



Short duration grazing on alfalfa
by Rodolfo Abel Agostinho

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Agronomy

Montana State University

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Abstract:

Livestock grazing alfalfa (*Medicago sativa* L.) usually have higher average daily gains and higher total gains per hectare than livestock grazing pure grass pastures. Problems of stand maintenance and weed encroachment occur if grazing management is not adequate. A grazing method that maintains alfalfa stands and prevents weed encroachment is needed.

This study was conducted to determine the effect of ten Short Duration Grazing (SDG) treatments by comparison of these treatments with traditional grazing and haying treatments. Field studies were conducted at two locations, and greenhouse studies were performed with two alfalfa cultivars in 1987. Information on forage production, plant morphology and accumulation of root reserves was obtained. The best forage production was obtained under hay and traditional grazing treatments. Forage production decreased with increased clipping stress. Leaf area decreased in all the SDG treatments with successive harvests. Leaf area variability increased with high clipping stress. The ratio of axial bud:crown bud did not produce a defined response. Root reserve accumulation was similar at greenhouse and field studies. Total nonstructural carbohydrates were lower with the high stress treatments and higher with the traditional grazing and hay treatments. Forage quality increased with clipping stress but was high under all treatments.

Forage quality and distribution throughout the season were also considered in the evaluation of the grazing systems.

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MONTANA STATE UNIVERSITY
Bozeman, Montana

March 1988

N378
Ag 972

APPROVAL

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This thesis has been read by each member of the author's graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the following:

Drs. R. L. Ditterline and L. E. Welty for their guidance, suggestions and support while serving as my major professors.

Drs. C. Marlow and L. E. Wiesner for their suggestions and assistance while serving on my graduate committee.

Dr. J. Brown for his assistance in chemical analyses utilized in this study.

Dr. N. Hill at the University of Georgia, Athens, Georgia, for his collaboration with the quality forage analyses.

The National Institute for Agricultural Technology (INTA), Argentina, for providing me the financial support for my graduate studies.

My wife and daughter for their support which allowed me to complete this degree.

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ABSTRACT

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This study was conducted to determine the effect of ten Short Duration Grazing (SDG) treatments by comparison of these treatments with traditional grazing and haying treatments. Field studies were conducted at two locations, and greenhouse studies were performed with two alfalfa cultivars in 1987. Information on forage production, plant morphology and accumulation of root reserves was obtained. The best forage production was obtained under hay and traditional grazing treatments. Forage production decreased with increased clipping stress. Leaf area decreased in all the SDG treatments with successive harvests. Leaf area variability increased with high clipping stress. The ratio of axial bud:crown bud did not produce a defined response. Root reserve accumulation was similar at greenhouse and field studies. Total nonstructural carbohydrates were lower with the high stress treatments and higher with the traditional grazing and hay treatments. Forage quality increased with clipping stress but was high under all treatments. Forage quality and distribution throughout the season were also considered in the evaluation of the grazing systems.

CHAPTER 1

INTRODUCTION

Alfalfa (Medicago sativa L.) is the most important forage crop in the world. It is very high yielding, has excellent nutritional quality and is very widely adapted.

Most research has been conducted on how to improve alfalfa's hay production, and only limited research has been conducted on how to best manage alfalfa as a pasture crop. Grazing decreases alfalfa stand life and allows for rapid weed encroachment. A better grazing management system for alfalfa is needed.

Short Duration Grazing (SDG) has been used effectively on other forage species but has not been evaluated for use on alfalfa. The objective of this study was to evaluate the effect of various SDG treatments on alfalfa's yield, morphological characteristics, root reserves, and nutritional value.

CHAPTER 2

LITERATURE REVIEW

History

Alfalfa is the most important forage crop in the world and is grown on more than 33 million hectares (ha) worldwide (5). Alfalfa has a long history as a forage crop. Ancient civilizations (Persians, Medes, Romans) utilized alfalfa to feed domestic animals. Alfalfa was used in Turkey more than 3000 years ago. This geographic area appears to be the main distribution point of alfalfa during its early dissemination (5).

Alfalfa was introduced to the new world by Spanish conquerors shortly after the discovery of America. Initial use was only in South America (81).

In 1851 seed from Chile was planted in California. From this time, an impressive invasion occurred in two periods. For the first 50 years, alfalfa spread primarily throughout the western States. Since the turn of the century, expansion has been primarily in the central and the eastern United States (31). Currently, more than 50% of the alfalfa hectareage is in the midwestern and eastern United States (36,44).

Severe droughts occurred between 1934 and 1936, and alfalfa during this time yielded much better than the common forage crops

(Timothy--Phleum pratense L. and clovers--Trifolium spp.). This greatly improved alfalfa's popularity and resulted in an explosive expansion of the crop in the eastern States (82).

Other factors important to this expansion include: genetic improvement (decreased winter kill and improved pest resistance); adjusting the soil environment (liming and fertilization); improved seed bed preparation and seeding techniques; discovering the physiological principles for crop management (hay and pasture); improved nitrogen fixation (better rhizobia); and new knowledge about pesticides (19).

Cutting Frequency

Many agronomic studies have been conducted on alfalfa. They can generally be divided into hay production and grazing utilization.

Most research has been done on hay production and has generally concentrated on maximizing yield and stand life (especially as affected by winterkill). Research conducted early in this century is considered to include some classic studies.

In 1916, McKee (52) stated that very little work had been done to determine the effect of clipping on subsequent yields of alfalfa. Some state Agricultural Experiment Stations were advising against clipping, while others claimed better weed control, invigorated growth, and greater root development from clipping.

In 1924, Graber (29) stated that alfalfa's response to various cutting treatments was pronounced. Forage yield, stand longevity,

plant vigor, and winter hardiness were greatly affected by cutting frequency at various growth periods. Plants were cut three, four, five, and six times per year. He concluded that

...the lessened vigor, diminution of stands, and consequent lower yields from early and frequent cutting of alfalfa was in part due to: 1) lack of sufficient root reserves for normal growth or an exhaustion of the reserves sufficient to cause actual death; 2) lessened absorptive capacity of plant roots for nutrients; 3) competition from encroaching weeds and grass due to less vigorous plants and thinning stands; and 4) greater susceptibility to winter-killing of plants with low food storage.¹

Grabner (29) stated

A better understanding of the chemical and biological nature of root reserves, their utilization and disposition may well prove significant in the improvement of some of our field practices, such as the proper maintenance of our hay crops, pastures and lawns, the eradication of certain weeds, and the solution of many of our winter-killing difficulties.²

This basic knowledge persisted for several years and was used as a basis for many studies by other researchers (1,30,32,39,56,90,95) who generally confirmed his findings about alfalfa growth behavior.

In 1930, Willard (95) found that extensive reductions of alfalfa root reserves, as measured by total root weight per hectare, consistently resulted in reduced yield and vigor. He did not mention the kind of root reserves.

Cooper and Watson (16) reported on the Total Available Carbohydrates (TAC) in roots of sainfoin (Onobrychis viciifolia

¹Grabner, L. F. 1924. Hay crops: the growth of alfalfa with various cutting treatments. J. Am. Soc. Agron. 16. Page 172.

²Ibid.

Scop.) and alfalfa under several management regimes. They concluded that cutting treatments had little effect on the final TAC level in roots of either species at the end of the growing season.

Reynolds (65) compared nonstructural carbohydrates trends in alfalfa roots with six harvest frequencies (eight, six, five, four, three, and two cuts per year). He obtained the lowest forage yield and the lowest carbohydrate levels with the eight-cut treatment. Many other researchers (4,21,22,23,25,27,55,62,66,72) obtained similar results.

Fall Management

In 1937, Silkett, Megee and Rather (73) analyzed the effect of late summer and early fall cutting on alfalfa winter hardiness in Michigan. They found that total season hay yield from alfalfa cut on critical September dates was significantly less than that of plants which were not cut on these dates. Alfalfa plants cut in September were more susceptible to winter injury.

Rather and Dorrance (64) used sheep to graze the plots during the fall and arrived at similar results. Many researchers (22,33,39,45,51,71,75) have corroborated their findings.

A recent study by Tesar and Yager in 1985 (89) contradicts previous ideas concerning fall management. They state that the third cutting may be made in September or early October in southern Michigan without decreasing subsequent yield or stand persistence. Perhaps the cultivars they were testing had better winterhardiness

than cultivars previously studied. Their findings are not in agreement with a recent Montana study (Welty and Ditterline, unpublished data) who found that cutting alfalfa 15-30 days prior to a killing frost severely reduced stand life and yield.

Many researchers attempted to obtain higher production through an increased number of cuttings per year (1,9,20,21,39,41,42,43,46,47,54,58,59,65,77,78,85,86,88,92,96,97). All studies analyzed alfalfa production under hay management and found decreased yield with increased cutting frequency.

Grazing Alfalfa

There are a limited number of studies related to alfalfa under grazing, and most studies were conducted with alfalfa in mixtures with grasses (1,7,11,12,13,15,23,24,82,85,92,94,97).

In 1924, Cox (19) stated that the alfalfa's value as a pasture crop was becoming better understood but that little research has been done to compare alfalfa with other legumes and with pasture grasses.

Some of the research that followed was done under range conditions (7,11,12,15), and most studies were conducted using simulated grazing. Simulated grazing studies have received criticism, and there is still no agreement on the reliability of these studies (2,7,13,18,49,50,63,91). The main objection is that different results in forage production are obtained under simulated grazing than with grazing animals.

In 1984, Counce, Bouton, and Brown (17) studied alfalfa persistence under mowing and continuous grazing. They reported that the prospects for selecting alfalfa for persistence under grazing was promising, but that such selection could lead to less productive alfalfa cultivars unless care is taken to insure productivity as well as persistence.

In 1939, Hildebrand and Harrison (39) analyzed alfalfa production under a wide combination of frequencies and clipping intensities. They cut alfalfa every 7, 14, and 30 days to heights of 2.5, 7.5, 15, 22.5, and 30 cm. They concluded that: 1) cutting alfalfa frequently and close to the crown resulted in depleted food reserves in the roots and markedly decreased hay yield and plant vigor; 2) alfalfa cut frequently at 30 cm resulted in decreased yield due to leaf loss from mature stems and a lack of vegetative growth; 3) alfalfa remained vigorous when cut back to a 15 cm height either biweekly or monthly. One-week intervals between cuttings failed to allow sufficient stored food to maintain the plant under unfavorable periods of growth; 4) cutting back to the 22.5 cm level resulted in good yields of top growth and roots when cut at weekly or biweekly intervals, whereas the monthly interval of cutting allowed the plants to mature and retarded vegetative growth; and 5) although cutting at 30 cm resulted in an abundance of food storage, the top growth yield above the cutting level was relatively low due to the maturing of the tops below the cutting level.

In 1958, Gross et al. (34) conducted a simulated grazing experiment. They harvested several alfalfa cultivars whenever plant height reached 20 cm. They obtained five and six harvests per year, but dry matter production was lower compared with traditional hay management. They concluded that frequent cutting depressed the yields of all cultivars.

Dennis et al. (21) conducted a three-year study with different clipping frequencies. They began harvesting each season when the alfalfa was 20 cm tall and harvested every one, two, three, four, and six weeks. Alfalfa yield was associated with cutting interval. The more often alfalfa was cut, the less productive it became. Weed invasion increased, and root production and winter survival of alfalfa decreased in all plots cut frequently. Regrowth was stimulated by frequent cutting for a short period, after which new growth was curtailed.

Most recently, Veronesi et al. (93) conducted a study looking for tolerance to frequent cutting regimes. They performed two cycles of phenotypic recurrent selection on alfalfa for its ability to withstand frequent harvesting and evaluated the selected material by harvesting when the plants' height reached 0.30 m, 0.45 m, and 1/10 bloom. The selected alfalfa yielded more than the control for all treatments. The highest yield was obtained with the 0.30 m cutting level. They concluded that the selected alfalfa had increased persistence, dry matter, and crude protein yield within each harvest treatment, but the selection did not eliminate the differences among

harvest treatments. They felt the common farming technique of cutting alfalfa at 1/10 bloom was best for exploiting alfalfa's potential, even with materials selected for tolerance to frequent cutting regimes.

A relatively new grazing system called Short Duration Grazing (SDG) has been successfully used on range and pasturelands (grasses) in southern Africa and the United States (28,38,40,61,87). This system involves subdividing existing range or pasture units into several paddocks (37,67) and grazing each paddock at a high stocking densities for a short time period so that all plants are uniformly grazed (69). All SDG studies have been conducted in areas with different climatic conditions than Montana's and with different types of vegetation (mainly grasses).

In 1980, Savory and Parson (68) described some of the main points of the grazing system. They state that it is not possible to work under rigid preconceptions. The stock (cattle, sheep or goats) are concentrated into substantial herds wherever possible for the desired herd effect of trampling, dunging, and urinating as they move around the paddock. The concentrated stock are held in each paddock for a very short time through the vegetation's growing months. These short periods are ideally anything from one day to about five days. The short grazing periods are interspersed with short rest periods ranging from 30 to 60 days. On planted pastures and with rhizomatous grasses, these rests are further reduced but not, as a general rule, on native range. Stocking rates are generally increased as soon as

it is considered safe. The method is generally, but not always, applied through the use of a grazing cell layout of fencing. These areas, or cells, are developed with very simple, inexpensive fencing from a central point called a cell center. The cell center generally contains water and whatever handling facilities are desired. There are several variations of this theme depending upon topography, herd structures, and fixed features of the ranch.

Alfalfa has not been evaluated using this grazing management system.

CHAPTER 3

MATERIALS AND METHODS

Yield studies were established in the spring of 1986 at the Arthur H. Post Field Research Laboratory near Bozeman, Montana, and at the Northwestern Agricultural Research Center near Kalispell, Montana, to evaluate the effect of different harvest regimes on alfalfa. Two cultivars (Spredor II and Maxim) were seeded in a randomized complete block design with 13 harvest treatments per cultivar, and four replications (Tables 1, 2, and 3). Treatments one to nine were a 3 x 3 factorial of cutting frequency and cutting intensity. Cutting frequencies were 8, 16 and 32 days and cutting intensities were 67, 50 and 33 percent topgrowth removal (Table 1). Treatment 10 was a graduated Short Duration Grazing (SDG) treatment with variable harvesting frequencies and intensities. Plots were cut frequently, but at low intensities early in the grazing season and were cut less frequently but with greater intensity later in the season (Table 2). Treatments 11-13 were controls in which the alfalfa was harvested using traditional grazing and hay (Table 3).

Table 1. Factorial arrangement of clipping frequencies and intensities used to evaluate alfalfa's response to simulated Short Duration Grazing at Bozeman and Kalispell, MT, 1987.

TREATMENT IDENTIFICATION	DAYS BETWEEN HARVEST	TOPGROWTH REMOVED	TOTAL HARVESTS PER TREATMENT
(#)	(ident.)	(days)	(%)
I	8/67	8	67
II	8/50	8	50
III	8/33	8	33
IV	16/67	16	67
V	16/50	16	50
VI	16/33	16	33
VII	32/67	32	67
VIII	32/50	32	50
IX	32/33	32	33

Table 2. Clipping frequencies and intensities of Graduated Short Duration Grazing (SDG) (Treatment 10) applied on alfalfa at Bozeman and Kalispell, MT, and in the greenhouse, 1987.

HARVEST	TOPGROWTH REMOVED	HARVEST FREQUENCY
(#)	(%)	(days)
1	33	8
2	33	8
3	33	16
4	50	16
5	50	32
6	67	Fall Management

Table 3. Traditional grazing and hay treatments (controls) applied on alfalfa at Bozeman and Kalispell, MT, and the greenhouse, 1987.

TREATMENT (#)	IDENTIFICATION (ident.)	TREATMENT DESCRIPTION
11	Prebud	After initial harvest (same date as the other treatments), it was cut at prebud stage to a height of 10 cm until August 14 (three cuts), then deferred until October 16 (Fall Management harvest)
12	Prebloom	Same as prebud, except at prebloom stage (two seasonal and fall harvest)
13	Hay	Harvested twice at ten percent bloom to a height of 10 cm and Fall Management harvest

Bozeman

1986

The experiment was seeded on May 16, 1986, in a Bozeman silt loam (Argic, Udic, Cryoboroll) soil that had previously been fertilized with 100 Kg/Ha of phosphorus. The fertilizer was incorporated and the seed bed firmly packed. Seeding rate was 11.2 Kg/Ha pure live seed (PLS) and the inoculated seed was planted approximately one cm deep. Plots were 1.5 m wide (five rows 30 cm apart) and 6 m long. A single row of orchardgrass (Dactylis glomerata L.) was established between each plot. The experiment was irrigated as needed to avoid moisture stress.

Management treatments were not imposed the establishment year. Only two hay harvests were made (August 4 and November 21). The plants were cut to a 10 cm height at each harvest. Total Dry Matter production was 3,704 and 3,396 Kg/Ha dry forage at each harvest, respectively.

Weeds were controlled by hand weeding in the establishment and 1.12 Kg/Ha AI Metribuzin [4-amino-6-(1,1-dimethoethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one]³ was applied in November 1986.

1987

Replication one was severely infested with Canada thistle (*Cirsium arvense* (L.) Scop.) and was eliminated from the study. The other three replications were relatively weed free.

All plots (except the traditional hay treatment) were harvested to the appropriate height when the alfalfa was 40 cm tall (May 23), and the harvest management treatments (Tables 1, 2, and 3) were then imposed (Table 4). Only one cultivar (Maxim) was used because weather precluded starting the management treatments on Spredor II at the correct time. The first harvest on the graduated short duration grazing treatment (SDG) was harvested one week earlier (May 15) than the other treatments because it rained immediately after these plots were harvested (Appendix A).

³Mention of a trademark, proprietary, product, or vendor is included for the benefit of the reader and does not imply endorsement by Montana State University to the exclusion of other suitable products.

Table 4. Harvest dates at Bozeman and Kalispell, MT, and the greenhouse in 1987.

HARVEST	BOZEMAN	KALISPELL	GREENHOUSE
(#)	(date)	(date)	(date)
1	15/15	5/4	4/27
2	5/23	5/12	5/5-7
3	5/31	5/20	5/13
4	6/8	5/29	5/21
5	6/16	6/5	5/29
6	6/24	6/12	6/6-10
7	7/5	6/22	6/14
8	7/13-14	6/29	6/22
9	7/21	7/7	6/30
10	7/29	7/15	7/8-11
11	8/6	7/23	7/16-19
12	8/14	7/31	7/24
13	10/16 (a)	8/7	8/1
14	—	8/14-18	8/9
15	—	9/25 (a)	8/17
16	—	—	8/25 (b)

(a) Fall Management Harvest

(b) Harvest at ground level

Immediately before harvest, plant height (cm) was determined (average of five measurements per plot) in order to calculate the appropriate cutting height for each treatment.

The plots were trimmed to a length of approximately five meters before each harvest. Forage yield was determined by cutting the center two rows of each plot to the appropriate height with a flail

harvester (Rem Manufacturing Inc., Swift Current, Saskatchewan, Canada) that had been modified to allow cutting at any height to 60 cm. Wet forage weight from each plot was recorded and a small sample (500 grams) was saved for moisture determinations. These samples (one for each plot/harvest) were weighed, dried at approximately 60°C for four days and reweighed. Moisture percentages were used to calculate dry matter yield (Kg/Ha). The dried samples were saved for nutritional analyses.

Seven stems from the border rows of each plot were hand harvested at the same height as the harvested rows, carefully placed in paper bags and maintained in a chest filled with ice until they could be processed for further analysis. The border rows were then cut at the same height as the harvested rows.

The stems were placed in the cool room (2-3°C) of the greenhouse immediately after leaving the field. Average time elapsed from cutting stems in the field to beginning leaf and stem measurements was 24 hours. Wet weight of stems with leaves was obtained. Leaflets from each stem were cut at the base of each pedicel and the total number of leaflets per plant and per stem were recorded. Leaflets from each plant were laid flat between two transparent sheets (10 x 28 cm) and placed on the belt of the leaf area meter (Hayashi Denko Co., AAM-5/7 model). Three measurements per sample were averaged to determine leaf area. A similar technique was used to measure stem area.

The materials were then dried for four days in a draft oven at 26°C and dry matter weights obtained. Leaflet area, stem area, stem area:leaflet area ratio, and dry matter were calculated.

On July 13, it was noted that the leaf area below the harvested cutting height was smaller than above the cutting height. Seven samples were then removed at each harvest, from the crown to the cutting height. They were handled as previously described.

Seven days after each harvest, a random 30 cm of row was measured to determine the number of axial and crown buds. Every visible crown bud was counted. Axial buds were counted when its regrowth level was higher than the previous harvest level. The axial bud:crown bud ratio was calculated for each plot after each harvest. A cumulative ratio was obtained for all buds throughout the growing season and was analyzed with MSUSTAT Program (Newman-Keuls test)(48).

The last forage harvest during the growing season was on August 14 to keep from confounding harvest regimes with fall management. The plots were harvested again on October 16, following a killing frost, at 10 cm height.

Five roots (approximately 30 cm long) per plant were obtained on August 14 and October 16 from the border rows. The roots were immediately hand cleaned, carefully stored in plastic bags and maintained in a chest filled with ice for approximately one hour, then stored in a freezer at -18°C. When the roots were completely frozen, they were cleaned with cold water. Roots were cut at the

crown, 5 cm, and 20 cm below the crown, and root diameter (mm) was measured at each location. Roots (crown level to 20 cm below the crown) from each plot were weighed, placed into a sandwich bag and then into a temperature resistant (autoclave) bag and boiled for 30 minutes to stop the enzymatic activity (53) related with the stored root carbohydrates. The roots were then transferred to a perforated paper envelopes and heat dried on forced draft oven for one hour at 100°C and 24 hours at 70°C (until constant weight). Root weight was obtained. The roots were ground with a Cyclone Sample Mill (UD Corporation, Boulder, CO) and the ground material was stored in carefully sealed glass bottles to avoid moisture absorption (80). Ground root material was analyzed with the procedure described by Smith (83). The material was carefully handled in accordance with suggestions of various researchers (drying methods—60; extraction and analysis methods—33,35,70,76,84).

Forage samples used to determine moisture percentage at each harvest were finely ground with a Laboratory Mill Model 4 (Arthur Thomas Company, Philadelphia, PA), reground with a Cyclone Sample Mill (UD Corporation, Boulder, CO) and sent to Dr. Nick Hill, University of Georgia, Athens, Georgia, for nutritional quality analysis. The analysis was conducted on a Near Infrared Spectrophotometry previously calibrated over the range of each analysis. Analyses included: crude protein, in vitro digestibility (IVDMD), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

Kalispell1986

The experiment was seeded in May 1986 in a Creston silt loam, coarse-silty, mixed family classified as Udic Haploboroll soil with a pH of 7.8, with Spredor II alfalfa at 11.2 kilograms PLS per hectare. Plots were 2.4 m wide (eight rows, 30 cm apart) and 6 m long. Two hay harvests were made on July 28 and October 6. The plots were cut to 10 cm height. Total dry matter production was 5,425 and 2,959 Kg/Ha of forage at each harvest. All other procedures were the same as Bozeman.

1987

Forage yield, axial and crown bud, plant height, and forage quality measurements were obtained the same as Bozeman. The harvest management treatments (Tables 1, 2, and 3) were initiated on May 5.

Greenhouse

Three hundred and ninety-six Conetainers (Ray Leach Inc., Canby, OR) with 300 cubic centimeters capacity were filled with commercially available Sunshine Mix # 1 (Fisons Western Co., Canada). Spredor II (two seeds/conetainer) was planted on January 29, 1987, in the Plant Growth Center at Bozeman, Montana. The plants were grown with 16 hours day and 8 hours night photoperiod. Temperature was 26.4°C during the day and 18°C at night. Plants were irrigated daily throughout the trial.

After emergence, seedlings were thinned to one plant per container. The previously describe harvest treatments (Tables 1, 2, and 3) were arranged in a randomized complete block design with four replications. Each plot consisted of seven plants.

Granular fertilizer (100 Kg/Ha N,P,K) was applied on April 15. The plants were then allowed to grow until flowering (March 12) when they were cut back to 10 cm. Harvest management treatments (Tables 1, 2, and 3) were started on April 27, 1987, when the alfalfa was cut to the appropriate height with scissors. The procedures used were the same as for the Bozeman Field study with the exception of leaf area determinations. The forage obtained at each harvest was separated in two groups: the main stem and the remaining material. After weighing the two groups (and calculating the total forage per plot), the main stem was utilized to obtain information on leaf area as described in the Bozeman study.

One week after the last cutting date, all plants were harvested at soil level and total forage was determined.

A record was kept on the number of live plants/plot, live shoot:dead shoot ratio of each plant, and visual observations on morphological changes during the trial.

Roots of each plant were frozen immediately after the last cut and processed in the same manner described for the Bozeman study.

CHAPTER 4

RESULTS AND DISCUSSION

Forage ProductionForage Quantity

Bozeman—Total Annual Forage Yields (May–October). Significant differences were obtained among the 13 treatments for total forage production of Maxim alfalfa (Table 5).

Hay, Prebud and Prebloom treatments produced the highest yields. Although there were no significant differences among these treatments ($p = 0.09$), there was a tendency for increasing yield with fewer harvests.

The eight-day clipping frequency treatments produced the least amount of forage, particularly at the high intensities (50 and 67%). The graduated SDG, 32/50, 16/33, 32/33 and 16/50 treatments had similar yields.

Total forage yields increased almost linearly when the rest period was increased for treatments where 50 and 67% of the topgrowth was removed (Figure 1). Total forage yields for the less stressful treatments (33% topgrowth removal) increased as the rest period was increased from 8 to 16 days but decreased as the rest period was increased from 16 to 32 days.

Table 5. Dry matter forage production of Maxim alfalfa at Bozeman in 1987 as affected by hay and simulated grazing treatments.

TREATMENT	YIELD		
	SEASONAL	FALL	TOTAL
	(May-Aug.)	(10/16)	
	-----kilograms hectare ⁻¹ -----		
8/67	6,352	497	6,849
8/50	5,834	847	6,681
8/33	6,934	1,314	8,248
16/67	7,871	723	8,594
16/50	8,550	1,643	10,193
16/33	7,032	3,671	10,703
32/67	7,989	2,728	10,717
32/50	7,775	4,032	11,807
32/33	5,154	5,051	10,205
Graduated SDG	88,272	3,019	11,291
Prebud	11,260	1,656	12,916
Prebloom	9,905	3,513	13,418
Hay	11,520	2,509	14,029
LSD (0.05)	1,136	361.7	1,402

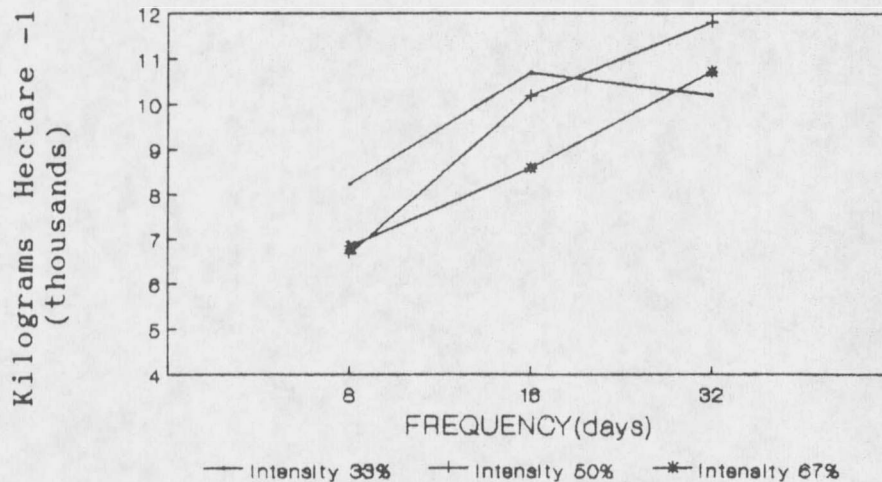


Figure 1. Total Dry Matter forage production of Maxim alfalfa as affected by clipping frequency and clipping intensity at Bozeman in 1987 (LSD at 0.05 = 791.9).

Bozeman-Seasonal Forage Yields (May-August). Hay and

traditional grazing treatments (Prebud and Prebloom) produced more forage from May through August than the other grazing treatments (Table 5). Treatments Graduated SDG and 16/50 produced the most forage of the SDG treatments during the grazing season. Treatment 32/33 produced almost 50% of the total annual yield in October. Treatments that have a high percentage of the total forage produced in October would not be desirable because less forage would be available for grazing.

Seasonal yield of the 33% intensity remained relatively constant as clipping frequency decreased from 8 to 16 days and

decreased when clipping frequency was decreased to 32 days (Figure 2).

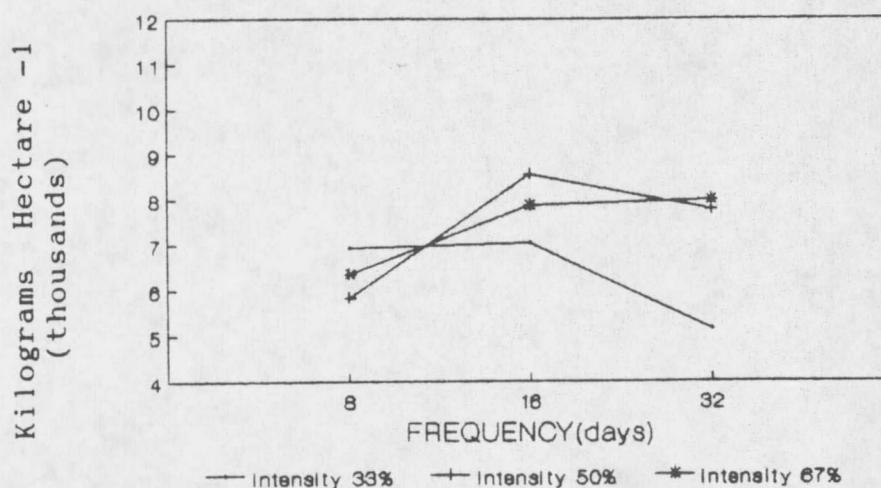


Figure 2. Seasonal Dry Matter forage production of Maxim alfalfa as affected by clipping frequency and clipping intensity at Bozeman in 1987 (LSD at 0.05 = 772.6).

Seasonal yield of the 67% intensity increased as clipping frequency decreased. Seasonal yield of the 50% intensity increased dramatically as clipping frequency decreased from 8 to 16 days, then decreased when clipping frequency was further decreased to 32 days. It appears that not enough topgrowth was removed on treatment 32/33 to allow adequate forage production from May through August. The lower yields of the 32/33 treatment may have been due to excessive leaf loss from shading.

Kalispell--Total Annual Forage Yields (May-October). Total annual forage production trends at Kalispell (Table 6) were similar to these at Bozeman (Table 5). Traditional treatments (Hay and Prebloom) produced the highest yields (Table 6). Hay produced 12 and 50% more forage than Prebloom and Prebud treatments, respectively. Four SDG grazing treatments (16/33, 32/67, 32/33 and Graduated) produced similar forage as the Prebud treatment. The interaction between frequency and intensity was non significant at Kalispell. Total forage yields increased almost linearly as days among harvests increased (Table 7). The shorter rest periods increased stress and reduced yields as compared to the longer rest periods. No differences were obtained between the 67 and 50% intensity treatment. Yields were significantly higher for the 33% treatment as compared to the 67 and 50% treatments (Table 8).

Kalispell--Seasonal Forage Yields (May-August). Low clipping intensity treatments (33 and 50%) had the lowest yields, regardless of clipping frequency (Table 6). Hay, Prebud and Prebloom treatments produced twice as much seasonal forage as most of the SDG treatments. The 32/67 treatment, which is similar to the Prebud treatment, produce more forage than any SDG treatment.

Seasonal production of the 67% intensity treatments was not affected by harvest interval (Figure 3). Forage yields for 50%

Table 6. Dry Matter Forage production of Spredor II alfalfa at Kalispell in 1987 as affected by haying and simulated grazing treatments.

TREATMENT	YIELD		
	SEASONAL	FALL	TOTAL
	(May-Aug.)	(9/25)	
	-----kilograms hectare ⁻¹ -----		
8/67	6,662	1,408	8,070
8/50	5,750	2,477	8,227
8/33	6,377	3,374	9,751
16/67	6,815	1,412	8,227
16/50	6,041	2,881	8,922
16/33	5,066	5,313	10,379
32/67	7,247	3,042	10,289
32/50	5,357	4,036	9,393
32/33	5,050	6,350	11,400
Graduated SDG	10,244	1,099	11,343
Prebud	10,278	594	10,872
Prebloom	9,668	4,812	14,480
Hay	11,029	5,245	16,274
LSD (0.05)	603.9	492.7	897.9

Table 7. Total forage production of 8, 16 and 32 day clipping frequency treatments at Kalispell in 1987 (averaged across intensity treatments).

REST PERIOD (days)	TOTAL DRY MATTER FORAGE (kilograms hectare ⁻¹)
8	8,683
16	9,170
32	10,360
LSD (0.05)	550.6

Table 8. Total forage production of 33, 50 and 67% intensity treatments at Kalispell in 1987 (averaged across clipping frequency treatments).

INTENSITY (% topgrowth removed)	TOTAL DRY MATTER FORAGE (kilograms hectare ⁻¹)
67	8,860
50	8,845
33	10,510
LSD (0.05)	550.6

treatments were reduced when the cutting interval was increased from 16 to 32 days and yields for the 33% treatments were reduced as the interval was increased from 8 to 16 days.

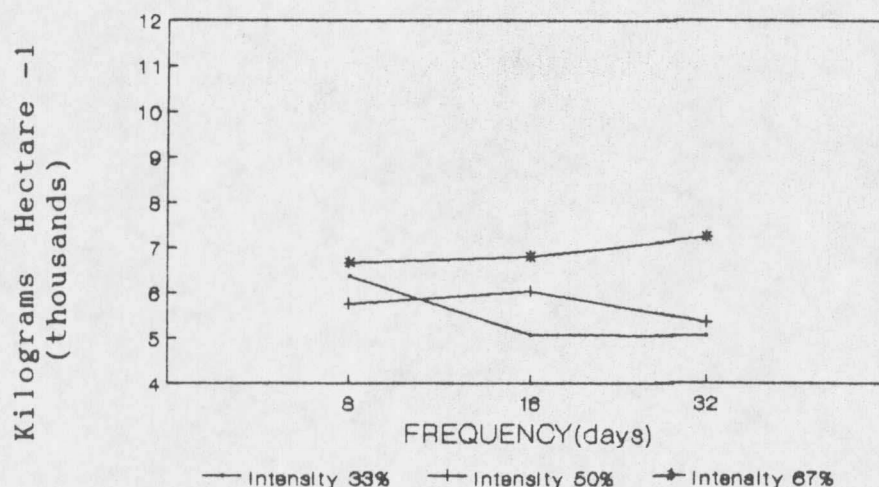


Figure 3. Seasonal Dry Matter production of Spredor II alfalfa as affected by clipping frequency and clipping intensity at Kalispell in 1987 (LSD at 0.05 = 374.6).

Greenhouse—Total Annual Forage Yields (May–August). As in the field studies, traditional management treatments (Hay, Prebud and Prebloom) produced the highest forage yields, and the treatments with higher stress (8/67 and 8/50) produced the lowest yields (Table 9).

The pattern for the significant frequency x intensity interaction, when total forage production was considered (Figure 4) was similar to Bozeman (Figure 1). Total forage yield responses for the 50 and 67% frequency intervals were almost linear, whereas a rest increase from 16 to 32 days decreased the yield of the 8-day treatment.

Table 9. Dry Matter Forage production of Spredor II alfalfa at the greenhouse in 1987 as affected by hay and simulated grazing treatments.

TREATMENT	YIELD		
	SEASONAL	LAST CUT	TOTAL
	(May-Aug.)	(8/25)	
	-----grams plant ⁻¹ -----		
8/67	1.803	0.422	2.225
8/50	1.890	0.510	2.400
8/33	1.830	0.948	2.778
16/67	2.205	0.660	2.865
16/50	1.963	1.134	3.097
16/33	1.680	1.475	3.155
32/67	2.102	1.243	3.345
32/50	1.670	1.615	3.285
32/33	1.030	1.843	2.873
Graduated SDG	2.223	0.957	3.180
Prebud	2.392	1.593	3.985
Prebloom	2.110	1.583	3.693
Hay	2.440	1.450	3.890
LSD(0.05)	0.336	0.181	0.399

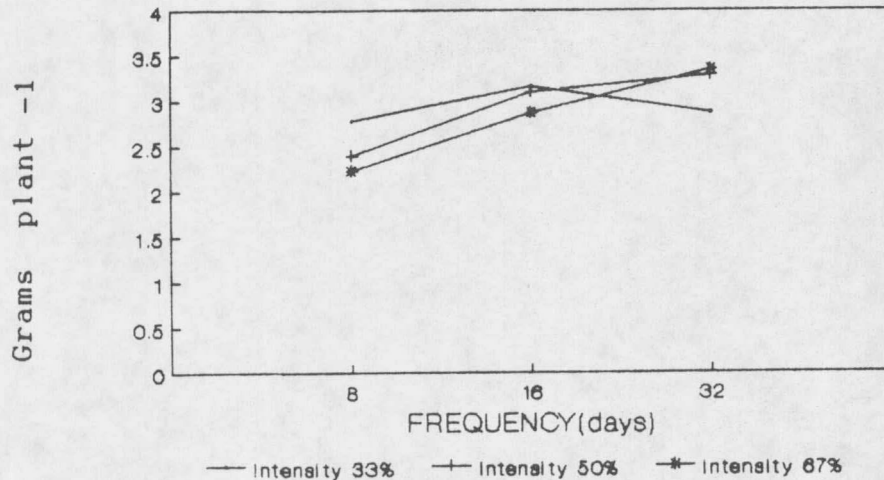


Figure 4. Total Dry Matter forage production of Spredor II alfalfa as affected by clipping frequency and clipping intensity at the greenhouse in 1987 (LSD at 0.05 = 0.226).

Greenhouse Seasonal Forage Yields (May-August). It is not possible to compare last harvest yields from the greenhouse study with the field studies, because different methodologies were used. Alfalfa at Bozeman and Kalispell were allowed a regrowth period after the last seasonal harvest of at least 45 days (until the first killing frost) and then were cut at 10 cm height. Alfalfa in the greenhouse study regrew only one week after the last seasonal harvest and were cut at ground level so that total dry matter production for the experiment could be determined.

Traditional management treatments produced the highest seasonal yields (Table 9). Graduated SDG, 32/67 and 16/67 had forage yields similar to the traditional treatments (Appendix B).

There was an interaction between frequency and intensity of clipping for seasonal forage production (Figure 5). It was similar to the interactions at at Bozeman and Kalispell, with only minor differences in the slope of the curves. As the number of days between harvest increased from 16 to 32 days, yields were decreased for all clipping intensities.

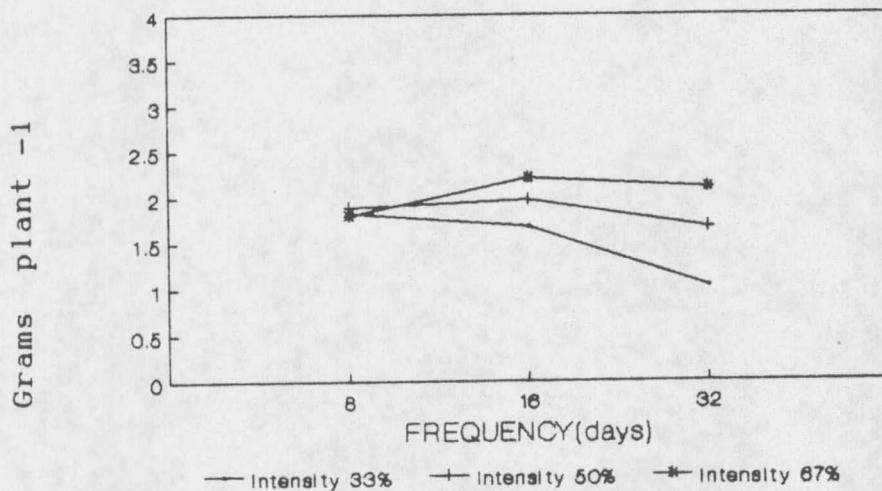


Figure 5. Seasonal Dry Matter forage production of Spredor II alfalfa as affected by clipping frequency and clipping intensity at the greenhouse in 1987 (LSD at 0.05 = 0.168).

Forage Quality

Crude Protein—Bozeman. Total crude protein production followed the same pattern as dry matter production at Bozeman (Figure 6). Prebud, Prebloom and Hay treatments produced more crude protein than many of the SDG treatments (8/67, 8/50, 8/33, 16/67, and 32/33).

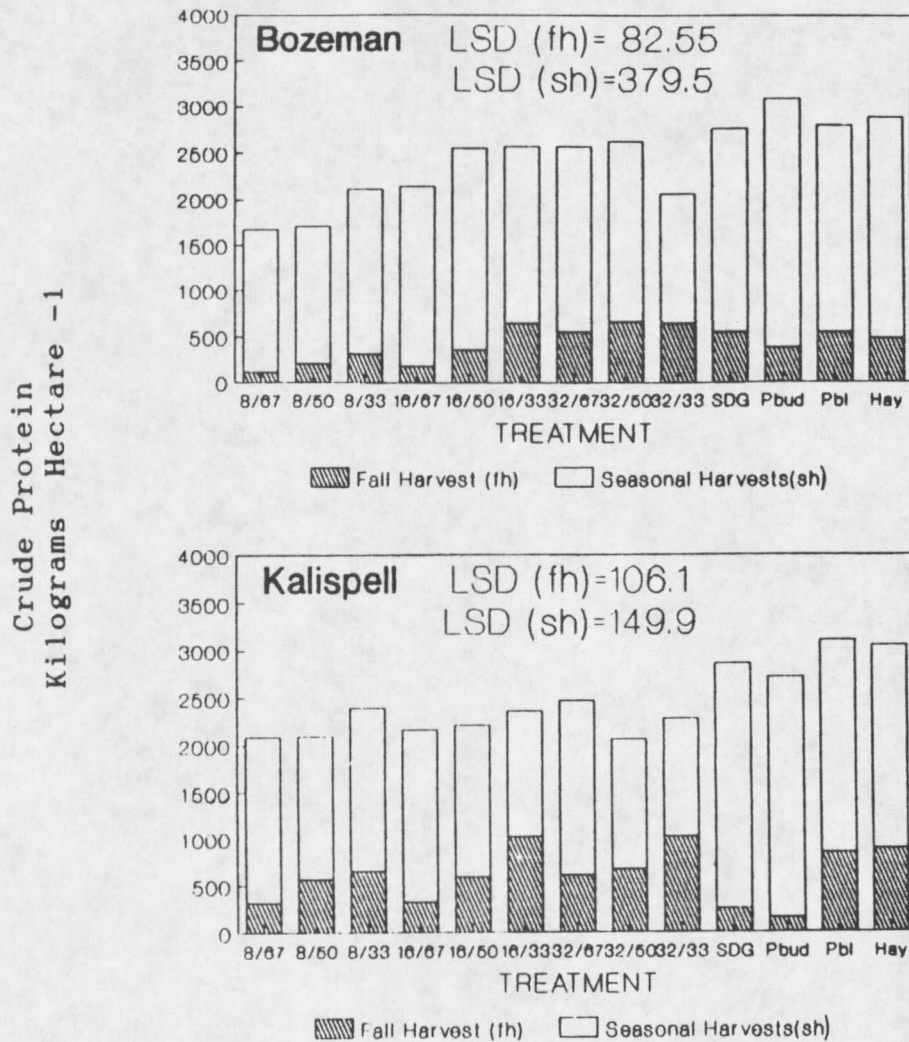


Figure 6. Total crude protein production of alfalfa grazing and hay treatments at Bozeman and Kalispell, MT, in 1987 (LSD at 0.05).

Eight-day treatments were low in total crude protein because of their low dry matter production. Total crude protein of treatment 32/33 was low because half of the forage was harvested in October (after killing frost) when protein percentages were low (10-14%).

Protein at the different harvests varied from 10 to 34%. Most of the protein values for the 8- and 16-day clipping frequencies were approximately 30% (Appendix C).

Crude protein levels of 30% are not necessary for adequate animal performance. Large frame bull calves and 300 pound yearling steers with expected average daily gains of 4 pounds require 24.7% crude protein in their diet (57). Crude protein requirements of most animals are below 20%.

Using forage with high crude protein can result in a waste of nutritional quality that will be used by the animal for less efficient processes (i.e., energy production). An excess of natural crude protein concentration in the forage will not have negative effects on animal production and will increase efficiency of feed use slightly (57).

Crude Protein--Kalispell. Total crude protein at Kalispell followed the same pattern as Bozeman (Figure 6). The traditional treatments (Hay, Prebud and Prebloom) and graduated SDG produced the most protein per hectare. The remaining nine treatments (factorial) did not have large variations in total protein production.

Total protein in the fall harvest at Kalispell comprised a large percentage of the total protein produced per hectare. Fall

protein per hectare decreased as clipping intensity increased for each clipping frequency (8, 16, and 32 days). This is a direct reflection of dry matter production (Table 6). Actual protein percentage was higher for the more intensively clipped treatments, but protein per hectare was determined more from dry matter production (Appendix D).

At fall harvest, the crude protein concentrations in the forage were the lowest of any time in the year. Crude protein of the seasonal harvested forage were 20 to 30% with some harvests above 30%. Most of the protein determinations in the fall were below or around 20% (14).

In Vitro Dry Matter Digestibility (IVDMD)---Bozeman. The IVDMD values for the initial harvest of the 8-day treatments were approximately 70% and then decreased for the next two harvests, because each consecutive harvest collected forage from lower in the canopy (older and less digestible material) (Figure 7). By the fourth harvest, IVDMD values for all the 8-day clipping treatments had recovered. This pattern was repeated during the season. The fall harvest (after killing frost) produced IVDMD equal to the first harvest.

The 16-day clipping treatments had an IVDMD pattern similar to the 8-day treatments, but with smaller variations among harvests (Figure 7). Treatments 16/67 and 16/50 had a marked drop in IVDMD in the second harvest, but by the third harvest IVDMD increased and

In Vitro Dry Matter Digestibility (%)

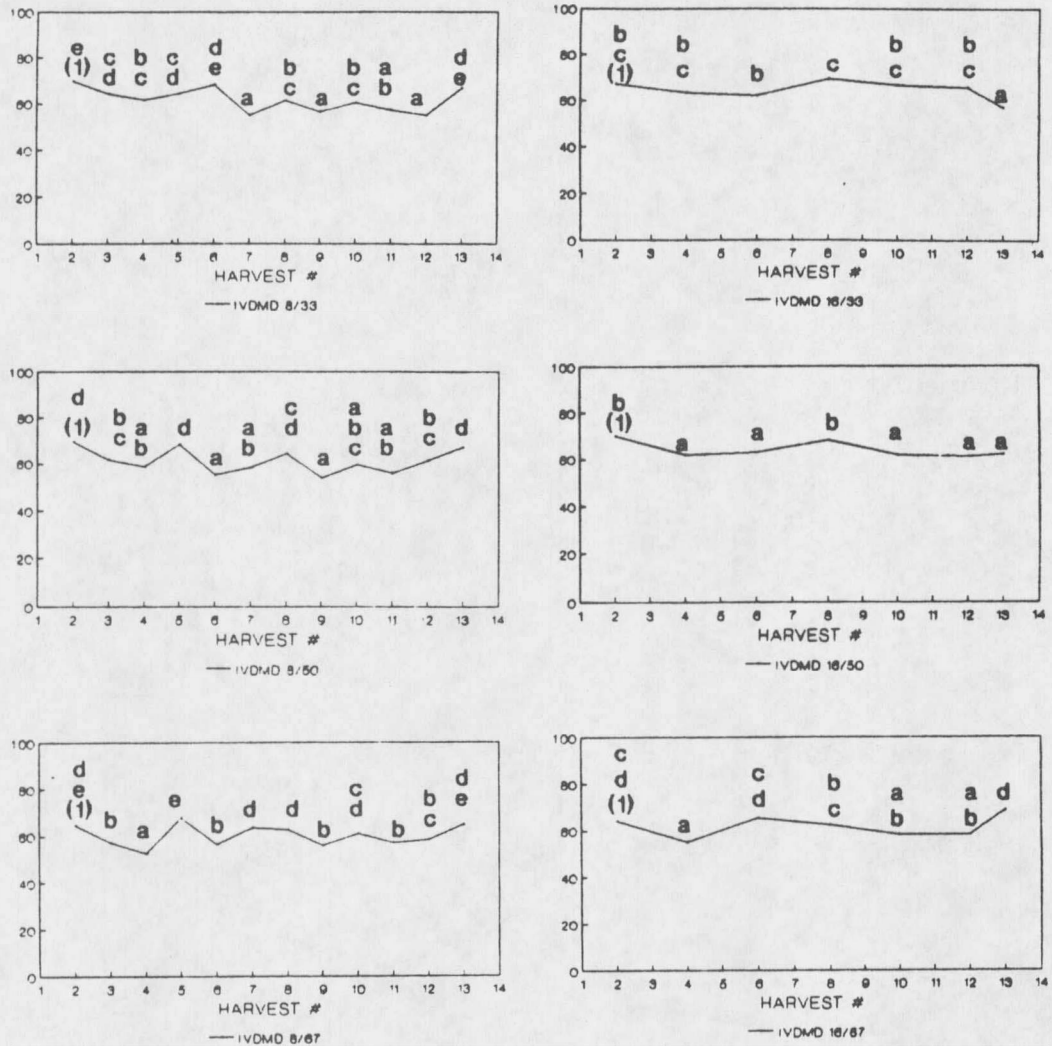


Figure 7. In vitro Dry Matter Digestibility (IVDMD) (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

remained high thereafter. Treatments 16/50 and 16/33 never dropped below 60% IVDMD throughout the season. Only treatment 16/33 had a low IVDMD value in the fall, due to the accumulation of deferred forage. Graduated SDG treatment followed the same pattern as treatment 16/50.

The 32-day clipping treatments had a declining IVDMD pattern throughout the season (Figure 8). The decline was greater for 33% than for the 50 and 67% intensity treatments for fall harvest.

The IVDMD was significantly reduced from first to second harvest for the Prebloom treatment (Figure 8). The most stable treatment (fewer fluctuations for IVDMD) occurred for Prebud.

Generally, all treatments produced IVDMD levels above 60%. Some harvests for the 8-day clipping treatments had values of 70% which can be detrimental for animal production. IVDMD values above 68% can reduce animal intake (3).

Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF)--
Bozeman. Neutral Detergent Fiber measures cell wall constituents including cellulose, hemicellulose, lignin, nitrogen and minerals, and is an indicator of animal intake while ADF is a measurement of cellulose, lignin and mineral residues (indigestible fraction) (26) and is related to digestibility. The lower the ADF value, the greater the digestibility.

Generally, NDF and ADF had similar response patterns for each treatment (Figures 9-12). Many treatments had increased NDF and ADF

In Vitro Dry Matter Digestibility (%)

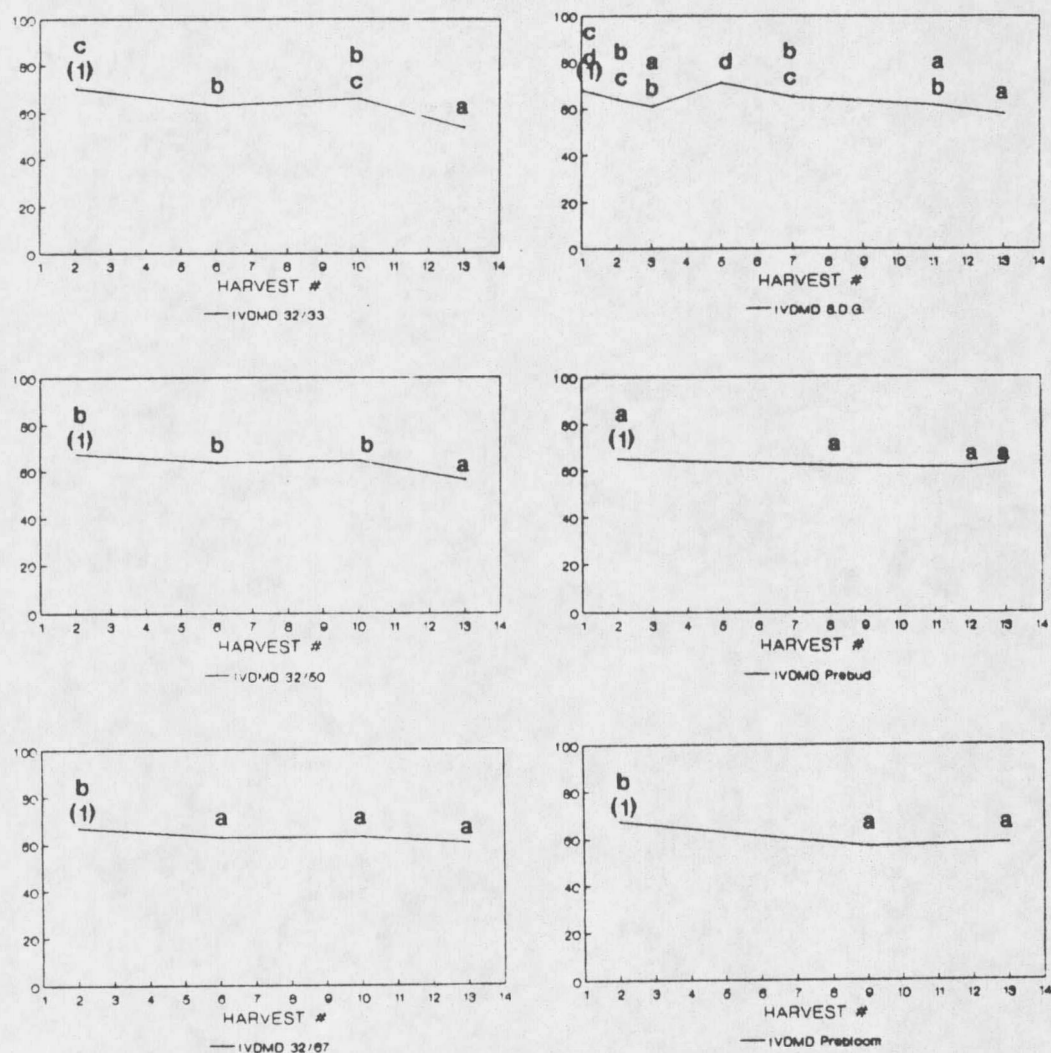


Figure 8. In vitro Dry Matter Digestibility (IVDMD) (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

Neutral Detergent Fiber (%)

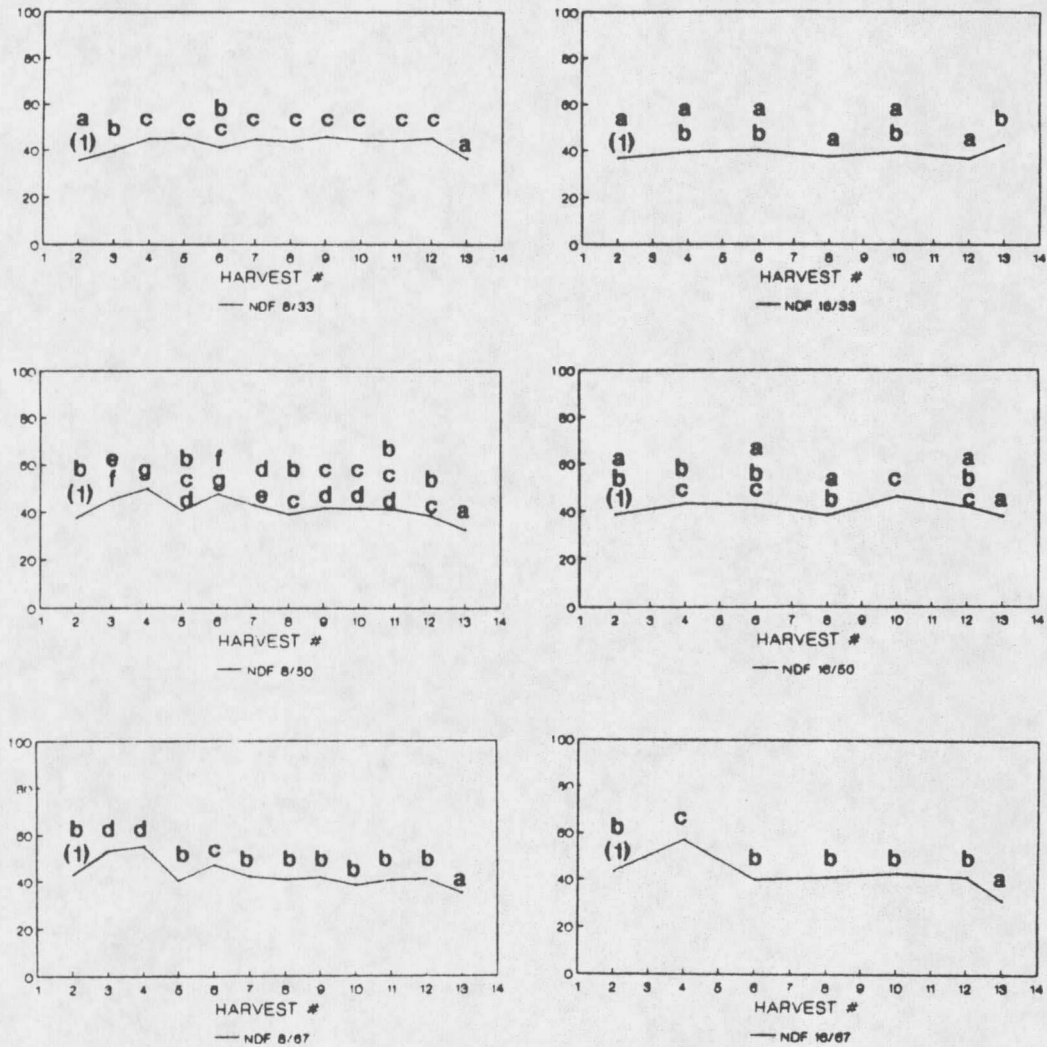


Figure 9. Neutral Detergent Fiber (NDF) (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

Neutral Detergent Fiber (%)

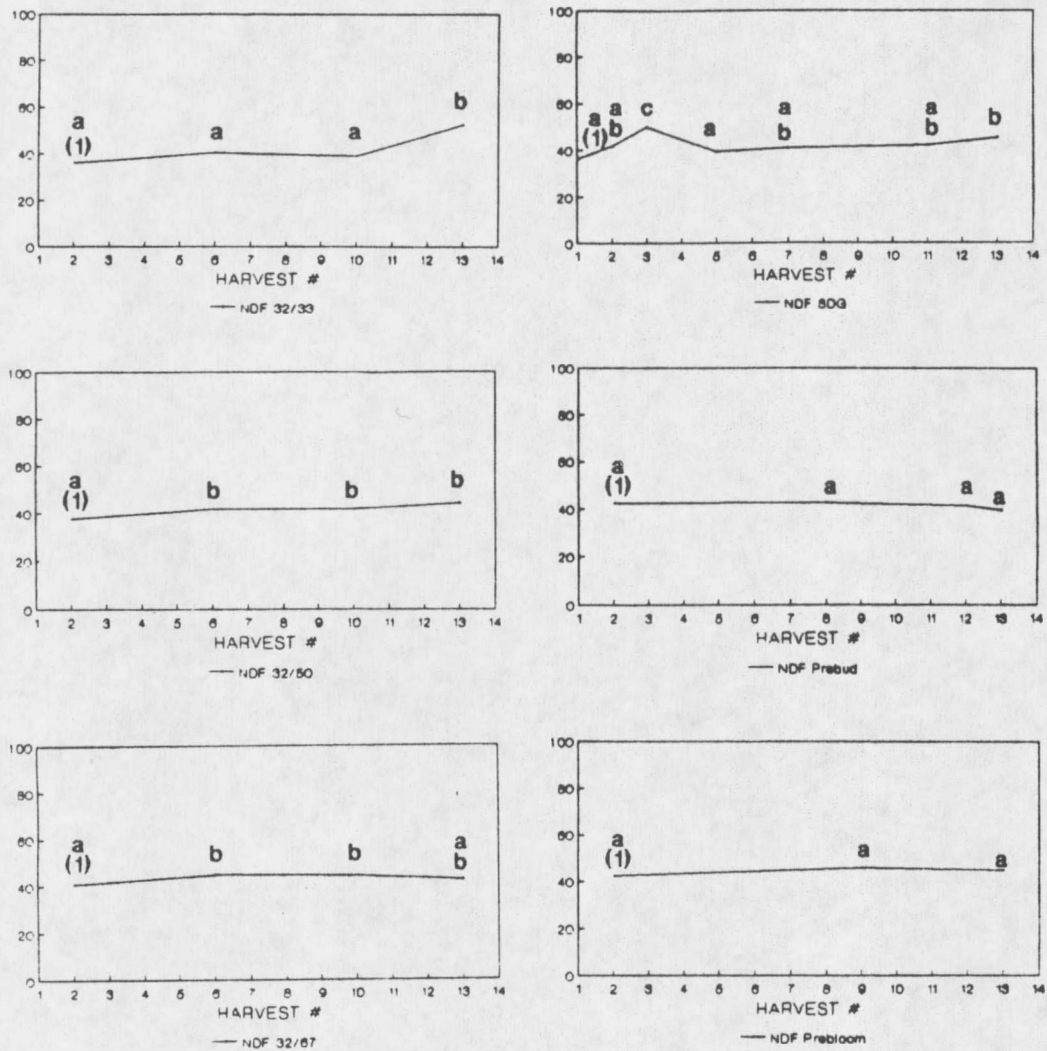


Figure 10. Neutral Detergent Fiber (NDF) (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Neuwman-Keuls test.

Acid Detergent Fiber (%)

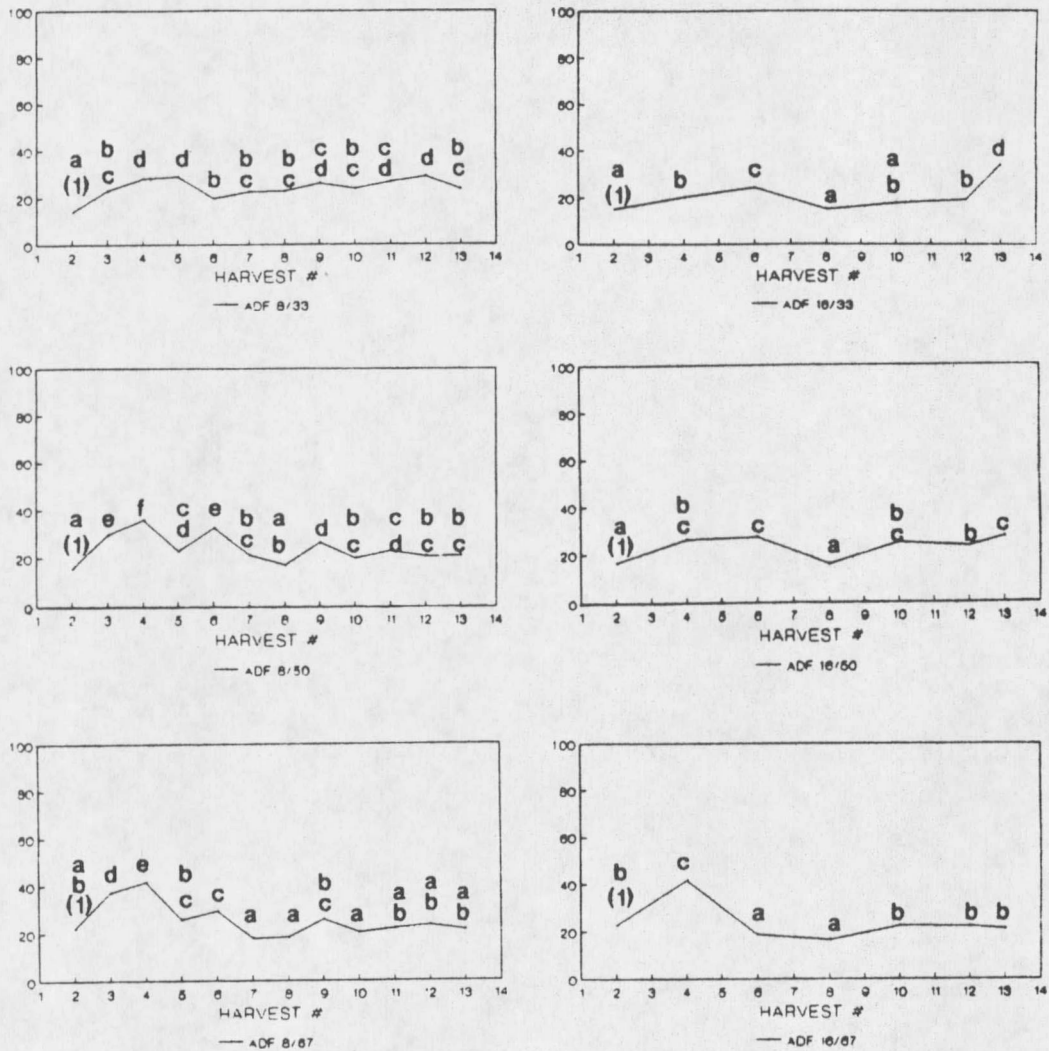


Figure 11. Acid Detergent Fiber (ADF) (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

Acid Detergent Fiber (%)

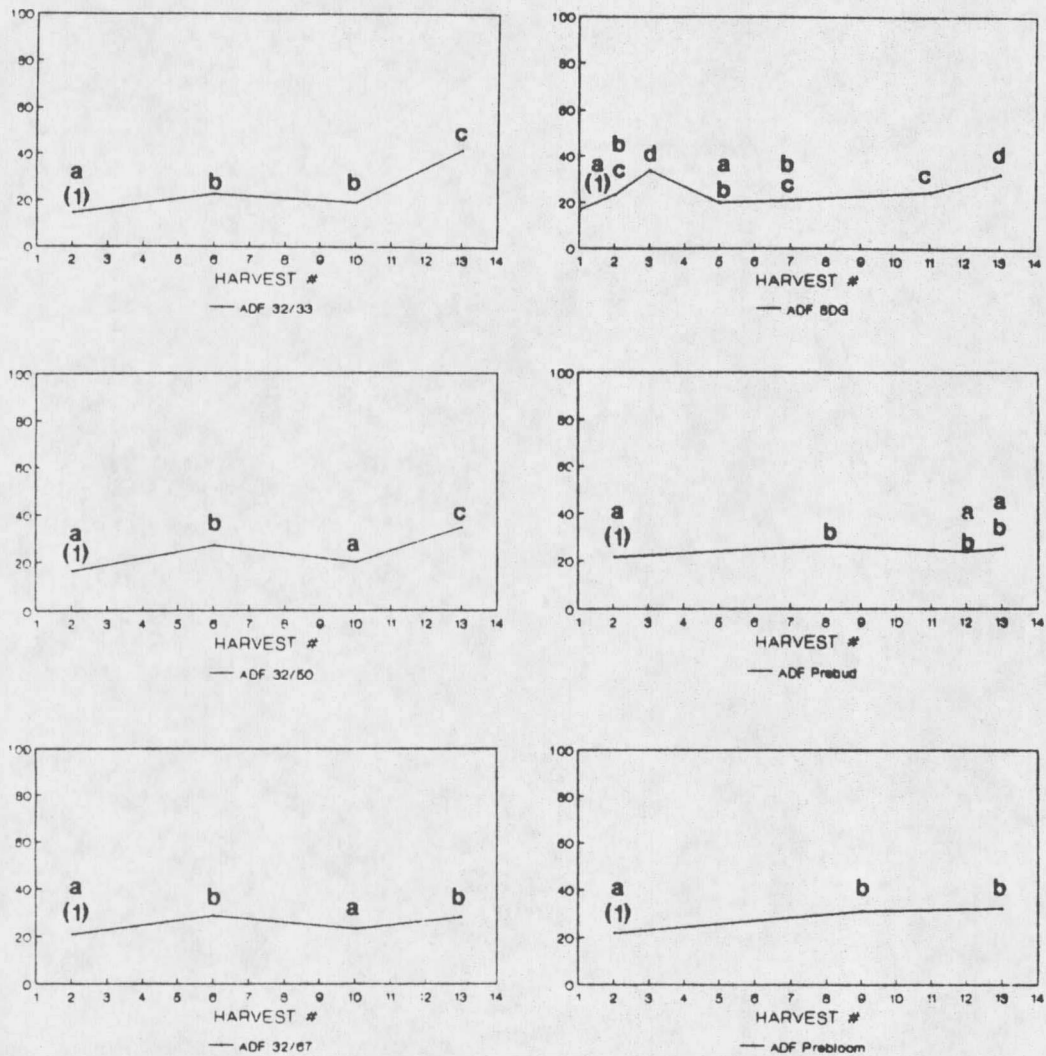


Figure 12. Acid Detergent Fiber (ADF) (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

for the fall harvest. This was expected because much of the material contained old stems that had not been harvested before (33% treatments). Also, both stems and leaves were affected by frosts that occurred before the last harvest.

There was a negative relationship between IVDMD and NDF-ADF for each treatment. Every IVDMD Figure had its mirror image in a corresponding NDF-ADF Figure (Figures 7-12).

No treatment produced NDF values above 60%. Values of NDF above this level limits forage intake by the animal (14).

Forage must have: 1) a crude protein greater than 19%, 2) an ADF less than 31%, and 3) an NDF less than 40%, in order to grade # 1 under the proposed guidelines for evaluating forage quality (26). Most of the treatments met these three requirements.

Seasonal Forage Distribution

A successful grazing system on alfalfa must meet the following objectives: 1) maintain high forage yields during the grazing season (May 15-August 15), 2) maintain even distribution of forage throughout the grazing season, 3) have good utilization of available forage, and 4) allow for adequate regrowth before the first killing frost. This experiment addresses objectives one, two and four, but not objective three. For example, grazing alfalfa in the Prebloom or Prebud stages will result in trampling and poor utilization.

A successful grazing system on alfalfa must first address objective four. If proper fall management is not followed, stands will be lost in two years (94). Deferring grazing between August 15

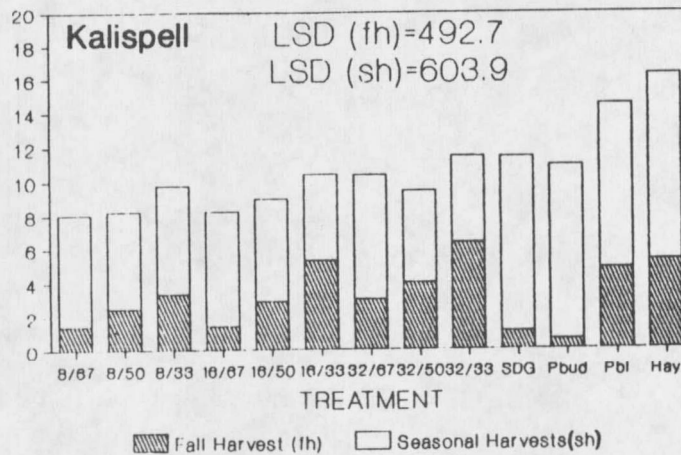
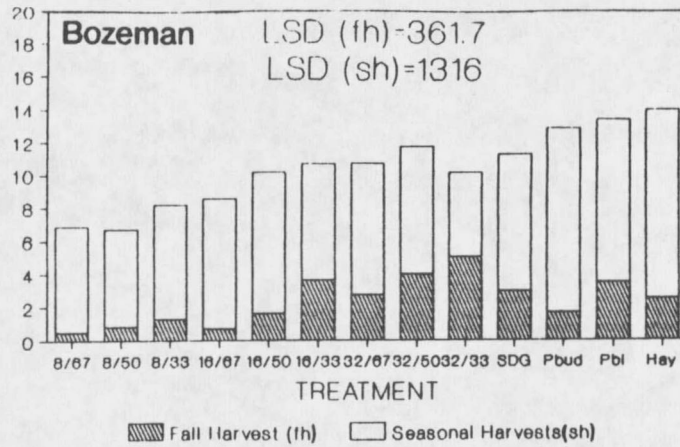
and October 1 will increase root carbohydrates and winter survival (16,22,23,24,30,45,51,64,71,72,73,74,75).

It is difficult to draw conclusions on stand life after one year of a multi-year experiment. However, I think that any grazing treatment resulting in minimal fall growth (low October yields) will decrease alfalfa stands in short time period. Removing 50 or 67% of the top growth every 8 days (8/50 and 8/67) or removing 67% of the top growth every 16 days (16/67) resulted in low fall yields (Figure 13). These treatments had less vigor and more weed encroachment than the other treatments. In the field studies, harvesting at prebud produced low fall yields (Tables 5 and 6).

Treatments that provided adequate fall growth in at least two locations included 8/33, 16/33, 16/50, 32/33, 32/50, 32/67 and Graduated SDG (Figure 13). Treatments 32/33, 32/50 and 16/33 produced an over abundance of forage for the fall harvest. The fall harvest of these treatments comprised from 34% (32/50--Bozeman) to 56% (32/33--Kalispell) of the total annual harvest. While this may result in excellent root reserve accumulation, it does not provide much forage during the grazing season.

Treatment 8/33 had good forage distribution throughout the grazing season except for several low harvests at Kalispell (Figures 14, 16, and 18). Treatments 16/50 and 32/67 had the most even forage distribution of all the treatments (Figures 14-19). Treatment 32/67 is similar to a prebud grazing and would probably result in trampling and poor utilization.

Kilograms Hectare -1
(thousands)



Grams plant -1

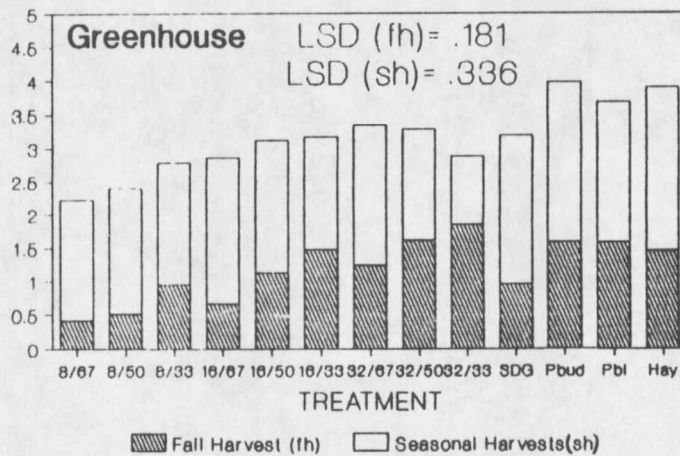


Figure 13. Contribution of fall harvest to total harvest yields at three locations in 1987 (LSD at 0.05).

Kilograms Hectare -1
(thousands)

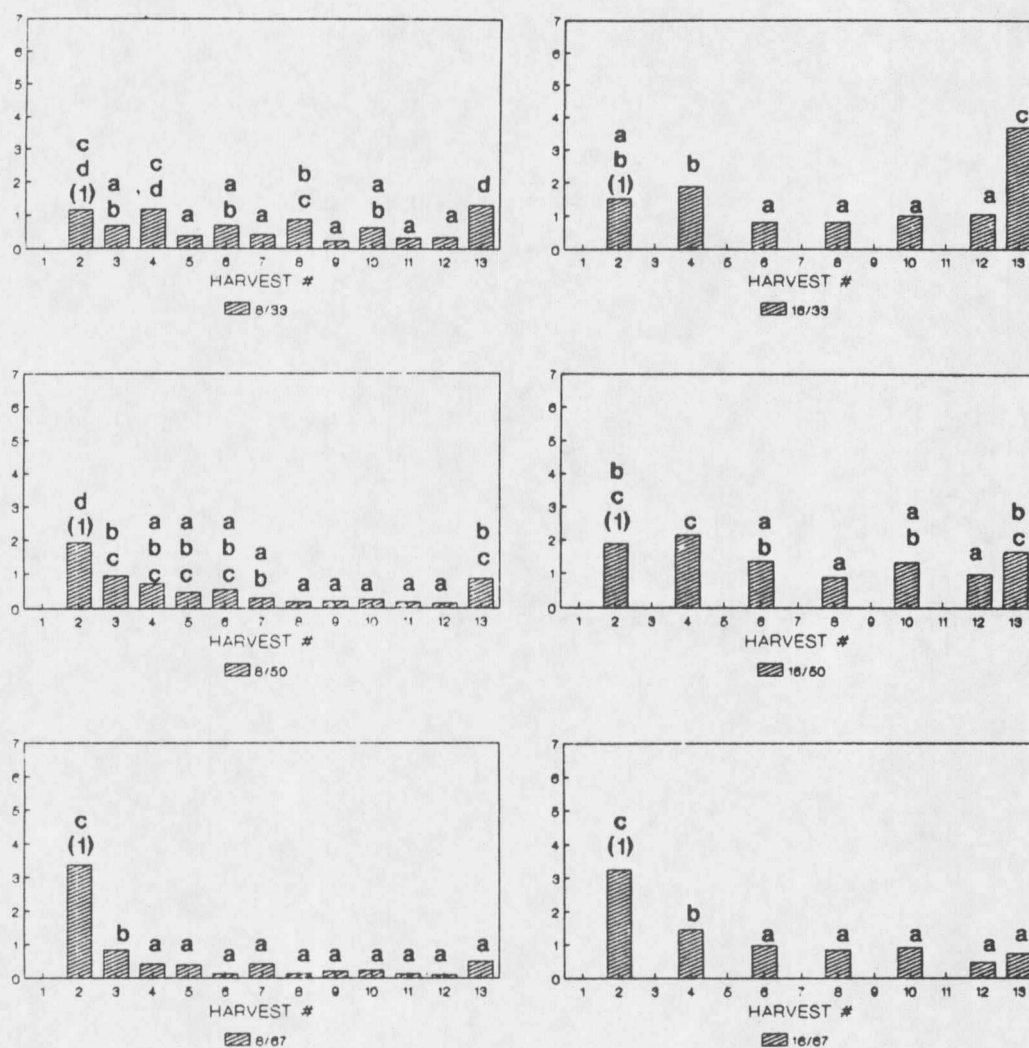


Figure 14. Forage production per harvest (treatments 8/33, 8/50, 8/67, 16/33, 16/50 and 16/67) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Neuman-Keuls test.

Kilograms Hectare -1
(thousands)

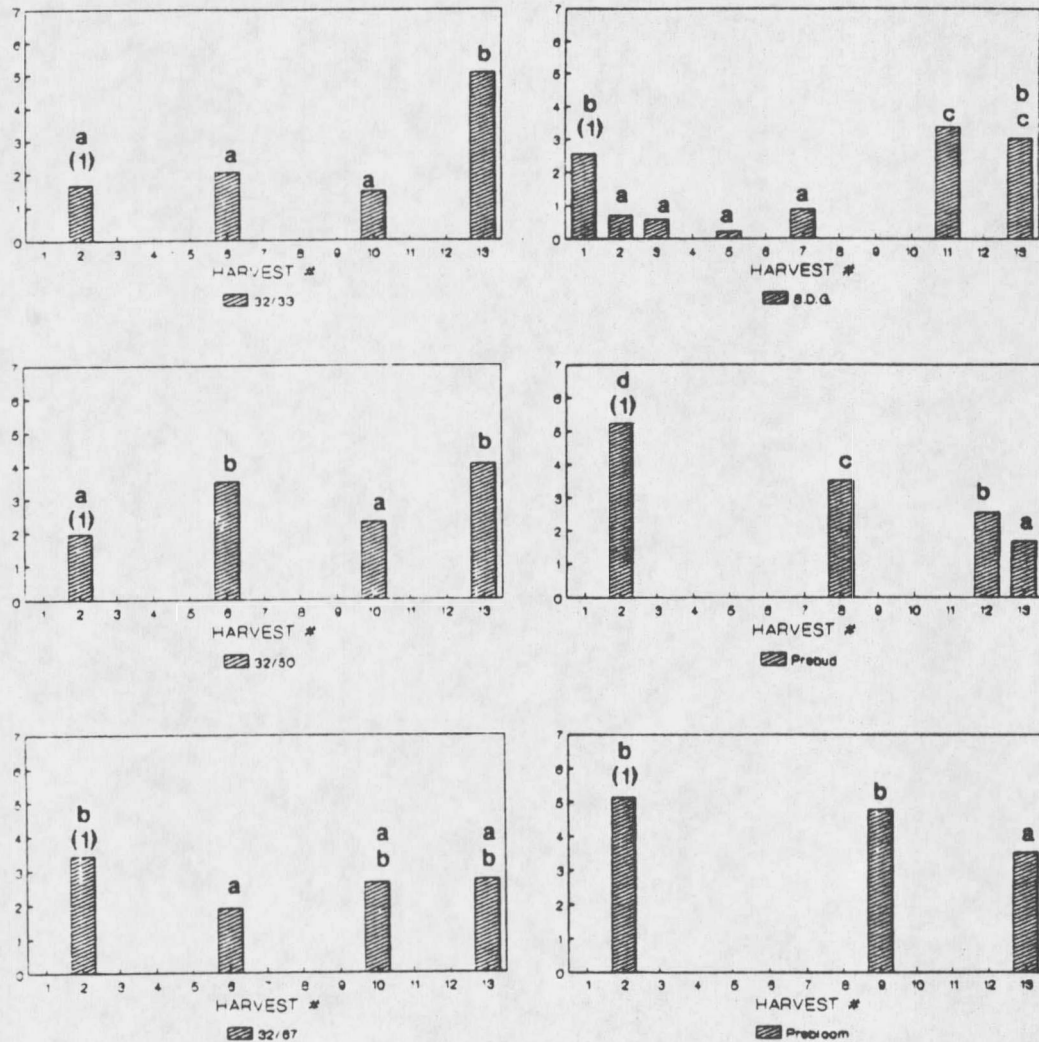


Figure 15. Forage production per harvest (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Bozeman, MT, in 1987. Fall management harvest identified as #13. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

Kilograms Hectare -1
(thousands)

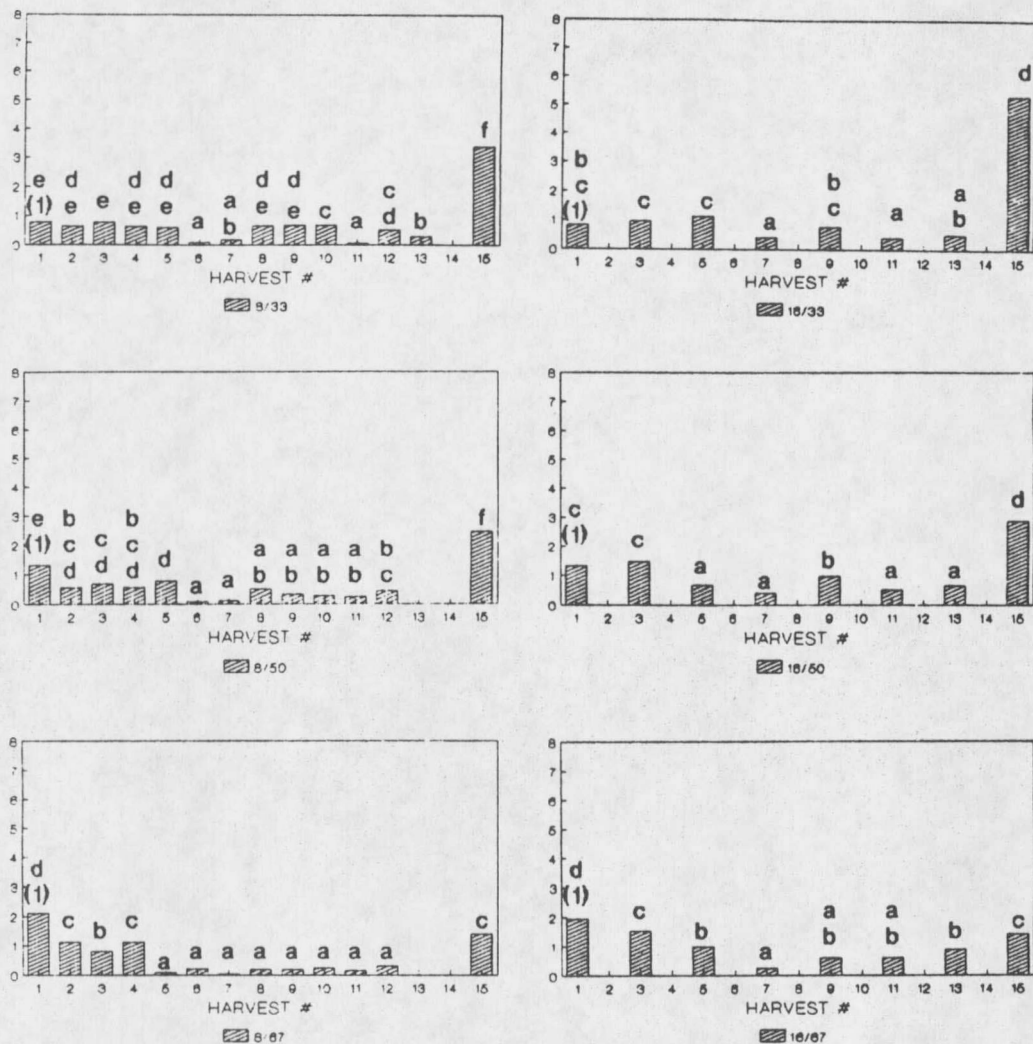


Figure 16. Forage production per harvest (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at Kalispell, MT, in 1987. Fall management harvest identified as #15. (Harvests not identified by the same letter differ at the 0.0t probability level by Newman-Keuls test.

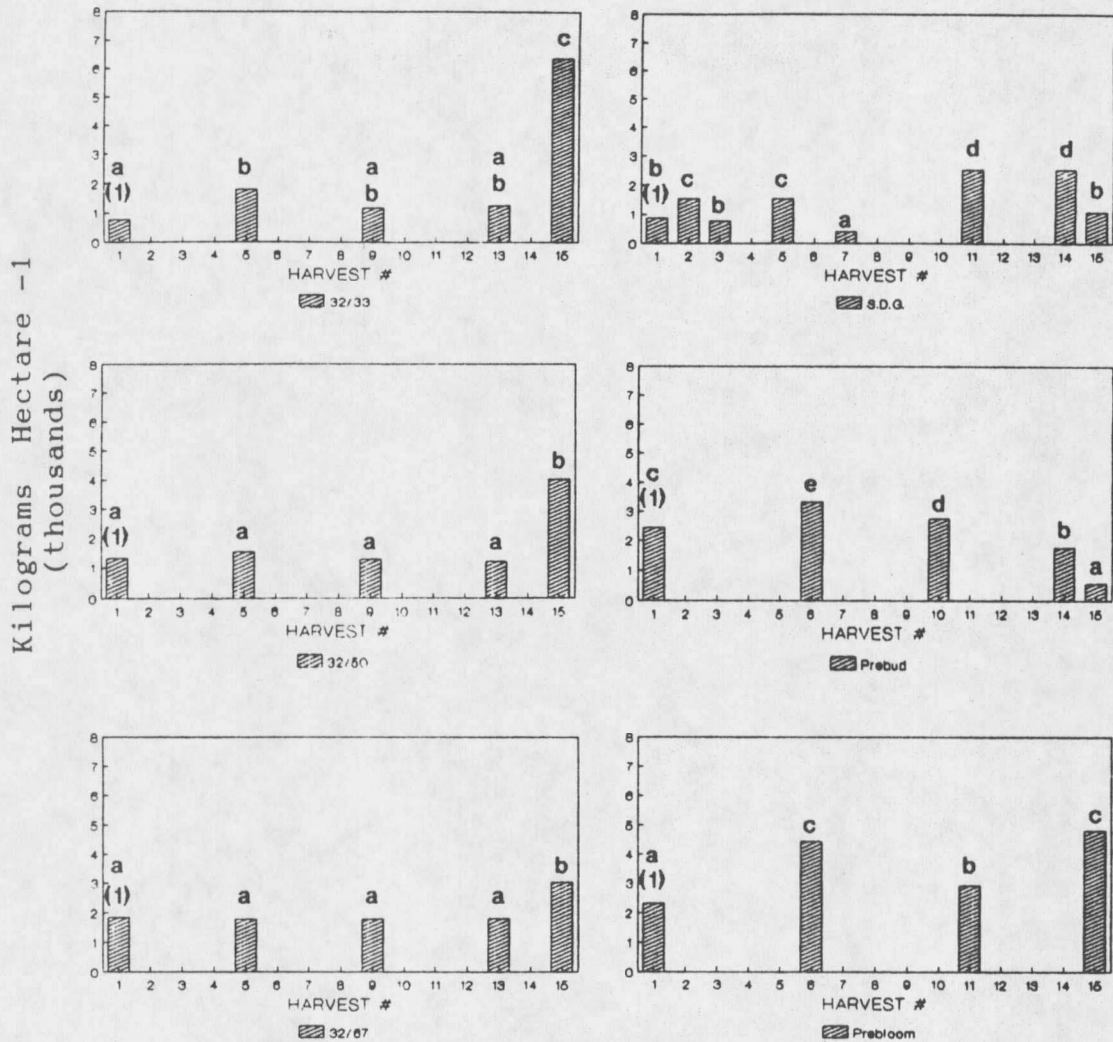


Figure 17. Forage production per harvest (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Kalispell, MT, in 1987. Fall management harvest identified as #15. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

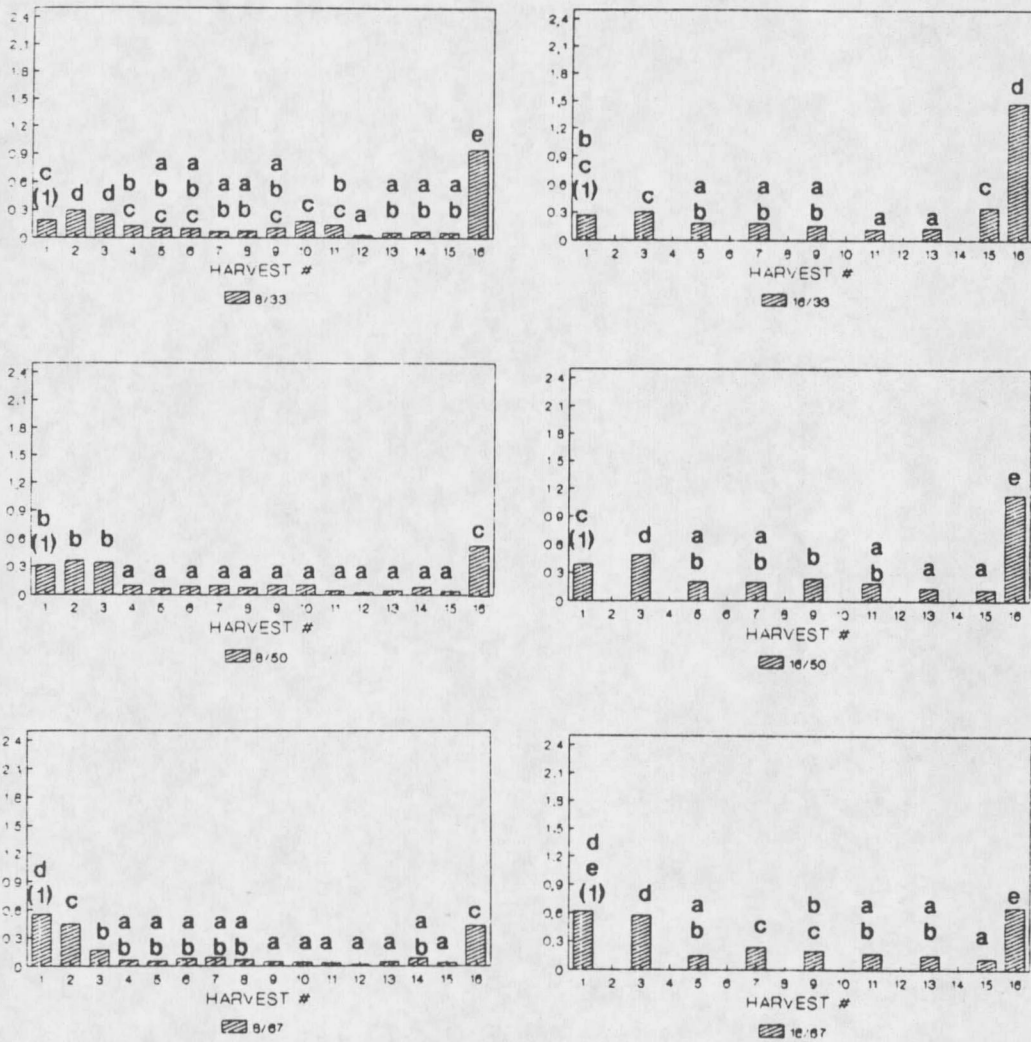
Grams plant⁻¹

Figure 18. Forage production per harvest (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at the greenhouse in 1987. Fall management harvest identified as #16. (1) Harvests not identified by the same letter differ at the 0.05 probability level by Newman-Keuls test.

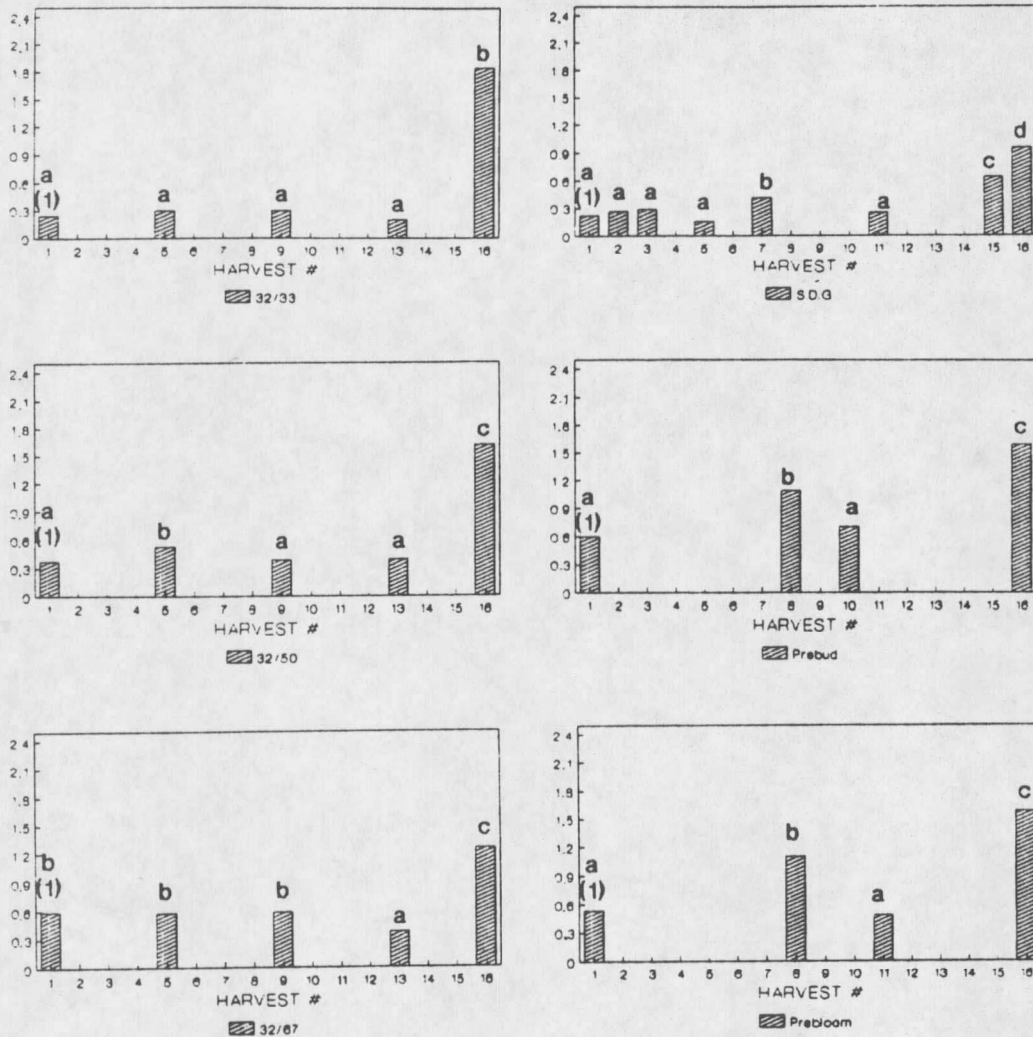
Grams plant⁻¹

Figure 19. Forage production per harvest (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud, and Prebloom) at the greenhouse in 1987. Fall management harvest identified as #16. (1) Harvests not identified by the same letter differ at the 0.01 probability level by Newman-Keuls test.

At Kalispell, Graduated SDG had reasonable forage distribution except for harvest 7 (Figure 17). The fall harvest for Graduated SDG at Kalispell was low, which could result in winter kill. At Bozeman, this treatment had a high first-harvest yield and then declined (related to the weather conditions) until harvest 7 (Figure 15) when yields started to increase because more top growth was being removed. At the greenhouse, the general pattern of the different treatments was similar to the field studies (Figures 14-19).

The amount of forage harvested in fall represented a bigger proportion of the total for treatment 32/33 (Figures 15, 17, and 19). The traditional grazing systems, with longer periods between harvests, produced the highest yields in all cases but had forage distributions that limited grazing management possibilities.

Morphological Studies

Leaflet Area

Leaflet area determinations (Table 10) were made at harvest number 12 on August 14 for all 13 treatments. Only treatments 8/67, 8/50, 8/33, 16/67, 16/50, 16/33, and Prebud were harvested on this date (Table 4). Leaflet area measurements for Graduated SDG, 32-day interval, Prebloom, and Hay treatments are not in accordance with the harvest schedule. This could affect the leaflet area values and, consequently, the relationship among the treatments.

Leaflet areas above harvest height ranged from 0.17 cm^2 . (Greenhouse, 8/33, harvest # 16) to 1.55 cm^2 (Bozeman, Hay, harvest

Table 10. Leaflet area above and below harvest height on August 14 at Bozeman in 1987.

TREATMENT	ABOVE	BELOW
	cm ²	
8/67*	0.52	0.24
8/50*	0.44	0.20
8/33*	0.56	0.31
16/67*	0.68	0.24
16/50*	0.78	0.33
16/33*	0.53	0.45
32/67	1.01	0.49
32/50	0.42	0.38
32/33	0.46	0.36
Graduated SDG	0.26	0.20
Prebud	1.23	0.33
Prebloom	1.20	0.28
Hay	0.44	0.20
LSD (0.05)	0.32	0.14

*Harvested on 8/14/87

11, Appendices E and F). This is in accordance with work of Brown et al. (6). They found leaf area values ranging from less than one cm² to 20 cm².

High and medium stress treatments (8/33, 8/50, 8/67, 16/33, 16/50, 16/67, 32/33, 32/50 and Graduated SDG) tended to have less leaflet area above the harvest level as compared to low stress

treatments (32/67, Prebud, Prebloom) at Bozeman (Table 10). Leaflet areas below the harvest level were not influenced as much by harvest treatments, and a discernible pattern was not apparent.

Leaflet areas (above and below cut) were smaller in the greenhouse study (Table 11) than they were in the field study at Bozeman (Table 10). Generally, greenhouse results (Table 11) corroborated the field study. Leaflet areas were smaller for high stress treatments.

Although statistical comparisons were not made, leaflet area was smaller below the harvest level than above the harvest level for every treatment throughout the grazing season at Bozeman (Figures 20 and 21).

Leaflet area above the harvest level was high for early harvests and then declined rapidly for high stress treatments (8- and 16-day treatments) at Bozeman (Figure 20). Intermediate and low stress treatments (32-day, Graduated SDG, Prebud, and Prebloom (Figure 21) showed a certain recovery in leaflet area during the second half of the trial as temperatures cooled (8).

Leaflet areas above harvest height in the greenhouse for 8-, 16- and 32-day treatments (except 32/67) (Figures 22 and 23) were reduced from first to second harvests and then stabilized or increased for harvests three and four. Leaflet area for treatment 32/67 was similar to that of Prebud and Prebloom.

Table 11. Leaflet area above and below harvest height for the last seasonal harvest in the greenhouse in 1987.

TREATMENT	ABOVE	BELOW
	cm ²	
8/67	0.23	0.12
8/50	0.20	0.16
8/33	0.17	0.13
16/67	0.21	0.17
16/50	0.21	0.19
16/33	0.26	0.20
32/67	0.30	0.18
32/50	0.28	0.21
32/33	0.26	0.24
Graduated SDG	0.19	0.20
Prebud	0.43	0.17
Prebloom	0.34	0.16
Hay	0.44	0.17
LSD (0.05)	0.08	0.05

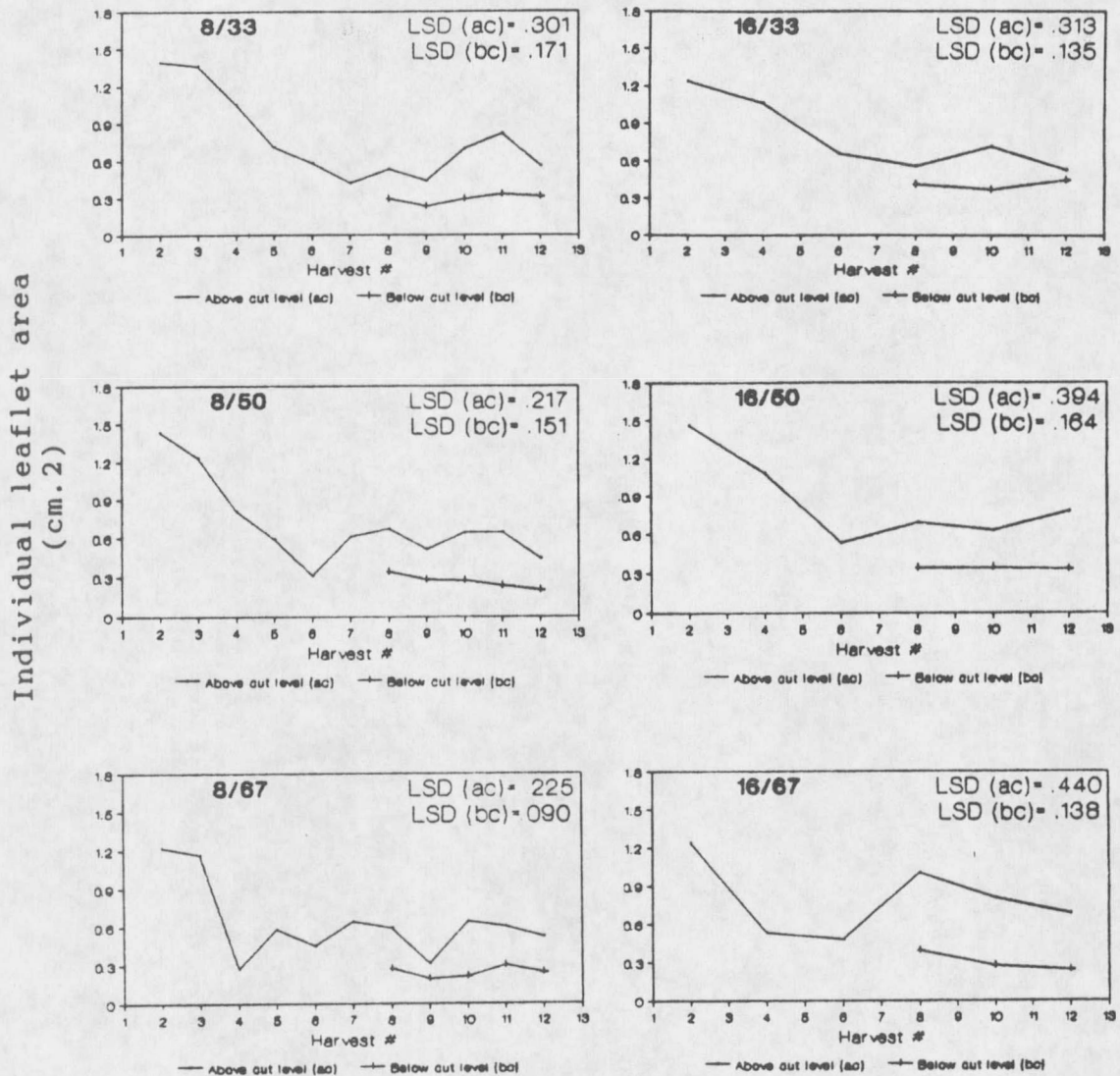


Figure 20. Individual leaflet area throughout the grazing season (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at Bozeman, MT, in 1987 (LSD at 0.05).

Individual leaflet area
(cm.2)

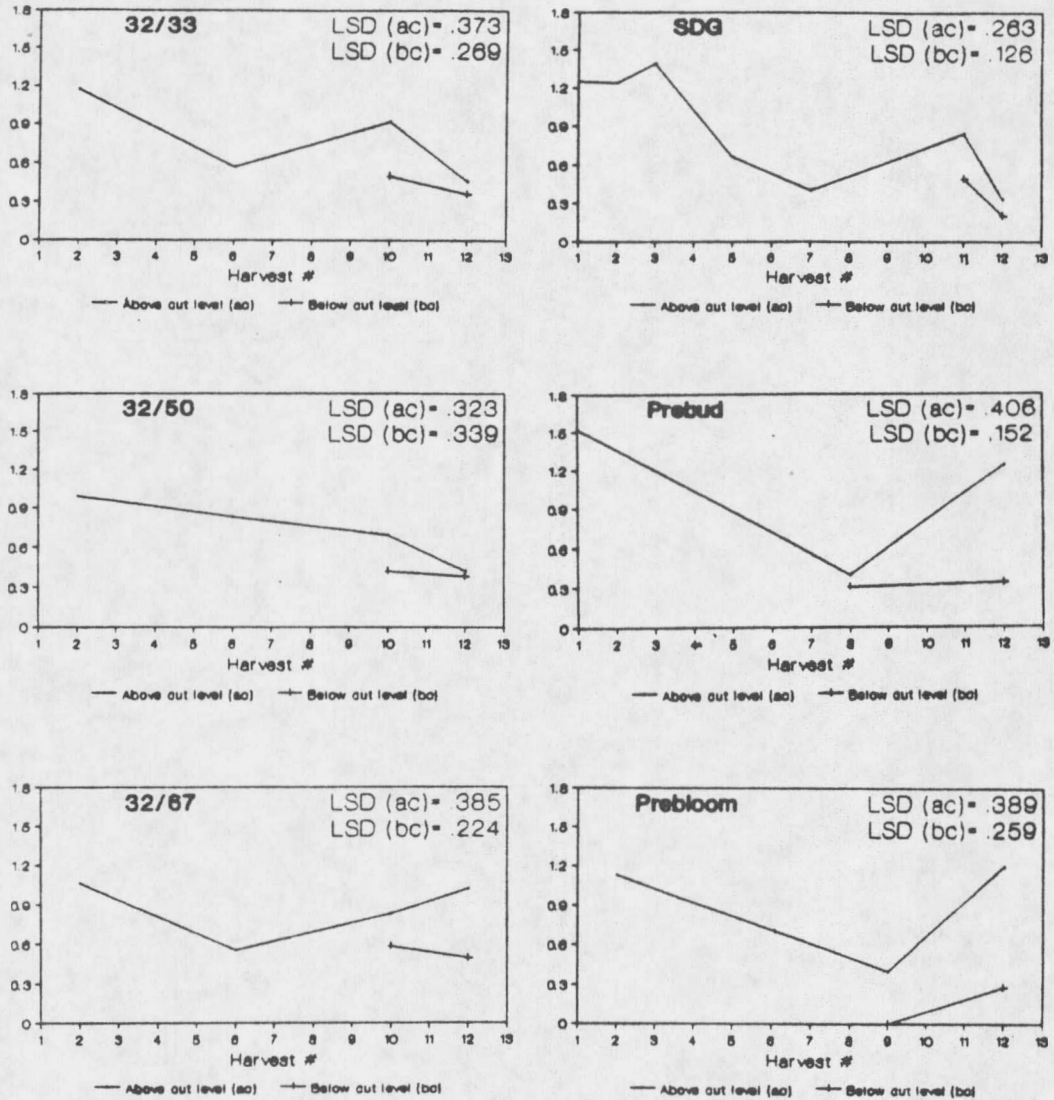


Figure 21. Individual leaflet areas throughout the grazing season (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at Bozeman, MT, in 1987 (LSD at 0.05).

Individual leaflet area
(cm.2)

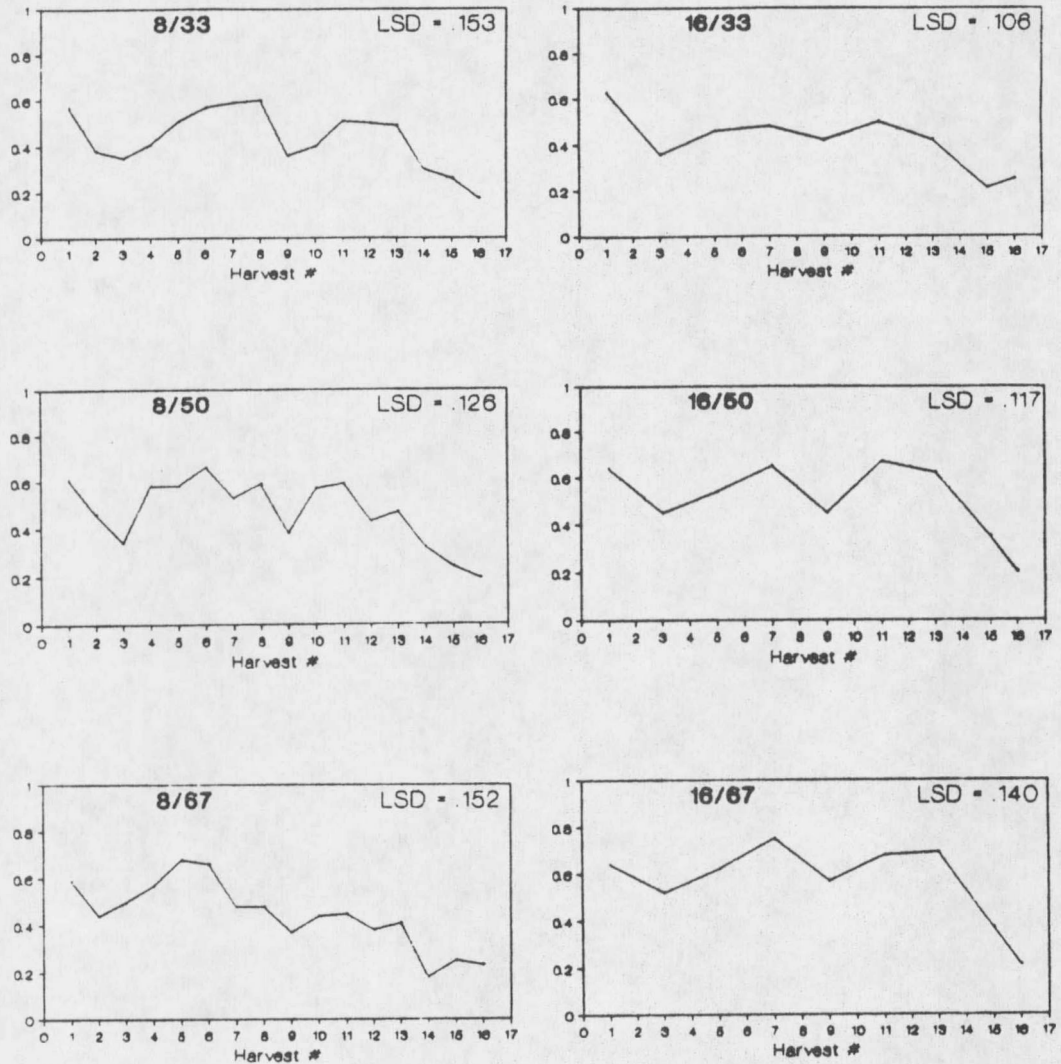


Figure 22. Individual leaflet area throughout the grazing season (treatments 8/33, 8/50, 8/67, 16/33, 16/50, and 16/67) at the greenhouse in 1987 (LSD at 0.05).

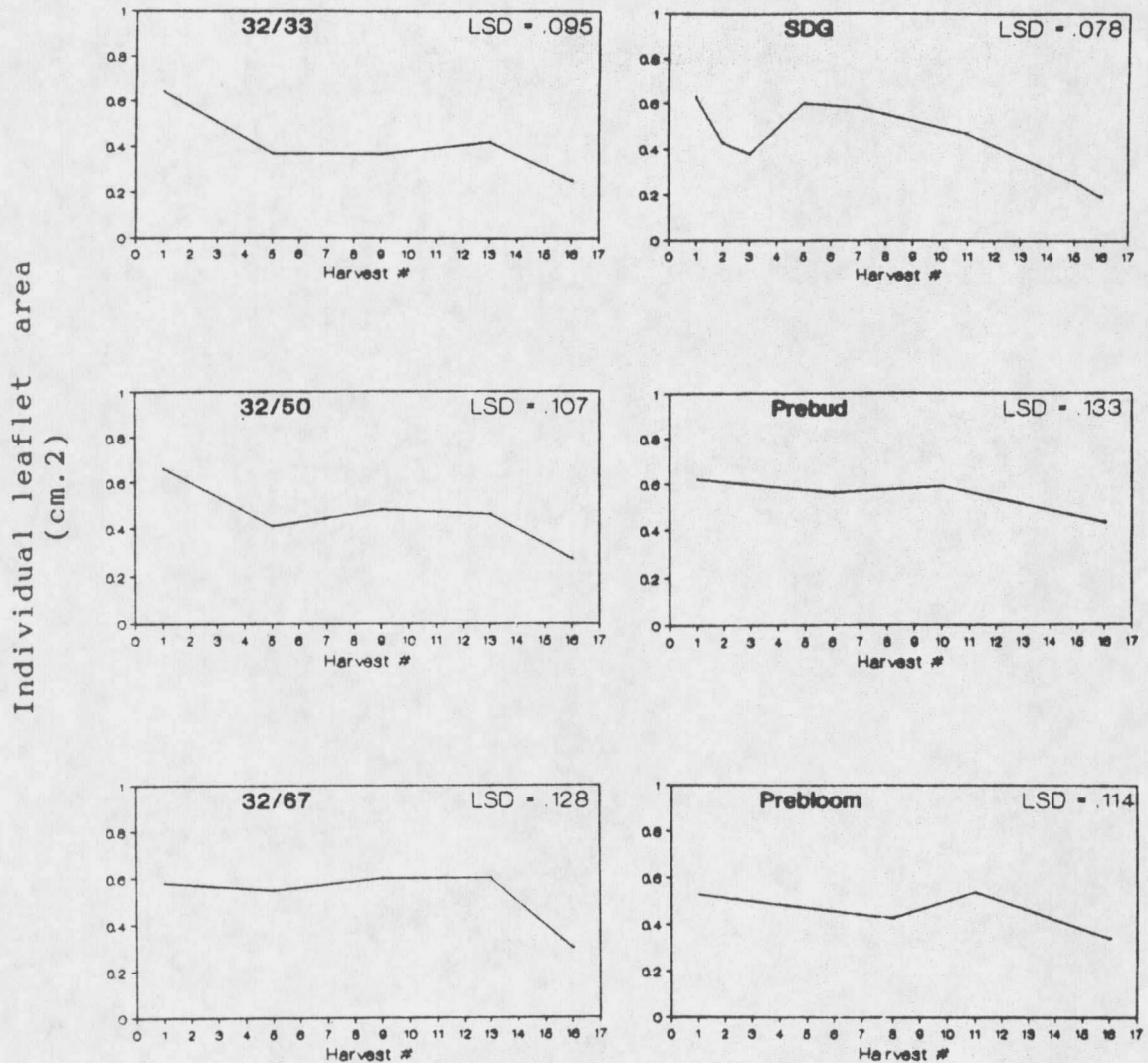


Figure 23. Individual leaflet area throughout the grazing season (treatments 32/33, 32/50, 32/67, Graduated SDG, Prebud and Prebloom) at the greenhouse in 1987 (LSD at 0.05).

Axial Buds versus Crown Buds

Axial bud:crown bud ratio represent the total number of buds counted per plant (greenhouse studies) and per 0.3 meter (Bozeman and Kalispell) during the season.

Axial versus crown growth changed with environment (Table 12). Kalispell and greenhouse ratios varied from 0.5 to 6.5, while Bozeman ratios varied from 0.07 to 0.86. These differences can be partly explained by differences in cultivar response. Evidently Spredor II (Kalispell and Greenhouse) has the ability to produce axial buds better than Maxim (Bozeman) (79).

Bozeman and Kalispell produced a similar ratio pattern regardless of the magnitude of differences between the two locations (Table 12). Generally, the ratio increased as the percentage of topgrowth removed was reduced. There also was a trend for higher ratios when the clipping interval was increased.

In the greenhouse, ratio patterns affected by clipping interval and intensity were opposite those of the field studies. The axial:crown bud ratio increased as more topgrowth was removed and as the clipping interval was decreased.

Traditional grazing and haying treatments produced the lowest ratios in all environments. Changing harvest patterns (interval or intensity) definitely altered the normal physiological plant response by stimulating the alfalfa plant to produce axial growth rather than crown growth. Whether this is good or bad for the plant will have to be determined over a period of years.

Table 12. Axial bud:Crown bud ratios for the 13 treatments at three locations in 1987.

TREATMENTS	BOZEMAN	KALISPELL	GREENHOUSE
8/67	0.56	1.75	6.44
8/50	0.45	2.12	4.68
8/33	0.72	2.86	3.69
16/67	0.24	2.09	4.70
16/50	0.55	2.86	3.12
16/33	0.80	3.43	2.06
32/67	0.65	2.44	2.59
32/50	0.71	3.14	1.29
32/33	0.86	3.00	0.76
Graduated SDG	0.44	3.29	1.99
Prebud	0.13	1.17	1.89
Prebloom	0.08	1.39	1.41
Hay	0.07	0.45	1.66
LSD (0.05)	0.18	1.28	1.14

There was no interaction frequency times intensity at any of the three locations.

Root ReservesBozeman

Root reserves are crucial for winter survival of alfalfa (23,39,64,65,66,72,74), but there is disagreement on how to measure the reserves needed by alfalfa plants to overwinter and produce vigorous spring growth. Total Nonstructural Carbohydrates percentage (TNC percent) addresses only carbohydrate concentration in the roots. Caldwell (10) calculated a carbohydrate pool that expresses TNC on a grams/plant basis. It is the product of root dry weight multiplied by TNC percent.

Under field conditions, at the last seasonal harvest, TNC increased when treatment stress decreased (Table 13). Treatment 32/33 had high TNC values, probably due to the large amount of aerial biomass present throughout the growing season.

The high stress treatments (8/67, 8/50) had significantly lower TNC values for the last seasonal harvest than most treatments. The TNC increased for all treatments at fall harvest (Table 14), but the increase was larger for treatments with high stress. The TNC value of treatment 8/67 increased from 0.06 (Table 13) to 0.94 grams per plant (Table 14), treatment 8/50 from 0.14 to 1.06 and treatment 16/67 from 0.3 to 0.6. All treatments had significant increases in TNC compared to the the last seasonal harvest (Tables 13-14).

Most of the treatments variation at high stress levels resulted from the change in percentage TNC. After the last seasonal harvest

Table 13. Dry Matter Weight, percentage TNC and pool TNC of Maxim alfalfa roots at the last seasonal harvest at Bozeman in 1987.

TREATMENT	D. M. WEIGHT (grams/plant)	TNC %	TNC (grams/plant)
8/67	0.60	10.4	0.06
8/50	0.96	14.5	0.14
8/33	1.49	24.0	0.36
16/67	1.52	15.5	0.30
16/50	2.21	28.8	0.61
16/33	1.71	30.3	0.53
32/67	1.23	22.0	0.27
32/50	1.55	26.8	0.43
32/33	2.42	33.7	0.81
Graduated SDG	1.66	31.0	0.51
Prebud	2.30	25.2	0.59
Prebloom	1.41	19.3	0.28
Hay	3.56	25.9	0.91
LSD (0.05)	1.00	5.34	0.287

Table 14. Dry Matter Weight, percentage TNC and pool TNC of Maxim alfalfa roots at fall harvest at Bozeman in 1987.

TREATMENT	D. M. WEIGHT (grams/plant)	TNC %	TNC (grams/plant)
8/67	2.28	40.6	0.94
8/50	3.03	35.0	1.06
8/33	2.10	32.9	0.70
16/67	1.89	31.8	0.60
16/50	1.72	36.7	0.63
16/33	3.22	35.2	1.15
32/67	2.44	38.3	0.95
32/50	3.96	37.5	1.48
32/33	3.67	32.9	1.22
Graduated SDG	2.46	37.1	0.91
Prebud	2.44	32.8	0.80
Prebloom	3.21	39.7	1.30
Hay	3.36	39.4	1.32
LSD (0.10)	1.30	4.3	0.51

on August 14, there was a prolonged period of high temperatures, and the first killing frost (0°C) did not occur until the first week of October. Generally the first killing frost occurs on September 15, so the plants had a long time to accumulate root reserves. In a normal year, TNC recovery could not be expected to be as large as it was in 1987.

Plant loss was evident in high stress treatments. The remaining plants suffered less competition and consequently had the opportunity to accumulate more reserves.

Greenhouse

Dry matter root weight in the greenhouse had a perfect response to treatment stress except hay, which had a lower root weight than expected (Table 15). This uniform response may be due to the controlled conditions in the greenhouse experiment, the lack of competition between plants (one plant per container), and/or the inclusion of lateral roots in the analysis.

Percentage TNC was as variable as in the field. Treatments with 8-day clipping frequency and 16/67 had significantly lower TNC than any other treatment. Possibly in a controlled environment, a very high stress level is necessary to affect TNC percent level.

With young, non-inoculated plants (7 months of age) energy was not used in the nitrogen fixation process and could have been stored in the roots. Plants can manifest their genetic potential under a controlled environment, and they did not have to compete for soil and water at the greenhouse study.

Table 15. Dry Matter Weight, percentage TNC and pool TNC of Spredor II alfalfa roots at simulated Fall Harvest at the greenhouse in 1987.

TREATMENT	D. M. WEIGHT (grams/plant)	TNC (%)	TNC (grams/plant)
8/67	0.43	25.4	0.12
8/50	0.65	38.1	0.25
8/33	1.13	38.9	0.44
16/67	0.77	39.3	0.31
16/50	1.30	41.1	0.54
16/33	1.65	41.3	0.68
32/67	1.33	45.8	0.62
32/50	1.83	44.3	0.82
32/33	2.39	42.9	1.05
Graduated SDG	1.49	45.4	0.68
Prebud	3.43	46.3	0.70
Prebloom	3.82	43.5	0.69
Hay	1.43	45.0	0.65
LSD (0.10)	0.35	5.6	0.21

The TNC pool values in the greenhouse were similar to those in the field study (Tables 13-15). There was a clear relationship between clipping stress and TNC pool. The higher the stress, the smaller the TNC pool. This is in agreement with previous works (16,21,23,24,27,39,56,64,65,66,72,73,74,95).

CHAPTER 5

SUMMARY AND CONCLUSIONS

Alfalfa's importance as a forage crop is well recognized. With a broad world distribution, it produces high quality forage under varied environmental conditions.

There is limited information on how to graze alfalfa with rotational grazing systems. The Short Duration Grazing (SDG) method appears promising for grasses, but it has never been tried with alfalfa under Montana's conditions.

The primary objective of this study was to determine the effect of simulated SDG treatments on yield, nutritive quality, root reserves, and morphological characteristics of alfalfa.

Hay and traditional grazing systems had the highest forage yields in greenhouse and field studies. Treatments with the highest clipping stress (8/67, 8/50, and 16/67) had the lowest yields. D).

All treatments had high forage quality (crude protein, digestibility, NDF, and ADF) at all harvests. High stress treatments had the best quality. In some cases the forage quality was so high that it would not have been fully utilized by the grazing animals.

Low clipping intensity treatments (33%) had a disproportionate amount of fall forage. Treatments with high combined stress

(intensity and frequency) had declining yields with successive harvests and low total forage production.

All the SDG treatments had declining patterns of leaflet size throughout the season. This was more marked with the high clipping stress treatments. Leaflet size below the harvest level was always smaller than that above the harvest level.

Axial bud to crown bud ratio varied considerably at the three different locations. The field studies produced similar trends (increased ratio when the clipping stress decreased), but the relative magnitude varied with location. Greenhouse axial bud to crown bud ratio was inverse to that found in the field.

During the grazing season, the higher the clipping stress, the lower the TNC. The root reserves recuperated rapidly between the last season harvest and October 15 in the field study. High stress treatments had the highest TNC percent after October 15. This was totally unexpected. In the greenhouse study, the clipping stress produced only minor TNC percent differences. TNC expressed as grams per plant was similar to the field results.

The study should be continued for several years to determine the long term effect of these treatments.

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APPENDICES

APPENDIX A

Table 16. Precipitation (mm) by day from May 1 through August 31, 1987, at Bozeman (B) and Kalispell (K), Montana.

DATE	MAY		JUNE		JULY		AUGUST	
	B	K	B	K	B	K	B	K
1		7.6	1.0	2.0			1.3	
2	6.1	0.5			7.9			
3		0.3			3.1			
4					2.8			
5			1.0		3.6	9.4		
6			0.3	1.3	2.8	1.8		
7			1.8			2.3	7.9	
8			2.8	0.8	1.0	3.3		
9	0.3	2.0	0.5	13.2	7.4			
10			2.3	0.5	18.5		0.3	
11			0.3		21.3			
12					0.3			0.5
13		2.5					0.3	2.3
14							1.3	16.0
15		1.0	0.3	0.3			14.7	4.8
16	15.5			8.9			10.9	
17	15.0		0.3	2.5	10.4	3.0	0.3	
18	6.9	0.8	0.5		12.2	1.0		
19	0.5		1.5	10.7	0.3	25.2		
20	9.1					2.6		
21	0.3			3.8	2.0	0.3		
22	0.8		18.8	5.6		39.4	2.5	
23		0.5			2.0	35.1		
24							15.0	
25							12.4	1.3
26	5.3	1.3						
27	16.0	4.3						
28	8.4	11.9						
29	1.0	2.8			0.3			
30					2.0			
31	10.9	12.5			10.2			
TOTAL	96.0	48.0	31.2	49.5	107.9	123.2	66.8	24.9

APPENDIX B

Table 17. Dry Matter Forage Production of Spredor II alfalfa as affected by hay and simulated grazing treatments at the greenhouse in 1987.

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant ⁻¹)
8/33	1	1	0.20
		2	0.19
		3	0.24
		4	0.12
	2	1	0.34
		2	0.24
		3	0.31
		4	0.27
	3	1	0.28
		2	0.23
		3	0.22
		4	0.26
	4	1	0.16
		2	0.13
		3	0.11
		4	0.12
	5	1	0.13
		2	0.08
		3	0.10
		4	0.11
	6	1	0.14
		2	0.11
		3	0.08
		4	0.08
	7	1	0.07
		2	0.08
		3	0.07
		4	0.06
	8	1	0.13
		2	0.06
		3	0.05
		4	0.05
	9	1	0.12
		2	0.11
		3	0.11
		4	0.09
	10	1	0.19
		2	0.19
		3	0.14
		4	0.18

Table 17—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant ⁻¹)
8/33	11	1	0.15
		2	0.14
		3	0.14
		4	0.12
	12	1	0.04
		2	0.03
		3	0.04
		4	0.01
	13	1	0.07
		2	0.06
		3	0.07
		4	0.02
	14	1	0.07
		2	0.05
		3	0.09
		4	0.05
	15	1	0.06
		2	0.07
		3	0.05
		4	0.04
	16	1	1.05
		2	1.02
		3	0.78
		4	0.94
8/50	1	1	0.43
		2	0.35
		3	0.18
		4	0.28
	2	1	0.44
		2	0.34
		3	0.32
		4	0.33
	3	1	0.34
		2	0.33
		3	0.31
		4	0.37

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant ⁻¹)
8/50	4	1	0.09
		2	0.11
		3	0.09
		4	0.09
	5	1	0.03
		2	0.06
		3	0.10
		4	0.07
	6	1	0.08
		2	0.07
		3	0.09
		4	0.12
	7	1	0.10
		2	0.10
		3	0.12
		4	0.09
	8	1	0.11
		2	0.06
		3	0.09
		4	0.05
	9	1	0.06
		2	0.09
		3	0.14
		4	0.14
	10	1	0.08
		2	0.13
		3	0.05
		4	0.16
	11	1	0.06
		2	0.04
		3	0.03
		4	0.05
	12	1	0.03
		2	0.03
		3	0.03
		4	0.03
	13	1	0.03
		2	0.04
		3	0.05
		4	0.07

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
8/50	14	1	0.08
		2	0.09
		3	0.04
		4	0.12
	15	1	0.06
		2	0.03
		3	0.04
		4	0.02
	16	1	0.54
		2	0.52
		3	0.45
		4	0.53
8/67	1	1	0.62
		2	0.40
		3	0.62
		4	0.56
	2	1	0.53
		2	0.43
		3	0.40
		4	0.43
	3	1	0.20
		2	0.15
		3	0.16
		4	0.15
	4	1	0.06
		2	0.06
		3	0.06
		4	0.06
	5	1	0.07
		2	0.05
		3	0.02
		4	0.07
	6	1	0.07
		2	0.05
		3	0.10
		4	0.09
	7	1	0.10
		2	0.07
		3	0.11
		4	0.07

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
8/67	8	1	0.07
		2	0.06
		3	0.08
		4	0.05
	9	1	0.04
		2	0.03
		3	0.06
		4	0.05
	10	1	0.05
		2	0.03
		3	0.03
		4	0.04
	11	1	0.04
		2	0.02
		3	0.04
		4	0.03
	12	1	0.02
		2	0.01
		3	0.03
		4	0.01
	13	1	0.04
		2	0.03
		3	0.06
		4	0.06
	14	1	0.01
		2	0.01
		3	0.02
		4	0.30
	15	1	0.04
		2	0.01
		3	0.04
		4	0.04
	16	1	0.37
		2	0.42
		3	0.52
		4	0.38

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
16/33	1	1	0.20
		2	0.32
		3	0.27
		4	0.26
	3	1	0.18
		2	0.31
		3	0.37
		4	0.36
	5	1	0.15
		2	0.17
		3	0.24
		4	0.17
	7	1	0.21
		2	0.20
		3	0.19
		4	0.14
	9	1	0.05
		2	0.10
		3	0.22
		4	0.24
	11	1	0.10
		2	0.12
		3	0.15
		4	0.10
	13	1	0.15
		2	0.13
		3	0.08
		4	0.16
	15	1	0.30
		2	0.33
		3	0.36
		4	0.39
	16	1	1.57
		2	1.43
		3	1.40
		4	1.50

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
16/50	1	1	0.34
		2	0.47
		3	0.35
		4	0.37
	3	1	0.50
		2	0.52
		3	0.42
		4	0.49
	5	1	0.16
		2	0.20
		3	0.18
		4	0.27
	7	1	0.20
		2	0.26
		3	0.16
		4	0.18
	9	1	0.18
		2	0.31
		3	0.22
		4	0.25
	11	1	0.18
		2	0.20
		3	0.19
		4	0.21
	13	1	0.11
		2	0.14
		3	0.13
		4	0.17
	15	1	0.12
		2	0.20
		3	0.10
		4	0.07
	16	1	1.15
		2	1.23
		3	1.10
		4	1.06

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant.-1)
16/67	1	1	0.61
		2	0.61
		3	0.68
		4	0.56
	3	1	0.63
		2	0.58
		3	0.55
		4	0.52
	5	1	0.16
		2	0.15
		3	0.19
		4	0.10
	7	1	0.24
		2	0.20
		3	0.24
		4	0.26
	9	1	0.18
		2	0.21
		3	0.18
		4	0.23
	11	1	0.14
		2	0.17
		3	0.19
		4	0.18
	13	1	0.19
		2	0.12
		3	0.18
		4	0.10
	15	1	0.12
		2	0.12
		3	0.14
		4	0.09
	16	1	0.68
		2	0.65
		3	0.65
		4	0.66

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
32/33	1	1	0.28
		2	0.23
		3	0.20
		4	0.26
	5	1	0.29
		2	0.26
		3	0.18
		4	0.45
	9	1	0.33
		2	0.40
		3	0.28
		4	0.17
	13	1	0.38
		2	0.17
		3	0.20
		4	0.04
	16	1	2.11
		2	2.12
		3	1.60
		4	1.54
32/50	1	1	0.34
		2	0.42
		3	0.35
		4	0.37
	5	1	0.56
		2	0.44
		3	0.58
		4	0.53
	9	1	0.28
		2	0.45
		3	0.42
		4	0.38
	13	1	0.39
		2	0.35
		3	0.38
		4	0.44
	16	1	1.54
		2	1.65
		3	1.61
		4	1.66

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
32/67	1	1	0.62
		2	0.6
		3	0.55
		4	0.58
	5	1	0.48
		2	0.68
		3	0.63
		4	0.49
	9	1	0.45
		2	0.53
		3	0.65
		4	0.68
	13	1	0.34
		2	0.46
		3	0.27
		4	0.4
	16	1	1.14
		2	1.37
		3	1.24
		4	1.22
Graduated	1	1	0.17
		2	0.21
		3	0.34
		4	0.16
	2	1	0.34
		2	0.27
		3	0.19
		4	0.26
	3	1	0.25
		2	0.26
		3	0.27
		4	0.36
	5	1	0.20
		2	0.17
		3	0.15
		4	0.11
	7	1	0.46
		2	0.41
		3	0.37
		4	0.40

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant ⁻¹)
Graduated	11	1	0.39
		2	0.18
		3	0.33
		4	0.10
	15	1	0.70
		2	0.63
		3	0.73
		4	0.48
	16	1	1.00
		2	1.00
		3	0.97
		4	0.86
Prebud	1	1	0.64
		2	0.59
		3	0.63
		4	0.54
	6	1	1.21
		2	1.23
		3	0.79
		4	1.13
	10	1	0.72
		2	0.73
		3	0.70
		4	0.66
	16	1	1.43
		2	1.55
		3	1.82
		4	1.57
Prebloom	1	1	0.34
		2	0.66
		3	0.70
		4	0.43
	8	1	1.18
		2	1.28
		3	1.07
		4	0.87

Table 17--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (grams plant -1)
Prebloom	11	1	0.62
		2	0.51
		3	0.48
		4	0.30
	16	1	1.66
		2	1.42
		3	1.60
		4	1.65
Hay	2	1	1.06
		2	1.23
		3	0.98
		4	0.87
	8	1	1.06
		2	1.13
		3	0.96
		4	0.83
	11	1	0.48
		2	0.42
		3	0.38
		4	0.36
	16	1	1.39
		2	1.48
		3	1.63
		4	1.30

APPENDIX C

Table 18. Dry Matter Forage Production, Crude Protein Production, in vitro Dry Matter Digestibility (IVDMD), Neutral Detergent Fiber (NDF), and Acid Detergent Fiber (ADF) of Maxim alfalfa at Bozeman, MT, in 1987 as affected by hay and simulated grazing treatments.

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha.-1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
8/33	2	2	1244.6	0.32	0.70	0.36	0.13
		3	874.6	0.30	0.71	0.34	0.12
		4	1345.8	0.28	0.67	0.37	0.17
	3	2	538.2	0.26	0.64	0.38	0.20
		3	740.0	0.24	0.64	0.41	0.24
		4	773.7	0.24	0.64	0.40	0.25
	4	2	1715.5	0.20	0.63	0.43	0.27
		3	740.0	0.18	0.62	0.44	0.27
		4	1042.7	0.17	0.60	0.47	0.31
	5	2	302.7	0.19	0.62	0.46	0.32
		3	370.0	0.23	0.66	0.45	0.27
		4	437.3	0.23	0.65	0.44	0.29
	6	2	773.7	0.29	0.69	0.41	0.21
		3	605.5	0.30	0.70	0.41	0.18
		4	706.4	0.28	0.66	0.41	0.20
	7	2	437.3	0.30	0.55	0.44	0.23
		3	370.0	0.30	0.55	0.45	0.23
		4	470.9	0.29	0.56	0.44	0.22
	8	2	975.5	0.26	0.62	0.43	0.24
		3	639.1	0.27	0.62	0.44	0.23
		4	1042.7	0.27	0.60	0.44	0.21
	9	2	250.3	0.27	0.58	0.45	0.27
		3	281.6	0.26	0.58	0.45	0.23
		4	184.6	0.26	0.54	0.48	0.30
	10	2	742.3	0.29	0.62	0.43	0.24
		3	598.0	0.29	0.60	0.44	0.24
		4	581.0	0.28	0.60	0.45	0.24
	11	2	344.2	0.27	0.57	0.43	0.27
		3	314.7	0.26	0.57	0.44	0.27
		4	311.1	0.27	0.58	0.45	0.26
	12	2	284.9	0.25	0.57	0.43	0.27
		3	350.3	0.26	0.55	0.46	0.29
		4	402.1	0.25	0.53	0.45	0.30
	13	2	1346.7	0.22	0.64	0.37	0.24
		3	1321.1	0.24	0.64	0.40	0.24
		4	1274.9	0.26	0.71	0.32	0.23

Table 18--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha.-1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
8/50	2	2	2119.1	0.28	0.70	0.39	0.18
		3	1446.4	0.30	0.69	0.36	0.14
		4	2220.0	0.30	0.69	0.38	0.15
	3	2	1278.2	0.18	0.63	0.47	0.32
		3	740.0	0.19	0.61	0.43	0.28
		4	807.3	0.20	0.60	0.45	0.28
	4	2	1177.3	0.17	0.61	0.48	0.34
		3	504.6	0.16	0.60	0.50	0.36
		4	437.4	0.16	0.56	0.51	0.36
	5	2	235.5	0.32	0.72	0.39	0.22
		3	571.8	0.30	0.65	0.43	0.25
		4	571.8	0.31	0.68	0.40	0.22
	6	2	773.7	0.23	0.58	0.48	0.32
		3	437.3	0.21	0.56	0.48	0.33
		4	403.6	0.20	0.51	0.47	0.33
	7	2	269.1	0.32	0.60	0.42	0.20
		3	269.1	0.33	0.61	0.42	0.19
		4	370.0	0.29	0.54	0.45	0.25
	8	2	101.0	0.31	0.65	0.39	0.17
		3	336.4	0.29	0.65	0.39	0.17
		4	134.5	0.31	0.64	0.39	0.16
	9	2	125.2	0.31	0.58	0.39	0.23
		3	286.6	0.29	0.55	0.42	0.25
		4	184.5	0.27	0.53	0.43	0.28
	10	2	216.5	0.31	0.61	0.42	0.20
		3	250.3	0.31	0.58	0.42	0.20
		4	281.6	0.31	0.60	0.40	0.20
	11	2	191.1	0.30	0.56	0.41	0.22
		3	191.1	0.29	0.56	0.41	0.22
		4	126.6	0.29	0.56	0.41	0.23
	12	2	222.9	0.28	0.59	0.39	0.21
		3	32.0	0.29	0.64	0.37	0.21
		4	188.8	0.29	0.60	0.39	0.20
	13	2	491.4	0.27	0.70	0.30	0.18
		3	1022.2	0.25	0.66	0.34	0.22
		4	1027.6	0.24	0.66	0.33	0.22

Table 18--Continued

TREATMENT	HARVEST	REPLICATION	FORAGE DRY MATTER	CRUDE PROTEIN	IVDMD	NDF	ADF
	(#)	(#)	(Kg. Ha.-1)	(%)	(%)	(%)	(%)
8/67	2	2	3531.9	0.25	0.65	0.43	0.23
		3	2825.5	0.26	0.63	0.42	0.21
		4	3733.7	0.24	0.66	0.44	0.23
	3	2	1042.7	0.18	0.58	0.50	0.35
		3	740.0	0.16	0.58	0.54	0.38
		4	706.4	0.16	0.55	0.56	0.38
	4	2	706.4	0.15	0.52	0.56	0.42
		3	336.4	0.16	0.53	0.55	0.41
		4	235.5	0.16	0.53	0.54	0.42
	5	2	336.4	0.19	0.63	0.44	0.31
		3	470.9	0.33	0.70	0.38	0.20
		4	370.0	0.30	0.66	0.40	0.25
	6	2	168.2	0.24	0.57	0.46	0.29
		3	134.5	0.24	0.56	0.47	0.30
		4	67.3	0.24	0.57	0.48	0.29
	7	2	538.2	0.31	0.64	0.41	0.18
		3	403.6	0.32	0.64	0.43	0.18
		4	302.7	0.31	0.63	0.41	0.18
	8	2	100.9	0.30	0.63	0.41	0.18
		3	168.2	0.30	0.64	0.42	0.19
		4	134.5	0.31	0.62	0.43	0.19
	9	2	344.2	0.26	0.53	0.43	0.29
		3	156.5	0.28	0.56	0.42	0.25
		4	123.0	0.30	0.58	0.40	0.23
	10	2	247.4	0.30	0.61	0.38	0.20
		3	253.3	0.32	0.63	0.38	0.19
		4	188.8	0.29	0.59	0.39	0.21
	11	2	157.4	0.28	0.56	0.41	0.24
		3	125.2	0.30	0.58	0.39	0.20
		4	95.0	0.31	0.56	0.41	0.21
	12	2	62.9	0.29	0.58	0.41	0.23
		3	123.0	0.28	0.57	0.40	0.22
		4	125.9	0.27	0.59	0.42	0.24
	13	2	404.3	0.24	0.67	0.31	0.22
		3	527.4	0.24	0.63	0.36	0.21
		4	560.0	0.24	0.64	0.38	0.21

Table 18--Continued

TREATMENT	HARVEST	REPLICATION	FORAGE DRY MATTER	CRUDE PROTEIN	IVDMD	NDF	ADF
	(#)	(#)	(Kg. Ha. -1)	(%)	(%)	(%)	(%)
16/33	2	2	1412.8	0.30	0.68	0.36	0.15
		3	1513.7	0.31	0.69	0.37	0.15
		4	1614.6	0.29	0.65	0.37	0.15
	4	2	2085.5	0.24	0.64	0.40	0.21
		3	2287.3	0.24	0.63	0.41	0.22
		4	1244.6	0.25	0.63	0.37	0.19
	6	2	773.6	0.23	0.62	0.40	0.25
		3	470.9	0.23	0.65	0.38	0.24
		4	1177.3	0.23	0.59	0.41	0.24
	8	2	740.0	0.30	0.70	0.37	0.13
		3	1110.0	0.30	0.67	0.37	0.15
		4	538.2	0.29	0.70	0.38	0.16
	10	2	989.8	0.33	0.69	0.38	0.16
		3	918.1	0.33	0.67	0.40	0.18
		4	1088.8	0.31	0.64	0.40	0.20
	12	2	912.7	0.27	0.65	0.36	0.19
		3	1361.3	0.26	0.65	0.38	0.20
		4	854.8	0.27	0.66	0.35	0.19
	13	2	3650.8	0.17	0.59	0.42	0.34
		3	3706.5	0.18	0.59	0.41	0.32
		4	3655.6	0.16	0.53	0.44	0.36
16/50	2	2	1547.3	0.29	0.71	0.41	0.17
		3	1917.3	0.31	0.73	0.38	0.15
		4	2152.8	0.28	0.67	0.37	0.16
	4	2	1715.5	0.20	0.62	0.45	0.25
		3	2724.6	0.21	0.62	0.42	0.25
		4	1984.6	0.19	0.62	0.43	0.28
	6	2	1345.5	0.24	0.65	0.41	0.26
		3	1412.8	0.25	0.64	0.41	0.26
		4	1311.8	0.23	0.59	0.45	0.29
	8	2	807.3	0.30	0.68	0.39	0.15
		3	975.5	0.29	0.68	0.38	0.16
		4	874.6	0.29	0.68	0.38	0.16
	10	2	1282.9	0.26	0.61	0.49	0.27
		3	1282.9	0.27	0.62	0.46	0.25
		4	1421.1	0.29	0.61	0.43	0.22

Table 18--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg./Ha.-1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
16/50	12	2	944.2	0.28	0.62	0.41	0.22
		3	1109.0	0.27	0.60	0.42	0.25
		4	839.9	0.28	0.60	0.42	0.22
	13	2	1617.8	0.21	0.61	0.36	0.28
		3	1788.2	0.22	0.63	0.35	0.26
		4	1524.5	0.22	0.61	0.41	0.27
16/67	2	2	3464.7	0.25	0.59	0.41	0.22
		3	3296.4	0.25	0.67	0.45	0.23
		4	2960.1	0.25	0.65	0.44	0.23
	4	2	1379.1	0.15	0.56	0.59	0.42
		3	1950.9	0.16	0.56	0.54	0.38
		4	1076.4	0.14	0.53	0.58	0.44
	6	2	874.6	0.29	0.65	0.40	0.20
		3	1143.6	0.29	0.65	0.40	0.18
		4	874.6	0.30	0.67	0.46	0.18
	8	2	874.6	0.30	0.62	0.41	0.16
		3	706.6	0.30	0.61	0.42	0.17
		4	908.2	0.30	0.64	0.39	0.16
	10	2	876.1	0.28	0.60	0.42	0.23
		3	1007.1	0.28	0.58	0.43	0.22
		4	835.1	0.28	0.56	0.43	0.22
	12	2	406.7	0.29	0.61	0.42	0.21
		3	531.9	0.28	0.58	0.40	0.22
		4	445.8	0.27	0.55	0.42	0.24
	13	2	755.6	0.26	0.69	0.33	0.21
		3	761.1	0.25	0.68	0.30	0.21
		4	653.0	0.26	0.68	0.32	0.21
32/33	2	2	1749.1	0.32	0.72	0.36	0.14
		3	1614.6	0.31	0.70	0.35	0.14
		4	1614.6	0.30	0.68	0.38	0.16
	6	2	1345.5	0.24	0.66	0.40	0.21
		3	2522.8	0.23	0.64	0.40	0.22
		4	2220.0	0.21	0.59	0.41	0.25
	10	2	1306.6	0.31	0.66	0.40	0.20
		3	1493.2	0.31	0.69	0.38	0.19
		4	1593.6	0.30	0.63	0.39	0.18

Table 18—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
32/33	13	2	4686.3	0.14	0.55	0.49	0.39
		3	5342.3	0.10	0.51	0.57	0.45
		4	5125.7	0.13	0.55	0.52	0.41
32/50	2	2	2186.4	0.29	0.69	0.36	0.17
		3	1782.8	0.30	0.69	0.36	0.13
		4	1883.7	0.28	0.63	0.40	0.19
	6	2	3599.2	0.20	0.64	0.43	0.29
		3	4238.3	0.21	0.64	0.40	0.24
		4	2724.6	0.20	0.63	0.42	0.28
	10	2	2429.6	0.28	0.64	0.43	0.21
		3	2271.0	0.30	0.66	0.41	0.19
		4	2208.8	0.30	0.63	0.41	0.20
	13	2	4071.4	0.15	0.55	0.45	0.36
		3	4081.0	0.17	0.58	0.44	0.33
		4	3944.4	0.16	0.56	0.43	0.35
32/67	2	2	3666.4	0.27	0.68	0.39	0.19
		3	3464.6	0.25	0.66	0.42	0.22
		4	3195.5	0.25	0.66	0.41	0.22
	6	2	2253.7	0.24	0.63	0.44	0.27
		3	1850.0	0.23	0.63	0.44	0.28
		4	1580.9	0.21	0.62	0.46	0.31
	10	2	2315.5	0.28	0.62	0.44	0.23
		3	3212.4	0.25	0.64	0.45	0.24
		4	2426.5	0.27	0.63	0.44	0.22
	13	2	2913.7	0.21	0.63	0.41	0.26
		3	2342.3	0.19	0.61	0.43	0.30
		4	2927.6	0.20	0.58	0.44	0.29
Graduated	1	2	2051.9	0.30	0.68	0.37	0.16
		3	2724.6	0.32	0.68	0.37	0.16
		4	2859.1	0.32	0.70	0.33	0.15
	2	2	571.8	0.22	0.65	0.39	0.22
		3	773.6	0.22	0.62	0.42	0.23
		4	773.6	0.21	0.65	0.44	0.25
	3	2	403.6	0.19	0.62	0.48	0.32
		3	672.7	0.17	0.60	0.53	0.35
		4	672.7	0.18	0.60	0.49	0.35

Table 18—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
Graduated	5	2	201.8	0.33	0.69	0.39	0.19
		3	269.0	0.34	0.72	0.40	0.20
		4	168.2	0.34	0.71	0.39	0.21
	7	2	1143.6	0.28	0.64	0.41	0.22
		3	605.5	0.29	0.66	0.40	0.19
		4	874.6	0.27	0.65	0.41	0.21
	11	2	2690.9	0.25	0.59	0.43	0.26
		3	3789.7	0.25	0.64	0.41	0.25
		4	3566.7	0.25	0.62	0.41	0.23
	13	2	2837.1	0.19	0.60	0.42	0.29
		3	3000.0	0.19	0.58	0.44	0.32
		4	3219.0	0.17	0.55	0.49	0.35
Prebud	2	2	5180.1	0.24	0.66	0.44	0.23
		3	5785.6	0.25	0.64	0.41	0.21
		4	4742.8	0.25	0.65	0.42	0.21
	8	2	3700.1	0.23	0.62	0.42	0.26
		3	3868.3	0.22	0.60	0.44	0.27
		4	2892.8	0.24	0.63	0.42	0.26
	12	2	2627.7	0.24	0.57	0.43	0.25
		3	2517.9	0.24	0.63	0.40	0.24
		4	2452.1	0.25	0.63	0.40	0.22
	13	2	1849.7	0.23	0.66	0.33	0.22
		3	1676.5	0.22	0.61	0.43	0.27
		4	1454.0	0.23	0.61	0.42	0.26
Prebloom	2	2	5247.4	0.24	0.67	0.41	0.21
		3	5045.6	0.25	0.67	0.46	0.23
		4	5112.8	0.24	0.68	0.40	0.20
	9	2	4500.7	0.22	0.58	0.44	0.29
		3	5224.5	0.19	0.55	0.48	0.34
		4	4582.3	0.22	0.56	0.46	0.30
	13	2	3095.9	0.16	0.57	0.44	0.31
		3	3538.0	0.15	0.57	0.49	0.36
		4	3907.0	0.16	0.60	0.41	0.29
Hay	5	2	6290.1	0.33	0.70	0.43	0.22
		3	6862.0	0.15	0.59	0.50	0.39
		4	7063.8	0.18	0.62	0.47	0.32

Table 18--Continued

TREATMENT	HARVEST	REPLICATION	FORAGE DRY MATTER (Kg.Ha.-1)	CRUDE PROTEIN (%)	IVDMD (%)	NDF (%)	ADF (%)
	(#)	(#)					
Hay	11	2	4748.8	0.17	0.59	0.53	0.36
		3	4780.4	0.2	0.59	0.49	0.32
		4	4808.7	0.2	0.59	0.47	0.30
	13	2	2612.8	0.18	0.59	0.44	0.31
		3	2467.9	0.2	0.59	0.44	0.30
		4	2452.9	0.2	0.62	0.41	0.28

APPENDIX D

Table 19. Dry Matter Forage Production and Crude Protein Production of Spredor II alfalfa at Kalispell, MT, in 1987 as affected by hay and simulated grazing treatments.

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg.Ha.-1)	CRUDE PROTEIN (%)	(Kg.Ha.-1)
8/33	1	1	650.06	0.28	182.02
		2	672.48	0.29	195.02
		3	896.64	0.29	260.03
		4	896.64	0.28	251.06
	2	1	560.40	0.29	162.52
		2	650.06	0.28	182.02
		3	694.90	0.28	194.57
		4	650.06	0.29	188.52
	3	1	896.64	0.26	233.13
		2	784.56	0.28	219.68
		3	762.14	0.27	205.78
		4	739.73	0.27	199.73
	4	1	560.40	0.25	140.10
		2	650.06	0.27	175.52
		3	694.90	0.26	180.67
		4	650.06	0.25	162.52
	5	1	470.74	0.24	112.98
		2	717.31	0.24	172.15
		3	672.48	0.24	161.40
		4	560.40	0.23	128.89
	6	1	134.50	0.28	37.66
		2	89.66	0.27	24.21
		3	89.66	0.28	25.11
		4	89.66	0.27	24.21
	7	1	179.33	0.29	52.01
		2	246.58	0.29	71.51
		3	134.50	0.29	39.00
		4	179.33	0.29	52.01
	8	1	694.90	0.28	194.57
		2	650.06	0.29	188.52
		3	605.23	0.28	169.46
		4	650.06	0.29	188.52
	9	1	784.56	0.26	203.99
		2	672.48	0.27	181.57
		3	537.98	0.27	145.26
		4	694.90	0.27	187.62
	10	1	448.32	0.27	121.05
		2	470.74	0.24	112.98
		3	403.49	0.24	96.84
		4	425.90	0.26	110.74

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha.-1)	CRUDE PROTEIN (%)	(Kg. Ha.-1)
8/33	11	1	112.08	0.29	32.50
		2	44.83	0.30	13.45
		3	44.83	0.29	13.00
		4	67.25	0.27	18.16
	12	1	515.57	0.32	164.98
		2	515.57	0.31	159.83
		3	537.98	0.31	166.78
		4	493.15	0.32	157.81
	13	1	425.90	0.25	106.48
		2	246.58	0.25	61.64
		3	156.91	0.26	40.80
		4	336.24	0.26	87.42
	15	1	3384.82	0.20	676.96
		2	3227.90	0.19	613.30
		3	3160.66	0.19	600.52
		4	3698.64	0.20	739.73
8/50	1	1	1546.70	0.27	417.61
		2	1031.14	0.28	288.72
		3	1457.04	0.28	407.97
		4	1255.30	0.27	338.93
	2	1	448.32	0.26	116.56
		2	627.65	0.28	175.74
		3	537.98	0.26	139.88
		4	605.23	0.29	175.52
	3	1	717.31	0.25	179.33
		2	717.31	0.24	172.15
		3	694.90	0.26	180.67
		4	694.90	0.24	166.78
	4	1	448.32	0.25	112.08
		2	627.65	0.24	150.64
		3	537.98	0.25	134.50
		4	605.23	0.24	145.26
	5	1	560.40	0.21	117.68
		2	874.22	0.23	201.07
		3	1098.38	0.19	208.69
		4	650.06	0.21	136.51
	6	1	112.08	0.29	32.50
		2	112.08	0.29	32.50
		3	89.66	0.28	25.11
		4	89.66	0.24	21.52

Table 19—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha.-1)	CRUDE PROTEIN (%) (Kg. Ha.-1)
8/50	7	1	134.50	0.30 40.35
		2	156.91	0.30 47.07
		3	112.08	0.30 33.62
		4	112.08	0.30 33.62
	8	1	224.16	0.28 62.76
		2	268.99	0.28 75.32
		3	246.58	0.29 71.51
		4	268.99	0.28 75.32
	9	1	336.24	0.30 100.87
		2	336.24	0.30 100.87
		3	291.41	0.30 87.42
		4	358.66	0.30 107.60
	10	1	291.41	0.30 87.42
		2	313.82	0.30 94.15
		3	268.99	0.30 80.70
		4	336.24	0.30 100.87
	11	1	268.99	0.29 78.01
		2	246.58	0.30 73.97
		3	224.16	0.30 67.25
		4	224.16	0.30 67.25
	12	1	448.32	0.31 138.98
		2	470.74	0.31 145.93
		3	425.90	0.31 132.03
		4	493.15	0.31 152.88
	15	1	2914.08	0.22 641.10
		2	2734.75	0.23 628.99
		3	2129.52	0.22 468.49
		4	2107.10	0.23 484.63
8/67	1	1	2174.35	0.26 565.33
		2	2264.02	0.27 611.28
		3	1995.02	0.27 538.66
		4	2017.44	0.27 544.71
	2	1	1210.46	0.24 290.51
		2	1098.38	0.24 263.61
		3	1120.80	0.24 268.99
		4	1053.55	0.25 263.39
	3	1	851.81	0.27 229.99
		2	784.56	0.28 219.68
		3	874.22	0.26 227.30
		4	762.14	0.27 205.78

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha.-1)	CRUDE PROTEIN (%) (Kg. Ha.-1)
8/67	4	1	1210.46	0.25 302.62
		2	1098.38	0.25 274.60
		3	1120.80	0.25 280.20
		4	1053.55	0.25 263.39
	5	1	134.50	0.18 24.21
		2	44.83	0.24 10.76
		3	156.91	0.20 31.38
		4	44.83	0.23 10.31
	6	1	201.74	0.28 56.49
		2	201.74	0.25 50.44
		3	201.74	0.29 58.51
		4	268.99	0.29 78.01
	7	1	67.25	0.28 18.83
		2	22.42	0.27 6.05
		3	44.83	0.29 13.00
		4	22.42	0.27 6.05
	8	1	179.33	0.28 50.21
		2	179.33	0.28 50.21
		3	224.16	0.28 62.76
		4	224.16	0.28 62.76
	9	1	201.74	0.30 60.52
		2	201.74	0.30 60.52
		3	224.16	0.25 56.04
		4	201.74	0.30 60.52
	10	1	246.58	0.29 71.51
		2	246.58	0.30 73.97
		3	291.41	0.30 87.42
		4	246.58	0.29 71.51
	11	1	156.91	0.29 45.50
		2	134.50	0.30 40.35
		3	201.74	0.29 58.51
		4	156.91	0.29 45.50
	12	1	291.41	0.30 87.42
		2	268.99	0.29 78.01
		3	336.24	0.30 100.87
		4	336.24	0.30 100.87
	15	1	537.98	0.24 129.12
		2	1613.95	0.23 371.21
		3	1748.45	0.24 419.63
		4	1770.86	0.21 371.88

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE	CRUDE	
			DRY MATTER (Kg. Ha.-1)	PROTEIN (%)	(Kg. Ha.-1)
16/33	1	1	784.56	0.28	219.68
		2	829.39	0.28	232.23
		3	851.81	0.29	247.02
		4	874.22	0.28	244.78
	3	1	1031.14	0.26	268.10
		2	963.89	0.26	250.61
		3	874.22	0.25	218.56
		4	1008.72	0.27	272.35
	5	1	1008.72	0.25	252.18
		2	941.47	0.25	235.37
		3	1479.46	0.24	355.07
		4	1098.38	0.25	274.60
	7	1	470.74	0.28	131.81
		2	358.66	0.28	100.42
		3	403.49	0.28	112.98
		4	425.90	0.28	119.25
	9	1	829.39	0.28	232.23
		2	874.22	0.28	244.78
		3	650.06	0.27	175.52
		4	829.39	0.28	232.23
	11	1	448.32	0.27	121.05
		2	403.49	0.28	112.98
		3	425.90	0.28	119.25
		4	313.82	0.28	87.87
	13	1	336.24	0.26	87.42
		2	358.66	0.27	96.84
		3	358.66	0.25	89.66
		4	1031.14	0.23	237.16
	15	1	5200.51	0.19	988.10
		2	5155.68	0.19	979.58
		3	5178.10	0.19	983.84
		4	5716.08	0.19	1086.06
16/50	1	1	1344.96	0.28	376.59
		2	1344.96	0.28	376.59
		3	1457.04	0.28	407.97
		4	1255.30	0.28	351.48

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	(Kg. Ha. -1)
16/50	3	1	1569.12	0.25	392.28
		2	1457.04	0.25	364.26
		3	1434.62	0.25	358.66
		4	1457.04	0.25	364.26
	5	1	694.90	0.25	173.72
		2	381.07	0.24	91.46
		3	739.73	0.25	184.93
		4	874.22	0.24	209.81
	7	1	358.66	0.30	107.60
		2	425.90	0.28	119.25
		3	403.49	0.28	112.98
		4	425.90	0.29	123.51
	9	1	1031.14	0.27	278.41
		2	963.89	0.26	250.61
		3	986.30	0.26	256.44
		4	896.64	0.27	242.09
	11	1	403.49	0.28	112.98
		2	515.57	0.29	149.51
		3	560.40	0.29	162.52
		4	582.82	0.30	174.84
	13	1	694.90	0.28	194.57
		2	672.48	0.28	188.29
		3	627.65	0.28	175.74
		4	605.23	0.27	163.41
	15	1	2891.66	0.20	578.33
		2	2689.92	0.20	537.98
		3	3295.15	0.21	691.98
		4	2622.67	0.20	524.53
16/67	1	1	1815.70	0.27	490.24
		2	2241.60	0.28	627.65
		3	1815.70	0.27	490.24
		4	1927.78	0.27	520.50
	3	1	1770.86	0.25	442.72
		2	1389.79	0.25	347.45
		3	1569.12	0.25	392.28
		4	1389.79	0.26	361.35
	5	1	291.41	0.26	75.77
		2	1300.13	0.23	299.03
		3	1232.88	0.23	283.56
		4	1143.22	0.22	251.51

Table 19—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg./Ha.-1)	CRUDE PROTEIN (%)	(Kg./Ha.-1)
16/67	7	1	179.33	0.30	53.80
		2	224.16	0.28	62.76
		3	291.41	0.29	84.51
		4	336.24	0.29	97.51
	9	1	560.40	0.30	168.12
		2	582.82	0.29	169.02
		3	627.65	0.29	182.02
		4	627.65	0.30	188.29
	11	1	537.98	0.29	156.02
		2	627.65	0.29	182.02
		3	582.82	0.30	174.84
		4	650.06	0.30	195.02
	13	1	829.39	0.29	240.52
		2	851.81	0.29	247.02
		3	874.22	0.29	253.52
		4	986.30	0.29	286.03
	15	1	1344.96	0.23	309.34
		2	1053.55	0.24	252.85
		3	1703.62	0.24	408.87
		4	1501.87	0.23	345.43
32/33	1	1	672.48	0.28	188.29
		2	919.06	0.26	238.95
		3	806.98	0.28	225.95
		4	717.31	0.27	193.67
	5	1	1658.78	0.26	431.28
		2	1770.86	0.26	460.42
		3	1815.70	0.26	472.08
		4	2039.86	0.27	550.76
	9	1	1165.63	0.24	279.75
		2	650.06	0.22	143.01
		3	1098.38	0.24	263.61
		4	1815.70	0.22	399.45
	13	1	986.30	0.22	216.99
		2	1031.14	0.29	299.03
		3	1277.71	0.23	293.87
		4	1770.86	0.22	389.59
	15	1	6388.56	0.16	1022.17
		2	5671.25	0.15	850.69
		3	6276.48	0.17	1067.00
		4	7105.87	0.15	1065.88

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	(Kg. Ha. -1)
32/50	1	1	1457.04	0.28	407.97
		2	1546.70	0.27	417.61
		3	1098.38	0.28	307.55
		4	1232.88	0.29	357.54
	5	1	1591.54	0.26	413.80
		2	1569.12	0.26	407.97
		3	1524.29	0.26	396.31
		4	1457.04	0.26	378.83
	9	1	1165.63	0.24	279.75
		2	1143.22	0.26	297.24
		3	1389.79	0.24	333.55
		4	1434.62	0.24	344.31
	13	1	1636.37	0.24	392.73
		2	874.22	0.27	236.04
		3	1232.88	0.25	308.22
		4	1075.97	0.26	279.75
	15	1	3676.22	0.18	661.72
		2	4169.38	0.19	792.18
		3	4438.37	0.12	532.60
		4	3877.97	0.18	698.03
32/67	1	1	1524.29	0.27	411.56
		2	1860.53	0.26	483.74
		3	2196.77	0.27	593.13
		4	1793.28	0.27	484.19
	5	1	1613.95	0.27	435.77
		2	1681.20	0.26	437.11
		3	1726.03	0.27	466.03
		4	2174.35	0.26	565.33
	9	1	2039.86	0.25	509.96
		2	1703.62	0.24	408.87
		3	1569.12	0.25	392.28
		4	1860.53	0.24	446.53
	13	1	1501.87	0.24	360.45
		2	1927.78	0.26	501.22
		3	1681.20	0.26	437.11
		4	2129.52	0.24	511.08
	15	1	2958.91	0.20	591.78
		2	3295.15	0.18	593.13
		3	2891.66	0.22	636.17
		4	3003.74	0.20	600.75

Table 19—Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	(Kg. Ha. -1)
Graduated	1	1	829.39	0.27	223.94
		2	941.47	0.28	263.61
		3	784.56	0.28	219.68
		4	919.06	0.28	257.34
	2	1	1300.13	0.28	364.04
		2	1748.45	0.28	489.57
		3	1726.03	0.28	483.29
		4	1389.79	0.28	389.14
	3	1	806.98	0.27	217.88
		2	829.39	0.27	223.94
		3	784.56	0.26	203.99
		4	739.73	0.27	199.73
	5	1	1300.13	0.24	312.03
		2	1748.45	0.24	419.63
		3	1726.03	0.23	396.99
		4	1389.79	0.25	347.45
	7	1	358.66	0.27	96.84
		2	358.66	0.27	96.84
		3	470.74	0.28	131.81
		4	448.32	0.28	125.53
	11	1	2779.58	0.22	611.51
		2	2510.59	0.25	627.65
		3	2151.94	0.25	537.98
		4	2689.92	0.24	645.58
	14	1	2622.67	0.23	603.21
		2	2264.02	0.25	566.00
		3	2600.26	0.24	624.06
		4	2757.17	0.24	661.72
	15	1	1188.05	0.22	261.37
		2	896.64	0.21	188.29
		3	1098.38	0.24	263.61
		4	1210.46	0.23	278.41
Prebud	1	1	2600.26	0.26	676.07
		2	242.09	0.25	60.52
		3	2219.18	0.26	576.99
		4	2533.01	0.26	658.58

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE DRY MATTER (Kg. Ha. -1)	CRUDE PROTEIN (%)	(Kg. Ha. -1)
Prebud	6	1	3115.82	0.24	747.80
		2	3295.15	0.24	790.84
		3	3676.22	0.24	882.29
		4	3227.90	0.24	774.70
	10	1	2757.17	0.24	661.72
		2	2555.42	0.24	613.30
		3	2869.25	0.25	717.31
		4	2824.42	0.24	677.86
	14	1	1770.86	0.27	478.13
		2	1636.37	0.27	441.82
		3	1681.20	0.28	470.74
		4	1927.78	0.27	520.50
	15	1	650.06	0.26	169.02
		2	582.82	0.24	139.88
		3	560.40	0.26	145.70
		4	560.40	0.26	145.70
Prebloom	1	1	2376.10	0.26	617.78
		2	2465.76	0.26	641.10
		3	2151.94	0.26	559.50
		4	2264.02	0.26	588.64
	6	1	4707.36	0.23	1082.69
		2	4393.54	0.22	966.58
		3	3990.05	0.23	917.71
		4	4684.94	0.22	1030.69
	11	1	2914.08	0.22	641.10
		2	2914.08	0.22	641.10
		3	2802.00	0.23	644.46
		4	3048.58	0.23	701.17
	15	1	5021.18	0.17	853.60
		2	4617.70	0.17	785.01
		3	4483.20	0.17	762.14
		4	5088.43	0.19	966.80
Hay	6	1	7845.60	0.20	1569.12
		2	7038.62	0.20	1407.72
		3	6904.13	0.17	1173.70
		4	7576.61	0.19	1439.56
	11	1	3496.90	0.20	699.38
		2	3788.30	0.21	795.54
		3	3653.81	0.20	730.76
		4	3810.72	0.22	838.36

Table 19--Continued

TREATMENT	HARVEST (#)	REPLICATION (#)	FORAGE	CRUDE	
			DRY MATTER (Kg.Ha.-1)	PROTEIN (%)	(Kg.Ha.-1)
Hay	15	1	5716.08	0.15	857.41
		2	5043.60	0.17	857.41
		3	4909.10	0.18	883.64
		4	5290.18	0.18	952.23

Table 20. Leaflet area per harvest of Spredor II alfalfa as affected by hay and simulated grazing treatments at greenhouse in 1987.

TREATMENT	H A R V E S T N U M B E R																LSD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
8/67	0.59	0.44	0.50	0.57	0.68	0.66	0.48	0.48	0.37	0.44	0.45	0.38	0.41	0.18	0.25	0.23	0.152
8/50	0.61	0.46	0.34	0.58	0.58	0.66	0.53	0.59	0.38	0.57	0.59	0.43	0.47	0.32	0.24	0.19	0.126
8/33	0.57	0.38	0.35	0.41	0.51	0.57	0.59	0.60	0.36	0.40	0.51	0.50	0.49	0.30	0.26	0.17	0.153
16/67	0.64		0.52		0.62		0.75		0.57		0.68		0.69		0.37	0.21	0.140
16/50	0.64		0.45		0.54		0.65		0.45		0.67		0.62		0.35	0.20	0.117
16/33	0.63		0.36		0.46		0.48		0.42		0.50		0.42		0.21	0.25	0.106
32/67	0.58				0.55				0.60				0.60			0.30	0.128
32/50	0.66				0.41				0.48				0.46			0.27	0.107
32/33	0.64				0.37				0.37				0.42			0.25	0.095
Graduated	0.63	0.43	0.38		0.60		0.58				0.47				0.26	0.19	0.078
Prebud	0.62					0.56				0.59						0.43	0.133
Prebloom	0.53							0.43			0.54					0.34	0.114
Hay		0.47						0.56			0.65					0.43	0.127

APPENDIX F

Table 21. Leaflet area per harvest above and below the cut level of Maxim alfalfa as affected by hay and simulated grazing treatments at Bozeman, MT, in 1987.

TREATMENTS	H A R V E S T N U M B E R												LSD
	1	2	3	4	5	6	7	8	9	10	11	12	
8/67	ac	1.22	1.16	0.27	0.58	0.45	0.64	0.59	0.31	0.64	0.60	0.52	0.225
	bc							0.27	0.19	0.21	0.30	0.24	0.090
8/50	ac	1.43	1.23	0.81	0.59	0.31	0.61	0.67	0.51	0.64	0.64	0.44	0.217
	bc							0.34	0.28	0.27	0.23	0.20	0.151
8/33	ac	1.39	1.36	1.05	0.71	0.58	0.42	0.53	0.44	0.70	0.82	0.56	0.301
	bc							0.29	0.23	0.29	0.33	0.31	0.171
16/67	ac	1.24		0.53		0.48		1.00		0.80		0.68	0.440
	bc							0.39		0.27		0.24	0.138
16/50	ac	1.46		1.08		0.53		0.69		0.63		0.78	0.394
	bc							0.34		0.34		0.33	0.164
16/33	ac	1.24		1.06		0.66		0.56		0.72		0.53	0.313
	bc							0.41		0.37		0.45	0.135
32/67	ac	1.06				0.55				0.83		1.02	0.385
	bc									0.58		0.49	0.224
32/50	ac	0.99				0.83				0.69		0.42	0.323
	bc									0.42		0.38	0.339
32/33	ac	1.17				0.57				0.92		0.46	0.373
	bc									0.50		0.36	0.269
Graduated	ac	1.25	1.24	1.39		0.66		0.40			0.84	0.33	0.263
	bc										0.49	0.20	0.126
Prebud	ac	1.52						0.39				1.23	0.406
	bc							0.30				0.33	0.152
Prebloom	ac	1.13							0.40			1.20	0.389
	bc								0.00			0.28	0.259
Hay	ac				1.04						1.55	0.44	0.342
	bc										0.44	0.20	0.173

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