AN ABSTRACT OF THE THESIS OF

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Title: Effects of Strip Versus Continuous Grazing Management on Diet Parameters and Performance of Yearling Steers Grazing Native Flood Meadow Vegetation in Eastern Oregon

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A trial was conducted May 1 to September 4, 1989 at the Eastern Oregon Agricultural Research Center (EOARC) Burns, OR to examine the effects of strip or continuous grazing management on the diet and performance of steers grazing native flood meadows. The objective was to determine if strip grazing would be a more efficient means of grazing management than continuous grazing.

The experiment was designed to test diet quality, botanical composition of the diet, daily dry matter (DM) intake and performance of yearling steers. Eighty yearling steers weighing 253±17 kg were selected from cattle at the Squaw Butte Experiment Station. The experimental design was a randomized complete block, with blocking based on past forage production. Treatments were continuous or strip grazing. A representative meadow of approximately 22.4 ha was divided into four equal pastures. Continuous grazing steers had access to 5.6 ha pastures for the duration of the study. Animals on strip grazing were confined to an area that was estimated to provide 5-7 days of forage using New Zealand portable electric fencing. Strip sizes were

predetermined based on standing forage crop. Steers were not allowed to graze more than 7 days in any one strip. Diet quality was estimated from bi-weekly esophageal samples. Extrusa was collected from 4 esophageal fistulated steers per treatment on two consecutive days. Collections were timed to coincide with the mid point of the strip being currently grazed. Samples were pooled by collection dates and analyzed for CP and IVOMD. Dietary DM intake was estimated from bi-weekly, 24 hr total fecal collections starting the day following esophageal collections. Total DM fecal output from 6 fecal collection steers per treatment was corrected with the %IVOMD to predict actual DM intake. Diet botanical composition was estimated by microhistological examination of fecal sub-samples. Animal weight gains were recorded bi-weekly. Experimental animals grazed together at all times during the trial. Initial stocking densities were 2.0 AU/ha in each treatment pasture. Steers were counted as .56 AU with 20 steers grazing 5.6 ha pastures. The average strip size over the trial was .46 ha; and depending upon standing crop of forage, ranged from .23-1.15 ha. Record moisture from snowmelt and rainfall resulted in greater than expected standing crop of forage. This growth resulted in under stocking of both treatment pastures. A 1.08 ha block was removed as hay from the higher forage producing strip treatment block to adjust for over abundant forage. This resulted in a total mean strip grazed area of 4.37 ha or 22% less than continuous grazing. Actual grazing density means over the summer were 2.6 AU/ha for continuous and 3.15 AU/ha for the strip treatment. Available forage was determined from clipped plots on a DM basis and expressed as herbage allowance at a given point in time. Herbage allowance for steers in continuous grazed pastures ranged from 405-1153 kg/AU when measured at bi-weekly intervals and 68-186 kg/AU for strip grazed steers when estimated at the beginning of each strip. Grazing pressure was higher for strip grazed steers (.10 AU/kg) compared to continuous (.02 AU/kg). Diet quality declined significantly over the summer (P<.01). Analysis for CP in steer diets provided values of 13.9 vs 10.9% for continuous and strip treatments, respectively. However, this difference was not significant (P=.14). Digestibility analysis suggested that forage in continuous diets tended (P=.07) to have higher IVOMD than strip diets (64.6 vs 60.7%), respectively. Daily herbage intake was similar (P=.42) for both treatments when expressed as a percentage of body weight. Diet botanical composition was positively affected by the type of management system. The amount of the major grass species, meadow foxtail (*Alopecurus pratensis*), was increased (P=.05) 39% in the diet of strip grazing steers. Differences were noted in the amounts of other, less frequently occurring grass species. The total amount of grass tended (P=.06) to be higher in strip diets (49% vs 35% for continuous). Rushes (*Juncus* spp.) and sedges (*Carex* spp.) contributed a similar percentage to the diets of both treatments. Forbs comprised less than .5% of the overall diet of both strip and continuous steers. Individual animal performance tended (P=.09) to be higher under continuous grazing management. The ADG was 1.16 and .77 kg for steers in continuous and strip grazing, respectively. However, total animal production per hectare grazed area (26.14 vs 22.13 kg/hd) was not considered different (P=.17).

Effects of Strip Versus Continuous Grazing Management on Diet Parameters and Performance of Yearling Steers Grazing Native Flood Meadow Vegetation in Eastern Oregon

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EFFECTS OF STRIP VERSUS CONTINUOUS GRAZING MANAGEMENT ON DIET PARAMETERS AND PERFORMANCE OF YEARLING STEERS GRAZING NATIVE FLOOD MEADOW VEGETATION IN EASTERN OREGON

INTRODUCTION

Seasonally flooded native meadowlands have been the focus of renewed and much needed study over the past few years. Areas that fit into this seasonally wet category are quite productive at certain times of the year, but often have a low overall level of production. Typically these native flood meadows (NFM) are found in the United States (US) throughout the northern great basin. Meadows located in the Harney basin of southeastern Oregon, which are the focus of this research, are similar to other meadows throughout the northwestern US.

Spring snowmelt insures an abundant supply of water in the spring and in average years lasts until July. Control of the water is minimal, resulting in more of a wild flooding system (Rumburg, 1963). The vast majority of the meadows are privately owned and are managed for production of winter hay. The traditional management regime for most NFM involves haying in mid July, grazing of remaining stubble in the fall and then providing winter feeding grounds for cows. Current estimates (Chamberlain, 1989 personal communication) place cow numbers at 60,000 head grazing local NFM at some point in the season. However, only 3,000 head are estimated to graze NFM in the summer months.

With proper fertilization, hay production is generally 3400 kg/ha, but regrowth potential in most years is very low (Rumburg, 1963; Gomm, 1978). Hay quality decreases with later dates of harvest (Raleigh et al., 1964). This is of particular concern, because wet conditions hamper early haying operations. Dates of harvest after late June increase hay volume, but quality is reduced.

A contributing factor to the quality of hay is the species composition of the meadow. Native flood vegetation in the area of southeastern Oregon has shifted from stands of predominantly *Juncus/Carex*, to stands of cool season grasses. The dominant cool season grass, meadow foxtail (*Alopecurus pratensis*) was introduced to the area and now represents approximately 41% of the stand (Angell, 1989 unpublished data). Meadow foxtail is high yielding, yet early maturing and is often very mature by mid June (Hannaway and McGuire, 1981).

The major problems that should be addressed regarding native flood meadows from the standpoint of a southeastern Oregon livestock producer are: (1) low quality of hay created by late harvest and (2) the shrinking number of grazing permits on public lands. These concerns require information on alternative forms of use for this important meadow resource, one of which is grazing by livestock.

Any grazing management system chosen for NFMs must be compatible with livestock production (Holechek, 1980). Many grazing systems have been developed over the years. The one which holds the most promise under the current conditions, is a short duration grazing (SDG) system designed to increase grazing pressure.

Proponents of these intensive grazing systems have claimed increased livestock and forage productivity on rangelands (Savory and Parsons, 1980) and in areas of abundant forage production (Sharrow, 1983).

This study involves a more flexible variation of SDG, and is commonly referred to as strip grazing. The system of grazing requires the use of movable electric fencing to confine animals to small areas of pasture, thus increasing grazing pressure. This aspect of movable fencing provides the added advantage of flexibility, by allowing the manager to regulate pasture sizes in accordance with the changing ratio of forage availability/animal demand.

Scientists in Great Britain (Holmes et el., 1950; Waite et al., 1950) reported that animal production per unit area could be increased when one day's requirement of forage was allocated using strip grazing. New Zealand researchers reported similar findings with two strips per day (Lucas and McMeekan, 1959). Research by Turner and Angell (1987) demonstrated that strip grazing rake-bunched NFM hay is a cost effective means of providing winter forage to cows. Allowance of approximately seven day's supply of bunched hay resulted in efficient use. This same concept may provide a similar positive response when used to manage spring and summer grazing of NFM standing live forage.

The specific objectives of this research were to compare continuous to strip grazing management in order to answer the following questions:

1. Is animal performance the same under continuous and strip grazing?

2. Will diet quality and DM intake be equal under both grazing systems?

3. Do strip and continuous grazing each have the same influence on the botanical composition of steer diets?

4. What effect if any will the two grazing systems have on the standing crop of forage?

LITERATURE REVIEW

Native Flood Meadows of Eastern Oregon

Classification and Vegetation

Native flood meadows (NFM) of eastern Oregon can be classified as seasonally wet due to the abundance of water from spring snowmelt (Rumburg, 1963). Water levels vary from year to year, but tend to peak in early June with little moisture remaining in the soil by late July. The meadow vegetation should be cut as hay once the soil has dried sufficiently to support farm machinery. Forage quality of NFM tends to follow the same pattern exhibited by most plant species. As the growing season progresses the leaf to stem ratio decreases as does the nutritive value of the plants (Walton, 1983). Protein levels may decrease by 1% per week during rapid stem elongation resulting in a crude protein (CP) content of 4-5% by August (Raleigh and Turner, 1984).

This decrease in quality of native flood vegetation (NFV) is best illustrated by examining data from research that studied quality of hay cut at different stages of growth. Rumburg (1963) studied the effects of earlier dates of haying on NFV. His findings showed earlier harvest dates increased regrowth yield without decreasing hay yields. Forage cut at earlier dates and subsequent regrowth were relatively high in CP content. Some of this response was due to levels of fertilization. This work agrees with that of Wallace et al. (1961) and Raleigh et al. (1964) who provided evidence of higher forage quality when harvested at earlier dates. Nutrient content and digestibility values from data gathered by Raleigh et al. (1964) are summarized in Tables 1 and 2. These studies suggest that by grazing intensively early in the growing season, forage production and quality might be increased.

TABLE 1. Crude Protein (CP), Cellulose, and Gross Energy Content of Native Flood Meadow Hay at Each Harvest Date During 1961 and 1962. Raleigh et al. (1964).

Date of Harvest	Composition		
	CP (%)	Cellulose (%)	Gross Energy (kcal)
1961			
June 9	10.1	31.57	4062
June 28	8.2	32.91	4068
July 17	5.8	33.84	4034
August 4	4.7	34.64	4075
1962			
June 21	9.9	31.44	3950
June 28	9.5	31.44	3950
July 5	8.9	31.47	3950
July 12	8.6	31.72	3909
July 19	8.1	30.97	3904
July 26	7.4	32.93	3904
August 2	6.8	33.22	3857
August 9	6.3	33.66	3969

TABLE 2. Apparent *in vivo* Digestibility of Crude Protein (CP), Dry Matter (DM), Cellulose (CEL) and Gross Energy (GE) from Native Flood Meadow Hay at Each Harvest Date During 1961 and 1962. Raleigh et al. (1964).

	Digestibility			
Date of Harvest	CP (%)	DM (%)	CEL (%)	GE (%)
1961				
June 9	63.0	61.8	68.0	60.3
June 28	60.2	56.6	59.8	55.8
July 17	48.4	51.7	55.1	50.5
August 4	35.2	49.2	54.0	47.8
1962				
June 21	64.1	65.2	71.8	64.0
June 28	64.5	65.2	73.4	64.5
July 5	64.2	65.7	71.7	64.8
July 12	61.0	60.3	66.0	59.7
July 19	58.2	61.1	65.5	60.1
July 26	53.1	58.7	65.4	57.9
August 2	46.7	55.3	63.0	53.3
August 9	39.5	51.4	60.4	49.9

A major factor influencing the quality of both pasture and hay is the species composition. Plant communities under most conditions are relatively dynamic, within certain limitations. In the case of flood meadows, soil fertility, water depth and duration of flooding determine the dominant plant species (Rumburg and Sawyer, 1965). Most research reports from this area prior to the 1980s, list rushes (*Juncus* spp.) and sedges (*Carex* spp.) as comprising the major portion of NFV. Deeper flooding (< 12 cm) tended to favor rushes over sedges, with some areas consisting of 90% rushes (Raleigh et al., 1964; Rumburg and Sawyer, 1965). Numerous species of cool season grasses native to the area can be found on most NFM. Some of the more common grasses listed by Cornely et al. (1983) include, nevada bluegrass (*Poa nevadensis*), sloughgrass (*Beckmania syzigachne*), redtop (*Agrostic alba*) and beardless wildrye (*Elymus triticoides*). Other cool season grass species have been introduced to the area and have become well established. An example is reed canarygrass (*Phalaris arundinacia* L.) which tends to grow better and yield more when growing in saturated soils (Gomm, 1978).

However, flood meadows in this particular region are undergoing major changes in botanical composition. The major factor in this change has been the introduction of meadow foxtail (*Alopecurus pratensis*) which is a particularly aggressive cool season grass that is well adapted to growing conditions found on flood meadows in eastern Oregon.

Current reclassification efforts by Angell (1989 unpublished data), have placed meadow foxtail as the most frequently occurring cool season grass species on meadows sampled at Eastern Oregon Agricultural Research Center (EOARC), Burns.

Previous Grazing Work on Native Flood Meadows

Over the past 20 Years there have been few research studies conducted with grazing animals on NFV in the northern great basin. Cooper et al. (1957) compared gains of cattle summered on NFM or open range. Their work showed in all years that under continuous grazing management, calves on meadows gained more than calves on range. However, this grazing trial did not compare management systems other than continuous grazing, or added benefits that might be derived from more intensive management.

Cornely et al. (1983) compared grazing, burning or haying on forage production of non-use flood meadows at the Malheur National Wildlife Refuge near Burns, OR. Haying and grazing resulted in similar yields, but grazing provided a higher percentage of live vegetation.

Raleigh and Turner (1984) suggested the use of an intensified grazing system for NFV based on previous studies done with "cream" grazing on irrigated pastures in the area. Cream grazing employs the same concept as strip grazing but differs in the desired level of forage removal by grazing from each sub-pasture (30-50% vs 60-70% removal under strip grazing).

Meadow Foxtail

Meadow foxtail (*Alopecurus pratensis L.*) is the most prevalent grass species on meadows in the study area. Meadow reclassification work by Angell (1989) (unpublished data) found that meadow foxtail was higher in actual frequency than all other grasses combined (Table 3). A feature of meadow foxtail is its growth habit and characteristic early maturity, which may result in potential management problems under certain conditions.

Meadow foxtail is a cool season, perennial bunchgrass that is indigenous to temperate areas of Asia and Europe (Walton, 1983). Its preference for high moisture and highly fertile soils make it a suitable pasture grass for the Pacific Northwest. In the 1950s, meadow foxtail was introduced to the Harney basin by livestock producers and has proliferated throughout the wetter areas. Spread of meadow foxtail has been facilitated by the wild flooding occurring in the spring, and this species can be found in abundance on most meadows. Hannaway and McGuire (1981) described the grass as being persistent and in some cases, having the potential of becoming a problem "weed". As a pasture grass, it provides good early growth and is often one of the first grasses to emerge in the spring (Walton, 1983). Canadian agronomists Tingle and van Adrichem (1974) noted that meadow foxtail clones were observed pushing through a blanket of snow in late April. This early growth results in early maturity, unless the plant is harvested as hay or grazed in the meantime. Most publications recommend cutting meadow foxtail for hay in late May or, no later than mid June for desirable quality (Tingle and van Adrichem, 1974; Hannaway and McGuire, 1981; Walton, 1983). During summers of low temperatures and high moisture, the plant may produce flower heads for the duration of the growing season (Lewis and Lang, 1957).

Yields from pure stands can average 2110 kg/hectare DM, with CP values ranging from 9.5 to 22.4%, depending on fertilization and stage of maturity (Tingle and van Adrichem, 1974). Waldie et al. (1983) conducted digestion trials with meadow foxtail and timothy (*Pleum pratense L.*) on cattle fed one of the two fresh cut forages. The grasses were fed over a two month period in the summer. Crude protein and *In vivo* DM digestion coefficients remained higher for meadow foxtail throughout the study. However, it should be noted that CP values were around 6% by late summer, down from 14% in mid June (Waldie et al., 1983). Rode and Pringle (1986) reported an increased carrying capacity for cattle grazing meadow foxtail pastures versus timothy. Diet work from this trial again showed a higher CP content for meadow foxtail than for timothy (17.2% vs 16.0%). *In vivo* digestibility was slightly lower for meadow foxtail, but DM intakes tended to be higher, 9.1 and 8.6 kg d^{-1} for meadow foxtail and timothy respectively (Rode and Pringle, 1986). Despite higher carrying capacity and diet quality, steers grazing meadow foxtail gained significantly less than steers on timothy (0.79 and 1.13 kg d^{-1} respectively). Further grazing work by Rode (1986) examined animal performance more closely, but it produced similar results. Yearling steers grazing meadow foxtail or timothy had available to them an average of 1457 and 1190 kg/ha DM respectively, yet gains were again lower for steers grazing meadow foxtail. These findings seem to point to a possible anti-quality compound in meadow foxtail. Reduced gains of the cattle were also noted when they were carried through a post feeding phase (Rode, 1986). Animals exhibited no apparent signs of morbidity or symptoms of acute toxicity in either grazing trial (Rode and Pringle, 1986; Rode, 1986). Reduced performance is often a chronic symptom of many anti-quality compounds. Examples are the perloline alkaloids implicated in fescue toxicosis (Martin, 1985) or tryptamine alkaloids associated with *Phalaris spp.* (Nicholson et al., 1989). Not withstanding the possibility of suspected anti-quality agents, meadow foxtail has proven to be a high yielding, palatable and high quality forage. However, growth characteristics of the plant indicate a need for early harvest, either by intensive grazing, or cutting as hay (Hannaway and McGuire, 1981; Walton, 1983). The need for intensive management was shown by Rode (1986) who noted that stocking rates of up to 10.5 steers ha^{-1} were required to control early growth. Meadow foxtail may lend itself very well to a high intensity grazing system such as strip grazing.

Intensive Grazing Systems

The practice of managing grazing animals on a continuous schedule in which livestock are allowed to graze year long on pasture or rangeland often results in undesirable changes in vegetation and thus poor animal performance. To counter these negative consequences, specialized systems of grazing have been investigated of which many are considered to be intensive both in terms of grazing pressure and managerial input (Stoddard et al., 1975). Development of intensive grazing management systems has been fueled by a desire to increase the overall productivity of pastures and to conserve natural resources.

One of the main objectives of intensive grazing management is to realize maximum animal production per unit of land. Such a method should take into consideration maximum forage production, while maintaining quality suitable for optimum animal growth (Holmes et al., 1950). Just as important a consideration would be to insure maximum utilization of increased herbage by grazing animals. One system that increases grazing intensity is rotational grazing. This involves sub-dividing existing pastures into smaller units or "paddocks", and moving animals among these paddocks (Stoddard, 1975). Deferred rotational grazing was recognized as having the added benefit of allowing a non-use period for plants to regain vigor (Sampson, 1913).

The term rotational grazing is used to describe many systems which employ more than two paddocks although not all are considered to be "intensive" grazing management (Denny and Barnes, 1977). "Non selective grazing" was developed in South Africa, and it employed rotational grazing methods coupled with high grazing pressures for short periods of time (Denny and Barns, 1977; Goodloe, 1979). The purported advantage of intensive stocking is derived from reduced selective grazing by shortening the time allowed for grazing a specific area (Heady, 1975). This is in contrast to continuous grazing of pastures where preferred plant species are utilized heavily resulting in wastage of equal quality, less palatable species. This system of non selective grazing management was renamed "short duration grazing" (SDG) and was defined by Savory (1978) as any grazing program that employs greater than five sub-pastures with movement of animals between units to allow 30-60 days rest between grazing periods.

With the advent of movable electric fencing, new methods of grazing management were made available to livestock producers. Much of the early work was done in Great Britain, New Zealand, and Australia. This technology was well suited to these countries where farms were small and generally highly productive. Woodman and Norman (1932) reported on a new grazing system called "close-folding", utilizing movable electric fences and designed to allocate one day's grazing for dairy cows.

New Zealand scientists Lucas and McMeekan (1959) applied this same concept of fencing small strips with electric wire. Calling their system "break-grazing", they allowed dairy cows two daily breaks of fresh forage. Close-folding and break-grazing both had similar results of increasing the overall stocking rates by 30-40% over rotational paddock grazing (Holmes et al., 1952; Lucas and McMeekan, 1959). Over the years, researchers implementing this concept have settled on the name "strip grazing", which seems to provide a more descriptive expression for this management system.

Strip grazing might best be defined as a grazing management system where by forage is allocated from a large unit into smaller, short term, variable sized units allowing stocking density to be increased and forage utilized extensively. Strip sizes can be varied to provide forage for any length of grazing. More often this period is one day. However, even with longer grazing periods, the concept of increasing grazing pressure remains the same. Proper judgment should be exercised to ensure the grazing period is not extended over too many days (5-7), resulting in damage to pastures from excessive trampling and animal wastes (Holmes et al., 1952).

Strip grazing has proven useful in rationed type grazing situations (McMeekan, 1956; Joblin, 1963). Turner and Angell (1987) demonstrated how strip-grazing rake-bunched hay can be a cost effective means of providing winter forage for cows while maintaining cow productivity and lowering costs. Their research has shown that allowance of a 7-day supply of feed results in efficient and more complete use of bunched hay.

Due to a lack in the literature on strip grazing one can draw comparisons from studies on short-duration grazing other than strip grazing. Many of these systems differ from strip grazing only in that sub-pastures have fixed dimensions, where strips may vary in size. The concept of increasing grazing intensity remains the same. However, because strip grazing tends to fit the description of SDG in a broad sense, it will be referred to in the following text as a SDG type system.

The following discourse will detail intensified grazing systems as they affect forage production, diet quality, composition and animal performance.

Vegetation Response Under Intensive Grazing

One major area of concern not often addressed in the literature is the effect of intensive grazing systems on the standing crop of forage. Angell (1986) proposed that under SDG livestock production might be increased if forage could be utilized before maturity and could maximize the period of high quality forage over the grazing season. Savory and Parsons (1980) claimed that increased carrying capacities could be obtained from SDG, due to increased forage production through advanced plant succession brought about by positive animal impact on nutrient cycles. This positive report and other conflicting results were based on different variations of SDG on lower producing rangelands. The herbaceous potential of the land to be grazed may play a larger part in the success of intensive grazing schemes.

Effects on Forage Standing Crop

Literature dealing with rangeland of lower growth potential will be explained first. In support of SDG, Texas researchers Heitschmidt et al. (1982a) reported a higher standing crop of forage by implementing a 10-pasture rest-rotation system. Likewise, Jung et al. (1985) saw a 36% increase in available forage when cattle were grazed at higher stocking rates facilitated by an eight paddock SDG system. In this same study, forage was more effectively utilized by SDG animals compared to forage grazed continuously. There are conflicting results from other studies on the Texas

High Plains. Total forage availability declined significantly over 14 day grazing periods at grazing pressures of 10, 20, 40, and 50 kg of forage per animal unit (AU) (Allison et al., 1982). Pitts and Bryant (1987) noted an overall decrease in forage availability over four years of SDG compared to continuous grazing.

Heitschmidt et al. (1987) found no differences in herbage dynamics between rotational or continuous grazing. However, they concluded that the herbaceous standing crop was higher in the continuous grazed treatment because of higher quantities of senesced forage.

Six years of SDG applied to Texas rangeland at four increasing levels of stocking had an overall negative affect on standing crop. Ralphs et al. (1990) maintained stocking rates up to 2.5 times the recommended level. Standing crop of forage declined as the rate of stocking increased, although declines were less than proportional during the growing season. These scientists noted an inverse proportional relationship between stocking rate and forage by fall, which indicated to them a potential feed shortage over the dormant winter season.

Increased stocking rates under season long grazing will also result in a similar decrease in forage standing crop and forage quality (Heitschmidt, 1989). The ability to maintain SDG at high stocking densities may depend upon adjustments in the number of grazing periods to account for variations in species diversity (Reece et al., 1988).

In some of these trials the scientists observed higher forage yields the first or second year, but overall declines after 3-4 years of grazing (Heitschmidt et al., 1987; Pitts and Bryant, 1987; Dormaar et al., 1988). A possible reason for this fluctuating pattern of forage yields might be partially explained by findings of Reece and co-workers (1988). They examined the vigor of two major grasses under two different SDG stocking rates. Over the four years of this study they observed increased numbers of tillers per plant as grazing intensity increased. Of major concern was a corresponding reduction in total organic reserves in both major grass species, which apparently resulted in lowered range condition by the end of the study.

Intensive grazing seems to have a more positive effect on the standing crop of forage on pastures with optimum growing conditions. Much of the literature from grazing trials on these types of pasturelands do not specifically mention herbage differences, but instead concentrate on animal productivity.

In early grazing trials by Holmes et al. (1950), more rapid regrowth in close-folded pastures compared to rotational grazing was observed. They attributed this to more complete utilization under the higher stocking density and less structural damage from shorter grazing periods per strip. Break-grazing of New Zealand pastures at higher stocking rates resulted in one quarter of the treatment pasture being cut for silage. This was in contrast to rotational paddock grazing of an equal size area which resulted in no harvestable surplus of forage at year's end (Lucas and McMeekan, 1959).

Sharrow (1983a,b) compared rotational to continuous grazing of sheep on grass-sub-clover (*Trifolium subterranium*) pastures of western Oregon. Data verified rotational grazing provided more total forage in the rapid growth period of mid and late spring. However, total available forage was lower on rotational pastures in late summer after active plant growth had ceased.

Effects on Forage Quality and Composition

Forage Quality

One of the possible benefits of a SDG type system is increased forage quality which results from maintaining forage in a less mature vegetative state through more steady utilization (Angell, 1986).

This was demonstrated on Texas rangeland by Heitschmidt et al. (1987) where continuous grazing resulted in more mature, rank forage compared to SDG. It is generally recognized that a negative correlation exists between increasing stocking rates and forage quality, and is exasperated when little or no rest period is provided (Heitschmidt et al., 1989).

Jung et al. (1985) presented contradictory data from SDG grazing of smooth bromegrass (*Bromus inermis*) pasture by heifers. Crude protein content of forage tended to be higher the second year, of two years of grazing under SDG when compared to continuous management. No other significant differences were noted in overall quality between treatments. They reasoned that increased grazing intensity in the SDG paddocks acted to retard plant maturity to some extent. However, forage CP and IVOMD were lower the last year from paddocks grazed later in the rotation sequence even though stocking rates had been increased from the previous year. This drop in quality, lead Jung et al. (1985) to suggest that SDG cells were probably understocked in both years.

Quality of intermediate wheatgrass (*Agropyron intermedium*) declined regardless of grazing intensity as reported by Nelson et al. (1989). This SDG trial was conducted in Washington state with cattle grazing an eight paddock rotational system at stocking densities ranging from 6-10 times higher than a season long treatment. Their findings suggest that forage maturation was similar under both treatments indicating variables other than grazing system were responsible for lower forage quality.

Botanical Composition

Changes in botanical composition are thought to be a result of improved grazing distribution brought on by increased grazing pressure from SDG (Sampson, 1913; Harris, 1970; Savory and Parsons, 1980).

Short duration grazing provided no favorable response when applied to North Dakota mixed grass prairie by Kirby and co-workers (1986). These scientists compared an 8-pasture SDG system to season long grazing at stocking rates of 1.2

AUM/ha and .67 AUM/ha respectively. They recorded increased forb utilization by SDG but no significant impact on browse and shrubs. They conceded that higher stocking densities might have a greater impact on animal distribution.

Ralphs et al. (1990) reported that six years of SDG at four stocking rates of up to 2.5 times the recommended level, did not significantly influence species composition of vegetation on Texas rangeland. They did however note, that species composition changed from the beginning to end of the study. The frequency percentage of forbs had increased and the proportion of tall to mid grasses had shifted in favor of tall grass species.

Holmes et al. (1952) stated that close-folding favored the more vigorous grasses, while checking the growth of some weeds. The control of weeds through intensive grazing is frequently practiced (Lucas and McMeekan, 1959; Sharrow, 1983).

An opposing view was presented by Joblin (1963), based on percentage ground cover data collected from a strip vs paddock grazing trial in Uganda. He found small but significant differences in botanical composition of local pastures grazed by steers under the two different grazing systems. Strip grazing decreased the percent ground cover of *Chloris gayana* with a corresponding increase in the percentage of bare ground.

The concept of controlled intensive grazing was employed on coastal rangeland in Somalia. Thurow and Hussain (1988) discovered that a SDG management system improved botanical composition on Somalian communal pasture. Intensive grazing preceding and during the rainy season opened the vine mat allowing grasses to re-establish. The resulting change in composition favored grasses, and acted to extend the grazing period into the dry season. During normal years of season long grazing, animals were forced off the pastures once the vines had died and decomposed.

Denny and Barnes (1977) investigated the effect of multi-paddock grazing systems at high stocking densities for short periods on botanical composition of African veld. The grazing site was reported to be in generally poor condition at the start, with vegetation consisting of widely spaced perennial grasses. Density of perennial grasses increased slightly but insignificantly over the four years of grazing. These investigators concluded that intensive grazing did not produce any important changes in botanical composition (Denny and Barnes, 1977; Denny and Steyn, 1977).

Similar results were reported by Pitts and Bryant (1987) on Texas rangeland comparing SDG and continuous grazing. They determined that botanical changes over the four year study occurred due to weather patterns and not grazing systems. Their conclusion were that SDG did not improve range condition.

Effect of Intensive Grazing on Animal Diet

Effects on Diet Quality

Diet quality is one factor that is influenced by a high level of usage. The single most important factor that effects the quality of a grazing ruminant's diet is the quality of vegetation from which to select. A change in forage quality will have a direct impact on diet quality. Likewise, a change in the ability to select from various plant species of differing nutritive value would possibly compromise the ruminant's nutritional status.

From previous discussions on the role of SDG on forage quality and composition, one might expect an improvement in forage quality due to delayed maturity (Heitschmidt et al., 1987). The reduction in selectivity brought about by SDG may be beneficial to plant communities, but most likely will have a negative impact on grazing animals (Heady, 1975). If these positive and negative effects result from SDG, then a trade off must occur with a positive ending balance in favor of the animal.

Reports of the nutrient status of cattle on arid rangeland are mixed, but tend to indicate an inverse relation. Overall diet quality of range cattle generally declines as stocking densities increase (Ralphs et al., 1986; Olson et al., 1989). This appears to be linked with the amount of grazing time in each paddock (Taylor et al., 1980; Ralphs et al., 1986; Pitts and Bryant, 1987).

Grazing studies conducted at the Texas Agriculture Experiment Station Sonora, (TAESS) Texas, illustrate the stocking density/grazing time interaction. Work by Taylor et al. (1980) compared SDG to high intensity low-frequency (HILF) grazing at grazing periods of 7 and 21 days respectively. Dietary crude protein (CP) remained higher for SDG, but in vitro organic matter digestibility (IVOMD) tended to drop off sharply towards the end of each 7 day period. This was in contrast to the 21 day (HILF) scheme where both CP and IVOMD were consistently lower. The researchers postulated that shorter grazing periods for SDG might reduce the decline in digestibility.

With this suggestion in mind, Ralphs et al. (1986) reduced grazing periods to 3 days and increased the stocking rate to 2.67 times the season long recommendations. They examined the diets of sheep and cattle under SDG and witnessed a decline in diet quality of both classes of livestock within 3 day grazing periods. This decline was greater in dietary IVOMD for cattle at higher stocking rates. However, the magnitude of the decline was similar for both sheep and cattle. Similar conclusions were reached by Olson et al. (1989) when examining a SDG system's impact on cattle nutrition. This three year study on Utah crested wheatgrass (*Agropyron desertorum*) rangeland looked at grazing periods of 1-4 days in a 10-paddock system. A significant decline in diet quality occurred over 2-3 day periods with large daily changes observed in all diet parameters. Therefore, Olson and co-workers (1989) recommended grazing periods of two days or less in each crested wheatgrass paddock because of the rapid decline in diet quality and ingestion rate.

Short duration grazing on mixed grass prairie over a two year period yielded no significant changes in dietary CP or IVOMD (Kirby and Parman, 1986). Olson and Malechek (1988) presented similar findings on crested wheatgrass range. Their study applied a more rigorous stocking density of .14 ha/AU for SDG compared to 1.4 ha/AU in a season long grazing (SLG) treatment. Over the three years CP and IVOMD remained relatively constant, with no differences between SDG and SLG.

A comparison of SDG to continuous grazing on sparsely covered rangeland in west Texas by Pitts and Bryant (1987) reported no significant difference in diet quality of SDG steers. The two researchers concluded that diet quality did not improve with SDG and steer performance was negatively affected by the increased stocking rates.

Grazing studies carried out in temperate regions of the world on highly productive pasture have provided data suggesting a decrease in diet quality with more intensive grazing (Jamieson and Hodgson, 1979a,b; Sharrow, 1983a; Nelson et al., 1989). Cattle grazing cool season grass pastures under SDG management in Washington state selected a diet that decreased in IVOMD linearly across grazing periods and years (Nelson et al., 1989). Earlier research in the Pacific Northwest by Sharrow (1983), reported similar trends in the diets of sheep on rotational paddock grazing. Sharrow (1983) and Nelson et al. (1989) compared SDG to continuous grazing, and each concluded that a reduced opportunity for dietary selection was to blame for lower quality diets.

Researchers in the United Kingdom provided a positive report from rough estimates on diet quality of dairy cows under close-folding (strip grazing) compared to rotational grazing management (Waite et al.,1950). They recorded similar values of estimated cow diets under rotation or close-folding for both digestible CP and energy. However, a later report by Waite et al. (1952) detailed higher nutrient values for diets of close-folding cows compared to those in rotational paddocks. They believed this difference resulted from poorer quality herbage on offer in the rotational paddocks as the grazing season progressed.

Intake

Dietary dry matter (DM) intake has been an issue of major concern when implementing a SDG type management system. Increases in stocking rates are known to lower DM intakes of grazing ruminants, and this difference is magnified with increasing animal size (Zoby and Holmes, 1983).

The two herbage factors with the greatest effect on voluntary DM intake are diet quality, and sward characteristics (Poppi et al., 1980; Hodgson, 1981). Diets of lower quality lead to a decreased rate of liquid and particulate passage, thus lowering herbage intake (Poppi et al., 1980). Grazing animals may spend more time selecting and prehending forage as quality decreases (Chacon et al., 1976).

The degree of importance of these two factors has been a point of difference between researchers. In the U. S., range nutritionists tend to place more emphasis on the role of forage and diet quality on animal intakes. In contrast, most researchers in the United Kingdom, New Zealand and Australia exert more effort into measuring the effects of forage height, density and toughness on herbage consumption.

A number of papers previously discussed, measured both diet quality and DM intake. Several authors reported lower diet quality under SDG (Waite et al., 1952; Sharrow, 1983; Nelson et al., 1989; Olson et al., 1989). However, Sharrow (1983) was the only one of these researchers to report little or no effect of rotational grazing on daily DM intake of grazing sheep. The others found differing levels of voluntary herbage intake depression under SDG. The degree of depression depended upon stocking rate and forage maturity.

Combined pasture grazing and *in situ* digestion work by Nelson et al. (1989), provides a helpful explanation of advancing plant maturity on intake. In conjunction with an intensive grazing study, these workers clipped forage from pastures adjacent to the grazed pastures and fed it to cannulated wethers. They witnessed significant linear decreases in digestibility, passage rate and intake as forage maturity increased.

To reinforce this concept in a different manner, Olson and Malechek (1988) observed no differences between heifer dietary quality or DM consumption under SDG and SLG management systems. Likewise, Allison et al. (1982) found that increased grazing pressure resulted in equal or greater DM intake. More importantly, they noted higher efficiency of harvest (46%), as grazing pressures were increased from 50 to 10 kg/AU per day.

The extent of sward characteristics affecting animal intake has been the object of several studies (Chacon et al., 1976; Jamieson and Hodgson, 1979a,b; Lowman et al., 1988). Variations in sward height and mass are thought to affect herbage intake by changing the grazing behavior of animals. However, the ability of the animal to compensate by increasing grazing time may be limited and could be greatly affected by grazing management systems (Hodgson, 1981).

Jamieson and Hodgson (1979a) found that daily herbage allowance under strip grazing management influenced intake of grazing calves. Reducing the daily herbage allowance by 75% resulted in approximately 18% decrease in daily dietary DM consumption. Later experimentation with strip grazed cattle by Hodgson and Jamieson (1981) provided additional information which supports earlier data. Their finding suggest that an intake response to increased diet digestibility may be limited if herbage mass is low at high digestibility levels. They reached this conclusion after examining herbage intake of three animal classes which peaked when both herbage and digestibility were at intermediate levels. Hodgson (1981) provided a review of previous data collected by himself and colleagues from previous grazing studies. After re-examining some of the results, he concluded that grazing height influenced ingestive behavior. Hodgson (1981) pointed to declines in rate of intake, and intake per bite with decreasing sward height as evidence of this relationship. However, in practical terms no indications were given of a critical sward height above which the rate of herbage intake showed no further increase.

A more recent grazing study (Lowman et al., 1988) support this contention of sward height affecting herbage consumption. They measured animal performance in relation to grass height over a two year period at two stocking intensities. They concluded that cattle grazing a sward height of 7 cm required 5 more weeks of grazing time to reach the same slaughter weight as their contemporaries grazing a sward height of 10 cm.

Botanical Composition of the Diet

Increases in levels of stocking have been shown to change species composition of some pasturelands (Holmes et al., 1952; Thurow and Hussain, 1989), in contrast to little or no effect on others (Denny and Barnes, 1977; Kirby et al., 1986; Pitts and Bryant, 1987). It has long been recognized that a grazing animals diet may not reflect the same proportion of plant species as that of the plant community. However, depending on the vegetation type, increased grazing pressure may have less of an impact on diet composition than would be expected.

The dietary botanical composition of grazing animals on study is often hinted at, but not often adequately measured. This is not surprising given the expense of collecting and analyzing this type of data.

Researchers at the TAESS have provided insight into the effect of increasing stocking rates on diet composition. Most of the studies show increasing selection of less palatable species over the entire season as stocking rates increase (Allison and Kothmann, 1979; Taylor et al., 1980; Ralphs et al., 1986). Data gathered by Ralphs et al. (1986) demonstrated how shifts to low quality less preferred forages can occur over short periods of time. These workers reported significant changes in diet selection over 3 day periods of SDG. The most noticeable changes were increased warm season grasses as a percentage of sheep diets, while cattle tended to switch from forbs and cool season grasses to coarse less palatable desert species such as sacahuista (*Nolina texana*) and prickly pear (*Opuntia machrorhiza).* An earlier grazing trial by

Taylor et al. (1980) demonstrated this same effect over longer periods of SDG management.

Contradictory results from SDG on mixed grass prairie in western North Dakota are reported by Kirby and Parman (1986), who stated that cattle exhibited no consistent variation in plant class selection over the grazing season. However, when Kirby et al. (1986) compared SDG to season long grazing on 5 separate range sights, they witnessed more than double the amount of forbs in cattle diets under SDG. They did not observe any significant increase in browse consumption at either stocking rate.

Pitts and Bryant (1987) presented data from SDG vs continuous grazing which support the earlier findings of Kirby et al. (1986). In their study, SDG cattle consumed 15% more forbs than continuous grazing cattle. A point of equal interest, was that more intensive grazing management appeared to delay the use of a major grass species, *Panicum obtusum*, one month later than continuous grazing. Pitts and Bryant (1987) believed this delay resulted in extended grazing of this warm season grass.

Rotational grazing management of sheep on cool season annual grass-clover pastures, resulted in significantly higher consumption of subclover during mid and late spring periods (Sharrow, 1983). Furthermore, Sharrow (1983) observed higher intakes of forbes in mid spring by rotationally grazed sheep. However, by early summer, continuous grazed sheep were consuming more forbs.

Animal Performance

The overall goal of most grazing systems is the enhancement of animal performance. The before mentioned factors, both forage and diet, contribute to the success of the chosen management system. In the case of SDG, any improvement in forage availability or quality must be properly managed to insure consumption and full usage. The relationship between stocking rate, forage and diet parameters have been covered. The following presents the relationship of stocking rate and grazing pressure applied in each situation.

Intensive grazing management in temperate regions of the world has lead to a general increase in production per ha by grazing ruminants. In the case of the close-folding vs rotational grazing trial with dairy cows (Holmes et al., 1950; Holmes et al., 1952), animal performance was measured by milk yields per cow. Holmes et al. (1950) found only slightly higher yields per cow under close-folding at stocking rates of 50-80 cows per acre, compared to rotational grazing at 6-8 cows per acre. They did notice slightly higher live weight gains for rotational cows. Later, Holmes et al.(1952) shortened grazing periods while increasing the stocking rate in the rotational treatment and reduced the grazing pressure in the close-folding treatments. Resulting data again showed equal yields per cow under both grazing systems. However, both groups of researchers reported increased production per ha from close-folding on the order of 20-40%.

Similar positive results were reported from New Zealand by Lucas and McMeekan (1959) who conducted a closely related study with break grazing vs two rotational schemes. The rotational paddocks were stocked at concentrations of 10 or 14 cows per acre, compared to 106 cows per acre in break grazed pastures. These scientists discovered that neither rate of stocking or grazing management affected milk quality. The most interesting revelation was a 7-10% better gross efficiency of converting feed to milk by break grazed cows in addition to an approximately 32% higher milk yield per acre. This same magnitude of increased yields occurred at the higher stocking rates in both break and rotational grazed treatments.

Workers at EOARC Burns, Oregon substantiated these findings through grazing work with steers grazing lush cool season vegetation. Grazing trials were conducted by Daugherty et al. (1979) on cream grazing, which is based on a concept similar to strip grazing. Cream grazing entails removal of one third to one half of available forage for short periods by increased grazing pressure. Stocking rates were equal for both cream and continuous treatments. Cream grazed steers exhibited improved ADG over the continuous grazing system. Research by Joblin (1963) examined steer performance under tropical conditions in Uganda. Cattle were continuously managed under strip or paddock grazing systems over a two year period. Strip grazing produced an advantage in animal performance over paddock grazing only under dry conditions. No advantage was found from strip grazing during normal moisture years.

Sharrow (1983), compared rotational to continuous grazing under the temperate conditions of western Oregon. The higher stocking rates under rotational grazing revealed an improvement in performance of sheep during the green-feed periods.

Animal performance under SDG systems in more arid regions tends to be mixed. Extensive grazing trials were conducted on veld in Rhodesia to examine animal performance over a number of years at different stocking rates utilizing several grazing systems. Denny and Barnes (1977) compared six rotational grazing procedures at two stocking rates. They found a highly significant negative linear relationship between grazing intensity and individual steer weight gains. This trend occurred irrespective of grazing procedure. Data from the dry dormant seasons suggest lower gains per steer at higher stocking rates. However, in more productive seasons, weight gains per unit area were much higher at the higher stocking rates. Denny and Barnes (1977) made the observation that animal performance was similar within a range of grazing procedures conducted at equal grazing intensities. This observation lead them to suggest only comparing limited types of grazing systems to continuous grazing when grazing intensities at a given stocking rate are the same.

In concurrent grazing trials at a different veld site, Denny and Steyn (1977) examined production parameters of breeding cows under 4 and 16 paddock grazing systems. Stocking densities were 3.3 and .8 AUs per ha for the 16 and 4 paddock systems respectively. They found no differences in fertility, cow weights, or weaning percentages between the two management regimes.

In the U. S., cattle grazing smooth bromegrass (*Bromis inermis*) pasture under continuous or SDG, produced more gain per ha at the higher stocking rate (Jung et al., 1985). Individual animal gains were similar in this study as were those of cattle on a similar trial in Texas conducted by Pitts and Bryant (1987). The major differences between the two separate grazing studies were in rates of stocking. Over a four year period, Pitts and Bryant (1987) applied rates ranging from 13.3-6.7 ha/AU for SDG and 13.3 ha/AU for continuous grazing. They reported equal gains for both treatments at rates of stocking equal to or 1.5 times the continuous level. Steer gains were depressed when the level of stocking in SDG was twice that of continuous.

In contrast, Jung et al. (1985) stocked at equal densities of 2.9 heifers/ha the first year, but increased SDG to 3.8 heifers/ha in year two of the trial. They concluded that grazing systems did not differ in ADG at either level of stocking.

More recently, Olsen and Malechek (1988) compared SDG to SLG, having based their research on many of the previously discussed studies. However, their experiments were designed to study heifer performance at stocking densities of .14 ha/AU and 1.4 ha/AU for SDG and SLG respectively. These same levels of stocking were maintained over the entire three years of grazing on crested wheatgrass rangeland. Animal performance fluctuated between treatments on a yearly basis, but tended to be equal overall. The one unexplained negative response resulting from

SDG occurred with pregnancy rates. These scientists noted that despite apparent adequate nutrition, heifers subjected to SDG exhibited pregnancy rates 3.6 to 8.3 percentage units lower than SLG heifers.

Diet Sampling Methods for Grazing Studies

There are two widely accepted methods of sample collection for estimating diet quality: intake and diet botanical composition of grazing animals. Other techniques have been employed with varying degrees of success; however, this section will discuss the techniques of esophageal sampling and total fecal collection employed in the following experiments.

Grazing studies present problems regarding sampling procedures. Diet parameters are not as easily measured as animal performance. Problems arise from a logistic standpoint based on mobility of experimental units and environmental factors. Holechek (1980) provides a comprehensive review of the pros and cons associated with a variety of widely used diet collection procedures.

Esophageal fistulation described by Ellis et al. (1984) involves surgically constructing a permanent hole in the esophagus which opens to the outside. Fistulas are closed with a wide assortment of plugs, most of which are removed prior to collection. This allows ingested forage to fall into a collection bag (Harris et al., 1967).

Total fecal collection requires the use of fecal collection bags placed on animals during collection periods of 24 hours or longer (Van Dyne, 1968). Researchers have employed both methods to estimate factors such as intake, digestibility and botanical composition. There are serious limitations for each method.

The extent depends upon experimental conditions and the parameters one wishes to estimate (Holechek, 1980).

Intake Estimates

Total fecal collection is a preferred approach for estimating daily herbage intake (Holechek et al., 1986). Significant differences in feed consumption or rates of gain do not exist between bagged and non bagged animals (Harris et al. 1967; Phar et al. (1971). If this technique is used to estimate intake under range conditions, it must be combined with a digestibility estimate to correct for DM disappearance (Van Dyne, 1969). Correction factors can be derived from esophageal sampling or with a regression equation if fecal N is used (Holeckek and Vavra, 1982).

Holechek et al. (1986) evaluated total fecal collection for determining dry matter intake of cattle. The DM disappearance was corrected for by dividing total fecal output by *in vitro* forage indigestibility estimated from standard *in vitro* digestion procedures. Results suggest a poor estimation of intake using 48-h in vitro digestibility.

On the other hand, esophageal collection is not a practical means of estimating DM intake (Holechek, 1980). This method is not effective because of the narrow collection window (30-45 minutes/sample) and the negative affect of fasting induced stress on the experimental animal (Chacon et al., 1976).

Diet Quality Estimation

Analysis of chemical composition from esophageal fistula extrusa gives satisfactory estimates of nitrogen content and organic matter digestibility (Cohen 1979). However, Acosta and Kothmann (1978) noted some apparent leaching of nutrients by saliva through the screen bottomed collection bags. Collection time, previous grazing experience and length of fasting tend to increase the amount of variation between samples (Sidahmed et al., 1977; Cohen, 1979).

Studies have been designed to evaluate fecal indices in predicting cattle diet quality. One such feeding trial by Wofford et al. (1985) revealed the inadequacies of this method when diets vary widely in chemical properties. Their data showed consistently poor correlations between actual diet IVOMD, CP and fecal nutritive characteristics. The use of fecal indices was only recommended in detection of CP deficiencies in cattle diets.

Diet Botanical Composition Estimates

Botanical composition of ruminant diets can be determined with varying degrees of success by microhistological examination of fecal or esophageal samples. This technique determines the frequency of plant species from the number of times a plant's fragments or cells are observed out of a certain number of microscopic fields at 100 power magnification (Sparks and Malechek, 1968).

Feeding behaviors of fistulated or non-fistulated cows and sheep were examined by Forbes and Beatie (1987). No differences were observed in botanical composition providing strict routines were followed during collection periods. Grazing studies by Holechek et al. (1982) found that fecal sampling was relatively quick, simple and inexpensive, but tended to provide poor estimates of diet composition when large amounts of forbs or browse were consumed.

McInnis et al. (1983) reported similar results when comparing diet composition of a known control to esophageal, fecal or stomach samples. Major differences existed between the collection methods. Esophageal samples provided the closest estimates of percentages of grass and forbs compared to the control. Grasses were significantly overestimated and forbs underestimated from fecal samples. The underlying conclusion is that plant species of lower digestibility are increasingly overestimated as digestion time is increased. Highly digestible plants are underestimated and may completely disappear by the time they are excreted in the feces (Vavra and Holechek, 1980; McInnis et al., 1983). Regression equations of estimated and actual plant composition values may be useful for correcting bias due to differential digestion (Vavra and Holeckek, 1980).

The majority of literature indicates that intensive systems of grazing management promote changes in vegetation and animal parameters. The effects of SDG on range vegetation tend to be negative both in terms of quality, quantity and composition. This differs from intensive grazing management of temperate pastureland which often improves the vegetation response. Animal diets and performance tend to mimic the forage response. Data from range studies document equal or lower diet quality, DM intake, and individual animal performance for animals under SDG compared to continuous grazing. However, researchers have reported increased animal production per unit area grazed with intensive grazing management of both rangeland and temperate pastures. Information on strip grazing is limited, but it seems to indicate a favorable response when this type of management scheme is applied to areas of high forage production. Native flood meadows of eastern Oregon fit into this category of high forage production. Therefor the following experiment was designed to test the efficacy of strip grazing management compared to continuous grazing on NFM forage and animal parameters.

METHODS

Study Area

The study was conducted at the Eastern Oregon Agriculture Research Center (EOARC) approximately five miles south west of Burns, Oregon. Meadow number "six east" was selected and used for the duration of this study. Selection was based upon uniformity of vegetation and similar to other meadows found in the valley. The field covered 22.4 ha, and yielded about 3620 kg/ha in 1984 and 85. Each pasture was fertilized every spring with 57 kg/ha of nitrogen.

Vegetation consists of a wide variety of cool season grasses mixed with rushes and sedges. The five most frequently occurring grasses are; meadow foxtail (*Alopecurus pratensis*), saltgrass (*Distichlis stricta*), reed canarygrass (*Phalaris arundinacea*), quackgrass (*Agropyron repens*) and nevada bluegrass (*Poa nevadensis*). Sedges (*Carex* spp.) are the second most frequent species followed closely by rushes (*Juncus* spp.). Lower lying areas that remain flooded for longer periods tend to support more rushes, while sedges are found on mid elevation areas between *Disticlis* and *Alopecurus*. Major forb species include hesperchiron (*Hesperochiron pumulus*), dandelion (*Taraxacum officinale*) and isolated patches of arrowgrass (*Triglochin maritima*). Forbs contribute only a small percentage of the total biomass. Frequency percentages of the most common identifiable species are listed in Table 3.

TABLE 3. Frequency percentages of the major plant species found on native flood meadows at EOARC Burns, Oregon. Estimates are based on the step point technique with 812 and 1061 points sampled on May 10 and June 25, 1989, respectively; from the same 23 ha pasture used in the current study (Angell, 1989; unpublished data).

Species	Common Name	Sample Date Freq. (%) May 10	Jun 25
Grasses			
Agropyron repens	Quack grass	1	2
Agrostis alba	Red top	<1	<1
Alopecurus pratensis	Meadow foxtail	41	35
Beckmannia syzigachne	Sloughgrass	<1	-
Distichlis stricta	Salt grass	2	5
Elymus canadensis	Canadian wildrye	<1	-
Elymus triticoides	Creeping wildrye	<1	<1
Hordeum jubatum	Foxtail barley	<1	<1
Hordeum nodosum	Meadow barley	<1	<1
Phalaris arundinacia	Reed canarygrass	1	1
Phleum pratense	Timothy	<1	<1
Poa nevadensis	Nevada blue grass	1	1
Rushes			
Juncus balticus	Baltic rush	9	14
Juncus nevadensis	Sierra Nevada rush	4	3
Juncus spp.	Rushes	<1	<1
Sedges			
Carex subjunca	Rusty sedge	7	19
Carex spp.	Carex	2	3
Eleochris palustris	Common spike sedge	1	-
Eleochris parvula	Little spike sedge	13	4
Forbs			
Lepidium perfoliatum	Clasping pepperweed	<1	<1
Madia glomerata	Cluster tarweed	<1	<1
Haplopappus lanceolatus	Lanceleaf goldenweed	1	<1
Hesperochiron pumulus	Dwarf hesperchiron	2	1
Potentilla anserina	Silverweed cinquefoil	<1	<1
Potentilla grasilis	Slender cinquefoil	<1	<1
Triglochin maritima	Arrow grass	3	3

Five strand barbed wire fencing surrounds the meadow. Four permanent sub-pastures of 5.6 ha were established by dividing the meadow equally with high-tensile steel electric fencing. Individual strip sub-pastures were fenced using New Zealand type polywire electric fencing. Details of pasture improvements are illustrated in figure 1.

Environmental

Weather parameters, including daily precipitation, maximum and minimum temperatures, and solar flux were recorded during the study. Daily precipitation and temperatures were compared to the 25 year means. Streamflow forecasts from the Silvies river near Burns were used to predict the amount of flooding expected from spring runnoff.

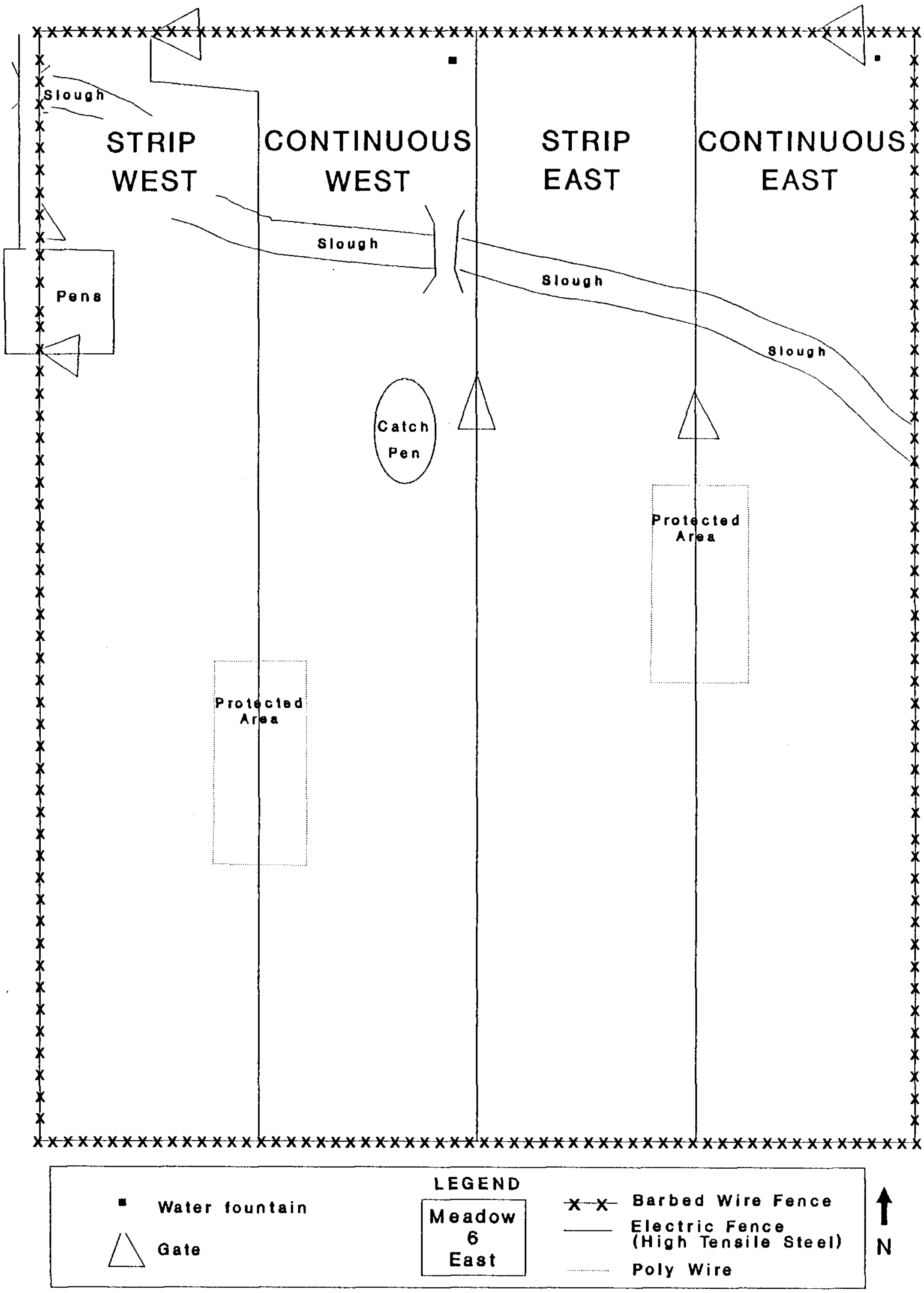


Figure 1. Map of study area showing main features, improvements, treatments and blocks.

Animals

Eighty yearling steers weighing 253±17 kg were selected at the Squaw Butte Experiment Station. On day one of the trial, steers were stratified by current weights into four groups and groups randomly allotted to treatments.

Prior to placing animals in treatment pastures, all steers received Ralgro[a] implants and individually numbered ear tags which were color coded by treatment and replication. Water, trace mineralized salt and a salt-bonemeal mix were available at all times. Monthly consumption of salt and bonemeal was recorded. No other supplements were provided. At weaning the previous fall, steers had received clostridia, Infectious Bovine Rhinotracheitis and Bovine Viral Diarrhea vaccinations and were revaccinated for the clostridia diseases prior to the trial. Insecticidal ear tags were applied at a later time. Prior to initiation of the study all animals were maintained on meadow vegetation.

Animal Assignment

Fifteen steers were randomly assigned to each replication solely for collection of performance data and 5 were used to obtain estimates of diet quality and fecal output. All steers were weighed bi-weekly after an overnight restriction from feed and water.

[a]International Minerals and Chemical Corporation, Veterinary Products Division, Terre Haute, IN.

Only weights from the 15 performance steers were used in gain analysis.

The remaining five animals in each replication were assigned for collection of data related to diet parameters. Two of the five diet steers were fistulated at the esophagus and utilized in estimating diet quality. These animals were surgically altered approximately one month before the start of the trial, using the surgical technique described by Ellis et al. (1984). The remaining three diet steers were used for total fecal collection in order to estimate dry matter intake and botanical composition.

Treatments and Grazing Management

Treatments were continuous or strip grazing, with two replications each. Continuous grazed animals had access to the entire area of each unit at all times. The remaining two pasture units were on strip-grazing management. The 20 animals on each strip-grazed unit were restricted to a small area of the pasture (strip) by using polywire electric fencing. Back grazing was not allowed (Figure 2). Strip areas were calculated to provide sufficient forage for a 5-7 day grazing period to achieve 65-70% utilization. Animal demand (DM/d) for a 6 day period was estimated by using NRC figures, based on current body weight, and expanded to total demand for 20 animals

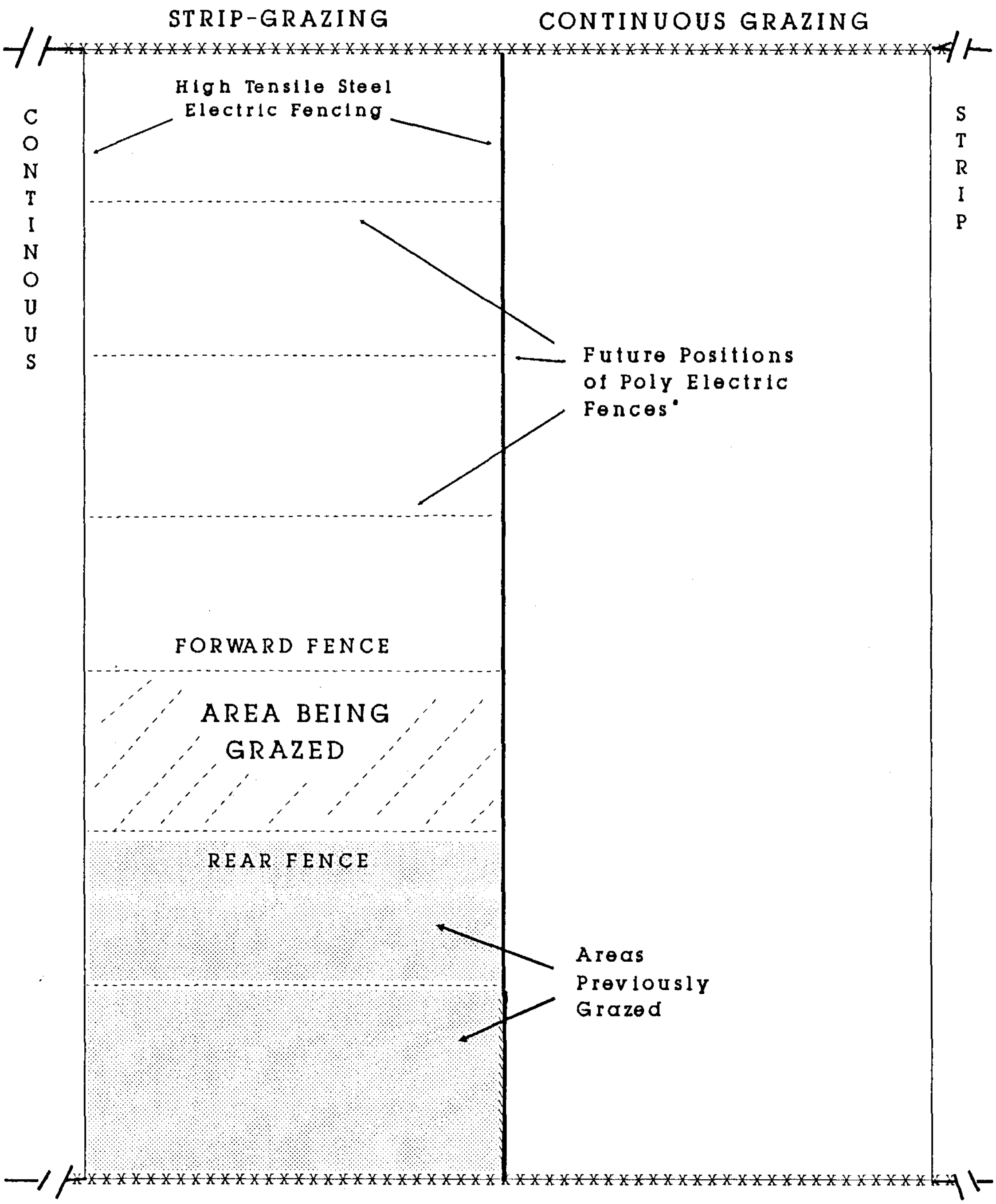


Figure 2. Diagram showing the arrangement of fences for strip and continuous grazing. Dashed lines represent New Zealand style poly electric fencing.

* For illustration only, these are not actual positions of fences.

over 6 days. Available forage was determined by clipping standing forage just prior to grazing.

Stocking densities were initially designed to be equal at 2.0 AU/ha with 20 steers assigned to equal sized pastures. However, stocking rates and grazing pressure changed with the size of individual strips and overall forage availability.

Esophageal fistulated and fecal collection animals were assigned randomly to treatments and grazed in their pastures along with the 15 performance steers for the duration of the trial.

Sampling

Performance

Individual animal performance was determined from bi-weekly weights. Steers were gathered at 1600 on the previous afternoon and penned with overnight restriction from feed and water. Weighing commenced at 0700 the following morning after the 15-16 h shrink period. Individuals were weighed at random, and all weights were obtained within 1.5 hours. Steers were immediately returned to treatment pastures. The only exception to this procedure occurred on August 4. Steers were gathered and penned as previously described. However, during the night a gate was unlocked, allowing all steers access to water. The following weigh day this problem was noticed at 0600 and the steers were re-penned. The majority of the animals were observed to be "full". Weighing was post-poned until 1300 to allow an additional shrink period.

Diet Quality

Diet quality was estimated from esophageal samples. Collections were made at approximately two week intervals to coincide with the second day of grazing in the currently grazed strips. During each collection period extrusa was collected on two consecutive days from both treatments.

Fistulated steers were gathered at 1900 the evening prior to collection and fasted over night. At 0700 the following morning collection animals in alternate pastures were fitted with screen bottom collection bags and released to graze (Cohen, 1979). Following a 30-45 minute grazing period, bags were removed and sub-samples taken from total extrusa. Samples were placed in sealed bags and immediately frozen for later laboratory analysis to determine digestibility and protein content of the diet.

In addition to bi-weekly collections, monthly esophageal collections were taken the last few hours and first hour in two consecutive strips. Monthly collections followed the same procedures as bi-weekly collections. The only exception was to increase sampling intensity by pooling esophageal animals from pastures adjacent to one another within each block, yielding four samples per pasture per day. These data were collected to determine if, and to what extent, diet quality changed between the end and beginning of successive strips.

Intake and Botanical Composition

Total fecal collections began the day following esophageal collections. Fecal collections were timed in this manner so that digestibility estimates preceded fecal collections by 24-48 hours. It was assumed that passage rates were 36-48 hours, and esophageal diets represented the diets of all steers in that pasture. This technique should improve estimates of intake derived from IVOMD and fecal output. Fecal bags were placed on the animals by 0700 and remained in place for 24 hours. Due to the time involved in handling, animals were bagged in alternate pastures on each collection date. Times were recorded after each group of steers was bagged and released so that bags could be removed at exactly the same time the following day. Increased fecal production in late July made it necessary to remove and weigh fecal material in the afternoon of the first day to avoid loss of feces from overflow. Upon removal of fecal bags, feces was weighed immediately to avoid desiccation. Two subsamples were taken at this time. Samples were obtained at random from several locations in the thoroughly mixed feces. The samples designated for botanical composition were immediately placed into pre-labeled 100 ml jars containing 40-50 ml ethyl alcohol and sealed. Concurrently, sub samples ranging from 350-450 g were placed into ziplock bags and frozen within one hour of collection for later analysis of DM content. Dry weights were later used to calculate total fecal DM production. This provided 6 samples per treatment for each date and was designed to provide 95% confidence that the estimate is within 10% of the mean (Holecheck and Vavra, 1982; Van Dyne, 1968).

Forage

Quantity of live standing crop was estimated at bi-weekly intervals on the continuously grazed treatment and on the first and last days of grazing in each strip grazed unit. Forage was clipped to ground level from ten 0.19 m^2 plots in both grazed and ungrazed areas. Ungrazed areas were established in a protected strip within each pasture unit. Protected areas were maintained for the duration of the study.

On the first clipping date of each month, forage was separated into grass, sedge/rush, and forb components. Forage availability inside protected areas and within grazed areas allowed an estimation of grazing efficiency on each system. The difference between grazed and ungrazed plots was referred to as "forage disappearance". This value was compared to estimated forage intake obtained from total fecal collections.

Laboratory Analysis

General

Esophageal samples collected for crude protein and digestibility (IVOMD) were dried at 55° C and ground to pass a 1mm screen. Laboratory analysis was conducted at EOARC. Ash content and kjeldahl nitrogen extractions (Harris, 1970) were performed on individual samples to determine percentage of crude protein (N X 6.25). Analysis of standard *in vitro* dry matter digestion (IVDMD) (Tilley and Terry, 1963) was conducted at the EOARC Union laboratory.

Intake

Fecal samples were removed from bags while frozen, immediately weighed and placed in a drying oven at 65° C. Dried samples were weighed to the nearest gram at intervals of 12-24 h until two identical weights were recorded, at which point the sample was considered dry. Intake was calculated from *In vitro* digestion values and total fecal production using the equation of Van Dyne (1968):

$$\text{Intake} = \frac{(100)\ \text{total fecal production}}{100 - \%\ \text{digestibility}}$$

Botanical Composition

Fecal samples were sent to Texas Tech University Lubbock, TX for analysis of botanical composition by the micro histological technique (Sparks and Malechek, 1968). This technique was modified from five slides (20 fields/slide) to two slides with 10 fields/slide because samples were not pooled across animals by date. Samples were examined for species of interest that were prevalent on the meadow (Table 3). The four major classifications were grasses, sedges, rushes and forbs.

Frequency percentages for each species were calculated from the number of microscopic fields that contained fragments of that species. The frequency percentages were converted to particle densities (Sparks and Malechek, 1968), using the formula developed by Fracker and Brischle (1944):

$$n = 100 \log_e \left(\frac{100}{100 - i} \right)$$

where: n = number of fragments per 100 quadrats likely to be present under strict mathematical probability when any given percentage (i) of quadrats contain one or more fragments each.

The relative densities of each plant species were calculated to represent the percent dry weight of that species in the diet using the following formula (Sparks and Malechek, 1968):

$$\text{Relative density} = \frac{\text{Density of fragments of a species}}{\text{Total density of fragments of all species}}$$

Statistical Analysis

The experiment was designed as a randomized complete block, with the blocking criterion being past estimated forage standing crop. Data were analyzed as a split-plot design (Steel and Torrie, 1980; p. 393). The statistical model contained effects of treatment and block in the whole plot, with block by treatment serving as whole plot error (error a). Sampling periods (n=9) and treatment by period interactions were contained in the sub-plot. The sub-plot error (error b) was the variation remaining after other effects in the model were accounted for.

Analysis of variance was conducted using General Linear Models of the Statistical Analysis System (SAS. 1987). Statistical significance was inferred at $P \leq .05$ unless otherwise stated. Predetermined mean separations between treatments by period were determined by nonorthogonal contrasts using Bonferroni (Dunn) t statistics. This procedure does not require a prior significant difference between means in the main effects, because the total probability of a Type I error (α) is divided among the number of designated comparisons (Gill, 1978). Comparisons were made between the calculated t and tabular critical values of t, where $t=\alpha/C$ (C=number of contrasts compared) resulting in a more conservative estimate. Nine comparisons were made (nine collection periods) and tested against tabulated values of t (Glass and Hopkins, 1984; p. 551) at significance levels of $P \leq 0.05/9$, 0.01/9, 0.005/9, 0.001/9.

RESULTS AND DISCUSSION

Precipitation

Winter precipitation is most critical for summer forage production, even though it does not usually fall on the study area. Above average snowfall in the higher elevations around Burns during the winter months provided spring runoff which was 117% of average as of April 1, 1989. Spring precipitation in the form of rainfall contributed to the already above average wild flooding. The monthly rainfall during the grazing season was consistently higher than the 25 year mean (Table 4), and translated into hay yields which were 2-3 times above average (Hammond, 1989; personal communication). The green feed period was extended several weeks beyond normal because of rain in late July and early August (Figure 3).

TABLE 4. Climatic data for the summer months at EOARC Burns, Oregon 1989.

	Temperature (C^0)				Precipitation (mm)	
Month	Max.	Min.	Mean	25 yr Mean	Total	25 yr Mean
May	17.6	2.1	9.9	11.1	25.9	22.4
June	24.6	6.7	15.6	15.0	26.9	21.3
July	29.8	7.8	18.8	18.8	17.8	8.9
August	26.0	7.1	16.6	16.6	29.0	10.4

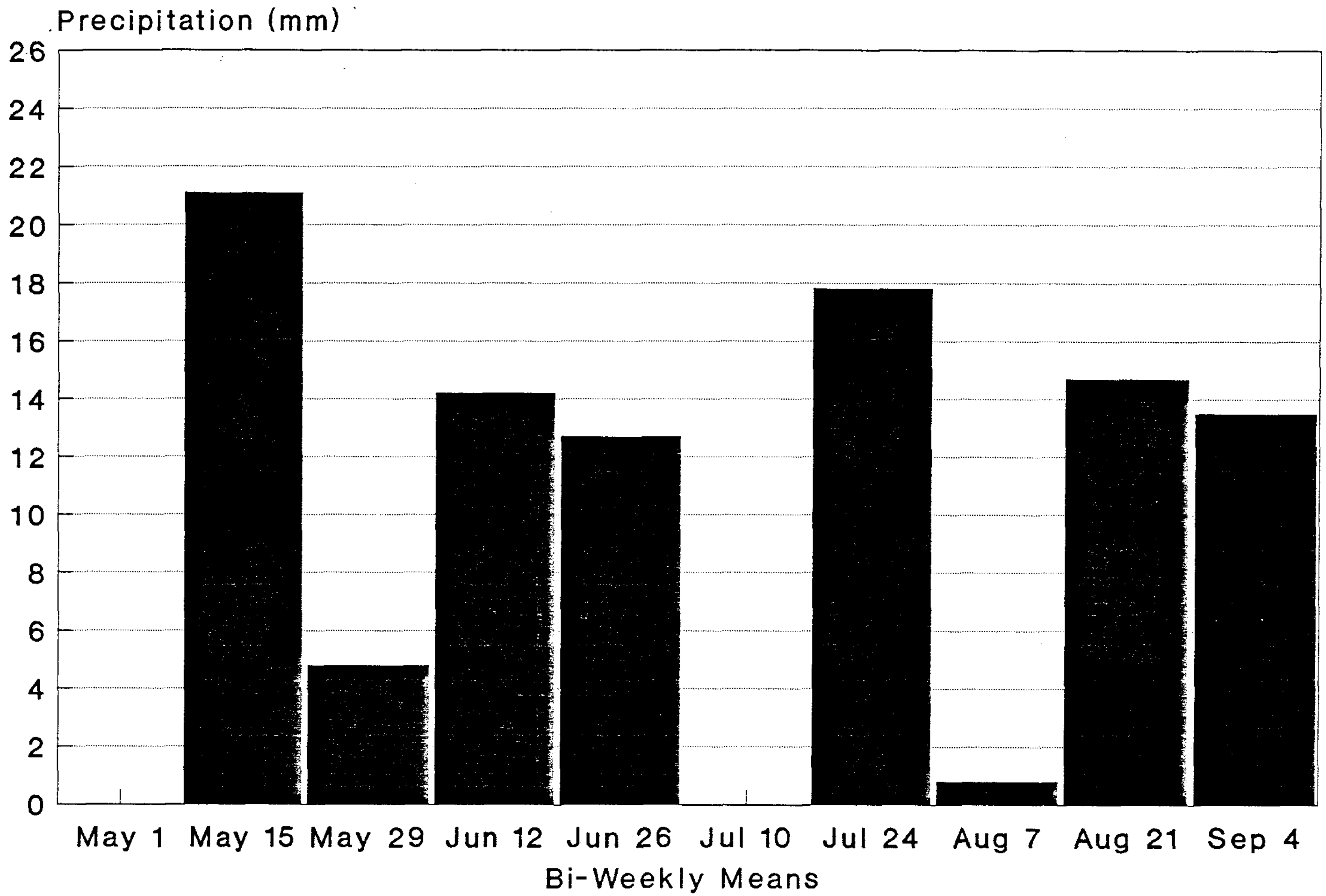


Figure 3. Precipitation between bi-weekly collection dates at EOARC Burns, Oregon from May 1 to Sept 4, 1989.

Forage Yield and Grazing Variables

Estimates of forage standing crop were based on plots clipped in each treatment pasture. Samples were clipped from ungrazed and grazed strips on strip grazed pastures prior to each move and at bi-weekly intervals from the entire grazed area of the continuous pastures. Vegetation clipped from predesignated protected areas within each block provided an estimate of total live standing crop of forage and growth rate of meadow vegetation when left undisturbed (Figure 4). This allowed an estimation of expected hay yields if the area had been cut for hay rather than grazed. The mean standing crop of forage over the four month grazing season was 5985 kg/ha with an average yield on July 10 of 9310 kg/ha. This date in July corresponds to the approximate date that haying operations commenced in 1989. Estimated hay yields from the present study are larger than that which would be expected because forage was clipped to ground level rather than leaving the normal 4-5 cm of stubble after mowing. Hay production during average years was reported to be ≈3400 kg/ha (Gomm, 1978; Hammond, 1989; personal communication), and 2250 kg/ha in early grazing studies on NMF's (Cooper et al., 1957).

Forage production was relatively slow in May and early June (Figure 4). Cooler temperatures (Table 4) checked plant growth, despite the saturated condition of the soil. Warmer weather in mid June stimulated growth which nearly doubled live

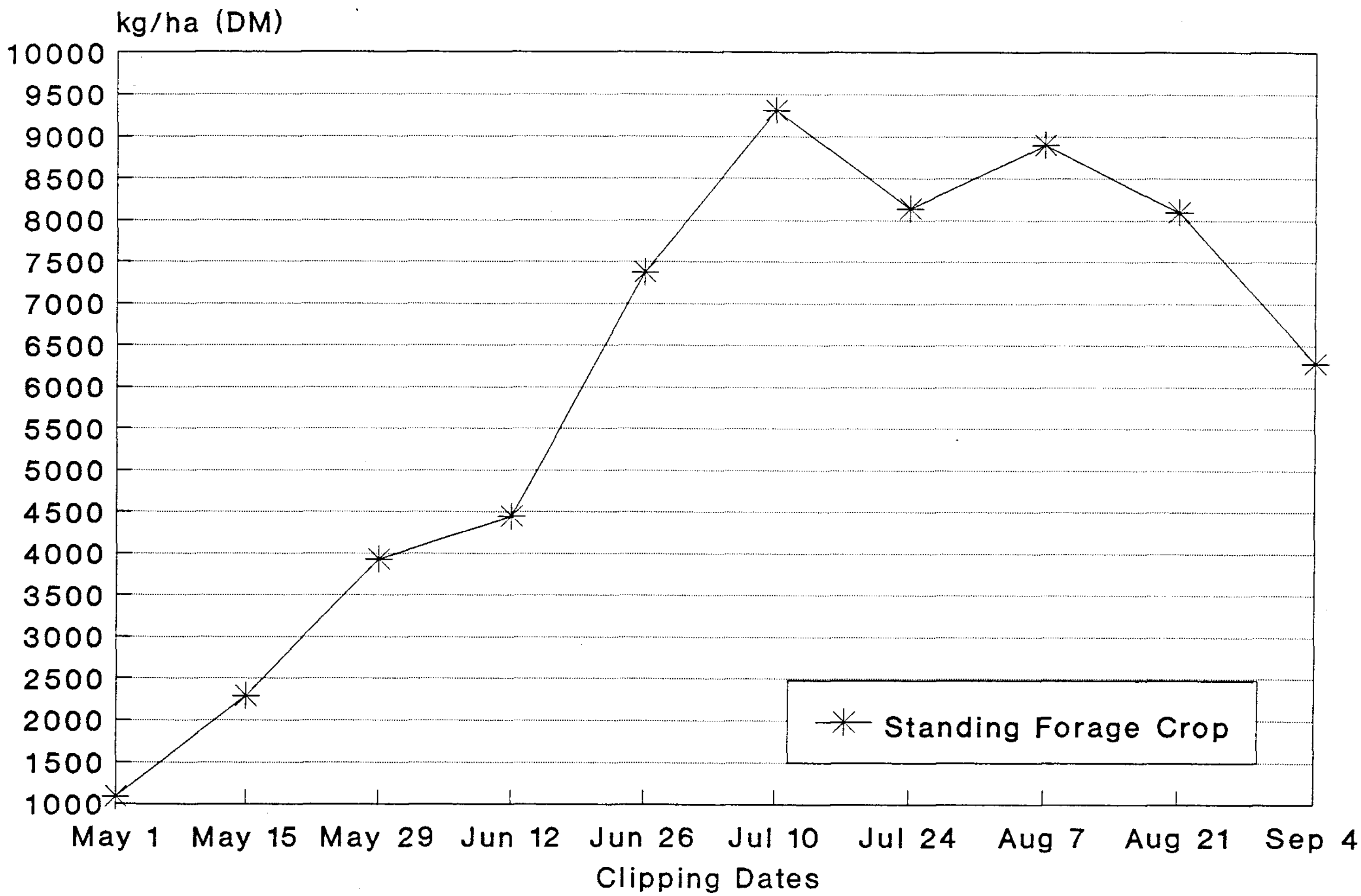


Figure 4. Standing crop of forage estimated from 10 .19m^2 plots clipped from .15 ha protected areas bi-weekly between May 1-Sept 4, 1989.

standing crop over the two week period from June 12-June 26. Plant growth was maintained at high levels during July because soil water remained at or above field capacity.

Live standing forage available to grazing animals within grazed areas was estimated from clipping data. Forage availability was expressed in terms of herbage allowance (kg/AU) and represents the weight of forage per unit of animal demand at any point in time (Scarnecchia, 1985).

The grazing pressure index (GPI) relates forage demand of grazing animals to available standing crop of forage (Scarnecchia and Kothman, 1982). Comparisons of GPI may be appropriate in this case because of unequal sizes of grazed pastures and differing lengths of grazing periods. One of the goals of strip grazing is to increase grazing pressure in order to reduce selective grazing and facilitate more extensive grazing of less preferred plant species/parts. In this study, strip grazing increased grazing pressure by three fold over continuous grazing (.65 vs .22 GPI, respectively). This difference was relatively constant over the summer (Tables 5,6). The most visible result of the increased grazing pressure in strip pastures was the disappearance of over 90% of meadow foxtail seed heads upon termination of grazing in each strip. This was compared to numerous individual mature meadow foxtail plants scattered over the continuous grazed pastures by mid summer. These mature plants were largely ignored by the continuous grazed steers and appeared to gradually increase in frequency with increasing forage availability. Peak standing crop of forage is reflected in the relative sizes of strips and herbage allowance for continuous grazed steers (Tables 5,6).

TABLE 5. Stocking variables, expressed in terms of herbage allowance, grazing pressure and grazing pressure index (GPI) (Scarnecchia, 1985) measured at bi-weekly intervals on continuous grazed pastures. Where 1 AU=1 animal unit=12 kg forage dry matter/day in animal demand.

Beginning Date	Area[1] (ha)	AU	Herbage Allowance[2] (kg/AU) Day of Sample: First	Last	Grazing Pressure[3] (AU/kg) Day of Sample: First	Last	GPI[4]
1989							
01-May	5.60	11.7	405	609	0.03	0.02	0.41
15-May	5.60	13.0	609	839	0.02	0.01	0.28
29-May	5.60	13.6	839	862	0.01	0.01	0.20
12-Jun	5.60	14.7	862	1153	0.01	0.01	0.19
26-Jun	5.60	15.3	1153	1063	0.01	0.01	0.15
10-Jul	5.60	16.0	1063	1112	0.01	0.01	0.16
24-Jul	5.60	16.8	1112	874	0.01	0.01	0.15
07-Aug	5.60	16.8	874	701	0.01	0.02	0.19
21-Aug	5.60	17.6	701	358	0.02	0.03	0.24
Mean	5.6	15.1	847	841	0.02	0.02	0.22

[1] Total area available for grazing between 14 day clipping dates.
[2] Weight of forage (kg DM) per unit animal demand at any point in time.
[3] Animal demand per unit weight of forage at any instant in time.
[4] Total forage demand for the 14 day grazing period divided by the forage standing crop at the beginning of the period.

TABLE 6. Stocking variables, expressed in terms of herbage allowance, grazing pressure and grazing pressure index (GPI) (Scarnecchia, 1985) measured on the first and last day of each grazed strip. Where 1 AU=1 animal unit=12 kg forage dry matter/day in animal demand.

Entry Date	Area[1] (ha)	AU	Herbage Allowance[2] (kg/AU) Day of Sample First	Last	Grazing Pressure[3] (AU/kg) Day of Sample First	Last	GPI[4]
1989							
01-May	1.15	11.7	115	44	0.10	0.27	0.68
06-May	0.62	11.7	68	47	0.18	0.25	1.15
11-May	0.56	11.7	75	63	0.16	0.19	1.04
17-May	0.53	12.8	95	40	0.13	0.30	0.82
24-May	0.49	12.8	100	42	0.12	0.29	0.78
31-May	0.46	13.2	118	41	0.10	0.29	0.66
06-Jun	0.48	13.2	130	67	0.09	0.18	0.60
13-Jun	0.43	13.9	153	59	0.08	0.20	0.51
20-Jun	0.36	13.9	144	64	0.08	0.19	0.54
26-Jun	0.38	14.5	186	100	0.06	0.12	0.42
03-Jul	0.31	14.6	125	38	0.10	0.32	0.63
08-Jul	0.28	14.9	120	45	0.10	0.27	0.65
15-Jul	0.24	14.9	120	31	0.10	0.39	0.65
22-Jul	0.23	15.4	116	14	0.10	0.86	0.67
30-Jul	0.27	15.4	127	23	0.09	0.51	0.61
05-Aug	0.31	14.9	146	35	0.08	0.35	0.54
12-Aug	0.42	14.9	176	54	0.07	0.22	0.44
18-Aug	0.52	15.4	167	67	0.07	0.18	0.47
26-Aug	0.70	15.4	181	56	0.07	0.22	0.43
Mean	0.46	14.1	130	49	0.10	0.30	0.65

[1] Total mean area available for grazing in strips on each date.

[2] Weight of forage (kg DM) per unit animal demand at any point in time.

[3] Animal demand per unit weight of forage at any point in time.

[4] Total forage demand for the grazing time in each strip divided by forage standing crop at the beginning of each strip.

Continuous grazed steers had the highest standing crop of forage available from late June through late July. The peak yield was recorded on July 24 with ≈3336 kg/ha of live standing forage available to continuous grazing animals. However, a large percentage of this forage (≈20-25%) was observed to be in an advanced stage of senescence and of low palatability. Grazing pressure (GP) in the continuous pastures was very light during mid summer compared to that in the strips.

The standing crop of forage in the strip pastures ranged from 1170 kg/ha the first week of grazing on the north end of the study area to 7097 kg/ha on the southern most strip the week before returning to regrowth . Forage yield estimates from strip pastures represent the area about to be grazed and the ungrazed areas immediately adjacent to that strip. Grazing pressure was highest in the strips during the first month of the study because plants were growing at a slower rate and forage yields were lower. Lower GP was exerted later in the summer as the standing crop of forage accumulated and steers were moved at a faster rate in an attempt to stay abreast of the rapidly maturing meadow foxtail (Table 6).

The original grazing plan was based on average forage production estimates from past year's data which indicated that initial stocking densities of 2 AU/ha would be adequate. This stocking density combined with the above average growing conditions resulted in under stocking of both treatment pastures. Under stocking was not as noticeable on the continuous grazed pastures, because the forage as a whole, was utilized more evenly. However, an over-supply of forage in the strip grazed pastures had become evident by mid June.

The west block of the strip grazed treatment was highly productive; and as a result, more forage was produced than could be used. This prompted a decision to cut as hay, the remaining 1 ha ungrazed portion of the pasture. This decision was based on the desire to return both strip treatment blocks to regrowth at the same time on June 26. No data from this hayed area were included in later analysis of forage or livestock parameters. However, removal of this area from grazing, did decrease the total amount of pasture area grazed by strip steers and in turn, was reflected in calculations of animal production per unit area.

Lucas and McMeekan (1959) described a similar situation with break-grazing on New Zealand pastures. They cut one quarter of the break-grazed pasture as silage upon termination of the grazing season. This was in comparison to rest-rotation pastures which had similar amounts of forage, but not of suitable height or quality for harvest. These researchers believed that break-grazing acted to conserve forage in a smaller area of suitable quantity for salvage as hay or silage. The following observations from the present study tend to support these assumptions.

The block of strip pasture cut as hay was the lowest and wettest portion of the study pasture. Although this block of pasture was effectively eliminated from the trial, it was interesting to note that upon harvest in mid July, approximately 10,000 kg of DM were removed as hay. This hay production value is mentioned only as a point of interest intended to illustrate the production potential of deeper flooded areas on these meadowlands.

Total live standing crop of forage on the last day of the grazing trial was approximately 1494 kg/ha on continuous pastures and 3773 kg/ha on strip pastures. The estimate from strip pastures does not include regrowth from the block removed as hay or forage remaining in the last grazed strip. This information suggests that the intensive grazing, followed by 50-60 days of rest, stimulated plant growth on strip pastures resulting in higher forage yields.

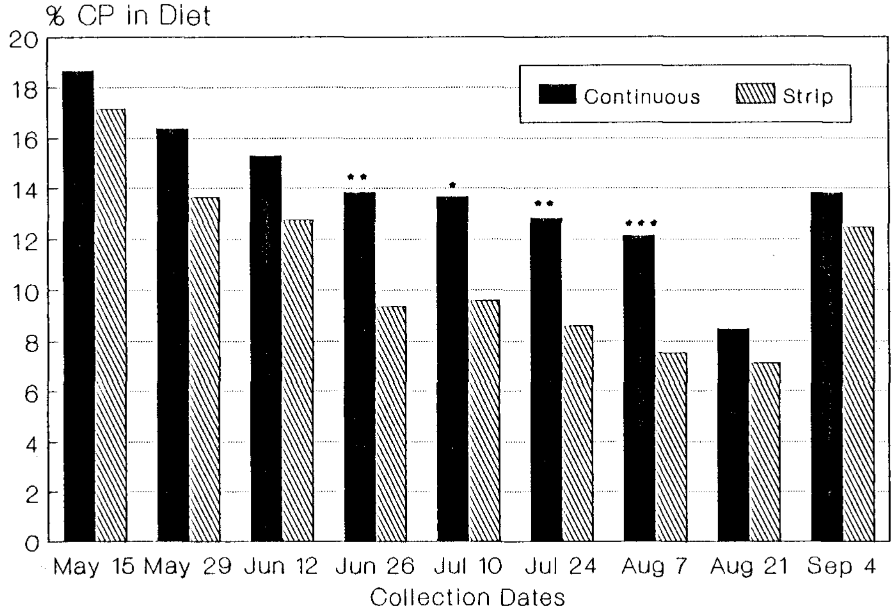
Diet Quality

Bi-Weekly Diet Sampling

Seasonal variations in the percentage of CP and IVOMD consumed by strip and continuous grazed steers is illustrated in Figure 5. Dietary CP and IVOMD both declined significantly (P<.05) over the course of the grazing trial, primarily because of advancing plant maturity (Rumberg, 1963; Raleigh et al., 1964; Nelson et al., 1989). Seasonal means for CP were 13.9% in the strip grazed diet and 10.9% for continuous grazing. The percentage of CP in the continuous diet was numerically higher than the strip treatment, but was not considered significantly different (P=.14).

Dry matter digestibility tended to be higher (P=.07) in the overall diet of continuous grazed steers, 64.6 vs 60.7% for strip animals. Other researchers (Sharrow, 1983; Kirby and Parman, 1986; Olson et al., 1989) have reported results which support a general trend toward lower diet quality under intensive grazing systems. Lower diet quality is thought to be a function of reduced selectivity as grazing pressure increases (Ralphs et al., 1986). Our findings are in contrast to experiments where SDG had no effect on diet quality (Taylor et al., 1980; Pitts and Bryant, 1987; Olson and Malechek, 1988).

Treatment means differed significantly for both CP and IVOMD on four collection dates at the height of the growing season (Figure 5). Differences between treatment CP values appeared be larger in comparison to IVOMD values although the



*,**,*** Continuous differs from strip grazing treatment (P<.05), (P<.01), (P<.005), respectively.

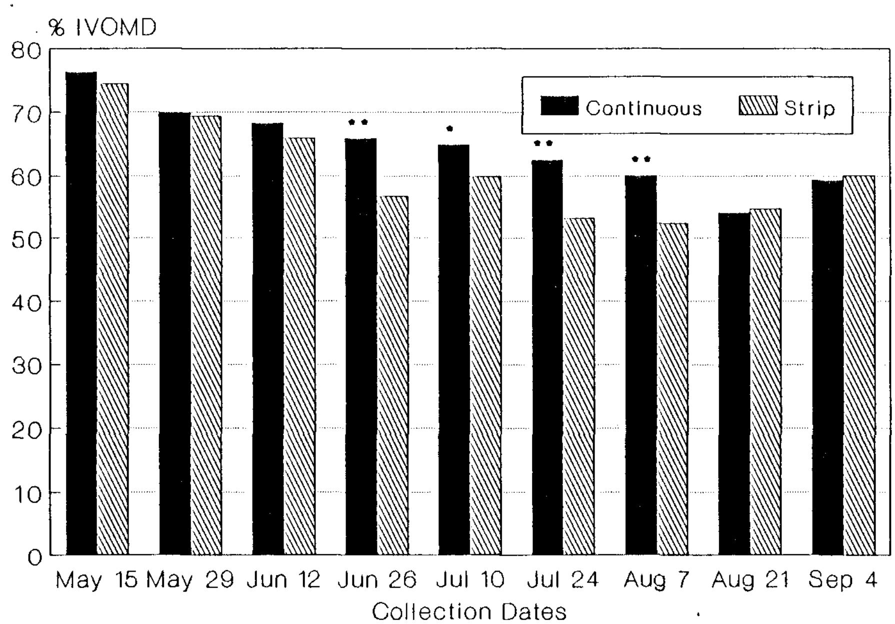


Figure 5. Percentage of crude protein (CP), and in vitro organic matter digestibility (IVOMD) of steer diets under continuous or strip grazing systems from May 1 to Sept 4, 1989.

*,** Continuous differs from strip grazing treatment (P<.05), (P<.001), respectively.

main effects of dietary CP were not considered significantly different. Crude protein and IVOMD both differed at various levels of significance between June 12 and Aug 7.

Continuous and strip diets were similar prior to mid June. Cool growing conditions between May 1 and June 10 tended to hold plant growth to a fairly slow rate. Strip grazed steers were able to maintain highesufficient diet quality prior to mid June because plants were a high quality vegetative stage. The second week of June brought warmer temperatures and a flush of growth from primarily meadow foxtail. This increased plant growth rate was reflected in the standing forage crop (Figure 4) and in herbage allowances for continuous grazed steers (Table 5). However, strip grazed steers were held to relatively constant grazing pressures in compliance with the management scheme. A difference in plant selection occurred as grazing pressure widened between treatments and most likely caused the change in diet quality.

Forage quality is likely to decrease rapidly at high rates of plant growth (Nelson et al., 1989). It would be reasonable to expect the decrease in forage quality to be offset somewhat by a higher herbage allowance and thus increase the ability of continuous grazing animals to select a higher quality diet as grazing pressure decreased (Ralphs et al., 1986). On the other hand, strip grazed steers did not have this advantage because grazing pressures were constantly maintained at much higher levels (Table 6). Increased grazing pressure forced the strip steers to consume higher quality plant parts during initial days grazing, resulting in lower quality forage to select from mid-late way through each strip. The reduction in selection had a dramatic effect on diet quality (Figure 5). Therefore, on June 26 continuous steers were able to select diets significantly higher in CP ($P<.01$) and IVOMD ($P<.001$) compared to strip grazed steers.

Differences between diets were still significant for both diet variables on July 10 ($P<.05$). These observations coincide with the first collection period after moving strip grazed steers back to regrowth. Visual observation indicated that vegetation in the first regrazed strips was less mature than the forage available in previously grazed strips. This difference is reflected more by %IVOMD of strip diets.

Continuing wet conditions in early July maintained the standing crop of forage at high levels until late July (Figures 3,4). The volume of plant regrowth is reflected in the herbage allowance and decreasing strip size after June 26 (Table 6). Regrowth available to strip grazed steers quickly increased in maturity, resulting in large differences in diet quality by late July and early August. Quality of continuous diets declined steadily, but the abundance of forage allowed for considerable selection as grazing pressure remained constant.

Above average precipitation in mid August combined with cooler night time temperatures, stimulated growth resulting in a higher quality forage available to both treatment groups. Increased CP and IVOMD in both treatment diets on the last collection date was probably caused by precipitation falling between July 24-Aug 21 (Figure 3).

Herbage allowance for continuous steers decreased rapidly over the last six weeks of the study (Table 5). A combination of lower herbage allowance and reduced forage quality would explain the large decrease in dietary CP levels on August 21 (Figure 5). The grazing pressure index was closer between grazing treatments during the last four weeks of the study and seems to describe the similarity between treatment diets exhibited over this period of time.

Monthly Diet Samples

Extrusa samples from monthly esophageal collections were obtained to provide supplementary data to bi-weekly collections. These data did help provide a better picture of day to day changes in diet quality occurring in each strip.

Pooling of collection animals within treatment blocks, increased the number of samples per date, but in turn created some additional problems from a logistical standpoint. Animal grazing behavior was negatively affected as new cattle were introduced into the resident grazing herd. This type of response was expected, even though all experimental animals were herd mates prior to initiation of the trial and grazed in adjacent pastures during the trial. Negative behaviors were manifested primarily in fighting and exploration of new surroundings rather than normal grazing. The collection window is relatively short for this type of sampling (30-45 min) because of constriction of tissue surrounding the fistula once the plug is removed (Ellis et al., 1984). Therefore, any time spent at activities other than grazing detracts from overall accuracy of the collection procedure.

The most interesting finding was that dietary CP did not differ significantly between the last few hours in the currently grazed strip and the first hour of grazing in the new strip (Table 7). Digestibility of the diets was similar, although larger differences were recorded between values of samples collected on June 7.

TABLE 7. Mean values for crude protein (CP) and in vitro organic matter digestibility (IVOMD) of esophageal extrusa collected monthly from strip treatment pastures one hour before or after movement to a new strip.

		Collection Date				
Item	Move (1hr)	7 Jun	9 Jul	19 Aug	Mean[1]	SEM[2]
CP	Before	12.85	10.84	8.39	10.60[a]	
(%)	After	12.85	11.46	*.* [3]	12.15[a]	1.07
IVOMD	Before	60.52	63.90	56.36	60.25[a]	
(%)	After	66.36	63.48	*.*	64.92[a]	2.70

[1] Means within rows differ ($P < .10$) when followed by different letters.

[2] Standard error of the mean calculated from move by block (error a) and move by block within period (error b); n=3.

[3] The "*.*" denotes missing data for that date due to collection difficulties.

Esophageal extrusa samples were not collected from the beginning of the new strip on August 19 because of difficulties with experimental animals and equipment. On the two previous collection dates, steers were able to select a relatively nutritious diet from available stubble remaining in grazed strips.

This data agrees with work on Texas rangeland by Taylor et al. (1980) who found no difference in diet quality over 7 d SDG periods. Contradictory results were reported by Ralphs et al. (1986) and Olson et al. (1989) stemming from data which showed a steady decrease in diet quality over 3 d SDG periods.

An important factor that is not evident from the data, was the mass of extrusa samples relative to time spent grazing. Amounts of forage prehended in grazed strips were observed to be considerably less than comparative samples from newly opened strips. Herbage mass collected in 30 min periods was visually estimated to be 50-75% less than collections from the first hour of new strips, or those collected at the mid point of grazing during bi-weekly collections. Similar observations were documented by Chacon et al. (1976), who noted an increase in grazing time was required to maintain diet quality as the quality and quantity of available forage declined.

It was observated that fistulated steers from continuous treatments initially refused to consume available forage in the grazed strips. This forage was more stemmy and contaminated with feces and urine, compared to forage available in continuous pastures. Contamination of forage by animal waste was more of a problem during the first two months when pastures were experiencing heavy flooding. Animal waste products were readily dispersed in the water and tended to contaminate large areas. Resident esophageal fistulated steers consumed this forage readily. This difference in preference was reflected by extrusa sample mass. Sample sizes from resident steers were noticeably larger compared to extrusa collected by the fistulated steers introduced from continuous grazed pastures.

Botanical Composition of Steer Diets

Strip grazing tended to increase (P=.06) the amount of grass in steer diets (Table 8). Botanical composition estimates from micro histological examination of fecal sub-samples showed a 28% increase in total grass species in strip grazed steer diets compared to continuous steer diets. These results are not surprising considering the number of reports of floristic changes in animal diets under intensive grazing management (Holmes et al., 1950; Joblin, 1963; Taylor et al., 1980; Sharrow, 1983a; Ralphs et al., 1986).

The rush and sedge component of steer diets was numerically higher for continuous animals (62.6%) but not considered different (P=.14) compared to strip grazed steer diets (49.0%). Forbs represented only a small fraction of plant material found in all experimental animal diets (<.5%) and no differences (P=.67) were detected in forb consumption between treatment groups.

Meadow foxtail was the most important grass species in the diet, comprising 27.1 and 43.9% of the total seasonal diet for continuous and strip grazed steers, respectively. The 39% increase in meadow foxtail consumption by strip grazed steers over continuous grazed steers was directly attributed to the effects of treatment (P=.05). A minor grass species, quackgrass, was also higher (P=.05) in strip grazed steer diets.

Holmes et al. (1950) reported that strip grazing of highly productive summer pasture favored the more vigorous grasses. This was apparently the case in the present study considering the vigorous nature of meadow foxtail and it's substantial contribution to the strip diet. Strip grazing may have increased the standing crop of meadow foxtail in addition to the grass being taller and easier for steers to prehend.

TABLE 8. Seasonal average percentages of the three major classifications of vegetation found in the steer diets under strip or continuous grazing on native flood meadows May 1 - Sept 4, 1989. These data are pooled from plant species identified by microhistological analysis of fecal samples.

	Treatment		
Item	Continuous	Strip	SEM[1]
Grass[2] (%)	34.74[a3]	48.46[b]	3.97
Rush/Sedge (%)	62.57[a]	48.96[a]	5.41
Forbs (%)	.41[a]	.26[a]	.01

[1] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.

[2] Based on total grass species - total meadow foxtail seeds.

[3] Means within rows differ (P<.10) when followed by different letters.

However, the most important factor determining changes in botanical composition of strip diets was that strip grazing restricted animals to specific areas of the meadow which contained only a certain number of plant communities. On the other hand, continuous managed animals were able to graze unrestricted among all available plant communities.

Figure 6 illustrates change in botanical composition of animal diets at each collection period in regard to the two major vegetation classes. Effects on strip grazed steer diets caused by the imposed restrictions on selectivity is evident. The first two strips in May were located at the north end of the study site in an area which generally receives less moisture from flooding. Plant communities in this area are diverse but tend to be dominated by sedge and rush. Strip diets were higher in sedge/rush and lowest in grasses when confined to this area. Percentages of these species in the strip diet were inverted as the strips were moved south into wetter areas containing more meadow foxtail and less sedge/rush.

Meadow foxtail was significantly higher ($P<.01$) in strip grazed steer diets in late May to early June and again in mid to late August (Figure 7). These collection periods coincide with strips located in areas of deep flooding composed of plant communities dominated by meadow foxtail. Likewise, sedge consumption peaked at 70% in strip diets when steers were returned to graze regrowth on the south end of the pasture (Figure 8).

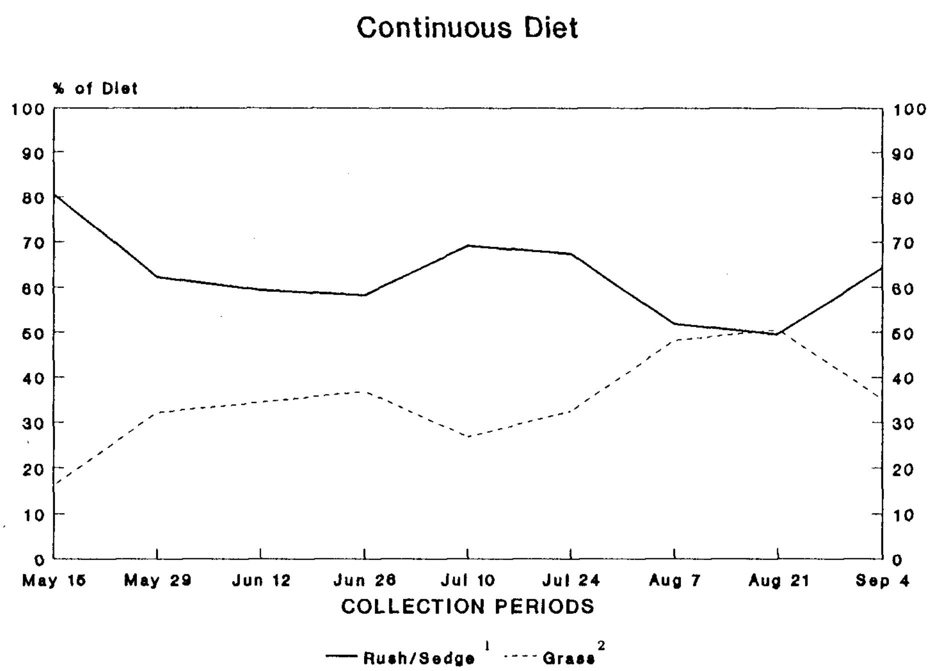
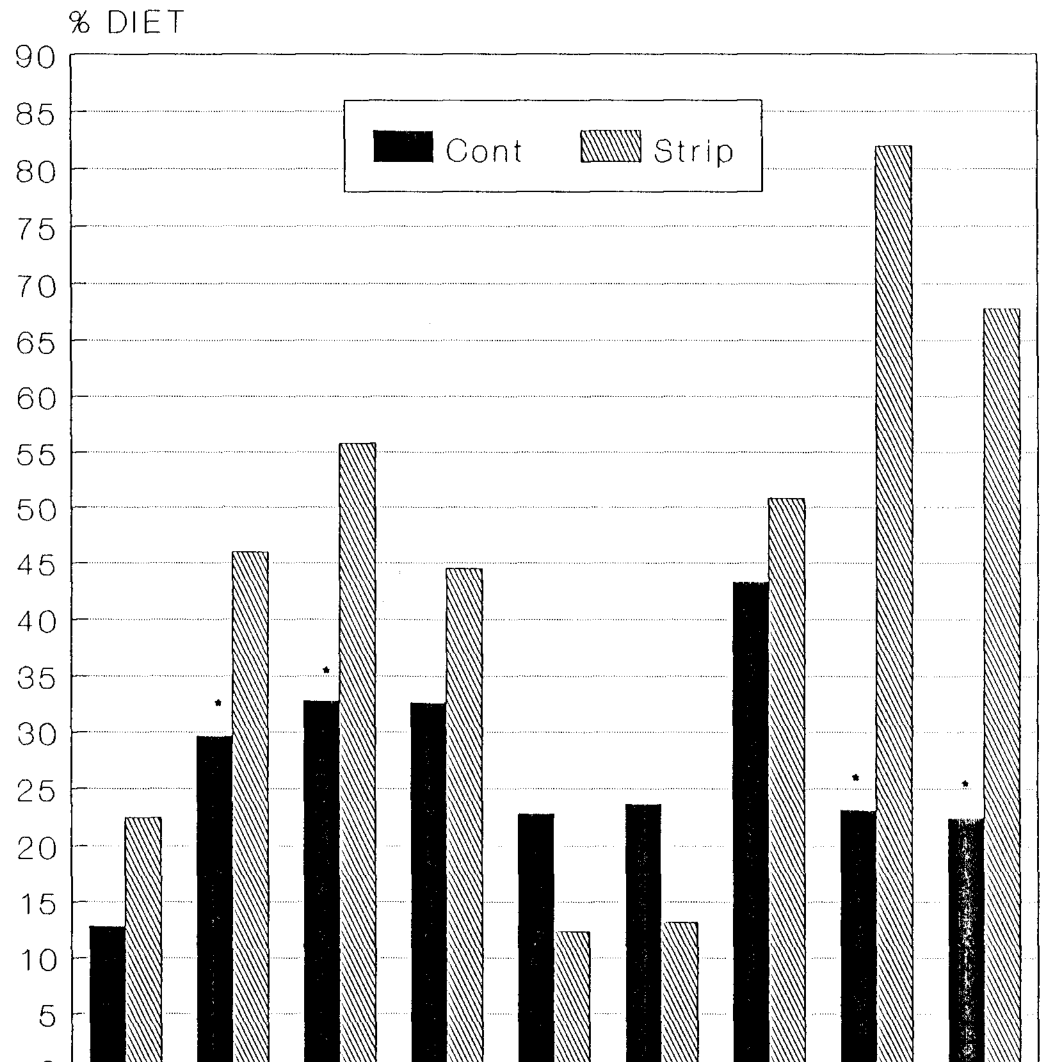


Figure 6. Percentage of grass and rush/sedge in the diet of steers grazing native flood meadow vegetation under continuous or strip grazing treatments May 1-Sept 4, 1989.

[1] Based on pooled estimates of sedge/rush in fecal sub-samples.

[2] Based on pooled estimates of grasses in fecal subsamples.



	5/15	5/29	6/12	6/26	7/10	7/24	8/7	8/21	9/4
Cont	12.83	29.66	32.83	32.66	22.83	23.66	43.33	23.16	22.5
Strip	22.5	46	55.83	44.5	12.33	13.16	50.83	82	67.83

Collection Dates

Figure 7. Percentage of meadow foxtail in the diet of steers grazing native flood meadow vegetation under continuous or strip grazing May 1-Sept 4, 1989.

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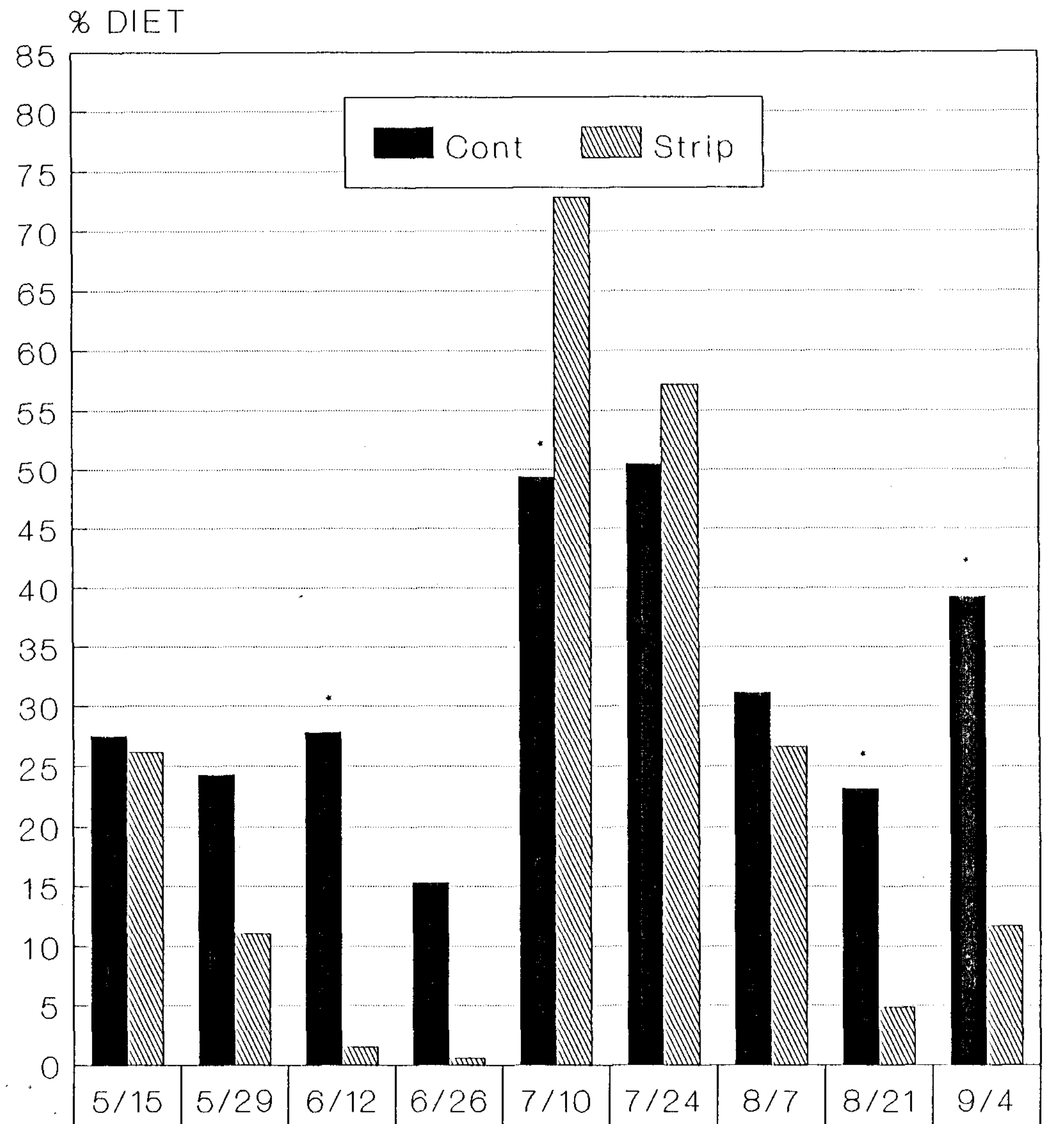
* Continuous differs from strip grazing treatment (P < .01).



	5/15	5/29	6/12	6/26	7/10	7/24	8/7	8/21	9/4
Cont	27.5	24.33	27.83	15.33	49.33	50.5	31.17	23.17	39.33
Strip	26.17	11	1.5	0.6	72.83	57.17	26.67	4.83	11.67

Collection Dates

Figure 8. Percentage of Carex in the diet of steers grazing native flood meadow vegetation under continuous or strip grazing May 1-Sept 4, 1989.

* Continuous differs from strip grazing treatment (P<.01).

Quantity of meadow foxtail in the continuous grazed steer diets remained relatively constant over the season. However, continuous steers appeared to select for sedges during mid July, the same period when sedges peaked in strip diets. It was during this same period that a peak occurred in standing crop of forage (Figure 4). Advancing plant maturity, and thus lower quality of meadow foxtail during this four week period, might provide a likely explanation for changes in plant preference by steers in both treatments. Changes in plant preference at different times in the grazing season have been documented by other researchers (Joblin, 1963; Denny and Barnes, 1977; Holechek, 1980; Sharrow, 1983a).

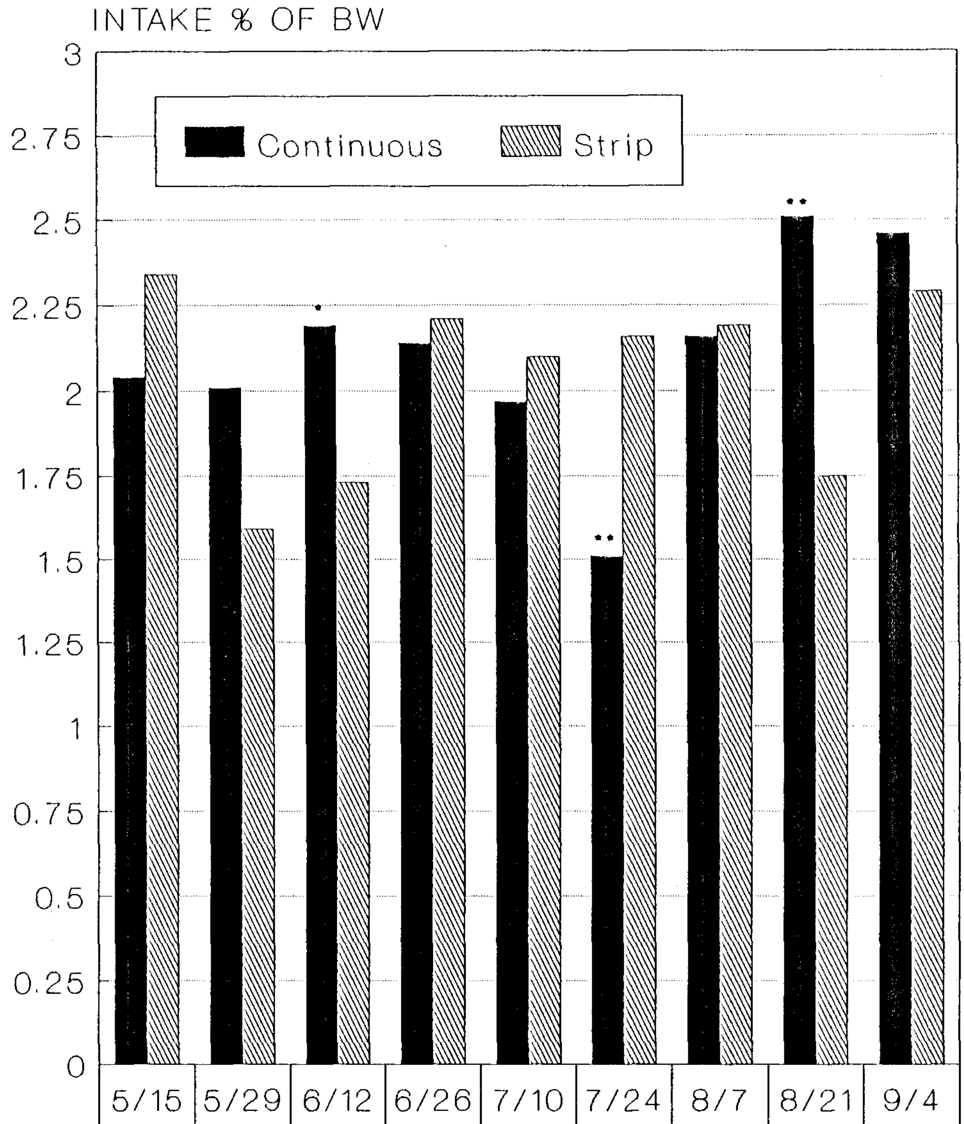
Sedges contributed a significantly higher ($P < .01$) percentage to continuous diets in late August compared to strip diets. This difference was probably because of a combination of restrictions imposed upon strip grazed steers and increased selection for sedges by continuous grazed steers as the standing crop of forage dwindled and matured.

Intake

Daily DM intakes were analyzed as kg DM/d on a percentage of body weight (BW) basis. There is a recognized linear relationship between metabolic body weight ($BW^{.75}$) and intake (Zolby and Holmes 1983; Bruckental et al., 1987). However, expressing BW on a metabolic basis was not necessary in our analysis because of the similarity between body mass of experimental animals.

There was no difference in main effects ($P=.42$) between treatment means for daily DM intake. Treatment means were 2.03 and 2.11% of BW for strip and continuous grazed steers, respectively. These results agree with intake estimates from other intensive grazing studies conducted on meadows (Holechek, 1980; Sharrow, 1983a) and rangeland (Allison et al., 1982; Olson and Malechek, 1988). Intake appeared to increase slightly over the five month study. This increase was not significant ($P>.05$), although one might expect higher levels of consumption as body mass and rumen capacity increase (Bruckental et al., 1987).

Daily herbage consumption tended to fluctuate as the season progressed (Figure 9). The data followed no clear patterns over collection periods, and any relationship to diet quality was not immediately obvious. Treatment means were different ($P<.05$) on three separate collection dates over the summer and each occurred approximately one month apart (Figure 9). There is no evidence to support intake being adversely affected by forage availability (Tables 5,6).



	5/15	5/29	6/12	6/26	7/10	7/24	8/7	8/21	9/4
Continuous	2.04	2.01	2.19	2.14	1.97	1.51	2.16	2.51	2.46
Strip	2.34	1.59	1.73	2.21	2.1	2.16	2.19	1.75	2.29

Collection Dates

Figure 9. Daily dry matter intake as a percentage of body weight by steers on continuous or strip treatments May 1-Sept 4, 1989.

*,** Continuous differs from strip grazing treatment (P<.01), (P<.005), respectively.

Intake was higher ($P < .05$) on June 12 for continuous grazed steers as forage availability increased rapidly. Therefore, strip grazed steers were grazing at higher grazing pressures. However, the GPI for strip steers had decreased over this same period of time which does not provide a logical explanation for the differential levels of intake.

There were highly significant differences ($P < .005$) recorded between treatments on July 24 and Aug 21 which are not easily explained. A large plunge in daily DM intake exhibited by continuous steers on July 24 could be the result of higher ambient temperatures. However, this explanation does not sufficiently explain the superior rate of intake by strip grazed steers on this same date.

The inverse was seen on Aug 21 when continuous steers consumed the highest amount of DM over the trial compared to below average consumption by strip grazed steers. Dietary IVOMD (Figure 5) was higher for the strip grazed steers during this collection period compared to previous dates. Therefore, one might expect an increase in DM intake by strip steers because of increased diet quality rather than the decline indicated by our data. Variations of this magnitude could be a result of sampling procedures or undocumented environmental interactions.

Animal Performance

Steer weight gains were better than expected and probably reflect the above average growing conditions. Individual steer performance under continuous grazing was considerably higher than the .78 kg ADG by yearling steers grazing the same meadows over the summer of 1954 (Cooper et al., 1957). Steers in the continuous treatment tended (P=.09) to perform better on an individual basis than strip grazed steers. These results differ from reports of equal individual animal gains under intensive grazing management (Denny et al., 1977; Holechek, 1980; Heitschmidt et al., 1982; Jung et al., 1985; Pitts and Bryant, 1987).

Mean ADG was 1.16 kg for continuous and .77 kg under strip grazing. The increased performance exhibited by continuous grazed steers is most likely a result of the higher plane of nutrition noted previously. Similar conclusions by other researchers (Joblin, 1963; Sharrow, 1983b) support a diet related decrease in animal performance under intensive grazing management.

Despite equal or reduced individual performance of animals under intensive grazing management, there is often higher total production per unit area grazed (Holmes et al., 1952; Sharrow, 1983b; Jung et al., 1985) Superior individual steer performance exhibited under continuous grazing was offset by the smaller total pasture area grazed under strip management (5.6 vs 4.37 ha), respectively. However, there was no significant difference (P=.17) between the two treatments when compared on a total production basis (Table 9). Animal production per hectare was not compared by period because comparisons of this type can not be justified as a result of changing strip sizes and the tendency of strips to overlap weigh dates.

TABLE 9. Average daily gain (ADG) and total gain per hectare of steers under strip or continuous grazing of native flood meadows May 1 - Sept 4, 1989.

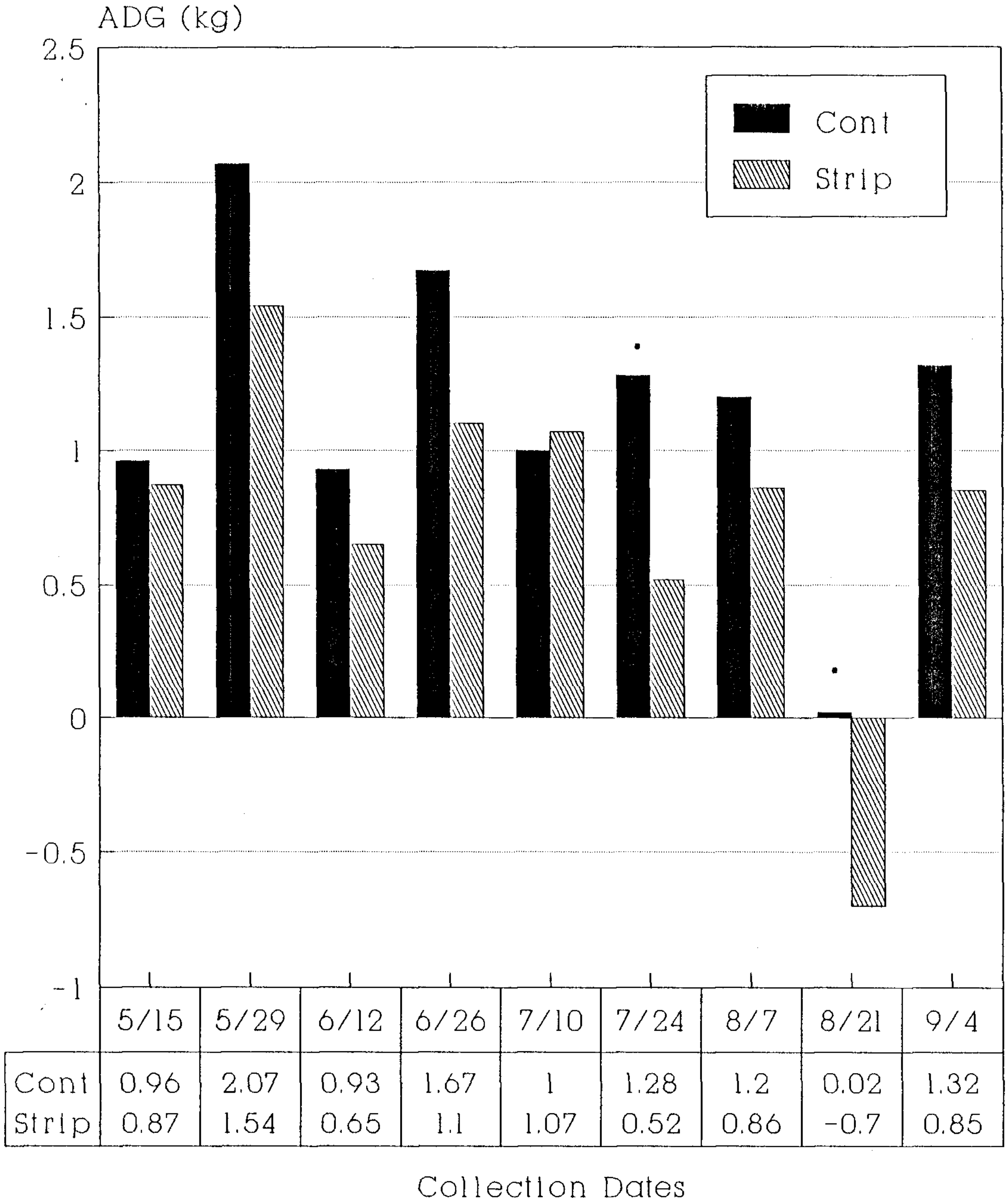
	Treatment		
Item	Continuous	Strip	SEM[1]
ADG (kg)	1.16[a3]	.77[b]	.21
Total gain[2] (kg/ha)	26.14[a]	22.13[a]	.16

[1] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.

[2] Based on total seasonal grazed areas of 5.6 and 4.37 ha for continuous or strip treatments, respectively.

[3] Means within rows differ ($P < .10$) when followed by different letters.

Seasonal variations in ADG are displayed in Figure 10. Continuous steers gained significantly more ($P < .01$) than strip grazed steers over the period ending July 24. This could be a possible result of the large difference in diet quality between treatments over this same period (Figure 4). Treatment means on Aug 21 are considerably lower for both treatments compared to ADG values on other dates. The low ADG values on this date were the result of a mishap during the normal shrink/weigh routine. Steers were fasted an additional six hours because of their escape from the dry alleyway during the night which allowed all animals access to water. The extra six hours of shrink was preferred to the option of regathering and fasting the steers on the following day. Additional time spent off feed and water produced an expected negative response on weights recorded on this date. Regardless of the inconvenience, all animals were treated equally and differences between treatments should be legitimate even though means from this collection period deviate considerably from other collection means. The differences between treatments on this date were significant.



	5/15	5/29	6/12	6/26	7/10	7/24	8/7	8/21	9/4
Cont	0.96	2.07	0.93	1.67	1	1.28	1.2	0.02	1.32
Strip	0.87	1.54	0.65	1.1	1.07	0.52	0.86	-0.7	0.85

Figure 10. Average daily gain (ADG) of steers (kg/hd/d) grazing native flood meadows under continuous or strip grazing May 1-Sept 4, 1989.

* Continuous differs from strip grazing treatment ($P < .01$).

GENERAL DISCUSSION

This chapter is designed to bring together the previously discussed components of the diet and their possible relationship to animal performance. Diet quality and intake over the four month grazing season are summarized in Table 10. It would be profitable to relate diet quality to parameters of ingestive behavior and performance. A number of researchers (Waite et al., 1952; Lucas and McMeekan, 1959; Jamieson and Hodgson, 1979a,b; Nelson et al., 1989; Olson et al., 1989) reported depressed DM intakes associated with intensive grazing systems. However, in the present study intake was equal for strip and continuous grazing steers.

One simple explanation for these results might be found in the conclusions of British scientists (Jamieson and Hodgson, 1979a;b; Hodgson, 1981) who discovered that forage mass and height exert a greater effect on DM intake than forage quality. Our data show that grazing pressure was high in the strip grazed pastures, but forage availability was never critical and sward height seldom fell below 10 cm. Grazing of cattle on pastures with a sward height of less than 10 cm has been implicated in reduced animal performance (Loweman et al., 1988) which implies a possible reduction in herbage intake.

Other studies (Poppi et al., 1980; Bruckental et al., 1987; Nelson et al., 1989) have shown a negative relationship between dry matter

TABLE 10. Values for dietary crude protein (CP), in vitro organic matter digestibility (IVOMD) and dry matter (DM) intake on a percentage body weight (BW) basis of steers under continuous (CONT) or strip grazed treatments over 14 d collection periods between May 1-Sept 4, 1989.

		Collection Periods Ending										
Item	Treatment	15 May	29 May	12 Jun	26 Jun	10 Jul	24 Jul	7 Aug	21 Aug	4 Sep	Seasonal Mean[1]	SEM[2]
CP[3]	CONT	18.66	16.37	15.29	13.85	13.68	12.84	12.15	8.47	13.82	13.91^{a}	
(%)	STRIP	17.16	13.66	12.75	9.35	9.58	8.60	7.53	7.11	12.46	10.90^{a}	1.16
IVOMD	CONT	76.18	69.91	68.23	65.90	64.90	62.46	60.05	54.17	59.37	64.58^{a}	
(%)	STRIP	74.38	69.38	65.90	56.82	59.89	53.18	52.35	54.70	60.10	60.74^{b}	1.49
Intake[4]	CONT	2.04	2.01	2.19	2.13	1.97	1.51	2.16	2.51	2.46	2.11^{a}	
(%/BW)	STRIP	2.34	1.59	1.73	2.21	2.20	2.16	2.19	1.75	2.29	2.03^{a}	.16
Intake	CONT	4.58	4.96	5.85	6.05	5.88	4.80	7.10	8.39	8.67	6.26^{a}	
(kg/d)	STRIP	5.21	3.82	4.40	5.82	5.87	6.14	6.48	4.94	6.75	5.49^{a}	.68

[1] Means of treatment main effects within dependent variables differ ($P<.10$) when followed by different letters.
[2] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.
[3] CP and IVOMD means were pooled from 8 esophageal samples per treatment collected bi-weekly to coincide with the mid-point of the currently grazed strip.
[4] Intake was estimated from 24 hr total fecal collections from 6 steers/treatment taken the day following esophageal collections and corrected with estimated %IVOMD.

intake and digestibility of the diet. Nelson et al. (1989) reported a slowing of liquid and particulate passage rates as IVOMD in the diet decreased leading to reductions in voluntary intake.

These results do not agree with our data which show similar treatment means for daily DM intake while IVOMD tended to be different between treatments. Furthermore, the four week period (July 10-Aug 7) over which strip diets were lowest in IVOMD corresponds to a similar period where herbage intake was slightly above the seasonal average (Table 10). Our results tend to agree with those of Sharrow (1983a) who reported that rotational grazing lowered diet quality but had no effect on herbage intakes of sheep. Perhaps digestibility of the steer diets recorded in our study needed to be lower before any decrease in herbage consumption could be detected. Other researchers (Hodgson and Jamieson, 1981; Bruckental et al., 1987) reported that forage digestibility in the range of 52-67% can lower voluntary intake.

Another possible explanation for the lack of intake depression could be an increased rate of passage caused by environmental variables unrelated to lower forage quality. Rate of passage was not monitored in this study. However, if moisture content of fecal material could be used (Table 11) as an indicator of passage rate, one might suspect an increased movement of material through the intestinal tract. The percentage of DM in the feces was noticeably low, considering the normal DM content of cattle feces ranges from 15 to 30% (Church, 1976).

TABLE 11. Total 24 hr fecal production on a wet or dry weight basis expressed as a percent of body weight (BW) from steers under continuous (CONT) or strip grazing treatments over 14 d collection periods between May 1-Sept 4, 1989.

Item	Treatment	Collection Periods Ending									Seasonal	
		15 May	29 May	12 Jun	26 Jun	10 Jul	24 Jul	7 Aug	21 Aug	4 Sep	Mean[1]	SEM[2]
Wet wt.[3]	CONT	4.96	6.37	5.88	5.86	5.90	5.35	6.54	7.44	6.95	6.14[a]	
(%/BW)	STRIP	4.62	5.55	5.39	6.76	6.49	7.09	6.67	6.28	6.26	6.15[a]	.42
Dry wt.	CONT	.53	.62	.64	.79	.76	.67	.94	1.05	1.00	.78[a]	
(%/BW)	STRIP	.55	.47	.63	.81	.75	.86	.96	.88	.87	.76[b]	.03
DM[4]	CONT	10.83	9.73	11.06	13.48	12.89	12.47	14.36	14.18	14.43	12.60[a]	
(%)	STRIP	11.75	8.70	11.57	12.00	11.54	12.13	14.46	14.25	14.47	12.33[a]	.91

[1] Means of treatment main effects within dependent variables differ ($P < .05$) when followed by different letters.
[2] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.
[3] Wet and dry fecal production means were pooled from six 24 hr fecal collections per treatment taken bi-weekly.
[4] Percentage of dry matter (DM) remaining after complete drying of fecal subsamples.

The relatively high moisture content of the feces may be a factor which could negate a slowing of particulate passage rate induced by lower digestibility of forage. Maintaining steers on green meadow vegetation prior to the study should have lessened the impact of a sudden change in diet on the normal digestive process.

One must also recognize that stress from normal handling of experimental animals during collection periods could result in stress induced scours (Church, 1979). However, a majority of steers were observed to have loose feces over the course of this study. During the first two months of grazing this observation would describe the condition of nearly all 80 steers. Many of these animals could be described as having "watery" feces.

This condition did not seem to affect rates of gain, nor were any steers noticed to be unthrifty or morbid in appearance. Data collected over the trial provides no evidence linking this persistent scouring condition to treatments, therefore one might examine certain environmental factors.

Two possible explanations for this persistent scouring condition are internal parasites, or anti quality compounds consumed in the diet. The first situation may be a more logical explanation considering the environmental conditions. Animals were grazed for 2-3 months on flooded pastures at temperatures conducive to development of most internal parasites (Church, 1976; Schmidt and Roberts, 1985). Infectious forms of parasites could easily be disseminated throughout the pasture from animal wastes deposited directly into standing water.

Fecal nematode egg counts on July 10 and Sept 4 were 79 and 76 eggs/g feces for both strip and continuous treatments (Blount, 1989; unpublished data). On July 10, 79 of the 80 experimental animals tested positive for coccidia. One of the symptoms of both coccidia and various other nematode infections is persistent diarrhea (Church, 1976; Schmidt and Roberts, 1985).

Anti quality compounds in the forage could provide an equally plausible explanation for digestive stress, and should be given serious consideration. There was no direct evidence that specifically pointed to anti quality factors in NFM forage. There was however, one grass species found on the meadow suspected to be toxic under certain conditions. Reed canarygrass (*Phalaris* spp.) is known to contain tryptamine alkaloids and has been shown to cause diarrhea in some cases (Martin, 1985). One would doubt the role this grass species might play as a promoter of scours, considering reed canarygrass comprised less than 1% by frequency of meadow vegetation (Table 3), and <.5% of the overall steer diet (Table 12).

The only other toxic plant identified on the study site was arrow grass (*Triglochin maritima*) which comprised <3% of the plant community (Table 3). Arrow grass contains cyanogenic glycosides which generally cause toxicity problems when consumed after the plant has been stressed by drought or an early frost (Cheeke, 1985). Symptoms of cyanide toxicosis do not often include diarrhea because of the rapid onset of some of the more extreme and irreversible stages of death.

The one grass species of considerable importance, yet untested potential source of anti quality compounds is meadow foxtail. This grass was visually estimated to comprise over 50% of the total biomass on the study area and was consumed as 27-44% of steer diets (Table 12). Canadian scientists (Rode, 1986; Rode and Pringle, 1986) reported reduced gains by cattle grazing pure stands of meadow foxtail. Despite reports of reduced performance, none of the literature specifically mentioned diarrhea or any other malady associated with the purported toxic effects of meadow foxtail consumption. It is possible that a yet undiscovered anti quality compound is synthesized by meadow foxtail and when consumed in large enough quantities may produce toxic side effects such as scouring.

There was one bit of evidence from the present study which tends to support the theory of toxic agents in meadow foxtail. This evidence was manifested in reduced rates of gain exhibited by strip grazed steers at certain times during the grazing season. On collection periods ending June 12 and Aug 21, meadow foxtail contributed 60-80% (Figure 8) to the diet of strip grazed steers. These periods correspond to periods of relatively low ADG (Figure 10) by strip grazed steers. Regardless of this coincidence, there remains no solid proof that anti quality compounds exist in meadow foxtail. Reductions in ADG on specific dates may have resulted from changes in nutritional status of the strip grazed steers.

TABLE 12. Percentage of the five major grass species in the diet of steers grazing under continuous (C) or strip (S) treatments over 14 day collection periods between May 1-Sept 4, 1989. Based on micro histological examination of fecal sub samples from bi-weekly total fecal collections.

		Collection Periods Ending										
Species[1]	Trt	15 May	29 May	12 Jun	26 Jun	10 Jul	24 Jul	7 Aug	21 Aug	4 Sep	Seasonal Mean[2]	SEM[3]
Agropyron repens	C	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.0	1.0	0.3[a]	
(% of Diet)	S	0.0	0.0	0.0	0.0	0.0	0.3	0.2	1.0	5.2	0.7[b]	4.3
Alopecurus pratensis	C	12.8	29.7	32.8	32.7	22.8	23.7	43.3	23.2	22.5	27.1[a]	
(% of Diet)	S	22.5	46.0	55.8	44.5	12.3	13.2	50.8	82.0	67.8	43.9[b]	4.2
Phalaris arundinacea	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0[a]	
(% of Diet)	S	0.0	0.7	0.0	0.0	0.0	0.7	0.0	1.0	0.5	0.3[a]	0.3
Poa nevadensis	C	0.0	0.0	0.0	0.0	0.2	0.8	0.7	0.8	0.0	0.3[a]	
(% of Diet)	S	0.0	0.0	0.0	0.0	1.3	2.5	0.5	0.3	1.3	0.7[a]	0.4
Muhlenbergia spp.	C	3.3	2.5	1.5	4.2	3.8	7.7	3.3	26.7	11.3	7.1[a]	
(% of Diet)	S	1.2	0.2	0.0	3.7	5.2	8.7	5.8	0.0	1.0	2.9[a]	4.3

[1] Percent of diet = relative density = density of fragments of a species/total density of fragments of all species (Sparks and Malechek, 1968).
[2] Means of treatment main effects within dependent variables differ ($P \leq .05$) when followed by different letters.
[3] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.

TABLE 13. Percentage of sedge (*Carex* spp.), rush (*Juncus* spp.), cattail (*Typha latifolia*) and forbs in the diet of steers grazing under continuous (C) or strip (S) treatments over 14 day collection periods between May 1-Sept 4, 1989. Based on micro histological examination of fecal sub samples from bi-weekly total fecal collections.

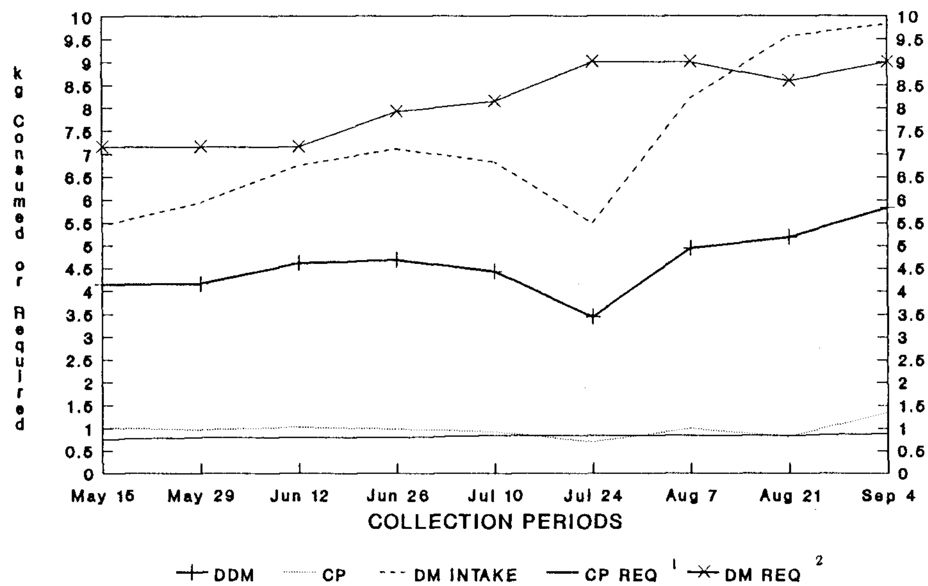
		Collection Periods Ending										
Species[1]	Trt	15 May	29 May	12 Jun	26 Jun	10 Jul	24 Jul	7 Aug	21 Aug	4 Sep	Seasonal Mean[2]	SEM[3]
Carex spp.	C	27.5	24.3	27.8	15.3	49.3	50.5	31.2	23.2	39.3	32.1[a]	
(% of Diet)	S	26.2	11.0	1.5	6.0	72.8	57.2	26.7	4.8	11.6	24.2[a]	5.5
Juncus balticus	C	46.2	26.0	15.0	30.2	14.0	11.8	15.0	20.0	19.8	22.0[a]	
(% of Diet)	S	32.5	14.3	15.8	30.8	5.3	14.5	11.5	4.5	7.7	15.2[a]	3.7
Juncus nevadensis	C	7.0	12.0	16.7	12.8	5.8	3.0	4.7	5.5	4.1	8.0[a]	
(% of Diet)	S	16.5	22.2	19.0	10.0	0.3	2.2	3.5	6.8	4.0	9.4[a]	2.8
Typha latifolia	C	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	1.0	0.6[a]	
(% of Diet)	S	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.2[a]	0.3
Forbs	C	1.0	0.3	1.6	0.6	0.0	0.0	0.0	0.0	0.0	0.2[a]	
(% of Diet)	S	1.2	0.3	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.5[a]	0.4

[1] Percent of diet = relative density = density of fragments of a species/total density of fragments of all species (Sparks and Malechek, 1968).
[2] Means of treatment main effects within dependent variables differ ($P \leq .05$) when followed by different letters.
[3] Standard error of the mean calculated from treatment by block (error a) and treatment by block within period (error b); n=16.

Perhaps a more descriptive way of examining diet quality and intake, as they affect animal performance, is to compare actual amounts of nutrients consumed vs required levels set forth by the NRC (1984). This type of contrast was made for the actual amounts of DM intake compared to the required level for medium frame yearling steers at their current weight and rate of gain (Figure 11). The daily intake of IVOMD (kg) or digestible DM (DDM) intake was also plotted. Unfortunately, required DDM values are not available in the NRC (1984); therefore, direct comparisons were not possible. However, DDM may be viewed as a measure of energy intake, thus used to estimate energy status of the grazing animal.

In the present study, intake of DDM remained relatively constant for both treatments over the grazing season. This suggests an increase in DM intake by steers to compensate for decreasing digestibility of available forage. The only way for steers to increase DM intake in the face of decreasing forage quality, would be if rate of passage were increased. Continuous grazing steers were able to maintain a level of DDM within a fairly narrow range of 4.2-5.8 kg/d over most of the summer. A gradual increase in DDM intake would be expected because of the animal's increasing demand for energy of maintenance and growth. Voluntary intake would be enhanced by increased rumen capacity as the animal grows. Net energy requirements for steers in this weight range require a gradually increase from 4.02 to 5.56 Mcal/d in order to support 1.0 kg of gain per day (Church, 1979).

Continuous Diet



Strip Diet

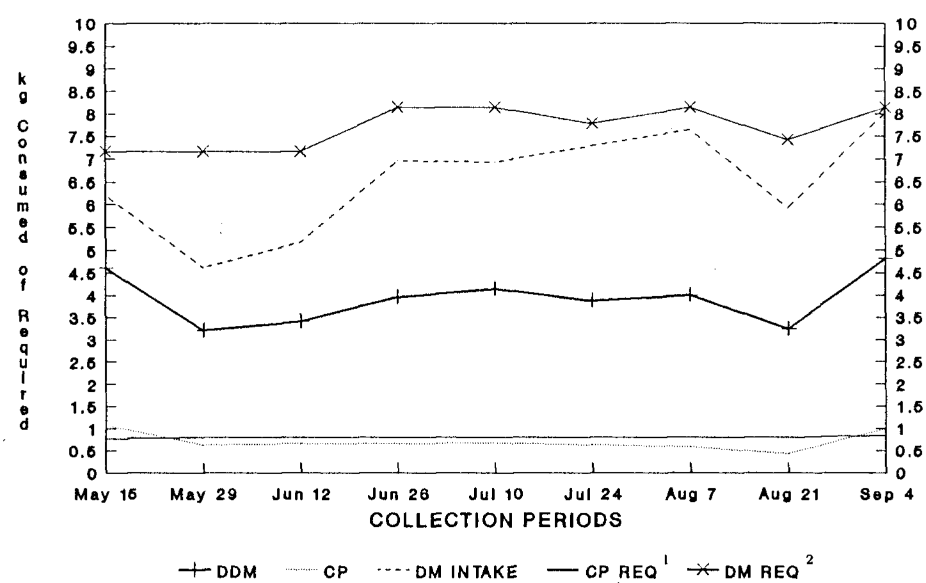


Figure 11. Actual daily intake in kg of dry matter (DM), crude protein (CP), and digestible dry matter (DDM) by steers in each treatment compared to required levels by the NRC (1984).

[1] Based on requirements for medium frame yearling steers gaining 1.0 kg/d.

[1] Based on current weight and rate of gain.

Intake data collected from continuous grazing animals on Aug 24 and from strip grazed steers on May 25 (Figure 11), are not consistent with adjacent collections or animal performance (Figure 10). Errors due to sampling could account for this variation. One must keep in mind that intake estimates are based upon one set of 24 hour collections per sampling date. This factor alone increases the likelihood of sampling error from possibly unrecognized environmental or physiological changes affecting the experimental animals.

The other diet variable plotted was kg CP consumed vs required levels for 1.0 kg of gain per day (NRC, 1984). The level of CP in the diet appears to describe animal performance over the season (Figure 11). Lower performance by the strip grazed steers after mid June (Figure 10) was probably a function of lower levels of CP in the diet. Strip grazed steer diets fell below the required levels of CP for 1.0 kg gain in mid May to late Aug. On the other hand, continuous steer diets were above the required level of CP for the 1 kg gain level over the same period. This difference in CP intake between treatments may explain the ability of continuous grazed steers to consistently perform at levels superior to strip grazed steers.

Economics and Practical Applications

The carrying capacity of eastern Oregon meadows has increased since the 1950's, when Cooper et al. (1957) reported that good quality meadow will carry 2.5 yearling steers/ha for 5 months of continuous spring-summer grazing. Their estimated optimum stocking density is considerably less than the approximately 3.6 yearling steers /ha in the current grazing trial. No direct comparison can be made of stocking densities in this study and those reported by Cooper et al. (1957). This is because of differences in grazing season length (4 vs 5 months) and the under stocking which occurred in our study as a result of above average forage production. Average hay crops from meadows in the study area have increased from approximately 2250 kg/ha in the 1950's (Cooper et al., 1957) to present yields of approximately 3400 kg/ha (Hammond, 1989; personal communication). This increase in yields can probably be attributed to fertilization and changes in species composition. Cooper et al. (1957) stated that carex and juncus were the predominant plant species on the meadows at the time of their study. These species tend to be low growing and less productive than meadow foxtail which currently makes up the bulk of meadow forage.

The estimated returns to the producer from each grazing system compared to normal haying are contained in Table 14. Costs of strip grazing included the labor required to moved fences, valued at \$4.00/hr and the costs of fencing materials which were pro rated over 5 years. The average time for moving ≈210 m of electric fence

TABLE 14. Variable costs and returns from pastures subjected to continuous or strip grazing management vs traditional hay production over the summer months at EOARC Burns, Oregon 1989.

	Credits and Debits/Grazing Treatment		
Item	Continuous	Strip	Traditional Haying[1]
Beef Production			
Returns/hd[2]	244.66	162.47	
Variable Costs/hd[3]			
Implants	1.00	1.00	
Salt/bonemeal	3.40	3.40	
Insect tags	.50	.50	
Fencing	0.00	2.40	
Labor	4.00	80.00	
Sub-total	8.90	87.30	
Total return ($/hd)	235.76	75.17	
Hay Production			
Returns/pasture[4]	0.00	336.00	1904.40
Cost of bailing[5]	0.00	54.00	372.60
Total return ($/pasture)	0.00	184.80	1531.80
Net proceeds[6] ($/ha)	842.00	376.86	273.53

[1] Hay production was based on the 1989 average yield of 2080 kg/ha from meadows at EOARC Burns.

[2] Based on the average selling price of $167.63/100 kg live weight in October 1989.

[3] Variable costs for grazing management include; salt @ $11.00/100 kg, bonemeal @ $63.00/100 kg, fencing materials pro-rated over 5 years and labor @ $4.00/hr.

[4] Based on current values of meadow hay @ $6.64/100 kg.

[5] Based on commercial rates for bailed hay @ $ 2.87/100 kg.

[6] Calculated from (beef returns/total ha grazed)+(hay returns/pasture area).

(105 m/forward and back fence) was approximately 35 min using a soft tire all terrain vehicle (ATV). Vehicles of this type are coming into greater use on flood meadows because ATVs are economical, maneuverable in flooded areas and subject vegetation to less physical damage compared to larger, hard tire vehicles. The cost of labor was extended to 1 hr/move to include time spent observing pasture/animal condition in order to make decisions concerning timing and size of the next strip.

Given the current conditions under which this study was conducted, continuous grazing returned the highest dollar value per hectare. This was a result of higher beef production per hectare and lower costs per hectare. Traditional haying returned considerably less per hectare than either grazing system. Cooper et al. (1957) reported returns from continuous grazing twice the value of proceeds from hay alone ($102.50/ha vs $62.50/ha). This compares to the present study where returns from beef produced on continuous grazed pastures were three times the returns from hay (Table 14). The increase is probably a function of the above average growing conditions or differences in the values of hay and beef between 1957 and 1989. The returns from strip grazing might have been much higher if the pastures had been stocked at twice the present level. This would have increased the returns in kg of beef and reduced the cost/hd of fencing and labor. Strip grazing was credited with returns from the 10,000 kg of hay removed in July. However, it is obvious from the values of beef vs hay that this forage may have been utilized more economically by grazing, had stocking been higher in the strip treatment.

The actual value of each grazing system as a practical management tool tends to be obscured by the need to follow strict guidelines set forth in the experimental design. It should be pointed out that strip grazing systems, taken alone, are relatively flexible. When consideration is given to strip grazing outside the confines of strict experimental procedures, one can see that possibilities as a management tool are not limited to summer grazing alone. Turner and Angell (1987) reported that strip grazing was a more efficient means of managing the consumption of rake bunch hay on NFM during winter feeding. Therefore, it might be feasible to incorporate strip grazing into a summer grazing/haying program that could be carried through into winter feeding. This would stretch the expense of electric fencing materials over most of the year thus reducing equipment costs. The option of removing excess forage as hay was not a feature of the current investigation, although this method was employed on one strip grazed block of pasture simply out of necessity. However, under normal production conditions, haying in combination with strip grazing might prove to be the most practical means of handling the flush of growth that occurs when growing conditions become optimum.

In such a system, the livestock producer would have some knowledge of expected runoff from streamflow forecasts based on snowpack, and thus be able to predict approximate summer forage production. Grazing animals could then be stocked according to estimates of available forage. Strip grazing could be implemented on all or parts of the meadows in accordance with requirements for winter hay. Cattle could be moved at a rate which covers the entire meadow in order to take advantage of high quality feed, while maintaining plants (specifically meadow foxtail) in a vegetative stage. The goal of 60-70% forage utilization employed in the present study might be excessive, at least in the first two months of grazing. One might select a level of usage between 60% and 30-40% suggested by Daugherty et al. (1979) in their study implementing "cream" grazing. However, it is critical that meadow foxtail be grazed with enough intensity to prevent early maturity. Animals could be stocked to the point that plant growth becomes optimum in order to keep up with the flush of new growth. The remaining pasture could be left to produce regrowth until flooding conditions abate to allow for haying operations. A lower yielding, but higher quality hay crop could be harvested for winter feeding, thus contributing to the animal gains realized from grazing high quality standing forage. If the harvested hay was rake-bunched, it would be a simple matter of shifting the strip grazing system to accommodate the winter feeding of cows.

Future grazing trials on NFMs should incorporate more management variables to include; put and take animals, mechanical means of dealing with surplus forage and year long use of all forage resources. However, it is important that the current grazing study be carried forth with the same experimental procedures for at least 2-3 years in order to determine the effect of seasonal variation on parameters of animal diet and performance.

CONCLUSIONS

Strip grazing resulted in consistently higher grazing pressures compared to continuous grazing. Higher grazing pressure reduced the ability of strip grazed steers to select a diet equal in quality to the diet of continuous grazed steers. Despite lower diet quality, strip grazed steers consumed an amount of DM/d as a percentage of body weight similar to that of continuous grazed steers. Strip grazing management tended to increase grass consumption and directly contributed to a 39% increase in meadow foxtail utilization over continuous management. Individual animal performance tended to be improved for continuous grazed steers which should be expected given their higher plane of nutrition. However, total animal gain per hectare was similar between management systems because of the smaller total pasture area utilized by strip grazed steers during the study. Replications of this experiment are needed over a period of at least 2-3 years before any firm conclusions could be made concerning animal performance under the two management systems. Changes in growing conditions and cumulative effects of grazing could have dramatic effects on future plant and animal responses.

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