GRAZING IMPACTS ON THE PRODUCTION STABILITY OF FESCUE PRAIRIE

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ABSTRACT
The fescue prairie in southwestern Alberta is highly productive but susceptible to grazing during the growing season. This study examined how production stability is affected by grazing impact. It was initiated in 1949 using four fixed stocking rates (1.2, 1.6, 2.4, 4.8 animal-unit-months ha^{-1}). Forage and livestock production were estimated over 4 or 15 years, respectively. The coefficient of variation (CV) for either primary or secondary production was constant over all rates except for the very heavily stocked paddock. Forage production, and therefore livestock production, in that paddock was dependent on precipitation during the growing season. Heavy grazing pressure resulted in lost management opportunities and jeopardized sustainable production.

KEYWORDS
Cattle, forage, soil, rough fescue

INTRODUCTION
The fescue prairie is one of the most productive grasslands on the Northern Great Plains. It represents an ecozone between the forest to the north and Mixed Prairie to the south. In southwest Alberta, the fescue prairie covers the foothills of the Rocky Mountains (Pavlick and Looman 1984) at elevations between 1,000 and 1,700 m above sea level. The dominant species is rough fescue (*Festuca campestris* Rydb.) but Parry oat grass (*Danthonia parryi* Scribn.) may dominate on drier sites. To the north and northeast, *F. campestris* is replaced by *F. hallii* (Vasey) Piper, a less tufted species, and associated with *Stipa spartea* var. *curtiseta* Hitchc.

Rough fescue is extremely susceptible to grazing during the growing season. Increasing grazing pressure will result in a shift of the grassland composition from one dominated by rough fescue to one consisting of less productive species including *Poa* spp. *Carex* spp., *Taraxacum officinale* Weber, and *Lappula echinata* Gilib. Heavy grazing pressure produces more beef per unit area (Willms et al. 1985) but introduces production instability. The purpose of this paper is to determine the nature of instability and examine some processes that contributed to it.

MATERIALS AND METHODS
The study was made on the fescue prairie in southwest Alberta (50° 12', 113° 57', 1,350 m). In 1949, 4 paddocks of varying size (65, 48, 32, and 16 ha) were constructed and each stocked with 13 cow-calf pairs from mid-May to mid-November. This produced fixed stocking rates of 1.2, 1.6, 2.4 and 4.8 animal-unit-months (AUM) per ha which were mostly maintained to the present. For subsequent reference, the paddocks are designated pL (low), pM (moderate), pH (heavy) and pVH (very heavy), respectively, . Single exclosures (about 0.5 ha) were constructed in each paddock. By 1959, overgrazing on the very heavily stocked paddock had reduced range condition and production so that it would no longer support the planned number of AUM's. Since 1960, the cattle were removed from that paddock when the cows started to lose weight. As a result, the stocking rate varied annually from 2.5 to 4.8 AUM ha^{-1} and averaged 3.2 AUM ha^{-1}. The cattle were weighed at monthly intervals and weight gains determined.

From 1983 to 1986, standing biomass was harvested in September from ten, 0.5-m^2 plots both inside and outside the exclosures of each paddock. The plots outside the exclosures were protected with cages (1-m^2 x 1-m high) which were moved to new areas each year. The herbage was clipped to ground level, dried to constant weight, weighed, and subsampled. The subsample was hand separated into current and previous years (litter) production. Proportions of currently produced herbage to total was applied to the whole to estimate currently produced standing biomass.

From 1984 to 1987, above-ground production in 2 grazed paddocks (pH and pVH) was estimated by harvesting 47 and 26, 0.5-m^2 plots, respectively, at monthly intervals. The plots were protected, and standing biomass estimated, as above. A paired plot was harvested outside the cage to estimate residual biomass. The cages were moved to a nearby location after each harvest. Above-ground production was estimated as the current standing biomass in cage at harvest 1 plus the sum of the monthly increments.

RESULTS AND DISCUSSION
Weights of individual cows and calves declined with increased stocking rate above 1.6 AUM ha^{-1} but gains per unit area increased as stocking rate increased (Table 1). For calf weight gains, an increase in stocking rate from 2.4 to 4.8 AUM ha^{-1} was associated with a substantial increase in the coefficient of variation (CV) among years. The absence of a higher CV for cows is indicative of the management decision to remove the animals from the very heavily grazed field when the cows started losing weight. Weight loss in pVH was usually attributed to a feed shortage caused by heavy grazing pressure which was about 80% of available forage (Willms 1988). However, weight gains also declined in other paddocks and, after September, became negative as a result of reduced forage quality due to senescence (Willms et al. 1986). These effects would offset the differences in treatment response among years and produce similar variation.

While the risk of weight loss for cows in pVH was negated by removing them early, the consequences for calf gains were directly related to the time spent in the paddock because calves continue gaining weight at the expense of their mothers. Therefore, the annual variability in standing biomass per paddock related directly to annual variability in calf weight gain resulting in a high CV (Table 1).

The effect of stocking on animal gains was mostly demonstrated at the very high rate and was the consequence of reduced available forage. Forage production is affected by species and soil moisture and, for the four years standing biomass and forage production were measured, the CV's followed a pattern similar to that of production from calves (Table 1).

Production stability, whether primary or secondary, is dependent on maintaining range in good condition. The cost of instability is the loss of management flexibility and production opportunities. Although livestock production per unit area increased with increased stocking rate (Table 1), forage production decreased and planned grazing became more dependent on growing-season precipitation. Forage production in pVH was derived from shallow rooted species which exhibited good regrowth potential if moisture became available. However, the heavy grazing pressure had created a droughty condition by removing the protective cover of litter and stimulating soil degradation (Table 1). The water-holding capacity was reduced with a shallower Ah (A1) horizon and reduced % C. In the lightly grazed paddocks where the soils and vegetation conserved soil moisture, forage production was less dependent on growing season precipitation.

Production stability on the heavily grazed paddocks was further jeopardized by the inability of the plant community to recover through succession or from disturbances. An estimate of almost 5,000 seeds m^{-2} in the seed pool of pVH consists of pygmy flower (*Androsace septentrionalis* L.) and members of the mustard family (*Draba* spp.) but only 2 seeds m^{-2} of rough fescue (Willms et al. 1995).
Heavy grazing pressure produces more beef per unit area but at the cost of management opportunities in the short-term and, in the long-term,

the economic sustainability of livestock production and the ecological sustainability of the grasslands. Variability was produced by the dependence of the heavily grazed community on precipitation during the growing season. This dependency was induced by shallow rooted species and lack of water storage. Production stability is achieved with grazing pressure that maintains the presence of productive species and litter cover.

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Table 1
Effects of fixed season-long stocking rates on production and community characteristics on the foothills rough fescue prairie.

	animal-unit-months ha^{-1}				
	0	1.2	1.6	2.4	4.8
Cow weight gains (n=15)[1]					
Individual animal					
Mean (kg)	-	86.0	88.0	70.2	67.8
CV	-	31.7	31.2	38.2	32.0
Per hectare					
Mean (kg ha^{-1})	-	17.2	23.6	28.2	54.4
Calf weight gains (n=15)[1]					
Individual animal					
Mean (kg)	-	147.0	148.3	141.9	103.4
CV	-	8.4	7.7	8.3	21.3
Per hectare					
Mean (kg ha^{-1})	-	29.5	39.7	57.0	83.0
Standing biomass (n=4, 1983 - 1986) (end of season)					
Mean (kg ha^{-1})	1838	2227	1862	1428	1277
CV	23	16	28	27	40
Forage production (n=4, 1984 - 1987)[2]					
Mean (kg ha^{-1})	-	-	-	2410	2026
CV	-	-	-	19	27
Seed bank[3] (number m^{-2})					
Native grasses 327	331	-	1077	1200	
Introduced grasses	167	1744	-	1248	1127
Native forbs	746	507	-	894	5058
Introduced forbs	444	121	-	340	387
Soil, Ah horizon[4]					
Depth (cm,)	20-24	16-21	15-19	10-14	6-9
Organic matter (C %)	11.4	11.0	10.5	8.5	7.5

[1]Livestock weight gain - mid-May to mid-November (1967 to 1982).
[2]Adapted from Willms 1988.
[3]Adapted from Willms et al. 1995.

Figure 1
Weight gains of calves over 15 years in relation to long-term, fixed stocking rates (light - pL, moderate - pM, heavy - pH, very heavy - pVH) on fescue prairie.