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# Seasonal Availability of Cool- and Warm-Season Herbage in the Northern Mixed Prairie

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## On the Ground

- Variability in spatial and temporal patterns of herbage production is common in grasslands and can affect land uses, such as grazing.
- Total herbage biomass in northern mixed grass prairie was similar on loamy and sand dune ecologic sites but varied in composition.
- Cool-season grasses were uniformly produced throughout the grazing season, whereas warm-season grasses grew rapidly during August.
- Litter conservation was important for increasing cool-season grass biomass, whereas warm-season grasses remained independent of litter.
- Biomass and composition of herbage in the northern mixed grass varies spatially and intra-annually, affecting seasonal grazing opportunities for livestock.

**Keywords:** ecologic site, forage production, inverse texture effect, litter, seasonal grazing opportunities.

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A key challenge in cattle production on rangelands is matching natural changes in the seasonal availability of forage production, with ongoing grazing activities throughout the growing season. Ideally, changes in seasonal plant growth and associated forage supply will provide a steady supply of nutrients that coincides with all phases of the beef production cycle, including spring green-up, early to mid-summer peak lactation, and when cattle begin putting on energy reserves in late summer in preparation for winter. In the northern regions of the Great Plains, much attention has been dedicated to minimizing the cost of livestock grazing due to the relatively short growing season.[1]

Within the mixed grass prairie, forage supply is known to be variable in both space[2,3] and time.[4,5] Variability in space is regulated by changes in ecologic site conditions, including factors that alter resource availability (water and nutrients) combined with associated changes in plant species composition. Among the critical soil characteristics altering grassland productivity is texture,[6] which has a marked impact on a number of soil properties regulating plant growth, including water infiltration rates, moisture holding capacity, nutrient exchange, and plant rooting opportunities. Although sandy soils tend to have lower water and nutrient availability compared with finer-textured soils, sandy soils enable deeper root penetration,[7] which can facilitate water use from the subsoil, including moisture that may have accumulated over the dormant season. In addition, sandy soils have the benefit of facilitating rapid water entry into the ground, allowing moisture to escape evaporation from the ground surface, a process that is particularly important when rainfall events are small. This can lead to greater production in sandy soils compared with adjacent loam soils,[8,9] a phenomenon known as the "inverse texture effect."[10] Variations in ecologic site conditions ultimately lead to many different plant community types in the northern mixed grass prairie,[8,11] each of which has its own expected level of productivity and corresponding grazing opportunities.[12]

Temporal variability in herbage production is caused by changes in growing conditions, which, in the case of the northern mixed grass, is mostly precipitation.[4,5] Moisture deficits in particular constrain plant production and grazing opportunities in the mixed grass region of western Canada.[13] Although the majority of precipitation occurs during the summer and therefore coincides with peak water demand from plant growth,[13] dormant season precipitation also contributes positively to production.[5] Moisture falling during the dormant season enters the soil and contributes to water recharge, which is then available to support plant growth the following summer.

Across the United States, grasslands dominated by either cool or warm-season species lead to a unimodal production pattern, whereas mixed communities can produce a bimodal pattern of seasonal plant production.[14] Limited information exists quantifying seasonal changes in herbage availability during the growing season in the northern mixed grass prairie of western Canada, including how changes in ecologic site conditions (soil texture) and associated changes in plant composition may alter this availability. Production in the northern mixed prairie is typically dominated by select cool-season grasses, such as needle-and-thread grass, together with western wheatgrass.[15] However, as vegetation in this region includes a mix of cool and warm-season plant species,[11] herbage availability is likely to reflect a combination of both components. Up to 90% of plant growth was complete in Montana grasslands by July 1,[16] largely due to dominance by cool-season grasses, and areas with mean annual temperatures below 10°C are typically dominated by cool-season grasses, such as in Montana, North Dakota, South Dakota, and northeast Colorado.[17] However, parallel investigations from western Canada are lacking, where mean temperatures seldom exceed 6°C. Grasslands with abundant cool-season species experience a marked pulse of early-season growth in spring[8,18] and then declines over the growing season.[19] Cool-season grasses are highly opportunistic of surface soil moisture, which they rapidly exploit with the initiation of growth in early spring.[20] Consequently, cool-season grass abundance tends to increase with winter precipitation.[21]

In contrast, prairie communities dominated by warm-season grasses produce little growth early in the growing season, only to produce disproportionately more biomass in mid- to late summer[8,22] and therefore rely directly on increases in summer precipitation.[21] In the case of some warm-season grasses found on dune areas, such as prairie sandreed (*Calamovilfa longifolia*), these species are deeper rooted[7] and are therefore better able to mitigate summer moisture stress,[20] presumably by accessing deep soil moisture reserves. Following the summer biomass peak, relative production of warm-season species declines and is progressively replaced by cool-season grasses into the fall.[22] Collectively, these changes in biomass production may alter season-long opportunities for cattle grazing across the landscape.

We quantified changes in herbage availability throughout the growing season across several locations of a northern temperate mixed grass prairie, representing contrasting ecologic sites varying primarily in soil texture. Specific objectives included (1) comparison of total herbage production and seasonal forage availability throughout the growing season, (2) quantification of the contribution of cool-season and warm-season grasses to forage availability, and (3) identification of implications for cattle grazing across the region.

## Mattheis Research Ranch

We evaluated seasonal herbage dynamics at the Mattheis Research Ranch. The Mattheis ranch is a recently established research facility operated by the University of Alberta in southeastern Alberta (Fig. 1) situated in the Dry Mixed Grass Prairie (50°53'N; 111°52'W) Natural Subregion,[23] which extends east into Saskatchewan and south into eastern Montana and North Dakota. This area of northern temperate native grasslands comprises a wide diversity of plant communities and vascular species, including both cool-season and warm-season grasses.[12] Moreover, the ranch has a combination of landforms across the property, including level prairie (Fig. 2, left) and rolling sand dunes (Fig. 2, right) that have stabilized. Consequently, a variety of ecologic sites are found within the Mattheis Ranch borders, including loamy and sand dune soils, enabling further quantification of seasonal herbage dynamics under different soil textures and growing conditions.

Loam areas (largely sandy loams comprising the Orthic Brown Chernozem Pemukan soil series) are dominated by needle-and-thread grass (*Hesperstipa comata*), western wheatgrass (*Pascopyrum smithii*), and blue grama grass (*Bouteloua gracilis*) and are representative of the Stipa-Bouteloua-Agropyron faciation,[11] with up to 40%, 28%, and 22% of biomass comprising these three groups, respectively. Adjacent sand dunes (loamy sand textured areas comprising Rego Brown Chernozems of the soil series Ventisant) include similar species but with less wheatgrass and the additional presence of prairie sandreed (*Calamovilfa longifolia*), an early successional rhizomatous species found across significant areas of southern Alberta and Saskatchewan.[11,24] Although most grasses are cool-season species, both blue grama and sandreed represent important warm-season components of this ecosystem.

Long-term growing conditions at Duchess, Alberta, 20 km south of the Mattheis Ranch, averages 354 mm, with 60% falling during the growing season from April 1 through August 31. However, dormant season precipitation from September through March is known to be important for increasing production in the mixed grass prairie.[5] During 2009, the year of data collection in this investigation, antecedent (September through March) and growing-season (April through August) moisture were 116 mm and 246 mm, respectively, the latter being 116% of the long-term mean. The growing season moisture was above average overall, whereas the early-season (April through June) rainfall was below normal (70 versus 137 mm), and late summer precipitation was elevated, in large part due to high rainfall during July (137 mm).

## Herbage Sampling

In early May of 2009, plots were set up in a randomized complete block design to assess seasonal patterns of herbage growth. At each of four locations (blocks), we sampled standing biomass (i.e., above-ground net primary production) monthly from early June through early September, inclusive. Two blocks were situated in the loamier prairie, and two others were within the stabilized sand dune complex; all sites were established in relatively level terrain to eliminate confounding effects of topography. Within each block, five