			
E	292	2.05289997	0.0070304793	0.0614890754	0.0466761217	25
RESIDUAL	292	2.05289997	0.0070304793			
CORRECTED TOTAL	303	2.22319868	0.0073372894			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.17029871	0.0154817013	2.20208	0.0144
DENOMINATOR:	E	292	2.05289997	0.0070304793		

ANALYSIS OF VARIANCE FOR VARIABLE GKDUNG   MEAN 0.220526316   C.V. 47.6564308 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	0.87778954	0.0797990487			
E	292	3.22512625	0.0110449529	0.0770703554	0.0585038215	25
RESIDUAL	292	3.22512625	0.0110449529			
CORRECTED TOTAL	303	4.10291579	0.0135409762			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	0.87778954	0.0797990487	7.22493	0.0001
DENOMINATOR:	E	292	3.22512625	0.0110449529		

ANALYSIS OF VARIANCE FOR VARIABLE GCADUNG   MEAN 0.882565789   C.V. 23.9751814 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAY	11	2.2912288	0.208293532			
E	292	13.0737698	0.044773184	0.155172408	0.117790759	25
RESIDUAL	292	13.0737698	0.044773184			
CORRECTED TOTAL	303	15.3649987	0.050709567			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAY	11	2.2912288	0.208293532	4.65219	0.0001
DENOMINATOR:	E	292	13.0737698	0.044773184		

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
DATA CHEMSITE; SET CHEMALYS;
  IF LOC=1 OR LOC=3 OR LOC=4 OR LOC=10 OR LOC=13 OR LOC=14 OR LOC=16
  OR LOC=17 OR LOC=19 OR LOC=20 OR LOC=21 OR LOC=22 OR LOC=23
  OR LOC=28 THEN SITE = 'LPRG';
  IF LOC=2 OR LOC=5 OR LOC=6 OR LOC=7 OR LOC=8 OR LOC=9 OR LOC=11 OR LOC=12
  OR LOC=15 OR LOC=18 OR LOC=24 OR LOC=25 OR LOC=26 OR LOC=27
  OR LOC=29 THEN SITE = 'SHPRG';

 348 OBSERVATIONS IN DATA SET CHEMSITE      33  VARIABLES

PROC SORT OUT=SITECHEM DATA=CHEMSITE; BY SITE DAY;

PROC ANOVA DATA=SITECHEM;
  CLASSES SITE; MEANS SITE;
  MODEL GNLIVE GPLIVE GKLIVE GCALIVE = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';

  DATA SET SITECHEM

  CLASSES          VALUES

  SITE             LPRG SHPR

PROC ANOVA DATA=SITECHEM;
  CLASSES SITE; MEANS SITE;
  MODEL GNDEAD GPDEAD GKDEAD GCADEAD = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';

  DATA SET SITECHEM

  CLASSES          VALUES

  SITE             LPRG SHPR

PROC ANOVA DATA=SITECHEM;
  CLASSES SITE; MEANS SITE;
  MODEL GNDUNG GPDUNG GKDUNG GCADUNG = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';

  DATA SET SITECHEM

  CLASSES          VALUES

  SITE             LPRG SHPR

PROC ANOVA DATA=SITECHEM;
  CLASSES SITE; MEANS SITE;
  MODEL GNGRN GPGRN GKGRN GCAGRN = SITE;
    POOL 'E' RESIDUAL/SITE; TEST SITE BY 'E';

  DATA SET SITECHEM

  CLASSES          VALUES

  SITE             LPRG SHPR
```

ANALYSIS OF VARIANCE FOR VARIABLE GNLIVE   MEAN 1.66596059   C.V. 31.3493479 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	1.1587968	1.15879680			
E	201	54.8254909	0.27276364	0.190179110	0.144205928	102
RESIDUAL	201	54.8254909	0.27276364			
CORRECTED TOTAL	202	55.9842877	0.27714994			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	1.1587968	1.15879680	4.24836	0.0381
DENOMINATOR:	E	201	54.8254909	0.27276364		

ANALYSIS OF VARIANCE FOR VARIABLE GPLIVE   MEAN 0.108620690   C.V. 43.5735262 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.007950460	0.00795045977			
E	201	0.450263333	0.00224011609	0.0172347389	0.0130684823	102
RESIDUAL	201	0.450263333	0.00224011609			
CORRECTED TOTAL	202	0.458213793	0.00226838511			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.007950460	0.00795045977	3.54913	0.0577
DENOMINATOR:	E	201	0.450263333	0.00224011609		

ANALYSIS OF VARIANCE FOR VARIABLE GKLIVE MEAN 1.36497537 C.V. 29.8905932 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.0623364	0.062336441			
E	201	33.4591384	0.166463375	0.148569286	0.112654686	102
RESIDUAL	201	33.4591384	0.166463375			
CORRECTED TOTAL	202	33.5214749	0.165947895			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.0623364	0.062336441	0.37448	0.5485
DENOMINATOR:	E	201	33.4591384	0.166463375		

ANALYSIS OF VARIANCE FOR VARIABLE GCALIVE MEAN 0.540247525 C.V. 37.0197492 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.29902532	0.299025320			
E	200	7.99986230	0.039999312	0.0731906891	0.0554969087	101
RESIDUAL	200	7.99986230	0.039999312			
CORRECTED TOTAL	201	8.29888762	0.041287998			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.29902532	0.299025320	7.47576	0.0069
DENOMINATOR:	E	200	7.99986230	0.039999312		

ANALYSIS OF VARIANCE FOR VARIABLE GNDEAD MEAN 0.903971014 C.V. 32.1090965 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	1.7402243	1.74022432			
E	343	28.8974354	0.08424908	0.0808370113	0.0613851734	173
RESIDUAL	343	28.8974354	0.08424908			
CORRECTED TOTAL	344	30.6376597	0.08906296			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	1.7402243	1.74022432	20.65571	0.0001
DENOMINATOR:	E	343	28.8974354	0.08424908		

ANALYSIS OF VARIANCE FOR VARIABLE GPDEAD MEAN 0.0444767442 C.V. 49.4854979 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.012634250	0.0126342501			
E	342	0.165671564	0.0004844198	0.00614758208	0.00466825813	172
RESIDUAL	342	0.165671564	0.0004844198			
CORRECTED TOTAL	343	0.178305814	0.0005198420			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.012634250	0.0126342501	26.08120	0.0001
DENOMINATOR:	E	342	0.165671564	0.0004844198		

ANALYSIS OF VARIANCE FOR VARIABLE GKDEAD MEAN 0.257151163 C.V. 69.0761636 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.3702624	0.370262360			
E	342	10.7909458	0.031552473	0.0496146828	0.0376756564	172
RESIDUAL	342	10.7909458	0.031552473			
CORRECTED TOTAL	343	11.1612081	0.032539965			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.3702624	0.370262360	11.73481	0.0010
DENOMINATOR:	E	342	10.7909458	0.031552473		

ANALYSIS OF VARIANCE FOR VARIABLE GCADEAD MEAN 0.472645349 C.V. 32.3303113 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.40972536	0.409725362			
E	342	7.98576737	0.023350197	0.0426814146	0.0324107744	172
RESIDUAL	342	7.98576737	0.023350197			
CORRECTED TOTAL	343	8.39549273	0.024476655			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.40972536	0.409725362	17.54698	0.0001
DENOMINATOR:	E	342	7.98576737	0.023350197		

ANALYSIS OF VARIANCE FOR VARIABLE GNDUNG MEAN 1.80488525 C.V. 15.9160032 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.1230001	0.123000123			
E	303	25.0040209	0.082521521	0.0851352215	0.0646315217	153
RESIDUAL	303	25.0040209	0.082521521			
CORRECTED TOTAL	304	25.1270210	0.082654674			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.1230001	0.123000123	1.49052	0.2207
DENOMINATOR:	E	303	25.0040209	0.082521521		

ANALYSIS OF VARIANCE FOR VARIABLE GPDUNG MEAN 0.224934211 C.V. 38.0346798 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.01276497	0.0127649656			
E	302	2.21043372	0.0073193169	0.0254386365	0.0193119384	152
RESIDUAL	302	2.21043372	0.0073193169			
CORRECTED TOTAL	303	2.22319868	0.0073372894			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.01276497	0.0127649656	1.74401	0.1844
DENOMINATOR:	E	302	2.21043372	0.0073193169		

ANALYSIS OF VARIANCE FOR VARIABLE GKDUNG MEAN 0.220526316 C.V. 52.7404876 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.01768997	0.0176899660			
E	302	4.08522582	0.0135272378	0.0345830396	0.0262539871	152
RESIDUAL	302	4.08522582	0.0135272378			
CORRECTED TOTAL	303	4.10291579	0.0135409762			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.01768997	0.0176899660	1.30773	0.2523
DENOMINATOR:	E	302	4.08522582	0.0135272378		

ANALYSIS OF VARIANCE FOR VARIABLE GCADUNG MEAN 0.882565789 C.V. 25.5497563 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.0091210	0.0091209973			
E	302	15.3558777	0.0508472771	0.0670490265	0.0509008057	152
RESIDUAL	302	15.3558777	0.0508472771			
CORRECTED TOTAL	303	15.3649987	0.0507095666			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.0091210	0.0091209973	0.17938	0.6759
DENOMINATOR:	E	302	15.3558777	0.0508472771		

ANALYSIS OF VARIANCE FOR VARIABLE GNGRN   MEAN 1.09066092   C.V. 29.7152605 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	2.1982575	2.19825747			
E	346	36.3424905	0.10503610	0.0899962187	0.0683416128	174
RESIDUAL	346	36.3424905	0.10503610			
CORRECTED TOTAL	347	38.5407480	0.11106844			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	2.1982575	2.19825747	20.92859	0.0001
DENOMINATOR:	E	346	36.3424905	0.10503610		

ANALYSIS OF VARIANCE FOR VARIABLE GPGRN   MEAN 0.0686781609   C.V. 68.9567626 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.014382271	0.0143822715			
E	346	0.776009683	0.0022428026	0.0131507404	0.00998645276	174
RESIDUAL	346	0.776009683	0.0022428026			
CORRECTED TOTAL	347	0.790391954	0.0022777866			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.014382271	0.0143822715	6.41263	0.0114
DENOMINATOR:	E	346	0.776009683	0.0022428026		

ANALYSIS OF VARIANCE FOR VARIABLE GKGRN   MEAN 0.211034483   C.V. 29.0078665 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.00000219	0.00000218938			
E	346	1.29662540	0.00374747225	0.0169990323	0.0129087828	174
RESIDUAL	346	1.29662540	0.00374747225			
CORRECTED TOTAL	347	1.29662759	0.00373667892			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.00000219	0.00000218938	0.00058	0.9788
DENOMINATOR:	E	346	1.29662540	0.00374747225		

ANALYSIS OF VARIANCE FOR VARIABLE GCAGRN   MEAN 0.569712644   C.V. 38.2494149 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
SITE	1	0.3407772	0.340777177			
E	346	16.4299941	0.047485532	0.0605111867	0.0459511876	174
RESIDUAL	346	16.4299941	0.047485532			
CORRECTED TOTAL	347	16.7707713	0.048330753			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	SITE	1	0.3407772	0.340777177	7.17644	0.0077
DENOMINATOR:	E	346	16.4299941	0.047485532		

APPENDIX U

COMPUTER CARD INPUT, PROCEDURES AND ANALYSES FOR FIBER COMPONENTS OF DUNG DEGRADATION

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
  COMMENT

    THE WATERSHED DUNG DEGRADATION IS ARRANGED SLIGHTLY DIFFERENT THAN
    WHAT APPEARS IN THE INPUT STATEMENT
    DAT IS NOT THE DATE BUT REFERS TO THE NUMBER OF DAYS AFTER DEPOSITION
      SAMPLES WERE COLLECTED ON DAY 0, 30, 60, 120 AND 240
    ENVELOPE NUMBER REMAINS IN COL 30-33 AS ENVNO
    LOCATION DOES NOT REFER TO A TUBE BUT THE NUMBER GIVEN THE PILE
    ALL OTHER INFORMATION REMAINS THE SAME AS LISTED FOR ADF AND DM DATA;

TITLE 'WATERSHED DUNG DEGRADATION 1976';

DATA DUAD; INPUT NREC = 2
  NAME $ 1-5 YR 7-8 DAT 10-12 LOC 14-15 TRANS 17 CD 19 TYPE $ 21 MATR $ 23-26
    REP 28 ENVNO 30-33 XBLENO $ 35-37 XBLEWT 39-41 2 XSAMPWT 45-47 2
    SAMNETWT 51-53 2 TOTDRYWT 55-57 2 HNDCALDM 61-66 4
      CD2 #2 19 ENVNO2 #2 30-33 XRBLNO #2 $ 35-37 BEAKNO #2 $ 39-41
      TARWT #2 43-46 4 TARSPLWT #2 48-51 4 XRBLORWT #2 53-58 4
      XRBLADF #2 60-65 4 XRBLADLR #2 67-72 4 XRBLASH #2 74-79 4;

IF MATR ='DUNG' THEN MATR = 'DUAD';
IF SAMNETWT < 0.1 THEN SAMNETWT = XSAMPWT - XBLEWT;
IF SAMNETWT > 0.2 THEN SAMNETWT = SAMNETWT;
DMP = DIV((TOTDRYWT-XBLEWT),SAMNETWT);
TDW = (TARSPLWT - TARWT) * DMP;
ADFP = DIV((XRBLADF-XRBLDRWT),TDW);
ADLP = DIV((XRBLADF-XRBLADLR),TDW);
CELLP = DIV((XRBLADLR-XRBLASH),TDW);
ADF = (XRBLADF - XRBLDRWT);
ADL = (XRBLADF - XRBLADLR);
CELL = (XRBLADLR - XRBLASH);
DRYWT = (TARSPLWT - TARWT);
IF TDW ¬> 0 THEN TDW = MISS(TDW);
IF ADF ¬> 0 THEN ADF = MISS(ADF);
IF ADL ¬> 0 THEN ADL = MISS(ADL);
IF CELL ¬> 0 THEN CELL = MISS(CELL);
IF DRYWT ¬> 0 THEN DRYWT = MISS(DRYWT);
OUTPUT; CARDS


  66 OBSERVATIONS IN DATA SET DUAD          35  VARIABLES

PROC SORT OUT=DUNG DATA=DUAD; BY MATR DAT ENVNO REP;
```

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

```
PROC ANOVA DATA=DUNG; CLASSES DAT;
  MODEL DMP ADFP ADLP CELLP = DAT;
  MEANS DAT|REP;
    POOL 'ERROR' RESIDUAL/DAT;
  TEST DAT BY 'ERROR';
```

DATA SET DUNG

CLASSES	VALUES
DAT	0 30 60 120 180 240
REP	1 2

```
PROC SORT OUT=DUNG DATA=DUAD; BY MATR DAT ENVNO REP;
```

```
PROC MEANS OUT=DUNX DATA=DUNG; BY MATR DAT ENVNO;
  VAR DMP ADFP ADLP CELLP;
```

```
PROC PRINT DATA=DUNX; BY MATR; ID DAT ENVNO;
  VAR DMP ADFP ADLP CELLP;
```

```
PROC MEANS OUT=DUDA DATA=DUNG; BY MATR DAT;
  VAR DMP ADFP ADLP CELLP;
```

```
PROC PRINT DATA=DUDA; BY MATR; ID DAT;
  VAR DMP ADFP ADLP CELLP;
```

ANALYSIS OF VARIANCE FOR VARIABLE DMP   MEAN 0.943484848   C.V. 0.792074183 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAT	5	0.0229976515	0.00459953030			
ERROR	60	0.0033508333	0.00005584722	0.00847708806	0.00637402758	11
RESIDUAL	60	0.0033508333	0.00005584722			
CORRECTED TOTAL	65	0.0263484848	0.00040536131			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAT	5	0.0229976515	0.00459953030	82.35916	0.0001
DENOMINATOR:	ERROR	60	0.0033508333	0.00005584722		

ANALYSIS OF VARIANCE FOR VARIABLE ADFP   MEAN 0.512110359   C.V. 7.03378407 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAT	5	0.073617858	0.0147235717			
ERROR	60	0.077849609	0.0012974935	0.0408600233	0.0307231545	11
RESIDUAL	60	0.077849609	0.0012974935			
CORRECTED TOTAL	65	0.151467468	0.0023302687			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAT	5	0.073617858	0.0147235717	11.34770	0.0001
DENOMINATOR:	ERROR	60	0.077849609	0.0012974935		

ANALYSIS OF VARIANCE FOR VARIABLE ADLP   MEAN 0.195941257   C.V. 12.1067539 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAT	5	0.0187096054	0.00374192108			
ERROR	60	0.0337643552	0.00056273925	0.0269091241	0.0202332996	11
RESIDUAL	60	0.0337643552	0.00056273925			
CORRECTED TOTAL	65	0.0524739607	0.00080729170			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAT	5	0.0187096054	0.00374192108	6.64948	0.0001
DENOMINATOR:	ERROR	60	0.0337643552	0.00056273925		

ANALYSIS OF VARIANCE FOR VARIABLE CELLP   MEAN 0.203962855   C.V. 10.7166788 %

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	LSD .01	LSD .05	DIVISOR
DAT	5	0.0207615572	0.00415231144			
ERROR	60	0.0286664455	0.00047777409	0.0247946084	0.0186433718	11
RESIDUAL	60	0.0286664455	0.00047777409			
CORRECTED TOTAL	65	0.0494280026	0.00076043081			

TESTS	SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB > F
NUMERATOR:	DAT	5	0.0207615572	0.00415231144	8.69095	0.0001
DENOMINATOR:	ERROR	60	0.0286664455	0.00047777409		

VITA

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Master of Science

Thesis: PLANT, SOIL AND DUNG FACTORS AFFECTING TALLGRASS PRAIRIE VEGETATION DURING DROUGHT CONDITIONS ON A NORTH CENTRAL OKLAHOMA RANGELAND WATERSHED

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Education: Graduated from Custer High School, Custer, South Dakota, May, 1965; enrolled in Animal Science at South Dakota State University, 1965-1968; completed a correspondence course from the University of Wyoming, 1970; received the Associate of Arts degree from Ohlone College in Fremont, California, in June, 1973, with a major in Computer Programming; received the Bachelor of Science degree from California Polytechnic State University, San Luis Obispo, in June, 1975, with a major in Animal Science; completed requirements for the Master of Science degree at Oklahoma State University, July, 1978.

Experience: Raised on a ranch in western South Dakota; Herdsman, Bull Test Station, California Polytechnic State University, San Luis Obispo, June, 1974 through May, 1975; Animal Science Research and Teaching Assistant, Oklahoma State University, September, 1975 through August, 1977; Rangeland Research Assistant, Oklahoma State University, September, 1977 through July, 1978.

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