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# PLANT MATERIALS TECHNICAL NOTE

## Seasonal Forage Quality of Five Tame Pasture Grasses on Dryland Pastures in Montana

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### Abstract

A study conducted at Montana State University in 2001 measured seasonal forage quality characteristics of native and non-native grass species and cultivars from three dryland sites across Montana. The objective of this Technical Note is to report the results for three cultivars of each of five tame grass species; crested wheatgrass, Altai wildrye, Russian wildrye, intermediate wheatgrass, and pubescent wheatgrass. Altai and Russian wildryes tended to maintain higher levels of crude protein into mid- and late-season than the wheatgrasses, suggesting recommending these species for pastures intended for mid- to late-season use. Acid detergent fiber and *in vitro* digestible matter, measures of digestible carbohydrates, were less variable among species, the exception being 'Douglas' crested wheatgrass maintained crude protein longer into the growing season than 'Hycrest' and CD-II. Differences in forage quality among tame grass species and their cultivars varied depending on the site. The results provide guidance for selecting tame grass species and their cultivars for pasture establishment or renovation depending on the intended season of use.

### Introduction

Seasonal forage quality is an important consideration when planning pasture development or renovation, and season-long forage and quality is an identified need in the Bridger Plant Materials Center (PMC) 2012-2017 Long Range Plan. For many reasons most pastures are planted to non-native grasses and legumes. This Technical Note re-analyzes, compares, and summarizes the results of the forage quality analysis for five tame pasture grasses grown over three years on three dryland sites in Montana (Blunt, 2001). The five grasses are crested wheatgrass (*Agropyron cristatum*), Altai wildrye (*Leymus angustus*), Russian wildrye (*Psathyrostachys juncea*), pubescent wheatgrass (*Thinopyrum intermedium* spp *barbulatum*), and intermediate wheatgrass (*Thinopyrum intermedium*). For each of the grasses, three cultivars were tested: 'Douglas', 'Hycrest', and 'CD-II' for crested wheatgrass ('Hycrest' and 'CD-II' are hybrids of *Agropyron cristatum* and *A. desertorum*); 'Pearl', 'Prairieland', and 'Eejay' for Altai wildrye; 'Bozoisky-Select', 'Mankota', and 'Swift' for Russian wildrye; 'Greenleaf', 'Luna', and 'Manska' for pubescent wheatgrass; and 'Oahe', 'Reliant', and 'Rush' for intermediate wheatgrass.

Crested wheatgrass is generally recommended for areas receiving less than 14 to 12 inches of precipitation annually (Ogle, 2006). It is considered desirable forage for livestock and wildlife in the spring, in the fall if available soil moisture allows re-growth, and is utilized by cattle and horses in the winter with supplemental protein. Reported protein content ranges from 18% in the spring; dropping to 4% as it matures. Digestible carbohydrates remain high during the active growth period. 'Douglas' was selected for large seed size and seedling vigor. It produces less forage than other varieties of crested wheatgrass, but the forage stays green longer into the growing season indicating protein and digestible carbohydrates will remain high (Ogle, 2006). 'Hycrest' is adapted to annual precipitation zones as low as eight inches and elevations from 5,000 to 9,500 feet. It has coarser leaves and stems than 'Douglas' suggesting lower forage quality (Ogle, 2006). 'CD-II' is a

selection of ‘Hycrest’ with similar forage quality, but it is adapted to colder temperatures (Ogle 2006).

Altai wildrye reportedly has a long period of growth beginning in early spring and continuing into fall, reaching peak forage production in late July (St. John, et al., 2010). This suggests a longer period of high forage quality than crested wheatgrass. ‘Prairieland’ was selected for high seed and forage yield and resistance to leaf spot diseases. The ‘Pearl’ selection increased seed yield over ‘Prairieland’ but at the cost of lower forage production. The ‘Eejay’ selection has higher seed and forage yield than ‘Prairieland’ while maintaining resistance to leaf spot diseases (St. John, et al., 2010).

Russian wildrye is considered one of the more versatile dryland forage grasses because it can be utilized during all seasons and because percent protein when cured is reportedly higher than wheatgrasses (Ogle, et al., 2005). It begins growth later in the spring than crested wheatgrass but has a longer growth period than most dryland grasses. It is recommended for late summer through winter grazing and is used as stockpile forage for fall and winter use. ‘Swift’ was selected for the ability to emerge from deep planting, seedling vigor, and large plants during the establishment year. ‘Mankota’ was selected for spring seedling vigor, and seed and forage yield. ‘Bozoisky-Select’ was selected for seedling vigor, leafiness, seed yield and for use on sagebrush (*Artemisia* species), juniper (*Juniperus* species), shadscale (*Atriplex confertifolia*), greasewood (*Sacrobatusvermiculatus*), and Indian ricegrass (*Achnatherum hymenoides*) habitat types (Alderson and Sharp, 1994).

Pubescent wheatgrass is a sub-species of intermediate wheatgrass adapted to slightly drier sites and used for hay and pasture (Ogle, et al., 2011). It is considered preferred forage for livestock and wildlife in spring, early summer and fall, and desirable forage in summer and winter. ‘Greenleaf’ was selected for forage type and cold hardiness intended for use in grass-alfalfa hay (Alderson and Sharp, 1994). ‘Luna’ was selected for rapid establishment and forage yield intended for irrigated hay and range and disturbed area re-seeding (Alderson and Sharp, 1994). ‘Manska’ was selected for vigor, resistance to leaf spot diseases, seed yield and winter survival, and is reported to have high forage quality compared to other intermediate wheatgrass varieties (Alderson and Sharp, 1994).

Like pubescent wheatgrass but not as drought tolerant, intermediate wheatgrass is used for hay and pasture. ‘Oahe’ was selected for high seed set, forage yield and rust resistance (Alderson and Sharp, 1994). ‘Reliant’ was selected for vigor, seed yield, winter survival, resistance to leaf-spotting diseases, and forage quality. ‘Rush’ was obtained from the German Botanical Garden, Berlin, and increased without selection (Alderson and Sharp, 1994). It reportedly has strong seedling emergence and vigor, good spring recovery, good spread by rhizomes, and high seed and forage yields (Ogle, et al., 2011).

## Forage Quality

Forage quality is mostly affected by plant maturity over the growing season, is inversely proportional to dry matter yield, and is a function of the leaf to stem ratio (Blunt, 2001). Leaves are packed with photosynthetic parenchyma cells high in protein and sugar-rich protoplasm whereas stems are structurally rigid because of cellulose and lignin-rich but indigestible cell walls. While forage quality predictably declines with maturity as leaf mass decreases relative to stem mass, it is variable depending on soil depth and texture, annual precipitation, and species.

Livestock performance is the ultimate determination of forage quality but estimates of forage quality constituents, including crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* digestible dry matter (IVDDM) can be used to predict animal performance. Crude protein is the amount of nitrogen from both protein and non-protein sources in the forage

and is predictive of available protein. Acid detergent fiber concentration measures cellulose and lignin in cell wall portions of the forage and relates to an animal's ability to digest forage; as ADF increases digestibility decreases. Neutral detergent fiber measures the total cell wall content of the forage including hemicelluloses and is predictive of the amount of forage an animal can consume; as NDF increases, dry matter intake decreases. *In vitro* digestible dry matter estimates the amount forage that is potentially digestible. Blunt (2001) used near infrared reflectance spectroscopy to measure CP, ADF, NDF, and IVDDM.

## Methods

Blunt (2001) tested 29 forage grass varieties selected from 14 native and non-native species. They were seeded in a randomized complete block design with four replications in May 1996 at three Montana sites; the Montana State University (MSU) Research Farm near Bozeman, the Bridger Plant Materials Center (PMC) near Bridger, and the Central Agricultural Research Center near Moccasin. Blunt (2001) reported the 30-year average annual precipitation at the Bozeman, Bridger, and Moccasin sites at 16.7, 13.7 and 16.5 inches, respectively. The Bridger site has the longest frost-free growing season, and the Moccasin site has shallower soils than the other two. Forage samples were collected every two weeks from May through July, and monthly from August through November in 1997, 1998, and 1999. During those years, growing season precipitation at all three sites was above average in 1997 and below average particularly in May and July in 1998 and 1999 (Blunt, 2001). Average growing season monthly temperatures at the three sites were in most cases plus or minus five degrees Fahrenheit (F) of the 30-year average. Blunt (2001) alludes to applied nitrogen fertilizer but gives no detail to timing, amount, or the number of fertilizations in the methods. The study was not irrigated.

**Data Analysis.** Blunt (2001) used analysis of variance (ANOVA) to determine the probability that variety, site (location), year, and interactions of all combinations of these variables affected the amount of CP, ADF, NDF, and IVDDM from samples harvested from each plot at each sampling date. This analysis allowed comparison of forage quality among all varieties, sites, and years. The results were tabulated by site, year, and sample date as the mean value of the four replications for each variety (Blunt, 2001). For each forage quality parameter, variety, location, and year were significant factors affecting quality. However, significant interaction effects indicate in many cases the effect of variety depended on the location or year, or the effect of location depended on the year.

The mean values for CP, ADF, and IVDDM (data for NDF were not available) reported by Blunt (2001) were used in a re-analysis to address more specific producer and conservation planner concerns. To understand seasonal variation, mean values were selected from late May (early-season), early July (mid-season), and October or November (late-season). The first question addressed was "how do species (and in the case of pubescent wheatgrass, sub-species) differ seasonally in forage quality across the range of sites and duration of the study"? Based on our current knowledge, the hypothesis is spring forage quality does not differ among species, but the wildrye species maintain higher forage quality into the late growing season and going into winter. To test this hypothesis, an ANOVA model used the three cultivar of each species as the replication variable, species as the main effect variable, and the variability associated with site and year was part of the model error. The analysis was run separately for early-, mid-, and late-season data.

Once a planner or producer decides on a species, the next question is, "do varieties of a species differ seasonally in forage quality"? For crested wheatgrass the hypothesis is 'Douglas' maintains forage quality longer into the growing season than 'Hycrest' and 'CD-II' crested wheatgrasses based on the observation it stays greener longer. For Altai wildrye, the null hypothesis that there are no differences among varieties applies because seed yield, seedling vigor, and disease resistance were selection criteria. For Russian wildrye 'Bozoisky-Select' is expected to have higher forage quality than 'Swift' and 'Mankota' because it was selected for leafiness.

For pubescent wheatgrass, higher forage quality was a selection criteria for ‘Manska’ and is expected to be greater than ‘Greenleaf and ‘Luna’. For intermediate wheatgrass, the null hypothesis applies because forage quality was not a selection criteria. Species were analyzed separately by season to test these hypotheses using an ANOVA model with site as the replication variable, cultivar as the main effect variable, and the variability associated with year in the model error.

The results of the analysis by Blunt (2001) found in many cases that differences among varieties in forage quality depended on the site or year, indicating site and climate variability were influential factors in forage quality differences among species and varieties. Therefore species and cultivar selection may be different in the Bozeman Area (which may also be representative of the Missoula Area), Miles City Area (represented by the Bridger site), and Great Falls area (represented by the Moccasin site). The hypotheses given above are the same for this test which used a split-plot ANOVA model with cultivar as the replication variable, species as the whole-plot variable, and season as the sub-plot variable. The model was run for each year at each site for CP and IVDDM. Data for ADF and NDF were not available for all years or all sites.

## Results

### Statewide Seasonal Forage Quality (data for Bozeman, Bridger and Moccasin combined)

**Do the five tame pasture species differ in forage quality seasonally?** The ANOVA for crude protein concentration supports a “yes” answer. Early-season CP concentrations were not different among species (P>0.1) and were 23% for pubescent and intermediate wheatgrasses, Russian and Altai wildryes, and 21% for crested wheatgrass, suggesting any of these species would provide equally nutritious spring forage as expected. Crude protein concentrations differed at mid-season (P<0.05). Altai wildrye crude protein concentration was 16%, significantly greater than pubescent, intermediate, and crested wheatgrasses (14%), but not Russian wildrye (16%) which was significantly greater than intermediate and crested wheatgrasses but not greater than pubescent wheatgrass. By late-season, Altai (11%) and Russian (10%) wildryes had more CP (P<0.05) than intermediate (9%) and crested (9%) wheatgrasses, but not pubescent wheatgrass (10%) which was not different than intermediate and crested wheatgrasses. The ANOVA for ADF found no differences among species at any season and ranged from 261 to 241 grams per kilogram in early-season, 335 to 314 grams per kilogram in mid-season and 392 to 367 grams per kilogram in late-season. Similarly, the ANOVA for IVDDM found no differences among species at any season and ranged from 629 to 584 grams per kilogram in early-season, 478 to 461 grams per kilogram in mid season and 373 to 337 grams per kilogram in late-season. Data were not available for NDF. The results support the hypothesis that all of the five tame grasses are equally nutritious early in the growing season and the CP results support recommending either Altai or Russian wildrye over the wheatgrasses for mid- and late-season pasture.

**Do varieties of a species differ in forage quality seasonally?** The ANOVAs for Altai and Russian wildryes, and pubescent and intermediate wheatgrasses support rejecting (P>0.1) the hypothesis cultivars within these species differ seasonally in CP, ADF, and IVDDM concentrations. Seasonal forage quality may be more a species trait than a variety trait, or other traits like seed size or quantity, seedling vigor, and resistance to disease play a bigger role than seasonal forage quality in the development of these cultivars. This suggests that when selecting a cultivar of one of these species, any of the ones tested will produce similar quality forage, and cultivar selection can be based on other factors like seed availability or price. Certified cultivar seed is still recommended over common seed because of the proven seed quality.

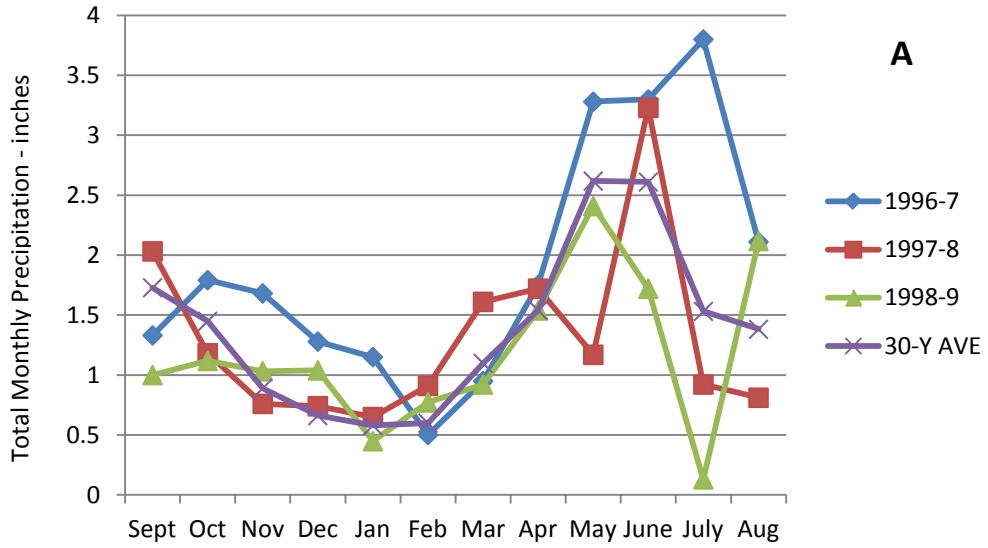
Similarly, ADF and IVDDM seasonal concentrations were similar among cultivars of crested wheatgrass (P>0.01). However, ‘Douglas’ crested wheatgrass (*A. cristatum*) had greater (P<0.05) CP concentration (23%) than both ‘Hycrest’ (21%) and ‘CD-II’ (21%) in early-season (both are *A. cristatum* X *A. desertorum*), more mid-season CP concentration (15%) than ‘CD-II’ (13%) but not

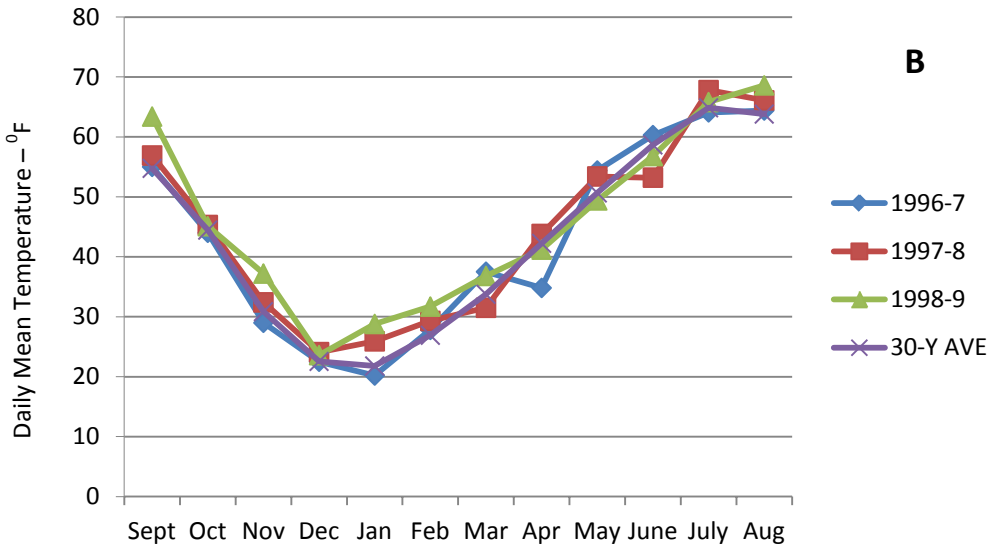
‘Hycrest’ (14%), but by fall differences were not statistically significant (P>0.1, 10% for “Douglas’ and 8% for ‘Hycrest and CD-II). The CP results support the hypothesis that ‘Douglas’, which stays green into the summer, maintains forage quality longer into the growing season. While this may be a species trait, persistent seasonal greenness may be a selection characteristic for developing cultivars for season-long forage quality, an identified need in the Bridger PMC 2012-2017 Long Range Plan.

**Seasonal Forage Quality by Area**

**Bozeman Area.** The ANOVA for the Bozeman site detected differences in CP concentration among species in 1997 and 1998 and differences among species in IVDDM in 1999 (P<0.05). In 1997, Altai wildrye had greater CP concentration mid-season than all other species, and Russian wildrye had greater CP concentration mid-season than all other species in 1998 (Table 1). In 1997, Altai wildrye had greater IVDDM than Russian wildrye in late-season, and in 1999, crested wheatgrass had greater IVDDM than Altai wildrye and intermediate wheatgrass in early season (Table 2). Precipitation (Figure 1A) during the growing season months at Bozeman was greater than the 30-year mean in 1997, by as much as 1.1 inches in July when temperatures (Figure 1B) were 0.9° F cooler for the month, and may have favored high July CP and late-season IVDDM concentrations in Altai wildrye. In 1998, precipitation at the Bozeman site was lower (except in June) than the 30-year mean. In July precipitation was 0.6 inches below the 30-year mean and temperature was 3° F warmer than the 30-year mean and may have favored high CP concentrations in Russian wildrye relative to the other species. In 1999, early-season precipitation at the Bozeman site was at or slightly below the 30-year average; however the average March temperature was significantly higher and may have contributed to the higher IVDDM concentration in crested wheatgrass relative to the other species. Temperature and soil moisture affect the timing of transition from vegetative to reproductive stages in grasses. There were no cultivar differences within any of the species for CP or IVDDM at Bozeman during the three years of the study.

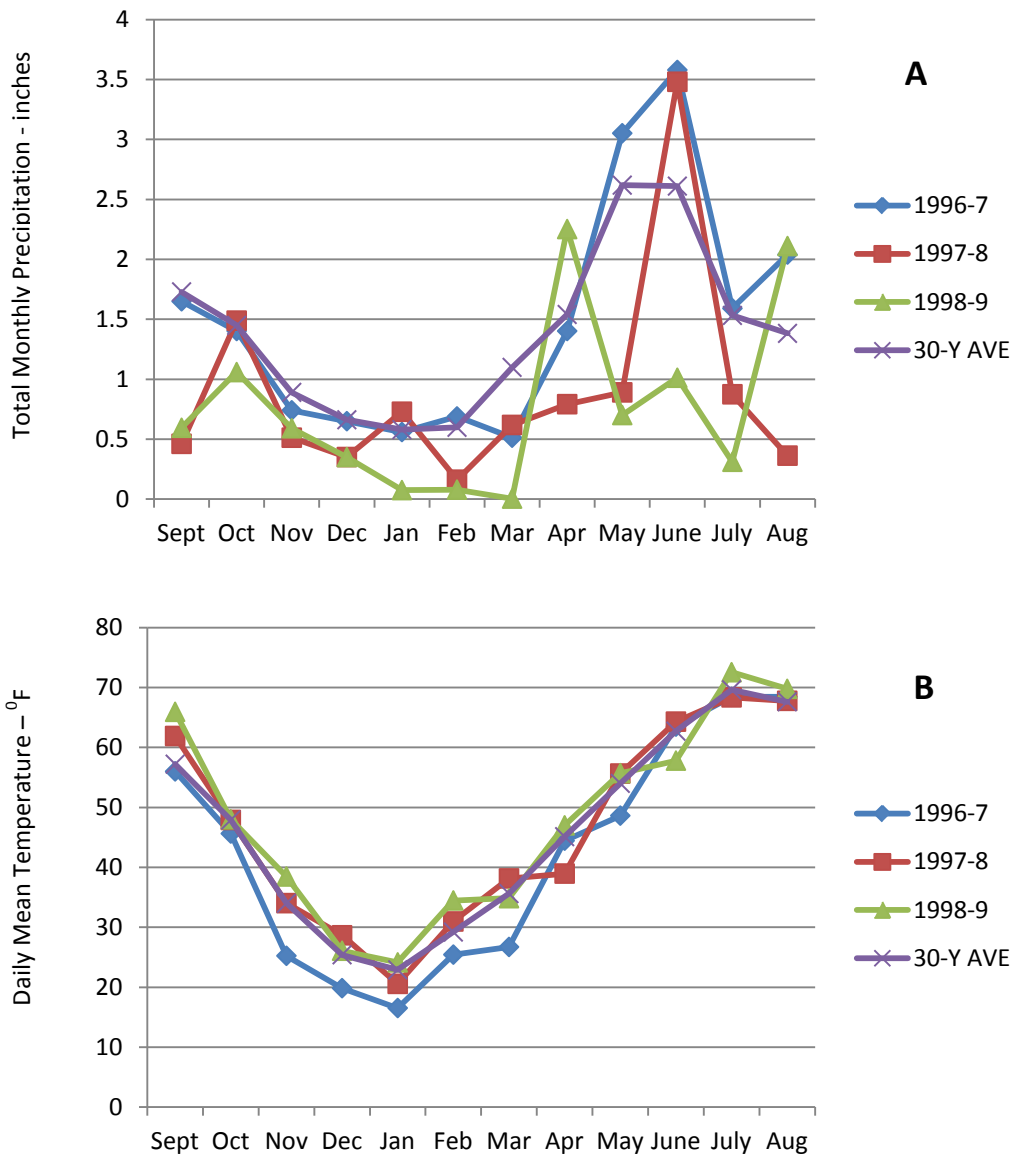
**Figure 1.** Monthly and 30-year average precipitation in inches (A) and temperature in degrees F (B) at the Bozeman site for the three years of the study.






**Miles City Area.** The ANOVA for the Bridger site detected differences in CP concentration among species in 1998 and differences among species in IVDDM in 1997, 1998, and 1999 ($P<0.05$). In 1998, pubescent wheatgrass had greater CP concentration early-season than Russian wildrye, and Altai wildrye had greater CP concentration mid-season than all other species except Russian wildrye (Table 1). Altai wildrye had greater IVDDM than crested wheatgrass in late-season in 1997 and greater than pubescent wheatgrass in late-season in 1998 (Table 2). In 1999, crested wheatgrass had greater early-season IVDDM than all other species, pubescent wheatgrass had greater mid-season IVDDM than Altai and Russian wildryes, and intermediate wheatgrass had greater mid-season IVDDM than Altai wildrye (Table 2). In 1998, the combined precipitation (Figure 2A) in March, April, and May was nearly three inches below the 30-year average and may have favored higher CP in pubescent wheatgrass over Russian wildrye. June precipitation in 1998 was 1.8 inches above the 30-year average and may have allowed Alti wildrye to maintain higher CP concentrations relative to Russian wildrye after the drier than normal spring. In 1997, precipitation in May, June, July, and August combined was 5.5 inches above the 30-year average and may have allowed Altai wildrye to maintain high IVDDM concentrations relative to crested wheatgrass. In 1998 when late-season IVDDM of Altai wildrye was greater than pubescent wheatgrass, early-season precipitation was lower than the 30-year average followed by a wetter than normal June. March, April, and May precipitation was 2.8 inches below the 30-year average in 1999 and may have contributed to crested wheatgrasses higher IVDDM relative to the other species. Temperatures (Figure 2B) were slightly above or below the 30-year average during those months and years at Bridger. Precipitation may have been a greater factor in species CP and IVDDM concentrations at Bridger because it is the driest of the three sites in the study. There were no differences among varieties within species at Bridger in any of the three years.

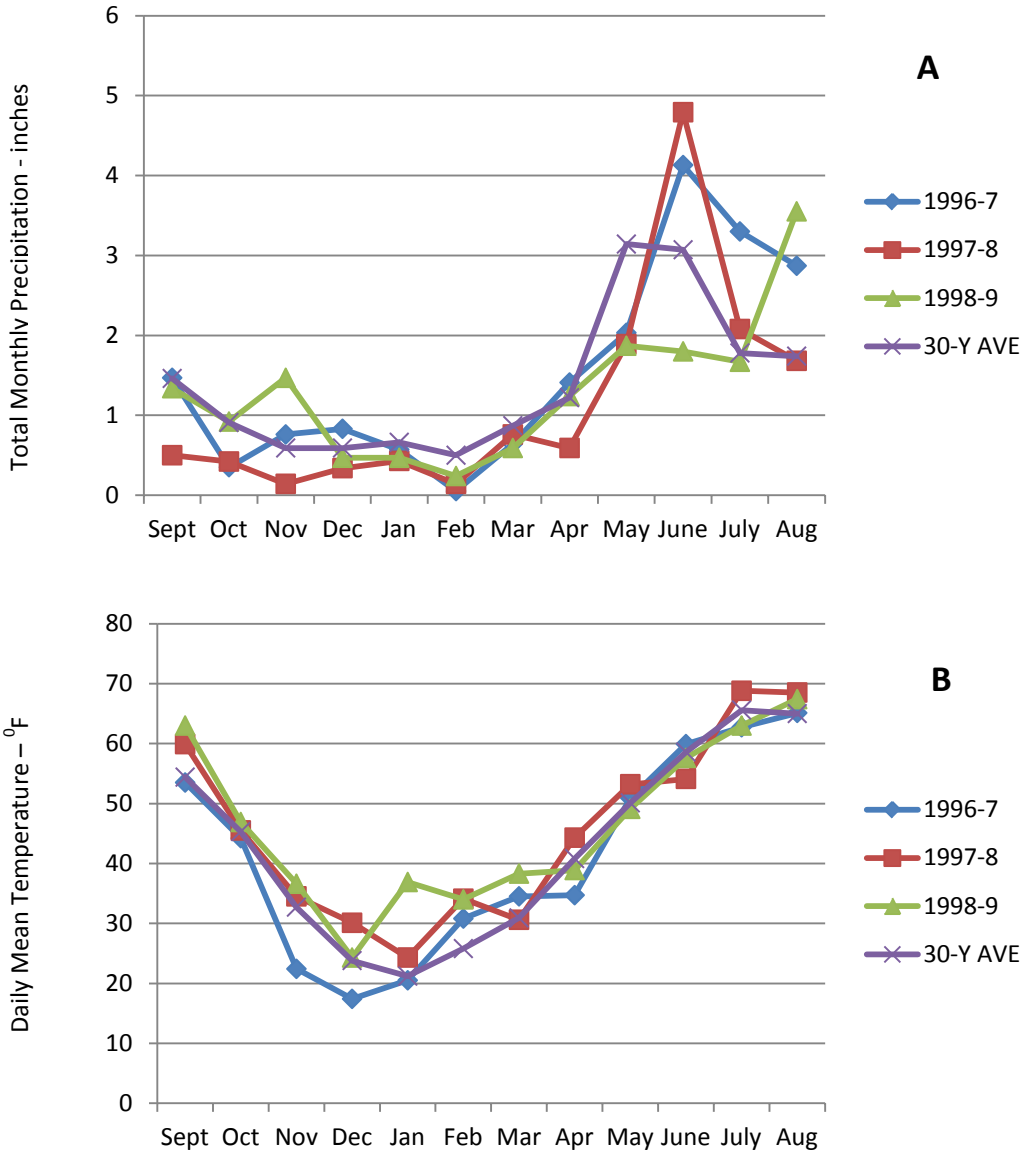
**Figure 2.** Monthly and 30-year average precipitation in inches (A) and temperature in degrees F (B) at the Bridger site for the three years of the study.




**Seasonal Forage Quality Great Falls Area.** The ANOVA for the Moccasin site detected differences in CP concentration among species in 1997, 1998, and 1999, and differences among species in IVDDM in 1997 ($P<0.05$). In 1997, Russian wildrye had greater CP concentration early-season than Altai wildrye, Altai wildrye had greater mid- and late-season CP concentration than all other species except Russian wildrye, and Russian wildrye had greater late-season CP concentration than intermediate wheatgrass (Table 1). In 1998, Russian wildrye had greater mid-season CP concentrations than intermediate wheatgrass and Altai wildrye had greater late-season CP concentration than intermediate wheatgrass (Table 1). In 1997, early-season IVDDM was greater in intermediate wheatgrass than crested wheatgrass (Table 2). The only difference among varieties of a species in CP concentration averaged over the growing season was in 1997 when 'Douglas' crested wheatgrass (17%) CP was greater than 'CD-II' hybrid crested wheatgrass CP (13%, Table 1). A cooler than normal April in 1997 (Figure 3A) may have favored greater CP concentration in Russian wildrye over Altai wildrye. In 1997 June, July, and August precipitation (Figure 3B) was 3.7 inches above the 30-year average and may have favored higher late season CP concentrations in Altai wildrye over the wheatgrass species, and Russian wildrye over

intermediate wheatgrass (Figure 3, A). This may also have allowed the 'Douglas' variety of crested wheatgrass to remain green longer in the growing season and maintain higher IVDDM compared to 'CD-II' variety. In 1998, June precipitation was 64% greater than the 30-year average and may have allowed Russian wildrye to maintain greater mid-season CP concentration, and Altai wildrye to maintain greater late-season CP concentration, compared to intermediate wheatgrass. A colder than normal November and December in 1996 may explain why intermediate wheatgrass had greater early-season IVDDM than crested wheatgrass in 1997.

**Figure 3.** Monthly and 30-year average precipitation in inches (A) and temperature in degrees F (B) at the Moccasin site for the three years of the study.



## Summary

The results of Blunt's forage trials show seasonal variation in forage quality among tame grass species particularly during mid- and late-season when Altai and Russian wildryes produced higher quality forage. This result was consistent across the three sites representing the Bozeman, Great Falls, and Miles City Areas and most likely is true for the Missoula Area. This supports recommending the wildrye species for pastures used for mid- or late-season grazing. The results also show little or no differences among varieties within a species with the exception of crested wheatgrass and hybrids of crested wheatgrass. The 'Douglas' variety of crested wheatgrass maintained forage quality longer into the growing season compared to 'Hycrest' and 'CD-II' hybrids. It appears forage quality and differences among species is affected by soil moisture and the wildryes are better able to maintain forage quality longer into the growing season provided adequate moisture. The length of the growing season and the depth of soil may also affect water availability and grasses ability to maintain forage quality under drought stress. Another factor affecting forage quality over time and not tested in Blunt's study is grazing management. Overgrazing reduces root growth in grasses making them more susceptible to drought stress and reduced forage quality.

Table 1. Average crude protein concentration over three years of five tame grass species grown on three sites in Montana. Superscript numbers indicate significant differences in crude protein concentration for the year and site (within the column) and the numbered footnotes describe the differences.

| | | Crude Protein (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bozeman | | | Bridger | | | Moccasin | | |
| **Species** | **Season** | **1997** | **1998** | **1999** | **1997** | **1998** | **1999** | **1997** | **1998** | **1999** |
| crested wheatgrass | Early | 22.8 | 21.0 | 25.2 | 19.2 | 21.2 | 21.5 | 22.7 | 21.5[9] | 18.7 |
| Altai wildrye | Early | 24.9 | 22.0 | 27.0 | 21.9 | 23.7 | 23.2 | 21.4 | 19.0 | 19.8 |
| Russian wildrye | Early | 23.7 | 22.6 | 28.0 | 18.6 | 20.5 | 21.7 | 24.6[5] | 20.7 | 22.9 |
| pubescent wheatgrass | Early | 25.3 | 22.8 | 27.1 | 19.1 | 23.9 | 26.4 | 22.8 | 21.5 | 19.1 |
| intermediate wheatgrass | Early | 25.4 | 23.5 | 27.1 | 19.5 | 24.2[3] | 25.1 | 23.2 | 20.9 | 17.8 |
| crested wheatgrass | Mid | 11.9 | 12.3 | 14.7 | 15.9 | 15.7 | 15.2 | 13.6 | 15.4 | 11.6 |
| Altai wildrye | Mid | 17.4[1] | 14.6 | 15.7 | 18.2 | 19.4[4] | 18.2 | 16.7[6] | 16.1 | 12.1 |
| Russian wildrye | Mid | 13.8 | 15.3[2] | 17.0 | 16.9 | 16.3 | 15.4 | 14.7 | 17.1[10] | 15.4 |
| pubescent wheatgrass | Mid | 14.4 | 13.8 | 16.1 | 14.9 | 15.5 | 16.1 | 12.3 | 15.6 | 10.9 |
| intermediate wheatgrass | Mid | 14.2 | 13.4 | 14.8 | 14.4 | 15.8 | 16.4 | 11.2 | 14.5 | 10.6 |
| crested wheatgrass | Late | 6.5 | 9.3 | 9.0 | 13.0 | 7.3 | 10.2 | 9.0 | 7.4 | 7.5 |
| Altai wildrye | Late | 8.3 | 11.7 | 11.7 | 12.0 | 10.0 | 9.6 | 12.9[7] | 8.8[11] | 10.0 |
| Russian wildrye | Late | 6.9 | 11.8 | 11.6 | 12.1 | 10.0 | 10.8 | 10.2[8] | 7.8 | 12.7 |
| pubescent wheatgrass | Late | 8.3 | 10.2 | 11.5 | 14.2 | 8.2 | 11.9 | 8.2 | 6.8 | 8.1 |
| intermediate wheatgrass | Late | 7.7 | 9.9 | 11.2 | 11.1 | 7.3 | 11.8 | 6.8 | 6.3 | 7.0 |

1. Percent crude protein was significantly greater in Altai wildrye than all other species mid-season in 1997 at Bozeman.
2. Percent crude protein was significantly greater in Russian wildrye than all other species mid- season in 1998 at Bozeman.
3. Percent crude protein was significantly greater in pubescent wheatgrass than Russian wildrye in early-season 1998 at Bridger.
4. Percent crude protein was significantly greater in Altai wildrye than all other species except Russian wildrye in mid-season 1998 at Bridger.
5. Percent crude protein was significantly greater in Russian wildrye than Altai wildrye in early- season 1997 at Moccasin.
6. Percent crude protein was significantly greater in Altai wildrye than all other species except Russian wildrye in mid-season 1997 at Moccasin.
7. Percent crude protein was significantly greater in Altai wildrye than all other species except Russian wildrye in late-season 1997 at Moccasin.
8. Percent crude protein was significantly greater in Russian wildrye than Intermediate wheatgrass in late-season 1997 at Moccasin.
9. Percent crude protein was significantly greater in pubescent wheatgrass than Altai wildrye in early season 1998 at Moccasin.
10. Percent crude protein was significantly greater in Russian wildrye than intermediate wheatgrass in mid-season 1998 at Moccasin.
11. Percent crude protein was significantly greater in Altai wildrye than intermediate wheatgrass in late-season 1998 at Moccasin.

Table 2. The average *in vitro* digestible matter (IVDDM) over three years of five tame grass species grown on three sites in Montana. Superscript numbers indicate significant differences in IVDDM concentration for the year and site (within the column) and the numbered footnotes describe the differences.

| | | ***In Vitro* Digestible Matter (kg/ha)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Bozeman** | | | **Bridger** | | | **Moccasin** | | |
| **Species** | **Season** | **1997** | **1998** | **1999** | **1997** | **1998** | **1999** | **1997** | **1998** | **1999** |
| crested wheatgrass | Early | 570 | 534 | 784[2] | 606 | 591 | 562[5] | 677 | 613 | 687 |
| Altai wildrye | Early | 515 | 533 | 679 | 656 | 534 | 474 | 666 | 565 | 630 |
| Russian wildrye | Early | 560 | 581 | 742 | 587 | 588 | 564 | 714 | 591 | 674 |
| pubescent wheatgrass | Early | 563 | 571 | 719 | 631 | 575 | 531 | 735 | 598 | 659 |
| intermediate wheatgrass | Early | 552 | 577 | 737 | 631 | 570 | 536 | 751[7] | 624 | 679 |
| crested wheatgrass | Mid | 309 | 390 | 472 | 461 | 424 | 501[6] | 512 | 625 | 604 |
| Altai wildrye | Mid | 409 | 387 | 476 | 472 | 383 | 399 | 525 | 558 | 537 |
| Russian wildrye | Mid | 333 | 410 | 495 | 454 | 353 | 408 | 574 | 633 | 590 |
| pubescent wheatgrass | Mid | 389 | 396 | 471 | 422 | 376 | 457[6] | 524 | 589 | 562 |
| intermediate wheatgrass | Mid | 399 | 400 | 498 | 407 | 372 | 447[6] | 530 | 612 | 587 |
| crested wheatgrass | Late | 354 | 398 | 348 | 294 | 338 | 354 | 502 | 245 | 360 |
| Altai wildrye | Late | 340[1] | 387 | 381 | 375[3] | 416[4] | 376 | 478 | 256 | 365 |
| Russian wildrye | Late | 230 | 336 | 354 | 335 | 335 | 359 | 476 | 221 | 389 |
| pubescent wheatgrass | Late | 289 | 396 | 371 | 323 | 332 | 347 | 468 | 259 | 354 |
| intermediate wheatgrass | Late | 314 | 456 | 401 | 330 | 336 | 343 | 478 | 289 | 394 |

1. *In vitro* digestible dry matter was significantly greater for Altai wildrye than Russian wildrye in late-season 1997 at Bozeman.
2. *In vitro* digestible dry matter was significantly greater for crested wheatgrass than intermediate wheatgrass and Altai wildrye in early-season 1999 at Bozeman.
3. *In vitro* digestible dry matter was significantly greater for Altai wildrye than crested wheatgrass in late-season 1997 at Bridger.
4. *In vitro* digestible dry matter was significantly greater for Altai wildrye than pubescent wheatgrass in late-season 1998 at Bridger.
5. *In vitro* digestible dry matter was significantly greater for Russian wildrye and crested wheatgrass than Altai wildrye in early-season 1997 at Bridger.
6. *In vitro* digestible dry matter was significantly greater for crested wheatgrass than all other species, for pubescent wheatgrass compared to Altai and Russian wildryes, and for intermediate wheatgrass compared to Altai wildrye in mid-season 1999 at Bridger.
7. *In vitro* digestible dry matter was significantly greater for intermediate wheatgrass than crested wheatgrass in early-season 1997 at Moccasin.

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