

AN ABSTRACT OF THE THESIS OF

Jess J. Wenick for the degree of Master of Science in Rangeland Resources presented on
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Abstract approved:

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For the last fifty years, meadow foxtail (*Alopecurus pratensis* L.) has been invading native flood meadows throughout the Harney Basin in southeastern Oregon. The expansion of this grass species has been the result of its broad climatic requirements and ability to withstand drought while thriving in saturated soil conditions for a large part of the growing season. Meadow foxtail starts growth as soon as adequate soil moisture exists. Managing this early maturing hay species can prove to be a challenge because soil saturation and elevated water tables make it difficult to harvest hay when forage quality and yield are maximized. The purpose of this study was to evaluate whether planned grazing would retard maturation and thus prolong forage quality. Treatments included a non-grazed control and grazing durations of 2, 4, 6, and 8 weeks. Grazing was initiated in May of 1998 and 1999 on six replications of each treatment arranged in a randomized block design. Within each treatment/replicate combination, ten 0.2 m^2 plots were clipped to ground level at about two week intervals from May to August. The samples were weighed and dried for standing crop estimation and 4 of the 10 samples were selected at

random and analyzed for acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP). Analyses of variance, least significant differences, and regression analyses were calculated to determine whether or not there were statistical differences of $P \leq 0.05$. We found that early spring grazing decreased forage yield significantly. An increase in CP with duration of defoliation was expected and obtained. The results of grazing on the fiber components of forage, however, were inconclusive. Grazing had minimal effect on fiber fractions, but did delay the decline in CP. However, there was a fairly severe decline in hay production, even with the shortest duration of grazing.

The Effect of Grazing Interval on Forage Quality and Production
of Meadow Foxtail.
by

Jess J. Wenick

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Bullet was younger, better looking, and stronger than Maggot. He just put up a fuss while being saddled. Even after a busted feed bunk, two broken lead ropes, a dismantled rein, and a few choice words, however, he proved that he was worthy to ride the river with.

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The Effect of Grazing Interval on Forage Quality and Production of Meadow Foxtail.

INTRODUCTION

Because of the long, unfavorable winter feeding period, the beef industry in the Intermountain West experiences an economic disadvantage when compared to other regions of the United States. Producers often need an average of two tons of hay per cow during these months.

In southeastern Oregon, flood meadows provide much of this feed through hay production and allow these producers to stay competitive with more temperate regions. Species composition of these meadows dictates both the quality and quantity of hay produced and the stages at which feed value is highest. Composition of the meadows has changed considerably in the last 40 years and research is needed to understand the characteristics of growth and maturity of introduced meadow species.

Meadow foxtail (*Alopecurus pratensis*) was introduced to the area in contaminated hay grown in other areas (Angell and Bailey 1998). This species has since spread throughout the Harney Basin and now dominates most hay fields. It does not appear to be sensitive to extreme temperatures as long as fertile, moist, or swampy conditions exist. Its long-lived perennial nature, winter hardiness, and broad climatic adaptations (Schoth 1945) as well as its ability to withstand drought (Hannaway and McGuire 1981) have resulted in its rapid expansion throughout the region (Schoth 1945).

Meadow foxtail starts growth as soon as soil temperatures begin to rise (Angell and Bailey 1998). Managing early maturing hay species can prove to be difficult because of the very nature of flood meadows. Gomm (1979a) noted that protein yield of meadow

grasses steadily declined at a rate of 0.08% per day after the soft dough stage of maturity. Such decreases in crude protein become a major factor in determining harvest dates, but early haying is not an option for most ranchers because standing water often remains on fields at its time of maturity.

In the northern United States, meadow foxtail appears to be used most commonly as a pasture grass. It is a climatic opportunist and will resist dormancy as long as adequate soil moisture conditions persist (Schoth 1945, Angell and Bailey 1998). Meadow foxtail pastures subjected to livestock grazing have been shown to be very productive and recover quickly once grazing is removed. Angell and Bailey (1998) proposed that a planned grazing system could be utilized in order to retard maturation and prolong a leafier stage of growth.

The purpose of this study was to initiate a planned grazing system that could be utilized to retard maturation and to evaluate plant responses in relation to length and timing of livestock grazing. It was our assumption that grazing would increase protein yields and lower fiber content in harvested grass. Simply stated, the null hypotheses of this study were (1) that grazing would not influence hay yield, and (2) that grazing would not influence hay quality.

LITERATURE REVIEW

Native Flood Meadows in the Harney Basin

Characteristics and historical forage composition

Livestock producers rely heavily on privately owned flood meadows as a source of both grazed forage and grass hay production (Angell and Bailey 1998). The meadows are classified as seasonally wet (Rumburg 1963) subject to seasonal flooding and characterized by a high water table in their natural state (Anonymous 1980).

Snow accumulation at higher elevations and the rate of spring runoff determine the extent of the flooding period. A flooding system of irrigation directs the water across the meadows for a period of eight to twelve weeks. Typically, meadows in the Silvies River drainage located in southeastern Oregon are continually flooded from early April to late June or early July, depending on the availability of water (Rumburg 1961, Rumburg and Sawyer 1965, Angell and Bailey 1998).

This management strategy mimics the seasonal flooding that would have historically occurred and results in saturated soil conditions that make it difficult to maintain stands of high quality forage species. It is a continuing challenge for cattlemen to obtain maximum hay and forage production because desired species are often hampered by excessive amounts of water in the early spring and a shortage of soil moisture in the latter part of the growing season (Rumburg and Sawyer 1965).

Historically, the flood meadows located at the Eastern Oregon Agricultural Research Center, approximately five miles from Burns Oregon, were different in plant composition than they are today. In studies done by Cooper (1956) and Rumburg and

Cooper (1961), the average production of these meadows was approximately $\frac{3}{4}$ to 1 ton per acre. At that time the species composition was a complex mixture of rushes, sedges, and grasses. These native species were adapted to periods of excess water followed by drought (Angell and Bailey 1998). Concentrations of each forage type depended on the level of flooding throughout the field, with rushes increasing with increases in depth and duration of standing water, and the density of grasses and sedges decreasing under these conditions (Gomm 1979a, Rumburg 1961).

Due to rapidly declining soil moisture after flooding ceased and high temperatures throughout the remainder of the growing season, these flood meadows produced no regrowth after the cutting of a single crop of hay (Rumburg 1963). It appears that flood meadow species were not adapted to regrow after an initial cutting. Even when adequate moisture and nutrients are provided, there was limited regrowth. Consequently, almost all hay production occurred during the short flooding period in the spring (Angell and Bailey 1998).

In Wyoming, cattle are not removed from flood meadows until two to three weeks after spring growth has begun. This level and timing of grazing does not appear to affect hay yield and is considered to allow a full growing season for wild hay crops (Stewart and Clark 1944). If hay production is not compromised, such practices have the potential of offering numerous benefits to producers, including a possible increase in forage quality at the time of cutting and as a buffer to delay turnout of cattle on range with limited forage. Holding cows and their spring-born calves on pasture in the spring would allow maximum production of range plants (Gomm 1979a).

Currently, flood meadow communities in eastern Oregon are shifting to stands dominated by the introduced grass, meadow foxtail (*Alopecurus pratensis* L.). Due to the resultant change in the composition of hay produced on these meadows, traditional management options should be reconsidered (Angell and Bailey 1998). Continued research is necessary to manage both challenges and opportunities provided by this change in stand composition.

Meadow foxtail

Indigenous to Europe, this perennial bunchgrass is distributed throughout North America, particularly in Wyoming, British Columbia, and Alberta (Waldie et al. 1983). It is moderately productive, early maturing, and is most commonly used for pasturing purposes. In cool, moist climates it is capable of remaining active long into the grazing season. Although it is drought resistant, the productivity of meadow foxtail declines under high temperature or moisture stress conditions (Hannaway and McGuire 1981).

In southeastern Oregon most meadow foxtail hay originates from flood meadows. Early maturity provides a competitive advantage and many of these meadows have become almost pure stands of this introduced species. Although time and method of initial introductions of this species are not well understood, it is known that meadow foxtail dominated stands have increased both in size and number (Schoth 1945, Angell and Bailey 1998).

Research has demonstrated that meadow foxtail does not reach an equilibrium tiller density quickly, but it is capable of having high rates of leaf area expansion when given the opportunity to regrow after herbivory (Van Esbroeck et al. 1995). Climatic

conditions greatly impact the period of heading. When mild conditions are prevalent, heading may occur throughout the entire growing season (Van Esbroeck et al, 1995). However, in southeastern Oregon heading usually occurs only during the early growing season due to the onset of high temperatures and reduced soil moisture by mid-summer.

Scientists have disagreed with one another on the status of meadow foxtail as a weedy species. Schoth (1945) claimed that there was no evidence that meadow foxtail had any weedy characteristics. However, Hannaway and McGuire (1981) held that its persistence qualifies it as a weed because it is difficult to displace with another forage species. In Europe, improved methods of meadow foxtail seed production are being sought because it is one of only a few grasses that grow well in high latitude pastures such as those found in Scandinavia (Simon 1994). In southeastern Oregon, however, it is not compatible with present meadow management systems because its maturity cycle is not well matched with time of harvest on flood meadow systems.

The Effect of Spring Grazing on Regrowth of Meadow Foxtail

Differences in the rate of growth and maturity among species present in a hay system make it very difficult to harvest for maximum yield and highest quality simultaneously (Worrel et al. 1986). In producing and feeding grass hay, growers often have to determine what compromises between harvesting for quality and yield are most appropriate for their operations (Kunelius et al. 1974, Hall 1998). Although sometimes overlooked, digestibility and protein content of harvested hay play important roles in ranch economics. Norton et al. (1997) observed that forage requirements and the need for protein supplements were reduced by higher quality forage, which thereby decreased

costs of production. Researchers and ranch managers recognize that there is a point in forage development where increased quality can compensate for reduced yield because intake is increased and forage is more thoroughly utilized by livestock.

It is recognized that some hay systems allow managers to obtain high biomass production while maintaining high quality forage. In a study done in Wyoming by Stewart and Clark (1944), it was found that spring grazing of hay meadows 20-35 days longer than usual not only increased forage yield, but increased total protein yield per acre 20% over hay grown after early pasturing.

In addition to the timing of initial harvest, frequency of cutting can also have a significant impact on forage quality and yield. In a Pennsylvania study, Hall (1998) established forage stands that were cut at intervals of 70, 45, and 35 days. He found forage quality to be greatest when cut at a 35-day interval. However, annual climatic variations can influence production. It was observed by Hall that this cutting interval provided the lowest dry matter yield in years of below-average rainfall.

Timing of irrigation within a growing season can greatly influence meadow and pasture production as well. While studying the native flood meadows of southeast Oregon, Rumburg and Sawyer (1965) discovered that biomass increased when the timing of irrigation was postponed from April 6 to April 20 with a comparable extension of moisture availability at the end of the season. The resultant increase in production averaged 0.25 tons per acre. However, not all native species were impacted similarly. Although the length of flooding increased rush yields, it had a negative impact on sedges and grasses.

Historically, the maturation of flood meadow species in the Harney Basin was similar to those studied by Reece et al. (1994) in the Nebraska sandhills. Reece observed that Nebraska meadow systems compensated for low initial dry matter yield by delayed maturity, rapid growth, and an increased response of forage species to nitrogen fertilizer. In these systems, delayed growth serves as an advantage to producers because optimal time of harvest can correspond with dry field conditions, allowing managers to venture onto the meadows with harvesting equipment. Because flood meadow hay can rapidly deteriorate in quality if left uncut beyond maturity (Stewart and Clark 1944), the timing of cutting is critical if hay quality and biomass are to be maximized.

Also in Nebraska, Worrel et al. (1986) studied how advancing the season of harvest changed the chemical composition of meadow hay. They concluded that the structural components of the forage (neutral detergent fiber) increased from June until the August harvest, and then decreased between the August and September harvests. Acid detergent fiber increased throughout the summer until the September harvest. By examining the results of their fiber analysis, they concluded that digestibility of hay decreased as the growing season progressed. Crude protein also declined from 8.5% in June to 5.99% in August and 4.90% in September.

In pasture systems, early maturing forages such as meadow foxtail can provide a good feed source for spring grazing livestock. Van Esbroeck et al. (1995) found that this species was as productive as the highest yielding of three *Bromus* grass species tested. Hannaway and McGuire (1981) concluded that early grazing could be successful at delaying meadow foxtail maturity. They also observed that it should be cut as early as possible in May if used as a hay crop. However, in a natural flooding irrigation system,

early cutting is not a feasible management option because there is still a considerable amount of standing water on the fields. Therefore, the digestibility and crude protein content of this meadow hay is greatly reduced with traditional flood meadow management.

It is believed that meadow foxtail is capable of providing a much higher quality feed for livestock than it is now providing on most ranches in the Harney Basin. Waldie et al. (1983) found that at all stages of maturity meadow foxtail digestibility was equal to or greater than that of timothy (*Phleum pratense* L.). Waldie et al. (1983) found that meadow foxtail exhibited a slightly lower yield than timothy at the early-heading stage, yet had a higher crude protein content and digestible dry matter. Rode and Pringle (1986) found timothy to be more digestible than meadow foxtail in terms of dry matter, crude protein, and acid detergent fiber, but they considered meadow foxtail to have potential as a good quality hay.

Nitrogen fertilizer has been proven effective at increasing the production of these meadows (Gomm 1978). Norton et al. (1997) noted that by adjusting harvest date and timing of nitrogen application, feed costs could be reduced.

Meadow foxtail responds positively to nitrogen. Kline and Broesma (1983) found that the yields of meadow foxtail, reed canarygrass (*Phalaris arundinacea* L.), and timothy increased 5, 5.3, and 2.3 times respectively, with spring fertilization. At low or no-application rates, meadow foxtail and reed canarygrass yields were much lower than that of timothy. Angell (1998) also found that meadow foxtail production is increased significantly with the application of fertilizer. During the three years of his study (1995-1997), yield increased 700, 340, and 440 lbs/acre when applying nitrogen fertilizer

treatments of 36, 72, or 108 lbs/acre. Angell suggested that due to consistent increases at each level of nitrogen applied, maximum yield potential of this species is as yet unknown. Tingle and van Adrichem (1974) observed that when cut at an early heading stage, meadow foxtail stands fertilized with nitrogen had higher crude protein and digestible dry matter levels than timothy. They also observed large increases in meadow foxtail dry matter yield in response to fertilization.

The studies mentioned above demonstrate that the yield and quality of meadow foxtail dominated hay systems have been successfully manipulated and improved by advancing the time of harvest, by influencing the extent and duration of irrigation, and by providing nitrogen fertilizer in the early spring. However, it is important to note that ultimately, the nutritional requirements of livestock, total hay costs, and supplementation costs should influence a manager's decisions for hay production (Reece et al. 1994).

Reece et al. (1994) believe that of all factors influencing hay yield and quality, harvest date decisions have the greatest potential for affecting protein concentration and dry matter yield in mid-June through mid-July. Since early hay harvesting is not feasible in flood meadow systems, ranchers will want to consider alternative harvesting techniques such as early-spring grazing to set back plant maturity while maintaining high biomass at the time of cutting.

MATERIALS AND METHODS

Study Site

The study was conducted at the Eastern Oregon Agricultural Research Center (EOARC), approximately 8 km (5 miles) southeast of Burns, Oregon ($43^{\circ} 31' N$, $119^{\circ} 02' W$). Burns is located in northern Harney County, 300 km (180 miles) west and slightly north of Boise, ID. The site is approximately 1260 m (4,135 feet) in altitude, with an annual rainfall of 308 mm (12 inches) consisting primarily of winter snowfall. The average daily temperature is $8^{\circ}C$ ($46^{\circ}F$), $30^{\circ}C$ ($86^{\circ}F$) being the average maximum in July and $-9^{\circ}C$ ($16^{\circ}F$) being the average minimum in January (Johnsgard 1963). The average frost-free period is 83 days, with a range of 20 to 116 days (Gomm 1979b). The study site was located in a 23-hectare flood meadow pasture which hosts a variety of grasses (mainly meadow foxtail), sedges, rushes, and forbs.

The study site soil type has been classified as a Fury-Skidoosprings-Opie complex. The three components of the complex vary in regard to soil parent material, with Fury and Opie soils originating from alluvial deposits and Skidoosprings soils originating from lacustrine sediments. Soil depth is greater than 152 cm (60 inches) to bedrock and the soil is poorly drained. Ponding, frost heave, salinity, and alkalinity are major soil limitations (Natural Resource Conservation Service 1999).

A modified step-point technique (Owensby 1973) was used to determine species composition within the study. Two hundred points were taken for the three enclosures located in the study area (enclosure 1 included replications 1 and 2, enclosure 2 included replications 3 and 4, and enclosure 3 included replications 5 and 6). Identification

occurred at the species level for all vegetation except sedges and rushes. These species were documented as “*Carex*” and “*Juncus*. ” This procedure was performed on August 3 and August 5 of 1999.

Experimental Design

The field study was conducted in 1998 and 1999 and utilized a randomized complete block design to account for environmental gradients such as varying topography, flooding depth, and plant composition. The design consisted of six blocks (15 m by 15 m in size) distributed within the pasture. Each block served as a replication of five treatments (3 m by 15 m in size). Electric fence was used to manipulate the timing of grazing for each treatment.

Replacement heifers belonging to the EOARC were used. Grazing intensity was manipulated by determining the necessary number of livestock required to graze the meadow to 50-70% utilization (or maintaining a residual biomass of 1000-2000 kg/ha). On May 3, 1998, seventy heifers were artificially inseminated and turned out on the meadow with two cleanup bulls. However, lack of feed became a problem by mid-July and twenty head had to be removed. On May 20, 1999, fifty-five heifers were artificially inseminated and turned out onto the meadow with one cleanup bull and none had to be removed from the study.

Although the role of cattle in this study was to maintain desired levels of defoliation throughout the pasture, information on animal performance may be beneficial for producers when considering the benefits and costs of implementing spring grazing programs on similar flood meadows. Therefore, all livestock were weighed every 28

days to determine rates of gain throughout the field season while grazing on meadow foxtail-dominated feed.

Prior to grazing, electric fence was placed around 15 m by 3 m non-grazed treatments within each replication. At two weeks intervals the electric fence was extended an additional 3 meters into the meadow. Thus, within each replication treatments were: 1) non-grazed (NG), 2) grazed for two weeks (G2), 3) grazed for four weeks (G4), 4) grazed for six weeks (G6), or 5) grazed for eight weeks (G8). At the end of the grazing period each block was 15 m by 15 m in size.

Sampling

Within each treatment/ replication combination, ten 0.2 m² plots were clipped to ground level at each sampling date for a total of 60 plots per treatment (10 plots * 6 replications). Sampling began when cattle were initially placed in the pasture (mid-May). Sampling dates were May 14, June 1, June 16, July 1, July 14, and August 11 of 1998 and May 18, June 4, June 18, July 2, July 16, and August 12 of 1999.

Lab Analysis

The clipped samples were placed in an oven set at 60°C to dry for at least 48 hours. Weights were then recorded to determine total biomass for the treatments at each clipping date.

Four of ten samples for each clipped treatment/ replication combination were randomly selected and ground through a 1 mm screen. Fiber analysis (Neutral Detergent Fiber and Acid Detergent Fiber) was conducted using the Ankom 200 Fiber Analyzer

(Fairport, NY). Crude protein was analyzed using the Tecator Digestion System 20 and Tecator Kjeltec 1030 Auto Analyzer (Fischer Scientific, Kent WA). Total samples per treatment/ date combination were 24 (4 samples per treatment * 6 replications).

Data Analysis

Analysis of variance was carried out using the Statistical Analysis System (SAS 1987). If a significant difference was detected, contrasts and LSDs (Least Significant Difference) were used to determine where the differences occurred between treatments. A regression analysis was then calculated to determine whether or not hay yield and forage quality were linearly related to the timing and duration of grazing. Statistical significance was set at $P \leq 0.05$ (a 95% confidence interval).

RESULTS

Temperature and Precipitation

Information collected from a weather station located in the proximity of the study site revealed that although temperature differences were minimal during the growing seasons of 1998 and 1999, precipitation (timing and amount) differed greatly (Figure 1).

In 1998 the high moisture months included January (43 mm), February (44 mm), March (28 mm), and May (62 mm). Total annual precipitation was 298 mm (compared to an average annual precipitation of 308 mm), with 235 mm occurring from January through September.

In 1999 only January and February (both providing 35 mm) were high moisture months. Total annual precipitation was 157 mm, with 129 mm occurring from January through September. In contrast, 12 mm of precipitation were received in March and 14 mm in May.

Temperature differences during the growing season were minimal with mean monthly temperatures for 1998 and 1999 being 43 versus 44°F in April, 49 versus 50°F in May, and 58 versus 59°F in June, respectively.

Species Composition and Basal Cover

The proportion and relative abundance of various species within the study area were measured. Meadow foxtail was the dominant species in all three enclosures, averaging 82% of total composition. Rushes (*Juncus* spp.), sedges (*Carex* spp.) and blue wild rye (*Elymus triticoides* Buckl.) made up the majority of remaining vegetation on the

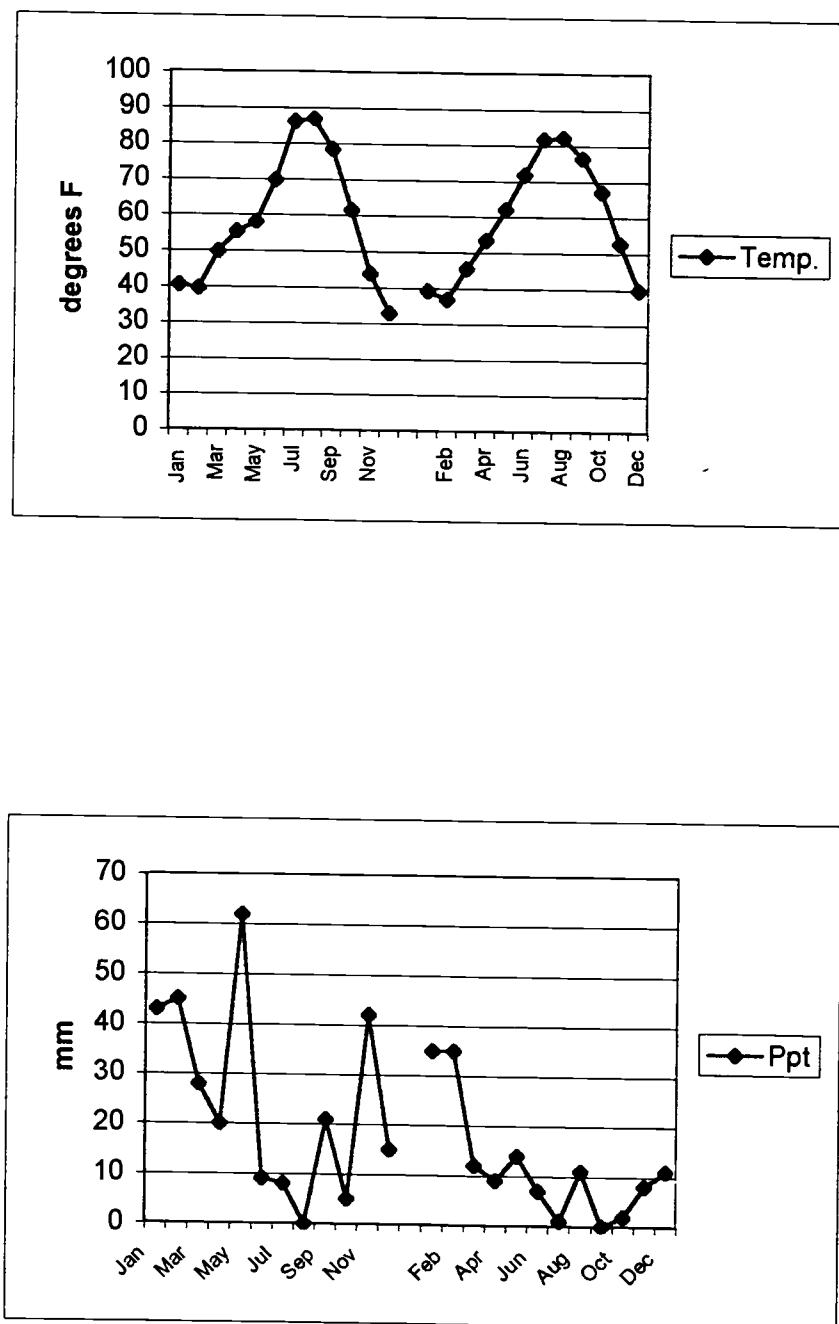


Figure 1. Temperature and precipitation data collected during 1998 and 1999.

site. Percent basal cover for all species, litter, and bare ground averaged 29%, 68%, and 4% respectively across all enclosures.

Forage Yield and Quality

Total biomass production was significantly different among all treatments in 1998 and 1999 (Figure 2). Grazing was found to reduce hay yield regardless of timing or duration. On July 14, 1998 and July 16, 1999 the yields of G2 were only 60 and 64% that of NG, respectively.

Crude protein content decreased with forage maturity. Therefore, % crude protein was higher in grazed than in non-grazed treatments (Figure 3). In 1998, all treatments (except G4 and G6 harvested on July 1) were significantly different from adjacent treatments through all clipping dates. In the unclipped treatment, crude protein values declined from 12.94% on May 14, 1998 to 6.2% on August 11, 1998 in the unclipped treatment.

In 1999, total crude protein values were higher than in 1998, but differences between treatments for each clipping date were less. Significant differences between NG and G2 were found on June 18, July 2, and July 16. Differences between G4 through G8 were generally not significant.

The result of grazing on NDF and ADF values between treatments for each clipping date was inconclusive (Figures 4 and 5). Both 1998 and 1999 NDF values were not significantly different among treatments. Exceptions were for June 1, 1998 and July

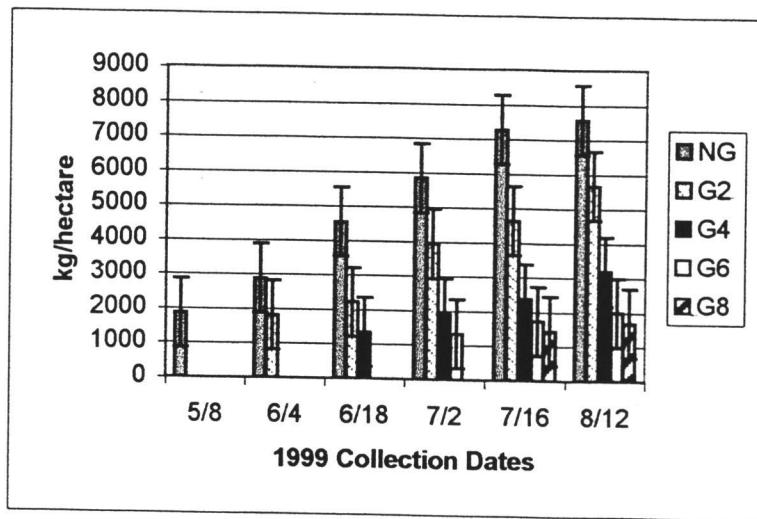
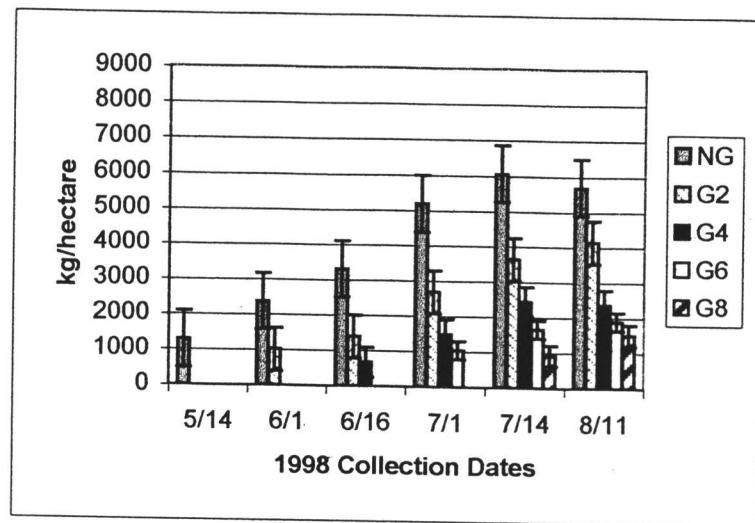


Figure 2. Change in biomass production in response to grazing treatments in 1998 and 1999. Error bars represent +/- one standard error of the mean.

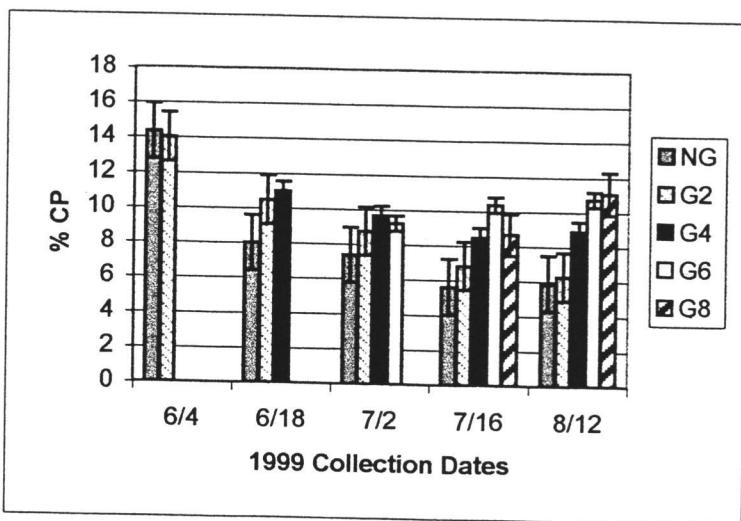
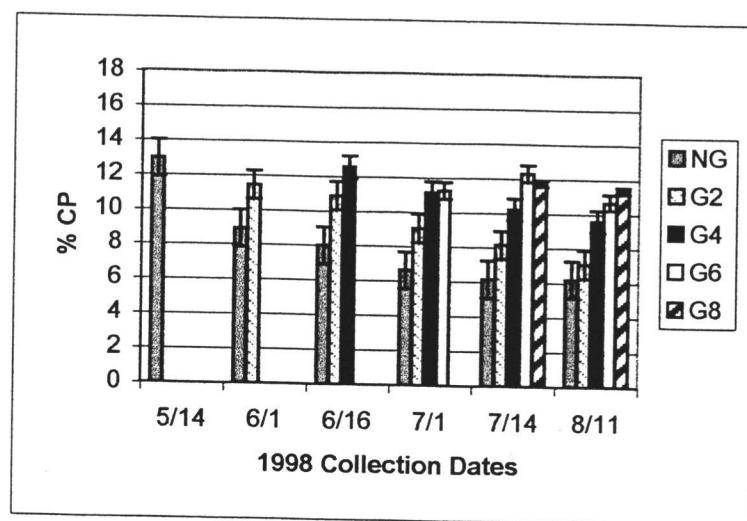


Figure 3. Change in crude protein concentration in response to grazing treatments in 1998 and 1999. Error bars represent +/- one standard error of the mean.

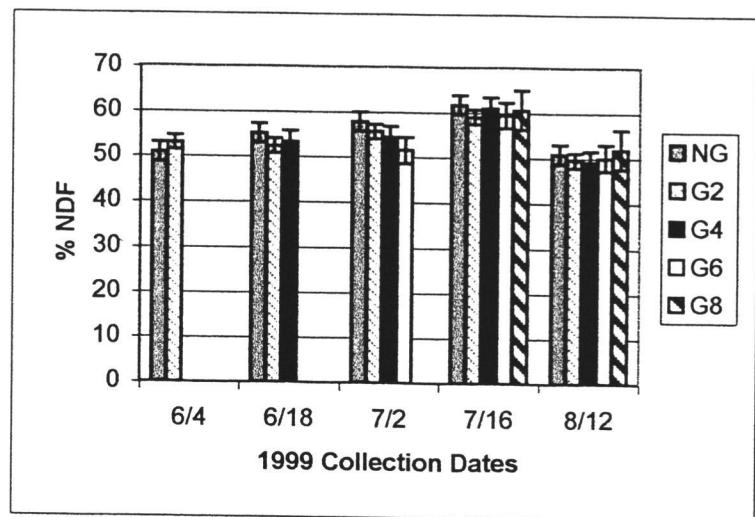
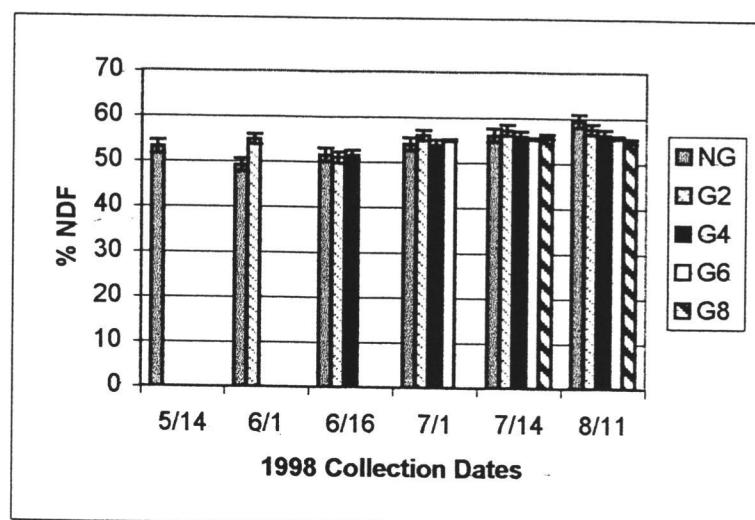


Figure 4. Change in NDF values in response to grazing treatments in 1998 and 1999. Error bars represent +/- one standard error of the mean.

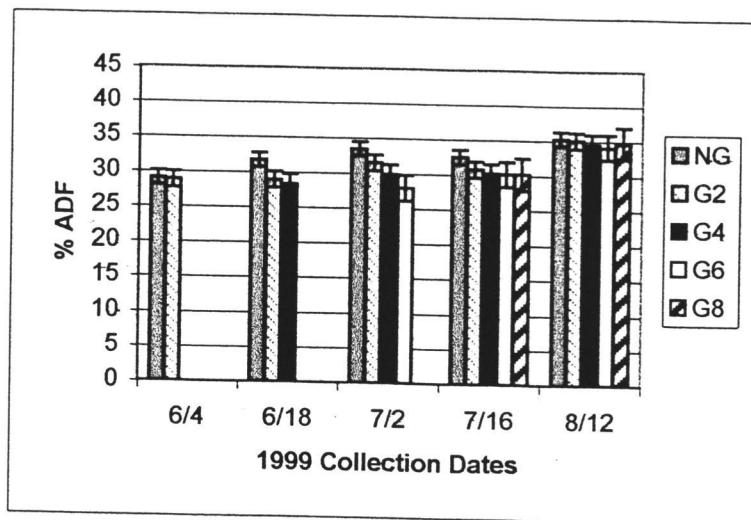
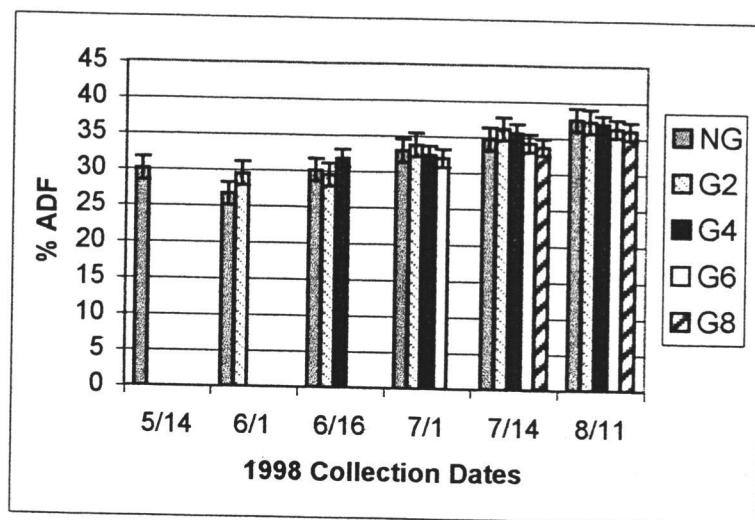


Figure 5. Change in ADF values in response to grazing treatments in 1998 and 1999. Error bars represent +/- one standard error of the mean.

2, 1999, where NG and G2 and NG and G8 were found to be significantly different, respectively. In 1998, the NDF values for NG only rose from 53.13% on May 14 to 59.47% on August 11. In 1999, NG NDF values rose from 50.91% on June 4 to 61.79% on July 16, but then fell to 50.89% by August 12.

Acid detergent fiber values had more statistically significant differences than did NDF values and were difficult to explain due to their inconsistencies. For example, NG and G2 on July 14, 1998 were significantly different, but NG and G6 were not. Overall, 1998 ADF values ranged from 30.10 on May 14 to 37.60 on August 11. The 1999 values ranged from 29.06 on June 4 to 35.31 on August 12.

Animal Performance

Statistical comparisons of heifer rate of gain were inappropriate because grazing was not replicated. Cattle were used to understand the effects of grazing on hay quality and yield. However, weights were recorded to provide an indication of possible economic impacts and/or benefits of initiating such a grazing program on private flood meadows.

Daily rates of gain averaged 0.84 kg (1.85 lbs), with a high of 1.35 kg (2.98 lbs) per day in May and a low of 0.10 kg (0.22 lbs)/day during the first two weeks of July. Observed gains for early June, late July, and late August were 1.35, 1.02, and 0.68 kg/day respectively. The total average gain per animal was 117 kg over the grazing season. The total gain per hectare for the season could not be calculated because cattle were taken on and off the field throughout the season to maintain desirable utilization levels.

In 1999, heifer average daily gain for the season was 1.03 kg (2.27 lbs)/day, with a high of 1.61 (3.56) in May and a low of 0.26 (0.58) in August (Table). Observed gains for early June, late July, and late August were 1.61, 1.15, and 0.26 kg/day. The total average gain per animal over the grazing season was 96 kg. The total gain per hectare for the season was 229 kg.

Table. Average daily gain (ADG) during the growing seasons of 1998 and 1999.

	May	June	July	August
	ADG (kg/head)			
1998	1.48	1.06	1.02	0.68
1999	1.61	1.09	1.15	0.26
mean	1.55	1.08	1.09	0.47

DISCUSSION

We found that spring grazing of this particular flood meadow hay system in the manner prescribed decreased forage yield significantly. An increase in crude protein with duration of defoliation was expected and obtained. However, the results of grazing on the fiber components of forages, which affect digestibility and intake, were inconclusive.

Potential hay yield was reduced regardless of the timing or duration of grazing during both years of the study. The 1998 and 1999 biomass production data revealed G2 treatments to be only 60 and 64% of NG treatments, respectively, at the usual time of cutting for the area (mid-July).

The differences observed between the NG and G2 treatments were not expected when this study was initiated. A West Virginia study (Belesky and Fedders 1994) revealed similar results for three cool-season grasses, orchardgrass (*Dactylis glomerata* L.), prairie-grass (*Sphenopholis obtusata* (Michx.) Scribn.), and a tall fescue x perennial ryegrass hybrid (*Festuca arundinacea* (L.) Vill. and *Lolium perenne* L.) in hay production systems. Belesky and Fedders (1994) found that growth rates were higher for grasses when managed for hay as opposed to defoliation early in the growing season. Stewart and Clark (1944), however, found that early season defoliation had no such impact. They observed that spring-pasturing cattle on wild meadows in Wyoming for 20 to 35 days past the usual time increased total hay yields.

Historically, the flood meadows at the Eastern Oregon Agricultural Research Center produced very little regrowth when native grass, rush, and sedge species were

removed by either livestock or haying equipment (Rumburg 1963). Since meadow foxtail began to dominate these systems in the 1970s and 1980s, however, many studies have suggested that providing nitrogen fertilizer in the early spring can lengthen the growing season for this species (Tingle and van Adrichem 1974, Kline and Broesma 1983, Angell 1998). Before now, however, the effect of defoliation on the standing crop of unfertilized meadow foxtail-dominated fields has remained unknown. The loss of hay production from two weeks of early spring grazing implies that further study is required to determine the additive effects of grazing and fertilization on spring grazing programs.

The data for this study reveals that production was higher in 1999 than in 1998, even though weather station data shows that 1998 was a wetter year. There can be two possible explanations for this. One is that stocking rates differed during the two field seasons. In 1998, 70 heifers were grazing the meadow, whereas only 55 heifers were turned out in 1999. Secondly, rainfall at the meadow site has far less impact on hay production than the amount of snowmelt being carried down the Silvies drainage from the mountains to the north. Below-average precipitation in Harney Valley does not necessarily imply that there is below-average snow pack in the mountains above.

We expected grazed treatments to increase quality forage because defoliation can postpone plant maturity. We did observe a corresponding increase in crude protein with duration of grazing. Typically, higher CP is inversely correlated to fiber (Fick et al. 1995).

There is a point in forage development where increased quality can compensate for reduced yield. Reece et al. (1994) observed that delayed maturity compensated for low initial dry matter yields in Nebraska meadow systems. When studying crude protein

levels in grasses, Worrel et al. (1986) reported a drop from 8.5 to 4.9% between June and September, which was consistent with our results. Crude protein dropped from 13 to 6% between mid May and mid-July and from 14 to 5.5% between early June and mid-July 1999.

The National Academy of Science (1984) states that 227 kg steers and heifers with average daily gains of 0.23 kg require 8.5% crude protein in their diets. Pregnant yearling heifers and mature cows (third trimester) require at least 8% crude protein. The crude protein values of non-grazed treatments in both growing seasons fell short of these standards. Crude protein values for G2 treatments were 8.15 and 6.84 for mid-July harvests in 1998 and 1999. Only 1998's treatment met the above requirements for all mentioned classes of cattle in mid-July.

The result of grazing treatments on the fiber components was not expected. NDF values ranged from 53 to 59% from mid-May through mid-August in 1998. Values fluctuated in 1999, starting at 50% in early June and peaking at 60% in mid-July. By mid-August, however, values dropped back to 50%. ADF values ranged from 30 to 38% from mid-May through mid-August in 1998. The 1999 values revealed a rise from 29 to 35% from early June to mid-August. In contrast, Cherney et al. (1993) found that the average differences in NDF concentration in five common pasture grasses ranged from less than 40% to more than 65% between early May and late June harvest dates. During this time, ADF concentrations increased from 20% to greater than 38% across harvest dates.

It is widely known that the stage of maturity at harvest time greatly affects the quality of wild hay (Stewart and Clark 1944). Because of the tendency for forage quality

to decline with maturity we expected the grazed treatments to have higher values compared to the non-grazed treatment. We are unable to interpret our results for grazing influence on fiber components. It is hypothesized that fiber values may have been low enough at the beginning of the two field seasons to minimize a grazing response.

SUMMARY

Grazing was found to reduce biomass production regardless of timing or duration. At the usual time of hay harvest (mid-July), grazing resulted in at least a 40% reduction in hay yield. Crude protein content decreased with forage maturity, but grazing did delay its decline. Grazing had a minimal effect on fiber fractions, which contrasts with initial assumptions.

The application of nitrogen fertilizer may be a prerequisite of compensatory growth after defoliation occurs in flood meadow systems. In its absence, regrowth does not occur at a rate that justifies early spring grazing as a means of increasing forage quality of harvested hay.

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Appendices

Appendix 1

Heifer Weight Gains and Alternative Pasture Management

Heifer weight gains during the study were slightly higher than anticipated. In 1998, ADG declined from 1.35 kg in early June to 0.68 kg in mid-August. Trends were similar in 1999, with 1.61 kg of daily gain in June and 0.26 kg in mid-August.

Yearling cattle grazing on sagebrush-bunchgrass rangeland in southeastern Oregon showed similar average daily gains throughout the season (Turner and DelCurto 1991). Daily gains averaged 1.13, 0.54 and 0.23 kg in early June, late July, and late August, respectively.

Placing August values aside, Raleigh and Turner (1980) observed lower daily gain in yearling heifers turned out on tall-fescue dominated irrigated pastures in the same proximity as this study. Observed gains were 0.73, 0.82, 0.78, and 0.63 kg per day in May through August, respectively. Holechek et al. (1981) examined the average daily gain of first-calf heifers on forest and grassland range in northeastern Oregon and reported that forest ranges provided gains of 0.61, 0.51, and 0.38 kg in early summer, late summer and fall, respectively, of 1976. Grasslands provided 0.43, 0.41, and 0.40 kg during the same sampling periods and growing season.

Because potential average daily gain is high in the flood meadows of southeastern Oregon, it is important to explore additional management options regarding these hay fields. Alternative uses of these resources may be sought in light of the uncertain future stocking rates of public land grazing permits and the current low quality of flood meadow hay.

Strip grazing involves increasing grazing pressure to small areas of pasture through the use of portable electric fencing. Two questions that should be asked when considering this management option are (1) Does continuous and strip grazing result in comparable animal performance, and (2) Will both grazing systems provide equal diet quality and dry matter intake (Blount 1990)?

Blount (1990) observed a mean average daily gain of 1.16 kg in steers that were selected to graze continuously throughout the field season. Those steers subjected to strip grazing gained 0.77 kg on average. It was concluded that the difference between the two grazing systems was diet related. In contrast, Holechek et al (1979) found no difference in livestock performance between season-long and rotational grazing systems in northeastern Oregon during a three-year study. Of course, the intensity of livestock and pasture management can differ greatly between strip and rotational grazing, resulting in varied results in livestock gain.

Blount (1990) found that diet quality was reduced in strip grazing treatments when compared to that of continuous grazing. However, grazing treatment did not influence dry matter intake. This is likely because sward height was not reduced below 10 cm, which is cited as a critical point of forage availability to beef cattle (Lowman et al. 1988).

In the process of increasing stocking density and/or forage utilization, both strip and rotational grazing can be very flexible in order to provide forage for varying durations of grazing. If, for example, a rotational grazing system had been set up in 1999 with a stocking rate of 2.5 heifers per hectare (one heifer per acre) and the pasture was grazed for 30 days (through mid June), 1350 kg of forage/ha would remain.

Assuming that the stubble height was slightly higher than 10 cm at this time, 3192 additional kilograms of forage would need to be produced before the pasture could support another 30 days of grazing at the same intensity. According to the biomass production data for that year, the pasture would have been ready for grazing again approximately 55 days later (mid-August). If the pasture had been grazed any longer in June, it is unlikely that it would have been able to support the herd again at the same stocking rate later in the season.

During the period that this pasture is being rested (mid-June to mid-August), another pasture of comparable size or some other forage base would need to be utilized. If another pasture was available with comparable yields as the first, it could easily support the herd during this time. A third pasture would need to be available as well for hay production. If it were 23 hectares and was comparable to the other two in biomass production, it would be more than capable of producing enough feed to carry 57 cattle through the winter months. In mid-September cattle could be turned back out on the second pasture and/or cleanup the third pasture. In successive years pasture use could be rotated to minimize soil compaction and plant stress during the early spring growing seasons.

Appendix 2

Producer Concerns

Two concerns that should be on every rancher's mind before turning cattle out to graze flooded meadows in early spring should be the risk of field compaction and livestock health problems associated with grazing in standing water for long periods of time. Although this author is unaware of any studies that correlate percent meadow foxtail cover with soil matting properties, it may be prudent to claim that heavy densities of meadow foxtail may protect the soil from compaction, trampling, and removal of plant root systems when grazed under saturated soil conditions. Incidences of such occurrences did happen during this study, but were restricted to isolated areas of the meadow that had been previously denuded of vegetation. One effective way of dealing with compaction is by rotating grazing and haying treatments over years.

Health problems that were experienced by the two groups of replacement heifers included one calf with pneumonia, one with lump-jaw, and three with pink-eye. There were zero incidences of foot rot or any other bacterial or fungal infection or infestation that might result from long-term exposure to standing water. It can be presumed that this did not occur because the topography of the study site varies, resulting in areas with standing water, and others that are completely dry. We provided mineral mix in the early spring where there was enough dry ground for all animals to rest comfortably.

Appendix 3

Protein Supplementation

Even though energy (carbohydrates and fats) is the most limiting nutrient in most beef cattle nutritional programs, protein could be the most important because it is an expensive supplement. For example, feeder quality alfalfa (17.5% crude protein) averages around \$75.00/ton. If the meadow hay is 6% crude protein and a ration is developed using feeder quality alfalfa, 0.17 tons of alfalfa would be required for every one-ton ration fed. Natural proteins such as those in legume crops work the best, but liquid or block protein supplementation is also an option. This form of supplement would cost between \$250 and \$450/ton. Therefore, some stockmen may find it advantageous to accept losses in yield if quality demands are met without having to ration the herd's diet over the winter.