Seasonal forage dry matter production and quality of 29 dryland grasses in Montana
by Kurtis Russell Blunt

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal and Range Science
Montana State University

Abstract:
Producers must have accurate and reliable measurements of both forage production and quality in their pastures. Previous studies with dryland grasses in Montana have mostly been limited to adaptation or yield performance of a few species at a single location.

The first objective of this study was to document yield and forage quality characteristics of adapted dryland grass varieties over a three-year period at three separate locations. Another objective was to accurately predict forage quality constituents of numerous dryland forage grasses using near infrared spectroscopy (NIRS). A third objective was to generate predictive models for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and in vitro digestible dry matter (IVDDM) using date or growing degree days. And finally, the last objective of this study was to demonstrate how forage quality information generated in this study can be useful for future improvement of animal carrying capacity predictions.

Twenty-nine dryland grass varieties were established at three Montana locations. Data were collected over a three-year period. Forage production and quality data were gathered under a wide range of climatic conditions. Interactions among years, varieties, and locations illustrated the variability of the climate in Montana and biological differences of varieties at different locations.

This study makes a strong case for the use of NIRS technology in estimating forage quality of dryland grasses in Montana. Compared to traditional wet chemistry procedures, NIRS proved to be much faster and generated accurate results.

Predictive models using date and growing degree days generated estimates of forage quality similar to NIRS but standard errors associated with model parameters limited statistical differences among varieties for season-long forage quality. However, it was determined that the rates of forage quality decline among many of the varieties studied were different ($P < 0.01$). The r^2 values for predicted forage quality ranged from 0.39 (Rosana, ADF) to 0.85 (Schwendimar, ADF) for the AGGD models and all were highly significant.

Strong negative correlations between yield and quality were not found in this study ($-0.3<0.3$). ADF and NDF were highly correlated ($r>0.79$). It appears that with optimal management, both forage production and quality can be. optimized.

Preliminary use of this data suggests that energy becomes limiting first as the growing season progresses, followed by intake and protein. Further studies should be devoted to modeling pasture carrying capacity with forage quality data.

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

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ABSTRACT

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The first objective of this study was to document yield and forage quality characteristics of adapted dryland grass varieties over a three-year period at three separate locations. Another objective was to accurately predict forage quality constituents of numerous dryland forage grasses using near infrared spectroscopy (NIRS). A third objective was to generate predictive models for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* digestible dry matter (IVDDM) using date or growing degree days. And finally, the last objective of this study was to demonstrate how forage quality information generated in this study can be useful for future improvement of animal carrying capacity predictions.

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Predictive models using date and growing degree days generated estimates of forage quality similar to NIRS but standard errors associated with model parameters limited statistical differences among varieties for season-long forage quality. However, it was determined that the rates of forage quality decline among many of the varieties studied were different ($P < 0.01$). The r^2 values for predicted forage quality ranged from 0.39 (Rosana, ADF) to 0.85 (Schwendimar, ADF) for the AGGD models and all were highly significant.

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CHAPTER 1

INTRODUCTION

Livestock producers are responsible for about half of the two billion dollars generated annually by Montana agriculture. Range, pasture, and harvested forages comprise about two-thirds of Montana's land base. Most livestock graze native range and/or improved pastures in Montana, utilizing about 40 million of the total 93 million acres in the state. As input costs for raising livestock increase, producers are looking for ways to stretch their forage base and maximize available nutrients, particularly producers maintaining dryland pastures. With an improved knowledge of level of production and standing forage quality, producers can better evaluate their forage base during and after the growing season to potentially reduce their cost of supplementation and winter feed costs. Even slight improvements in forage quality or grazing efficiency could result in significant economic benefits for producers and communities.

Taken literally, forage quality is most often measured by livestock performance. Certain concentrations of nutrients and cell contents have been proven to produce desired livestock responses. These responses can be measured in terms of maintenance, gain, and reproductive success. Crude protein, acid detergent fiber, neutral detergent fiber, and in vitro digestible dry matter concentrations are the most commonly measured forage quality constituents used to predict animal performance. Presently, laboratory wet chemistry analyses are the predominant methods of analyzing these constituents. Even though many producers routinely test their hay base for forage quality very few have any

estimate of their standing forage quality. This can limit livestock performance because dryland pastures are often the major forage source for producers. Consequently, there is a high demand for fast, accurate and economical analyses of standing forages, using scientifically accepted methods that accurately predict livestock response. While researchers continue to develop new technology, improvements that accelerate the process and allow more producers to have a better knowledge of their dryland forage base are sorely needed.

Most of the current information dealing with forage production and quality of dryland forage grasses in Montana is generated by the Montana Agricultural Experiment Station (MAES) research centers. Forage yield trials often encompass a relatively small number of species or varieties available due to limited resources and staff. The information generated is published in station reports, but the results are generally site specific as only one station has conducted the evaluation. Thus, adaptation and yield trials are usually useful only for local producers to estimate potential production. Even with this realization there have been few studies to evaluate phenological and nutritional components of dryland forage grasses in Montana across several locations and years with standardized methodology.

Forage grass production on range or in non-irrigated improved pastures is directly related to the amount of moisture and nutrients available to the plants and individual species or varietal adaptations to environmental stress. Adequate precipitation during the months of April, May and June are critical for maximum forage production. Time of harvest or grazing and the age of stands also affect production. Phenological stage of

maturity is highly correlated to dry matter production with maximum production for most species occurring during the period between boot and anthesis. Production of dry matter decreases substantially beyond anthesis as resources are diverted from vegetative production to reproductive structures and the development of the seeds themselves. Maximum dry matter production for dryland grasses also generally begin to decline after the second and third years after establishment.

The forage quality constituents of dryland grasses are affected by many of the same factors that determine dry matter production. Phenology, available nutrients, regrowth and species or varietal differences affect the livestock response generated from forage grasses throughout the growing season and beyond. In general, grasses are most digestible when they are in the vegetative stage when leaf:stem ratios are the highest. As forage plants mature, the leaf:stem ratio decreases with the shift from vegetative production to reproductive structures. Digestible and indigestible fiber constituents replace soluble cell contents as plants become more mature reducing the concentrations of nutrients and energy. High fiber levels reduce the ability of livestock to process the forage, which in turn reduces intake.

Potential for dry matter production and forage quality is highly variable among grass species depending on time of harvest or grazing, and the phenology of the plant at harvest. Species and individual cultivars have been developed to offer producers more choices to supplement or improve their existing forage base.

The use of near infrared reflectance spectroscopy has gained scientific credibility and acceptance since the 1970's when Norris et al. (1976) first used it to predict forage

quality constituents. The technique involves the bombardment of specific bands of near infrared light wavelengths into a ground forage sample. These specific wavelengths are reflected by chemical bonds associated with individual forage quality constituents, and the concentration of each constituent in the sample can be determined. Advancements and improvements in the hardware and software have reduced sample analysis time and expense, and increased the accuracy of predicted concentrations of forage quality constituents in analyzed samples.

The objectives of this project were to document yield and forage quality characteristics of adapted dryland grass varieties over three complete growing seasons at three different locations in Montana. Twenty nine varieties of dryland grass were evaluated throughout the grazing season to estimate forage production and quality. Near Infrared Reflectance Spectroscopy (NIRS) equations were used to predict several forage quality constituents. Further, predictive equations to estimate forage quality constituents using date or growing degree days were developed. A future goal for this study will be to fine-tune AUM predictions for these species with their availability of crude protein or digestible dry matter based on growth stage or climate data.

Hypotheses to be tested were: 1) NIRS can accurately and consistently predict forage quality constituents of dryland forage grasses in Montana throughout the year, 2) the decline in forage quality with maturity is similar among species, and 3) forage quality constituents can be accurately predicted by the day of the year and accumulated heat units.

CHAPTER 2

LITERATURE REVIEW

Dryland Forage Grass Species

Livestock production is responsible for the nearly two billion dollars generated annually by agriculture in Montana every year. The primary source of forage for these livestock is the 40 million acres of range and pasture land (Montana Agricultural Statistics 2000).

Many cool season perennial species and cultivars are used by Montana producers to balance their forage bases, reduce pressure on native pastures and provide emergency forage during drought and other periods of low production (Smoliak et al, 1990). The most popular grasses in Montana used for hay and pasture production are *Agropyron cristatum* (L.) Gaertn. (fairway crested wheatgrass) and *Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey (intermediate or pubescent wheatgrasses) (Smoliak et al, 1990). Other grasses used for pasture production are *Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould (thickspike wheatgrass), *E. trachycaulus* (Link) Gould ex. Shinners (slender wheatgrass), *E. wawawaiensis* J. Carlson (Snake River wheatgrass), *Leymus angustus* (Trin.) Pilger (Altai wildrye), *Leymus cincereus* (Scribn. & Merr.) A. Love (Great Basin wildrye), *Nassella viridula* (Trin.) Barkworth (green needlegrass), *Pascopyrum smithii* (Rydb.) A. Love (western wheatgrass), *Psathyrostachys juncea* (Fisch.) Nevski (Russian wildrye), and *Pseudoroegneria spicata* (Pursh) A. Love (bluebunch wheatgrass) (Smoliak et al., 1990).

A. cristatum (L.) Gaertn. (fairway crested wheatgrass) is an introduced, persistent, drought tolerant, winter hardy grass with an extensive bunchgrass root system. It is noted for the ability to withstand heavy utilization once established and is extremely competitive if planted in a mix. (USDA, NRCS 2000).

A. desertorum (Fisch. ex Link) J. A. Schultes (standard crested wheatgrass) is also an introduced species. It is more drought tolerant than fairway crested wheatgrass and is specifically adapted to the Great Plains, intermountain and the northwest regions of the United States and is more tolerant of saline soil conditions than fairway crested wheatgrass (USDA, NRCS 2000).

A. cristatum x A. desertorum (hybrid crested wheatgrass) was developed to increase the competitiveness of crested wheatgrass in colder environments. New cultivars of hybrid crested wheatgrass have better forage yield than either parents (USDA, NRCS 2000).

A. fragile (Roth) Candargy (Siberian wheatgrass) is an introduced bunchgrass similar to fairway and standard crested wheatgrasses but it has finer leaves and stems. It is also the most drought tolerant of the three and remains the most palatable as summer progresses (USDA, NRCS 2000).

E. lanceolatus (Scribn. & J.G. Sm.) Gould (thickspike wheatgrass) is a native species. It is long-lived, drought tolerant, has good seedling vigor and is strongly rhizomatous. Thickspike is very well adapted to stabilize disturbed areas, but it has relatively low forage yield when compared to other species. Thickspike wheatgrass does not compete well when planted with aggressive species, but seedling vigor, rhizomes and

drought tolerance makes it well suited for reclaiming low rainfall areas (USDA, NRCS 2000).

E. trachycaulus (Link) Gould ex Shinners (slender wheatgrass) is a relatively short-lived cool season native bunch grass species. It is less drought tolerant than crested or western wheatgrasses but it has good tolerance to alkaline conditions. Slender wheatgrass maintains high forage production for the first three to four years, then generally declines (Smoliak et al, 1990). It is moderately tolerant of grazing, but it performs the best when in grown in a pasture and hay situation with a legume (USDA, NRCS 2000).

E. wawawaiensis J. Carlson (Snake River wheatgrass) was originally identified as bluebunch wheatgrass, and is one of the most drought tolerant native bunchgrasses in the United States. This species is best suited for pasture and rangeland use and becomes somewhat coarse during the summer (USDA, NRCS 2000)..

Leymus angustus (Trin.) Pilger (Altai wildrye) is an introduced species that is predominately a bunchgrass but may also develop short rhizomes. It is winterhardy and very drought tolerant. It performs well in dry conditions and in saline soils but has limited seedling vigor and initial competitiveness. Once established, this species is very persistent and competitive (Smoliak et al, 1990). Aftermath growth must be removed by clipping or grazing to maintain maximum seed yield as normal seed yield is generally relatively low. Altai wildryes perform best in areas where annual precipitation exceeds 35 cm (Smoliak et al, 1990).

L. cincereus (Scribn. & Merr.) A. Love (Great Basin wildrye) is a native, long-lived cool season bunchgrass that can become very large and coarse. It has an extensive deep coarse fibrous root system and is well adapted to the stabilization of disturbed areas. Great Basin wildrye is one of the first grasses to green up in the spring and is reported to maintain high forage quality and palatability beyond the growing season. (USDA, NRCS 2000). Careful grazing management is very important with this species due to an elevated growing point; a residual stubble height of 25 to 30 centimeters is recommended to reduce grazing damage. It is considered excellent wildlife habitat and can provide shelter from the wind (USDA, NRCS 2000).

Nassella viridula (Trin.) Barkworth (green needlegrass) is a long-lived native bunchgrass that is highly palatable for livestock and wildlife. Under range conditions this species is generally found in areas of slightly higher moisture accumulation. It is very common throughout the grazing lands of the western United States but is usually not the predominant species in the plant community. It is generally seeded in plant mixtures, as pure stands have been know to experience partial die out (Smoliak et al, 1990).

Pascopyrum smithii (Rydb.) A. Love (western wheatgrass) is the most common and well known species of native grass in the West. It is strongly rhizomatous and palatable to all classes of livestock and wildlife. Poor germination and initial competitiveness result in stands that are often not fully established for several years. This species greens up in March to early April and matures in mid-July to August (USDA, NRCS 2000).

Psathyrostachys juncea (Fisch.) Nevski (Russian wildrye) is a long-lived, introduced bunchgrass. It is tolerant of drought, cold and mild salinity. Growth begins about two weeks after standard crested wheatgrass in the spring, the forage is palatable for a longer period than most other dryland grasses (USDA, NRCS 2000). Russian wildrye is not well suited to hay production due to the growth form of mostly basal leaves that are difficult to recover with conventional haying equipment. Careful management is required as it does not tolerate prolonged continuous grazing. Russian wildrye pastures should be planted in pure stands and fenced to allow for strict grazing management (USDA, NRCS 2000).

Pseudoroegneria spicata (Pursh) A. Love (bluebunch wheatgrass) is a native, perennial bunchgrass. It is long-lived and very palatable to wildlife and livestock but will not tolerate intensive prolonged grazing. Bluebunch wheatgrass has a fairly high growing point, and 15 centimeters of growth in the spring is recommended before turnout of animals. Deferred and rest-rotation grazing programs are effective in maintaining stand health (USDA, NRCS 2000).

Thinopyrum intermedium (Host) Barkworth & D.R. Dewey (intermediate or pubescent wheatgrass) is an introduced species used in hay and pasture lands throughout the West. It is a long-lived grass that can have short rhizomes with some cultivars becoming sod forming under irrigation (Ross, 1963; Smoliak et al., 1990; USDA, NRCS 2000). It is palatable to all classes of livestock and wildlife and is considered to be good forage throughout the growing season and into the fall and winter. This species is used to stabilize disturbed areas due to its rhizomatous root system. Excellent wildlife cover can

be created using this species when strips are left ungrazed. This species will not tolerate heavy continuous utilization and established stands should be allowed to attain 10 to 30 centimeters of growth before livestock are turned in during the spring (USDA, NRCS 2000). Stands have consistently out-yielded grass/legume mixes so stocking rates can be set higher than other stands of forage grasses. Varieties of pubescent wheatgrass perform well in areas where annual precipitation exceeds 28 cm (USDA, NRCS 2000).

Forage production of dryland grasses

There are many factors that affect dryland forage production in Montana. The combination of precipitation, available soil nutrients, timing and frequency of grazing or harvest, and the age of the stand in improved pastures determine production and forage quality (Stitt, 1958).

Suleiman et al. (1999) reported that prairie grasses matured much earlier, and maximum forage yield was achieved earlier in the growing season during years of below normal precipitation. Stitt (1958) found that long-term (eight year) forage production of several forage grasses in central Montana were highly correlated ($r^2 = .86$, $P < .01$) with total precipitation received during April and May. White (1986) reported a 50% decline in dry matter production of Russian wildrye and crested wheatgrass following a 25% decline in April through June precipitation near Sidney, MT.

Waller et al. (1985) reported cool season grasses have an optimum temperature range for forage production of 15 to 24 °C. Generally soil temperatures between

approximately 4 to 7 ^{o} C must be reached before the initialization of growth in the spring (Waller et al., 1985).

Cool season grasses are more productive in the spring and fall due in part to cooler temperatures, shorter photoperiods, and generally higher soil moisture. As summer progresses, growth rate declines and dormancy are induced by higher temperatures and lower precipitation (Waller et al., 1985). In fall, as temperatures decrease and if soil moisture becomes available, some cultivars may resume growth.

Nitrogen (N) fertilization is important for cool-season grasses and annual dry matter production is positively related to the level of applied N (Moyer et al., 1995; Overman et al., 1994). However, cool temperatures early in the spring limit the amount of N made available to plants by soil organisms. This is believed to be one of the major reasons why cool season grasses consistently respond to N fertilizer in many areas of the Great Plains (Waller et al., 1985). Dryland and rangeland fertilization is not widely practiced, as producers perceive it to be uneconomical. This perception was challenged by Lorbeer et al. (1994) in trials where 50 and 100 pounds of N per acre applied to native and introduced stands of forage grass at Havre, MT. Fertilized plots significantly outyielded unfertilized plots at an economical level for 7 years. Wight and Black (1979) found that N fertilization of cool season grasses near Sidney, MT increased forage yield.

Biomass production increases steadily in the spring until peak production is reached. This is followed by a period of relatively low production due to rapid decline in growth rate (Fairbourn, 1983). Most forage grasses reach maximum *in vitro* dry matter digestibility (IVDMD) production between the boot stage and anthesis (Fairbourn, 1983).

Timely harvest or grazing prior to boot stage may delay summer dormancy in grasses that generally mature before the onset of hot, dry weather (Waller et al., 1985). Summer productivity could potentially be increased if the vegetative stage is maintained longer into the summer (Waller et al., 1985).

White and Wight (1981) reported a rapid loss of dry matter production one to two months after peak production. They attributed this loss to the release of seeds, rapid decline in the translocation of nutrients to vegetative structures, and reduction in overall respiration leading to higher fiber and lignin concentrations.

Stand age also affects the production of dryland forage grasses. Lorbeer et al. (1994) reported that introduced forage grasses usually reach peak production in the second or third year after establishment. Yields of intermediate and crested wheatgrasses were found to be significantly highest during the first year after establishment than the second and third years (Wichman and Dubbs, 1986). Similarly, Lawrence (1973) found the maximum yield of intermediate wheatgrass stands occurred during the second year after establishment. In a four-year study near Swift Current, SK, Russian wildrye production was found to peak during the second year post establishment (Leyshon et al., 1990). Another long-term study in southern Saskatchewan involving Russian wildrye reported maximum forage production was highest in the first three years after planting (Kilcher et al., 1976).

Forage quality of dryland grasses

Plant maturity is the main factor affecting the forage quality of grasses and legumes (Kalu and Fick, 1983; and Nelson and Moser, 1994). Thus plant maturity can affect how well forage quality can be matched to animal requirements (Mitchell et al., 2001). White (1986) and White and Wight (1984) found that forage quality of dryland grasses was inversely proportional with forage dry matter yield. Suleiman et al. (1999) reported that knowledge of the yield of grasses as they mature helps to maximize the utilization of nutrients that can be captured by grazing. Dubbs (1970), Stannard and Kelley (1993), and White (1986) have reported that forage quality of grasses can vary based on the growth stage of the plant at the time of consumption or harvest, species differences, and available nutrients prior to and during the growing season. Cool season grasses utilize nutrients less efficiently as temperature increases during the growing season, but they generally have higher crude protein concentrations than warm season grasses (Waller et al., 1985).

Forages are more digestible to livestock early in their growth cycle. Abdalla et al. (1988) attributed this to a continuous reduction in the leaf:stem ratio from initial growth in the spring until the onset of dormancy in the later summer or fall. Forage quality of grasses decline as the plant matures (Murray et al., 1978; Newell and Moline, 1978; Stannard and Kelley, 1993). They attributed this decline to a reduction in mineral uptake as photosynthetic processes continued to proceed throughout the flowering and seed development stages. Perry and Baltensperger (1979), Griffin and Jung (1983), and

Mitchell et al. (1994) found that warm-season grasses follow this trend as well. Mayland et al. (1992) noted that the decline in forage quality and digestibility with advanced maturity was associated with more carbon in the plant cell. Carbon is bound in less digestible structural elements in the plant cell, and other important mineral concentrations are diluted when digestibility decreases. Mayland et al. (1992) also reported that *in vitro* digestible dry matter and other mineral concentrations decreased linearly as the plants matured. A study conducted in 1981 by White and Wight reported the *in vivo* digestibility of dryland forage grasses declined 22% between April and December.

Certain nutrients must be present in order for forage grasses to maintain productivity and forage quality. Aside from available moisture, N is the most important nutrient to plants. With fertilization, plant uptake of N increases as the rate of N applied increases (Black and Reitz, 1969). Lawrence et al. (1970), Reid et al. (1966), and Smitka et al. (1960) found that crude protein concentrations of crested wheatgrass, intermediate wheatgrass, orchardgrass (*Dactylis glomerata* L., Russian wildrye, and smooth bromegrass (*Bromus inermus* L.) increased as the rate of applied N increased. Monson and Burton (1982), and Puoli et al. (1991) found that this trend occurred in warm season grasses as well. Lorbeer et al. (1994) noted that the amount of crude protein produced per hectare was significantly higher in plots fertilized with N than unfertilized plots, and that this was still at an economical level 7 years later.

Forage quality varies among species. Russian wildrye at anthesis was reported to have sufficient crude protein to enable yearling steers to gain up to one kilogram per day while crested wheatgrass at the same stage of maturity could only support mature cow

maintenance (White, 1986). Wichman and Dubbs (1986) reported that intermediate and pubescent wheatgrasses produced more kilograms of crude protein per hectare than Russian wildrye or crested wheatgrass. Comparisons of a particular forage quality constituent per unit area are useful, however limitations on intake must also be considered.

Analysis of dryland forage grass quality

The ultimate measure of forage quality is livestock performance. Estimates of predicted animal performance are based upon forage quality constituents that can be tested by conventional wet chemistry procedures or near infrared reflectance spectroscopy (NIRS). Constituents used to determine forage quality are crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* digestible dry matter (IVDDM). Crude protein concentration in forages is a measure that can indicate whether or not the forage can meet the daily protein requirements of an animal. Measures of crude protein are based on the total concentration of forage N from both protein and non-protein sources. Crude protein estimates of pasture or standing forages is more predictive of available protein than hays or processed forages. Acid detergent fiber concentration is a measure of the amount of highly indigestible plant material in the forage and can be used to estimate energy content. The lower the amount of indigestible components in the forage, the more the animal will be able to digest. Neutral detergent fiber concentration is a measure of the cell wall material present in the forage. Increasingly higher concentrations of cell wall material equates to less forage being

potentially consumed and processed. For this reason NDF is negatively related to intake. *In vitro* digestible dry matter is an estimate of the amount of forage that is potentially digestible and is based on actual or simulated feeding trials with animals or by procedures creating environments similar to the rumen (Church and Pond, 1988; Gray, 1988).

Near infrared reflectance spectroscopy is a new technology for analyzing forage quality that is accurate, economical, precise, simple and quick (Barnes, 1973). Further, NIRS can be used to predict parameters related to livestock performance, and has gained acceptance for use by the scientific community. Norris et al. (1976) were the first to use NIRS to estimate forage quality. Shenk, Westerhaus, Abrams, Barnes, and Martens are some of the many researchers that have evaluated and improved NIRS technology through their research. This technology estimates the concentration of each forage quality constituent in the sample by measuring the amount of specific wavelengths of infrared light that are reflected off certain chemical bonds associated with each constituent (Marten et al., 1985; Shenk and Westerhaus, 1994). Near infrared reflectance spectroscopy (NIRS) has provided fast, and increasingly accurate, and inexpensive method of estimating the forage quality constituents of forages (Fahey & Hussein, 1999). The NIRS procedure has been used to predict CP, NDF, ADF, IVDDM, fecal nitrogen and a number of other parameters associated with forage quality, forage intake and digestibility. The NIRS technique has been proven to be an accurate method of predicting forage quality components when the following criteria are met: 1) laboratory analyses of the calibration samples must be accurate; 2) proper wavelengths must be selected; 3) calibration samples adequately represent unknown samples; 4) proper data

processing techniques must be used (Marten, 1985; Hruschka, 1987). Norris et al. (1976) accurately predicted CP, ADF, NDF, and lignin concentrations of legumes and forage grasses. Mayland et al. (1992) compared the seasonal trends in quality of *Agropyron* spp. and chose the NIRS method for analysis. Ward et al. (1982) successfully predicted CP (r^2 = 0.98) and ADF (r^2 = 0.90) in range forage using NIRS. Albrecht et al. (1987) analyzed cell-wall carbohydrates and starch in alfalfa using NIRS. Suleiman et al. (1999) accurately analyzed nutrient and mineral concentration of grasses in east-central Alberta using NIRS technology, across several stages of growth at harvest. Clark et al. (1989) measured trace elements of alfalfa, crested wheatgrass, and tall fescue and concluded that NIRS was generally more accurate in predicting trace mineral concentrations than by using the NRC table values. In Montana, Murphy (1996) developed NIRS equations that accurately predicted CP, ADF, NDF, and IVDDM of five dryland forage grasses.

CHAPTER 3

MATERIALS AND METHODS

Dryland Forage Grasses

Twenty-nine forage grass varieties were selected from 14 species used commonly in dryland situations in Montana and the west (Table 1). The varieties were: 'Douglas', 'Hycrest', 'CDII', and 'Nordan' crested wheatgrass; 'P-27' and 'Vavilov' Siberian wheatgrass; 'Critana', 'Bannock', and 'Schwendimar' thickspike wheatgrass; 'Pryor' and 'Revenue' slender wheatgrass; 'Secar' Snake River wheatgrass; 'Pearl', 'Prairieland', and 'Eejay' Altai wildrye; 'Trailhead' and 'Magnar' Great Basin wildrye; 'Rosana' western wheatgrass; 'Bozoisky-Select', 'Mankota', and 'Swift' Russian wildrye; 'Goldar' blueblunch wheatgrass; 'Greenleaf', 'Luna', and 'Manska' pubescent wheatgrass; and 'Oahe', 'Reliant', and 'Rush' intermediate wheatgrass (complete variety descriptions are shown in Appendix A – Table 69).

Experimental Design

This research project was funded by the Montana State University Foundation Seed Program, in cooperation with the NRCS Plant Materials Center in Bridger, MT. Grasses for this study were planted at three Montana locations: the USDA-NRCS Plant Materials Center near Bridger, the Central Agricultural Research Center near Moccasin, and the Montana State University Research Farm near Bozeman.

Table 1. Cool season perennial grasses evaluated for forage yield and quality at Bozeman, Bridger and Moccasin, MT in 1997, 1998 and 1999.

Scientific name	Common name	Variety
Agropyron cristatum (L.) Gaertn.	Fairway crested wheatgrass	Douglas
A.cristatum X A. desertorum	Crested wheat grass hybrid	Hycrest
	Crested wheat grass hybrid	CDII
A. desertorum (Fisch. Ex Link) J.A.Schultes	Standard crested wheatgrass	Nordan
A. fragile (Roth) Candargy	Siberian crested wheatgrass	P-27
	Siberian crested wheatgrass	Vavilov
Elymus lanceolatus (Scribn. & J.G. Sm.) Gould	Thickspike wheatgrass	Critana
	Thickspike wheatgrass	Bannock
	Thickspike wheatgrass	Schwendimar
E. trachycaulus (Link) Gould ex Shinners	Slender wheatgrass	Pryor
	Slender wheatgrass	Revenue
E. wawawaiensis (J. Carlson)	Snake River wheatgrass	Secar
Leymus angustus (Trin.) Pilger	Altai wildrye	Pearl
	Altai wildrye	Prairieland
	Altai wildrye	Eejay
L. cinereus (Scribn. & Merr) A. Love	Great Basin wildrye	Trailhead
	Great Basin wildrye	Magnar
Nassella viridula (Trin.) Barkworth	Green needlegrass	Lodorm
Pascopyrum smithii (Rydb.) A. Love	Western wheatgrass	Rosana
Psathyrostachys juncea (Fisch.) Nevski	Russian wildrye	Bozoisky-Select
	Russian wildrye	Mankota
	Russian wildrye	Swift
Pseudoroegneria spicata (Pursh) A. Love	Bluebunch wheatgrass	Goldar
Thinopyrum intermedium (Host) Barkworth & D.R. Dewey	Pubescent wheatgrass	Greenleaf
	Pubescent wheatgrass	Luna
	Pubescent wheatgrass	Manska
	Intermediate wheatgrass	Oahe
	Intermediate wheatgrass	Reliant
	Intermediate wheatgrass	Rush

Trial plots were planted in May, 1996. All varieties were seeded with plot equipment in a randomized complete block design with four replications at each study site. Plots (1.3m X 7m) consisted of four single rows spaced on 30-cm centers. All plots were established at recommended seeding rates and managed during the seeding year for optimum dryland production.

Procedures

In 1997, 1998, and 1999 forage samples were collected every two weeks from May through July. Monthly samples were then taken in August through November. Sampling dates and protocols were coordinated among the three study sites to capture all phenological growth stages and allow comparison among locations. A sample area of approximately 0.22 m^2 was obtained by clipping 60 linear cm of forage within an inside row. Plots were clipped by hand to a uniform height of eight cm. Measurements of plant height and Feeks growth stage (Large, 1954) were collected until plants reached full maturity (data not presented). Clipped samples were weighed immediately in the field, dried (60 °C), and re-weighed for dry matter concentration. Sample dry matter weights were converted to kg ha^{-1} for an estimate of forage yield. At the end of each season plots were clipped back to a uniform height (8 cm), and the dry forage was removed.

All forage samples were sequentially ground through Wiley and Cyclone mills to 1mm in preparation for scanning analysis. Samples were stored in manila envelopes and sealed in plastic bags prior to analysis. Samples were scanned with a NIRSystems Inc. Model 4500 spectrophotometer (NIRSystems, Inc., Silver Spring, MD 301-680-9600).

Forage Grass Quality Analyses

Scans produced by the NIRS were entered into the database of the ISI infrared software "Infratec 2" (NIRSystems, Inc. Silver Spring, MD 301-680-9600). The "Center" and "Select" programs were used to develop a calibration equation that selected a subset of 48 samples from the 90 chosen to represent all locations, years, growth stages and varieties sampled during the project. Duplicate samples of all 48 samples were submitted to Midwest Labs (Omaha, NE 402-334-7770) and the MSU Animal Nutrition Laboratory. These samples were analyzed to determine CP, ADF, NDF and IVDDM concentrations using National Forage Testing Association (AOSA 1990) recommended methods. Murphy (1996) determined that separate equations for different species of cool season grasses were not necessary as the equation he developed was highly predictive for CP, ADF, NDF and IVDDM across five species. The laboratory results were entered into the "Calibration" program and individual equations for the prediction of CP, ADF, NDF and IVDDM were created. Error limits for each equation were established using the standard error of calibration (SEC) values provided by the software (Undersander et al., 1993). Validation of these calibration equations was accomplished by selecting a group of 28 independent samples representative of the entire data set. This validation set supported by laboratory wet chemistry data was used to test accuracy and repeatability of the equations. Midwest Labs (Omaha, NE) and the MSU Animal Nutrition Laboratory also analyzed these samples for CP, ADF, NDF, and IVDDM. These lab values were entered into the database. The "Predict" program then used the calibration formula to

predict the CP, ADF, NDF, and IVDDM concentrations of the validation set using the scans created by the spectrophotometer. The predicted values for each constituent were tested against the wet chemistry values created by the laboratories using the "Statistics" program provided by the software. Standard error of prediction corrected for bias (SEP C) was generated for each of the four prediction equations.

Data Analyses

This experiment was analyzed as a split-split plot design with variety, location and year as main effects and reps as split plot effect. Individual analyses of variance (ANOVA) for yield and quality were computed for each harvest date at each location for 1997, 1998 and 1999 on a template generated in Microsoft Excel (Copyright © 1985-1999 Microsoft Corporation). Significant effects (P = 0.05) were determined by ANOVA. Forage quality and yield data were also analyzed using SAS, (Version 8.1). Means across sample dates within each year and location were used to generate overall ANOVA (SAS, Version 8.1) due to unequal number of sample dates among years and locations, and unequally spaced dates among years and locations. Further ANOVA (SAS, Version 8.1) were generated to identify main effects of year, location, variety, and the year x location, year x variety, location x variety, and year x location x variety interactions. Analyses of variance were generated within each location for year, variety and year x variety. Overall means, means across locations, means across sample dates and LSD (P = 0.05) values were generated by SAS. Summary tables of forage quality

concentrations across locations or dates were generated where non-significant interactions made such summarization valid.

Predictive quadratic models were also generated, using the "LSMEANS" program in SAS (Version 8.1) to estimate the concentrations of CP, ADF, NDF, and IVDDM of the 29 varieties in the trial from late-May through November 1. Separate models were developed for each constituent, using accumulated growing degree days (AGDD) and the standardized Julian Date (JD) to predict the concentrations of each forage quality constituent. Separate models were developed for each variety, and both linear and quadratic models were developed. For comparison, similar varieties were chosen to evaluate each model where appropriate. Values for Julian date and AGDD associated with June 1, July 15, and September 15 were chosen to allow practical comparison of NIRS predicted values and values generated from the JD and AGDD predictive models.

CHAPTER 4

RESULTS AND DISCUSSION

Climate Data

The growing seasons of 1997 through 1999 were very diverse, and provided good variability for evaluation for dryland grass production in Montana. In 1997, total precipitation was higher than the 30-year means (Table 2), and temperatures were slightly cooler (Table 3). In contrast, precipitation levels were lower, and mean temperatures higher in 1998 and 1999 at all locations.

In 1997, at Bozeman and Bridger, total precipitation from the fall of 1997 through the 1997 growing season was 37% and 30% above normal, respectively (Table 2). Mean temperatures during this period were normal at Bozeman, but cooler at Bridger (Table 3). Annual precipitation at Moccasin during 1997 was 14% above normal, and mean temperatures were cooler than normal (Table 2-3).

In 1998, total precipitation was below normal at all locations, but distribution varied among locations (Table 2). Fall 1997 and winter precipitation were above normal at Bozeman through April, but below normal at Moccasin and Bridger (Table 2). June precipitation was 26 % to 94 % higher than normal at the three locations, but July and August were drier than normal (Table 2). Mean temperatures in 1998 were warmer at all locations (Table 3).

Precipitation subsequent to fall 1998 declined significantly and was below normal at all locations, and mean temperatures were higher than normal in 1999 at all locations

Table 2. Summary of monthly precipitation (cm) for crop years 1997, 1998, 1999 and 30-year means at Bozeman, Moccasin and Bridger, MT.

Bozeman (cm)
Montana State University Agronomy Research Farm (Station 241047)

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
1996/1997	3.38	4.55	4.27	3.25	2.92	1.27	2.41	4.45	8.33	8.38	9.65	5.36	58.22
1997/1998	5.16	3.00	1.93	1.88	1.65	2.31	4.09	4.37	2.97	8.20	2.34	2.06	39.95
1998/1999	2.54	2.84	2.62	2.64	1.14	1.96	2.34	3.91	6.12	4.37	0.33	5.38	36.20
30-year mean	4.39	3.68	2.26	1.68	1.47	1.52	2.79	3.91	6.65	6.63	3.89	3.51	42.39

Moccasin (cm)
Central Montana Agricultural Research Center (Station 245761)

1996/1997	3.73	0.89	1.93	2.11	1.45	0.13	1.63	3.58	5.16	10.49	8.38	7.29	47.85
1997/1998	1.27	1.07	0.36	0.86	1.09	0.36	1.93	1.50	4.80	12.17	5.28	4.27	34.95
1998/1999	3.40	2.34	3.73	1.19	1.19	0.61	1.50	3.15	4.75	4.57	4.24	9.02	39.70
30-year mean	3.71	2.31	1.50	1.50	1.68	1.27	2.21	3.10	7.98	7.80	4.52	4.42	41.99

Bridger (cm)
Natural Resource Conservation Service Plant Materials Center (Station 241102)

1996/1997	4.19	3.56	1.88	1.65	1.42	1.75	1.30	3.56	7.75	9.09	4.04	5.18	45.36
1997/1998	1.17	3.78	1.30	0.89	1.85	0.41	1.57	2.01	2.26	8.84	2.22	0.92	27.22
1998/1999	1.51	2.69	1.50	0.89	0.19	0.20	0.01	5.72	1.78	2.57	0.79	5.36	23.32
30-year mean	3.63	2.82	1.73	1.55	2.01	1.37	2.69	4.34	6.15	4.70	1.75	2.11	34.85

Source: http://www.wrcc.sage.dri.edu/summary/climsmmt.html

Table 3. Summary of monthly temperature data for crop years 1997, 1998, 1999 and 30-year means at Bozeman, Moccasin and Bridger, MT.

Bozeman °C
Montana State University Agronomy Research Farm (Station 241047)

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Mean
1996/1997	12.78	6.67	-1.67	-5.28	-6.56	-2.33	3.06	1.56	12.44	15.72	17.83	18.00	6.00
1997/1998	13.83	7.39	0.22	-4.39	-3.39	-1.50	-0.28	6.56	11.89	11.78	19.89	18.94	6.72
1998/1999	17.44	7.28	2.89	-4.67	-1.78	-0.17	2.67	5.11	9.67	13.78	18.78	20.33	7.61
30-year mean	12.64	6.92	-0.64	-5.25	-5.67	-2.83	0.97	5.69	10.36	14.81	18.25	17.67	6.14

Moccasin °C
Central Montana Agricultural Research Center (Station 245761)

1996/1997	11.94	6.78	-5.33	-8.11	-6.39	-0.67	1.39	1.50	10.50	15.50	17.06	18.39	5.22
1997/1998	15.50	7.50	1.39	-1.06	-4.28	1.17	-0.78	6.83	11.78	12.28	20.44	20.28	7.61
1998/1999	17.22	8.28	2.56	-4.28	-2.72	1.11	3.50	3.83	9.50	14.22	17.22	19.67	7.50
30-year mean	12.44	7.39	0.39	-4.56	-6.00	-3.45	-0.61	4.89	10.05	14.77	18.66	18.33	6.05

Bridger °C
Natural Resource Conservation Service Plant Materials Center (Joliet Station 241506)

1996/1997	13.33[1]	7.57	-3.76	-6.76	-8.60	-3.65	-2.94	6.91	9.23	17.48	20.24	20.25	5.78
1997/1998	16.61	8.83	1.12	-1.86	-6.36	-0.58	3.41	3.86	13.13	17.94	20.19	19.87	8.01
1998/1999	18.85	8.89	3.59	-3.29	-4.37	1.37	1.58	8.33	13.17	14.33	22.52	20.98	8.83
30-year mean[1]	14.00	8.83	1.11	-3.67	-5.06	-1.56	2.00	7.28	12.22	17.06	20.89	19.78	7.72

[1] Joliet, MT data were used due to missing Bridger temperature data during 1997-1999.
Source: http://www.wrcc.sage.dri.edu/summary/climsmmt.html.

(Table 2). Consequently, forage production declined steadily at all locations for 1997 through 1999 (Fig 1).

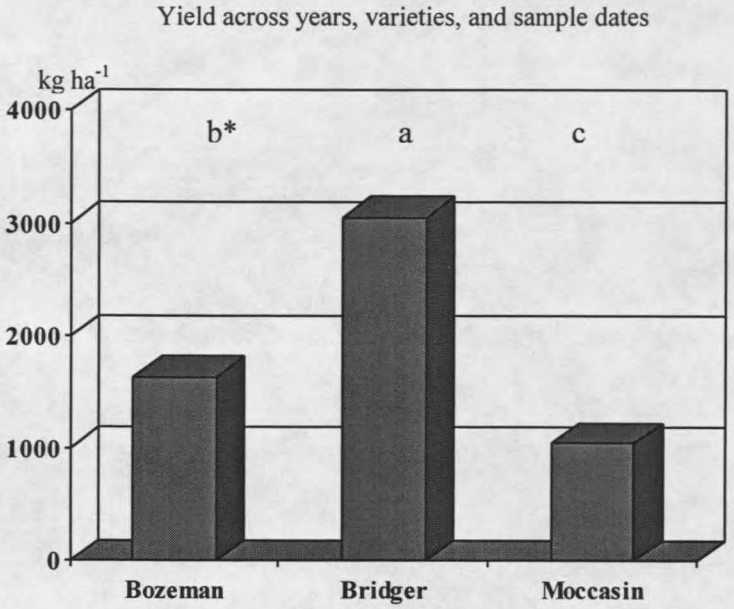
Harvest Dates

Forage samples were collected approximately every two weeks May through July and once a month from August through October at Bozeman in 1997, and 1999, and through September in 1998. Samples were collected through November at Bridger in 1997, 1998, and 1999. Moccasin samples were collected through July in 1997, through October in 1998, and through September in 1999 (Table 4).

Initially, consistent sample dates at all locations were intended, however this was not feasible due to different dates of green-up, climate conditions, and labor constraints. Further, insufficient plant height or maturity data were collected for one or more years or locations, thus these data are not presented.

NIRS Calibration and Validation Statistics

Calibration equations were developed for CP, ADF, NDF, and IVDDM. The development of these calibrations equations were not generated until after the processing of 1999 samples in order to include representative samples from all three sampling years. Ten individual samples from each year and location combination in the trial were selected to ensure each species would be fairly represented in the calibration set. Care was taken to include samples of each species throughout the growing season so that early, middle, and late season samples were present for each species. The standard errors of the



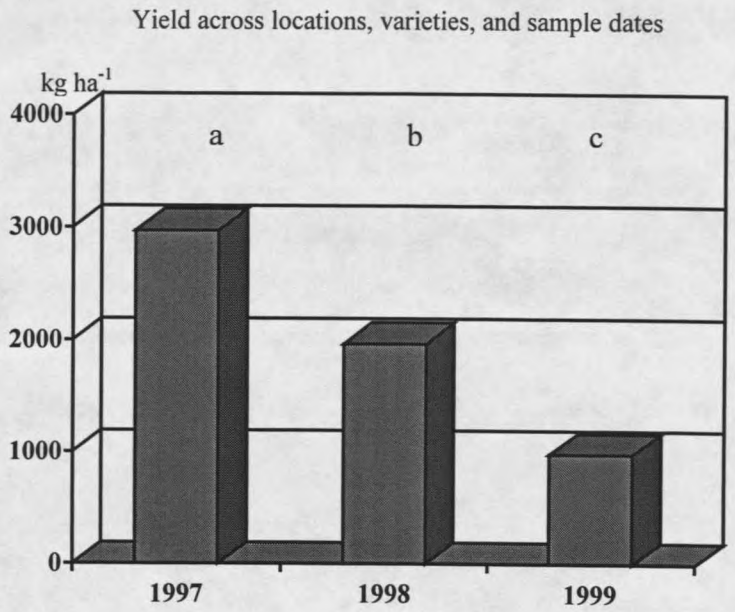


Figure 1. Summary of mean dry matter production at three locations in 1997 to 1999.
*Bars within each graph denoted by different letters are significantly different ($P < 0.05$).
(Note: Y x V, Vx L, L x Y, V x Y x L were all highly significant sources of variation).

Table 4. Harvest dates of 29 dryland grasses sampled at Bozeman, Bridger and Moccasin, MT during 1997, 1998 and 1999, displayed as calander date, Julian date (JD) and accumulated growing degree days (AGGD).

Bozeman	1997		Bridger	1997		Moccasin	1997	
Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD
23-May	144	220[1]	29-May	150	247	19-May	140	139
4-Jun	156	342	12-Jun	164	433	2-Jun	154	243
18-Jun	170	506	26-Jun	178	578	16-Jun	168	406
2-Jul	184	634	10-Jul	192	736	30-Jun	182	548
13-Aug	226	1208	8-Aug	221	1154	14-Jul	196	693
30-Oct	304	1849	8-Sep	252	1551	28-Jul	210	892
			8-Oct	282	1806			
			7-Nov	312	---			
	1998			1998			1998	
Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD
27-May	148	286	8-May	129	146	8-May	129	133
11-Jun	163	396	22-May	143	243	26-May	147	257
24-Jun	176	505	5-Jun	157	350	5-Jun	157	326
8-Jul	190	679	19-Jun	171	458	22-Jun	174	454
22-Jul	204	880	10-Jul	192	710	13-Jul	195	725
20-Aug	233	1385	31-Jul	213	1062	4-Sep	248	1593
24-Sep	268	1871	21-Aug	234	1399	6-Oct	280	1929
			18-Sep	262	1836			
			23-Oct	297	2002			
			23-Nov	328	---			
	1999			1999			1999	
Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD	Calendar Date:	JD	AGGD
19-May	140	98	6-May	127	58	24-May	145	138
2-Jun	154	231	20-May	141	106	4-Jun	156	244
16-Jun	168	346	3-Jun	155	239	15-Jun	167	324
30-Jun	182	520	17-Jun	169	360	29-Jun	181	490
14-Jul	196	687	2-Jul	184	529	15-Jul	197	665
12-Aug	225	1150	15-Jul	197	701	20-Aug	233	1187
15-Sep	259	1565	16-Aug	229	1199	15-Sep	259	1471
13-Oct	287	1752	15-Sep	259	1565			
			15-Oct	289	1764			
			15-Nov	320	---			

[1] Accumulated growing degree days base 5°C, for the period of 1 April to 1 November.

individual calibration equations were 13.5, 20.5, 24.5, and 77.9 g kg^{-1} for CP, ADF, NDF, and IVDDM respectively (Table 5). The multiple correlation coefficients squared (r^2) for the calibration equations developed were 0.96, 0.94, 0.98, and 0.88 for CP, ADF, NDF, and IVDDM respectively (Table 5). The correlation coefficients were determined to be high enough and errors low enough to continue to the validation process. Twenty eight samples were independently selected from the data set to validate the calibration equations. The laboratory analyses of these samples were then compared to the predicted values created by the calibration equations. The correlation coefficients squared (r^2) for the predicted and laboratory values of the validation set were 0.94, 0.89, 0.92, and .70 for CP, ADF, NDF, and IVDDM respectively despite the fact that some of the validation sample values were outside the range of values included in the calibration set (Table 5). For IVDDM, the relatively low validation correlation coefficient squared ($r^2 = 0.70$) could reasonably be attributed to the fact that some of the samples selected for the validation set were outside the upper and lower range of the calibration set (Table 5). The accuracy and validity of the calibration equations was determined using methods accepted by the National Forage Testing Association and described by Undersander and Maylor (1993): 1) compare the standard errors of the validation set to the standard error confidence limits, and 2) compare the biases of the validation set to the bias confidence limits. Standard error confidence limits for individual constituent equations were created by multiplying 1.29 x the standard error of calibration. Bias confidence limits for individual constituent equations were created by multiplying 0.55 x the standard error of calibration. The standard errors and biases of the validation set must be below the

Table 5. Calibration and validation statistics for CP, ADF, NDF and IVDDM concentrations (g kg^{-1}).

	Mean	Range	Standard Error	Standard Error Confidence Limit	Bias	Bias Confidence Limit	r^2
CP							
Calibration	141.4	40.4 - 258.3	13.5				0.96***
Validation	140.5	25.4 - 286.0	15.4	17.4*	0.0	7.4**	0.94****
ADF							
Calibration	344.9	219.6 - 486.1	20.5				0.94
Validation	348.3	194.6 - 551.1	26.1	26.5	-8.3	11.3	0.89
NDF							
Calibration	603	433.5 - 807.7	24.5				0.98
Validation	605.4	416.7 - 803.0	25.9	31.6	-1.3	13.5	0.92
IVDDM							
Calibration	449.5	120.5 - 763.7	77.9				0.88
Validation	446.1	73.3 - 809.0	98.0	100.5	14.4	42.8	0.70

* Standard Error Confidence Limit = 1.29 x (Standard Error Calibration).
** Bias Confidence Limit = 0.55 x (Standard Error Calibration).
*** Multiple correlation coefficient squared for equation development.
**** Correlation coefficient squared between predicted and measured constituents.

confidence limits in order for the individual constituent calibration equations to be valid. Using the criteria described in Undersander and Maylor (1993) the validation set standard errors and biases for CP, ADF, NDF, and IVDDM were all below the confidence limits and proves the accuracy and validity of the calibration equations for all constituents.

For this study, 7619 samples were analyzed by NIRS, and projected laboratory costs for wet chemistry analyses would have been $198,094 (7619 x $26). Ordinarily, researchers using NIRS technology include ten percent of the samples they are analyzing in their calibration set. Projected lab costs for including ten percent of the samples analyzed in this study would have been approximately $19,809. Due to the large number of samples involved in this study, and the cost of wet chemistry procedures, this was not an option for this project. The equations were assumed to be predictive across species, locations, and years, even though far fewer samples were used for calibration and validation.

Forage Yield

For the three-year period, forage dry matter data were obtained on 7830 observations. In the overall analysis of variance for dry matter yield, differences ($P < 0.0001$) were detected for the main effects of varieties (V), years (Y), locations (L) and all possible interactions – V x L, V x Y, L x V, and V x L x Y (Table 6). Direct comparisons among grass varieties averaged across locations or years were confounded due to the significant interactions. Average yields at Bridger (3059 kg ha^{-1}) were 87% and 193% higher than those at Bozeman or Moccasin, respectively (Fig. 1), when

Table 6. Mean squares (MS) and probabilities of larger F statistics (P > F) from the overall analyses of variance for forage yield and quality of 29 cool season grasses across all sample dates for three years and three locations.

		Dry matter (kg ha^{-1})		CP (g kg^{-1})		ADF (g kg^{-1})		NDF (g kg^{-1})		IVDDM (g kg^{-1})	
	df	MS	P>F	MS	P>F	MS	P>F	MS	P>F	MS	P>F
Model	287	139.0*	<.0001	9.1	<.0001	12.4	<.0001	11991.7	<.0001	109.2	<.0001
Year (Y)	2	4327.5	<.0001	7.1	0.2159	501.0	<.0001	486.8	0.0002	1264.0	<.0001
[Rep(Y)]	9	12.2	<.0001	3.9	0.2251	3.1	0.4245	18.0	0.0275	3.0	0.9913
Location (L)	2	11690.4	<.0001	52.5	0.0027	108.6	<.0001	1602.1	<.0001	10468.9	<.0001
Y x L	4	6703.4	<.0001	126.7	<.0001	123.9	<.0001	437.9	<.0001	736.4	<.0001
[Rep x L(Y)]	18	23.8	<.0001	6.3	0.0036	5.8	0.01	14.6	0.0345	10.3	0.7398
Variety (V)	28	125.4	<.0001	33.8	<.0001	36.1	<.0001	116.8	<.0001	107.2	<.0001
L x V	56	34.4	<.0001	5.0	0.0011	3.9	0.0598	13.8	0.0029	17.3	0.0731
Y x V	56	52.1	<.0001	3.1	0.3644	3.8	0.0823	10.5	0.1256	18.8	0.0256
Y x L x V	112	17.0	<.0001	2.4	0.9317	2.1	0.9920	5.4	0.9992	5.5	1.000
[MSE]	7543**	2.7	<.0001	2.9	<.0001	3.0	<.0001	8.6	<.0001	13.4	<.0001

* All MS values are multiplied by 0.001.

** Error df for CP, ADF, NDF and IVDDM = 7332 due to insufficient sample quantities of some samples.

summarized across varieties, years, and sample dates. In previous replicated forage trials at these locations, dry matter yields of numerous species of *Agropyron* , *Leymus*, *Psathyrostachys*, and *Thinopyrum* at Bridger are typically higher than those at Moccasin or Bozeman, but not to the same degree (Cash unpublished data). Bridger has more AGGD and a longer frost-free period than Bozeman or Moccasin. The large differences among locations in this study as well as the interactions of varieties, years and locations were likely due to extrapolation from small sample areas, differences in sampling procedures, or to the larger number of late sampling dates in the season at Bridger. Forage dry matter yields declined steadily from 2974 kg ha^{-1} in 1997, to 979 kg ha^{-1} in 1999, when summarized across varieties, locations and sample dates (Figure 1). This was likely due to low precipitation levels at all locations in 1998 and 1999 (Table 2).

The highest dry matter yields were generally recorded for the intermediate and pubescent wheatgrass varieties, and the lowest for Bannock, Schwendimar, Secar and Goldar (Table 7). Across all observations, Reliant intermediate wheatgrass had significantly higher ($P < 0.05$) forage yields than all other cultivars except Rush, and equivalent to 161% of the mean of all varieties. Goldar had the lowest production across all observations, equivalent to an average of 59% of the trial means. However, due to the significant V x L, V x Y, and V x L x Y interactions, direct varietal comparisons among varieties were confounded. For this reason, statistical comparisons among varieties for dry matter yield are most appropriate for the individual sampling dates within each of the nine location-year combinations (Tables 8-16). Sample dates nearest to June 1, July 15, and September 15 are discussed specifically to provide practical comparison, among

Table 7. Dry matter production (kg ha^{-1}) of 29 dryland forage grasses summarized across annual sample dates and years.

Variety	Across years			Overall Mean
	Bozeman	Bridger	Moccasin	
Douglas	1604.8	2824.3	934.8	1788.0
Hycrest	1883.4	3985.5	1428.6	2432.5
CDII	1969.7	4222.4	1250.9	2481.0
Nordan	1762.3	3326.6	1162.0	2083.6
P-27	1604.3	3610.0	1149.8	2121.4
Vavilov	2064.9	3831.7	1244.7	2380.4
Critana	988.2	2682.1	839.6	1503.3
Bannock	1095.4	2258.9	1025.4	1459.9
Schwendimar	1012.3	2189.1	908.9	1370.1
Pryor	1905.5	3401.1	1378.6	2228.4
Revenue	1488.0	2801.4	1373.8	1887.7
Secar	1329.6	1655.2	948.9	1311.2
Pearl	1491.6	2528.3	616.6	1545.5
Prairieland	1549.3	3274.3	778.8	1867.5
Eejay	1653.6	3269.4	776.9	1900.0
Trailhead	2267.8	2181.2	801.7	1750.2
Magnar	1745.4	3484.5	822.8	2017.6
Lodorm	1533.7	2391.1	1448.8	1791.2
Rosana	1000.0	2340.9	675.7	1338.9
Bozoisky-Select	1353.6	2904.5	610.5	1622.8
Mankota	1081.5	2787.5	550.7	1473.2
Swift	1100.7	2617.5	574.2	1430.8
Goldar	1259.6	1203.6	911.7	1124.9
Greenleaf	1696.2	3946.2	1314.9	2319.1
Luna	2089.2	4189.7	1323.1	2534.0
Manska	2092.3	4441.5	1431.9	2655.2
Oahe	2014.7	5027.2	1566.1	2869.3
Reliant	2543.8	5220.4	1457.7	3074.0
Rush	2544.2	4413.2	1609.4	2855.6
Mean	1634.1	3058.7	1044.5	1912.4
LSD (0.05)	598.3*	1864.2*	523.8*	212.0**

* The Y x V interaction was significant ($P < 0.01$).

** The Y x L x V interaction was significant ($P < 0.01$).

varieties for producers interested in early, middle, and late season dry matter production in Montana.

During the first harvest year at Bozeman (1997), mean dry matter yields of all varieties increased from 520 kg ha^{-1} in mid-May to 3110 kg ha^{-1} in mid-August (Table 8). On June 4, Manska had the highest level of forage production, and was higher ($P < 0.05$) than all other varieties except Luna, Pryor, and CDII. Lodorm produced the least amount of dry matter. Crested wheatgrass is typically utilized as early pasture, and the two improved crested wheatgrass cultivars (Hycrest and CDII) had numerically slightly higher forage production than Douglas or Nordan. By early July, Rush produced more ($P < 0.05$) forage than all varieties except Reliant, Pryor, and Greenleaf. At the late date in October, Reliant and Rush had significantly higher ($P < 0.05$) dry matter production than all other varieties including Altai and Basin wildrye varieties, which are typically utilized for deferred fall grazing (Table 8).

During the second harvest year at Bozeman (1998), mean dry matter yields of all varieties increased from 836 kg ha^{-1} at the end of May to 2222 kg ha^{-1} at the end of July (Table 9). In 1998, Bannock, Schwendimar, Critana and Rosana had slow greenup and recovery from the winter (Table 9). Similar slow greenup was experienced in other stands of these varieties in the Bozeman area in 1998, so this did not appear to be caused by management of the trial. In this second harvest year, Nordan, Trailhead, Vavilov, Eejay, CDII, Hycrest, Bozoisky-Select, and Manska had superior forage yields on May 27. In the second week of July high yielding varieties were Trailhead, Rush, Reliant,

Table 8. Dry matter production (kg ha^{-1}) of 29 dryland grasses at six sampling dates at Bozeman, MT in 1997.

Date:	5/23/97	6/4/97	6/18/97	7/2/97	8/13/97	10/30/97	
Variety							Mean
Douglas	527.4	919.7	1676.7	2114.4	2891.8	2351.9	1747.0
Hycrest	707.2	1107.7	1647.1	2648.8	2866.1	2868.3	1974.2
CD II	708.9	1244.7	2490.1	3041.6	3149.5	3265.6	2316.7
Nordan	560.8	979.6	1742.3	3000.7	2952.6	2851.9	2014.7
P-27	395.0	949.0	1410.1	2220.9	2958.9	2626.9	1760.1
Vavilov	642.3	933.4	1976.4	2762.0	3144.0	2932.5	2065.1
Critana	437.7	821.4	1610.6	2337.3	2564.4	2216.8	1664.7
Bannock	545.9	760.6	1480.8	2371.6	2414.2	2429.1	1667.0
Schwendimar	560.1	871.6	1435.6	2151.2	1982.9	2996.2	1666.3
Pryor	821.9	1643.8	3173.3	4227.9	3682.5	3109.9	2776.5
Revenue	460.6	965.4	2024.5	3250.2	3892.5	2944.2	2256.3
Secar	405.8	605.3	1341.1	2139.2	2323.1	2038.9	1475.6
Pearl	247.4	521.9	810.1	998.6	2907.7	3446.9	1488.7
Prairieland	279.8	620.4	965.1	1963.0	2377.9	3215.1	1570.2
Eejay	249.3	445.9	1064.2	1999.5	3000.5	3179.3	1656.5
Trailhead	384.6	955.8	1584.4	2496.9	3204.1	2965.6	1931.9
Magnar	395.2	746.2	1193.8	1989.9	2782.2	2982.0	1681.5
Lodorm	201.9	396.9	1037.0	1873.6	1832.9	2138.7	1246.8
Rosana	375.0	856.3	1089.9	2516.6	2035.8	2548.8	1570.4
Bozoisky-Select	527.9	850.0	1337.5	1570.4	1755.5	2072.8	1352.4
Mankota	274.3	649.0	1000.0	1405.8	1759.6	1834.6	1153.9
Swift	249.0	443.3	640.9	1218.0	1368.8	1645.2	927.5
Goldar	453.6	820.4	1528.1	1722.4	1956.7	2068.8	1425.0
Greenleaf	631.0	1201.2	1973.1	3446.9	4630.5	3504.6	2564.5
Luna	872.8	1596.4	2145.4	3089.9	4663.9	3269.5	2606.3
Manska	882.2	2013.7	3174.5	3239.7	4834.9	3909.9	3009.1
Oahe	677.9	1601.9	2557.2	3067.5	5228.6	3826.9	2826.7
Reliant	652.6	1567.1	4211.8	4398.8	5788.5	5247.6	3644.4
Rush	950.7	1504.1	3292.3	4636.1	5246.6	5234.1	3477.3
Mean	520.0	985.8	1779.8	2548.3	3110.1	2956.0	1983.3
LSD (0.05)	235.3	429.6	771.9	1299.3	1485.1	1300.0	734.74

Table 9. Dry matter production (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Bozeman, MT in 1998.

Date:	5/27/98	6/11/98	6/24/98	7/8/98	7/22/98	8/20/98	9/24/98	
Variety								Mean
Douglas	754.6	1724.8	1745.7	1813.7	1905.8	1677.6	1578.6	1600.1
Hycrest	1020.9	1535.1	2601.7	2417.8	1977.9	2088.2	2102.6	1963.5
CD II	1090.1	1526.9	2212.5	2691.8	2359.1	2282.0	2178.8	2048.8
Nordan	1242.3	1571.4	2172.6	1824.8	1911.1	1754.8	2002.2	1782.7
P-27	759.6	1215.1	1641.6	1851.2	2916.8	1788.7	1775.2	1706.9
Vavilov	1186.1	1610.3	2397.8	2528.6	2886.5	2059.9	2792.3	2208.8
Critana	382.2	471.6	570.2	720.9	711.1	702.6	810.8	624.2
Bannock	---[1]	---	---	532.9	915.4	382.7	722.4	638.3
Schwendimar	---	---	293.0	546.4	965.1	470.2	837.0	622.4
Pryor	655.5	988.2	1873.1	1659.1	2472.4	1667.5	1870.0	1598.0
Revenue	402.9	579.3	1228.4	1261.1	2226.0	1149.0	1644.7	1213.0
Secar	791.3	876.2	1726.0	1304.6	1223.8	1066.3	1323.6	1187.4
Pearl	826.9	1473.6	1935.6	2109.1	2529.6	2133.7	2243.8	1893.2
Prairieland	885.3	1317.1	1962.3	2012.3	2965.9	2032.0	2247.4	1917.4
Eejay	1141.3	1151.7	2098.3	1577.4	2768.0	1566.1	2815.4	1874.0
Trailhead	1240.9	1841.8	3266.8	3324.3	4642.3	2624.5	2709.4	2807.1
Magnar	628.8	1323.6	1796.6	2009.9	3202.6	2121.4	2828.1	1987.3
Lodorm	863.2	1485.1	1839.7	2520.0	2987.3	2069.0	2349.8	2016.3
Rosana	---	203.4	356.5	517.8	1006.5	1092.8	1237.5	735.7
Bozoisky-Select	959.6	1302.9	1723.8	1670.7	1814.4	1064.9	1773.3	1472.8
Mankota	665.6	899.5	1222.8	1516.1	1223.1	923.3	1351.7	1114.6
Swift	816.3	1111.8	1803.4	1501.9	1433.4	1182.2	1626.7	1353.7
Goldar	609.9	1040.9	1328.8	1221.9	1671.4	756.5	1117.1	1106.6
Greenleaf	678.8	1001.0	1434.4	1519.2	2075.7	1949.0	1548.1	1458.0
Luna	854.8	1405.0	2138.5	2384.1	3192.3	1978.8	2541.8	2070.8
Manska	951.4	1231.7	2275.2	1711.5	2656.3	2713.2	2508.4	2006.8
Oahe	662.7	1374.3	2183.2	2158.2	2063.0	2305.5	2276.2	1860.4
Reliant	916.8	1380.5	2553.1	2860.3	2945.4	2934.1	3241.3	2404.5
Rush	766.8	1517.5	1991.6	3086.8	2795.7	3715.6	3183.4	2436.8
Mean	836.8	1267.5	1912.5	1822.6	2222.1	1732.7	1973.8	1645.2
LSD (0.05)	506.0	707.0	945.4	1292.9	1603.7	1456.3	1432.5	643.84

[1] Poor early season growth in all replications, no samples were taken.

CDII, Vavilov, and Lodorm. On September 24, Reliant, Rush, Magnar, Eejay, Vavilov, and Trailhead provided high levels of dry matter (Table 9).

During the third harvest year at Bozeman (1999), mean dry matter yields of all varieties increased from 230 kg ha^{-1} in mid-May to 2163 kg ha^{-1} in mid-June (Table 10). Similar to 1998, Bannock, Rosana, and Schwendimar experienced a delayed greenup until the middle of June. Trailhead produced significantly more forage than all other varieties except Douglas and Hycrest on June 2. In mid-July Reliant, Magnar, Lodorm, Trailhead, Vavilov, Luna, and Eejay produced high forage yields. In September, Vavilov produced significantly ($P < 0.05$) more forage than all other varieties except Rush, Hycrest, Reliant, and Pryor (Table 10).

In general, the intermediate and pubescent wheatgrass varieties as a group produced more dry matter than the other species in the first two years of the trial. A combination of low precipitation, warmer temperatures and stand decline (lower yields with increasing age of the stand) may explain why this trend was not observed in the final year of the trial. CDII and Hycrest produced numerically higher amounts of dry matter than Douglas and Nordan every year at Bozeman with the exception of Hycrest in 1997 when Nordan was higher (Table 8). Because 1997 was much wetter (Table 2) and was cooler (Table 3) than 1998 and 1999 the decline in overall dry matter production among varieties attributable to stand decline is difficult to quantify beyond speculation. Some possible explanation of disproportional declines of dry matter production may be the differential rooting depths of established stands of these species. Deeper-rooted species would have been able to tap into deeper soil moisture reserves in 1998 and 1999.

Table 10. Dry matter production (kg ha^{-1}) of 29 dryland grasses at eight sampling dates at Bozeman, MT in 1999.

Date:	5/19/99	6/2/99	6/16/99	6/30/99	7/14/99	8/12/99	9/15/99	10/13/99	
Variety									Mean
Douglas	269.2	2179.9	2342.5	1445.1	1842.8	1315.4	1253.4	1091.3	1467.4
Hycrest	301.7	2119.8	2621.6	2330.9	2018.4	1059.3	1866.0	1384.6	1712.7
CD II	335.3	1763.3	2635.1	1646.6	1830.5	1164.1	1568.5	1404.4	1543.4
Nordan	304.1	1461.7	3037.4	1535.7	1913.7	1268.5	1362.4	1037.6	1490.1
P-27	281.3	1274.5	1939.8	1489.5	1908.8	1230.2	1262.6	1378.6	1345.8
Vavilov	314.9	1983.1	2841.9	2109.3	2278.4	2150.1	2329.0	1359.1	1920.8
Critana	161.1	672.8	1044.2	626.1	918.0	616.3	681.5	683.9	675.5
Bannock	---[1]	---	---	746.2	1566.2	776.4	763.0	535.7	981.5
Schwendimar	---	239.2	---	757.0	913.2	651.2	788.2	522.2	748.1
Pryor	127.4	987.9	1841.1	1504.4	1679.4	1250.1	1776.2	1569.1	1341.9
Revenue	86.5	869.0	1139.1	861.7	1555.2	997.0	1166.2	1282.5	994.7
Secar	230.8	1735.8	2144.0	1275.4	1623.0	842.8	1476.0	1280.6	1326.1
Pearl	97.4	1415.0	1209.5	1013.2	1702.3	863.7	1229.0	1215.1	1093.2
Prairieland	204.3	1218.8	1869.5	1123.4	1350.0	951.7	1400.2	1165.9	1160.4
Eejay	145.4	1209.7	1792.3	1612.9	2179.6	1441.3	1525.6	1535.2	1430.2
Trailhead	536.1	3159.7	3778.7	2424.6	2308.5	1208.3	1574.3	1526.8	2064.5
Magnar	280.0	1896.4	2043.6	1979.6	2714.8	1148.8	1225.1	1253.0	1567.6
Lodorm	147.8	1364.4	2172.5	1492.7	2317.3	842.9	1291.8	1076.3	1338.2
Rosana	---	---	---	445.3	747.4	571.9	837.7	866.0	693.7
Bozoisky-Select	399.0	1558.2	1702.2	1426.7	1721.5	872.2	1235.9	971.2	1235.8
Mankota	257.2	1309.0	2036.4	866.7	828.5	617.8	1060.7	832.9	976.2
Swift	319.7	1351.4	2075.1	872.6	1223.4	540.0	937.3	850.8	1021.3
Goldar	198.3	1378.1	1824.9	1462.1	1643.8	908.4	1310.5	1250.0	1247.0
Greenleaf	153.8	871.0	1801.4	1061.9	1522.1	1151.0	1171.3	798.7	1066.3
Luna	217.5	1608.3	2709.5	1781.1	2245.7	1507.1	1336.5	1319.1	1590.6
Manska	158.7	1227.9	1792.1	1239.3	2039.5	1263.8	1135.8	1232.0	1261.2
Oahe	149.0	1546.4	1976.3	1203.7	2120.0	1241.9	1411.7	1209.7	1357.4
Reliant	170.7	1481.6	2454.4	1605.6	2717.7	1052.6	1851.9	1323.7	1582.3
Rush	159.9	1557.5	3399.8	1346.9	2041.0	1555.5	2198.0	1493.1	1718.9
Mean	230.9	1507.7	2162.5	1354.7	1774.9	1071.0	1345.7	1153.4	1307.7
LSD (0.05)	131.9	1041.2	1283.1	882.8	1069.1	665.2	669.6	489.1	730.6

[1] Poor early season growth in all replications, no samples were taken.

Previous trials have demonstrated stand decline is also a major factor in the long-term productivity of many varieties in this trial, but climatic factors make quantifying this factor difficult.

During the first harvest year at Bridger (1997), mean dry matter yields of all varieties increased from 3377 kg ha^{-1} near the end of May to 6244 kg ha^{-1} in mid-July (Table 11). Oahe produced more ($P < 0.05$) dry matter than all other varieties except Reliant, Rush, Luna, Manska, Greenleaf and Hycrest on May 29. In mid-July, Oahe produced more ($P < 0.05$) dry matter than all varieties than Reliant, Pryor, Rush, Hycrest, and Manska. Oahe produced more ($P < 0.05$) forage than all other varieties except Reliant in September (Table 11).

During the second harvest year at Bridger (1998), mean dry matter yields of all varieties increased from 1184 kg ha^{-1} in early May to 4336 kg ha^{-1} in mid-July (Table 12). Luna produced more ($P < 0.05$) forage than all other varieties except Douglas and Reliant on June 5. Reliant, CDII, Luna, Prairieland, Eejay, P-27, and Oahe produced superior dry matter yields in mid-July. Magnar produced more ($P < 0.05$) forage than all other varieties with the exception of Reliant in September (Table 12).

During the third harvest year at Bridger (1999), mean dry matter yields of all varieties increased from 444 kg ha^{-1} in early May to 1325 kg ha^{-1} in mid-July (Table 13). Eejay produced more ($P < 0.05$) forage than all other varieties except Magnar and Prairieland on June 3. On July 15, Magnar produced more ($P < 0.05$) forage than all other varieties. On September 15, Magnar produced more ($P < 0.05$) dry matter than all

Table 11. Dry matter production (kg ha^{-1}) of 29 dryland grasses at eight sampling dates at Bridger, MT in 1997.

Date:	5/29/97	6/12/97	6/26/97	7/10/97	8/8/97	9/8/97	10/8/97	11/7/97	
Variety									Mean
Douglas	2752.4	3233.2	5048.1	4801.7	6826.9	4609.4	4152.6	3671.9	4387.0
Hycrest	5042.1	5805.3	6430.3	9284.9	8587.7	8407.5	8407.5	8076.9	7505.3
CD II	4326.9	6292.1	8143.0	8052.9	9885.8	6658.7	6610.6	10054.1	7503.0
Nordan	4903.8	5228.4	7554.1	8040.9	6989.2	5552.9	5727.2	4909.9	6113.3
P-27	3209.1	5132.2	4741.6	7139.4	8557.7	4988.0	5685.1	5961.5	5676.8
Vavilov	4308.9	4861.8	6412.3	7476.0	7968.8	6195.9	5132.2	6406.3	6095.3
Critana	4200.7	4615.4	6244.0	6995.2	4272.8	5504.8	5552.9	4753.6	5267.4
Bannock	2536.1	5090.1	4945.9	5607.0	4615.4	4332.9	5492.8	3720.0	4542.5
Schwendimar	2542.1	3287.3	4212.7	4777.6	5564.9	4957.9	4002.4	5132.2	4309.6
Pryor	4278.8	5270.4	7566.1	9351.0	7271.6	6899.0	6947.1	7457.9	6880.3
Revenue	3275.2	4879.8	6292.1	7662.3	7920.7	6388.2	5516.8	5625.0	5945.0
Secar	1105.8	2121.4	2512.0	2457.9	2007.2	1875.0	1881.0	1790.9	1968.9
Pearl	1917.1	1406.3	4459.1	2992.8	2253.6	2968.8	4200.7	2692.3	2861.3
Prairieland	1532.5	2656.3	5462.7	4495.2	2614.2	3750.0	3762.0	2902.6	3396.9
Eejay	1364.2	2542.1	2842.5	3924.3	4068.5	3665.9	5168.3	4140.6	3464.5
Trailhead	1965.1	2091.3	2794.5	2391.8	2025.2	2950.7	2854.6	1953.1	2378.3
Magnar	1574.5	2998.8	3762.0	4116.6	5474.8	3912.3	4477.2	4254.8	3821.4
Lodorm	1135.8	2842.5	4104.6	4381.0	3485.6	3786.1	4062.5	3323.3	3390.2
Rosana	2349.8	3738.0	5072.1	4326.9	4585.3	4873.8	5534.9	5631.0	4514.0
Bozoisky-Select	3125.0	4128.6	4867.8	6526.4	4591.3	5306.5	5240.4	4669.5	4806.9
Mankota	2632.2	3695.9	4483.2	4795.7	4254.8	4519.2	4405.0	4861.8	4206.0
Swift	2445.9	4026.4	4104.6	4867.8	3713.9	3335.3	3683.9	3599.8	3722.2
Goldar	829.3	1826.9	1989.2	1526.4	1496.4	1959.1	1935.1	1592.5	1644.4
Greenleaf	5132.2	5402.6	7518.0	7968.8	8227.2	8683.9	7758.4	7722.4	7301.7
Luna	5865.4	5078.1	6814.9	7872.6	7307.7	7067.3	7277.6	7698.3	6872.7
Manska	5204.3	7578.1	8918.3	8954.3	8527.6	8930.3	8870.2	9465.1	8306.0
Oahe	6550.5	7253.6	9543.3	10582.9	11262.0	11021.6	9242.8	10120.2	9447.1
Reliant	5937.5	5967.5	9399.0	10354.6	11298.1	10637.0	9885.8	10234.4	9214.2
Rush	5883.4	6310.1	7704.3	9345.0	8996.4	7506.0	8557.7	7842.5	7768.2
Mean	3376.7	4322.8	5653.1	6243.8	6022.4	5560.1	5587.0	5526.4	5286.5
LSD (0.05)	1511.3	1645.2	2073.3	1833.9	1949.0	1992.5	1618.8	1790.6	808.0

Table 12. Dry matter production (kg ha^{-1}) of 29 dryland grasses ten sampling dates at Bridger, MT in 1998.

Date:	5/8/98	5/22/98	6/5/98	6/19/98	7/10/98	7/31/98	8/21/98	9/18/98	10/23/98	11/23/98	
Variety											Mean
Douglas	805.3	1550.5	3485.6	4361.8	4890.6	5340.1	3508.4	4049.3	3292.1	3316.1	3460.0
Hycrest	2061.3	1754.8	1832.9	3448.3	3298.1	3693.5	3857.0	5311.3	4187.5	4548.1	3399.3
CD II	1286.1	1959.1	2794.5	6008.4	6909.9	4384.6	4367.8	2835.3	4097.4	4091.3	4017.7
Nordan	1201.9	1995.2	2602.2	4217.5	4680.3	3705.5	3201.9	3201.9	3153.8	2829.3	3079.0
P-27	1262.0	1887.0	2247.6	5792.1	6128.6	5778.8	4512.0	5347.4	5317.3	5197.1	4264.7
Vavilov	1947.1	1995.2	2932.7	5437.5	5329.3	5135.8	5924.3	5263.2	4572.1	6002.4	4454.0
Critana	1021.6	1183.9	1682.7	2949.5	3075.7	2046.9	2390.6	3256.0	3220.0	3436.3	2426.3
Bannock	294.5	432.7	1706.7	3093.8	2865.4	2744.0	2060.1	2408.7	1675.5	1345.0	1862.6
Schwendimar	36.8	462.7	925.5	2276.4	2504.8	2143.0	2228.4	3093.8	2438.7	3244.0	1935.4
Pryor	1033.7	937.5	1772.8	2775.2	3051.7	4667.1	3796.9	4313.7	4241.6	4578.1	3116.8
Revenue	781.3	1015.6	1634.6	2619.0	3592.5	3248.8	2384.6	2324.5	2817.3	2667.1	2308.5
Secar	781.3	613.0	1706.7	2462.7	3274.0	2563.7	2540.9	2847.4	2781.3	2492.8	2206.4
Pearl	991.6	1292.1	3317.3	3226.0	3616.6	5652.6	4373.8	3568.5	3995.2	3971.2	3400.5
Prairieland	961.5	2512.0	3365.4	4373.8	6393.0	4420.7	4079.3	3754.8	5022.8	5551.7	4043.5
Eejay	937.5	1820.9	2433.9	4043.3	6224.8	4703.1	5197.1	4157.5	7210.3	6200.7	4292.9
Trailhead	1965.1	1514.4	2848.6	1639.4	2805.3	4180.3	3995.2	2691.1	2450.7	4121.4	2821.2
Magnar	901.4	1574.5	1646.6	2793.3	4313.7	6451.9	5437.5	9325.7	5701.9	5581.7	4372.8
Lodorm	2241.6	3263.2	3197.1	4259.6	3532.5	4438.7	4007.2	3129.8	3123.8	2691.1	3388.5
Rosana	157.0	889.4	1628.6	2072.1	2522.8	3357.0	3105.8	2607.0	2432.7	2703.1	2147.5
Bozoisky-Select	2536.1	2938.7	2908.7	3670.7	3274.0	3615.4	2613.0	3232.0	2468.8	3238.0	2922.1
Mankota	1502.4	2524.0	2866.6	4307.7	3376.2	3699.5	2366.6	2901.4	2691.1	3280.0	2951.6
Swift	2385.8	3239.2	3227.2	4385.8	3123.8	2377.4	1873.8	2847.4	3550.5	3256.0	3026.7
Goldar	835.3	943.5	462.7	2036.1	2408.7	2329.3	1411.1	1056.5	1098.6	2174.3	1475.6
Greenleaf	835.3	1754.8	2710.3	4181.5	5064.9	6295.7	3766.8	3448.3	5052.9	4896.6	3800.7
Luna	985.6	2157.5	4801.7	7576.9	6423.1	5153.8	4620.2	4656.3	5137.0	4307.7	4582.0
Manska	1628.6	1790.9	2494.0	3742.8	5155.0	4186.3	4433.9	6152.6	4169.5	4944.7	3869.8
Oahe	1496.4	2253.6	2524.0	3802.9	5996.4	6367.8	5726.0	5996.4	4950.7	6284.9	4539.9
Reliant	859.4	1820.9	3395.4	6651.4	6970.0	6031.3	5701.9	7300.5	5587.7	5828.1	5014.7
Rush	601.0	1430.3	3173.1	5840.1	4950.7	5009.6	4500.0	5239.2	5383.4	6140.6	4226.8
Mean	1183.9	1707.2	2494.0	3932.7	4336.3	4266.3	3723.6	4060.6	3856.0	4100.7	3358.9
LSD (0.05)	861.5	1032.2	1430.0	2032.2	2380.3	1801.4	2282.6	2307.3	2124.5	2494.7	836.8

Table 13. Dry matter production (kg ha^{-1}) of 29 dryland grasses at ten sampling dates at Bridger, MT in 1999.

Date:	5/6/99	5/20/99	6/3/99	6/17/99	7/2/99	7/15/99	8/16/99	9/15/99	10/15/99	11/15/99	
Variety											Mean
Douglas	358.4	559.3	508.8	776.9	729.4	1126.1	442.6	715.9	585.7	457.5	626.1
Hycrest	522.4	1342.9	972.0	937.9	1208.7	1255.0	941.0	1563.3	1116.6	659.9	1052.0
CD II	934.8	1168.3	1474.4	981.8	1269.8	1369.9	795.8	1158.7	1244.8	1068.5	1146.7
Nordan	440.9	880.6	658.7	945.4	1033.3	858.3	574.4	948.3	892.2	643.8	787.6
P-27	504.3	847.8	1028.8	1061.5	1236.7	1241.1	680.4	790.1	685.9	810.1	888.7
Vavilov	493.8	1028.0	1120.2	1238.4	1088.7	1345.3	707.6	902.2	898.2	635.8	945.8
Critana	252.0	480.0	345.4	458.8	300.2	514.7	371.4	365.4	199.1	239.2	352.6
Bannock	97.0	152.2	373.4	644.2	327.3	422.3	305.3	369.4	571.7	455.5	371.8
Schwendimar	100.2	186.7	265.2	355.4	269.2	423.5	491.6	287.3	479.6	363.4	322.2
Pryor	110.2	118.6	133.0	153.0	139.0	405.4	325.6	329.3	213.1	135.0	206.2
Revenue	52.1	154.6	121.0	155.0	231.2	267.2	167.1	157.1	103.0	103.0	151.1
Secar	457.7	903.8	708.3	800.9	847.9	1085.9	708.8	926.3	669.9	794.1	790.4
Pearl	326.8	479.2	1229.2	2252.0	1771.6	1930.6	1396.7	1091.3	1409.9	1342.9	1323.0
Prairieland	536.3	1173.1	2165.9	3892.1	3393.0	2824.3	2026.4	2268.4	3127.8	2417.9	2382.5
Eejay	759.6	1943.9	2423.9	3781.0	1913.8	2661.1	1708.1	1601.8	2326.9	1388.6	2050.9
Trailhead	337.7	848.6	1629.8	2088.6	2445.2	1115.1	1181.0	1638.6	883.4	1273.2	1344.1
Magnar	502.5	1329.3	2246.0	2547.4	2381.9	4726.3	2791.5	2691.5	1499.6	1877.4	2259.3
Lodorm	314.0	384.6	427.1	412.4	407.4	511.6	322.3	545.7	311.3	311.3	394.8
Rosana	164.3	209.1	223.6	405.4	631.7	415.1	367.4	527.6	383.4	287.3	361.5
Bozoisky-Select	688.3	1255.6	1497.6	1455.9	1408.9	904.3	515.7	649.8	649.8	818.1	984.4
Mankota	788.9	1359.0	1379.8	1209.4	1111.3	1804.3	1026.8	1122.6	1090.5	1160.7	1205.3
Swift	886.5	1785.3	1462.3	1616.7	1306.3	720.4	540.7	868.2	934.3	918.3	1103.9
Goldar	202.3	641.8	641.8	551.0	530.6	712.4	316.5	487.6	395.4	427.5	490.7
Greenleaf	332.6	524.8	770.0	647.4	626.5	1254.4	403.8	1328.9	740.8	734.0	736.3
Luna	595.9	1413.5	1391.8	1414.2	1248.5	1302.2	783.5	1074.5	1026.4	892.2	1114.3
Manska	615.6	1094.6	1209.9	1749.4	1782.5	1353.8	772.3	1020.4	880.2	1008.4	1148.7
Oahe	230.8	778.8	1092.9	1182.9	865.9	1766.4	1011.6	1641.4	1230.8	1144.6	1094.6
Reliant	568.7	782.1	1226.8	1461.7	2246.1	2393.3	1257.5	1523.2	1555.3	1312.9	1432.7
Rush	692.9	1115.4	1336.5	1668.2	1683.6	1708.6	1124.8	1302.9	1008.4	808.1	1244.9
Mean	443.7	859.8	1036.9	1270.5	1187.4	1324.8	829.6	1030.9	934.9	844.5	976.3
LSD (0.05)	390.6	427.1	480.7	826.4	800.6	1283.4	1280.6	745.8	735.0	618.0	322.9

varieties except Prairieland. Thickspike, slender, and western wheatgrass varieties and Lodorm produced less forage than the other varieties throughout the year (Table 13).

The intermediate and pubescent wheatgrasses displayed generally higher production than the other species throughout the trial at Bridger. The improved crested wheatgrass varieties Hycrest and CDII out-produced Douglas and Nordan throughout the trial except in 1998 (Table 12). The wildryes appeared to maintain their level of production better than the other species, producing equal to greater amounts of dry matter in 1999 than crested, intermediate, and pubescent wheatgrass (Table 13). Slender wheatgrass varieties produced proportionately high yields in 1997 (Table 11) but declined in 1998 (Table 12) and 1999 (Table 13) compared to other species.

During the first harvest year at Moccasin (1997), mean dry matter yields of all varieties increased from 284 kg ha^{-1} in mid-May to 3495 kg ha^{-1} near the end of July (Table 14). Hycrest produced more ($P < 0.05$) forage than all other varieties except Pryor, Vavilov, Manska, Rush, Oahe, Revenue, and Lodorm. Oahe produced more ($P < 0.05$) dry matter than all other varieties except Rush, Revenue, Reliant, Manska, Pryor, Hycrest, and Greenleaf in Mid-July. Oahe produced more ($P < 0.05$) forage than all other varieties with the exception of the other intermediate and pubescent varieties, Revenue, Hycrest, and Pryor on July 28 (Table 14). The last sample date in 1997 was July 28 due to a severe hail event.

During the second harvest year at Moccasin (1998), mean dry matter yields of all varieties increased from 149 kg ha^{-1} in early May to 1471 kg ha^{-1} in early September (Table 15). Lodorm produced more ($P < 0.05$) forage than all other varieties except

Table 14. Dry matter production (kg ha^{-1}) of 29 dryland grasses at six sampling dates at Moccasin, MT in 1997.

Date:	5/19/97	6/2/97	6/16/97	6/30/97	7/14/97	7/28/97	
Variety							Mean
Douglas	259.6	551.7	204.3	2803.6	2713.5	3543.3	1679.3
Hycrest	793.3	830.0	34.9	3476.0	4326.9	4913.0	2395.7
CD II	790.9	552.4	49.3	2596.2	3560.1	3941.1	1915.0
Nordan	423.1	513.9	81.7	2956.3	3593.3	3852.2	1903.4
P-27	293.3	554.1	71.6	2412.3	3624.5	3776.4	1788.7
Vavilov	521.6	683.9	69.2	2269.2	3594.5	4188.7	1887.9
Critana	399.0	553.6	284.9	1838.5	2688.7	3852.2	1602.8
Bannock	281.3	415.4	294.0	2500.0	3360.1	4044.5	1815.9
Schwendimar	238.0	327.6	295.7	2159.4	3254.3	3768.0	1673.8
Pryor	447.1	798.8	143.8	3313.2	4378.6	4466.3	2258.0
Revenue	286.1	594.5	520.0	3616.1	4821.6	5330.0	2528.0
Secar	129.8	378.6	124.5	1501.9	1755.5	2650.2	1090.1
Pearl	62.5	106.5	170.2	553.6	599.3	1189.9	447.0
Prairieland	28.8	243.5	194.2	1206.3	1069.7	1869.0	768.6
Eejay	52.9	148.6	203.8	740.4	1692.3	1888.2	787.7
Trailhead	209.1	286.1	344.5	1840.9	2179.1	2638.2	1249.6
Magnar	103.4	185.1	335.3	1396.6	2065.6	2608.2	1115.7
Lodorm	240.4	582.5	653.4	2642.5	2961.1	3209.1	1714.8
Rosana	113.0	152.2	390.1	1660.6	1989.2	2066.1	1061.9
Bozoisky-Select	288.5	503.1	416.6	1595.7	1497.1	1857.0	1026.3
Mankota	221.2	476.7	361.8	1032.0	1414.7	1364.2	811.7
Swift	168.3	389.4	316.1	1382.9	1301.2	1542.1	850.0
Goldar	283.7	370.9	161.1	1974.8	1861.3	2391.8	1173.9
Greenleaf	245.2	504.8	568.0	3146.2	4098.6	4299.3	2143.7
Luna	322.1	509.6	332.5	3507.9	3948.3	5081.7	2283.7
Manska	283.7	677.4	733.2	3306.5	4653.8	5060.1	2452.4
Oahe	360.6	596.9	573.3	3640.6	5052.4	5628.1	2642.0
Reliant	204.3	459.9	720.0	2664.2	4683.4	4921.4	2275.5
Rush	165.9	658.2	801.2	3547.6	4989.2	5414.2	2596.0
Mean	283.7	468.8	326.9	2319.7	3024.0	3495.2	1653.0
LSD (0.05)	144.2	259.6	146.6	762.0	1031.3	1211.5	886.9

Table 15. Dry matter production (kg ha^{-1}) of 29 dryland grasses at six sampling dates at Moccasin, MT in 1998.

Date:	5/8/98	5/26/98	6/22/98	7/13/98	9/4/98	10/6/98	
Variety							Mean
Douglas	86.5	341.3	363.0	841.3	706.7	726.0	510.8
Hycrest	163.5	411.1	901.4	1540.9	1435.1	1228.4	946.7
CD II	226.0	399.0	1098.6	1569.7	1495.2	1201.9	998.4
Nordan	105.8	218.8	793.3	1134.6	1427.9	1341.3	836.9
P-27	134.6	230.8	576.9	1288.5	1259.6	1235.6	787.7
Vavilov	230.8	295.7	829.3	1502.4	1699.5	1545.7	1017.2
Critana	93.8	139.4	351.0	800.5	997.6	1019.2	566.9
Bannock	194.7	370.2	632.2	1067.3	1033.7	1608.2	817.7
Schwendimar	125.0	223.6	451.9	1226.0	1238.0	978.4	707.1
Pryor	91.3	293.3	920.7	1889.4	1865.4	1793.3	1142.2
Revenue	62.5	211.5	649.0	1668.3	2076.9	1512.0	1030.0
Secar	110.6	228.4	572.1	1858.2	1488.0	1641.8	983.2
Pearl	161.1	216.3	379.8	1242.8	1387.0	843.8	705.1
Prairieland	281.3	293.3	473.6	1264.4	1937.5	1189.9	906.7
Eejay	163.5	466.3	959.1	930.3	764.4	949.5	705.5
Trailhead	247.6	336.5	504.8	1257.2	927.9	1019.2	715.5
Magnar	226.0	437.5	492.8	1004.8	1427.9	1000.0	764.8
Lodorm	399.0	528.8	1519.2	2538.5	2593.8	2430.3	1668.3
Rosana	24.0	105.8	310.1	851.0	1161.1	754.8	534.5
Bozoisky-Select	86.5	151.4	415.9	567.3	848.6	641.8	451.9
Mankota	132.2	288.5	420.7	884.6	721.2	653.8	516.8
Swift	79.3	185.1	228.4	826.9	730.8	846.2	482.8
Goldar	149.0	240.4	800.5	1781.3	1576.9	879.8	904.6
Greenleaf	139.4	286.1	764.4	1713.9	1819.7	2028.8	1125.4
Luna	153.8	307.7	925.5	1593.8	1180.3	1336.5	916.3
Manska	113.0	278.8	863.0	1814.9	1930.3	1968.8	1161.5
Oahe	91.3	336.5	1062.5	1884.6	1935.1	2141.8	1242.0
Reliant	170.7	252.4	1084.1	1851.0	2557.7	1954.3	1311.7
Rush	122.6	314.9	1180.3	2180.3	2454.3	2317.3	1428.3
Mean	149.0	288.5	706.7	1399.0	1471.2	1336.5	891.8
LSD (0.05)	141.8	213.9	317.3	718.8	574.5	468.8	378.9

Eejay, Magnar, Hycrest, CDII, Bannock, Douglas, Trailhead, Oahe, and Rush on May 26. On July 13, Lodorm produced more ($P < 0.05$) dry matter than all other varieties except Rush, Pryor, Oahe, Secar, and Reliant. On September 4, Lodorm produced more ($P < 0.05$) forage than all other varieties except Reliant, Rush, and Revenue (Table 15).

During the third harvest year at Moccasin (1999), mean dry matter yields of all varieties increased from 127 kg ha^{-1} in late May to 1250 kg ha^{-1} in mid-September (Table 16). Hycrest produced more ($P < 0.05$) dry matter than all other varieties except Eejay, Lodorm, and CDII on May 24. In mid-July, Lodorm, Magnar, CDII, Eejay, Hycrest, Luna, and Vavilov produced superior amounts of dry matter. Lodorm, P-27, Oahe, Vavilov, Hycrest, Secar, CDII and Reliant had superior forage production in September (Table 16).

As with the other two locations, intermediate and pubescent wheatgrass as a group out-performed the other species throughout the trial at Moccasin. Hycrest and CDII were very productive during all years. Pryor and Revenue produced proportionately high forage yields throughout the trial as well. Lodorm performed more competitively at Moccasin than in Bridger and Bozeman. As a group the wildryes did not perform as strongly in dry matter production as found at Bozeman and Bridger.

Overall, intermediate and pubescent wheatgrass varieties generally out-performed the other varieties in this trial at all locations. CDII and Hycrest usually produced greater amounts of dry matter than Douglas and Nordan. Pryor generally out-performed Revenue throughout the trial as well. Trailhead performed well at all locations throughout the trial but was most dominant at Bozeman. Magnar consistently out-

Table 16. Dry matter production (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1999.

Date:	5/24/99	6/4/99	6/15/99	6/29/99	7/15/99	8/20/99	9/15/99	
Variety								Mean
Douglas	96.2	305.3	536.1	507.2	644.2	1081.7	1274.0	634.8
Hycrest	293.3	336.5	882.2	1050.5	1113.0	1430.3	1580.5	955.5
CD II	213.9	343.8	875.0	564.9	1233.2	1055.3	1544.5	833.1
Nordan	153.8	415.9	627.4	682.7	1028.8	843.8	1406.3	736.0
P-27	125.0	370.2	514.4	644.2	1012.0	1673.1	1772.8	872.3
Vavilov	199.5	300.5	757.2	742.8	1088.9	1050.5	1622.6	827.1
Critana	103.4	338.9	293.3	302.9	336.5	365.4	685.1	346.4
Bannock	108.2	348.6	192.3	254.8	629.8	680.3	904.6	444.6
Schwendimar	93.8	276.4	137.0	271.6	351.0	552.9	721.2	343.8
Pryor	50.5	295.7	637.0	548.1	939.9	1264.4	1394.2	732.4
Revenue	115.4	293.3	334.1	399.0	754.8	980.8	1095.7	567.6
Secar	129.8	286.1	603.4	887.0	805.3	1137.0	1562.5	771.6
Pearl	88.9	521.6	408.7	420.7	653.8	1389.4	1394.2	695.7
Prairieland	132.2	322.1	555.3	536.1	435.1	1158.7	1370.2	643.9
Eejay	252.4	504.8	401.4	673.1	1177.9	1293.3	1472.4	825.0
Trailhead	72.1	209.1	351.0	430.3	620.2	740.4	685.1	445.0
Magnar	175.5	387.0	355.8	471.2	1269.2	622.6	884.1	595.8
Lodorm	223.6	252.4	817.3	673.1	1290.9	1579.3	1875.0	958.6
Rosana	48.1	396.6	230.8	305.3	307.7	887.0	829.3	429.9
Bozoisky-Select	170.7	247.6	314.9	189.9	259.6	509.6	799.3	355.2
Mankota	115.4	281.3	274.0	283.7	329.3	391.8	661.1	333.8
Swift	108.2	298.1	439.9	343.8	435.1	456.7	679.1	394.6
Goldar	125.0	418.3	461.5	338.9	766.8	911.1	1520.4	649.0
Greenleaf	74.5	226.0	430.3	485.6	757.2	1353.4	1232.0	671.5
Luna	139.4	394.2	764.4	625.0	1110.6	1168.3	1226.0	775.5
Manska	69.7	300.5	456.7	488.0	826.9	1257.2	1436.3	690.3
Oahe	74.5	360.6	519.2	598.6	1009.6	1562.5	1634.6	822.3
Reliant	74.5	300.5	567.3	608.2	774.0	1627.4	1532.5	783.1
Rush	74.5	379.8	509.6	680.3	1009.6	1502.4	1460.3	802.9
Mean	127.4	334.1	490.4	516.8	790.9	1052.9	1250.0	653.0
LSD (0.05)	91.3	NS*	281.3	300.5	526.4	543.3	485.6	254.6

* The F test for variety effect was not significant at the 0.05 level.

performed Trailhead at Bridger. No specific wildrye variety was dominant consistently throughout the trial at Moccasin. Bozoisky-Select was dominant among the Russian wildryes at Bozeman, but no Russian wildrye variety was consistently dominant at Bridger or Moccasin in the trial. Goldar, Secar, and Lodorm were generally out-performed by most other varieties at Bridger and Bozeman, but performed more competitively at Moccasin. The wildryes were less competitive at Moccasin than at Bozeman and Bridger. The combination of extreme precipitation lows and highs, and apparent differences in relative competitiveness among species at each location resulted in few varieties or species showing dominance across locations throughout the trial with the obvious exception of the intermediate and pubescent wheatgrasses.

Forage Quality

For the three-year period, concentrations of CP, ADF, NDF, and IVDDM were predicted for 7619 samples using NIRS.

Crude Protein Concentration

In the overall analysis of variance for CP concentration, the main effects of varieties (V) and locations (L) and interactions Y x L, and L x V (Table 6) were significant ($P < 0.01$) sources of variation. The main effect year (Y) and interactions Y x V and Y x V x L were not significant ($P > 0.05$). Valid comparisons across locations were confounded by significant interactions involving locations. Summarization of data across years and sample dates within locations is possible due to the non-significance of

the Y x V interaction (Table 6). Again, for practical comparisons, individual sample dates near June 1, July 15, and September 15 for 1997, 1998, and 1999 are discussed at each location.

Due to the non-significant interaction of Y x V when locations were analyzed separately, mean CP concentration can be summarized across sample dates and years for Bozeman, Bridger, and Moccasin (Table 17, Fig. 2). CP concentrations were similar at Bozeman and Bridger, but lower at Moccasin. The shallow soil profile at Moccasin limits the amount of water that may be stored prior to the growing season. The combination of low precipitation during two growing seasons and a relatively smaller potential soil moisture reserve compared to the other locations may explain why plants may not have been able to access and utilize the applied nitrogen fertilizer and did not experience elevated levels of CP at Moccasin.

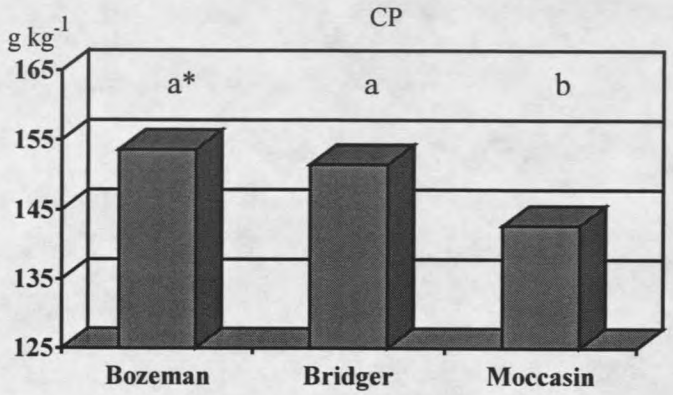
At Bozeman, Manska and Eejay had significantly higher ($P < 0.05$) mean CP concentrations than all other varieties except Pearl, Prairieland, Swift, Rosana, Bozoisky-Select, Mankota, Rush, Schwendimar, Trailhead, Reliant, Magnar, Secar, Luna, and Douglas (Table 17). Douglas had significantly higher ($P < 0.05$) CP concentration than Hycrest and CDII (Table 17). As a group the wildryes had higher levels of CP than the other species in the trial at Bozeman. Lodorm had had the lowest CP concentration at Bozeman followed by Hycrest and CDII.

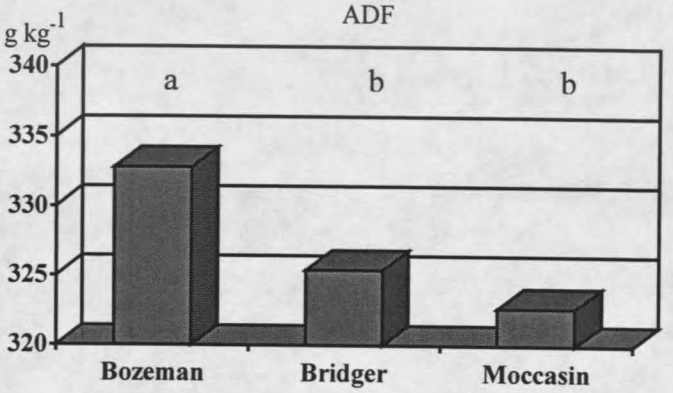
During the first harvest year at Bozeman (1997), mean CP concentrations of all varieties declined from 240 g kg^{-1} on May 23, to 75 g kg^{-1} at the end of October (Table 18). Eejay had significantly higher ($P < 0.05$) CP concentration than all other varieties

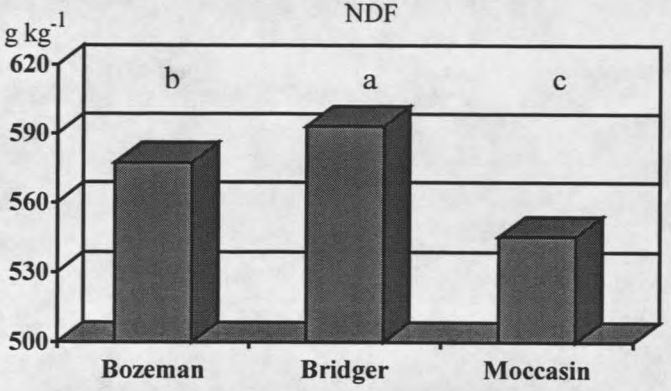
Table 17. Crude protein concentrations (g kg^{-1}) of 29 dryland forage grasses summarized across annual sample dates and years.

Variety	Across years			Overall Mean
	Bozeman	Bridger	Moccasin	
Douglas	155.0	158.7	150.1	154.6
Hycrest	132.9	142.4	139.2	138.2
CDII	133.7	140.1	134.7	136.2
Nordan	140.8	141.8	133.3	138.6
P-27	145.9	141.5	146.3	144.6
Vavilov	148.5	134.5	132.3	138.4
Critana	143.5	138.9	140.4	140.9
Bannock	140.8	142.2	132.8	138.6
Schwendimar	159.7	152.4	140.1	150.7
Pryor	130.8	130.9	136.3	132.7
Revenue	144.6	146.0	137.2	142.6
Secar	156.9	136.5	149.6	147.7
Pearl	168.6	173.6	154.1	165.4
Prairieland	168.4	175.3	148.4	164.0
Eejay	169.3	176.8	159.1	168.4
Trailhead	158.9	158.0	165.1	160.6
Magnar	157.1	166.7	152.5	158.8
Lodorm	122.2	114.5	122.5	119.7
Rosana	167.2	170.1	145.8	161.0
Bozoisky-Select	165.3	153.6	163.1	160.7
Mankota	163.2	158.4	158.6	160.1
Swift	167.5	161.8	167.5	165.6
Goldar	148.7	132.1	147.6	142.8
Greenleaf	151.7	156.8	145.4	151.3
Luna	156.2	152.3	140.9	149.8
Manska	169.3	164.4	130.8	154.8
Oahe	147.2	155.0	130.8	144.4
Reliant	158.1	156.1	129.2	147.8
Rush	160.5	156.4	135.7	150.8
Mean	153.6	151.5	142.7	149.3
LSD (0.05)	17.2	13.9	14.5	9.3*

* The V x L interaction was significant ($P < 0.01$).







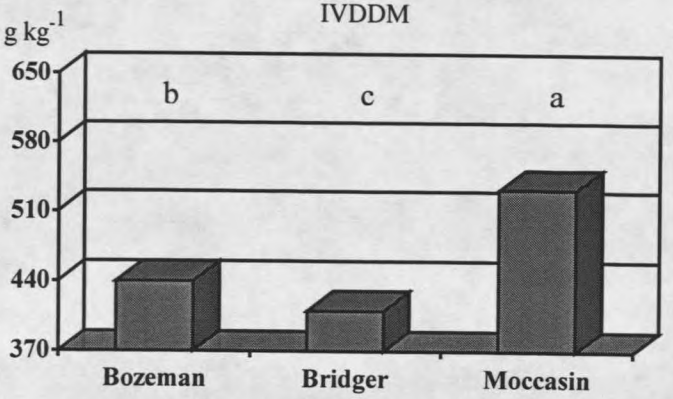


Figure 2. Summary of forage quality across years, varieties, and sample dates.
*Bars within each graph denoted by different letters are significantly different ($P < 0.05$). Locations have significant interactions with varieties or years for most traits (Table 6).

Table 18. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses over five sampling dates at Bozeman, MT in 1997.

Date:	5/23/97	6/4/97	6/18/97	7/2/97	10/30/97	
Variety						Mean
Douglas	259.3	211.9	138.7	116.2	74.8	160.2
Hycrest	204.6	169.8	108.6	69.3	61.2	122.7
CD II	220.3	173.8	110.0	77.5	60.1	128.3
Nordan	239.6	172.8	129.7	98.4	59.9	140.1
P-27	244.1	182.1	126.2	89.5	70.6	142.5
Vavilov	232.0	176.7	141.1	102.3	61.0	142.6
Critana	212.6	148.8	90.9	83.8	64.0	120.0
Bannock	216.9	155.4	108.3	85.9	102.3	133.8
Schwendimar	222.8	189.1	147.8	118.3	103.7	156.3
Pryor	240.6	153.4	108.1	87.3	56.6	129.2
Revenue	234.3	177.1	117.4	63.9	48.7	128.3
Secar	242.1	209.8	129.0	101.2	93.5	155.1
Pearl	244.8	221.5	157.1	145.1	85.9	170.9
Prairieland	258.7	215.4	189.2	142.5	95.4	180.2
Eejay	243.7	228.4	175.6	143.5	68.0	171.8
Trailhead	259.3	219.9	160.0	122.3	75.5	167.4
Magnar	250.4	210.1	161.5	139.3	79.6	168.2
Lodorm	224.5	180.3	111.8	73.2	32.7	124.5
Rosana	261.1	206.0	144.1	102.2	96.8	162.0
Bozoisky-Select	243.4	198.5	133.8	108.5	63.6	149.6
Mankota	237.6	205.7	138.2	98.5	63.8	148.8
Swift	232.0	198.3	140.6	106.8	89.0	153.3
Goldar	222.5	176.9	133.6	98.2	80.4	142.3
Greenleaf	247.6	194.9	146.2	117.9	70.4	155.4
Luna	246.2	186.9	130.3	104.1	89.0	151.3
Manska	266.3	203.6	155.9	124.6	88.6	167.8
Oahe	258.0	193.7	134.2	112.0	67.7	153.1
Reliant	241.8	217.6	150.0	113.2	73.6	159.2
Rush	262.1	211.7	142.7	126.7	88.4	166.3
Mean	240.3	192.7	136.6	105.9	74.6	150.0
LSD (0.05)	24.8	24.1	25.7	31.5	27.8	40.1

except Pearl, Trailhead, Reliant, Douglas, Rush, Magnar, Secar, Rosana, and Mankota on June 4. On July 2, Pearl had significantly higher ($P < 0.05$) CP concentration than all other varieties except Eejay, Prairieland, Magnar, Rush, Manska, Trailhead, Schwendimar, and Douglas. In October, Schwendimar, Bannock, Rosana, Prairieland, Secar, Swift and Luna maintained relatively high levels of CP (Table 18).

During the second year of harvest at Bozeman (1998), mean CP concentrations for all varieties declined from 216 g kg^{-1} on May 27, to 107 g kg^{-1} on September 24 (Table 19). Due to delayed growth in the spring Bannock, Schwendimar and Rosana and remained mostly vegetative throughout the year with most plants not producing seed. Declines in CP concentration occurred later in the season for these three varieties and would not be especially representative of most stands being utilized for grazing and hay production in Montana at present. Across season comparisons of these varieties versus the other cultivars in this study may not be meaningful. Rush had significantly higher ($P < 0.05$) CP concentration than all other varieties than Luna, Manska, Mankota, Douglas, Oahe, Reliant, Prairieland, Swift, and P-27 on May 27. On July 8, Rosana had significantly higher ($P < 0.05$) CP concentration than all other varieties except Schwendimar, Mankota, Bozoisky-Select, and Eejay. On September 24, Rosana had significantly higher ($P < 0.05$) CP concentration than all other varieties except Schwendimar, Bannock, Swift, Mankota, Pearl, Eejay, P-27, Luna, Goldar, Magnar, and Critana (Table 19).

In the third year of harvest at Bozeman (1999), mean CP concentrations of all varieties declined from 268 g kg^{-1} on May 19, to 106 g kg^{-1} in mid-October (Table 20).

Table 19. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses at seven sampling dates at Bozeman, MT in 1998.

Date:	5/27/98	6/11/98	6/24/98	7/8/98	7/22/98	8/20/98	9/24/98	
Variety								Mean
Douglas	230.0	188.8	174.2	137.8	128.6	111.3	97.3	152.6
Hycrest	200.7	172.3	159.2	111.0	110.9	85.1	99.0	134.0
CD II	198.9	171.7	158.7	120.5	121.7	76.7	82.6	133.0
Nordan	214.1	169.1	159.0	121.0	112.2	89.3	97.4	137.4
P-27	223.4	174.9	162.7	114.2	104.1	87.9	114.9	140.3
Vavilov	220.8	186.6	159.6	130.4	126.4	89.9	99.4	144.7
Critana	196.1	178.8	173.7	145.8	140.8	124.6	110.4	152.9
Bannock	217.2	198.7	192.5	124.7	145.4	127.5	135.0	163.0
Schwendimar	211.0	199.9	212.0	164.8	182.5	150.1	141.8	180.3
Pryor	195.5	146.3	133.3	99.9	94.2	71.5	86.5	118.2
Revenue	214.8	179.3	166.8	136.8	124.4	99.0	82.5	143.4
Secar	218.6	184.0	161.0	137.4	138.8	108.6	105.1	150.5
Pearl	220.7	201.2	169.3	145.1	120.6	117.7	123.6	156.9
Prairieland	225.3	177.1	176.1	139.8	127.7	124.5	107.4	154.0
Eejay	215.2	196.6	170.8	152.1	144.6	120.7	119.2	159.9
Trailhead	218.8	191.4	164.6	137.6	125.5	119.6	103.3	151.5
Magnar	205.0	187.5	166.6	131.5	129.9	106.6	111.9	148.4
Lodorm	161.1	124.3	116.9	87.6	95.4	66.0	78.3	104.2
Rosana	210.9	219.2	239.3	183.6	180.9	139.5	144.0	188.2
Bozoisky-Select	219.6	188.8	175.1	153.9	149.9	153.1	98.3	162.7
Mankota	234.4	176.9	175.8	158.7	159.3	134.5	127.3	166.7
Swift	224.7	177.5	199.8	145.5	173.7	163.7	128.4	173.3
Goldar	207.5	184.1	166.5	139.5	113.1	124.2	112.5	149.6
Greenleaf	208.5	184.3	172.5	131.2	111.1	119.9	86.1	144.8
Luna	238.5	191.1	163.1	147.9	124.7	111.8	113.2	155.8
Manska	235.8	209.3	187.0	135.6	135.0	120.4	107.1	161.5
Oahe	227.6	176.0	157.5	132.2	93.4	88.8	89.9	137.9
Reliant	226.3	199.6	167.3	123.6	131.9	107.8	102.2	151.2
Rush	250.8	194.3	172.7	146.6	125.8	86.6	105.6	154.6
Mean	216.3	183.8	170.8	135.7	130.1	111.2	107.2	150.7
LSD (0.05)	29.3	28.7	29.1	31.6	33.2	31.1	35.6	23.39

Table 20. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bozeman, MT in 1999.

Date:	5/19/99	6/2/99	6/16/99	6/30/99	7/14/99	8/12/99	9/15/99	10/13/99	
Variety									Mean
Douglas	260.6	222.8	172.3	144.8	132.1	94.4	100.3	90.5	152.2
Hycrest	243.3	202.9	146.9	146.2	120.1	93.9	88.3	93.9	141.9
CD II	250.8	203.1	152.8	151.5	106.2	79.3	89.5	84.3	139.7
Nordan	257.3	205.9	158.6	137.3	117.8	99.1	93.9	88.5	144.8
P-27	269.6	234.3	158.4	143.9	125.7	103.0	104.1	100.5	154.9
Vavilov	263.9	222.0	183.9	144.6	138.6	115.3	109.9	86.6	158.1
Critana	264.8	208.9	173.5	142.0	135.5	117.2	109.0	109.8	157.6
Bannock	---[1]	---	---	170.2	125.2	106.1	105.1	107.7	125.8
Schwendimar	---	---	---	190.1	150.5	118.7	127.5	125.8	142.5
Pryor	281.8	200.4	158.2	158.4	130.4	78.9	76.4	76.0	145.1
Revenue	283.2	232.5	196.7	155.1	150.5	83.6	104.7	91.4	162.2
Secar	272.7	207.9	186.1	158.4	132.3	120.2	118.5	125.0	165.1
Pearl	269.3	234.5	193.3	188.0	163.8	135.2	123.2	117.3	178.1
Prairieland	258.9	221.9	194.3	142.2	165.2	146.9	126.8	112.1	171.0
Eejay	281.9	228.4	200.0	141.7	168.8	140.2	125.3	122.2	176.1
Trailhead	252.1	225.8	164.7	150.7	142.3	115.0	104.4	106.3	157.7
Magnar	255.2	225.5	158.0	178.7	121.7	97.4	102.7	98.4	154.7
Lodorm	264.9	187.5	141.9	133.6	108.3	89.7	90.3	86.3	137.8
Rosana	---	---	---	156.2	186.1	154.4	141.8	119.0	151.5
Bozoisky-Select	285.3	236.5	211.3	191.0	164.3	124.1	135.2	120.8	183.6
Mankota	271.0	240.8	193.0	164.4	155.5	138.3	116.5	113.4	174.1
Swift	283.8	231.6	197.3	153.5	169.0	138.6	120.9	112.9	176.0
Goldar	263.3	207.5	169.3	151.6	133.6	114.2	97.2	96.1	154.1
Greenleaf	254.5	202.3	159.8	148.5	132.0	104.6	129.9	107.6	154.9
Luna	268.0	228.9	180.3	155.2	127.7	99.6	116.1	117.6	161.7
Manska	288.5	235.5	184.5	179.7	165.7	126.8	129.6	118.6	178.6
Oahe	259.0	202.8	167.9	133.6	126.4	105.8	103.2	106.8	150.7
Reliant	275.3	230.4	170.6	153.8	146.9	104.0	113.6	115.7	163.8
Rush	279.7	211.8	167.2	157.8	129.9	109.3	116.1	112.7	160.6
Mean	267.6	218.9	174.6	155.9	140.4	112.2	111.0	105.6	157.7
LSD (0.05)	28.4	32.3	32.6	NS*	36.1	33.8	24.3	26.4	30.13

[1] Poor early season growth in all replications, no samples were taken.

* The F test for variety effect was not significant at the 0.05 level.

Again, Bannock, Schwendimar, and Rosana experienced delayed growth in the spring and did not produce sufficient dry matter for sampling until June 30 and remained basically vegetative throughout the sampling year with most plants not producing seed. Numerically, on June 2, Mankota had the highest CP concentration, followed by Bozoisky-Select, Manska, Pearl, Reliant, and Revenue. On July 14, Rosana had significantly higher ($P < 0.05$) CP concentration than all other varieties except Swift, Eejay, Manska, Prairieland, Bozoisky-Select, Pearle, Mankota, Revenue, and Schwendimar. On September 15, Rosana had significantly higher ($P < 0.05$) CP concentration than all other varieties except Bozoisky-Select, Greenleaf, Schwendimar, Manska, Prairieland, Eejay, Pearl, Swift and Secar (Table 20).

Bridger mean CP concentrations across sample dates and years were similar to those at Bozeman. Eejay had significantly higher ($P < 0.05$) CP concentration than all other varieties except Prairieland, Pearl, Rosana, Magnar, and Manska (Table 17). Douglas had significantly higher ($P < 0.05$) CP concentration than Hycrest, CDII, and Nordan. All other varieties had significantly higher ($P < 0.05$) CP concentration than Lodorm. Like Bozeman, the wildryes generally had higher CP concentrations than the other species with the exception of Manska and Rosana (Table 17).

During the first harvest year at Bridger (1997), mean CP concentrations of all varieties declined from 192 g kg^{-1} on May 29, to 117 g kg^{-1} in November (Table 21). There was significant dry matter production at Bridger prior to the first harvest date and plants were further along phenologically than the other two locations at their first harvest dates. Sampling began at Bridger earlier in May in the subsequent years of the trial to get

Table 21. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bridger, MT in 1997.

Date:	5/29/97	6/12/97	6/26/97	7/10/97	8/8/97	9/8/97	10/8/97	11/7/97	
Variety									Mean
Douglas	209.4	171.6	162.0	92.0	127.3	135.6	154.6	143.7	153.3
Hycrest	192.8	182.4	166.1	122.3	114.2	119.3	86.9	110.5	136.8
CD II	174.6	153.9	150.0	89.3	97.7	128.9	104.2	135.5	132.9
Nordan	189.1	171.1	129.2	79.3	95.4	127.6	120.6	134.3	134.1
P-27	179.7	134.3	145.1	75.1	106.6	123.4	116.9	109.3	126.9
Vavilov	195.3	158.1	143.9	114.9	109.5	108.2	113.9	126.8	133.8
Critana	160.7	123.6	117.9	125.2	91.7	118.5	96.7	94.8	116.1
Bannock	164.2	133.5	120.2	125.5	70.6	153.8	125.1	113.4	128.7
Schwendimar	177.9	152.2	127.9	125.5	101.0	137.0	134.6	110.9	133.4
Pryor	178.2	160.7	151.7	71.7	89.3	92.7	88.6	72.9	116.2
Revenue	199.5	180.0	146.7	89.4	124.3	132.7	108.4	106.0	140.4
Secar	181.5	149.4	134.9	117.4	113.3	143.9	136.7	146.1	140.4
Pearl	209.5	198.8	190.2	160.6	157.7	198.3	143.4	123.1	172.7
Prairieland	221.3	190.8	181.2	154.8	141.5	194.7	153.1	125.7	170.4
Eejay	228.2	193.8	174.6	161.1	153.3	183.1	137.4	110.1	167.7
Trailhead	207.3	188.4	175.8	110.4	133.1	151.8	121.3	101.6	153.3
Magnar	214.5	179.4	173.6	136.6	150.1	153.3	111.4	104.1	152.9
Lodorm	162.1	126.3	106.3	58.8	99.9	107.5	54.0	58.7	99.1
Rosana	210.4	155.6	159.9	158.6	128.1	152.4	124.8	117.2	150.9
Bozoisky-Select	192.5	159.0	157.6	142.4	110.2	152.4	133.5	111.7	144.9
Mankota	186.1	165.7	160.2	113.7	142.4	154.7	144.1	109.0	151.7
Swift	180.4	158.2	189.7	123.9	104.1	190.1	142.3	142.5	158.2
Goldar	194.0	148.6	147.0	105.0	116.9	143.6	119.3	112.5	135.9
Greenleaf	208.3	162.5	141.2	123.9	126.7	125.4	107.8	141.2	142.1
Luna	171.4	141.5	149.5	114.6	133.3	139.4	123.7	159.0	141.6
Manska	194.8	172.3	158.1	100.5	125.2	131.1	119.2	124.5	144.9
Oahe	189.7	169.7	131.9	129.1	109.8	132.1	120.8	112.1	136.9
Reliant	196.1	151.2	149.0	119.1	122.2	141.7	110.4	106.4	137.0
Rush	198.6	169.8	150.9	123.3	117.8	127.1	123.9	115.9	140.9
Mean	192.0	162.1	151.4	116.0	117.7	141.4	119.9	116.5	141.2
LSD (0.05)	24.1	27.1	29.1	53.2	34.3	26.4	30.7	27.5	16.3

a more representative sampling of early season CP concentration at this location. On May 29, Eejay had significantly higher ($P < 0.05$) CP concentrations than all other varieties except Prairieland, Magnar, Rosana, Pearl, Douglas, Greenleaf, and Trailhead. On July 10, Eejay had the highest CP concentration numerically, followed by Pearl, Rosana, Prairieland, Bozoisky-Select, and Magnar. Pearl had significantly higher ($P < 0.05$) CP concentration than all other varieties except Prairieland, Swift, and Eejay on September 8 (Table 21).

During the second harvest year at Bridger (1998), mean CP concentrations of all varieties declined from 255 g kg^{-1} on May 8, to 80 g kg^{-1} in November (Table 22). On June 5, Rosana had significantly higher ($P < 0.05$) CP concentration than all other varieties. Eejay had significantly higher ($P < 0.05$) CP concentration than all other varieties except Pearl, Prairieland, Rosana, Bozoisky-Select, Magnar, Trailhead, Mankota, Manska, and Critana on July 10. On September 18, Schwendimar had significantly higher ($P < 0.05$) CP concentration than all other varieties except Eejay, Rosana, Prairieland, Bozoisky-Select, Swift, Mankota, Pearl, Rush, Manska, Magnar, Bannock, and Reliant (Table 22).

During the third harvest year at Bridger (1999), mean CP concentrations of all varieties declined from 242 g kg^{-1} on May 6, to 105 g kg^{-1} in November (Table 23). On June 3, Manska had significantly higher ($P < 0.05$) CP concentration than all other varieties except Magnar, Prairieland, Greenleaf, Eejay, Reliant, Rosana, Pearl, Oahe, Douglas, and Rush. Eejay had significantly higher ($P < 0.05$) CP concentration than all other varieties except Rosana and Pearl on July 15. On September 15, Prairieland had

Table 22. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses at ten sampling dates at Bridger, MT in 1998.

Date:	5/8/98	5/22/98	6/5/98	6/19/98	7/10/98	7/31/98	8/21/98	9/18/98	10/23/98	11/23/98	
Variety											Mean
Douglas	260.3	234.5	169.6	173.2	162.0	113.9	125.4	100.9	81.7	77.4	149.9
Hycrest	259.8	206.4	178.6	166.0	158.1	105.1	100.6	80.7	69.9	43.9	136.9
CD II	214.4	196.4	158.6	158.5	151.6	91.3	96.3	87.2	68.4	60.0	128.3
Nordan	229.2	208.4	188.4	164.9	148.2	112.4	104.2	99.5	69.0	50.5	137.5
P-27	237.0	187.2	162.7	165.2	141.4	94.8	97.1	87.4	51.7	90.3	131.5
Vavilov	226.6	164.2	156.2	140.5	150.2	89.7	77.1	84.2	47.2	73.8	121.0
Critana	260.0	233.0	195.2	158.1	166.4	108.9	101.7	101.0	93.9	83.6	150.2
Bannock	271.9	231.7	192.5	162.3	152.7	115.9	108.0	111.4	98.3	103.4	154.8
Schwendimar	266.0	236.3	202.5	163.9	152.9	113.9	116.1	142.2	118.0	124.3	163.6
Pryor	257.8	204.1	185.5	154.8	122.7	87.7	86.3	78.5	68.1	53.7	129.9
Revenue	238.3	214.3	175.7	145.1	142.3	113.8	106.0	105.3	90.2	84.2	141.5
Secar	234.0	182.4	160.0	129.5	139.4	98.5	98.8	92.9	80.9	80.2	129.7
Pearl	289.5	245.6	202.4	196.4	193.0	141.1	152.4	126.1	92.3	76.4	171.5
Prairieland	274.9	218.9	191.1	210.2	191.0	149.3	151.5	137.4	102.4	90.0	171.7
Eejay	288.6	245.8	191.8	189.5	197.5	136.6	141.2	139.0	105.1	85.6	172.1
Trailhead	234.7	201.7	178.1	180.8	169.2	110.9	129.8	97.7	89.5	87.0	147.9
Magnar	254.2	234.8	197.1	191.5	171.0	115.1	142.7	114.1	99.7	94.5	161.5
Lodorm	182.1	132.6	140.0	114.1	116.3	81.9	90.6	75.8	54.4	52.7	104.1
Rosana	253.8	280.3	259.6	210.5	185.6	138.2	144.1	138.3	87.9	92.5	179.1
Bozoisky-Select	244.2	178.7	178.3	173.3	172.6	123.3	125.4	131.3	96.4	72.3	149.6
Mankota	243.2	214.0	179.6	157.4	168.5	117.1	143.1	127.7	87.7	90.3	152.9
Swift	257.0	221.3	162.2	179.3	145.5	140.8	141.5	131.3	116.5	99.9	159.5
Goldar	219.7	166.7	163.5	150.9	125.0	94.0	94.2	89.6	62.2	73.4	123.9
Greenleaf	281.7	234.0	174.0	168.4	153.4	107.6	98.3	104.4	79.6	76.5	147.8
Luna	264.4	219.9	175.6	148.9	146.3	95.5	108.4	87.8	68.5	85.2	140.1
Manska	287.6	263.3	197.1	179.4	166.5	105.6	107.8	117.6	96.5	82.3	160.4
Oahe	294.2	246.1	203.7	178.7	161.8	110.8	100.6	101.2	79.6	68.0	154.5
Reliant	278.7	241.9	187.1	165.8	150.6	112.5	107.2	111.0	75.4	94.5	152.5
Rush	285.3	237.5	188.5	150.0	159.7	105.3	109.6	124.5	64.2	70.0	149.5
Mean	254.8	216.6	182.6	166.4	157.3	111.4	114.0	107.8	82.6	79.9	147.3
LSD (0.05)	37.0	34.0	40.2	24.1	31.4	26.5	31.5	33.1	31.6	29.7	26.9

Table 23. Crude protein concentrations (g kg^{-1}) of 29 dryland grasses at nine sampling dates at Bridger, MT in 1999.

Date:	5/6/99	5/20/99	6/3/99	6/17/99	7/15/99	8/16/99	9/15/99	10/15/99	11/15/99	
Variety										Mean
Douglas	220.4	224.5	211.7	208.9	173.4	145.8	126.1	129.6	115.1	172.8
Hycrest	245.1	204.5	204.6	178.5	144.9	127.6	103.5	88.1	85.5	153.6
CD II	249.1	216.1	198.0	192.6	137.8	111.4	104.8	118.4	104.1	159.1
Nordan	214.1	198.4	192.9	185.3	150.2	119.2	108.8	113.5	102.2	153.8
P-27	257.9	238.6	202.6	196.8	155.9	117.1	111.2	109.3	105.8	166.1
Vavilov	208.0	191.3	194.8	190.2	140.3	108.4	95.9	104.9	104.7	148.7
Critana	230.7	209.1	185.8	177.4	136.1	106.0	101.2	107.0	99.5	150.3
Bannock	234.6	201.0	179.4	150.1	127.9	105.1	101.9	104.0	83.4	143.0
Schwendimar	218.9	226.1	194.0	167.1	150.6	129.0	120.4	125.0	111.2	160.3
Pryor	243.8	227.9	187.8	169.3	137.2	94.8	90.6	96.6	71.4	146.6
Revenue	172.5	198.6	191.8	204.9	154.5	121.2	125.7	129.1	114.0	156.9
Secar	213.7	195.5	174.7	144.7	126.9	108.2	97.4	94.9	100.5	139.6
Pearl	232.6	211.4	218.6	220.6	176.4	161.5	143.3	123.0	102.7	176.7
Prairieland	258.2	243.0	235.8	207.4	169.9	161.8	158.1	131.6	89.1	183.9
Eejay	264.9	242.2	226.6	196.1	199.2	167.6	153.1	144.6	96.9	187.9
Trailhead	260.2	226.3	205.5	195.3	171.9	143.5	118.4	121.3	112.0	172.7
Magnar	273.9	240.5	236.8	216.6	168.8	149.4	126.4	145.8	110.3	185.4
Lodorm	201.4	184.5	184.6	167.3	119.2	109.8	107.3	98.7	91.1	140.4
Rosana	242.9	230.4	221.6	207.9	178.3	150.6	143.8	140.8	107.6	180.4
Bozoisky-Select	240.6	212.4	207.4	172.2	142.9	116.0	151.8	142.1	112.6	166.4
Mankota	249.3	216.9	204.0	194.0	165.4	130.4	137.6	128.4	109.0	170.6
Swift	252.7	222.9	188.7	176.6	152.9	131.8	144.4	135.5	102.7	167.6
Goldar	213.5	207.8	154.0	154.3	115.9	104.0	91.2	92.9	95.2	136.5
Greenleaf	275.9	265.7	227.1	201.3	166.0	127.5	117.7	130.5	112.6	180.5
Luna	287.7	242.7	211.2	187.9	150.9	120.4	119.6	136.1	121.4	175.3
Manska	270.1	281.5	238.6	212.4	166.5	134.7	128.5	136.1	123.0	187.9
Oahe	263.7	247.2	212.6	192.9	159.9	127.1	117.7	129.7	113.5	173.8
Reliant	239.6	265.1	222.0	205.4	163.4	136.8	125.2	133.2	120.1	179.0
Rush	280.0	241.0	211.4	193.4	169.3	145.4	118.2	128.7	120.9	178.7
Mean	241.9	224.6	204.3	188.5	154.2	128.0	120.3	121.3	104.8	165.3
LSD (0.05)	33.7	36.2	30.5	27.2	24.2	24.7	19.8	23.0	19.5	24.53

significantly higher ($P < 0.05$) CP concentration than all other varieties except Eejay, Bozoisky-Select, Swift, Rosana, and Pearl (Table 23).

At Moccasin, Swift had significantly higher ($P < 0.05$) mean CP concentration than all other varieties except Trailhead, Bozoisky-Select, Eejay, Mankota, and Pearl (Table 17). Douglas had significantly higher ($P < 0.05$) CP concentration than CDII and Nordan (Table 17). Like Bozeman and Bridger, the wildryes as a group had higher CP concentrations than the other species. Lodorm had the lowest CP concentration at Moccasin followed by Reliant, Manska, and Oahe (Table 17).

During the first harvest year at Moccasin (1997), mean CP concentrations of all varieties declined from 229 g kg^{-1} on May 19, to 89 g kg^{-1} in July 28 (Table 24). In 1997, Magnar had significantly higher ($P < 0.05$) CP concentration than all other varieties except Rosana, P-27, Swift, Trailhead, Eejay, Rush, Greenleaf, Prairieland, and Revenue on June 2. On July 14, Swift had significantly higher ($P < 0.05$) CP concentration than all other varieties except Eejay, Pearl, Trailhead, Prairieland, Mankota, Secar, Rosana, and Douglas. On July 28, Eejay had significantly higher ($P < 0.05$) CP concentration than all other varieties except Trailhead, Pearl, Swift, Prairieland, Magnar, Douglas, Bozoisky-Select, and Secar (Table 24).

During the second harvest year at Moccasin (1997), mean CP concentrations of all varieties declined from 207 g kg^{-1} on May 8, to 72 g kg^{-1} on October 6 (Table 25). Trailhead had significantly higher ($P < 0.05$) CP concentration than all other varieties except Magnar, Bozoisky-Select, Greenleaf, Schwendimar, Goldar, Revenue, Mankota, Nordan, Critana, Luna, Rosana, and Oahe on June 5. On July 13, Swift had significantly

Table 24. Crude protein concentrations (kg ha^{-1}) of 29 dryland grasses at five sampling dates at Moccasin, MT in 1997.

Date:	5/19/97	6/2/97	6/30/97	7/14/97	7/28/97	
Variety						Mean
Douglas	238.6	220.8	154.5	114.9	101.1	166.0
Hycrest	228.6	199.6	138.3	103.4	96.5	153.3
CD II	214.1	200.7	114.4	80.4	70.5	136.0
Nordan	219.3	193.4	107.4	62.5	67.8	130.1
P-27	236.9	234.6	117.3	90.4	69.5	149.7
Vavilov	219.1	214.5	110.7	67.8	63.1	135.0
Critana	231.7	214.0	129.7	102.7	88.7	153.4
Bannock	226.8	209.3	125.8	78.1	92.9	146.6
Schwendimar	234.0	204.3	128.8	90.8	68.1	145.2
Pryor	222.4	200.0	106.8	91.8	72.5	138.7
Revenue	228.8	219.9	102.7	74.6	56.1	136.4
Secar	239.3	214.9	153.0	120.1	97.6	165.0
Pearl	228.3	214.0	183.2	150.9	133.8	182.0
Prairieland	183.4	219.9	162.6	143.2	116.8	165.2
Eejay	231.3	226.7	154.6	152.3	135.2	180.0
Trailhead	231.5	227.8	175.5	146.2	135.0	183.2
Magnar	228.9	244.8	151.6	109.9	104.7	168.0
Lodorm	225.5	200.7	116.9	95.9	71.0	142.0
Rosana	217.0	240.8	126.1	119.7	91.6	159.0
Bozoisky-Select	237.8	218.4	128.4	106.9	99.7	158.2
Mankota	245.2	217.2	146.4	122.4	89.1	164.1
Swift	254.7	229.4	167.9	154.8	117.5	184.9
Goldar	234.0	208.5	132.9	108.3	85.5	153.8
Greenleaf	241.0	221.3	132.0	100.0	86.9	156.2
Luna	221.3	204.2	124.5	93.9	86.0	146.0
Manska	223.8	198.7	111.1	77.1	71.5	136.4
Oahe	225.9	206.5	101.2	71.3	72.1	135.4
Reliant	227.7	184.5	112.5	81.9	62.5	133.8
Rush	241.2	223.6	122.9	88.9	68.9	149.1
Mean	228.9	214.2	132.4	103.5	88.7	153.5
LSD (0.05)	NS*	25.8	43.1	41.1	39.1	40.1

* The F test for variety effect was not significant at the 0.05 level.

Table 25. Crude protein concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1998.

Date:	5/8/98	5/26/98	6/5/98	6/22/98	7/13/98	9/4/98	10/6/98	
Variety								Mean
Douglas	211.0	181.7	179.0	162.7	159.4	84.5	86.9	152.2
Hycrest	213.7	183.3	166.0	155.5	140.6	79.5	67.9	143.8
CD II	206.2	188.8	165.8	142.2	136.4	71.6	67.3	139.8
Nordan	228.8	205.4	187.1	150.0	131.9	83.3	67.9	150.6
P-27	238.1	218.3	182.3	167.5	156.0	79.2	72.2	159.1
Vavilov	215.1	192.0	170.8	150.6	137.5	79.3	78.3	146.2
Critana	179.5	195.4	186.6	160.7	133.7	62.2	56.5	139.2
Bannock	180.9	174.1	162.5	136.4	118.2	67.3	77.0	130.9
Schwendimar	167.9	188.9	194.7	164.2	125.5	78.2	78.0	142.5
Pryor	228.1	192.9	171.1	155.8	122.1	63.0	63.8	142.4
Revenue	214.5	216.1	191.2	166.1	127.8	67.8	59.5	149.0
Secar	205.8	199.4	182.1	158.8	142.9	73.9	74.1	148.1
Pearl	189.3	196.8	177.1	170.6	148.7	82.9	83.5	149.8
Prairieland	196.3	185.2	168.4	147.8	144.9	76.9	84.9	143.5
Eejay	184.8	200.9	178.5	164.6	153.1	88.0	93.5	151.9
Trailhead	231.0	218.4	205.1	180.3	155.6	79.1	85.4	165.0
Magnar	246.8	222.1	198.6	186.9	142.6	78.8	69.4	163.6
Lodorm	167.1	166.5	157.0	132.3	118.0	61.8	55.2	122.6
Rosana	175.4	183.0	184.5	166.6	148.3	79.1	45.7	140.4
Bozoisky-Select	219.7	203.5	198.5	181.2	159.5	98.4	80.6	163.1
Mankota	194.7	196.6	190.6	157.4	157.2	90.3	78.2	152.1
Swift	206.0	179.8	178.4	175.1	182.5	83.9	74.8	154.4
Goldar	221.3	188.7	191.8	168.7	157.1	78.2	80.0	155.1
Greenleaf	205.8	196.0	195.1	153.2	127.4	74.6	70.7	146.1
Luna	222.7	205.8	186.1	162.9	143.6	72.0	70.2	151.9
Manska	217.1	194.0	175.4	151.3	128.8	60.4	62.8	141.4
Oahe	215.7	206.0	183.4	150.3	119.4	68.4	63.9	143.9
Reliant	205.2	203.7	179.0	134.4	114.2	60.0	59.1	136.5
Rush	207.3	193.6	181.4	152.3	132.5	68.1	65.9	143.0
Mean	206.7	195.7	181.6	158.8	140.2	75.5	71.5	147.1
LSD (0.05)	34.6	30.0	22.6	NS*	28.7	18.9	18.3	29.2

* The F test for variety effect was not significant at the 0.05 level.

higher ($P < 0.05$) CP concentration than all other varieties except Bozoisky-Select, Douglas, Mankota, Goldar, P-27, and Trailhead. On September 4, Bozoisky-Select had significantly higher ($P < 0.01$) CP concentration than all other varieties except Mankota, Eejay, Douglas, Swift, Nordan, Pearl, and Hycrest (Table 25).

During the third harvest year at Moccasin (1999), mean CP concentrations of all varieties declined from 194 g kg^{-1} on May 24, to 71 g kg^{-1} on August 20 (Table 26). Bozoisky-Select had significantly higher ($P < 0.05$) CP concentration than all other varieties except Swift, Mankota, Trailhead, Eejay, Douglas, Goldar, Pearl, Prairieland, and Rosana on June 4. On July 15, Trailhead had significantly higher ($P < 0.05$) CP concentration than all other varieties except Bozoisky-Select, Schwendimar, Mankota, Magnar, Eejay, Rosana, Greenleaf, and CDII. On September 15, Bozoisky-Select had significantly higher ($P < 0.05$) CP concentration than all other varieties except Mankota, Swift, Rosana, Eejay, and Prairieland (Table 26).

Overall, the wildryes out-performed the other cultivars throughout the trial. Douglas had higher CP concentration than the other crested wheatgrass varieties throughout the trial. Manska had higher CP concentration than the other wheatgrass varieties throughout the trial at Bridger and Bozeman. Greenleaf had the highest CP levels among the wheatgrasses two of the three years at Moccasin. Revenue was more dominant than Pryor at Bozeman and Bridger, but this trend was reversed at Moccasin where Pryor out-performed Revenue two out of three years. Swift was the most dominant Russian wildrye at Bridger and Bozeman, but Bozoisky-Select out-performed Swift two out of three years at Moccasin. Lodorm generally had the lowest CP

Table 26. Crude protein concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1999.

Date:	5/24/99	6/4/99	6/15/99	6/29/99	7/15/99	8/20/99	9/15/99	
Variety								Mean
Douglas	191.6	192.0	160.7	125.0	104.6	73.7	76.9	132.1
Hycrest	169.9	176.0	143.2	102.4	96.2	79.0	78.2	120.7
CD II	199.7	187.4	145.0	121.2	110.0	65.1	70.5	128.4
Nordan	188.4	170.2	142.0	114.3	99.4	59.9	61.2	119.3
P-27	200.3	185.0	153.0	126.2	100.3	71.4	73.8	130.0
Vavilov	169.1	167.5	140.9	103.8	100.3	58.2	68.9	115.5
Critana	197.3	174.9	158.9	125.1	96.5	60.2	86.6	128.5
Bannock	202.6	164.3	147.1	111.9	96.2	53.7	70.0	120.8
Schwendimar	159.0	182.2	162.7	120.3	127.0	83.9	92.5	132.5
Pryor	232.6	181.2	156.9	92.4	94.9	54.7	82.4	127.9
Revenue	179.7	175.3	168.5	130.1	100.8	56.6	73.5	126.4
Secar	201.2	175.5	172.9	137.2	96.8	77.0	89.4	135.7
Pearl	195.5	190.1	151.4	116.2	99.3	74.7	86.3	130.5
Prairieland	200.8	189.6	151.0	121.2	105.1	84.0	103.5	136.5
Eejay	198.2	197.0	171.4	124.6	115.9	99.3	110.5	145.3
Trailhead	208.8	210.1	170.6	143.4	141.9	67.0	88.3	147.2
Magnar	187.9	179.9	152.4	129.3	119.5	47.7	65.0	126.0
Lodorm	186.3	144.7	123.4	91.1	74.0	39.0	61.5	102.9
Rosana	173.7	189.4	163.0	130.6	114.2	83.5	111.4	138.0
Bozoisky-Select	234.8	224.8	196.5	158.9	134.0	91.3	135.4	168.0
Mankota	230.5	214.4	180.5	152.2	126.1	90.4	123.5	159.7
Swift	219.7	224.1	184.6	149.8	131.4	110.8	123.4	163.4
Goldar	199.2	190.3	155.0	132.6	93.4	83.7	83.9	134.0
Greenleaf	191.2	186.0	168.4	113.0	113.0	74.5	91.4	133.9
Luna	198.1	175.2	147.5	113.7	96.0	57.1	86.2	124.8
Manska	184.6	160.3	141.6	101.4	94.6	54.6	66.0	114.7
Oahe	183.8	150.2	136.8	99.9	89.6	63.3	68.9	113.2
Reliant	165.5	157.3	137.4	109.9	96.4	76.3	77.9	117.2
Rush	183.6	158.5	138.8	107.8	91.5	60.0	64.3	114.9
Mean	194.2	181.8	155.9	120.9	105.5	70.7	85.2	130.6
LSD (0.05)	40.8	35.9	36.2	33.0	33.2	29.1	32.8	26.78

concentration of all varieties throughout the trial. Pryor and Secar also had relatively low levels of CP, especially at Bridger.

A standard belief is that standing dead forage of these varieties after frost should contain less than six percent CP. A possible explanation why CP levels continue at a higher level late in the season in this trial may be the fact that the plots were fertilized. Nitrogen fertilizer stimulates vegetative growth and plants in the trial may have as a result remained vegetative later into the growing season and maintained higher CP concentrations as they matured (Murphy and Cash, unpublished data 1995).

Acid Detergent Fiber Concentration

In the overall analysis of variance for ADF concentration, the main effects varieties, locations, years, and the Y x L interaction were highly significant ($P < 0.01$). Interactions for L x V, Y x V, and Y x L x Y were found to be non-significant ($P > 0.05$) (Table 6). Figure 2 indicates Bozeman had higher mean ADF concentration than Bridger and Moccasin. When locations were analyzed separately, the main effects year and variety at all locations were significant ($P < 0.05$) but the interaction Y x V was non-significant ($P > 0.05$) at all locations (Tables 27 to 29). This allowed valid summarization of ADF concentration across sample dates and years within each individual location. Tables are available to compare ADF concentrations of varieties within individual sample dates and years at each location (Appendix C).

In 1998 and 1999 at Bozeman, Bannock, Schwendimar, and Rosana had delayed growth in the spring and remained mostly vegetative throughout both seasons with very

Table 27. Overall analyses of variance for forage yield and quality across all sample dates at Bozeman, MT in 1997, 1998 and 1999.

		Dry matter (kg ha^{-1})		CP (g kg^{-1})		ADF (g kg^{-1})		NDF (g kg^{-1})		IVDDM (g kg^{-1})	
	df	MS	P>F	MS	P>F	MS	P>F	MS	P>F	MS	P>F
Model	95	15.0*	<.0001	6.3	<.0001	15.4	<.0001	25.3	<.0001	71.0	<.0001
Year (Y)	2	153.8	<.0001	14.4	0.0398	423.1	<.0001	462.9	<.0001	2111.6	<.0001
[Y x Rep]	9	3.9	0.0219	3.1	0.4507	2.6	0.6329	11.4	0.0071	6.0	0.9106
Variety (V)	28	27.1	<.0001	12.7	<.0001	13.8	<.0001	36.0	<.0001	56.0	<.0001
Y x V	56	6.7	<.0001	3.1	0.4937	3.3	0.4431	6.5	0.0192	12.3	0.6732
[MSE]	2284**	1.8	<.0001	3.1	<.0001	3.3	<.0001	4.5	<.0001	13.5	<.0001

* All MS values are multiplied by 0.001.
** Error df for CP, ADF, NDF and IVDDM = 2188.

Table 28. Overall analyses of variance for forage yield and quality across all sample dates at Bridger, MT in 1997, 1998 and 1999.

		Dry matter (kg ha^{-1})		CP (g kg^{-1})		ADF (g kg^{-1})		NDF (g kg^{-1})		IVDDM (g kg^{-1})	
	df	MS	P>F	MS	P>F	MS	P>F	MS	P>F	MS	P>F
Model	95	282.5*	<.0001	13.1	<.0001	14.7	<.0001	48.1	<.0001	23.5	<.0001
Year (Y)	2	8428.5	<.0001	159.0	0.0017	290.6	0.0003	469.6	<.0001	264.9	0.0003
[Y x Rep]	9	64.4	<.0001	11.2	<.0001	12.7	<.0001	32.6	0.0004	11.2	0.3958
Variety (V)	28	182.6	<.0001	23.5	<.0001	18.9	<.0001	100.1	<.0001	38.3	<.0001
Y x V	56	87.3	<.0001	2.7	0.4370	3.1	0.1807	9.5	0.8823	9.6	0.6914
[MSE]	3152**	3.9	<.0001	2.7	<.0001	2.7	<.0001	12.2	<.0001	10.7	<.0001

* All MS values are multiplied by 0.001.
** Error df for CP, ADF, NDF and IVDDM = 3036.

Table 29. Overall analysis of variance for forage yield and quality across all sample dates at Moccasin, MT in 1997, 1998 and 1999.

		Dry matter (kg ha^{-1})		CP (g kg^{-1})		ADF (g kg^{-1})		NDF (g kg^{-1})		IVDDM (g kg^{-1})	
	df	MS	P>F	MS	P>F	MS	P>F	MS	P>F	MS	P>F
Model	95	14.1*	<.0001	6.5	<.0001	6.0	<.0001	21.4	<.0001	26.4	<.0001
Year (Y)	2	344.4	<.0001	101.6	<.0001	54.2	<.0001	477.1	<.0001	343.3	<.0001
[Y x Rep]	9	1.7	0.4472	2.8	0.5506	0.8	0.9886	7.3	0.4968	7.2	0.9271
Variety (V)	28	14.1	<.0001	10.1	<.0001	12.7	<.0001	23.7	<.0001	44.6	<.0001
Y x V	56	4.7	<.0001	2.0	0.9841	1.6	0.9990	5.8	0.9269	7.7	0.9999
[MSE]	2107**	1.7	<.0001	3.2	<.0001	3.2	<.0001	7.8	<.0001	17.3	0.0011

* All MS values are multiplied by 0.001.
** Error df for CP, ADF, NDF and IVDDM = 2108.

few plants producing seed so ADF concentration increased later in the year than the other varieties. Comparisons of these varieties versus the other cultivars may not be meaningful in 1998 and 1999.

Due to the non-significant interaction of Y x V when locations were analyzed separately, mean ADF concentration can be summarized across sample dates and years for Bozeman, Bridger, and Moccasin (Tables 27 to 29). Practical comparisons within species were used to contrast varieties during sample dates nearest to June 1, July 15, and September 15.

At Bozeman, mean ADF concentrations ranged from 314 g kg^{-1} to 388 g kg^{-1} among varieties when averaged across sample dates and years (Table 30). Vavilov had higher ADF concentration than all other varieties ($P < 0.05$). CDII had significantly higher ($P < 0.05$) ADF concentration than Douglas. Pryor had significantly higher ($P < 0.05$) ADF concentration than Revenue. Luna had significantly higher ($P < 0.05$) ADF concentration than Manska. Critana and Bannock had significantly higher ($P < 0.05$) ADF concentration than Schwendimar at Bozeman (Table 30).

At Bridger, mean ADF concentrations ranged from 300 g kg^{-1} to 354 g kg^{-1} among varieties when averaged across years and sample dates (Table 30). Pryor had significantly higher ($P < 0.05$) ADF concentration than all other varieties except Lodorm, Secar, Critana, and Bannock. Critana had significantly higher ($P < 0.05$) ADF concentration than Schwendimar. Pryor had significantly higher ($P < 0.05$) ADF concentration than Revenue. Luna had significantly higher ($P < 0.05$) ADF concentration than Manska at Bridger (Table 30).

Table 30. Acid detergent fiber (g kg^{-1}) concentrations of 29 dryland forage grasses summarized across annual sample dates and years.

Variety	Across years			Overall Mean
	Bozeman	Bridger	Moccasin	
Douglas	323.2	311.8	305.2	313.4
Hycrest	339.6	321.0	317.7	326.1
CDII	341.3	323.6	320.9	328.6
Nordan	336.3	322.1	320.0	326.1
P-27	338.1	328.1	316.8	327.6
Vavilov	388.3	328.1	327.5	347.9
Critana	354.8	349.1	336.9	346.9
Bannock	356.1	347.2	346.5	349.9
Schwendimar	335.0	332.3	337.5	334.9
Pryor	370.2	354.0	336.0	353.4
Revenue	337.7	322.1	328.7	329.5
Secar	335.9	349.9	336.6	340.8
Pearl	325.7	307.8	320.4	318.0
Prairieland	325.6	311.7	326.1	321.1
Eejay	328.0	313.0	323.3	321.4
Trailhead	348.3	324.0	313.4	328.6
Magnar	338.6	320.2	318.1	325.6
Lodorm	356.3	350.5	351.7	352.8
Rosana	319.1	300.2	316.1	311.8
Bozoisky-Select	320.0	325.1	295.3	313.5
Mankota	313.6	316.8	304.2	311.5
Swift	317.6	320.3	297.5	311.8
Goldar	340.2	326.6	320.0	329.0
Greenleaf	335.8	323.1	318.9	325.9
Luna	344.2	331.9	328.9	335.0
Manska	322.7	316.9	326.1	321.9
Oahe	336.2	324.8	326.9	329.3
Reliant	327.0	320.5	327.4	325.0
Rush	332.5	323.7	336.2	330.8
Mean	332.8	325.4	322.7	326.9
LSD (0.05)	18.0	15.0	12.9	9.48*

* The Y x L was significant ($P < 0.01$).

At Moccasin, mean ADF concentrations ranged from 295 g kg^{-1} to 352 g kg^{-1} among varieties when averaged across years and sample dates (Table 30). Lodorm had significantly higher ($P < 0.05$) ADF concentration than all other varieties. Douglas had significantly lower ($P < 0.05$) ADF concentration than Hycrest, CDII, and Nordan. Rush had significantly higher ($P < 0.05$) ADF concentration than Greenleaf at Moccasin (Table 30).

Overall, Russian wildrye varieties generally had the lowest ADF concentrations when averaged across years and locations. Lodorm and Pryor consistently had the highest ADF concentrations when averaged across years and locations. Revenue had lower ADF concentration than Pryor throughout the trial. Douglas had the lowest concentration of the crested wheatgrasses and CDII had the highest. Prairieland had the lowest ADF concentration of the Altai and Basin wildryes, while Trailhead was the highest of the group at Bridger and Bozeman. The exact opposite of this trend was found at Moccasin, where Trailhead had the lowest ADF concentration and Prairieland was highest. Mankota had the lowest ADF concentration of the Russian wildryes at Moccasin. This trend was reversed at Bozeman and Bridger, where Bozoisky-Select was lowest and Mankota highest. At Bozeman and Bridger, Manska had the lowest ADF concentration of the intermediate and pubescent wheatgrass varieties, and Luna the highest of the group. At Moccasin, Greenleaf had the lowest concentration in the intermediate and pubescent wheatgrass group, with Rush having the highest.

The ADF concentrations at the end of the season appear to be lower in this study than previous trials with these species in Montana (White and Wight 1981; White and

Wight 1984; White 1986). A possible explanation of this could be that fertilization of the trials in the spring could have provided enough additional N to stimulate or maintain vegetative production later into the season. Since the ADF equation generated by the NIRS software met all quality control criteria, the estimates generated by that equation should be considered to be valid and representative of the actual concentrations in the samples analyzed.

Neutral Detergent Fiber Concentration

In the overall analysis of variance for NDF concentration, highly significant effects ($P < 0.01$) were varieties, locations, years, and the interactions Y x L and L x V (Table 6). Interactions for Y x V and V x L x V were found to be non-significant ($P > 0.05$) (Table 6). Figure 2 indicates that Bridger had significantly higher ($P < 0.05$) mean NDF concentration than Bozeman and Moccasin. Moccasin had significantly lower ($P < 0.05$) mean NDF concentration than Bozeman. This is probably due to Bridger having a greater number of late sample dates than Bozeman, and Moccasin having fewer late sample dates than Bozeman. Locations were also analyzed separately and significant differences ($P < 0.05$) were found for the main effects year and variety for all locations (Tables 27 to 29). The Y x V interaction for NDF at Bozeman was significant ($P < 0.05$) (Table 27) but non-significant ($P > 0.05$) at Bridger (Table 28) and Moccasin (Table 29). This allows for the valid summarization of NDF concentration at Bridger and Moccasin across years and sample dates (Table 31). Bozeman NDF concentrations are discussed for individual sample dates closest to June 1, July 15, and September 15. Tables are

Table 31. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland forage grasses summarized across annual sample dates and years.

Variety	Across years			Overall Mean
	Bozeman	Bridger	Moccasin	
Douglas	567.5	573.3	526.9	555.9
Hycrest	590.4	585.7	532.2	569.4
CDII	588.4	591.9	544.1	574.8
Nordan	587.8	600.9	540.7	576.5
P-27	581.9	595.1	539.4	572.1
Vavilov	586.0	592.5	546.8	575.1
Critana	597.0	632.4	553.5	594.3
Bannock	594.4	618.3	570.1	594.3
Schwendimar	575.4	608.3	569.7	584.5
Pryor	626.7	644.1	570.0	613.6
Revenue	590.7	634.0	564.5	596.4
Secar	597.4	622.5	544.8	588.2
Pearl	569.0	546.3	531.6	549.0
Prairieland	568.0	548.9	540.8	552.6
Eejay	576.3	584.1	541.3	567.2
Trailhead	576.8	562.2	527.8	555.6
Magnar	567.0	565.8	538.6	557.1
Lodorm	649.4	679.9	607.2	645.5
Rosana	543.7	556.2	524.9	541.6
Bozoisky-Select	590.3	613.8	520.1	574.7
Mankota	583.1	606.6	549.0	579.6
Swift	597.2	611.0	528.3	578.8
Goldar	585.8	606.4	539.6	577.3
Greenleaf	558.0	576.0	531.9	555.3
Luna	565.7	585.8	538.7	563.4
Manska	546.7	560.1	541.0	549.2
Oahe	566.2	580.3	541.2	562.6
Reliant	561.3	577.9	537.9	559.0
Rush	559.9	573.5	551.7	561.7
Mean	577.3	593.2	545.3	572.0
LSD (0.05)	25.1*	26.0	24.2	15.9**

* The Y x V interaction was significant ($P < 0.02$).

** The Y x L and V x L interactions were significant ($P < 0.01$).

available to compare NDF concentrations of varieties within individual sample dates and years at Bridger and Moccasin (Appendix C). At Bozeman, Bannock, Schwendimar, and Rosana had delayed growth in the spring and most plants remained vegetative in 1998 and 1999, so declines in NDF concentration occurred later in the growing season for these three varieties. Comparisons between these varieties and the other cultivars may not be meaningful in 1998 and 1999.

At Bridger, mean NDF concentrations ranged from 546 g kg^{-1} to 680 g kg^{-1} among varieties when averaged across years and sample dates (Table 31). Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties. Nordan had significantly higher ($P < 0.05$) NDF concentration than Douglas. Eejay had significantly higher ($P < 0.05$) NDF concentration than Pearl and Prairieland (Table 31).

At Moccasin, mean NDF concentrations varied from 520 g kg^{-1} to 607 g kg^{-1} among varieties when averaged across years and sample dates (Table 31). Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties. Mankota had significantly higher ($P < 0.05$) NDF concentration than Bozoisky-Select (Table 31).

Below normal precipitation in May at Bozeman was followed by a very wet June (Table 2) that triggered additional vegetative growth and caused NDF concentrations to decrease in late July, likely causing the significant ($P < 0.05$) interaction of Y x V at Bozeman. Similar precipitation patterns were also evident at Bridger and Moccasin but the interactions were highly non-significant ($P > 0.88$) (Tables 28 and 29).

The mean NDF concentrations at Bozeman in 1997 increased from 477 g kg^{-1} on May 23, to 691 g kg^{-1} at the end of October (Table 32). Lodorm had significantly higher

Table 32. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at five sampling dates at Bozeman, MT in 1997.

Date:	5/23/97	6/4/97	6/18/97	7/2/97	10/30/97	
Variety						Mean
Douglas	444.3	567.5	619.0	658.9	709.3	599.8
Hycrest	493.8	597.2	648.4	683.1	687.5	622.0
CD II	472.1	595.2	702.1	681.7	700.2	630.3
Nordan	465.3	574.1	668.1	682.4	734.2	624.8
P-27	461.8	601.0	673.1	682.7	713.3	626.4
Vavilov	477.2	616.0	642.4	696.0	729.7	632.3
Critana	493.3	638.1	691.1	676.6	718.5	643.5
Bannock	511.2	630.1	675.9	709.5	692.0	643.7
Schwendimar	523.2	602.8	633.0	674.8	700.8	626.9
Pryor	477.7	631.7	708.1	738.5	780.1	667.2
Revenue	483.2	578.9	638.2	689.6	764.4	630.9
Secar	518.7	584.0	671.8	683.0	694.6	630.4
Pearl	473.8	554.3	622.8	626.0	631.3	581.6
Prairieland	468.0	574.2	570.1	633.4	619.0	572.9
Eejay	484.1	574.4	598.2	646.8	678.0	596.3
Trailhead	442.6	516.0	596.7	637.3	688.1	576.1
Magnar	441.6	535.0	568.3	599.2	634.8	555.8
Lodorm	542.9	646.6	671.7	721.5	745.0	665.5
Rosana	448.2	557.0	625.4	632.6	624.8	577.6
Bozoisky-Select	483.1	597.4	655.7	692.2	719.1	629.5
Mankota	488.0	592.6	642.5	710.1	724.7	631.6
Swift	507.0	618.6	645.2	698.6	687.8	631.4
Goldar	524.9	609.4	631.4	620.0	663.7	609.9
Greenleaf	446.0	558.4	592.6	624.5	684.9	581.3
Luna	457.0	579.7	629.8	666.8	662.6	599.2
Manska	439.1	574.8	608.1	635.7	645.3	580.6
Oahe	423.8	557.4	613.6	644.9	696.6	587.3
Reliant	488.3	557.5	628.6	659.7	670.8	601.0
Rush	444.7	560.6	636.3	648.8	640.2	586.1
Mean	476.7	585.5	638.2	667.4	691.1	611.8
LSD (0.05)	36.6	37.9	49.4	46.7	58.7	53.65

($P < 0.05$) NDF concentration than all other varieties except Critana, Pryor, Bannock, Swift, Vavilov, and Goldar on June 4. Trailhead had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Magnar. On July 2, Pryor had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Lodorm, Mankota, Bannock, Swift, Vavilov, and Bozoisky-Select. Magnar had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Goldar, Greenleaf, Rosana, Pearl, Prairieland, Manska, Trailhead, and Oahe on July 2. In October, Pryor had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Revenue, Lodorm, Nordan, Vavilov, and Mankota. Prairieland had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Rosana, Pearl, Magnar, Rush, Manska, Luna, Goldar, and Reliant in October (Table 32).

In 1998, NDF concentration increased from 526 g kg^{-1} on May 27, to 619 g kg^{-1} on July 8 (Table 33). Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties on May 27. Luna had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Manska, Oahe, Rush, Reliant, Bozoisky-Select, and Mankota on May 27. On July 8, Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties. Rosana had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Douglas on July 8. On September 24, Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Critana, Bozoisky-Select, Pryor, and Swift. Manska had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Reliant, Rosana, Luna, Rush, Vavilov, P-27, Goldar, Schwendimar, and Hycrest (Table 33).

Table 33. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at seven sampling dates at Bozeman, MT in 1998.

Date:	5/27/98	6/11/98	6/24/98	7/8/98	7/22/98	8/20/98	9/24/98	
Variety								Mean
Douglas	499.5	527.5	535.0	579.5	518.5	543.5	569.0	538.9
Hycrest	562.9	561.3	579.2	623.2	585.5	595.8	549.3	579.6
CD II	516.8	547.6	571.2	629.3	532.7	580.2	580.9	565.5
Nordan	533.0	571.8	563.6	610.0	551.2	597.5	569.4	570.9
P-27	517.5	557.4	549.4	625.8	564.5	576.9	529.1	560.1
Vavilov	519.7	580.5	583.4	632.3	553.1	580.1	526.0	567.9
Critana	544.7	550.2	565.7	604.9	548.1	569.9	662.6	578.0
Bannock	518.5	516.5	554.3	611.6	554.9	564.8	578.9	557.1
Schwendimar	525.7	510.7	533.5	593.6	517.4	555.1	546.2	540.3
Pryor	549.2	577.5	599.1	657.7	621.2	643.0	632.3	611.4
Revenue	519.2	526.8	542.8	606.4	568.9	597.2	605.6	566.7
Secar	575.4	604.0	607.4	643.3	549.4	576.7	587.4	591.9
Pearl	522.8	543.8	578.4	649.8	613.7	594.0	553.6	579.4
Prairieland	522.5	560.8	561.6	637.8	598.9	594.1	567.2	577.6
Eejay	526.6	567.8	577.7	628.6	581.4	602.8	551.5	576.6
Trailhead	527.8	553.2	575.1	606.6	583.0	567.4	598.0	573.0
Magnar	546.9	547.9	560.4	612.3	562.4	575.7	594.0	571.4
Lodorm	636.6	661.8	661.2	717.9	624.9	695.5	679.9	668.3
Rosana	526.6	512.2	487.4	546.6	512.8	518.7	490.6	513.6
Bozoisky-Select	503.2	554.2	569.3	616.3	570.2	583.3	642.1	576.9
Mankota	505.5	546.6	546.8	601.3	541.7	602.1	591.6	562.2
Swift	534.0	619.0	553.2	669.5	546.7	582.3	626.6	590.2
Goldar	573.8	568.8	578.2	598.6	546.9	546.5	539.4	564.6
Greenleaf	524.0	513.6	529.3	610.0	565.6	514.8	557.1	544.9
Luna	476.3	529.7	559.1	586.7	560.2	533.4	516.1	537.4
Manska	480.8	500.1	540.9	607.0	541.3	518.7	480.0	524.1
Oahe	487.0	528.8	559.5	600.7	624.2	557.3	559.7	559.6
Reliant	496.4	503.6	564.3	633.5	545.1	538.3	481.8	537.6
Rush	489.4	529.0	552.3	611.1	574.6	561.3	521.9	548.5
Mean	526.3	550.8	563.4	619.0	564.1	574.7	568.5	566.7
LSD (0.05)	38.3	35.2	34.8	41.2	57.7	47.8	69.6	24.04

In 1999, NDF concentration increased from 443 g kg^{-1} on May 19, to 639 g kg^{-1} on September 15 (Table 34). In the third year of harvest at Bozeman, Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Secar, Goldar, and Critana on June 2. Mankota had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Bozoisky-Select, Manska, Luna, Magnar, Trailhead, Oahe, and Pearle on June 2. On July 14, Lodorm had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Pryor, CDII, and Secar. Rosana had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Manska, Swift, Mankota, Bozoisky-Select, Douglas, Eejay, Trailhead, Hycrest, and Vavilov on July 14. On September 15, Swift had significantly higher ($P < 0.05$) NDF concentration than all other varieties except Pryor, Trailhead, Lodorm, Mankota, Bozoisky-Select, and Magnar. Schwendimar had significantly lower ($P < 0.05$) NDF concentration than all other varieties except Rosana, Vavilov, Reliant, Rush, Greenleaf, Revenue, Manska, Prairieland, and CDII on September 15 (Table 34).

Ignoring Rosana, Pearl and Manska generally had the lowest overall NDF concentrations, and Lodorm had the highest in the trial. Douglas had consistently lower NDF concentration than the other crested wheatgrass varieties. Pearl and Prairieland generally had lower NDF concentration than the other Altai and Basin wildrye varieties, with Eejay having relatively higher concentration. Revenue had lower NDF concentration than Pryor throughout the trial. Bozoisky-Select had relatively lower NDF concentration than the other Russian wildrye varieties, Mankota having the highest concentration. Of the intermediate and pubescent wheatgrass varieties, Manska had the

Table 34. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses over eight sampling dates at Bozeman, MT in 1999.

Date:	5/19/99	6/2/99	6/16/99	6/30/99	7/14/99	8/12/99	9/15/99	10/13/99	
Variety									Mean
Douglas	409.6	508.4	550.8	555.3	543.8	626.2	650.9	666.5	563.9
Hycrest	440.9	531.0	571.9	562.0	552.4	626.8	637.9	633.5	569.6
CD II	434.2	523.3	551.0	562.8	600.8	624.2	621.5	638.2	569.5
Nordan	443.2	508.0	568.1	530.8	571.4	624.7	640.9	654.1	567.7
P-27	415.6	499.2	577.2	554.5	553.0	586.6	649.8	638.6	559.3
Vavilov	442.5	527.8	567.3	577.3	576.5	535.7	591.2	645.7	558.0
Critana	466.5	552.0	555.1	568.4	566.7	597.7	649.8	599.3	569.4
Bannock	---[1]	---	---	539.6	588.0	600.8	635.5	576.4	582.4
Schwendimar	---	---	---	525.5	559.4	573.7	568.1	568.4	559.0
Pryor	440.4	541.7	588.7	561.4	607.6	662.4	701.8	707.4	601.4
Revenue	462.3	516.4	570.6	566.6	588.3	643.0	612.8	635.3	574.4
Secar	492.6	567.2	576.0	540.3	595.4	582.6	628.3	576.5	569.9
Pearl	457.9	492.6	550.5	527.1	558.7	560.1	630.4	590.5	546.0
Prairieland	455.7	510.7	572.5	561.3	551.1	552.8	621.3	603.5	553.6
Eejay	439.7	512.7	563.0	563.0	551.8	567.8	636.5	612.8	555.9
Trailhead	450.8	490.6	590.8	555.7	573.8	633.0	693.0	663.4	581.4
Magnar	453.7	484.7	579.4	525.3	578.8	653.2	662.5	653.6	573.9
Lodorm	484.7	574.0	627.3	586.9	627.4	664.2	686.5	665.3	614.5
Rosana	---	---	---	553.7	521.1	518.4	574.0	532.3	539.9
Bozoisky-Select	446.2	477.1	522.1	524.7	543.7	674.3	680.1	647.9	564.5
Mankota	436.4	465.1	519.2	522.4	539.6	611.4	684.4	666.2	555.6
Swift	439.3	490.4	538.9	553.5	539.0	619.5	716.4	663.0	570.0
Goldar	485.7	564.0	597.7	560.4	574.8	615.4	646.5	619.1	583.0
Greenleaf	422.3	490.2	556.2	545.4	554.5	612.2	604.7	597.3	547.9
Luna	434.1	482.9	541.0	545.2	569.9	636.3	647.9	627.2	560.6
Manska	416.9	477.6	541.5	524.8	522.8	584.4	619.5	594.8	535.3
Oahe	411.7	492.4	538.8	548.4	559.8	615.2	624.9	623.1	551.8
Reliant	418.6	499.2	550.4	546.7	557.5	601.8	599.5	588.7	545.3
Rush	420.0	518.8	544.1	539.5	561.9	587.3	599.5	589.3	545.1
Mean	443.1	511.4	561.9	549.2	565.1	606.6	638.5	623.4	564.4
LSD (0.05)	22.6	29.0	36.1	NS*	32.9	47.5	54.4	52.6	30.1

[1] Poor early season growth in all replications, no samples were taken.

* The F test for variety effect was not significant at the 0.05 level.

lowest NDF concentration and Luna had the highest. Lodorm consistently had the highest NDF concentration of all varieties throughout the course of the trial.

Again, as with ADF concentration, estimated NDF concentrations of the varieties in this trial were lower at the end of the season than expected. Maturity can be delayed and vegetative production increased and extended later into the season when N fertilizer is applied to dryland grasses. The equation for NDF concentration generated from the NIRS software meet all quality control criteria and the values should be credible.

In Vitro Digestible Dry Matter Concentration

In the overall analysis of variance for IVDDM concentration, highly significant effects ($P < 0.01$) were varieties, locations, years, and the interaction Y x L, with Y x V less significant at $P = 0.0256$ (Table 6). Interactions for Y x L and Y x L x V were found to be non-significant ($P > 0.05$) (Table 6). Figure 2 indicates that Bridger had significantly lower ($P < 0.05$) mean IVDDM concentration than Bozeman and Moccasin. Moccasin had significantly higher ($P < 0.05$) mean IVDDM concentration than Bozeman. This is probably due to Bridger having a greater number of late sample dates than Bozeman, and Moccasin having fewer late sample dates than Bozeman. Bozeman, Bridger, and Moccasin were also analyzed independently. The analysis of variance for the main effects year and variety were found to be significant ($P < 0.05$) at all locations and the interaction Y x V was non-significant ($P > 0.05$) at all locations for IVDDM (Table 27 to 29). Since the Y x V was found to be non-significant, valid summarization and comparison of individual varieties across sample dates and years can be made within

each location (Table 35). Specific sample dates closest to June 1, July 15, and September 15 are discussed for each year and location to provide more detailed and practical information.

At Bozeman, mean IVDDM concentrations varied from 370 g kg^{-1} to 477 g kg^{-1} among varieties when averaged across sample dates and years (Table 35). Magnar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Reliant, Rush, Oahe, Manska, Douglas, Greenleaf, Trailhead, Prairieland, Revenue, Luna, and Bozoisky-Select. Secar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Bannock, Critana, and Pryor. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Nordan. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor at Bozeman (Table 35).

At Bridger, mean IVDDM concentrations ranged from 361 g kg^{-1} to 449 g kg^{-1} among varieties when averaged across sample dates and years (Table 35). Critana had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rush, Douglas, CDII, Hycrest, Magnar, and Reliant. Critana had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Secar, and Lodorm. Critana had significantly lower ($P < 0.05$) IVDDM concentration than Bannock and Schwendimar at Bridger (Table 35).

At Moccasin, mean IVDDM concentrations varied from 482 g kg^{-1} to 577 g kg^{-1} among varieties when averaged across sample dates and years (Table 35). Douglas had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Bozoisky-Select, Revenue, Reliant, Oahe, Magnar, CDII, and Mankota. Lodorm had

Table 35. *In vitro* digestible dry matter concentrations of 29 dryland forage grasses summarized across annual sample dates and years.

Variety	Across years			Overall Mean
	Bozeman	Bridger	Moccasin	
Douglas	460.2	429.8	577.4	489.2
Hycrest	430.1	428.3	542.9	467.1
CDII	435.8	429.0	551.1	472.0
Nordan	419.0	414.3	529.8	454.4
P-27	418.1	392.8	535.7	448.9
Vavilov	405.0	404.0	520.5	443.2
Critana	390.8	361.2	510.0	420.7
Bannock	386.1	399.9	508.9	431.6
Schwendimar	408.2	406.9	502.5	439.2
Pryor	393.7	396.2	538.4	442.8
Revenue	443.4	420.8	567.7	477.3
Secar	370.4	371.5	486.5	409.5
Pearl	435.5	416.4	515.3	455.7
Prairieland	443.5	418.2	529.1	463.6
Eejay	437.3	415.5	505.8	452.9
Trailhead	451.6	448.5	541.8	480.6
Magnar	476.5	427.1	552.4	485.3
Lodorm	409.1	382.3	481.6	424.3
Rosana	426.5	394.6	546.0	455.7
Bozoisky-Select	443.2	397.0	576.4	472.2
Mankota	447.4	412.2	549.4	469.7
Swift	420.9	389.7	539.1	449.9
Goldar	409.3	414.6	515.7	446.6
Greenleaf	453.2	415.9	545.9	471.7
Luna	443.3	414.6	523.1	460.3
Manska	461.2	417.4	540.6	473.1
Oahe	464.2	416.0	555.8	478.7
Reliant	470.2	423.7	567.6	487.2
Rush	464.5	430.6	536.3	477.2
Mean	440.2	410.4	532.2	461.0
LSD (0.05)	34.4	26.2	28.0	19.8*

* The Y x L and Y x V interactions were significant ($P < 0.05$).

significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Secar, Schwendimar, and Eejay. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Hycrest and Nordan. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor. Bozoisky-Select had significantly higher ($P < 0.05$) IVDDM concentration than Swift. Reliant had significantly higher ($P < 0.05$) IVDDM concentration than Luna and Rush at Moccasin (Table 35).

During the first harvest year at Bozeman (1997), mean IVDDM concentration of all varieties decreased from 548 g kg^{-1} on May 23, to 254 g kg^{-1} on October 30 (Table 36). Trailhead had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Magnar, Oahe, and Rush on June 4. Critana had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Vavilov, Bannock, Lodorm, Goldar, Swift, Pryor, Hycrest, Secar, Nordan, P-27, and Eejay on June 4. On July 2, Magnar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Prairieland, Pearl, Eejay, Greenleaf, Oahe, and Rosana. Secar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Bannock, Pryor, Vavilov, Mankota, Nordan, Lodorm, Swift, Critana, Luna, Schwendimar, and Hycrest. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor. Magnar had significantly higher ($P < 0.05$) IVDDM concentration than Trailhead on July 2. Prairieland had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rosana, Reliant, Pearl, Rush, Manska, Eejay, and Bannock on October 30. Pryor had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Revenue, Vavilov, Nordan, Secar, Trailhead, Critana, Mankota, P-27,

Table 36. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at five sampling dates at Bozeman, MT in 1997.

Date:	5/23/97	6/4/97	6/18/97	7/2/97	10/30/97	
Variety						Mean
Douglas	580.4	464.4	342.8	296.6	220.0	380.8
Hycrest	549.5	412.4	341.9	276.9	282.3	372.6
CD II	579.8	440.2	243.4	285.0	261.0	361.9
Nordan	546.9	414.2	290.0	246.7	177.1	335.0
P-27	555.3	417.4	280.5	278.0	208.4	347.9
Vavilov	525.9	387.5	333.9	240.9	175.0	332.6
Critana	544.9	373.5	239.7	271.4	195.0	324.9
Bannock	519.2	400.3	294.2	213.8	300.3	345.6
Schwendimar	477.1	432.1	353.4	276.7	295.0	366.9
Pryor	578.1	408.1	277.0	231.4	136.4	326.2
Revenue	551.6	463.6	396.2	321.7	174.6	381.5
Secar	496.0	413.9	242.0	198.4	178.6	305.8
Pearl	512.7	446.0	372.1	367.5	330.8	405.8
Prairieland	518.0	432.2	437.2	370.8	380.2	427.7
Eejay	513.5	422.5	418.3	356.9	310.1	404.3
Trailhead	634.5	538.6	383.3	291.1	180.3	405.6
Magnar	626.9	520.6	454.2	412.0	270.9	456.9
Lodorm	528.3	402.1	351.5	265.6	214.9	352.5
Rosana	528.2	446.4	342.9	340.0	341.8	399.9
Bozoisky-Select	549.3	435.5	311.5	290.8	211.4	359.7
Mankota	573.0	425.7	345.1	241.0	198.2	356.6
Swift	558.9	406.2	341.0	266.9	281.1	370.8
Goldar	502.4	403.9	321.1	306.1	241.3	355.0
Greenleaf	556.5	482.3	408.0	356.5	265.5	413.8
Luna	574.9	464.1	358.7	272.4	292.3	392.5
Manska	556.0	477.5	398.5	327.3	310.2	413.9
Oahe	583.5	502.2	410.2	342.8	281.3	424.0
Reliant	515.3	478.9	400.8	310.0	337.9	408.6
Rush	557.0	491.9	386.0	328.2	323.5	417.3
Mean	548.0	441.5	347.4	296.0	254.3	377.4
LSD (0.05)	41.4	49.4	73.2	78.9	80.1	30.6

Bozoisky-Select, and Lodorm on October 30. On this date, Hycrest and CDII had significantly higher ($P < 0.05$) IVDDM concentration than Nordan at Bozeman (Table 36).

During the second harvest year at Bozeman (1998), mean IVDDM concentration of all varieties decreased from 539 g kg^{-1} on May 27, to 333 g kg^{-1} on August 20 (Table 37). Trailhead had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Bozoisky-Select, Luna, Douglas, Mankota, Oahe, Reliant, Magnar, Manska, Secar, and Rush on May 27. Secar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Critana, Rosana, Hycrest, Goldar, Bannock, Vavilov, and Lodorm on May 27. On July 8, Rosana had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Revenue, Mankota, Schwendimar, Douglas, and Bozoisky-Select. Secar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Lodorm, Swift, Pryor, Pearl, Hycrest, CDII, Critana, Vavilov, and Manska on July 8. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Hycrest and CDII on this date. Schwendimar had significantly higher ($P < 0.05$) IVDDM concentration than Critana on July 8. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor on this date. Swift had significantly lower ($P < 0.05$) IVDDM concentration than Bozoisky-Select and Mankota on this date. On September 24, Reliant had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Manska. Critana had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Secar, Bosoiky-Select, Revenue, Swift, Lodorm, and Trailhead on September 24. Critana had

Table 37. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at seven sampling dates at Bozeman, MT in 1998.

Date:	5/27/98	6/11/98	6/24/98	7/8/98	7/22/98	8/20/98	9/24/98	
Variety								Mean
Douglas	588.0	526.4	533.4	435.7	471.0	401.8	413.5	481.4
Hycrest	490.6	485.7	434.7	366.5	372.1	337.0	421.1	415.4
CD II	552.9	512.0	453.8	366.8	430.1	359.5	358.6	433.4
Nordan	520.0	484.5	478.0	381.8	420.1	303.7	388.1	425.2
P-27	521.3	495.5	502.0	366.2	366.3	324.3	375.5	421.6
Vavilov	503.9	466.8	422.5	370.0	375.6	301.7	392.6	404.7
Critana	481.5	459.0	419.4	367.0	357.4	315.3	257.2	379.5
Bannock	501.4	474.3	419.3	413.5	386.9	329.6	349.1	410.6
Schwendimar	489.4	473.9	541.1	443.7	394.6	344.7	376.6	437.7
Pryor	532.5	528.7	474.4	356.4	353.2	228.9	274.4	392.6
Revenue	529.4	558.3	539.6	458.3	402.7	322.5	313.1	446.3
Secar	463.7	412.6	379.1	315.1	380.4	270.4	292.1	359.1
Pearl	527.3	516.9	481.3	365.3	313.8	313.0	372.0	412.8
Prairieland	529.1	510.5	472.0	386.8	336.5	301.2	379.2	416.5
Eejay	543.3	466.5	464.9	409.1	359.0	310.9	345.2	414.1
Trailhead	612.3	565.0	494.3	401.4	381.9	328.5	330.4	444.8
Magnar	574.6	573.0	523.0	402.2	422.4	378.9	362.1	462.3
Lodorm	514.1	490.1	456.0	340.9	368.4	255.6	317.1	391.7
Rosana	488.1	494.8	551.2	488.0	421.5	333.5	433.1	458.6
Bozoisky-Select	610.8	547.0	515.8	435.2	415.4	358.1	304.9	455.3
Mankota	587.9	533.5	540.2	454.2	457.0	350.4	386.7	472.8
Swift	543.2	413.0	503.5	342.0	411.9	303.8	315.2	404.7
Goldar	495.3	474.0	428.2	394.0	376.3	338.5	360.0	409.5
Greenleaf	552.9	542.9	503.6	391.3	370.2	387.1	385.3	447.6
Luna	594.8	543.8	493.6	417.6	348.4	343.3	405.9	449.6
Manska	564.5	549.7	499.4	378.3	382.6	382.3	470.1	461.0
Oahe	584.0	555.3	503.9	403.9	353.2	388.7	391.1	454.3
Reliant	582.9	557.6	494.2	401.4	388.2	382.5	539.2	478.0
Rush	563.6	550.7	505.2	394.0	393.2	365.4	437.1	458.5
Mean	539.4	509.0	483.7	394.7	386.6	333.1	370.5	431.0
LSD (0.05)	50.7	47.7	53.5	63.4	78.1	63.1	76.2	26.7

significantly lower ($P < 0.05$) IVDDM concentration than Bannock and Schwendimar on this date. Mankota had significantly higher ($P < 0.05$) IVDDM concentration than Bozoisky-Select. Greenleaf had significantly lower ($P < 0.05$) IVDDM concentration than Manska and Reliant on September 24 at Bozeman (Table 37).

During the third harvest year at Bozeman (1999), mean IVDDM concentration of all varieties decreased from 731 g kg^{-1} on May 19, to 342 g kg^{-1} on September 15 (Table 38). On June 2, Magnar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Trailhead, Bozoisky-Select, Mankota, and Douglas. Secar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Vavilov on June 2. Douglas had significantly higher ($P < 0.01$) IVDDM concentration than Hycrest and Nordan on this date. On July 14, Douglas had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Bozoisky-Select, Mankota, Hycrest, Swift, Oahe, P-27, Manska, Greenleaf, Reliant, Nordan, Eejay, and Rush. Secar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Pearl, Goldar, Vavilov, Critana, and Schwendimar on July 14. CDII had significantly lower ($P < 0.05$) IVDDM concentration than Hycrest and Douglas on this date. On September 15, Reliant had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rush, Vavilov, CDII, Schwendimar, Greenleaf, Oahe, Hycrest, Nordan, Revenue, Douglas, and Lodorm. Swift had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Bozoisky-Select, Critana, Mankota, and Trailhead on September 15. Critana had significantly lower ($P < 0.05$) IVDDM concentration than Schwendimar on this date.

Table 38. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bozeman, MT in 1999.

Date:	5/19/99	6/2/99	6/16/99	6/30/99	7/14/99	8/12/99	9/15/99	10/13/99	
Variety									Mean
Douglas	803.3	643.7	602.8	478.6	537.7	413.0	358.0	311.1	518.5
Hycrest	762.1	595.5	527.7	464.6	527.5	417.8	370.3	354.3	502.5
CD II	786.8	618.9	573.2	471.7	468.5	414.6	382.9	379.4	512.0
Nordan	739.6	584.5	533.1	507.4	488.2	402.7	367.8	350.6	496.7
P-27	705.6	582.5	502.0	470.6	508.2	445.0	323.9	340.4	484.8
Vavilov	698.5	546.8	492.2	438.8	458.9	497.6	395.3	293.7	477.7
Critana	740.2	569.6	528.5	462.6	459.7	353.5	296.3	333.9	468.0
Bannock	---[1]	---	---	469.4	469.6	401.1	326.2	343.7	402.0
Schwendimar	---	---	---	475.1	460.7	397.5	382.3	384.2	420.0
Pryor	747.3	587.6	566.6	459.6	444.9	366.9	267.2	258.6	462.3
Revenue	803.7	607.0	593.3	468.4	464.8	378.7	366.1	337.6	502.5
Secar	639.9	501.9	501.5	465.9	407.9	374.7	325.1	355.5	446.6
Pearl	678.1	600.2	595.1	470.1	446.3	402.4	321.3	389.4	487.9
Prairieland	683.3	582.0	576.8	493.5	469.0	388.9	340.6	357.7	486.5
Eejay	675.9	570.2	603.0	463.4	483.6	417.6	340.8	394.6	493.6
Trailhead	784.3	672.0	603.8	495.1	473.0	358.6	303.0	345.3	504.4
Magnar	791.6	689.2	609.0	491.1	481.4	330.3	340.3	349.9	510.4
Lodorm	676.2	590.9	550.8	463.8	475.4	382.0	356.4	370.0	483.2
Rosana	---	---	---	465.6	478.7	408.6	341.9	410.0	421.0
Bozoisky-Select	769.5	670.0	645.0	510.5	535.9	335.6	283.2	367.0	514.6
Mankota	756.3	666.0	613.7	491.6	528.6	387.1	300.4	358.5	512.8
Swift	698.7	635.1	601.3	481.3	511.0	386.5	248.7	335.9	487.3
Goldar	682.4	565.1	519.4	455.4	447.3	368.5	318.9	352.1	463.6
Greenleaf	732.1	608.9	555.6	446.7	495.2	400.2	377.9	369.4	498.3
Luna	710.0	625.5	601.7	461.3	478.7	360.2	314.0	350.3	487.7
Manska	716.4	612.9	580.0	505.8	496.0	412.5	352.6	393.4	508.7
Oahe	753.9	606.4	603.3	464.7	508.5	423.0	373.6	381.3	514.3
Reliant	722.8	622.0	583.8	513.8	490.4	429.9	417.9	413.0	524.2
Rush	733.7	586.2	567.4	513.5	483.4	435.0	415.8	407.8	517.9
Mean	730.5	605.4	570.4	476.5	482.0	396.2	341.7	358.2	486.5
LSD (0.05)	36.6	47.0	48.5	NS*	56.1	57.5	61.8	50.3	30.3

[1] Poor early season growth in all replications, no samples were taken.

Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor on September 15. Luna had significantly lower ($P < 0.05$) IVDDM concentration than Greenleaf, Rush, and Reliant on this date at Bozeman (Table 38).

During the first harvest year at Bridger (1997), mean IVDDM concentration of all varieties decreased from 603 g kg^{-1} on May 29, to 295 g kg^{-1} on October 8 (Table 39). On May 29, Magnar had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Prairieland, Trailhead, Eejay, Douglas, Greenleaf, and Reliant. Secar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except P-27, and Critana on May 29. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Nordan, Hycrest and CDII on this date. On June 26, Swift had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Magnar, Douglas, Trailhead, Eejay, Pearl, Prairieland, Rosana, and CDII. On June 26, Oahe had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Secar, Bannock, P-27, Critana, Schwendimar, Greenleaf, Lodorm, Rush, Reliant, Goldar, Bozoisky-Select, Pryor, Vavilov, and Luna. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Nordan on this date. Swift had significantly higher ($P < 0.05$) IVDDM concentration than Bozoisky-Select and Mankota on June 26. On September 8, Reliant had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rush, Hycrest, CDII, Trailhead, Oahe, Manska, Goldar, Prairieland, Greenleaf, and Pearl. Critana had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Revenue, Bozoisky-Select, Mankota, Schwendimar, Vavilov, Douglas, Swift, Lodorm, Eejay, Secar, and Bannock on

Table 39. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bridger, MT in 1997.

Date:	5/29/97	6/12/97	6/26/97	7/10/97	8/8/97	9/8/97	10/8/97	11/7/97	
Variety									Mean
Douglas	655.0	517.3	493.0	313.0	388.3	290.5	235.6	288.2	410.7
Hycrest	575.8	498.6	441.5	437.8	409.8	379.1	325.2	285.9	419.2
CD II	585.9	490.5	448.2	302.6	297.5	377.3	315.2	308.6	403.3
Nordan	573.6	461.7	440.8	306.5	306.9	334.8	250.9	239.6	377.1
P-27	536.8	443.1	398.7	267.8	271.2	318.9	252.9	226.5	350.6
Vavilov	567.3	460.8	427.1	422.3	361.5	286.6	279.7	225.1	378.8
Critana	543.3	409.7	403.2	383.2	226.9	235.6	229.2	224.9	332.0
Bannock	577.2	440.6	398.1	392.9	178.9	300.6	292.4	278.3	364.8
Schwendimar	581.5	477.3	406.8	406.2	277.9	285.5	308.5	279.6	377.9
Pryor	569.9	463.6	424.8	272.0	266.4	243.4	243.4	217.9	348.9
Revenue	595.9	519.0	441.0	318.5	352.0	267.6	216.2	262.3	385.9
Secar	501.1	399.9	383.5	396.9	285.1	299.8	288.8	308.7	358.0
Pearl	627.7	546.1	474.5	429.1	311.4	335.5	318.4	405.7	431.1
Prairieland	676.8	574.5	461.1	388.7	296.3	348.8	332.5	370.8	431.2
Eejay	663.3	550.9	481.2	420.8	274.0	296.3	339.9	348.2	421.8
Trailhead	670.1	560.8	486.8	348.7	324.2	370.7	322.0	271.4	433.8
Magnar	681.2	555.0	494.4	396.0	315.9	330.0	266.7	252.9	411.5
Lodorm	576.7	470.7	415.6	301.7	275.2	292.0	270.7	281.8	373.1
Rosana	598.7	492.6	449.4	409.5	333.5	303.9	294.3	286.9	396.1
Bozoisky-Select	614.0	447.5	424.5	418.5	241.7	269.8	271.5	326.5	376.8
Mankota	585.9	475.8	439.6	348.1	291.9	270.5	274.2	317.4	389.9
Swift	559.7	460.5	496.9	338.2	302.9	291.2	267.2	361.3	384.7
Goldar	579.9	433.1	423.8	464.7	328.0	358.5	334.4	311.3	404.2
Greenleaf	643.6	465.4	409.7	398.9	375.5	337.4	281.1	312.7	403.0
Luna	630.9	462.1	430.5	406.2	423.4	325.8	305.8	345.3	416.3
Manska	616.7	504.7	426.1	278.0	402.1	359.2	321.1	310.1	413.8
Oahe	624.2	501.7	382.3	394.3	371.3	368.4	357.1	300.5	412.5
Reliant	643.4	475.9	421.2	371.2	348.4	402.0	361.6	348.3	421.5
Rush	625.2	504.5	417.6	398.1	393.3	385.8	386.5	341.4	431.6
Mean	602.8	485.0	435.9	370.0	318.3	319.5	294.6	297.9	395.2
LSD (0.05)	52.0	51.2	52.1	NS*	79.5	67.1	58.4	53.9	33.6

* The F test for variety effect was not significant at the 0.05 level.

September 8. Douglas had significantly lower ($P < 0.05$) IVDDM concentration than Nordan, CDII, and Hycrest on this date. Bannock had significantly higher ($P < 0.05$) IVDDM concentration than Critana on September 8. Luna had significantly lower ($P < 0.05$) IVDDM concentration than Reliant on this date (Table 39).

During the second harvest year at Bridger (1998), mean IVDDM concentration of all varieties decreased from 572 g kg^{-1} on May 8, to 276 g kg^{-1} on November 23 (Table 40). On May 22, Trailhead had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Mankota, Revenue, Magnar, Greenleaf, Vavilov, Eejay, Rush, P-27, Luna, Prairieland, and Douglas. Secar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Lodorm, Swift, and Critana. Mankota had significantly higher ($P < 0.05$) IVDDM concentration than Swift and Bozoisky-Select on this date. On July 10, Trailhead, Goldar, Douglas, Hycrest, Vavilov, P-27, and CDII had high IVDDM concentrations. Swift had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Reliant, Rosana, Bannock, and Secar. Trailhead had significantly higher ($P < 0.05$) IVDDM concentration than Magnar on July 10. Swift had significantly lower ($P < 0.05$) IVDDM concentration than Bozoisky-Select and Mankota on this date. On September 18, Rush had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties. Critana, Pryor, Secar, Prairieland, Pearl, Eejay, Luna, Revenue, Swift, Rosana, Bozoisky-Select, and Magnar had low IVDDM concentrations on September 18. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Hycrest and Nordan on this date. Critana had significantly lower ($P < 0.05$) IVDDM concentration than Bannock and

Table 40. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at ten sampling dates at Bridger, MT in 1998.

Date:	5/8/98	5/22/98	6/5/98	6/19/98	7/10/98	7/31/98	8/21/98	9/18/98	10/23/98	11/23/98	
Variety											Mean
Douglas	627.2	510.3	463.3	525.8	434.2	430.2	346.3	343.7	326.2	258.8	426.6
Hycrest	540.0	481.5	461.4	511.0	433.9	420.9	398.5	411.6	322.6	206.5	418.8
CD II	606.8	503.8	462.2	500.2	403.9	355.7	383.0	406.4	366.4	248.2	423.7
Nordan	576.7	490.6	502.3	497.4	394.8	402.8	410.5	425.7	321.8	258.0	428.1
P-27	591.9	516.3	479.8	476.1	404.3	356.2	336.7	361.1	252.8	251.2	402.6
Vavilov	568.6	529.4	468.4	467.2	411.8	358.9	355.5	411.4	290.2	248.4	411.0
Critana	527.6	454.4	442.0	406.7	379.1	327.1	269.6	292.2	298.4	253.7	365.1
Bannock	570.3	473.9	453.8	433.1	359.8	368.4	314.6	370.5	381.9	337.1	406.3
Schwendimar	600.1	483.8	475.0	442.2	369.4	377.4	298.9	375.1	398.7	383.6	420.4
Pryor	567.6	494.8	459.8	433.2	345.8	348.8	310.1	300.2	313.7	250.6	382.5
Revenue	622.5	549.3	510.8	514.9	398.3	396.6	349.2	335.8	324.4	297.9	430.0
Secar	498.7	409.1	400.9	380.8	363.6	325.4	309.2	323.1	291.5	259.5	356.2
Pearl	535.5	500.2	445.3	438.1	394.7	359.9	349.0	325.6	409.8	328.6	408.7
Prairieland	538.0	512.4	439.7	476.0	365.8	346.0	365.3	325.5	414.2	355.1	413.8
Eejay	527.3	523.1	436.2	434.5	388.1	385.8	359.5	332.2	423.8	371.2	418.2
Trailhead	658.3	564.7	471.8	506.6	447.1	408.9	412.5	351.3	315.8	255.5	439.3
Magnar	646.1	540.4	507.4	479.8	366.0	361.1	337.8	338.2	334.5	263.6	417.5
Lodorm	509.0	421.8	452.2	482.8	388.2	355.8	263.7	309.6	283.7	225.9	369.3
Rosana	538.6	472.0	481.5	494.9	359.6	392.4	324.7	336.7	354.0	252.9	400.7
Bozoisky-Select	584.6	476.0	471.3	434.5	375.2	364.1	334.9	337.8	318.0	239.7	393.6
Mankota	622.3	559.1	475.7	446.9	384.8	366.4	367.4	357.2	318.0	281.8	418.0
Swift	556.9	444.6	385.9	448.2	297.7	362.8	336.9	336.0	369.9	275.5	381.4
Goldar	538.6	478.9	464.8	456.5	440.9	392.5	311.6	370.4	301.4	250.1	400.6
Greenleaf	577.8	530.8	492.7	478.8	371.4	399.7	316.7	369.0	317.2	269.2	412.3
Luna	579.9	515.9	468.2	407.5	388.3	383.3	360.7	333.6	329.7	259.9	402.7
Manska	568.3	507.5	478.0	455.3	369.7	390.7	355.0	407.0	346.5	272.2	415.0
Oahe	549.4	499.8	477.2	451.2	379.0	402.6	339.5	349.5	325.4	260.0	403.4
Reliant	581.7	502.8	482.1	464.1	349.0	400.5	351.2	406.7	344.7	309.6	419.2
Rush	579.8	516.8	479.8	408.3	387.0	395.0	361.7	515.6	337.2	277.1	425.8
Mean	572.1	498.8	465.1	460.4	384.5	377.1	342.4	360.6	335.6	275.9	407.3
LSD (0.05)	62.6	55.6	NS*	58.4	66.9	45.9	61.5	66.1	65.6	57.0	34.8

* The F test for variety effect was not significant at the 0.05 level.

Schwendimar on September 18. Luna had significantly higher ($P < 0.05$) IVDDM concentration than Reliant, Manska and Rush on this date (Table 40).

During the third harvest year at Bridger (1999), mean IVDDM concentration of all varieties decreased from 579 g kg^{-1} on May 6, to 329 g kg^{-1} on September 15 (Table 41). On June 3, Pryor, Magnar, Trailhead, Revenue, CDII, Douglas, Manska, Goldar, Bozoisky-Select, and Nordan had high IVDDM concentrations. Eejay had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Rosana, Pearl, Hycrest, Prairieland, Swift, Secar, Critana, Vavilov, and Schwendimar on June 3. Hycrest had significantly lower ($P < 0.05$) IVDDM concentration than CDII on this date. On July 15, CDII had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Douglas, Vavilov, Hycrest, Trailhead, Luna, Revenue, Magnar, Nordan, and P-27. Swift had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Rosana, Vavilov, Prairieland, Pearl, Bannock, Eejay, Lodorm, and Bozoisky-Select on July 15. Swift had significantly lower ($P < 0.05$) IVDDM concentration than Mankota on this date. On September 15, Hycrest had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Trailhead and Magnar. Critana had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Luna, Bozoisky-Select, Lodorm, Swift, Vavilov, and Mankota on September 15. Nordan had significantly lower ($P < 0.05$) IVDDM concentration than Hycrest on this date. Critana had significantly lower ($P < 0.05$) IVDDM concentration than Bannock and Schwendimar on September 15. Luna had significantly lower ($P <$

Table 41. *In vitro* digestible dry matter concentrations (g kg^{-1}) of 29 dryland grasses at nine sampling dates at Bridger, MT in 1999.

Date:	5/6/99	5/20/99	6/3/99	6/17/99	7/15/99	8/16/99	9/15/99	10/15/99	11/15/99	
Variety										Mean
Douglas	618.5	566.5	496.5	493.1	502.3	371.3	336.4	315.9	368.7	452.1
Hycrest	586.6	525.9	455.6	437.7	490.7	431.8	416.0	346.0	330.8	446.8
CD II	594.4	540.9	500.6	459.7	508.5	453.4	357.8	362.9	362.1	460.0
Nordan	571.7	526.3	490.3	444.5	472.9	390.3	326.3	348.1	368.0	437.6
P-27	572.3	500.6	468.3	429.9	465.1	398.7	312.5	329.4	347.7	424.9
Vavilov	553.2	489.8	471.8	450.0	493.5	421.7	298.2	307.0	315.2	422.3
Critana	549.9	516.0	461.6	424.3	392.2	277.5	260.3	296.3	301.2	386.6
Bannock	636.9	557.3	479.1	429.5	401.7	334.6	315.3	349.5	353.8	428.6
Schwendimar	559.1	518.3	475.9	412.7	437.6	336.7	359.2	324.7	377.2	422.4
Pryor	617.4	597.8	512.7	468.9	461.5	379.7	360.7	359.2	356.5	457.2
Revenue	579.5	582.4	504.5	454.8	477.0	345.5	327.6	366.6	381.3	446.6
Secar	525.4	456.3	460.8	403.8	422.2	345.9	331.5	330.2	327.7	400.4
Pearl	535.3	480.0	452.9	416.9	399.1	312.5	331.9	364.6	391.4	409.4
Prairieland	536.0	465.9	456.0	365.7	393.9	344.4	359.4	397.3	368.0	409.6
Eejay	505.1	477.2	435.1	369.8	404.7	348.3	356.4	391.0	369.7	406.4
Trailhead	644.0	574.7	507.8	471.9	485.4	441.0	407.6	358.3	360.8	472.4
Magnar	612.0	587.9	511.9	482.5	474.7	386.2	376.5	315.0	322.2	452.1
Lodorm	579.6	502.9	482.9	412.1	417.7	286.1	273.8	338.0	347.2	404.5
Rosana	527.9	504.5	439.6	383.6	386.1	316.2	309.2	302.4	314.8	387.1
Bozoisky-Select	588.9	583.3	492.7	430.2	420.8	298.6	273.2	355.5	343.6	420.8
Mankota	571.9	578.1	484.3	426.6	427.1	333.6	303.7	353.5	379.3	428.7
Swift	557.5	531.1	459.8	407.7	374.7	293.1	297.8	350.1	354.5	402.9
Goldar	599.7	542.1	494.1	479.3	450.7	371.0	324.3	343.8	347.6	439.2
Greenleaf	606.7	535.3	503.3	442.2	437.5	403.2	328.5	283.6	351.0	432.4
Luna	585.2	538.5	488.7	459.3	478.1	325.3	265.2	328.7	354.4	424.8
Manska	591.2	518.6	495.7	456.6	456.2	345.6	312.4	296.5	337.0	423.3
Oahe	641.1	551.0	485.3	445.4	444.3	327.6	319.5	333.2	341.5	432.1
Reliant	564.9	538.4	479.1	441.2	440.7	374.4	351.3	343.6	340.7	430.5
Rush	568.0	519.8	486.7	453.4	457.0	434.5	340.0	305.6	346.5	434.6
Mean	578.6	531.3	480.5	436.3	443.9	359.6	328.7	337.8	350.4	427.5
LSD (0.05)	55.8	56.4	43.4	45.5	46.4	52.4	46.6	50.5	43.7	13.4

0.05) IVDDM concentration than Manska, Oahe, Greenleaf, Rush, and Reliant on this date (Table 41).

During the first harvest year at Moccasin (1997), mean IVDDM concentration of all varieties decreased from 701 g kg^{-1} on May 19, to 465 g kg^{-1} on July 28 (Table 42). Bozoisky-Select had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Reliant, Magnar, Rush, Trailhead, Greenleaf, Rosana, Douglas, and Hycrest on June 2. Secar, Lodorm, Pearl, Nordan, Eejay, Critana, Bannock, Schwendimar, Prairieland, P-27, and Vavilov had relatively low IVDDM concentration on this date. On June 2, Nordan had significantly lower ($P < 0.05$) IVDDM concentration than Douglas. Bozoisky-Select had significantly higher ($P < 0.05$) IVDDM concentration than Swift and Mankota on this date. Luna had significantly lower ($P < 0.05$) IVDDM concentration than Reliant on June 2. On July 14, Swift had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Prairieland, Mankota, Magnar, and Douglas. Bannock had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Vavilov, Schwendimar, Nordan, Secar, Rush, Lodorm, P-27, Luna, Reliant, and Goldar on July 14. Douglas had significantly higher ($P < 0.05$) IVDDM concentration than Nordan on this date. Bannock had significantly lower ($P < 0.05$) IVDDM concentration than Critana on July 14. Eejay had significantly lower ($P < 0.05$) IVDDM concentration than Prairieland. Swift had significantly higher ($P < 0.05$) IVDDM concentration than Bozoisky-Select on this date. On July 28, Douglas had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rosana, Hycrest, Magnar, Oahe, Pearl, Swift, Trailhead, Reliant, Prairieland, and

Table 42. *In vitro* digestible dry matter concentrations (kg ha^{-1}) of 29 dryland grasses at five sampling dates at Moccasin, MT in 1997.

Date:	5/19/97	6/2/97	6/30/97	7/14/97	7/28/97	
Variety						Mean
Douglas	732.4	601.5	561.6	541.6	531.5	593.7
Hycrest	623.5	598.5	500.2	509.3	516.0	549.5
CD II	675.1	584.5	473.6	490.9	456.6	536.1
Nordan	653.9	549.5	478.4	458.0	474.9	522.9
P-27	691.6	572.0	477.6	479.0	429.4	529.9
Vavilov	686.3	573.4	469.4	432.4	434.4	519.2
Critana	721.3	560.9	498.9	499.1	437.9	543.6
Bannock	721.8	562.1	457.4	430.1	458.3	525.9
Schwendimar	687.7	566.5	475.5	449.6	391.6	514.2
Pryor	686.6	591.6	491.9	527.4	411.6	541.8
Revenue	682.1	581.3	531.2	499.4	439.1	546.6
Secar	668.8	539.7	449.1	467.1	432.2	511.4
Pearl	686.7	549.2	547.9	528.6	505.3	563.5
Prairieland	641.8	568.3	539.8	582.4	484.0	563.3
Eejay	670.1	557.4	486.6	513.4	446.2	534.7
Trailhead	759.5	610.9	529.1	513.7	494.1	581.5
Magnar	744.6	641.1	583.7	543.2	509.8	604.5
Lodorm	636.8	543.9	449.6	477.6	421.6	505.9
Rosana	687.0	603.9	566.1	579.3	518.5	591.0
Bozoisky-Select	735.0	647.5	580.7	511.8	482.5	591.5
Mankota	706.5	584.5	592.7	558.4	446.6	577.7
Swift	699.7	585.2	548.5	591.1	499.0	584.7
Goldar	660.0	572.2	470.9	485.6	420.0	521.7
Greenleaf	734.5	604.9	536.1	502.1	465.0	568.5
Luna	738.6	582.5	505.0	479.9	471.6	555.5
Manska	731.1	588.1	529.5	494.0	466.3	561.8
Oahe	720.7	583.3	524.0	470.9	508.9	561.6
Reliant	786.3	647.3	558.8	485.1	489.1	593.3
Rush	746.5	615.0	507.7	477.5	436.1	556.6
Mean	700.6	585.0	514.5	502.7	464.8	553.5
LSD (0.05)	73.7	51.4	63.8	58.3	53.3	36.9

Bozoisky-Select. Schwendimar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pryor, Goldar, Lodorm, P-27, Secar, Vavilov, Rush, Critana, and Revenue on July 28. CDII had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Hycrest and Douglas on this date. Schwendimar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Bannock on July 28. Eejay had significantly lower ($P < 0.05$) IVDDM concentration than Pearle on this date. Rush had significantly lower ($P < 0.05$) IVDDM concentration than Oahe on July 28 (Table 42).

During the second harvest year at Moccasin (1998), mean IVDDM concentration of all varieties decreased from 590 g kg^{-1} on May 8, to 245 g kg^{-1} on October 6 (Table 43). On May 26, Mankota, Bozoisky-Select, Douglas, P-27, Vavilov, Reliant, Nordan, Revenue, CDII, and Manska had relatively high IVDDM concentration. Swift had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pearl, Eejay, Prairieland, Lodorm, Schwendimar, Secar, Rush, Pryor, Trailhead, Critana, Luna, Greenleaf, Rosana and Hycrest on May 26. Swift had significantly lower ($P < 0.05$) IVDDM concentration than Bozoisky-Select and Mankota on this date. On July 13, CDII had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Douglas, Hycrest, Trailhead, Revenue, Magnar, and Rosana. Secar, Luna, Greenleaf, Critana, Bannock, Rush, Pearl, Lodorm, Manska, and Eejay had relatively lower IVDDM concentration on July 13. Nordan had significantly lower ($P < 0.05$) IVDDM concentration than Douglas and CDII on this date. On September 4, Bozoisky-Select, Hycrest, Revenue, Douglas, CDII, Nordan, Mankota, P-27, Greenleaf, Magnar, and Pearl

Table 43. *In vitro* digestible dry matter concentrations (kg ha^{-1}) of 29 dryland grasses seven sampling dates at Moccasin, MT in 1998.

Date:	5/8/98	5/26/98	6/5/98	6/22/98	7/13/98	9/4/98	10/6/98	
Variety								Mean
Douglas	649.4	653.4	713.8	633.8	595.6	401.2	221.0	552.6
Hycrest	567.8	616.7	646.7	608.6	572.8	405.7	273.6	527.4
CD II	621.3	634.7	670.7	632.8	602.9	389.6	240.5	541.8
Nordan	558.5	641.1	667.1	604.8	526.8	387.9	212.5	514.1
P-27	624.5	649.5	657.6	625.6	533.0	378.8	206.0	525.0
Vavilov	597.2	646.4	629.3	568.6	520.3	366.0	246.1	510.6
Critana	555.9	600.3	652.8	547.2	482.4	311.2	184.2	476.3
Bannock	576.7	623.1	637.0	561.7	484.6	294.3	214.5	484.6
Schwendimar	521.4	581.7	643.1	571.1	508.9	356.4	258.4	491.6
Pryor	616.3	589.5	655.9	600.4	523.2	333.2	214.7	504.7
Revenue	664.0	635.4	693.4	691.9	553.1	401.8	296.3	562.3
Secar	536.0	586.6	595.3	526.8	469.6	305.0	221.6	463.0
Pearl	564.5	560.2	628.1	593.2	491.5	370.5	220.3	489.8
Prairieland	598.8	573.5	595.9	568.3	504.8	361.6	280.8	497.7
Eejay	532.0	566.1	607.7	512.0	499.7	360.2	267.7	477.9
Trailhead	621.7	600.1	670.5	599.5	555.1	353.2	256.0	522.3
Magnar	653.0	631.8	659.4	605.1	551.8	376.2	251.0	532.6
Lodorm	537.6	578.2	580.9	498.3	492.9	318.9	251.2	465.4
Rosana	515.7	615.8	676.5	610.7	548.8	371.6	234.8	510.6
Bozoisky-Select	616.6	661.4	723.5	678.4	520.5	410.3	248.5	551.3
Mankota	594.8	662.8	718.0	587.4	504.5	387.3	218.3	524.7
Swift	560.2	556.6	629.7	634.0	512.8	356.1	195.6	492.1
Goldar	569.3	618.5	656.6	555.8	512.7	310.0	241.0	494.8
Greenleaf	618.9	613.2	681.5	595.3	478.5	378.6	261.9	518.3
Luna	600.8	609.2	663.4	558.9	473.6	306.2	248.0	494.3
Manska	575.0	632.1	626.6	611.7	496.3	345.2	267.6	507.8
Oahe	612.5	624.3	681.4	627.9	524.1	361.1	263.9	527.9
Reliant	659.7	641.4	642.1	626.9	508.9	350.9	310.8	534.4
Rush	599.4	587.2	633.6	581.5	490.3	343.0	292.3	503.9
Mean	590.3	613.5	653.0	593.7	518.6	358.3	244.8	510.3
LSD (0.05)	78.6	60.1	64.1	71.5	60.3	57.2	54.7	15.8

had relatively high IVDDM concentration. Bannock had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Secar, Luna, Goldar, Critana, Lodorm, Pryor, Rush, Manska, and Reliant on September 4. Bannock had significantly lower ($P < 0.05$) IVDDM concentration than Schwendimar on this date. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Pryor on September 4. Luna had significantly lower ($P < 0.05$) IVDDM concentration than Greenleaf on this date (Table 43).

During the third harvest year at Moccasin (1999), mean IVDDM concentration of all varieties decreased from 655 g kg^{-1} on May 24, to 355 g kg^{-1} on September 15 (Table 44). On May 24, Pryor had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Bozoisky-Select, CDII, Oahe, and Manska. Schwendimar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Lodorm, and Eejay on May 24. Hycrest had significantly lower ($P < 0.05$) IVDDM concentration than CDII on this date. Schwendimar had significantly lower ($P < 0.05$) IVDDM concentration than Critana and Bannock on May 24. Pryor had significantly higher ($P < 0.05$) IVDDM concentration than Revenue on this date. Mankota had significantly lower ($P < 0.05$) IVDDM concentration than Bozoisky-Select on May 24. On July 29, Revenue had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Douglas, Bozoisky-Select, Oahe, Nordan, P-27, Hycrest, CDII, Magnar, Mankota, Rush, Greenleaf, Vavilov, and Reliant. Lodorm had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Pearl, Secar, Critana, Pryor, Prairieland, Bannock, Revenue, Schwendimar, Luna, Trailhead, Rosana,

Table 44. *In vitro* digestible dry matter concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MTin 1999.

Date:	5/24/99	6/4/99	6/15/99	6/29/99	7/15/99	8/20/99	9/15/99	
Variety								Mean
Douglas	699.3	700.5	694.5	633.0	620.1	418.8	336.1	586.0
Hycrest	638.7	669.6	582.8	592.0	570.5	428.0	381.4	551.9
CD II	722.3	652.6	683.2	588.1	567.5	452.1	362.6	575.5
Nordan	664.2	623.7	644.6	603.0	606.1	426.2	300.2	552.6
P-27	665.1	675.4	662.2	593.2	573.8	392.5	302.5	552.1
Vavilov	624.9	611.7	643.1	577.0	560.4	404.2	300.9	531.7
Critana	677.7	620.6	627.1	526.4	489.9	314.6	302.7	508.4
Bannock	681.6	583.8	627.2	541.5	511.3	317.7	350.4	516.2
Schwendimar	522.6	585.2	621.6	546.1	537.2	340.2	359.5	501.8
Pryor	784.4	680.9	707.1	533.9	559.6	360.5	355.0	568.8
Revenue	663.3	695.0	738.0	642.6	604.5	401.9	414.0	594.2
Secar	627.6	536.6	556.6	521.5	498.7	324.2	331.6	485.3
Pearl	631.0	586.4	622.4	511.7	471.5	305.6	319.9	492.6
Prairieland	662.0	609.7	597.1	534.0	524.0	361.2	395.7	526.2
Eejay	597.7	555.6	580.0	564.1	503.7	353.6	378.0	504.7
Trailhead	685.3	618.3	640.6	556.0	548.6	316.0	287.4	521.7
Magnar	664.0	612.1	635.9	581.5	548.2	324.3	274.7	520.1
Lodorm	547.0	549.8	572.9	511.3	490.3	309.2	334.0	473.5
Rosana	589.1	592.6	655.2	557.2	555.9	377.5	427.9	536.5
Bozoisky-Select	724.8	687.4	717.0	622.3	574.2	367.9	411.5	586.4
Mankota	641.3	649.0	659.9	579.7	533.0	369.7	388.3	545.8
Swift	656.4	643.4	662.2	568.3	522.9	362.5	367.8	540.5
Goldar	610.3	615.1	620.5	567.6	550.2	384.4	366.2	530.6
Greenleaf	638.8	632.4	676.7	578.6	562.9	379.6	386.8	550.8
Luna	637.0	620.9	633.4	549.2	546.2	326.5	323.7	519.6
Manska	701.7	619.7	651.2	559.1	573.9	409.0	351.5	552.3
Oahe	718.2	655.3	688.4	605.7	580.7	436.0	361.9	578.0
Reliant	652.0	646.1	682.8	576.7	557.9	450.9	460.0	575.2
Rush	666.2	653.4	653.5	579.0	527.6	399.0	361.1	548.5
Mean	655.0	627.0	646.1	569.0	547.3	372.9	354.9	538.9
LSD (0.05)	83.2	81.7	72.7	69.0	NS*	73.5	64.7	28.0

* The F test for variety effect was not significant at the 0.05 level.

Manska, Eejay, Goldar, and Swift on July 29. Revenue had significantly higher ($P < 0.05$) IVDDM concentration than Revenue on this date. On September 15, Reliant had significantly higher ($P < 0.05$) IVDDM concentration than all other varieties except Rosana, Revenue, Bozoisky-Select, and Prairieland. Magnar had significantly lower ($P < 0.05$) IVDDM concentration than all other varieties except Trailhead, Vavilov, P-27, Critana, Pearl, Luna, Secar, Lodorm, and Douglas on September 15. Nordan had significantly lower ($P < 0.05$) IVDDM concentration than Hycrest on this date. Pearl had significantly lower ($P < 0.05$) IVDDM concentration than Prairieland on September 15. Luna had significantly lower ($P < 0.05$) IVDDM concentration than Reliant on this date (Table 44).

Overall, when averaged across years and locations, Douglas had the highest IVDDM concentration, and Secar and Lodorm had the lowest concentration in the trial. Douglas had the highest IVDDM concentration of all crested wheatgrass varieties, Nordan had the lowest. Douglas was originally developed to retain its quality longer than other crested wheatgrass varieties, and this data shows it does. Pryor had lower IVDDM concentration than Revenue throughout the trial. Magnar had the highest IVDDM concentration of the Altai and Basin wildrye varieties and Eejay had the lowest. Bozoisky-Select generally had higher IVDDM concentration than the other Russian wildrye varieties, and Swift had the lowest. Of the intermediate and pubescent wheatgrass varieties, Luna consistently had the lowest IVDDM concentration and Reliant had the highest. Reliant and Manska were selected for improved forage quality in North Dakota. Results from this study provide credible evidence that they provide higher

forage quality than the other intermediate and pubescent wheatgrasses in Montana as well.

As with CP concentration, IVDDM concentration appeared to remain high later into maturity than would be expected. Optimum fertilization of the trials gives a plausible reason why this is the case. The IVDDM equation generated by the NIRS software met the quality control criteria and values generated from it should be considered viable. The validation set $r^2 = 0.70$ for IVDDM concentration was the lowest of all constituents presented, and this agrees with previous NIRS research in Montana (Murphy, 1996). Likely, the addition of more samples to the validation set might increase the r^2 value and increase confidence in the NIRS-estimated IVDDM concentrations. However, IVDDM is a complex interaction of plant and microbial factors, and it may be necessary to develop separate NIRS prediction equations for individual species.

Predictive Models for Forage Quality

Predictive models for CP, ADF, NDF and IVDDM were generated using the "LS Means" procedure in SAS (Version 8.1). One group of predictive models uses the Julian date to estimate the concentration of individual constituents, the other uses accumulated growing degree days (°C). Models were developed for CP, ADF, NDF and IVDDM for each variety, based on regression with JD and AGDD (Tables 45 to 52). A quadratic function provided the best fit. Further multivariate analyses are possible, but beyond the

Table 45. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating crude protein concentrations (CP g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT during 1997, 1998 and 1999 from Julian date (JD).

Predicted CP = Y-int + X_1(JD) + X_2(JD^2) (for JD 127 to 328)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	254	617.7802	-3.7954	0.0069	29.0069	0.2769	0.0006	0.73*
Hycrest	251	621.8810	-3.9333	0.0071	28.4014	0.2727	0.0006	0.77
CDII	251	684.6394	-4.6127	0.0088	29.4641	0.2840	0.0006	0.76
Nordan	251	651.1317	-4.2847	0.0081	28.3089	0.2724	0.0006	0.76
P-27	250	721.7656	-4.8797	0.0093	28.7559	0.2745	0.0006	0.77
Vavilov	254	627.4839	-4.0777	0.0076	28.5344	0.2728	0.0006	0.73
Critana	251	611.1585	-3.8421	0.0070	28.1403	0.2684	0.0006	0.74
Bannock	243	623.5103	-4.0940	0.0078	30.1510	0.2857	0.0006	0.68
Schwendimar	240	591.0905	-3.6936	0.0070	28.8340	0.2741	0.0006	0.67
Pryor	251	712.4718	-4.7964	0.0089	26.5153	0.2534	0.0006	0.83
Revenue	250	648.9770	-4.1574	0.0077	31.6777	0.3009	0.0007	0.72
Secar	251	602.3136	-3.8069	0.0071	25.2633	0.2412	0.0005	0.76
Pearl	255	547.5799	-2.9784	0.0050	32.4260	0.3096	0.0007	0.67
Prairieland	254	529.5749	-2.8516	0.0048	32.7784	0.3124	0.0007	0.64
Eejay	252	571.9585	-3.2018	0.0055	31.9603	0.3057	0.0007	0.69
Trailhead	253	617.3082	-3.6553	0.0064	24.9592	0.2380	0.0005	0.81
Magnar	248	669.5845	-4.1616	0.0076	28.1431	0.2691	0.0006	0.78
Lodorm	251	525.0040	-3.3098	0.0059	31.7557	0.3017	0.0007	0.65
Rosana	242	516.7050	-2.7477	0.0046	36.8384	0.3495	0.0008	0.58
Bozoisky-Select	253	542.9124	-3.0459	0.0053	31.8984	0.3060	0.0007	0.65
Mankota	251	526.0486	-2.8311	0.0048	29.9300	0.2861	0.0006	0.69
Swift	251	561.8591	-3.2255	0.0058	28.3904	0.2710	0.0006	0.69
Goldar	251	573.7963	-3.5074	0.0063	23.8131	0.2267	0.0005	0.79
Greenleaf	257	754.2663	-5.1094	0.0098	28.7212	0.2752	0.0006	0.78
Luna	258	761.8927	-5.2654	0.0103	29.1460	0.2812	0.0006	0.76
Manska	259	729.5510	-4.8052	0.0091	33.4963	0.3202	0.0007	0.71
Oahe	256	758.7940	-5.2086	0.0100	30.7309	0.2954	0.0007	0.76
Reliant	253	711.1586	-4.7473	0.0090	31.9184	0.3024	0.0007	0.72
Rush	253	746.2867	-5.0168	0.0096	31.8990	0.3044	0.0007	0.74

* All r^2 were highly significant ($P < 0.01$).

Table 46. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating crude protein concentrations (CP g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT. during 1997, 1998 and 1999 from accumulated growing degree days (AGDD).

Predicted CP = Y-int + X_1(AGDD) + X_2(AGDD^2) (for AGDD 58 to 2002)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	238	248.1360	-0.2008	0.000066	4.8188	0.0132	0.000006	0.74*
Hycrest	237	239.7595	-0.2097	0.000069	4.9040	0.0135	0.000007	0.75
CDII	239	236.5690	-0.2148	0.000072	4.8471	0.0132	0.000006	0.75
Nordan	239	241.4466	-0.2302	0.000082	4.6213	0.0128	0.000006	0.76
P-27	242	263.5354	-0.2639	0.000095	4.9776	0.0137	0.000007	0.77
Vavilov	241	236.1596	-0.2096	0.000071	4.7964	0.0132	0.000007	0.74
Critana	244	238.1212	-0.2051	0.000069	4.9011	0.0134	0.000007	0.72
Bannock	235	234.7749	-0.2164	0.000080	5.4628	0.0145	0.000007	0.64
Schwendimar	228	241.4527	-0.1999	0.000073	5.2332	0.0141	0.000007	0.64
Pryor	242	254.5746	-0.2647	0.000092	4.5188	0.0123	0.000006	0.82
Revenue	246	247.0596	-0.2160	0.000072	5.6755	0.0155	0.000008	0.68
Secar	242	236.5374	-0.1961	0.000067	4.2695	0.0116	0.000006	0.75
Pearl	243	248.1044	-0.1576	0.000045	5.7715	0.0158	0.000008	0.62
Prairieland	241	245.2871	-0.1580	0.000049	5.7353	0.0156	0.000008	0.59
Eejay	238	252.7936	-0.1693	0.000053	5.4837	0.0151	0.000007	0.63
Trailhead	240	253.4251	-0.1850	0.000056	4.3027	0.0119	0.000006	0.78
Magnar	241	267.9643	-0.2262	0.000075	5.1130	0.0141	0.000007	0.75
Lodorm	240	210.2153	-0.2001	0.000069	5.3365	0.0146	0.000007	0.66
Rosana	228	243.8281	-0.1474	0.000043	6.9109	0.0182	0.000009	0.53
Bozoisky-Select	242	248.4407	-0.1833	0.000062	5.2767	0.0145	0.000007	0.64
Mankota	238	252.7809	-0.1862	0.000063	4.9119	0.0136	0.000007	0.68
Swift	240	247.7488	-0.1722	0.000056	4.8101	0.0131	0.000006	0.67
Goldar	240	238.4768	-0.2071	0.000071	4.1457	0.0113	0.000006	0.78
Greenleaf	243	260.4381	-0.2330	0.000080	4.8514	0.0131	0.000006	0.77
Luna	244	258.6967	-0.2450	0.000089	5.0427	0.0139	0.000007	0.73
Manska	243	271.9913	-0.2479	0.000086	5.8138	0.0158	0.000008	0.71
Oahe	242	256.7433	-0.2455	0.000087	5.4402	0.0147	0.000007	0.72
Reliant	245	253.1427	-0.2324	0.000083	5.9109	0.0161	0.000008	0.66
Rush	246	264.4002	-0.2507	0.000090	5.7400	0.0157	0.000008	0.70

* All r^2 were highly significant ($P < 0.01$).

Table 47. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating acid-detergent fiber concentrations (ADF g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT during 1997, 1998 and 1999 from Julian date (JD).

Predicted ADF = Y-int + X_1(JD) + X_2(JD^2) (for JD 127 to 328)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	231	-111.9525	3.2012	-0.0052	27.3838	0.2669	0.0006	0.83**
Hycrest	235	-54.0446	2.8317	-0.0046	25.9819	0.2532	0.0006	0.81
CDII	227	-149.3363	3.8316	-0.0070	27.2956	0.2666	0.0006	0.80
Nordan	233	-143.6700	3.6883	-0.0065	27.5425	0.2680	0.0006	0.81
P-27	236	-174.4208	4.0049	-0.0072	32.5008	0.3169	0.0007	0.76
Vavilov	236	-58.8901	2.9832	-0.0050	29.7083	0.2894	0.0007	0.74
Critana	239	-67.3458	3.1484	-0.0053	30.5964	0.2980	0.0007	0.76
Bannock	216	-75.9397	3.3589	-0.0060	27.4388	0.2659	0.0006	0.77
Schwendimar	218	90.7466	1.7092	-0.0025	30.6096	0.2970	0.0007	0.61
Pryor	232	-206.7669	4.3705	-0.0075	32.5455	0.3170	0.0007	0.83
Revenue	225	-56.9628*	2.8566	-0.0046	31.8388	0.3101	0.0007	0.75
Secar	230	51.3329	2.2519	-0.0038	24.2053	0.2351	0.0005	0.72
Pearl	236	-77.7928	3.2483	-0.0061	35.5596	0.3456	0.0008	0.58
Prairieland	235	-67.2757	3.2327	-0.0062	31.4780	0.3060	0.0007	0.60
Eejay	230	8.4619*	2.4694	-0.0044	29.4846	0.2873	0.0007	0.62
Trailhead	237	-72.0720	2.9777	-0.0047	32.7729	0.3186	0.0007	0.76
Magnar	235	-142.9889	3.6918	-0.0064	31.8653	0.3103	0.0007	0.77
Lodorm	230	-49.6746*	3.2686	-0.0060	29.4944	0.2862	0.0007	0.70
Rosana	224	97.3933	1.5294	-0.0024	35.6140	0.3442	0.0008	0.41
Bozoisky-Select	228	-120.4959	3.3551	-0.0057	30.1901	0.2935	0.0007	0.77
Mankota	233	-57.6964*	2.7341	-0.0044	33.1835	0.3233	0.0007	0.71
Swift	226	-58.4848	2.8583	-0.0048	30.2160	0.2933	0.0007	0.73
Goldar	232	36.1028*	2.1703	-0.0035	23.9721	0.2336	0.0005	0.74
Greenleaf	238	-151.0417	3.7711	-0.0067	29.6816	0.2890	0.0007	0.78
Luna	237	-220.5757	4.5996	-0.0087	28.3044	0.2758	0.0006	0.80
Manska	238	-157.3973	3.8421	-0.0070	31.9912	0.3117	0.0007	0.74
Oahe	237	-176.5340	4.0494	-0.0073	26.9814	0.2629	0.0006	0.82
Reliant	240	-150.3243	3.8858	-0.0072	32.9688	0.3210	0.0007	0.69
Rush	227	-199.8517	4.4039	-0.0083	27.8668	0.2716	0.0006	0.80

*Values not significant at 0.05 level. ** All r^2 were highly significant ($P < 0.01$).

Table 48. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating acid detergent fiber concentrations (ADF g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT. During 1997, 1998 and 1999 from accumulated growing degree days (AGDD).

Predicted ADF = Y-int + X_1(AGDD) + X_2(AGDD^2) (for AGDD 58 to 2002)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	221	211.2531	0.1752	-0.000046	4.2606	0.0119	0.000006	0.83*
Hycrest	220	233.2626	0.1575	0.000044	4.0964	0.0116	0.000006	0.79
CDII	222	228.1876	0.1820	-0.000055	4.1475	0.0116	0.000006	0.80
Nordan	223	219.7457	0.1937	-0.000059	4.2546	0.0119	0.000006	0.81
P-27	222	212.6965	0.2218	-0.000073	4.6777	0.0132	0.000007	0.79
Vavilov	222	237.3684	0.1637	-0.000048	4.4165	0.0125	0.000006	0.76
Critana	217	247.7701	0.1736	-0.000051	4.1348	0.0116	0.000006	0.80
Bannock	206	254.6268	0.1757	-0.000057	4.3952	0.0119	0.000006	0.76
Schwendimar	208	261.9014	0.1226	-0.000037	4.9076	0.0134	0.000007	0.59
Pryor	221	221.5992	0.2470	-0.000076	4.7310	0.0133	0.000007	0.85
Revenue	216	233.1821	0.1518	-0.000038	4.8400	0.0136	0.000007	0.76
Secar	220	274.2036	0.1264	-0.000036	3.6977	0.0103	0.000005	0.75
Pearl	222	239.6513	0.1460	-0.000045	5.3643	0.0150	0.000007	0.60
Prairieland	219	239.4272	0.1715	-0.000061	4.5219	0.0126	0.000006	0.66
Eejay	220	247.7419	0.1442	-0.000050	4.5092	0.0128	0.000006	0.59
Trailhead	225	232.3943	0.1606	-0.000040	4.9067	0.0138	0.000007	0.76
Magnar	220	218.7727	0.2079	-0.000066	4.6675	0.0132	0.000007	0.78
Lodorm	222	266.9014	0.1662	-0.000052	4.6269	0.0127	0.000006	0.72
Rosana	215	247.5513	0.1054	-0.000034	5.7912	0.0155	0.000008	0.39
Bozoisky-Select	221	209.3825	0.1912	-0.000059	4.5425	0.0127	0.000006	0.78
Mankota	218	211.7823	0.1713	-0.000050	4.7045	0.0132	0.000007	0.75
Swift	218	224.8834	0.1573	-0.000044	4.5257	0.0126	0.000006	0.75
Goldar	220	252.6866	0.1262	-0.000036	3.6534	0.0103	0.000005	0.74
Greenleaf	224	218.0536	0.2029	-0.000062	4.4403	0.0125	0.000006	0.81
Luna	222	220.7210	0.2324	-0.000080	4.2000	0.0119	0.000006	0.82
Manska	226	216.0643	0.2021	-0.000066	4.7554	0.0133	0.000007	0.75
Oahe	220	218.0646	0.2101	-0.000068	4.0150	0.0112	0.000006	0.83
Reliant	222	220.6097	0.2085	-0.000074	4.7601	0.0135	0.000007	0.72
Rush	215	221.1600	0.2316	-0.000084	4.2673	0.0123	0.000006	0.79

* All r^2 were highly significant ($P < 0.01$).

Table 49. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating neutral-detergent fiber concentrations (NDF g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT during 1997, 1998 and 1999 from Julian date (JD).

Predicted NDF = Y-int + X_1(JD) + X_2(JD^2) (for JD 127 to 328)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	216	36.3279*	3.6447	-0.0050	54.2493	0.5210	0.0012	0.73**
Hycrest	216	160.7279	2.7811	-0.0035	45.1286	0.4350	0.0010	0.73
CDII	213	36.9783*	4.0543	-0.0065	45.5646	0.4390	0.0010	0.74
Nordan	218	83.0061*	3.4766	-0.0049	49.9738	0.4803	0.0011	0.72
P-27	220	-37.4624*	4.6828	-0.0078	54.1276	0.5204	0.0012	0.68
Vavilov	224	81.6162*	3.6728	-0.0057	56.0174	0.5375	0.0012	0.61
Critana	212	75.9305*	3.5065	-0.0044	46.0188	0.4418	0.0010	0.82
Bannock	191	23.4582*	4.3079	-0.0069	40.3222	0.3829	0.0009	0.82
Schwendimar	206	114.5306	3.4506	-0.0053	54.0947	0.5147	0.0012	0.63
Pryor	218	-60.2768*	4.9190	-0.0074	43.3238	0.4147	0.0009	0.85
Revenue	215	85.5841*	3.6301	-0.0051	48.6473	0.4667	0.0011	0.75
Secar	220	271.7598	2.1870	-0.0028	49.0297	0.4711	0.0011	0.58
Pearl	215	21.5702*	4.3191	-0.0080	52.2455	0.5022	0.0012	0.52
Prairieland	208	56.6294*	4.0931	-0.0076	46.2650	0.4439	0.0010	0.57
Eejay	220	-3.6008*	4.6471	-0.0087	52.8140	0.5069	0.0012	0.54
Trailhead	217	101.0423	3.2764	-0.0048	49.7806	0.4778	0.0011	0.67
Magnar	216	-6.8394*	4.4103	-0.0075	50.3595	0.4834	0.0011	0.67
Lodorm	220	44.7575*	4.7461	-0.0081	60.3305	0.5817	0.0013	0.62
Rosana	205	84.5341*	3.5231	-0.0060	60.4166	0.5768	0.0013	0.48
Bozoisky-Select	224	-55.4940*	4.7527	-0.0076	54.4301	0.5221	0.0012	0.72
Mankota	220	-6.1831*	4.3384	-0.0068	52.5757	0.5041	0.0012	0.72
Swift	219	128.3539	3.2529	-0.0048	55.9239	0.5358	0.0012	0.60
Goldar	218	217.5505	2.6277	-0.0038	45.2216	0.4342	0.0010	0.63
Greenleaf	221	-111.4058	5.1915	-0.0088	53.7089	0.5151	0.0012	0.71
Luna	217	-144.4635	5.6668	-0.0100	47.8103	0.4596	0.0011	0.75
Manska	220	-141.0648	5.5730	-0.0101	48.4416	0.4649	0.0011	0.71
Oahe	221	-129.7391	5.4314	-0.0094	50.6294	0.4863	0.0011	0.74
Reliant	216	-165.1793	5.9279	-0.0110	49.0551	0.4723	0.0011	0.72
Rush	218	-13.5069*	4.5148	-0.0078	50.0612	0.4805	0.0011	0.67

*Values not significant at 0.05 level. ** All r^2 are highly significant ($P < 0.01$).

Table 50. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating neutral detergent fiber concentrations (NDF g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT. during 1997, 1998 and 1999 from accumulated growing degree days (AGDD).

Predicted NDF = Y-int + X_1(AGDD) + X_2(AGDD^2) (for AGDD 58 to 2002)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	200	423.1459	0.2126	-0.000039	8.8025	0.0240	0.000012	0.75*
Hycrest	201	458.6358	0.1852	-0.000041	7.5003	0.0205	0.000010	0.71
CDII	203	450.6534	0.2234	-0.000058	7.5667	0.0207	0.000010	0.73
Nordan	198	448.8938	0.2127	-0.000048	7.8474	0.0215	0.000011	0.74
P-27	207	431.4110	0.2642	-0.000075	8.9881	0.0246	0.000012	0.68
Vavilov	203	455.2564	0.2187	-0.000059	8.9203	0.0244	0.000012	0.63
Critana	199	457.8460	0.2094	-0.000035	7.4865	0.0204	0.000010	0.81
Bannock	189	461.7302	0.2331	-0.000061	7.9424	0.0207	0.000010	0.75
Schwendimar	193	468.1926	0.2018	-0.000051	9.6772	0.0253	0.000012	0.61
Pryor	204	448.4750	0.2829	-0.000068	7.3993	0.0199	0.000010	0.84
Revenue	199	478.1378	0.1898	-0.000037	8.2747	0.0221	0.000011	0.72
Secar	204	505.7497	0.1361	-0.000026	8.0134	0.0217	0.000011	0.58
Pearl	201	449.8010	0.1960	-0.000060	8.4667	0.0231	0.000012	0.53
Prairieland	201	453.7678	0.2177	-0.000078	7.9831	0.0216	0.000011	0.52
Eejay	205	447.9459	0.2336	-0.000077	8.7258	0.0238	0.000012	0.56
Trailhead	198	443.5684	0.1828	-0.000035	7.7585	0.0213	0.000011	0.72
Magnar	202	434.9575	0.2297	-0.000062	8.2369	0.0226	0.000011	0.69
Lodorm	203	512.8717	0.2612	-0.000074	8.9736	0.0246	0.000012	0.68
Rosana	189	436.8336	0.1779	-0.000042	9.9284	0.0257	0.000013	0.56
Bozoisky-Select	206	418.8328	0.2916	-0.000082	8.3152	0.0227	0.000011	0.76
Mankota	201	441.7596	0.2227	-0.000047	8.1435	0.0221	0.000011	0.76
Swift	200	459.4902	0.1898	-0.000038	8.2013	0.0222	0.000011	0.71
Goldar	202	495.2547	0.1427	-0.000028	7.1063	0.0193	0.000010	0.65
Greenleaf	203	407.2411	0.2873	-0.000087	8.4023	0.0229	0.000011	0.72
Luna	203	415.9105	0.2936	-0.000088	7.3643	0.0200	0.000010	0.78
Manska	201	402.5293	0.3016	-0.000100	7.7820	0.0213	0.000011	0.73
Oahe	204	401.6215	0.3243	-0.000104	7.9225	0.0218	0.000011	0.76
Reliant	199	409.7718	0.3193	-0.000111	7.8343	0.0215	0.000011	0.73
Rush	200	438.5545	0.2513	-0.000080	8.2911	0.0227	0.000011	0.64

* All r^2 were highly significant ($P < 0.01$).

Table 51. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2) standard errors (SE) and coefficients of determination (r^2) for estimating *in vitro* digestible dry matter concentrations (IVDDM g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT during 1997, 1998 and 1999 from Julian date (JD).

Predicted IVDDM = Y-int + X_1(JD) + X_2(JD^2) (for JD 127 to 328)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	210	1053.2835	-3.7746	0.0042	70.9897	0.6727	0.0015	0.75**
Hycrest	218	728.0610	-1.2017*	-0.0006*	70.2265	0.6653	0.0015	0.63
CDII	213	1025.7368	-3.9208	0.0052	68.3716	0.6473	0.0015	0.69
Nordan	213	904.5913	-2.8161	0.0025*	67.1060	0.6375	0.0014	0.71
P-27	214	955.7116	-3.7328	0.0045	73.5987	0.6981	0.0016	0.69
Vavilov	216	898.2368	-2.9089	0.0028	67.6682	0.6413	0.0014	0.71
Critana	219	1107.7943	-5.0615	0.0074	67.5265	0.6401	0.0014	0.74
Bannock	210	1217.5819	-6.2262	0.0108	60.8530	0.5755	0.0013	0.72
Schwendimar	206	1103.4211	-5.2654	0.0091	56.3392	0.5320	0.0012	0.69
Pryor	217	1231.5601	-5.8651	0.0088	71.8434	0.6809	0.0015	0.76
Revenue	206	1207.5824	-5.5173	0.0085	58.5445	0.5539	0.0012	0.80
Secar	218	920.1838	-3.7523	0.0055	62.5854	0.5933	0.0013	0.64
Pearl	220	1145.4943	-5.5608	0.0096	75.5897	0.7163	0.0016	0.56
Prairieland	210	1107.1161	-5.2986	0.0093	65.0828	0.6155	0.0014	0.60
Eejay	216	1030.7500	-4.4976	0.0074	75.8696	0.7177	0.0016	0.53
Trailhead	216	1223.0682	-5.3462	0.0076	64.9629	0.6165	0.0014	0.79
Magnar	218	1243.5489	-5.4862	0.0077	71.4790	0.6778	0.0015	0.77
Lodorm	216	1030.8885	-4.3784	0.0063	63.5436	0.6028	0.0014	0.72
Rosana	207	794.2938	-2.0200	0.0013*	72.1230	0.6818	0.0015	0.61
Bozoisky-Select	217	1178.9904	-5.1931	0.0074	83.5486	0.7918	0.0018	0.68
Mankota	217	1178.9879	-5.2265	0.0078	77.8848	0.7393	0.0017	0.68
Swift	216	1077.6200	-4.7376	0.0072	87.3889	0.8287	0.0019	0.57
Goldar	214	1006.4429	-4.0673	0.0057	54.7023	0.5185	0.0012	0.76
Greenleaf	219	1109.3777	-4.7281	0.0069	63.1549	0.5986	0.0013	0.74
Luna	218	1267.7984	-6.2703	0.0102	64.3280	0.6084	0.0014	0.76
Manska	214	1028.4128	-4.0834	0.0057	59.7600	0.5653	0.0013	0.73
Oahe	217	1067.7181	-4.3112	0.0060	66.0393	0.6260	0.0014	0.71
Reliant	219	1050.4437	-4.2650	0.0065	74.9353	0.7100	0.0016	0.58
Rush	215	1005.0168	-3.8800	0.0055	62.5979	0.5928	0.0013	0.68

*Values not significant at 0.05 level.

**All r^2 were highly significant ($P < 0.01$).

Table 52. Prediction equation, Y intercepts (Y-int), coefficients (X_1 and X_2), standard errors (SE) and coefficients of determination (r^2) for estimating *in vitro* digestible dry matter concentrations (IVDDM g kg^{-1}) for 29 dryland grasses at Bozeman, Bridger and Moccasin, MT. during 1997, 1998 and 1999 from accumulated growing degree days (AGDD).

Predicted IVDDM = Y-int + X_1(AGDD) + X_2(AGDD^2) (for AGDD 58 to 2002)

Variety	N	Y-int	X_1	X_2	SE Y-int	SE X_1	SE X_2	r^2
Douglas	226	652.7481	-0.2446	0.000029*	13.6486	0.0366	0.000018	0.70**
Hycrest	226	592.5712	-0.1900	0.000030	11.9033	0.0320	0.000016	0.60
CDII	227	637.1776	-0.2868	0.000069	12.8795	0.0346	0.000017	0.64
Nordan	227	611.4586	-0.2400	0.000042	12.3285	0.0334	0.000016	0.66
P-27	226	618.1624	-0.2587	0.000045	13.5361	0.0366	0.000018	0.66
Vavilov	227	595.7180	-0.2450	0.000049	12.3677	0.0332	0.000016	0.64
Critana	228	603.1097	-0.3164	0.000070	11.7695	0.0314	0.000015	0.75
Bannock	219	627.2464	-0.3743	0.000115	11.2876	0.0297	0.000014	0.71
Schwendimar	215	594.6345	-0.2989	0.000088	10.2511	0.0269	0.000013	0.69
Pryor	223	650.3423	-0.3728	0.000089	12.6428	0.0335	0.000016	0.77
Revenue	213	653.2517	-0.3172	0.000074	10.4223	0.0277	0.000014	0.78
Secar	224	540.4949	-0.2088	0.000039	10.4381	0.0279	0.000014	0.67
Pearl	225	614.0387	-0.3068	0.000082	11.9001	0.0316	0.000015	0.67
Prairieland	224	618.5885	-0.3244	0.000098	11.7186	0.0311	0.000015	0.64
Eejay	227	590.9483	-0.2479	0.000061	12.4060	0.0335	0.000017	0.58
Trailhead	223	693.9156	-0.3636	0.000088	10.5063	0.0281	0.000014	0.81
Magnar	228	691.7000	-0.3657	0.000086	11.4268	0.0310	0.000015	0.79
Lodorm	229	591.0398	-0.2843	0.000066	10.0807	0.0270	0.000013	0.75
Rosana	217	573.6878	-0.1649	0.000014*	12.9664	0.0341	0.000017	0.59
Bozoisky-Select	226	671.0461	-0.3584	0.000085	14.5565	0.0389	0.000019	0.69
Mankota	225	654.5703	-0.3075	0.000064	12.8030	0.0343	0.000017	0.71
Swift	228	610.4029	-0.2665	0.000050	14.3907	0.0390	0.000019	0.63
Goldar	225	602.1048	-0.2761	0.000065	9.7322	0.0262	0.000013	0.75
Greenleaf	227	635.1010	-0.3011	0.000073	10.9187	0.0292	0.000014	0.73
Luna	229	653.7709	-0.3554	0.000092	10.5596	0.0282	0.000014	0.78
Manska	226	641.8650	-0.3231	0.000088	10.8604	0.0290	0.000014	0.72
Oahe	228	653.6152	-0.3229	0.000082	12.0182	0.0320	0.000016	0.70
Reliant	227	633.9468	-0.2897	0.000079	12.4478	0.0334	0.000016	0.60
Rush	228	636.0514	-0.3063	0.000085	10.8119	0.0290	0.000014	0.68

*Values not significant at 0.05 level.

**All r^2 were highly significant ($P < 0.01$).

scope of this study. Confidence limits (95%) were generated for all of the equations. There were many significant ($P < 0.05$) differences among varieties when x_1, and x_2 coefficients were compared. These data indicate that the rates (slopes) of decline in forage quality with advancing maturity (as JD or AGDD) are different among varieties. The r^2 values for forage quality ranged from 0.39 (Rosana ADF) to 0.85 (Schwendimar ADF) for the AGDD models, and all were highly significant ($P < 0.01$).

Confidence intervals ($P < 0.05$) and graphs were generated for all varieties and all regression models (not shown). Due to the significant interactions and large standard errors associated with JD-based regressions and some of the AGDD models, few significant ($P < 0.05$) differences were detected among varieties for season-long forage quality. Early in the season, Bozoisky-Select had significantly ($P < 0.05$) higher levels of CP (Figure 3) and IVDDM (Figure 4) than Lodorm green needlegrass.

Several varieties were selected to demonstrate utilization of the AGDD models for prediction of dryland forage quality when appropriate varieties are used for early pasture (June 1), summer pasture or hay production (July 15) or deferred fall pasture (September 15).

On June 1, predicted CP levels of Bozoisky-Select Russian wildrye are 7 to 11 % higher than those of Hycrest crested wheatgrass (Table 53), and there are similar differences between varieties found for ADF, NDF and IVDDM (Tables 54, 55, and 56).

If grazed or cut for hay on July 15, predicted CP levels of Manska pubescent wheatgrass were 7 to 10 % higher than those of Oahe intermediate wheatgrass (Table 57). The predicted ADF and NDF concentrations of Manaska are numerically lower than

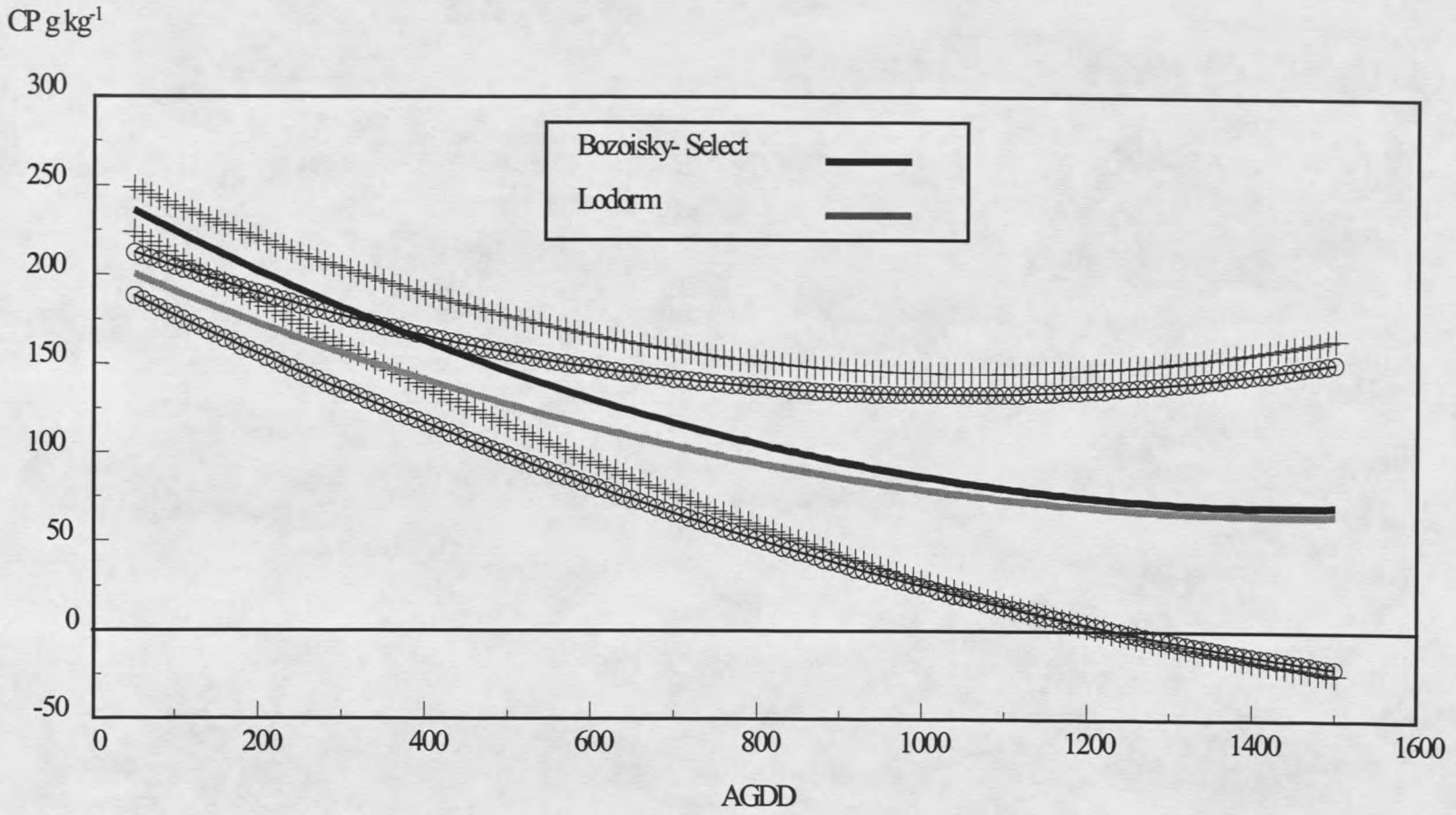


Figure 3. Seasonal variation for levels of crude protein (CP) concentrations of Bozoisky-Select Russian wildrye and Lodorm green needlegrass predicted by regression equations (Table 46) on accumulated growing degree days (AGDD), base 5 degrees C (+ and o are 95% confidence intervals).

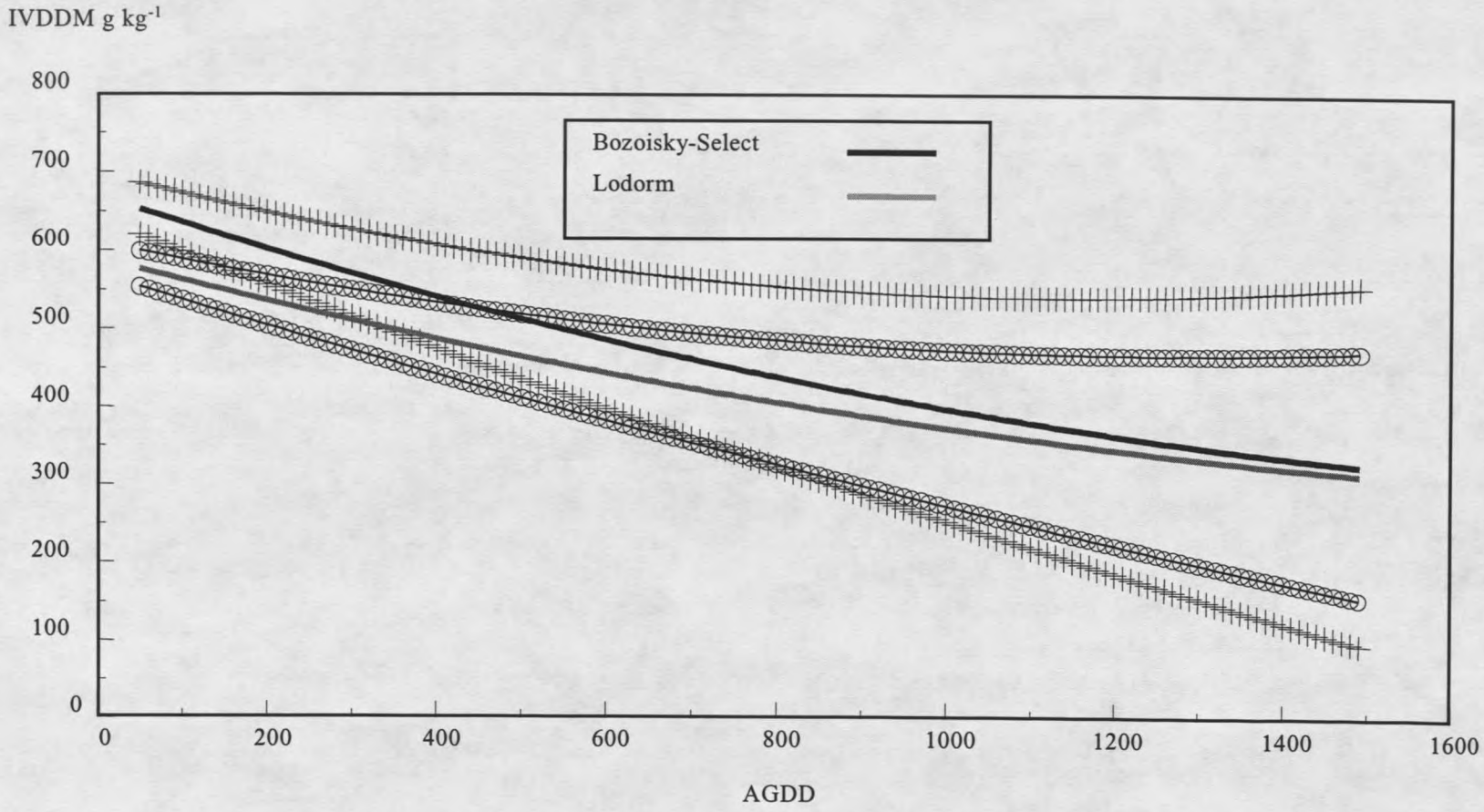


Figure 4. Seasonal variation for levels of in vitro digestible dry matter (IVDDM) concentrations of Bozoisky-Select Russian wildrye and Lodorm green needlegrass predicted by regression equations (Table 52) on accumulated growing degree days (AGDD), base 5 degrees C (+ and o are 95% confidence intervals).

Table 53. Comparison of actual and predicted levels of CP concentration (g kg^{-1}) for Hycrest crested wheatgrass and Bozoisky-Select Russian wildrye used for early pasture (approx. June 1).

			Hycrest		Bozoisky-Select	
	Actual Date	AGGD	Actual CP	Predicted CP	Actual CP	Predicted CP
Bozeman	6/4/97	342	169.8	175.5	198.5	193.0
	5/27/98	286	200.7	184.8	219.6	201.1
	6/2/99	231	202.9	194.4	236.5	209.3
Bridger	5/29/97	247	192.8	191.5	192.5	206.9
	6/5/98	350	178.6	174.2	178.3	193.0
	6/3/99	239	204.6	193.0	207.4	208.2
Moccasin	6/2/97	243	199.6	192.3	218.4	207.6
	5/26/98	257	183.3	189.8	203.5	205.4
	6/4/99	244	176.0	192.1	224.8	207.6

Table 54. Comparison of actual and predicted levels of ADF concentration (g kg^{-1}) for Hycrest crested wheatgrass and Bozoisky-Select Russian wildrye used for early pasture (approx. June 1).

			Hycrest		Bozoisky-Select	
	Actual Date	AGGD	Actual ADF	Predicted ADF	Actual ADF	Predicted ADF
Bozeman	6/4/97	342	334.8	292.3	307.1	267.9
	5/27/98	286	267.7	281.9	238.4	259.2
	6/2/99	231	267.8	272.0	233.1	250.4
Bridger	5/29/97	247	263.9	274.8	266.6	253.0
	6/5/98	350	278.9	293.8	285.5	269.1
	6/3/99	239	261.0	273.4	258.7	251.7
Moccasin	6/2/97	243	290.1	274.1	269.2	252.4
	5/26/98	257	260.0	276.6	243.6	254.6
	6/4/99	244	280.2	274.3	243.9	252.5

Table 55. Comparison of actual and predicted levels of NDF concentration (g kg^{-1}) for Hycrest crested wheatgrass and Bozoisky-Select Russian wildrye used for early pasture (approx. June 1).

			Hycrest		Bozoisky-Select	
	Actual Date	AGGD	Actual NDF	Predicted NDF	Actual NDF	Predicted NDF
Bozeman	6/4/97	342	597.2	517.2	597.4	509.0
	5/27/98	286	562.9	508.2	503.2	495.5
	6/2/99	231	531.0	499.2	477.1	481.8
Bridger	5/29/97	247	592.8	501.9	584.0	485.9
	6/5/98	350	498.3	518.4	521.5	510.8
	6/3/99	239	526.1	500.6	539.9	483.8
Moccasin	6/2/97	243	493.7	501.2	464.2	484.8
	5/26/98	257	436.6	503.5	377.7	488.4
	6/4/99	244	478.3	501.4	465.7	485.1

Table 56. Comparison of actual and predicted levels of IVDDM concentration (g kg^{-1}) for Hycrest crested wheatgrass and Bozoisky-Select Russian wildrye used for early pasture (approx. June 1).

			Hycrest		Bozoisky-Select	
	Actual Date	AGGD	Actual IVDDM	Predicted IVDDM	Actual IVDDM	Predicted IVDDM
Bozeman	6/4/97	342	412.4	531.1	435.5	558.4
	5/27/98	286	490.6	540.7	610.8	575.5
	6/2/99	231	595.5	550.3	670.0	592.8
Bridger	5/29/97	247	575.8	547.5	614.0	587.7
	6/5/98	350	461.4	529.7	471.3	556.0
	6/3/99	239	455.6	548.9	492.7	590.2
Moccasin	6/2/97	243	598.5	548.2	647.5	589.0
	5/26/98	257	616.7	545.7	661.4	584.6
	6/4/99	244	669.6	548.0	687.4	588.7

Table 57. Comparison of actual and predicted levels of CP concentration (g kg^{-1}) for Oahe intermediate wheatgrass and Manska pubescent wheatgrass used for mid-season hay production (approx. July 15).

			Oahe		Manska	
	Actual Date	AGGD	Actual CP	Predicted CP	Actual CP	Predicted CP
Bozeman	7/2/97	634	134.2	136.1	155.9	149.4
	7/8/98	679	132.2	130.2	135.6	143.3
	7/14/99	687	126.4	129.1	165.7	142.3
Bridger	7/10/97	736	129.1	123.2	100.5	136.1
	7/10/98	710	161.8	126.3	166.5	139.3
	7/15/99	701	159.9	127.4	166.5	140.5
Moccasin	7/14/97	693	71.3	128.4	77.1	141.5
	7/14/98	725	119.4	124.5	128.8	137.5
	7/15/99	665	89.6	132.0	94.6	145.2

Table 58. Comparison of actual and predicted levels of ADF concentration (g kg^{-1}) for Oahe intermediate wheatgrass and Manska pubescent wheatgrass used for mid-season hay production (approx. July 15).

			Oahe		Manska	
	Actual Date	AGGD	Actual ADF	Predicted ADF	Actual ADF	Predicted ADF
Bozeman	7/2/97	634	398.7	323.9	388.6	317.7
	7/8/98	679	359.1	329.4	362.7	322.9
	7/14/99	687	323.2	330.3	300.3	323.8
Bridger	7/10/97	736	343.8	335.9	261.5	329.1
	7/10/98	710	327.0	333.0	326.2	326.3
	7/15/99	701	289.0	331.9	273.0	325.3
Moccasin	7/14/97	693	402.8	331.0	389.3	324.4
	7/13/98	725	334.4	334.6	335.9	327.9
	7/15/99	665	332.6	327.7	319.6	321.3

those of Oahe (Tables 58 and 59). Interestingly, the predicted and most of the actual IVDDM levels of Oahe are numerically higher (NS at P = 0.05) than those of Manska (Table 60). Manska was bred for improved IVDDM (USDA, NRCS 2000), but in this study, IVDDM levels showed no significant improvement above other intermediate or pubescent wheatgrass varieties.

For deferred fall pasture on September 15, Prairieland Altai wildrye had from 7 to 15 % higher predicted CP levels than Trailhead Basin wildrye (Table 61). The actual and predicted levels of ADF and NDF for Prairieland on September 15 are numerically lower than those of Trailhead (Tables 62 and 63). Most predicted levels of IVDDM for Prairieland were higher than those for Trailhead (Table 64). Similar to the CP prediction, these differences are not statistically significant (P = 0.05) by the AGDD regression model, and there are several large discrepancies between actual versus predicted CP of these *Leymus* species. This could be due to the high standard errors associated with the regression models, or possibly poor performance of NIRS prediction for species that tend to retain higher forage quality levels at maturity.

Correlations Among Dry Matter Yield and Forage Quality

Simple linear correlations (r) were computed within all 29 varieties for all combinations of dry matter yield, CP, ADF, NDF, and IVDDM (Table 65). In general, most correlations among forage quality traits were relatively high ($r < -0.70$ or $r > 0.70$) and highly significant ($P < 0.01$). Eejay Altai wildrye was an exception; correlations

Table 59. Comparison of actual and predicted levels of NDF concentration (g kg^{-1}) for Oahe intermediate wheatgrass and Manska pubescent wheatgrass used for mid-season hay production (approx. July 15).

			Oahe		Manska	
	Actual Date	AGGD	Actual NDF	Predicted NDF	Actual NDF	Predicted NDF
Bozeman	7/2/97	634	644.9	565.4	635.7	553.5
	7/8/98	679	600.7	573.9	607.0	561.2
	7/14/99	687	559.8	575.3	522.8	562.5
Bridger	7/10/97	736	640.8	584.0	461.8	570.3
	7/10/98	710	531.2	579.4	526.9	566.3
	7/15/99	701	526.9	577.9	496.9	564.8
Moccasin	7/14/97	693	640.5	576.4	617.5	563.5
	7/13/98	725	529.8	582.1	522.9	568.6
	7/15/99	665	558.2	571.3	562.8	558.9

Table 60. Comparison of actual and predicted levels of IVDDM concentration (g kg^{-1}) for Oahe intermediate wheatgrass and Manska pubescent wheatgrass used for mid-season hay production (approx. July 15).

			Oahe		Manska	
	Actual Date	AGGD	Actual IVDDM	Predicted IVDDM	Actual IVDDM	Predicted IVDDM
Bozeman	7/2/97	634	342.8	481.9	327.3	472.4
	7/8/98	679	403.9	472.2	378.3	463.1
	7/14/99	687	508.5	470.5	496.0	461.4
Bridger	7/10/97	736	394.3	460.4	278.0	451.7
	7/10/98	710	379.0	465.7	369.7	456.8
	7/15/99	701	444.3	467.6	456.2	458.6
Moccasin	7/14/97	693	470.9	469.2	494.0	460.2
	7/13/98	725	524.1	462.6	496.3	453.9
	7/15/99	665	580.7	475.1	573.9	465.9

Table 61. Comparison of actual and predicted levels of CP concentration (g kg^{-1}) for Trailhead Basin wildrye and Prairieland Altai wildrye used for deferred fall pasture (approx. September 15).

			Trailhead		Prairieland	
	Actual Date	AGGD	Actual CP	Predicted CP	Actual CP	Predicted CP
Bozeman	10/30/97	1849	75.2	102.8	95.4	120.7
	9/24/98	1871	103.3	103.3	107.4	121.2
	9/15/99	1752	104.4	101.2	126.8	118.9
Bridger	9/8/97	1551	151.8	101.2	194.7	118.1
	9/18/98	1836	97.7	102.5	137.4	120.4
	9/15/99	1565	118.4	101.1	158.1	118.0
Moccasin	7/28/97	892	135.0	133.0	116.8	143.3
	10/6/98	1929	85.4	104.9	84.9	122.8
	9/15/99	1471	88.3	102.5	103.5	118.9

Table 62. Comparison of actual and predicted levels of ADF concentration (g kg^{-1}) for Trailhead Basin Wildrye and Prairieland Altai wildrye used for deferred fall pasture (approx. September 15).

			Trailhead		Prairieland	
	Actual Date	AGGD	Actual ADF	Predicted ADF	Actual ADF	Predicted ADF
Bozeman	10/30/97	1849	472.8	392.6	403.0	348.0
	9/24/98	1871	399.2	392.9	371.4	346.8
	9/15/99	1752	416.6	391.0	350.6	352.7
Bridger	9/8/97	1551	333.8	385.3	299.8	358.7
	9/18/98	1836	374.8	392.4	339.5	348.7
	9/15/99	1565	351.8	385.8	322.2	358.4
Moccasin	7/28/97	892	338.6	343.8	360.4	343.9
	10/6/98	1929	405.3	393.4	392.3	343.3
	9/15/99	1471	415.6	382.1	376.0	359.7

Table 63. Comparison of actual and predicted levels of NDF concentration (g kg^{-1}) for Trailhead Basin Wildrye and Prairieland Altai wildrye used for deferred fall pasture (approx. September 15).

			Trailhead		Prairieland	
	Actual Date	AGGD	Actual NDF	Predicted NDF	Actual NDF	Predicted NDF
Bozeman	10/30/97	1849	688.1	661.9	619.0	589.6
	9/24/98	1871	598.0	663.1	567.2	588.0
	9/15/99	1752	693.0	656.4	621.3	595.8
Bridger	9/8/97	1551	513.1	642.9	492.4	603.8
	9/18/98	1836	652.1	661.2	579.9	590.5
	9/15/99	1565	615.6	643.9	536.4	603.4
Moccasin	7/28/97	892	543.8	578.8	590.4	585.9
	10/6/98	1929	661.1	666.0	668.3	583.5
	9/15/99	1471	722.5	636.7	619.1	605.2

Table 64. Comparison of actual and predicted levels of IVDDM concentration (g kg^{-1}) for Trailhead Basin Wildrye and Prairieland Altai wildrye used for deferred fall pasture (approx. September 15).

			Trailhead		Prairieland	
	Actual Date	AGGD	Actual IVDDM	Predicted IVDDM	Actual IVDDM	Predicted IVDDM
Bozeman	10/30/97	1849	180.3	322.5	380.2	353.8
	9/24/98	1871	330.4	321.7	379.2	354.7
	9/15/99	1752	303.0	327.0	340.6	351.1
Bridger	9/8/97	1551	370.7	341.7	348.8	351.2
	9/18/98	1836	351.3	323.0	325.5	353.3
	9/15/99	1565	407.6	340.4	359.4	351.0
Moccasin	7/28/97	892	494.1	439.6	484.0	407.2
	10/6/98	1929	256.0	320.0	280.8	357.5
	9/15/99	1471	287.4	349.5	395.7	353.5

Table 65. Simple correlations (r) among forage yield (Y), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* digestible dry matter (IVDDM) of 29 grass varieties.

Variety	N	Y:CP	Y:ADF	Y:NDF	Y:IVDDM	CP:ADF	CP:NDF	CP:IVDDM	ADF:NDF	ADF:IVDDM	NDF:IVDDM
Douglas	259	-0.28	0.31	0.28	-0.35	-0.90	-0.77	0.61	0.87	-0.81	-0.78
Hycrest	259	-0.24	0.30	0.31	-0.34	-0.92	-0.79	0.65	0.86	-0.79	-0.79
CDII	259	-0.19	0.28	0.26	-0.40	-0.91	-0.77	0.66	0.86	-0.82	-0.77
Nordan	259	-0.29	0.33	0.40	-0.34	-0.92	-0.80	0.64	0.88	-0.81	-0.80
P-27	259	-0.40	0.44	0.45	-0.49	-0.92	-0.82	0.72	0.89	-0.85	-0.82
Vavilov	259	-0.34	0.38	0.37	-0.42	-0.90	-0.77	0.66	0.87	-0.83	-0.81
Critana	259	-0.32	0.35	0.35	-0.35	-0.93	-0.83	0.77	0.86	-0.86	-0.83
Bannock	235	-0.25	0.38	0.39	-0.34	-0.89	-0.81	0.67	0.87	-0.81	-0.76
Schwendimar	239	-0.40	0.49	0.49	-0.45	-0.87	-0.79	0.65	0.83	-0.74	-0.71
Pryor	259	-0.39	0.48	0.48	-0.48	-0.93	-0.89	0.79	0.91	-0.89	-0.84
Revenue	259	-0.38	0.45	0.50	-0.42	-0.92	-0.77	0.69	0.81	-0.78	-0.79
Secar	259	-0.43	0.44	0.43	-0.45	-0.87	-0.75	0.75	0.82	-0.88	-0.80
Pearl	259	-0.22	0.28	0.29	-0.39	-0.90	-0.76	0.60	0.83	-0.74	-0.67
Prairie	259	-0.17	0.28	0.31	-0.46	-0.88	-0.75	0.51	0.80	-0.68	-0.58
Eejay	259	-0.19	0.31	0.28	-0.33	-0.84	-0.20	0.60	0.55	-0.67	-0.21
Trailhead	259	-0.27	0.32	0.27	-0.33	-0.91	-0.87	0.83	0.89	-0.90	-0.79
Magnar	259	-0.25	0.31	0.28	-0.46	-0.92	-0.83	0.72	0.86	-0.83	-0.76
Lodorm	259	-0.44	0.41	0.32	-0.40	-0.92	-0.79	0.74	0.81	-0.83	-0.82
Rosana	243	-0.29	0.32	0.37	-0.38	-0.85	-0.75	0.52	0.79	-0.55	-0.64
Bozoisky-Select	259	-0.26	0.35	0.39	-0.44	-0.93	-0.80	0.75	0.87	-0.87	-0.87
Mankota	259	-0.17	0.25	0.32	-0.38	-0.94	-0.86	0.75	0.90	-0.87	-0.86
Swift	259	-0.12*	0.18	0.28	-0.29	-0.93	-0.81	0.74	0.87	-0.85	-0.86
Goldar	259	-0.41	0.49	0.32	-0.38	-0.85	-0.74	0.77	0.78	-0.84	-0.78
Greenleaf	258	-0.34	0.43	0.42	-0.42	-0.92	-0.83	0.70	0.86	-0.81	-0.77
Luna	259	-0.30	0.33	0.33	-0.33	-0.92	-0.81	0.73	0.86	-0.85	-0.79
Manska	259	-0.29	0.42	0.41	-0.39	-0.91	-0.81	0.61	0.87	-0.76	-0.72
Oahe	259	-0.30	0.39	0.39	-0.44	-0.92	-0.82	0.63	0.88	-0.78	-0.78
Reliant	259	-0.33	0.47	0.49	-0.49	-0.91	-0.77	0.55	0.84	-0.71	-0.73
Rush	259	-0.37	0.45	0.41	-0.45	-0.93	-0.80	0.67	0.84	-0.79	-0.75

* Not significant at P = 0.05; all other values are highly significant (P < 0.01).

between CP:NDF (r = -0.20) ADF:NDF (r = 0.55) and NDF:IVDDM (r = -0.21) were numerically lower than those from Pearl and Prairieland wildrye, and all 26 other varieties. Also, the correlations among CP:IVDDM and NDF:IVDDM for Eejay, Pearl and Prairieland were numerically lower than those for the other varieties. In general the wildrye varieties maintained higher CP and IVDDM levels throughout the study relative to other varieties. The specific reasons for differential correlations among forage quality traits of these varieties could be due to deeper rooting (more water or N extraction), or anatomical features of these *Leymus* varieties that allow plants to remain green year-round. All forage quality traits were measured by NIRS, and reasonably high correlations were expected. However, the data from these Altai wildrye entries indicates some possible caution on using single NIRS prediction equations across species.

Correlations among dry matter production and forage quality traits were mostly low ($-0.3 < r < 0.3$), but highly significant ($P < 0.01$). In general, these weak correlations between yield and forage quality contrast with previous studies (Cash, unpublished data). Forage yield is usually highly correlated with ADF or NDF levels, however in this study, correlations were relatively low ($0.18 < r < 0.50$). As expected, ADF and NDF were highly correlated ($r > .79$), except for Eejay ($r = 0.55$).

In this study, the low correlations among forage yield and quality were likely due to extreme variation among locations or years, with smaller variation in forage quality. Crude protein concentrations were negatively correlated to forage yield, with the strongest negative r values ($r < -0.40$) for P-27, Schwendimar, Secar, Lodorm and Goldar. Generally, these varieties had lower yield levels throughout the study. In summary, these

correlation values suggest that dryland grass forage quality is not strongly and negatively correlated to dry matter production under ideal management and across the wide range of production environments studied.

CHAPTER 5

PRACTICAL APPLICATION OF FORAGE YIELD AND QUALITY TRAITS

A major goal of this research was to collect reliable forage quality and production data for estimating carrying capacity or stocking rates. Current methods used by ranchers and numerous agencies consist of estimating animal units (AU) or animal unit months (AUM) for dryland pasture based on some estimate of dry matter production. These field methods are simple, reliable, and useful for estimating forage availability of mixed range or improved pasture stands. However, limited seasonal forage quality data are available for most common species and varieties. In forage and range systems, forage quality can dictate animal performance, so forage availability alone may not be a reliable indicator of animal performance in that pasture.

Summarized data for this study were used to develop three practical models for a Montana range-based cow-calf operation (Tables 66 to 68). Actual forage yield data were used to calculate AU and AUM as typically is done. Actual forage yield on dates closest to June 1, July 15, and September 15 were averaged across locations. Predicted forage quality data were then used to estimate potential limitations in daily intake (NDF), CP or TDN (estimated from IVDDM). The model was based on a late-winter calving, operation and compares the varieties for differences in AUM and forage quality on June 1, July 15, and September 15. Available forage dry matter was converted to 50% utilization of total production ("take half-leave half"). AUM ha^{-1} values were based on available forage dry matter and NRC suggested levels of dry matter intake for cattle at

Table 66. Carrying capacity of 29 dryland forage grasses grazed on **June 1** estimated by forage availability or by intake and nutrient concentrations. Animal unit-months [AUM] calculated for one cow-calf pair with combined body weight of 636 kg, and NRC requirements.

Variety	Forage Dry Matter (kg ha^{-1})	Available Forage Dry Matter (kg ha^{-1}) @ 50% Utilization	AUM ha^{-1} (Based on Forage Availability)	%NDF	%IVDDM	%CP	Potential DMI (kg AU^{-1} d^{-1}) as % of NRC Suggested Level (11.7 kg)	Potential TDN(kg AU^{-1} d^{-1}) as % of NRC Requirement (6.36 kg)	Potential CP (kg AU^{-1} d^{-1}) as % of NRC Requirement (1.05 kg)
Douglas	1311.0	655.5	1.7	51.0	58.5	20.6	128.8	107.1	199.4
Hycrest	1519.2	759.6	1.9	52.4	54.2	19.0	125.1	99.2	184.1
CDII	1554.3	777.2	2.0	53.4	55.9	18.7	122.9	102.3	181.5
Nordan	1444.1	722.0	1.9	51.7	54.4	19.2	126.7	99.6	186.7
P-27	1180.4	590.2	1.5	51.9	54.5	20.3	126.4	99.7	196.4
Vavilov	1527.2	763.6	2.0	52.2	53.1	19.3	125.5	97.1	187.5
Critana	1015.2	507.6	1.3	54.2	51.7	18.7	121.0	94.6	181.0
Bannock	958.4	479.2	1.2	54.2	54.7	18.1	121.0	100.0	175.2
Schwendimar	760.1	380.0	1.0	52.9	54.4	19.2	124.1	99.6	185.9
Pryor	1206.6	603.3	1.5	55.2	54.8	18.6	118.8	100.3	180.5
Revenue	929.7	464.9	1.2	53.3	56.9	20.0	123.0	104.2	194.3
Secar	838.5	419.2	1.1	55.3	48.9	19.4	118.6	89.6	187.8
Pearl	1119.1	559.5	1.4	51.0	53.3	21.2	128.7	97.5	205.7
Prairieland	1183.0	591.5	1.5	51.7	54.1	21.2	126.8	99.0	205.4
Eejay	1126.5	563.3	1.4	51.8	52.8	21.6	126.7	96.6	209.4
Trailhead	1403.5	701.8	1.8	50.2	58.9	21.2	130.5	107.8	206.0
Magnar	1083.1	541.6	1.4	50.4	59.7	21.5	130.1	109.2	208.6
Rosana	809.4	404.7	1.0	47.2	55.5	21.7	138.9	101.6	210.9
Bozoisky-Select	1311.2	655.6	1.7	50.3	58.8	20.9	130.2	107.6	202.6
Mankota	1172.1	586.0	1.5	51.3	56.9	20.9	127.7	104.2	202.5
Swift	1179.9	598.9	1.5	53.7	53.1	20.2	122.1	97.1	196.1
Goldar	641.3	320.7	0.8	54.4	53.4	18.8	120.4	97.8	182.2
Greenleaf	1375.6	687.8	1.8	49.9	57.0	20.2	131.4	104.4	196.0
Luna	1925.5	962.8	2.5	50.9	56.5	20.0	128.9	103.4	193.8
Manska	1595.3	797.7	2.0	50.0	56.5	20.6	131.1	103.4	200.3
Oahe	1696.9	848.5	2.2	50.2	57.1	19.9	130.7	104.6	193.2
Reliant	1726.4	863.2	2.2	50.2	15.2	58.0	130.6	106.2	196.7
Rush	1730.5	865.2	2.2	51.6	14.8	56.5	127.0	103.5	199.2
Lodorm	972.0	486.0	1.2	58.6	13.0	52.1	118.8	95.4	164.6

Table 67. Carrying capacity of 29 dryland forage grasses grazed on **July 15** estimated by forage availability or by intake and nutrient concentrations. Animal unit-months [AUM] calculated for one cow (545 kg) and calf (182 kg) pair, and NRC requirements.

Variety	Forage Dry Matter (kg ha^{-1})	Available Forage Dry Matter (kg ha^{-1}) @ 50% Utilization	AUM ha^{-1} (Based on Forage Availability	%NDF	%IVDDM	%CP	Potential DMI (kg AU^{-1} d^{-1}) as % of NRC Suggested Level (10.1 kg) Cow	(5 kg) Calf	Potential TDN (kg AU^{-1} d^{-1}) as % of NRC Requirement (5.36 kg) Cow	(2.27 kg) Calf	Potential CP (kg AU^{-1} d^{-1}) as % of NRC Requirement (0.77 kg) Cow	(0.68 kg) Calf
Douglas	2309.8	1154.9	2.4	53.2	47.5	13.2	121.8	82.1	89.5	104.7	173.8	126.9
Hycrest	3100.4	1551.2	3.2	57.1	46.5	11.8	113.4	76.4	87.6	102.4	155.3	113.4
CDII	3362.2	1681.1	3.5	56.5	44.4	11.2	114.7	77.3	83.7	97.8	147.2	107.4
Nordan	2897.3	1448.6	3.0	57.0	43.1	11.2	113.8	76.7	81.3	95.0	147.0	107.3
P-27	2935.0	1467.5	3.1	56.9	43.1	11.7	113.9	76.8	81.1	94.7	152.8	111.6
Vavilov	3100.6	1550.3	3.2	58.9	43.5	12.0	110.1	74.2	81.9	95.7	157.1	115.2
Critana	2043.1	1021.5	2.1	59.1	41.4	12.5	109.6	73.9	78.0	91.1	164.1	119.8
Bannock	2047.0	1023.5	2.1	60.8	40.9	11.5	106.5	71.8	77.0	90.0	150.8	110.1
Schwendimar	1794.2	897.1	1.9	59.6	43.2	13.4	108.7	73.2	81.4	95.2	175.8	128.3
Pryor	3064.7	1532.4	3.2	60.7	41.4	10.6	106.7	71.9	77.9	91.1	139.6	101.9
Revenue	2759.2	1379.6	2.9	59.2	45.5	11.6	109.6	73.8	85.7	100.2	151.7	110.7
Secar	1811.5	905.8	1.9	59.7	39.3	12.4	108.6	73.2	74.1	86.6	162.4	118.6
Pearl	1760.7	880.3	1.8	56.5	43.3	15.4	114.6	77.3	81.5	95.3	201.5	147.2
Prairieland	2423.0	1211.5	2.5	57.3	44.3	15.1	113.1	76.2	83.5	97.6	197.7	144.3
Eejay	2485.2	1242.6	2.6	57.3	44.2	16.0	113.0	76.2	83.3	97.4	210.4	153.6
Trailhead	2055.4	1027.7	2.1	54.1	45.2	14.4	119.8	80.8	85.1	99.5	189.1	138.1
Magnar	2690.1	1345.0	2.8	57.1	46.4	13.8	113.4	76.5	87.4	102.2	180.9	132.1
Rosana	1577.2	788.6	1.6	55.5	46.1	15.3	116.8	78.7	86.8	101.5	200.6	146.5
Bozoisky-Select	1999.1	999.5	2.1	59.2	45.4	14.3	109.5	73.8	85.5	99.9	187.3	136.7
Mankota	1817.2	908.6	1.9	57.8	44.2	14.1	112.1	75.6	83.3	97.4	184.5	134.7
Swift	1690.9	845.5	1.8	59.6	41.7	14.6	108.7	73.2	78.7	92.0	191.3	139.7
Goldar	1516.1	758.0	1.6	57.2	45.0	12.0	113.3	76.3	84.8	99.2	156.8	114.5
Greenleaf	3038.4	1519.2	3.2	57.4	44.4	12.9	112.9	76.1	83.6	97.8	169.8	124.0
Luna	3330.0	1665.0	3.5	57.7	43.8	12.5	112.3	75.7	82.5	96.5	164.0	119.7
Manska	3305.5	1652.8	3.4	55.0	43.0	12.9	117.7	79.3	81.0	94.7	169.0	123.4
Oahe	3737.6	1868.8	3.9	58.1	45.0	12.2	111.5	75.1	84.8	99.1	160.6	117.2
Reliant	4111.5	2055.7	4.3	59.8	43.5	12.3	108.3	73.0	82.0	95.8	161.7	118.0
Rush	3771.9	1886.0	3.9	58.0	43.8	13.0	111.7	75.3	82.6	96.5	170.3	124.3
Lodorm	2436.3	1218.1	2.5	63.6	40.6	9.5	101.8	68.6	76.4	89.3	124.1	90.6

Table 68. Carrying capacity of 29 dryland forage grasses grazed on **September 15** estimated by forage availability or by intake and nutrient concentrations. Animal unit-months [AUM] calculated for one cow (545 kg) and calf (273 kg) pair, and NRC requirements.

VARIETY	Forage Dry Matter (kg ha^{-1})	Available Forage Dry Matter (kg ha^{-1}) @ 50% Utilization	AUM ha^{-1} (Based on Forage Availability)	%NDF	%IVDDM	%CP	Potential DMI (kg AU^{-1} d^{-1}) as % of NRC Suggested Level (10.1 kg) Cow	(6.8kg) Calf	Potential TDN (kg AU^{-1} d^{-1}) as % of NRC Requirement (5.36 kg) Cow	(4.55kg) Calf	Potential CP (kg AU^{-1} d^{-1}) as % of NRC Requirement (0.77 kg) Cow	(0.71 kg) Calf
Douglas	2231.4	1115.7	2.2	63.5	35.9	10.0	102.0	68.8	67.6	79.1	130.8	95.5
Hycrest	3338.6	1669.3	3.3	62.0	39.8	9.0	104.5	70.5	75.0	87.7	117.5	85.8
CDII	2738.5	1369.2	2.7	63.3	37.3	8.5	102.3	69.0	70.2	82.1	111.6	81.5
Nordan	2511.8	1255.9	2.5	63.8	35.4	8.9	101.5	68.4	66.6	77.9	116.5	85.1
P-27	2622.1	1311.1	2.6	63.4	33.5	9.3	102.2	68.9	63.0	73.7	121.6	88.8
Vavilov	3102.9	1551.4	3.1	63.3	34.0	8.6	102.3	69.0	64.1	74.9	112.2	81.9
Critana	2041.1	1020.6	2.0	68.5	28.8	9.4	94.5	63.7	54.2	63.3	122.7	89.6
Bannock	1889.8	944.9	1.9	65.0	34.1	10.4	99.7	67.2	64.2	75.0	137.0	100.0
Schwendimar	2076.4	1038.2	2.0	63.0	35.3	11.2	102.9	69.3	66.6	77.9	147.4	107.6
Pryor	2891.6	1445.8	2.9	70.0	29.8	7.8	92.6	62.4	56.2	65.6	101.9	74.4
Revenue	2569.7	1284.9	2.5	66.5	33.8	8.9	97.4	65.7	63.6	74.4	116.2	84.8
Secar	1798.6	899.3	1.8	63.8	31.3	10.1	101.6	68.4	59.0	69.0	132.9	97.1
Pearl	2057.7	1028.9	2.0	58.4	35.7	12.3	110.9	74.8	67.3	78.6	160.8	117.4
Prairieland	2423.6	1211.8	2.4	58.5	37.5	12.4	110.8	74.7	70.7	82.6	162.8	118.9
Eejay	2341.2	1170.6	2.3	60.0	35.2	12.5	107.9	72.8	66.3	77.5	163.4	119.3
Trailhead	2086.8	1043.4	2.1	62.9	34.2	10.6	103.0	69.4	64.4	75.3	139.0	101.5
Magnar	3098.3	1549.2	3.1	61.6	35.3	10.4	105.2	70.9	66.6	77.8	136.5	99.7
Rosana	1854.3	827.2	1.8	57.1	37.6	12.2	113.4	76.4	70.9	82.8	160.2	117.0
Bozoisky-Select	1975.0	987.5	1.9	64.7	33.2	11.8	100.2	67.5	62.5	73.0	155.4	113.5
Mankota	1726.3	863.1	1.7	65.7	33.8	11.5	98.7	66.5	63.6	74.4	150.2	109.7
Swift	1579.1	789.6	1.6	64.3	33.3	12.5	100.8	68.0	62.7	73.2	164.5	120.1
Goldar	1498.7	749.4	1.5	62.7	34.1	9.6	103.3	69.6	64.3	75.1	125.6	91.7
Greenleaf	3004.0	1502.0	3.0	61.8	36.6	9.9	104.9	70.7	69.0	80.6	129.2	94.4
Luna	3048.2	1524.1	3.0	63.2	33.8	10.1	102.6	69.1	63.6	74.4	132.5	96.8
Manska	3564.9	1782.5	3.5	60.4	37.5	10.0	107.2	72.3	70.7	82.6	131.2	95.8
Oahe	3930.2	1965.1	3.9	62.7	36.8	9.1	103.3	69.6	69.4	81.1	119.7	87.4
Reliant	4312.6	2156.3	4.3	60.5	41.7	9.6	107.1	72.2	78.6	91.9	126.5	92.3
Rush	3776.9	1888.5	3.7	60.3	39.5	9.8	107.5	72.4	74.5	87.1	128.4	93.8
Lodorm	2324.4	1162.2	2.3	71.1	31.5	7.6	91.1	61.4	59.4	69.5	100.0	73.0

each date (kg AU^{-1} day^{-1}). Potential dry matter intake was based on the equation "120 / % NDF" as % body weight day^{-1}. IVDDM was used as an estimate of TDN. TDN and CP were compared among varieties using NRC minimum daily requirements. Cow weights on these dates were assumed to be 545 kg and calf weights were 91, 182, and 272 kg respectively. Cow and calf weights were combined for June 1 but broken out for July 15 and September 15 as the calf's diet becomes more dependent on forage. Adequate minerals and water, but no supplements were assumed to be available. Obviously, the numerous interactions among variety, year, and location preclude statistical analyses of these data. However, overall means for forage yield and quality parameters across years and locations were used to demonstrate the possible use of this information. Rosana, Bannock and Schwendimar are ignored in all variety comparisons due to their delayed maturity during the trial and their forage quality may not be representative of most stands.

On June 1, TDN was most limiting and Secar provided only 90% of the AU daily requirements (Table 66). Magnar provided the highest level of TDN on this date. Of the species most appropriate for June 1 grazing, daily TDN requirements were best met by Douglas, CDII, Bozoisky-Select, Mankota and all of the intermediate or pubescent wheatgrass varieties. As expected, requirements for dry matter intake and CP were met by all varieties (Table 66).

On July 15, TDN was most limiting for cows and calves. Secar provided the lowest percent of required TDN, Douglas provided the highest (Table 67). Suggested levels for cow daily dry matter intake were met by all varieties, however, not for calves

on a strict forage diet. Potential intake levels were highest for Douglas and lowest for Lodorm. All varieties would supply sufficient CP on this date for cows. This was also true for the calves with the exception of Lodorm, which provided only 91% of requirements.

On September 15, similar to July 15, TDN was most limiting. Varieties provided less than 79% of minimum TDN requirements for cows and less than 92% for calves (Table 68). Lodorm did the poorest job of supplying TDN to the animals, while Reliant provided the most. For cows, all varieties except Pryor, Revenue, Mankota, and Lodorm would meet suggested dry matter intake levels. Calves would not be able to meet their dry matter intake levels on any variety at this date. Lodorm had the lowest potential intake level on September 15, while Pearl had the highest on this date. Cows would be able to meet their protein requirements from all varieties on this date. The calves would only be able to meet their protein requirements on wildrye pastures. Lodorm provided the least CP to cows and calves, while Swift provided the most.

In general, energy was most limiting at all dates. Most of the varieties, with the exception of wildryes failed to meet CP requirements for calves late in the season. Dry matter intake was generally not limiting for cows but was a major concern for calves on July 15, and September 15. Lodorm green needlegrass performed poorly in every category.

It is assumed that the calf intake and nutrient deficiencies during mid-summer could be compensated by increased milk consumption. However, increased milk production would require increased intake and nutrient demands of the cow, and the net

effect to the AU would be similar to the models shown. In Montana, most ranchers with cow-calf operations desire heavy fall calves for market, and the potential limitations of dryland pastures are apparent in these models.

As illustrated, forage quality information like that generated in this study can be useful in determining potential factors limiting animal performance. The addition of forage quality estimations to forage availability data should provide a more accurate prediction of potential AUM and allow producers to make better management decisions regarding their forage base.

CHAPTER 6

CONCLUSIONS

Producers must have accurate and reliable measurements of both forage production and plant forage quality in their pastures in order to most efficiently utilize their forage base. Little is known about seasonal forage quality distribution and if this information could be used to better estimate carrying capacity and stocking rates.

Compared to traditional wet chemistry procedures, NIRS was fast, accurate, and much cheaper than the $198,094 it would have cost to analyze the 7,619 samples in this trial using traditional methods. NIRS equations met all quality control criteria. NIRS accurately predicted forage quality constituents across a broad range of dryland grass varieties and locations.

Interactions between years, varieties, and locations found when analyzing the data illustrate the variability of the climate and biological differences of these varieties at different locations in Montana. V x Y x L interactions are typical of yield trials conducted in Montana, even in "average" years. Climatic volatility and varietal interactions among locations or years confounded attempts to summarize forage production data across locations and years, but also provided the opportunity to measure the forage quality associated with each of these environmental extremes.

Overall, intermediate and pubescent wheatgrass varieties generally out-performed the other varieties in this trial at all locations in terms of dry matter production. The wildryes were less competitive at Moccasin than at Bozeman and Bridger. Extreme

precipitation lows and highs, and apparent differences in species relative competitiveness at each location resulted in few varieties being dominant across locations except the intermediate and pubescent wheatgrasses.

Wildryes out-performed the other cultivars throughout the trial in the production of CP. Russian wildrye varieties generally had the lowest ADF concentrations when averaged across years and locations. Pearl Altai wildrye and Manska pubescent wheatgrass generally had the lowest NDF concentrations of all varieties in the trial. Lodorm green needlegrass consistently had the highest NDF concentration. When averaged across years and locations, Douglas had the highest IVDDM concentration, Secar and Lodorm had the lowest. NIRS did not estimate IVDDM as well as the other constituents. The validation set $r^2 = 0.70$ for IVDDM concentration was the lowest of all constituents. This finding was consistent with Murphy (1996) as he reported difficulty generating an NIRS equation for IVDDM that would meet quality control criteria. IVDDM is a complex interaction of plant and microbial factors, and it may be necessary to develop separate NIRS prediction equations for individual species in order to bring prediction of this constituent up to the level of the others.

Forage quality values generated by NIRS were higher for CP and IVDDM, and lower for ADF and NDF in standing mature forage than those reported in previous studies in Montana. This could be due to optimum fertilization of the trials plots.

Using the AGDD predictive models for forage quality, individual rates of forage quality decline among the varieties were compared. Standard errors associated with the rate of decline (X_1) were small. In general, varieties that had high forage quality had

faster rates of forage quality decline. Varieties with lower forage quality generally lost quality at a slower rate. When wildryes were compared to the intermediate and pubescent wheatgrasses, NIRS predicted values indicated both had high initial quality, but the wildryes generally had a more moderate rate of forage quality decline.

Predictive models using date or AGDD generated using LSMEANS in SAS (Version 8.1) had large standard errors associated with the Y-intercepts. Few statistical differences among varieties for season-long forage quality existed when 95% confidence intervals were generated. However, predicted values, especially those during the growing season were very similar to NIRS estimates. These models provide an easy short cut for producers that want a general estimate of forage quality.

Simple linear correlations (r) were computed within all 29 varieties for all combinations of dry matter yield, CP, ADF, NDF, and IVDDM. In general, most correlations among forage quality traits were relatively high ($r < -0.70$ or $r > 0.70$) and highly significant ($P < 0.01$). Correlations among dry matter production and forage quality traits were mostly low ($-0.3 < r < 0.3$), but highly significant ($P < 0.01$). In general, these weak correlations between yield and forage quality contrast with previous studies. Forage yield is usually highly correlated with ADF or NDF levels, however in this study, correlations were relatively low ($0.18 < r < 0.50$). As expected, ADF and NDF were highly correlated ($r > .79$). Low correlations among forage yield and quality were likely due to extreme variation among locations or years, with smaller variation in forage quality. Crude protein concentrations were negatively correlated to forage yield, with the strongest negative r values < -0.40. These correlation values suggest that

dryland grass forage quality is not strongly and negatively correlated to dry matter production under ideal management and across the wide range of production environments studied. Therefore, with proper variety selection and good grazing management, it should be possible for Montana producers to optimize both forage production and quality of dryland pastures.

The information generated in this study can be useful for future improvement of AUM predictions. Data generated in this study suggest insufficient TDN levels and diminishing CP concentration appear to limit animal performance more than dry matter intake during mid-season and late-season grazing. Lodorm consistently provided the least amount of nutrients. The wildryes generally had higher CP and potential dry matter intake than the other varieties late in the season. Intermediate and pubescent wheatgrasses provided the most AUM ha^{-1} throughout the year. Intermediate and pubescent wheatgrass were the most productive grasses in the trial, and for cows met NRC requirements for intake and CP season-long, and provided more TDN than the wildryes. The wildryes were less productive but met protein and intake requirements throughout the year for both cows and calves. The wildryes provide slightly less TDN than the wheatgrasses. It would appear that more pounds of beef could be raised on intermediate or pubescent wheatgrass pastures than the rest of the varieties in the trial if energy requirements could be supplemented.

Montana livestock and grass hay producers could benefit substantially from this scientifically-conducted, competitive trial comparing forage quality characteristics and production levels of dryland forage grasses in Montana.

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APPENDICES

APPENDIX A

FULL DESCRIPTIONS OF 29 VARIETIES TESTED

Table 69. Full descriptions of 29 varieties tested.

Agropyron cristatum (L.) Gaertn. (Fairway crested wheatgrass)

Douglas fairway crested wheatgrass was developed by the ARS, NRCS, and the Agricultural Experiment Station in Logan, UT and released in 1994 (USDA, NRCS 2000). This variety was developed with material originating from Iran, Turkey and the former USSR. Its seed is larger than other crested wheatgrass varieties and has excellent seedling vigor. It produces less forage than other accessions but is thought to retain its forage quality longer into the growing season as it remains green longer into the summer. This variety is most successful in areas where annual precipitation exceeds 33 cm (USDA, NRCS 2000).

Agropyron cristatum X *A. desertorum* (crested wheatgrass hybrid)

Hycrest hybrid crested wheatgrass was released by the ARS, NRCS, and the Utah Agricultural Experiment Station in 1984 (Asay et al., 1985b; USDA, NRCS 2000). It is a hybrid between Fairway and Standard crested wheatgrass. Hycrest is usually larger and more productive than Fairway and Standard. It is best used as spring pasture (Asay et al., 1985; Smoliak et al., 1990). Hycrest is easier to establish than either of its parents, has higher forage production during the year of establishment and is well adapted to a wide spectrum of soils and elevations. Productive stands have been reported in areas where annual precipitation is as low as 20 cm (USDA, NRCS 2000).

Table 69. continued:

CDII hybrid crested wheatgrass was released by ARS in Logan, UT in 1996 (USDA, NRCS 2000). It is a selection of Hycrest and was released to ensure the genetic purity of the selection. Under cold conditions it has higher production than Hycrest. All other characteristics are similar to Hycrest (USDA, NRCS 2000).

Agropyron desertorum (Fisch. Ex Link) J.A. Schultes (standard crested wheatgrass)

Nordan standard crested wheatgrass was released by the ARS and North Dakota Agricultural Experiment Station in 1953. It was developed by the ARS at the Northern Great Plains Research Laboratory in Mandan, ND (USDA, NRCS 2000). It has good seedling vigor and yields are comparable to more recent releases. It is very palatable in the spring and fall, but becomes less so in the summer. Nordan performs well in areas where annual precipitation exceeds 20 cm (USDA, NRCS 2000).

Agropyron fragile (Roth) Candargy (Siberian wheatgrass)

P-27 Siberian wheatgrass was released in 1953 by the NRCS Plant Materials Centers in Aberdeen, ID; Pullman, WA; and the Idaho Agricultural Experiment Station (USDA, NRCS 2000). This variety was developed with accessions originally collected from Kazakhstan. It is considered to be more drought tolerant than Fairway, Standard, and hybrid forms of crested wheatgrass. It has awnless seeds, finer leaves and is reported to retain its quality longer into the season than other crested wheatgrasses. P-27 produces

Table 69. continued:

less forage than other accessions and has less seedling vigor but once established has better survivability during extended drought events. It is well adapted to areas receiving 20 cm or more annual precipitation (USDA, NRCS 2000).

Vavilov Siberian wheatgrass was released in 1994 by the ARS and Utah Agricultural Experiment Station in Logan, UT. It was developed from P-27 and other accessions from Turkey and the former USSR. Seedling vigor is comparable to Hycrest and superior to P-27. Like P-27, Vavilov is better adapted to sandy soils and more drought tolerant than other crested wheatgrass varieties. It performs best in areas receiving greater than 20 cm annually. Vavilov is expected to replace P-27 in the future (USDA, NRCS 2000).

Elymus lanceolatus (Scribn. & J.G. Sm.) Gould (thickspike wheatgrass)

Critana thickspike wheatgrass was developed and released in 1971 by the NRCS Plant Materials Center in Bridger, MT (USDA, NRCS 2000). It is tolerant of drought, has good seedling vigor and easily establishes on disturbed sites. Twenty cm is generally accepted as the minimum level of annual precipitation required for the continued success of this variety. Critana is known for displaying a great deal of genetic diversity phenotypically (USDA, NRCS 2000)

Schwendimar thickspike wheatgrass was developed by the NRCS Plant Materials Center in Pullman, WA in 1994 (USDA, NRCS 2000). It was developed from

Table 69. continued:

collections taken from dunes and sandy soils near The Dalles, OR. It is adapted for quick stabilization of coarse textured soils and does well on sites with northwest aspect and greater than 20 cm of annual precipitation (USDA, NRCS 2000).

Bannock thickspike wheatgrass was developed and released by the NRCS Plant Materials Center in Aberdeen, ID in 1995 (USDA, NRCS 2000). It is a composite of several collections from The Dalles, OR; Pocatello, ID; and Quincy WA. It is a prolific forage producer and competes well in dry conditions. This cultivar is adapted to deep loamy soils in the Northwest and Intermountain regions where annual precipitation exceeds 20 cm (USDA, NRCS 2000).

Elymus trachycaulus (Link) Gould ex Shinners (slender wheatgrass)

Revenue slender wheatgrass was released by the Canada Department of Agriculture in 1970 (Reynolds, 1998). It is selected for saline tolerance, quick establishment and high forage quality and production. Revenue is very popular for pasture seedings (Reynolds, 1998). It prefers areas that receive more than 35 cm of annual precipitation (Smoliak et al, 1990).

Pryor slender wheatgrass was released by the NRCS Plant Materials Center in Bridger, MT in 1988 (USDA, NRCS 2000). Pryor was selected for drought and salinity tolerance, and seedling vigor. It is a popular choice for seedings in disturbed areas and

Table 69. continued:

areas of high salinity or alkalinity. Pryor matures late enough in the year to be negatively affected by drought. Stands are very productive for the first three to four years, then generally decline. Growth begins relatively early in the spring but some grazing management is required as it is not resistant to prolonged heavy utilization. Pryor requires at least 35 cm of annual precipitation in order to maintain the stand (Smoliak et al, 1990).

Elymus wawawaiensis J. Carlson (Snake River wheatgrass)

Secar Snake River wheatgrass was released by the NRCS Plant Materials Center in Pullman, WA; the Washington Agriculture Research Center and cooperatively with the ID, OR, MT, and WY Agricultural Experiment Stations in 1980 (USDA, NRCS 2000). Collections from the Snake River gorge area near Lewiston, Idaho were used to develop Secar. It is recognized as one of the most drought tolerant native grasses available for cultivation as it can survive in environments receiving less than 20 centimeters annually. It has good seedling vigor and has the ability to establish in dry conditions. Secar was developed to be incorporated into seed mixes revegetating native rangeland plant communities (USDA, NRCS 2000).

Table 69. continued:

Leymus angustus (Trin.) Pilger (Altai wildrye)

Prairieland Altai wildrye was released by Agriculture Canada in 1976. It was developed from collections originating in the former USSR (Reynolds, 1998). Prairieland was selected for its good curing qualities and tolerance to high salinity and alkalinity. It maintains higher protein levels after the plant becomes dormant and provides excellent fall and winter forage for livestock and wildlife (Smoliak et al, 1990).

Pearl Altai wildrye was released by Agriculture Canada in 1989. Canadian trials conducted by Agriculture Canada demonstrated Pearle has higher seed production but lower forage yield than Prairieland (Reynolds, 1998). It possesses a tolerance to highly saline and alkaline soils (Smoliak et al, 1990).

Eejay was released by Agriculture Canada in 1989. It was developed from collections originating from the former USSR (Reynolds, 1998). Eejay's curing qualities are similar to Prairieland and is also excellent fall and winter forage for livestock and wildlife (News 98). It is adapted to clay and clay loam soils with elevated water tables. Eejay has greater seed production than Prairieland and the highest forage production of all Altai wildrye selections (Reynolds, 1998).

Table 69. continued:

Leymus cincereus (Scribn. & Merr.) A. Love (Great Basin wildrye)

Magnar Altai wildrye was first collected by the NRCS Plant Materials Center in Pullman, WA. It was subsequently developed by the NRCS Plant Materials Center in Aberdeen, ID and released in 1979 (USDA, NRCS 2000). Magnar prefers a wide variety of soils and can be found in areas that are weakly saline. It has fair seedling vigor and is a good forage producer. It provides good cover for livestock and wildlife and can be utilized for winter forage. Early spring grazing can damage the plant due to its elevated growing point. It is adapted to areas of the Western United States that receive 20 or more cm of precipitation annually. Magnar has also been reported to survive in areas receiving only 18 cm annually (USDA, NRCS 2000).

Trailhead Great Basin wildrye was released in 1991 by the NRCS Plant Materials Center in Bridger, MT (USDA-SCS, 1991). Trailhead demonstrates better stand longevity and drought tolerance than other basin wildrye selections. Trailhead can tolerate moderate alkalinity but is not adapted to long periods of prolonged flooding. 'Trailhead' is not recommended for hay production due to a highly elevated growing point. Wildlife and livestock in addition to consuming the plant can find excellent shelter from the elements, providing a natural windbreak and cover from predators (USDA, NRCS 2000; Smoliak et al., 1990). It is adapted to areas where annual precipitation is 20 cm and higher but has been shown to survive in areas receiving less than 13 cm (USDA, NRCS 2000).

Table 69. continued:

Nassella viridula (Trin.) Barkworth (green needlegrass).

Lodorm green needlegrass was released in 1970 by the ARS and NRCS Plant Materials Center in Bismark, ND (USDA, NRCS 2000). It is very common throughout the grazing lands of the western United States but is usually not the predominant species in the plant community. It is generally seeded in plant mixtures, as pure stands may experience partial stand decline (Smoliak et al, 1990). It performs the best in areas receiving at least 38 cm of precipitation annually (USDA, NRCS 2000).

Pascopyrum smithii (Rydb.) A. Love (western wheatgrass)

Rosana western wheatgrass was collected from the area near Forsyth, MT and was released by the NRCS Plant Materials Center in Bridger, MT in 1972 (USDA, NRCS 2000). It is a northern type that was selected for its improved seedling vigor and ease of establishment. Rosana is one of the first grasses to green up in the spring. It is very palatable and preferred by livestock and wildlife species. Rosana may have low forage productivity, but it may be utilized as native hay in areas where the density of the stand is sufficient. It is also very tolerant of heavy utilization by grazing animals. It is adapted to rangelands where annual precipitation exceeds 25 cm and does well in planted stands where annual precipitation exceeds 30 cm (USDA, NRCS 2000).

Table 69. continued:

Psathyrostachys juncea (Fisch.) Nevski (Russian wildrye)

Swift Russian wildrye was released by Agriculture Canada in 1978. Swift was derived from 'Sawki' and 'Mandan 1546'. It was selected for its seedling vigor and good seedling emergence. Like Mankota, Swift is reported to be adapted for fall grazing. It is best adapted to locations where 25 cm or more precipitation is received annually (USDA, NRCS 2000).

Bozoisky-Select was released in 1984 by the ARS, the NRCS, and the Utah Agricultural Experiment Station in Logan, UT (Asay et al, 1985a; USDA, NRCS 2000). Bozoisky-Select is an improved cultivar of Russian wildrye. Protein content of the forage is reported to remain at relatively high levels when saved for fall grazing. Bozoisky-Select is usually not established for hay production due to the fact that its basal leaves are very difficult to harvest with haying equipment. This variety has a very long growing season and is reported to maintain its quality well beyond the end of the growing season (Asay et al., 1985a; Smoliak et al, 1990). 'Bozoisky-Select' performs best in areas of annual precipitation above 25 cm.

Mankota Russian wildrye was released from the ARS in Mandan, ND, the NRCS Plant Materials Center in Bismark, ND; and the North Dakota Agricultural Experiment Station in 1991 (USDA, NRCS 2000). Mankota was selected for high forage production and good seedling vigor. Protein content of the forage is reported to remain at relatively high levels when saved for fall grazing. Mankota was selected for improved seedling

Table 69. continued:

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vigor, resistance to leaf diseases and higher forage yield. It is best adapted to locations where over 30 centimeters of precipitation is received annually (USDA, NRCS 2000).

Pseudoroegneria spicata (Pursh) A. Love (bluebunch wheatgrass)

Goldar bluebunch wheatgrass was developed from a collection gathered from seed in the area near Asotin, WA by the NRCS Plant Materials Center in Aberdeen, ID. It was released in 1989 cooperatively by the Idaho and Utah Agricultural Experiment Stations, ARS, and NRCS Plant Materials Centers in Aberdeen, ID (USDA, NRCS 2000). Secar competes well in areas that receive as little as 20 cm annually (USDA, NRCS 2000).

Thinopyrum intermedium (Host) Barkworth & D.R. Dewey (intermediate or pubescent wheatgrass).

Luna pubescent wheatgrass was released by the New Mexico Agricultural Experiment Station and the NRCS Plant Materials Center in Los Lunas, NM in 1963 (USDA, NRCS 2000). Luna originated from seed selections from Russia and Turkey. It was selected for good forage production, seedling vigor and easy establishment. Of the pubescent wheatgrasses developed in the United States, it is the mostly widely adapted and distributed (USDA, NRCS 2000). This variety will not maintain its productivity under heavy continuous grazing management.

Table 69. continued:

Manska was developed by the Great Plains Research Laboratory in Mandan, ND. The ARS, NRCS Plant Materials Center in Bismark, ND, the University of Nebraska and NRCS 2000). It was selected for improved forage quality, seedling vigor, resistance to leaf spot and high forage production (Berdahl et al, 1993). Manska has been reported to have higher forage quality than other pubescent wheatgrass cultivars.

Greenleaf pubescent wheatgrass was developed from unknown European and Asian sources (USDA, NRCS 2000). Agriculture Canada Research Station used commercial seed sources from North Dakota and Washington to develop the variety and it was released in 1996. It was developed to be a winterhardy cultivar that could be used in both pasture and hay production. It produces more forage than 'Topar' and has better seedling vigor than 'Mandan 759'. This variety will not maintain its productivity under heavy continuous grazing management.

Oahe intermediate wheatgrass was released in 1961 by the South Dakota Agriucltural Experiment Station in Brookings, SD (Ross, 1963; USDA, NRCS 2000). It is palatable to all classes of livestock and wildlife (Ross, 1963; Smoliak et al, 1990; USDA, NRCS 2000). It was selected for its uniform color, vigor, rhizomotous growth habit, drought tolerance and for its high seed yield. It is well adapted for grazing, hay production and conservation applications. Oahe prefers well drained soils and performs the best in areas receiving more than 30 cm of annual precipitation (USDA, NRCS 2000).

Table 69. continued:

Reliant intermediate wheatgrass was developed by the Northern Great Plains Research Laboratory in Mandan, North Dakota and was jointly released by ARS, North Dakota Agricultural Experiment Station, and by the NRCS Plant Materials Center in Bismark, ND in 1991 (USDA, NRCS 2000). It was selected for resistance to leaf spot, improved forage quality and production, increased seed production, and improved winter survival. Reliant is more persistent and high yielding when in a hay pasture management program than any other intermediate wheatgrass (USDA, NRCS 2000).

Rush intermediate wheatgrass was developed by the NRCS Plant Materials Center in Aberdeen, ID from seed sources originating from Germany. It was released in 1994 by the Idaho Agricultural Experiment Station and the NRCS Plant Materials Center in Aberdeen, ID (USDA, NRCS 2000). It is more rhizomatous than most other intermediate selections. It was selected for better seedling emergence and seedling vigor, high forage and seed production, wide leaves and good spring recovery from grazing and harvest. Seed of Rush generally larger than that of other intermediate wheatgrass cultivars and is specifically adapted for conservation and revegetation of disturbed areas. It is also well suited for both dryland and irrigated pasture and hay production (USDA, NRCS 2000).

APPENDIX B

ADF CONCENTRATIONS AT BOZEMAN, BRIDGER, AND MOCCASIN

Table 70. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at five sampling dates at Bozeman, MT in 1997.

Date:	5/23/97	6/4/97	6/18/97	7/2/97	10/30/97	
Variety						Mean
Douglas	233.4	293.2	362.1	387.8	454.1	346.1
Hycrest	272.1	334.8	388.4	418.6	437.3	370.2
CD II	263.4	326.5	416.5	408.5	448.4	372.7
Nordan	251.2	322.8	389.6	403.6	465.7	366.6
P-27	249.8	325.9	393.8	405.4	465.4	368.1
Vavilov	262.7	332.5	374.3	406.1	466.8	368.5
Critana	285.0	369.4	441.6	427.8	480.8	400.9
Bannock	296.1	368.0	428.1	450.0	442.1	396.9
Schwendimar	295.4	337.3	383.6	419.5	439.2	375.0
Pryor	268.0	365.7	433.3	444.7	519.1	406.2
Revenue	264.9	328.7	385.8	436.7	499.9	383.2
Secar	284.0	335.8	422.3	436.6	460.6	387.9
Pearl	266.6	300.8	350.3	358.0	412.2	337.6
Prairieland	259.1	310.4	324.6	362.3	403.0	331.9
Eejay	273.8	303.9	335.6	365.8	429.8	341.8
Trailhead	254.4	307.9	371.4	403.9	472.8	362.1
Magnar	259.8	311.0	352.3	367.4	447.0	347.5
Lodorm	266.3	327.7	383.7	424.3	472.5	374.9
Rosana	261.5	314.5	377.5	393.4	415.2	352.4
Bozoisky-Select	246.8	307.1	386.6	394.5	467.4	360.5
Mankota	238.8	292.9	360.8	407.8	465.1	353.1
Swift	244.6	307.3	360.7	401.4	426.5	348.1
Goldar	282.7	343.0	395.8	403.7	451.8	375.4
Greenleaf	257.8	312.2	360.0	390.1	468.3	357.7
Luna	260.8	321.9	396.8	423.1	447.3	370.0
Manska	246.6	299.1	363.1	388.6	443.2	348.1
Oahe	250.6	296.1	370.6	398.7	461.4	355.5
Reliant	258.9	290.9	365.6	399.6	444.0	351.8
Rush	249.8	296.7	373.0	394.2	433.4	349.4
Mean	262.2	320.1	380.9	404.2	453.1	364.1
LSD (0.05)	15.1	23.2	29.2	32.6	38.4	44.81

Table 71. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at seven sampling dates at Bozeman, MT in 1998.

Date:	5/27/98	6/11/98	6/24/98	7/8/98	7/22/98	8/20/98	9/24/98	
Variety								Mean
Douglas	236.1	268.7	292.8	327.0	325.6	351.8	361.6	309.1
Hycrest	267.7	280.5	318.7	359.9	352.7	377.5	348.0	329.3
CD II	264.8	277.6	317.7	357.8	344.6	374.2	372.5	329.9
Nordan	260.6	281.8	305.1	344.5	342.5	375.4	359.9	324.3
P-27	259.4	277.1	307.4	360.3	370.8	377.1	347.4	328.5
Vavilov	271.2	290.0	323.5	351.7	351.2	373.4	356.1	331.0
Critana	295.0	307.3	333.2	363.0	360.7	374.0	397.7	347.3
Bannock	277.9	298.7	326.5	360.3	348.0	349.6	347.3	329.8
Schwendimar	283.3	299.3	279.3	330.7	320.0	330.3	318.5	308.8
Pryor	291.3	309.1	349.8	394.5	382.1	418.3	408.2	364.8
Revenue	267.2	269.0	303.1	345.1	359.9	373.6	372.0	327.1
Secar	308.5	324.4	352.8	374.2	351.4	381.7	380.6	353.4
Pearl	274.0	287.3	325.2	361.6	387.1	376.8	367.2	339.9
Prairieland	278.5	296.3	318.5	358.2	380.4	375.2	371.4	339.8
Eejay	277.8	295.7	326.6	351.5	364.7	369.2	364.5	335.7
Trailhead	277.6	293.9	337.9	366.1	380.9	380.2	399.2	348.0
Magnar	285.3	284.8	323.1	366.1	355.1	383.6	369.7	338.2
Lodorm	302.5	327.0	350.1	388.2	375.5	414.6	407.4	366.5
Rosana	283.3	270.6	281.9	309.9	317.2	323.2	298.3	297.8
Bozoisky-Select	238.4	263.5	297.0	324.5	335.1	333.5	384.5	310.9
Mankota	229.7	254.7	283.5	309.7	307.6	346.4	335.3	295.3
Swift	251.8	292.1	277.2	347.4	313.3	324.5	368.6	310.7
Goldar	293.1	302.9	322.8	344.7	357.1	341.5	334.8	328.1
Greenleaf	278.8	271.8	306.1	357.9	369.5	348.0	371.5	329.1
Luna	265.5	287.6	332.8	358.7	372.5	379.3	364.0	337.2
Manska	260.3	269.7	306.9	362.7	361.7	353.6	336.8	321.7
Oahe	260.4	277.5	319.1	359.1	385.4	374.6	374.5	335.8
Reliant	255.4	269.7	313.9	369.4	365.4	361.6	334.3	324.2
Rush	254.6	280.2	318.0	362.9	370.1	378.5	359.6	332.0
Mean	270.7	286.5	315.5	354.0	355.4	366.2	362.4	330.1
LSD (0.05)	18.0	21.6	22.9	27.9	32.8	33.4	35.3	25.5

Table 72. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bozeman, MT in 1999.

Date:	5/19/99	6/2/99	6/16/99	6/30/99	7/14/99	8/12/99	9/15/99	10/13/99	
Variety									Mean
Douglas	193.9	245.5	280.6	321.1	317.7	363.7	382.4	409.6	314.3
Hycrest	212.3	267.8	308.7	325.0	323.4	348.0	381.1	387.4	319.2
CD II	209.5	261.3	298.7	325.0	348.2	363.9	373.7	390.5	321.4
Nordan	203.8	259.7	298.8	319.9	326.5	361.9	379.3	395.6	318.2
P-27	213.0	251.1	304.5	330.4	321.3	348.8	384.1	388.0	317.7
Vavilov	216.2	263.2	305.8	335.3	321.3	326.6	358.4	395.5	315.3
Critana	214.2	279.1	305.1	329.3	326.3	341.1	367.0	368.3	316.3
Bannock	---[1]	---	---	310.6	333.8	352.8	364.3	365.0	341.6
Schwendimar	---	---	---	300.6	318.4	330.1	318.6	338.4	321.2
Pryor	203.5	278.5	303.6	329.9	347.2	392.0	425.1	438.6	339.8
Revenue	183.2	243.0	262.3	321.8	313.6	363.8	352.1	382.7	302.8
Secar	234.2	300.0	313.3	327.8	348.6	351.1	373.8	362.7	326.4
Pearl	214.1	258.4	274.2	301.8	312.1	317.4	355.2	363.6	299.6
Prairieland	220.0	269.8	280.7	324.2	308.0	319.6	350.6	367.4	305.0
Eejay	214.5	273.3	270.1	331.6	312.4	332.7	353.4	364.0	306.5
Trailhead	221.1	261.6	306.5	323.5	346.9	389.8	416.6	414.0	335.0
Magnar	210.2	259.5	303.0	315.5	347.6	399.5	396.3	409.5	330.1
Lodorm	200.5	274.4	309.5	333.1	338.6	375.3	393.5	395.2	327.5
Rosana	---	---	---	328.1	291.5	290.2	314.4	310.9	307.0
Bozoisky-Select	180.2	233.1	244.1	289.4	297.4	344.8	356.4	363.5	288.6
Mankota	189.2	231.5	261.0	300.9	299.7	325.9	364.3	366.5	292.4
Swift	189.8	237.4	254.1	320.5	291.0	323.1	366.8	369.1	294.0
Goldar	227.6	270.3	302.2	330.9	322.3	336.3	373.6	374.8	317.3
Greenleaf	218.3	275.2	303.8	336.3	329.2	362.1	358.1	382.5	320.7
Luna	219.2	262.7	288.3	332.3	335.7	386.8	389.5	389.4	325.5
Manska	199.8	253.4	278.7	295.6	300.3	335.4	357.2	367.7	298.5
Oahe	216.1	269.0	289.9	336.2	323.2	351.8	372.2	380.6	317.4
Reliant	209.0	250.5	287.8	319.4	316.5	343.5	355.9	357.1	305.0
Rush	207.2	268.2	298.9	325.4	336.0	355.2	362.9	374.9	316.1
Mean	210.4	261.4	289.8	321.4	322.6	349.4	368.9	378.4	315.2
LSD (0.05)	17.8	20.3	23.2	NS*	24.9	29.5	26.5	33.1	30.1

[1] Poor early season growth in all replications, no samples were taken.

* The F test for variety effect was not significant at the 0.05 level.

Table 73. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bridger, MT in 1997.

Date:	5/29/97	6/12/97	6/26/97	7/10/97	8/8/97	9/8/97	10/8/97	11/7/97	
Variety									Mean
Douglas	244.1	284.8	289.2	243.6	334.8	354.5	358.8	372.0	320.4
Hycrest	263.9	277.0	314.3	328.5	338.6	341.9	384.8	393.3	330.3
CD II	280.6	310.8	320.7	263.0	366.1	333.4	367.9	360.4	336.3
Nordan	269.4	297.7	334.5	262.1	363.0	349.6	374.4	373.4	338.9
P-27	278.2	324.1	328.2	279.0	367.5	342.2	369.6	394.7	347.1
Vavilov	269.3	305.4	321.8	340.9	349.6	361.0	370.3	380.3	337.3
Critana	306.0	357.3	352.9	342.1	407.1	388.0	416.1	428.3	374.7
Bannock	313.2	359.6	366.2	353.9	411.8	360.3	389.6	405.8	370.1
Schwendimar	300.4	325.0	353.0	337.5	389.6	366.9	373.0	406.5	356.5
Pryor	287.7	325.1	340.9	286.6	407.0	417.9	431.5	458.8	381.4
Revenue	253.8	284.7	327.8	250.8	352.9	368.1	401.5	408.5	341.4
Secar	314.1	338.7	349.9	343.3	362.1	353.5	371.2	367.7	350.1
Pearl	261.7	291.4	305.9	316.2	321.2	285.3	327.0	333.8	305.3
Prairieland	252.6	290.5	320.7	351.3	352.2	299.8	317.5	330.1	314.3
Eejay	255.1	294.7	318.3	334.9	337.3	308.0	344.3	371.3	320.5
Trailhead	264.3	293.5	311.1	232.0	351.4	333.8	383.2	418.8	333.2
Magnar	255.5	299.2	313.3	352.4	339.2	331.6	395.1	404.2	336.3
Lodorm	291.4	337.0	361.3	281.6	369.4	348.4	391.7	395.3	358.8
Rosana	260.6	314.8	324.0	302.5	336.8	308.4	350.5	368.0	320.7
Bozoisky-Select	266.6	322.2	328.0	325.0	388.8	345.8	376.1	374.9	340.9
Mankota	276.6	308.6	317.3	229.4	351.6	337.6	354.0	382.8	329.3
Swift	288.9	317.4	291.2	359.6	339.8	301.1	353.9	335.5	323.4
Goldar	279.0	332.9	324.8	325.0	351.5	336.3	360.9	384.5	336.9
Greenleaf	250.6	314.7	339.5	341.8	364.1	363.1	400.1	372.6	343.3
Luna	279.8	339.0	336.0	363.8	343.1	353.7	380.4	350.0	343.2
Manska	270.7	310.5	335.0	261.5	351.3	350.9	386.6	393.0	343.3
Oahe	266.4	314.0	350.9	343.8	362.9	348.3	369.9	401.2	344.7
Reliant	257.6	330.2	339.4	360.6	369.0	340.7	373.4	392.5	345.4
Rush	265.6	320.3	338.6	356.8	360.3	353.3	358.7	384.2	342.2
Mean	273.2	314.5	329.5	312.7	360.0	344.2	373.5	384.2	340.2
LSD (0.05)	25.9	28.2	28.8	117.9	31.6	30.4	35.5	33.9	20.5

Table 74. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at ten sampling dates at Bridger, MT in 1998.

Date:	5/8/98	5/22/98	6/5/98	6/19/98	7/10/98	7/31/98	8/21/98	9/18/98	10/23/98	11/23/98	
Variety											Mean
Douglas	211.1	244.8	286.8	284.4	299.3	347.7	350.3	377.3	404.7	426.8	323.3
Hycrest	219.5	263.2	278.9	290.2	305.0	348.1	357.1	373.1	405.7	459.7	330.1
CD II	239.4	260.1	295.8	296.9	321.4	374.3	361.2	376.5	391.9	434.6	335.2
Nordan	227.9	252.7	265.7	286.7	317.8	358.9	349.5	357.6	407.5	439.7	326.4
P-27	234.8	275.4	290.1	299.9	332.9	382.6	366.1	362.4	429.0	418.6	339.2
Vavilov	243.9	286.8	293.2	315.5	313.5	368.1	378.9	361.1	420.0	428.1	340.9
Critana	243.4	272.0	290.3	324.2	307.9	364.2	388.3	391.6	402.1	420.8	340.5
Bannock	230.9	280.8	308.6	332.8	335.3	361.3	376.8	387.1	387.9	393.8	339.5
Schwendimar	235.1	275.4	285.6	321.9	323.6	346.2	356.3	332.7	361.1	362.5	320.0
Pryor	239.5	273.3	290.2	328.1	352.4	394.0	404.5	420.8	429.7	460.3	359.3
Revenue	236.9	243.6	271.9	301.6	321.8	344.1	358.0	355.0	396.5	401.5	323.1
Secar	282.1	316.2	324.8	349.8	330.2	369.2	377.0	385.5	413.1	424.0	357.2
Pearl	226.2	260.5	290.7	309.4	297.9	349.3	323.1	353.5	355.4	387.4	315.3
Prairieland	241.9	274.4	304.3	297.3	324.2	343.3	311.0	339.5	344.4	369.6	315.0
Eejay	236.3	252.9	298.1	307.3	311.4	355.1	336.8	337.8	342.1	384.5	316.2
Trailhead	249.2	280.4	301.1	292.6	302.1	349.0	335.7	374.8	401.1	421.8	330.8
Magnar	234.8	269.5	293.7	300.6	331.9	369.2	321.9	356.6	378.8	409.8	326.7
Lodorm	291.2	330.6	310.0	330.1	342.6	385.0	389.6	400.9	431.6	445.7	365.7
Rosana	246.6	241.8	243.6	272.1	291.2	307.0	302.8	289.8	334.9	378.9	290.9
Bozoisky-Select	225.3	281.0	285.5	302.3	308.6	356.3	340.6	344.5	370.1	431.4	324.6
Mankota	221.4	249.9	284.7	307.1	307.1	354.2	317.1	341.6	390.2	396.1	316.9
Swift	227.4	264.1	318.0	298.6	346.1	328.8	324.9	343.3	352.9	392.8	319.7
Goldar	264.0	300.3	290.3	305.3	310.4	340.1	347.2	352.6	393.2	412.3	331.6
Greenleaf	220.2	247.4	281.1	298.5	322.7	360.7	360.6	361.2	404.8	429.2	328.6
Luna	228.7	263.5	298.3	342.6	341.7	383.7	363.0	385.7	411.1	424.0	344.2
Manska	224.6	227.4	260.8	304.0	326.2	363.2	356.3	341.1	375.5	414.7	319.4
Oahe	220.3	244.3	256.2	297.7	327.0	363.4	369.0	365.8	392.4	439.3	327.5
Reliant	220.6	252.0	277.1	316.3	343.1	351.8	353.2	344.0	389.6	398.0	324.6
Rush	223.1	254.3	291.4	341.0	335.9	370.6	357.7	320.2	401.7	435.4	333.1
Mean	236.1	266.8	288.5	308.8	321.8	358.2	352.9	359.8	390.3	415.2	329.8
LSD (0.05)	19.2	20.6	34.9	25.5	35.3	30.5	34.8	40.3	36.3	35.6	26.38

Table 75. Acid detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at nine sampling dates at Bridger, MT in 1999.

Date:	5/6/99	5/20/99	6/3/99	6/17/99	7/15/99	8/16/99	9/15/99	10/15/99	11/15/99	
Variety										Mean
Douglas	241.5	238.9	243.3	241.3	250.9	317.7	354.5	365.3	371.9	291.7
Hycrest	232.0	256.9	261.0	273.1	280.5	314.1	346.8	378.4	382.4	302.8
CD II	236.0	249.1	265.1	264.1	290.3	312.9	358.5	355.6	362.9	299.4
Nordan	250.6	259.5	260.6	261.8	277.6	318.4	354.4	360.2	367.0	301.1
P-27	227.3	238.2	263.5	261.0	288.4	320.4	351.7	361.9	370.1	298.1
Vavilov	259.7	272.5	263.4	262.4	282.8	320.9	361.4	363.0	368.8	306.1
Critana	262.8	284.5	291.0	290.5	320.9	373.9	396.8	377.7	391.0	332.1
Bannock	245.8	286.1	289.7	312.9	325.3	366.6	381.7	378.8	400.8	332.0
Schwendimar	274.0	274.9	283.0	295.5	308.5	353.3	360.3	362.0	371.4	320.3
Pryor	244.0	259.3	272.3	280.1	297.9	358.4	385.5	388.4	406.8	321.4
Revenue	289.5	272.1	269.8	243.2	252.9	326.5	351.2	347.4	363.1	301.7
Secar	290.0	314.6	302.8	325.6	324.5	362.6	386.0	385.1	392.0	342.6
Pearl	255.5	285.4	272.5	276.3	296.3	315.9	334.0	342.0	346.3	302.7
Prairieland	246.2	274.0	274.2	298.4	312.0	324.2	322.2	330.3	369.9	305.7
Eejay	250.5	276.8	276.1	301.6	271.8	296.9	317.2	321.0	362.5	297.2
Trailhead	227.9	261.1	288.3	294.0	285.8	322.3	351.8	362.7	379.1	308.1
Magnar	228.1	248.9	255.8	268.1	299.2	325.7	348.6	331.6	376.8	298.1
Lodorm	264.3	288.0	281.9	304.7	320.6	362.4	375.3	370.6	374.9	327.0
Rosana	254.2	261.8	264.7	273.9	266.5	295.6	316.0	320.5	347.4	289.0
Bozoisky-Select	230.6	242.2	258.7	292.3	322.1	371.6	345.2	348.1	377.9	309.9
Mankota	226.9	245.5	261.2	272.9	301.1	352.0	352.8	354.0	372.5	304.3
Swift	232.3	251.6	288.6	297.7	323.7	362.2	356.5	360.6	387.1	317.8
Goldar	254.6	274.7	296.9	279.0	311.3	322.5	357.1	351.7	355.8	311.5
Greenleaf	225.3	232.4	249.6	258.8	282.0	332.0	362.0	359.4	374.6	297.3
Luna	230.5	244.9	269.3	278.9	291.3	356.9	375.9	356.1	370.1	308.2
Manska	224.2	229.8	245.1	257.6	273.0	322.7	340.9	340.3	359.4	288.1
Oahe	223.9	248.2	256.4	268.3	289.0	339.9	361.7	359.8	371.7	302.1
Reliant	251.6	231.8	253.2	256.7	284.4	318.6	339.5	337.9	349.0	291.4
Rush	227.1	250.8	260.9	275.1	277.7	308.0	351.7	354.7	355.6	295.7
Mean	245.1	260.5	269.6	278.1	293.4	333.6	355.1	356.0	371.7	307.0
LSD (0.05)	24.7	24.2	24.4	26.1	22.1	24.8	20.8	22.9	22.9	23.0

Table 76. Acid detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at five sampling dates at Moccasin, MT in 1997.

Date:	5/19/97	6/2/97	6/30/97	7/14/97	7/28/97	
Variety						Mean
Douglas	234.2	287.3	306.4	351.0	351.3	306.0
Hycrest	256.8	290.1	341.2	363.5	356.4	321.6
CD II	253.8	300.3	360.7	390.6	393.4	339.8
Nordan	247.6	306.4	355.1	400.0	381.0	338.0
P-27	244.7	288.6	359.6	379.1	396.1	333.6
Vavilov	252.3	290.9	365.1	400.7	393.2	340.4
Critana	248.9	311.3	355.8	379.0	399.5	338.9
Bannock	254.0	315.2	381.8	420.2	393.2	352.9
Schwendimar	256.3	313.6	365.1	398.9	421.8	351.1
Pryor	259.6	303.8	382.1	376.5	415.2	347.4
Revenue	257.7	295.0	372.0	397.5	422.0	348.8
Secar	261.4	317.1	360.0	370.0	390.1	339.7
Pearl	265.2	317.0	317.0	336.8	336.0	314.4
Prairieland	301.0	308.7	334.0	334.7	360.4	327.8
Eejay	270.4	308.0	356.6	342.5	359.6	327.4
Trailhead	248.4	298.6	331.2	348.0	338.6	313.0
Magnar	247.2	282.3	331.8	361.2	360.6	316.6
Lodorm	274.5	314.7	378.6	384.3	404.3	351.3
Rosana	262.2	278.4	336.6	347.0	363.3	317.5
Bozoisky-Select	220.9	269.2	330.3	361.6	367.5	309.9
Mankota	235.4	291.5	315.9	337.3	381.2	312.3
Swift	235.9	281.1	306.1	312.4	345.6	296.2
Goldar	260.9	307.6	356.6	368.1	392.4	337.1
Greenleaf	231.8	284.9	345.4	378.4	389.9	326.1
Luna	245.5	306.0	351.7	387.0	386.9	335.4
Manska	242.3	299.6	358.9	389.3	392.6	336.5
Oahe	243.1	302.5	370.1	402.8	387.6	341.2
Reliant	229.4	296.1	362.3	400.9	406.9	339.1
Rush	236.5	281.8	366.9	399.9	415.6	340.1
Mean	251.0	298.2	350.2	373.1	382.8	331.1
LSD (0.05)	35.5	24.0	41.8	33.4	35.6	34.1

Table 77. Acid detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1998.

Date:	5/8/98	5/26/98	6/5/98	6/22/98	7/13/98	9/4/98	10/6/98	
Variety								Mean
Douglas	240.5	258.7	253.6	274.3	294.9	359.1	386.0	295.3
Hycrest	248.7	260.0	270.1	290.8	311.2	358.9	389.7	304.2
CD II	251.8	263.0	277.5	290.4	305.1	365.0	394.8	306.8
Nordan	235.1	237.8	249.0	284.4	320.5	361.5	403.5	298.8
P-27	223.5	231.1	257.7	275.6	307.0	365.2	404.6	295.0
Vavilov	248.7	251.0	273.7	295.2	319.2	370.7	396.0	307.8
Critana	299.6	269.5	277.1	310.9	343.9	413.7	436.6	335.9
Bannock	294.3	283.8	297.9	322.0	355.5	415.6	419.0	341.2
Schwendimar	305.0	279.8	269.3	303.3	347.6	379.2	401.0	326.5
Pryor	248.3	271.2	284.9	300.5	347.2	406.6	437.6	328.0
Revenue	251.8	251.4	262.6	280.3	339.7	386.2	412.9	312.1
Secar	288.8	279.0	293.3	316.5	339.7	394.6	414.0	332.3
Pearl	271.3	270.0	273.9	285.1	323.3	365.0	399.1	312.5
Prairieland	278.9	280.4	293.8	309.6	328.1	376.6	392.3	322.8
Eejay	293.7	273.8	285.0	308.3	319.4	365.7	382.2	318.3
Trailhead	249.8	247.3	254.3	279.5	316.8	387.2	405.3	305.7
Magnar	228.3	237.8	260.3	274.6	319.9	375.9	412.1	301.3
Lodorm	304.9	297.4	306.1	329.7	349.0	405.0	423.6	345.1
Rosana	309.7	276.5	266.4	282.6	316.0	360.5	390.5	314.6
Bozoisky-Select	237.5	243.6	242.9	248.4	310.2	349.9	391.6	289.2
Mankota	270.9	242.4	249.2	281.7	306.1	363.0	403.7	302.4
Swift	265.0	283.2	272.0	266.9	288.8	362.1	389.9	304.0
Goldar	254.3	267.8	262.5	287.5	309.7	372.2	381.1	305.0
Greenleaf	258.3	262.3	254.6	291.2	340.1	374.4	411.8	313.2
Luna	250.0	259.9	268.3	301.8	338.3	390.3	412.1	317.2
Manska	251.3	257.7	273.9	288.8	335.9	384.6	407.6	314.3
Oahe	249.4	249.7	259.3	292.1	334.4	384.6	410.5	311.4
Reliant	253.7	255.7	269.8	302.4	345.7	386.8	412.2	318.0
Rush	264.9	277.0	281.0	305.8	345.7	398.4	416.2	327.0
Mean	263.0	262.7	270.3	292.4	326.2	378.6	404.7	314.0
LSD (0.05)	37.0	33.4	22.0	35.6	28.4	28.2	22.4	29.6

Table 78. Acid detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1999.

Date:	5/24/99	6/4/99	6/15/99	6/29/99	7/15/99	8/20/99	9/15/99	
Variety								Mean
Douglas	259.4	261.9	278.7	303.4	313.4	373.2	410.8	314.4
Hycrest	276.9	280.2	314.1	327.1	328.1	375.6	390.3	327.5
CD II	251.4	274.7	295.6	304.3	313.0	376.9	395.5	315.9
Nordan	262.6	282.1	295.3	307.7	319.7	377.7	416.8	323.1
P-27	263.2	266.6	288.6	309.2	321.9	387.8	415.6	321.8
Vavilov	285.9	292.0	297.2	324.6	328.0	388.7	423.5	334.3
Critana	269.5	291.1	297.9	333.3	343.8	413.2	409.4	336.9
Bannock	266.3	314.7	312.1	348.4	347.0	419.7	410.0	345.5
Schwendimar	336.0	297.0	299.7	331.6	315.7	375.6	389.2	335.0
Pryor	233.2	278.9	292.0	349.0	341.7	420.2	412.1	332.4
Revenue	294.7	284.9	275.9	311.7	325.2	393.5	390.8	325.2
Secar	276.2	308.1	308.5	329.7	339.5	401.2	400.8	337.7
Pearl	266.6	285.6	297.9	337.7	342.7	404.4	406.0	334.4
Prairieland	269.9	286.5	314.8	330.8	329.6	386.8	376.0	327.8
Eejay	277.1	292.6	301.3	321.1	329.2	378.8	370.1	324.3
Trailhead	261.7	267.3	286.3	302.4	300.3	417.9	415.6	321.6
Magnar	270.3	300.3	300.0	310.5	323.4	416.6	434.2	336.5
Lodorm	308.6	321.3	327.9	347.5	359.1	430.2	415.9	358.6
Rosana	307.2	287.6	285.9	309.0	315.0	360.4	349.1	316.3
Bozoisky-Select	230.3	243.9	250.1	286.1	287.7	369.8	340.2	286.9
Mankota	249.7	246.7	265.5	293.1	304.7	373.3	352.0	297.9
Swift	246.8	247.6	258.6	292.3	306.9	346.4	347.9	292.4
Goldar	284.1	280.9	295.7	305.2	320.4	360.0	378.4	317.8
Greenleaf	274.9	275.0	274.0	319.9	313.7	384.4	379.4	317.3
Luna	277.4	289.7	296.9	326.2	330.7	406.4	411.4	334.1
Manska	272.1	288.2	295.5	324.1	319.6	386.7	406.1	327.5
Oahe	267.0	296.0	289.1	326.1	332.6	381.0	404.7	328.1
Reliant	299.2	300.3	296.0	323.1	321.4	364.7	371.7	325.2
Rush	284.7	296.9	305.6	333.3	345.0	404.6	419.3	341.3
Mean	273.2	284.1	293.0	319.6	324.8	388.8	394.6	325.4
LSD (0.05)	41.3	34.5	32.9	29.8	33.1	32.9	37.8	34.6

APPENDIX C

NDF CONCENTRATIONS AT BRIDGER AND MOCCASIN

Table 79. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at eight sampling dates at Bridger, MT in 1997.

Date:	5/29/97	6/12/97	6/26/97	7/10/97	8/8/97	9/8/97	10/8/97	11/7/97	
Variety									Mean
Douglas	532.0	585.4	552.9	462.2	550.1	606.7	640.3	607.9	586.4
Hycrest	592.8	616.5	596.1	621.3	555.3	549.1	629.5	646.6	600.9
CD II	597.0	649.5	615.4	477.1	626.8	543.8	629.5	578.2	609.5
Nordan	592.9	636.2	633.5	495.2	636.8	591.9	670.4	653.2	634.4
P-27	575.4	666.8	612.5	516.5	642.6	572.5	605.5	637.3	625.1
Vavilov	547.3	610.2	606.8	630.6	580.3	588.1	619.0	634.3	602.1
Critana	623.4	676.8	641.5	618.4	678.8	644.9	704.3	709.9	662.3
Bannock	643.7	693.6	674.5	642.4	520.3	613.8	676.6	677.3	664.4
Schwendimar	617.6	663.0	660.0	661.8	664.9	623.3	661.7	661.6	651.7
Pryor	609.7	657.8	628.0	523.0	690.4	710.2	728.5	741.7	682.9
Revenue	583.6	644.1	653.7	508.3	639.3	693.5	760.2	777.9	678.7
Secar	619.6	658.9	653.6	643.5	636.8	595.8	635.1	602.2	630.7
Pearl	553.2	599.7	602.4	601.8	589.4	474.0	558.0	533.0	563.9
Prairieland	553.9	613.5	600.5	635.4	603.9	492.4	534.4	509.8	568.0
Eejay	540.7	598.7	593.4	629.5	603.1	514.7	551.3	578.3	576.2
Trailhead	549.6	585.3	564.0	438.7	577.7	513.1	602.3	624.7	575.2
Magnar	563.3	617.4	604.9	646.2	574.5	520.5	631.7	611.6	596.3
Lodorm	621.8	702.4	704.7	540.8	702.9	651.9	716.2	676.6	687.2
Rosana	546.3	654.6	610.1	614.7	584.0	506.6	590.8	570.0	584.6
Bozoisky-Select	584.0	654.5	621.7	640.3	687.4	625.3	645.9	644.7	638.0
Mankota	594.7	655.9	648.6	468.4	638.0	616.0	620.0	654.7	631.6
Swift	616.0	654.9	582.9	678.3	628.0	583.8	636.2	606.4	623.3
Goldar	562.7	667.7	638.5	616.5	648.6	572.3	627.8	624.5	619.8
Greenleaf	558.1	655.7	637.0	620.4	573.6	569.9	652.1	586.7	606.7
Luna	604.1	675.6	613.3	638.0	535.1	589.5	627.9	559.2	605.3
Manska	575.6	634.0	606.8	461.8	555.9	568.3	624.8	595.8	597.1
Oahe	567.7	649.9	658.1	640.8	583.3	544.0	582.7	613.7	605.0
Reliant	584.2	679.0	639.8	671.3	618.3	543.8	603.4	607.7	618.4
Rush	577.2	644.1	622.2	641.7	578.6	547.2	554.5	619.0	598.1
Mean	582.3	644.9	623.4	585.7	610.5	578.2	631.7	625.7	618.1
LSD (0.05)	38.8	43.5	48.8	NS*	NS*	63.2	63.9	54.7	24.5

* The F test for variety effect was not significant at the 0.05 level.

Table 80. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at ten sampling dates at Bridger, MTin 1998.

Date:	5/8/98	5/22/98	6/5/98	6/19/98	7/10/98	7/31/98	8/21/98	9/18/98	10/23/98	11/23/98	
Variety											Mean
Douglas	361.0	452.2	528.4	465.8	511.0	612.2	633.7	651.5	731.8	774.3	572.2
Hycrest	420.0	481.5	498.3	497.1	504.4	607.5	632.1	663.7	740.2	759.9	580.5
CD II	414.1	495.0	538.7	513.0	525.6	650.7	657.6	673.3	719.4	752.9	594.0
Nordan	414.8	480.5	486.2	513.1	538.8	639.2	645.4	639.9	755.1	778.8	589.2
P-27	410.3	499.8	537.0	529.9	554.5	646.8	652.7	626.7	763.2	721.0	594.2
Vavilov	418.6	510.3	529.9	527.1	522.4	644.2	646.0	630.1	761.5	740.3	593.0
Critana	410.0	480.6	492.7	554.8	516.9	622.7	722.7	717.5	756.7	799.5	607.4
Bannock	392.7	499.2	525.1	535.3	557.9	616.0	672.9	677.4	709.4	736.8	592.3
Schwendimar	406.1	499.1	500.8	554.7	556.7	639.7	673.9	605.8	709.9	680.3	582.7
Pryor	409.9	521.4	521.5	561.6	609.5	684.3	718.7	730.6	796.5	806.1	636.0
Revenue	399.9	507.1	532.8	552.5	580.8	659.6	688.2	667.8	763.4	788.3	614.0
Secar	479.4	571.4	564.2	551.1	555.0	654.6	673.8	667.5	720.9	745.5	618.3
Pearl	379.7	442.2	517.8	517.8	503.3	614.5	580.2	581.2	619.0	701.0	545.7
Prairieland	375.8	493.8	524.3	514.1	540.4	614.7	562.3	579.9	624.3	646.6	547.6
Eejay	379.0	445.0	525.8	550.1	530.7	614.0	585.5	594.9	645.9	660.9	553.2
Trailhead	408.7	482.8	514.2	489.7	491.0	600.5	581.8	652.1	737.0	723.1	568.1
Magnar	406.7	500.4	499.6	529.5	535.5	630.8	589.4	608.7	677.3	689.3	566.7
Lodorm	538.3	633.2	571.6	590.1	637.3	718.6	777.8	767.8	832.9	846.1	691.4
Rosana	404.1	444.0	441.4	513.5	528.5	602.3	600.9	558.4	663.0	687.8	544.4
Bozoisky-Select	403.0	521.5	521.5	541.1	548.7	651.3	643.7	614.0	716.5	804.0	596.5
Mankota	385.8	500.4	535.2	567.8	562.9	663.8	658.3	641.8	718.7	775.3	601.0
Swift	458.6	519.6	587.8	538.8	587.3	622.9	651.7	638.9	684.9	760.8	605.1
Goldar	469.5	551.4	517.2	542.0	529.7	620.3	664.4	654.2	714.3	757.3	602.0
Greenleaf	366.1	449.7	495.3	508.8	534.3	612.2	641.5	619.8	715.4	748.2	569.1
Luna	393.8	490.4	531.9	545.1	535.4	648.7	624.3	646.8	706.3	730.8	585.4
Manska	377.6	445.8	479.2	530.3	526.9	620.8	607.1	577.3	687.4	698.0	555.0
Oahe	385.8	462.6	473.2	524.1	531.2	618.7	640.2	629.4	709.3	742.6	571.7
Reliant	389.9	460.3	502.9	568.0	557.9	612.2	633.3	600.0	699.8	700.5	572.5
Rush	377.0	467.9	503.9	582.8	519.4	625.3	629.9	545.6	707.2	706.7	566.6
Mean	408.1	493.4	517.2	534.8	542.5	633.4	644.5	636.6	716.8	740.1	589.9
LSD (0.05)	36.3	38.9	59.6	40.5	50.4	47.0	64.0	66.4	55.3	60.6	68.5

Table 81. Neutral detergent fiber concentrations (g kg^{-1}) of 29 dryland grasses at nine sampling dates at Bridger, MT in 1999.

Date:	5/6/99	5/20/99	6/3/99	6/17/99	7/15/99	8/16/99	9/15/99	10/15/99	11/15/99	
Variety										Mean
Douglas	458.1	466.7	505.6	464.8	478.0	609.5	702.0	691.9	674.0	561.2
Hycrest	464.6	492.7	526.1	523.6	541.8	581.2	659.5	691.2	700.0	575.6
CD II	475.7	489.6	532.5	510.8	540.5	574.2	689.1	670.3	667.3	572.2
Nordan	490.0	494.2	538.7	521.3	539.6	595.6	693.2	669.4	670.5	579.2
P-27	461.9	466.4	524.8	525.3	529.7	586.4	684.5	661.5	650.2	565.6
Vavilov	492.4	507.6	529.1	530.1	539.9	607.4	717.2	673.7	644.3	582.4
Critana	497.8	498.6	537.2	536.2	621.0	714.9	796.7	713.7	732.0	627.6
Bannock	470.2	516.9	545.0	567.0	569.8	654.5	696.3	668.3	695.8	598.2
Schwendimar	514.1	515.7	536.3	564.6	559.2	639.6	673.5	661.6	649.3	590.4
Pryor	463.4	487.1	569.3	566.6	582.3	666.6	729.6	718.9	736.0	613.3
Revenue	552.0	557.2	576.2	557.6	579.8	645.7	682.6	663.5	667.4	609.1
Secar	541.1	567.9	572.2	597.4	588.0	637.5	688.6	697.7	675.9	618.5
Pearl	453.9	511.9	527.9	519.0	504.9	530.8	573.7	562.2	579.2	529.3
Prairieland	439.2	473.2	504.6	565.8	533.1	548.7	536.4	568.9	610.3	531.1
Eejay	468.8	487.9	509.5	560.2	502.3	545.4	559.7	557.9	581.9	530.4
Trailhead	439.1	488.8	512.6	521.7	504.8	540.4	615.6	621.8	646.4	543.5
Magnar	451.6	458.6	500.8	499.3	516.6	568.1	602.1	599.7	621.6	535.4
Lodorm	511.9	570.3	576.1	613.0	637.5	742.3	800.6	751.2	746.8	661.1
Rosana	466.6	469.7	501.6	534.3	527.3	562.0	614.9	590.4	589.7	539.6
Bozoisky-Select	450.4	501.2	539.9	591.2	602.6	700.6	707.6	670.8	697.2	606.8
Mankota	449.5	489.9	527.6	553.1	584.0	648.6	680.9	678.7	674.2	587.4
Swift	478.0	528.1	555.6	584.7	594.3	673.4	669.9	666.5	690.7	604.6
Goldar	511.4	529.1	569.8	546.6	567.8	610.0	693.3	674.3	675.3	597.5
Greenleaf	419.3	446.0	467.0	499.9	515.6	613.2	682.4	671.4	655.8	552.3
Luna	420.8	464.6	490.1	519.6	524.4	660.5	748.6	638.5	632.8	566.7
Manska	447.8	426.4	466.4	487.2	496.9	586.1	630.2	603.8	607.8	528.1
Oahe	416.1	456.7	497.2	518.0	526.9	634.5	699.0	667.5	661.7	564.2
Reliant	472.9	442.6	485.6	494.9	537.5	583.9	652.2	601.4	614.8	542.9
Rush	463.6	473.2	510.0	516.9	510.0	546.9	663.6	665.6	652.3	555.8
Mean	470.4	492.4	525.3	537.6	546.7	614.1	673.9	654.2	658.7	574.8
LSD (0.05)	39.6	39.6	39.9	43.8	40.9	59.8	49.2	51.8	44.0	38.8

Table 82. Neutral detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at five sampling dates at Moccasin, MT in 1997.

Date:	5/19/97	6/2/97	6/30/97	7/14/97	7/28/97	
Variety						Mean
Douglas	384.7	501.7	546.6	571.0	570.1	514.8
Hycrest	423.2	493.7	556.3	587.5	587.4	529.6
CD II	437.4	521.2	590.0	606.2	621.9	555.3
Nordan	417.5	540.8	584.8	635.9	608.0	557.4
P-27	414.3	514.3	595.7	591.0	633.5	549.8
Vavilov	423.9	522.3	601.2	631.6	652.1	566.2
Critana	413.4	517.1	558.9	580.6	615.8	537.2
Bannock	412.4	530.1	609.2	636.4	608.4	559.3
Schwendimar	427.1	522.6	607.5	639.7	657.3	570.8
Pryor	439.2	524.8	590.1	596.6	643.1	558.8
Revenue	433.7	512.5	597.7	627.5	659.5	566.2
Secar	438.2	517.3	556.0	572.3	589.9	534.7
Pearl	402.2	496.7	508.6	546.1	540.4	498.8
Prairieland	452.6	499.8	548.9	532.3	590.4	524.8
Eejay	414.7	487.1	562.7	558.4	585.0	521.6
Trailhead	427.6	494.8	527.7	550.6	543.8	508.9
Magnar	425.8	488.1	525.0	565.3	564.4	513.7
Lodorm	466.7	568.2	611.5	617.8	645.1	581.9
Rosana	400.2	448.2	546.8	537.7	574.6	501.5
Bozoisky-Select	389.4	464.2	559.3	601.3	605.4	523.9
Mankota	401.1	501.1	541.8	588.7	632.5	533.0
Swift	382.5	499.8	542.6	524.9	581.1	506.2
Goldar	438.7	526.0	570.0	570.3	607.7	542.5
Greenleaf	374.1	484.2	563.4	597.5	610.8	526.0
Luna	413.7	508.8	583.5	603.9	586.0	539.2
Manska	389.0	517.1	591.4	617.5	623.1	547.6
Oahe	398.4	526.6	605.6	640.5	605.6	555.3
Reliant	360.6	491.8	573.9	620.8	633.3	536.1
Rush	388.0	504.2	589.2	601.1	628.4	542.2
Mean	413.5	507.8	570.5	591.4	607.0	538.0
LSD (0.05)	47.5	41.4	49.8	44.1	50.9	50.1

Table 83. Neutral detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1998.

Date:	5/8/98	5/26/98	6/5/98	6/22/98	7/13/98	9/4/98	10/6/98	
Variety								Mean
Douglas	410.8	421.8	422.5	507.5	450.7	587.3	688.2	498.4
Hycrest	443.1	436.6	446.5	512.1	478.6	592.0	647.3	508.0
CD II	435.1	434.5	426.8	521.6	476.5	604.0	652.4	507.3
Nordan	410.5	382.0	430.6	520.4	503.6	572.7	661.6	497.3
P-27	392.3	386.2	411.9	507.4	492.6	581.1	686.8	494.0
Vavilov	405.6	411.3	460.6	541.9	498.0	572.4	631.5	503.0
Critana	472.9	427.9	404.4	530.4	538.7	675.1	760.2	544.2
Bannock	464.4	445.6	459.9	563.0	568.8	687.7	733.6	560.4
Schwendimar	530.7	444.7	446.9	527.3	553.9	648.9	701.4	550.5
Pryor	416.7	469.2	467.9	549.0	543.5	683.2	727.5	551.0
Revenue	433.0	431.7	454.7	510.5	557.5	644.4	675.2	529.6
Secar	457.3	435.0	464.8	507.4	505.6	640.2	662.7	524.7
Pearl	463.6	426.9	434.3	517.6	513.7	617.7	716.2	527.1
Prairieland	448.2	448.0	468.8	553.6	523.4	640.2	668.3	535.8
Eejay	473.3	447.6	439.8	547.9	530.2	623.7	668.2	533.0
Trailhead	424.6	431.0	399.5	492.4	504.8	634.9	661.1	506.9
Magnar	395.8	412.9	432.6	501.5	506.5	627.3	690.1	509.5
Lodorm	533.8	507.0	531.4	613.7	587.1	703.2	725.6	600.3
Rosana	486.7	398.3	420.1	505.5	519.7	616.1	715.8	523.2
Bozoisky-Select	429.2	377.7	392.9	473.2	510.5	626.5	707.5	502.5
Mankota	462.6	413.1	421.3	549.0	553.6	686.9	753.4	548.6
Swift	448.0	451.2	454.8	510.4	509.5	667.2	738.3	539.9
Goldar	432.0	438.7	403.3	507.7	487.7	614.9	653.5	505.4
Greenleaf	399.2	419.8	418.8	526.6	560.8	616.0	665.5	515.2
Luna	401.5	419.9	437.3	531.5	510.6	630.5	652.7	512.0
Manska	405.3	414.4	445.6	523.3	522.9	626.5	642.6	511.5
Oahe	410.9	418.6	425.8	523.4	529.8	619.9	665.7	513.4
Reliant	381.8	399.8	458.0	534.1	568.6	640.2	652.2	519.2
Rush	448.1	462.8	472.8	562.7	531.0	611.5	644.2	533.3
Mean	438.5	428.1	439.8	526.6	522.0	630.8	684.5	524.3
LSD (0.05)	67.7	50.1	48.8	50.5	54.6	55.2	65.8	54.6

Table 84. Neutral detergent fiber concentrations (kg ha^{-1}) of 29 dryland grasses at seven sampling dates at Moccasin, MT in 1999.

Date:	5/24/99	6/4/99	6/15/99	6/29/99	7/15/99	8/20/99	9/15/99	
Variety								Mean
Douglas	528.1	526.9	518.1	546.2	534.2	649.9	668.7	567.4
Hycrest	511.5	478.3	532.3	543.1	550.7	644.4	652.4	559.0
CD II	507.5	543.0	526.0	569.9	549.4	625.9	666.4	569.7
Nordan	501.7	500.3	519.1	541.3	549.6	664.4	696.1	567.5
P-27	484.8	511.8	515.6	555.1	574.6	663.9	714.3	574.3
Vavilov	512.1	498.2	505.5	552.9	569.2	666.6	692.7	571.0
Critana	483.5	543.3	511.8	557.2	599.0	685.9	688.0	581.2
Bannock	496.5	562.5	549.6	587.2	589.7	686.2	662.7	590.6
Schwendimar	573.4	549.0	550.8	572.5	568.6	654.3	646.3	587.8
Pryor	482.3	549.0	538.5	621.9	607.1	715.0	688.8	600.4
Revenue	563.7	544.4	543.0	583.7	585.5	707.6	655.6	597.6
Secar	512.9	539.8	529.2	537.8	586.5	668.5	650.9	575.1
Pearl	502.6	493.6	511.8	541.4	583.9	693.3	656.3	569.0
Prairieland	486.3	514.7	539.5	566.5	571.9	635.6	619.1	561.9
Eejay	499.2	534.1	506.2	553.6	581.9	651.3	659.4	569.4
Trailhead	491.9	485.4	481.8	545.6	559.6	686.6	722.5	567.6
Magnar	529.9	505.6	531.7	544.6	581.6	725.0	729.0	592.5
Lodorm	555.6	574.1	595.4	639.9	640.6	751.1	719.0	639.4
Rosana	549.7	495.9	482.7	528.6	565.1	645.8	583.4	550.2
Bozoisky-Select	448.4	465.7	485.7	524.5	572.3	640.2	601.0	534.0
Mankota	506.0	484.9	511.0	545.5	594.4	670.8	649.8	566.1
Swift	473.1	479.9	484.5	527.7	565.7	627.4	613.1	538.8
Goldar	535.7	538.6	522.3	535.2	583.9	625.9	655.3	571.0
Greenleaf	519.1	494.5	494.5	546.8	549.8	663.3	613.6	554.5
Luna	493.8	483.5	500.6	560.6	558.2	700.2	658.6	565.1
Manska	462.1	516.1	503.5	575.6	562.8	657.8	670.2	564.0
Oahe	449.9	493.8	503.3	552.5	558.2	658.2	667.8	554.8
Reliant	470.8	501.7	517.3	582.2	576.4	634.8	625.6	558.4
Rush	504.0	519.2	524.5	570.1	598.5	671.8	669.7	579.7
Mean	504.7	514.7	518.5	558.9	574.8	668.0	661.9	571.6
LSD (0.05)	58.5	41.5	44.6	47.1	NS*	55.9	60.3	39.7

* The F test for variety effect was not significant at the 0.05 level.