SHORT COMMUNICATION

Seasonal herbage dynamics on Aspen Parkland landscapes in central Alberta

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[1]*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada T6G 2P5;* [2]*Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada T6G 2H1 (e-mail: edward.bork@ualberta.ca);* [3]*Animal Research Institute, Council for Scientific and Industrial Research, P.O. Box AH 20, Achimota, Ghana.*
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Asamoah, S. A., Bork, E. W., Irving, B. D., Price, M. A. and Hudson, R. J. 2004. **Seasonal herbage dynamics on Aspen Parkland landscapes in central Alberta.** Can. J. Anim. Sci. **84**: 149–153. We evaluated the temporal dynamics of herbage biomass and protein within riparian meadows and upland grasslands of native Aspen Parkland rangeland to understand the contribution of each to livestock foraging. For the growing season monitored, meadows were greater in forage yield and crude protein ($P < 0.05$), leading to important implications for sustainable livestock production and rangeland conservation.

Key words: Crude protein, forage production, riparian meadow, upland grassland

Asamoah, S. A., Bork, E. W., Irving, B. D., Price, M. A. et Hudson, R. J. 2004. **Dynamique des herbages saisonniers dans les forêts-parcs à trembles du centre de l'Alberta**. Can. J. Anim. Sci. **84**: 149–153. Les auteurs ont évalué la dynamique temporelle de la biomasse et de la concentration de protéines des herbages dans les prés riverains et les prairies sèches des grands parcours dans les forêts-parcs à trembles du centre de l'Alberta afin d'élucider l'apport de chaque facteur à l'utilisation des fourrages par le bétail. Durant la période végétative à l'étude, les prés ont enregistré un meilleur rendement fourrager et protéique, ce qui a d'importantes incidences sur l'élevage durable du bétail et la protection des grands parcours.

Mots clés: Protéine brute, production fourragère, prés riverains, prairies sèches

Livestock production is an economically important land use activity in the Aspen Parkland (AP) of central Alberta. Although many native rangelands have been converted into cropland or tame pasture for sustaining the increasing demand for livestock forage in the province (McCartney 1993), approximately 5% of the region remains as native vegetation.

The Parkland has undulating topography with strong effects of aspect on the distribution of plant communities and soils. Differential plant community production patterns are likely within these landscapes, offering non-uniform foraging opportunities for livestock. In order to identify grazing strategies (i.e., season of defoliation) necessary to maintain long-term herbage productivity, quality, and range condition within the Aspen Parkland, an understanding is required of the season-long dynamics of herbage yield and quality within these complex landscapes.

We quantified and contrasted the temporal growing season dynamics of herbage yield and crude protein within adjacent riparian meadow and upland grassland communities of a native Aspen Parkland landscape in central Alberta, Canada during 2000. Although Willms (1988) has documented these patterns for the Fescue Prairie region of southwestern Alberta, with Bork et al. (2001) providing similar information for Alberta's boreal grasslands, comparative data for the Aspen Parkland are currently lacking. The implications of this information for sustainable livestock production and rangeland conservation are discussed.

The study was conducted at the University of Alberta Kinsella Research Station, located 140 km southeast of Edmonton, Alberta (53°01′N, 111°34′W) within the Aspen Parkland Ecoregion. The climate is continental, with growing season average monthly temperatures ranging from 10.9°C in May to 16.7°C in July (Environmental Canada, unpublished data). Average annual and growing season (May to August inclusive) precipitation from 1960 to 2000 was 428 and 259 mm, respectively. During 2000, the year of data collection, May to August precipitation was 291 mm, 12% above the long-term mean. The authors acknowledge that the current study represents one growing season and as such, year-to-year variation in rainfall and temperature could have significant impacts on the results.

Vegetation on the ranch is representative of the Fescue association (Coupland 1961). Plant communities vary with slope

Abbreviations: **AP**, Aspen Parkland; **CP**, crude protein; **CPY**, crude protein yield; **DM**, dry matter and aspect (Wheeler 1976), as well as disturbances such as livestock grazing and prescribed burning (Bailey et al. 1990). Grasslands common on well-drained uplands are representative of the *Stipa–Agropyron* or *Festuca–Stipa* faciations, while lowlands are dominated by hygric species (Wheeler 1976).

Dominant graminoids (and their abundance by canopy cover) on riparian meadows included *Carex rostrata* (60.3%), *Poa pratensis* (27.8%), *Carex aquatilis* (19.3%), *Poa palustris* (14.8%) and *Carex praegracilis* (13.1%), with forbs consisting of *Taraxacum officinale* (35.1%) and *Thermopsis rhombifolia* (13.6%). Upland grasslands were dominated by *Bromus inermis* (25.4%), *Poa pratensis* (19.6%), *Festuca hallii* (17.2%), *Carex obtusata* (16.8%) and *Stipa curtiseta* (13.2%). Upland forbs included *Achillea millefolium* (15.8%), *Thermopsis rhombifolia* (12.6%) and *Melilotus officinale* (35.0%), and the shrub *Symphoricarpos occidentalis* (15.8%). In the year of the study, meadows initially had traces of standing water originating from snowmelt, which disappeared by the first date of sampling (May 22).

The experimental design for data collection was a randomized block (Zar 1999), with six locations and repeated sampling throughout the growing season. At each location, a riparian meadow of approximately 0.1 ha, together with a spatially paired south-facing, upland grassland, were examined. Riparian meadows were randomly selected with two in each of three, 10-ha grazing paddocks. Paddocks were part of a larger, short-duration rotational system grazed yearly by heifers at moderate stocking rates, with all communities in good range condition.

The main treatment was considered to be the plant community (meadow vs. grassland), with repeated sampling occurring within each plant community ($N = 12$) at each of six dates of initial defoliation scheduled as follows: May 22, June 4, June 18, July 3, July 30, and Sep. 2, 2000. Defoliation dates were selected to document successive phenological changes within communities and simulate varying dates of initial deferment of livestock grazing.

Vegetation sampling was conducted using 12, 1.5-m × 1.5-m range cages randomly distributed in each community after snow melt. Beginning May 22, all aboveground herbage was clipped within a 40 × 80 cm quadrat from two randomly selected cages within each community. This procedure was repeated using previously unsampled cages on each of the five subsequent dates. Additionally, herbage regrowth was harvested in all previously clipped quadrats 2000 Sep. 14. Each clip sample was sorted into graminoids and forbs, oven-dried at 30°C for 72 h, and weighed to determine both initial and regrowth dry matter (DM) yields (kg ha^{-1}). Total accumulated yield was determined by adding initial and regrowth DM yields.

Graminoid and forb samples were ground through a 1-mm screen of a Wiley Mill, and analyzed for crude protein (CP) using the Dumas method and a LECO FP-428 analyzer (Lee et al. 1996). Crude protein yield (CPY) was calculated as the CP fraction of DM yield in kg ha^{-1}, using the relationship: (CP/100) × DM yield.

Soil moisture was measured in each plant community during the first five initial sampling dates. A 2-cm soil core was used to take quadruplicate sub-samples to a 15-cm depth from four random locations within each community. Moist soil core weights were immediately recorded in the field, and subsequently oven-dried at 30°C for 72 h, and reweighed to determine mean gravimetric moisture.

Data analyses were performed using PROC GLM of SAS (SAS Institute, Inc. 1999). A normality test indicated no data transformations were necessary. In addition, preliminary statistical tests determined that for the growing season studied, there were no significant ($P > 0.05$) effects of the three paddocks on the response variables, either alone or in combination with the plant community. Each riparian meadow-upland grassland community pair was therefore considered an independent block replicate in subsequent analysis.

Repeated measure analysis of variance (ANOVA) was used to examine the impact of deferring initial defoliation date on forage characteristics within each community (Zar 1999). The effects of plant community, defoliation date, and their interaction, on herbage DM yield and crude protein, were examined. Specific response variables included initial graminoid and forb DM yield, as well as total accumulated (initial plus regrowth) DM yield of each component. Initial and total yield were analyzed individually, as both are important for livestock production. Initial growth is indicative of opportunities for early season grazing, while accumulated yield is representative of maximum season-long grazing opportunities under each defoliation regime. Analysis was also conducted on CP concentration (%) and the CPY (kg ha^{-1}) of initial graminoid, regrowth graminoid, and initial forb components. In addition, the CPY of total accumulated (initial + regrowth) graminoid was determined. Mean comparisons were conducted for all significant treatment effects using Tukey's test (Zar 1999). Unless otherwise indicated, results were considered significant at $P < 0.05$.

During the 2000 growing season, soil moisture remained lower on uplands than riparian meadows throughout the growing season ($P < 0.001$) by an average of 46%. Moisture ranged from 0.13 to 0.28 g cm^{-3} on uplands and from 0.34 to 0.46 g cm^{-3}on lowlands throughout the growing season. Within each plant community, soil moisture was significantly lower ($P < 0.05$) in June than July or August, likely due to above normal (+81%) July rainfall.

Plant community type, defoliation date and their interaction all had significant effects ($P < 0.01$) on initial graminoid DM yields. Upland grasslands ranged from 606 kg ha^{-1} on May 22 to 2004 kg ha^{-1} on Sep. 2, while riparian meadows ranged from 1517 to 5526 kg ha^{-1} over the same period (Table 1). The marked difference in yield between community types concurs with the findings of Willms (1988) for the Fescue Prairie in southwestern Alberta and Bork et al. (2001) for the Boreal Mixedwood, which indicate that upland grasslands produce less season-long herbage than riparian meadows.

The high level of graminoid production from riparian meadows highlights their importance for supporting livestock production. However, this finding must be tempered by the fact that riparian meadows represent a relatively small fraction of the landscape within the Parkland. In this investigation, riparian meadows and upland grasslands rep-

Table 1. Seasonal dynamics of graminoid and forb dry matter yield, crude protein, and crude protein yield in upland grassland and riparian meadow communities on a native Aspen Parkland rangeland in central Alberta during 2000

		Date of sampling					
Variable	Community type	May 22	Jun. 4	Jun. 18	Jul. 3	Jul. 30	Sep. 02
Dry matter yield (kg ha^{-1})							
Initial graminoids	Upland	606*Aa*	843*Aab*	1000*Aab*	1263*Ab*	1642*Abc*	2004*Ac*
	Meadow	1517*Ba*	2444*Bb*	2946*Bb*	3943*Bc*	5956*Bd*	5526*Bd*
Accumulated graminoids	Upland	2101*A*	1910*A*	2093*A*	1942*A*	1748*A*	2047*A*
	Meadow	5862*B*	6015*B*	5531*B*	5378*B*	6228*B*	5526*B*
Crude protein (%)							
Initial graminoids	Upland	13.6*Ac*	11.4*Ab*	10.8*Ab*	9.1*Aab*	9.1*Aab*	7.3*Aa*
	Meadow	16.9*Bc*	15.3*Bbc*	13.4*Bb*	11.0*Aab*	9.3*Aab*	8.5*Aa*
Regrowth graminoids	Upland	9.0*a*	9.2*a*	10.6*a*	10.7*a*	14.4*b*	–
	Meadow	7.8*a*	8.0*a*	9.5*ab*	10.5*b*	15.0*c*	–
Initial forbs	Upland	19.3*b*	14.7*a*	15.7*ab*	14.2*a*	13.8*a*	12.4*a*
	Meadow	16.5*b*	18.0*b*	17.7*b*	14.7*b*	14.0*ab*	9.9*a*
Crude protein yield (kg ha^{-1})							
Initial graminoids	Upland	84*Aa*	99*Aa*	108*Aa*	116*Aab*	150*Ac*	146*Ab*
	Meadow	267*Ba*	378*Bb*	386*Bb*	435*B*c	551*Bd*	462*Bc*
Regrowth graminoids	Upland	145*Ab*	105*Aa*	122*Ab*	76*Aa*	25*Aa*	–
	Meadow	339*Bc*	289*Bbc*	245*Bbc*	153*Bb*	41*Aa*	–
Accumulated graminoids	Upland	221*Ab*	199*Aab*	220*Ab*	188*Aab*	175*Aab*	146*Aa*
	Meadow	606*Bb*	667*Bb*	631*Bb*	588*Bb*	592*Bb*	462*Ba*
Initial forb	Upland	43*b*	19*a*	44*b*	36*b*	106*c*	91*c*
	Meadow	4*a*	13*a*	31*b*	46*b*	77*b*	53*bc*

A, B, Within each sampling date and variable, community means with different uppercase letters differ significantly ($P < 0.05$).
a–c Within a variable and community, means among sampling dates with different lowercase letters differ significantly ($P < 0.05$).

resented an average of 4 and 52%, respectively, of the total landscape within the study paddocks, indicating uplands continue to provide the majority of total available forage. Conversely, despite their limited area, meadows demand special attention because of their importance for hydrological functioning, the provision of wildlife habitat, and as a concentrated source of abundant forage for livestock.

Seasonal changes in the difference between plant communities were also evident. Initial graminoid DM yields from uplands were 60% less than meadows in May, but this difference increased to 72% in late July, only to decline in September (Table 1). Although both communities exhibited progressive seasonal growth, meadows attained peak production in late July while upland grasslands continued to increase into September. This trend suggests the importance of upland grasslands for forage in the Aspen Parkland may increase late in the growing season, a finding also reported by Willms (1988).

Greater yields in riparian meadows are likely caused by more available water. Although both landscape positions experienced the same rainfall, meadows may receive additional water from adjacent uplands, either as over-land runoff or through groundwater movement. Meadows also benefit from greater water recharge during spring via snow and meltwater accumulation. Bork et al. (2001) found that Boreal lowlands were more likely to respond to precipitation occurring during the previous dormant season while uplands relied heavily on growing season rainfall.

Total season-long accumulated graminoid DM yield was significantly different between the two plant communities ($P < 0.001$), but unlike initial yield, did not vary ($P > 0.05$) throughout the growing season (Table 1). Mean accumulated graminoid yield was consistently greater on riparian meadows (5757 kg ha^{-1}) than upland grasslands (1974 kg ha^{-1}) throughout the growing season, regardless of initial clipping date. The lack of significant temporal change in accumulated graminoid yield in either plant community suggests graminoid regrowth appears to compensate for earlier one-time clipping irrespective of the timing of initial defoliation. However, the high graminoid regrowth found here may have been enhanced by high July rainfall. It should also be noted that repeated early-season defoliation, particularly if accompanied by drought, could alter range condition and the future production potential of these plant communities.

Initial and total accumulated forb yields were similar between plant communities ($P > 0.05$). Mean initial forb DM yield increased ($P < 0.01$) from 208 kg ha^{-1} in May to 814 kg ha^{-1} in September. In contrast, total accumulated forb DM yield remained similar ($P > 0.05$) at all sampling dates, averaging 591 kg ha^{-1}. Overall, forb production was only 30 and 10% of graminoid production on upland grasslands and riparian meadows, respectively, indicating graminoids provided the greatest source of herbage within these landscapes. These results also suggest that, unlike graminoids, the production dynamics of forbs on native Aspen Parkland rangelands are independent of landscape position, potentially due to the type and distribution of forb species within community types.

Initial graminoid CP concentration and CPY differed ($P < 0.001$) between plant communities, and were also affected by the date of initial defoliation ($P < 0.05$). Crude protein concentrations in initial graminoid samples were greater in riparian meadows than upland grasslands during early-season from May through June (Table 1). This observation was also reported by Willms (1988) for Fescue Prairie grasslands. The early season difference in CP concentration may be due to differences in graminoid species among the two plant communities. Meadows were dominated by hygric sedges (*Carex* spp.) while uplands consisted mainly of smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). Additionally, high protein within riparian communities during spring may be linked to favorable growth due to abundant soil moisture, and plants remaining in a younger, more vegetative stage of growth.

The simultaneous temporal decline in graminoid CP in riparian meadows and upland grasslands communities better describes the varying season-long CP dynamics on Aspen Parkland rangelands. From May to September, upland initial graminoid CP concentration declined from 13.6 to 7.3%, while meadows declined from 16.9 to 8.5%, representing a total decrease of 46% on uplands and 50% on meadows. Notably, while the CP concentration of upland communities met or exceeded the average requirement for both yearling heifers (i.e., 10.6%) and lactating cows (i.e., 11%) from May to mid-June (National Research Council 1996), this date was extended 2 wk for riparian meadows.

Similar to the pattern for CP, initial graminoid CPY was greatest on the meadows (Table 1). In contrast, however, CPY increased temporally with progressively later dates of initial defoliation. Season-long initial graminoid CPY on upland grasslands ranged from 83 kg ha^{-1} in May to 146 kg ha^{-1} in September. Within riparian meadows, these values varied from 267 kg ha^{-1} in May, to a peak of 550 kg ha^{-1} in late July, and then declined to 461 kg ha^{-1} in September. The marked temporal increase in graminoid CPY in meadows into mid-summer indicates the large increase in graminoid DM yield more than offset any reduction in CP concentration. The decline in CPY after late July in riparian meadows may be attributed to the onset of dormancy and CP decline.

Regrowth graminoid CP concentration was similar ($P > 0.05$) between plant communities, but changed ($P < 0.001$) with the initial defoliation date. As expected, mean regrowth graminoid CP was lowest for graminoids initially defoliated earlier in the season (8.4% after May 22) and greatest for regrowth following late season defoliation (14.7% after 30 Jul.). This pattern is likely due to later regrowth remaining younger and more vegetative, resulting in increased CP concentration (Philips et al. 1999). Regrowth graminoid CPY varied significantly ($P < 0.05$) between plant communities, initial defoliation date, and their interaction. Early to late season regrowth graminoid CPY ranged from 145 to 25 kg ha^{-1} on upland grasslands, and from 338 to 41 kg ha^{-1} on riparian meadows (Table 1). Following initial clipping, regrowth graminoid CPY declined within both community types, with relatively greater declines in meadows.

One of the most important forage variables affecting livestock production is the accumulated graminoid DM yield of crude protein, as this parameter is indicative of total seasonal CP availability. This parameter differed significantly ($P < 0.05$) across both community types and initial defoliation dates, being greatest on meadows and lowest on uplands. Accumulated graminoid CPY ranged from 605 to 461 kg ha^{-1} with initial defoliation in May and September, respectively, on meadows, while on upland grasslands, it ranged from 220 to 146 kg ha^{-1} over the same dates (Table 1). These results provide further evidence on the importance of riparian meadows for providing disproportionately abundant, high protein forage and associated feeding opportunities (on a per-unit area basis) throughout the growing season. This may also explain why forage utilization is greater in lowland meadows than upland grasslands (Willms 1988).

No seasonal differences in accumulated graminoid CPY were evident in either community type when initial defoliation was delayed into late July (Table 1). This finding indicates that for the growing season studied, and provided current year grazing is done prior to August, the practice of deferred grazing allows livestock producers to maximize CPY while meeting other objectives such as facilitating vegetation recovery or the maintenance of wildlife (e.g., waterfowl) habitat. It is also important to note, however, that these results assess the entire plant community rather than only that portion selected by livestock. Additionally, the exact temporal window of deferment probably varies based on vegetation composition and seasonal growing conditions.

Initial forb CP and CPY were similar ($P > 0.05$) between the two plant communities examined. Initial forb CP and CPY varied significantly with the date of defoliation ($P < 0.01$). Average forb CP declined from 17.9 to 11.1% from May to September, while forb CPY followed a reverse pattern, increasing from 25 to 75 kg ha^{-1} over the same period. Although season-long forb CP concentration seemed to be comparatively greater than that of graminoids, forb CPY was less than graminoid CPY as a result of very low forb production.

Results of this study reinforce the importance of riparian meadows for livestock production in rangelands of the Aspen Parkland. Although riparian meadows constituted only a small fraction of this landscape, they provided greater levels of graminoid biomass (on a unit area basis) throughout the growing season (May to September). Additionally, among all variables measured, graminoids from riparian meadows had greater forage crude protein throughout much of the early and middle part of summer, resulting in greater levels of CPY throughout the entire growing season.

Despite the typical phenological changes in herbage yield and crude protein throughout the growing season, no differences were found in total season-long accumulated (initial + regrowth) herbage characteristics with different dates of initial defoliation (i.e., deferment) prior to August.

These results suggest livestock grazing can be carried out on native Aspen Parkland rangelands at any time after mid-May without altering total season-long production, although consideration should be given to animal distribution patterns, vegetation recovery following initial defoliation, and growing conditions. The finding that year-long accumulated graminoid CPY can be maximized following deferment provided initial defoliation occurs prior to August has implications for balancing livestock production with the conservation of riparian meadows. Finally, we acknowledge that interpretation of these results must be tempered by the single growing season of data available. As such, additional studies are recommended to further refine our understanding of forage production dynamics in the Aspen Parkland.

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