Precipitation, Soils and Herbage Production on Southeast Wyoming Range Sites

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Abstract

Herbage production and precipitation were determined at 13 locations in 483 ha of mixed grass range 1975–1979; production was determined at all locations 1982–1983, but precipitation was measured only at the main weather station. Vegetation and herbage production were more uniform on sites with similar subsoil than on sites with similar surface soil, the usual basis for site classification. Within any year, herbage production on similar sites was not correlated with spatial distribution of precipitation. Across years 1975–1979 and 1982–1983, herbage production on sites with sandy subsoil was correlated with March–April weather station precipitation (r^2 = 0.866) and March–April plus May–August precipitation (R^2 = 0.95**). Herbage production on sites with loamy subsoil was not significantly correlated with precipitation in March–April (r^2 = 0.32) or any other period.**

Variation in precipitation from year to year is reflected in variations in range herbage production. Hart and Carlson (1975) reviewed 6 studies in which linear regressions of total annual herbage production on precipitation were calculated; coefficients of determination (r^2) were as high as 0.61. Rauzi (1964) found that annual herbage yields southeast of Cheyenne, Wyo., were correlated with May–June (r^2 = 0.46) and April–September (r^2 = 0.57) precipitation. However, less attention has been paid to variations in herbage production caused by spatial variation in precipitation in a single year.

We became concerned with such variation in 1974, when we began a grazing study (Hart et al. 1983) on 483 ha, or nearly 2 sections, of mixed-grass range northwest of Cheyenne, Wyo. The study area was divided first into 2 and later into 3 pastures, each with a different stocking rate treatment. We wanted to determine if the response to stocking rate was being confounded by differences in herbage production, caused by differences in precipitation, among the 3 pastures.

Materials and Methods

We established a network of range gauges spaced 0.8 km (0.5 mi) apart over the study area in 1975 (Fig. 1). The plastic gauges were wedge-shaped in cross-section; this magnified the amount of water caught during light rains, so small amounts could be read more accurately. Precipitation in each gauge was recorded and the gauges emptied after each rain- or snowfall from 1 May to 30 September 1975 through 1979. Precipitation from 1 October to 30 April was measured in a standard Weather Service rain gauge at the headquarters of the High Plains Grasslands Research Station, about 0.6 km south of the south boundary of the study area.

In the spring of 1975, we established 30 by 23-m macroplots on the major soil types in the study area. Soil types were identified by the preliminary soil survey of Rauzi et al. (1976). A more detailed soil survey (Stevenson et al. 1984) realigned some soil type boundaries. Exclosures were randomly placed outside a different corner of each macroplot annually, but remained on the same soil, slope and plant community (Fig. 2).

Exclosures were pyramidal with a frame of 2-cm-wide angle iron

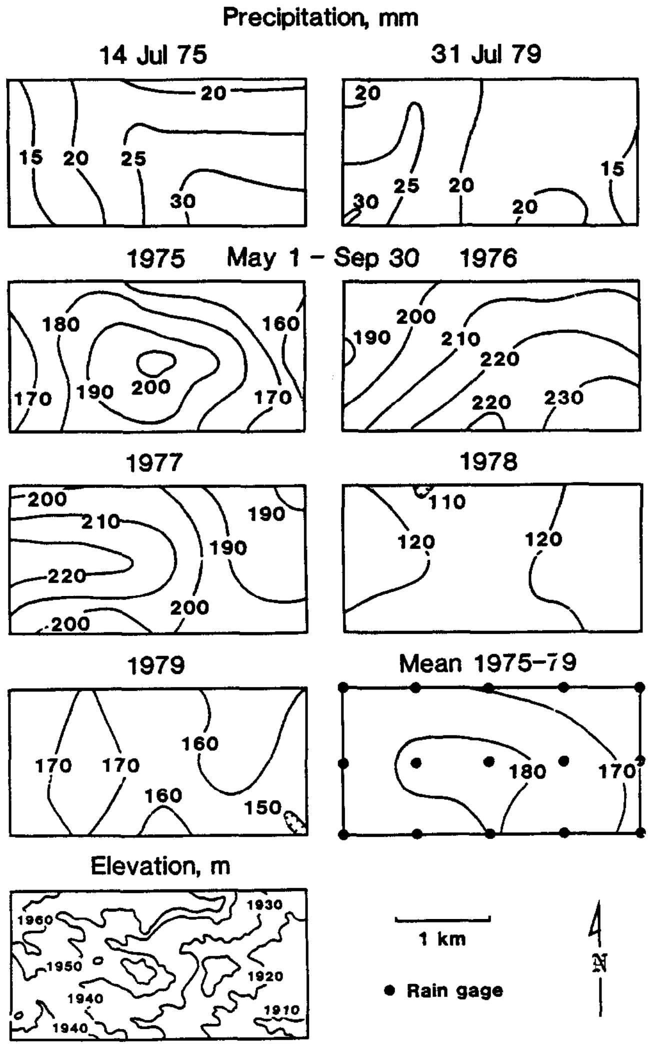

Fig. 1. *Typography of and rain gauge locations on the study area, and distribution of precipitation by 5-year mean, 1975-79 growing seasons (1 May-30 Spetember), and 2 selected storms.*

covered with 5- by 10-cm wire mesh. Exclosures were about 1. m long, 1.2 m wide, and 0.9 m high. Steel stakes held them in place during the grazing season. In August of each year, at the estimated time of peak standing crop, exclosures were removed and 2 frames 30 by 60 cm were placed at random on the area formerly covered by the exclosures. Herbage was clipped to ground level by species or species groups, dried at 60°C, and weighed to the nearest 0.1 g. Species or species groups are western wheatgrass (*Agropyron smithii* Rydb.), blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths), needleandthread (*Stipa comata* Trin. & Rupr.), sedges (mostly, *Carex eleocharis* Bailey with some *Carex filifolia* Nutt.), other grasses, and forbs.

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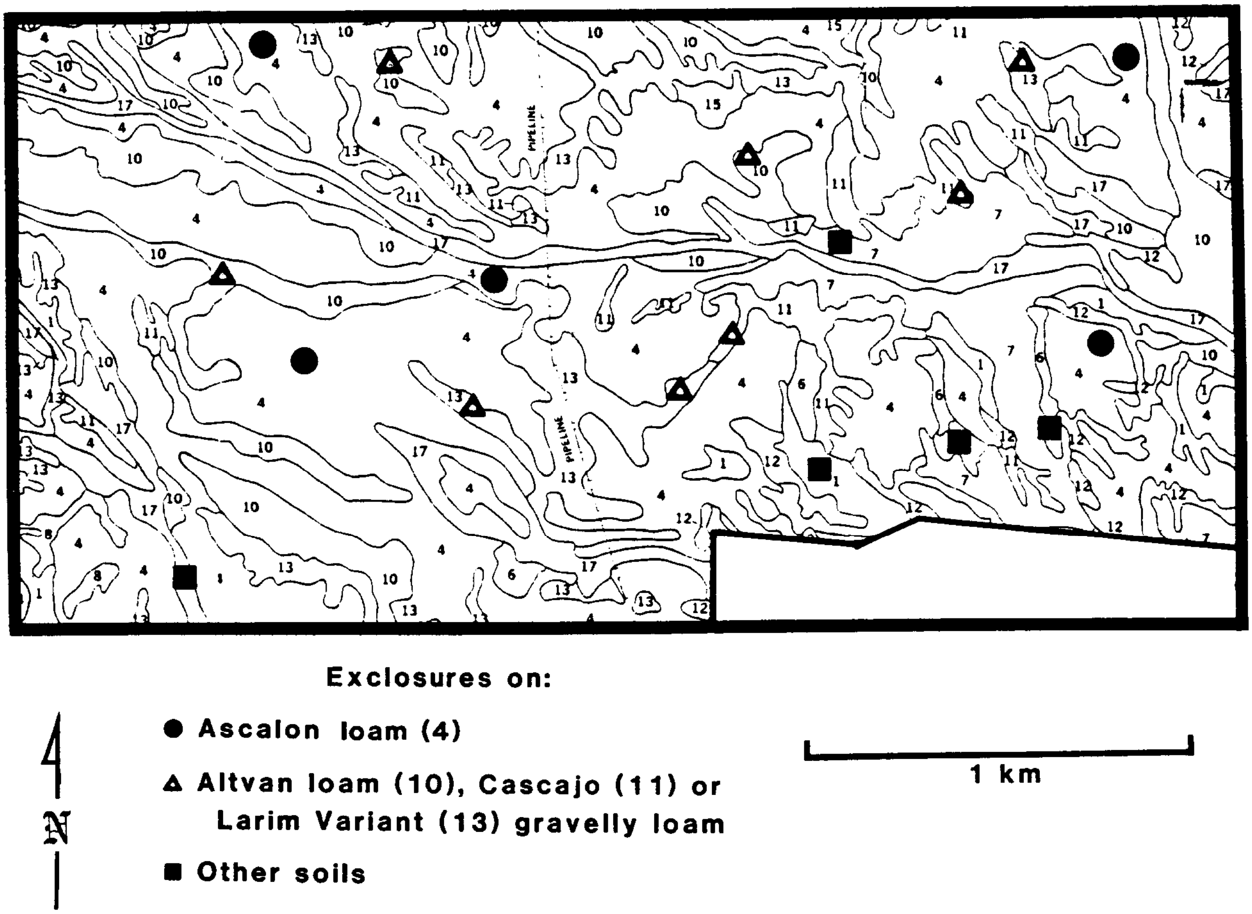

Fig. 2. *Location of exclosures for determining herbage production.*

Results will be reported only from Ascalon and Altvan (Aridic Argiustolls) loams, and Cascajo (Aridic Calciorthid) and Larim Variant (Ustollic Haplargid) gravelly loams. Typical texture profiles of these 4 soils, which cover about 83% of the study area, are shown in Fig. 3. The soil at any site may differ slightly from the typical profile. Site classification, slope, and number of exclosures are shown in Table 1. Of the other soil types, Ascalon Variant loam was represented by 2 exclosures so close together there was little difference between them in precipitation. Only 1 exclosure each was located on Nucla and Albinas loams and Aberone Variant gravelly loam; no exclosures were on Epping silt loam and Manter fine sandy loam.

Table 1. Characteristics of four soil types and associated vegetation.

Measurement	Ascalon loam	Altvan loam	Cascajo gravelly loam	Larim variant gravelly loam
Subsoil Texture	Loamy	Sandy		
Range site	Loamy	Loamy	Very shallow	Gravelly loamy
Slope, %	0–3	3–6	6–15	6–15
Number of exclosures	5	3	2	3
Forage yield, kg DM/ha	1100 a	930 b	890 b	840 b
Species composition by weight, percent				
Western wheatgrass	14 a	11 a	13 a	9 a
Blue grama	56 ab	47 b	50 ab	60 a
Needleleaf sedge	14 a	17 a	14 a	12 a
Needleandthread	4 b	11 a	12 a	6 ab
Other graminoids	3 a	2 a	4 a	4 a
Forbs	8 a	13 a	8 a	8 a
Species frequency, percent of 5 × 5 cm squares;				
Western wheatgrass	26 a	14 b	18 ab	13 b
Blue grama	82 a	76 a	78 a	78 a
Needleleaf sedge	54 a	46 a	42 a	45 a
Species frequency, percent of 41 × 41 cm squares;				
Needleandthread	52 a	58 a	48 a	53 a

a,b Figures in the same row followed by the same letter are not significantly different ($p<0.05$) as determined by t-test.

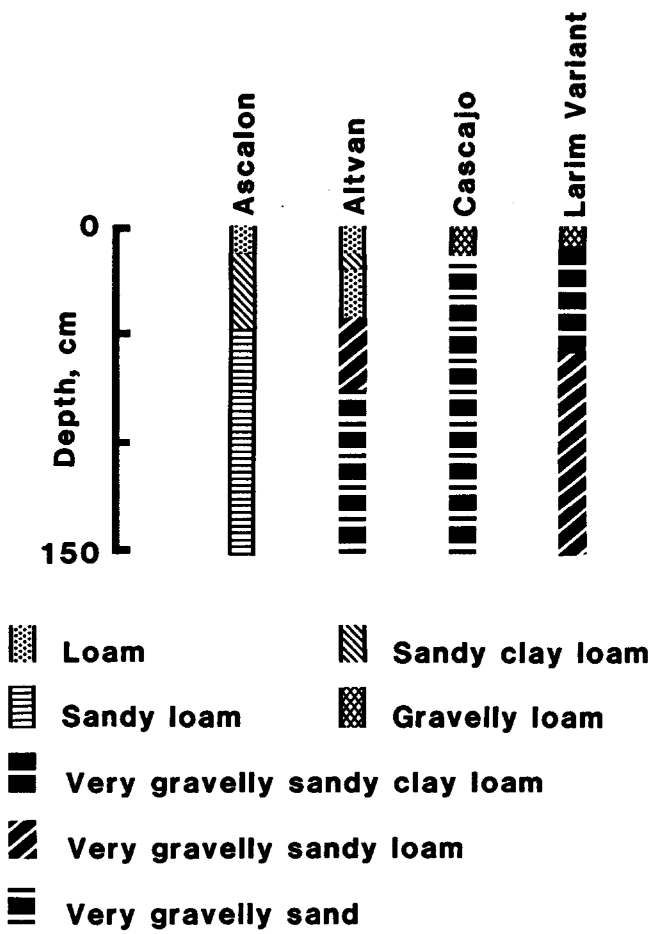

Fig. 3. *Typical texture profiles of soils on which herbage production was determined.*

May–September precipitation at each exclosure was estimated by linear interpolation between the nearest rain gauges. Rainfall isohyets were located similarly. Dean and Snyder (1977) note that "only the isohyetal method specifically describes areal rainfall distribution."

Botanical composition on the macroplots was determined in June of each year with frequency of occurrence in nested quadrats (Hyder et al. 1965). Blue grama, western wheatgrass, and needleleaf sedge *(C. eleocharis)* were sampled with 5 × 5-cm quadrats because of high relative frequency. All other species were sampled with 41 × 41-cm quadrats.

Analyses of variance and *t*-tests for means with unequal subclass numbers were used to compare yield and botanical composition on the 4 major soil types. Linear regression related herbage production to precipitation amounts.

Results and Discussion

The 4 soils were divided into 2 groups, according to similarities in yield and botanical composition of the associated vegetation. Altvan, Cascajo, and Larim Variant were grouped, because single-year or 5-year-mean yields did not differ significantly among these 3 soils (Table 1). Blue grama made up less of the herbage yield on Altvan than on Larim Variant, but frequency of blue grama was the same on both soils. No other differences in botanical composition were found among these 3 soils, all with sandy subsoils (Fig. 3). However, the 5-year-mean herbage yields on Ascalon, with a loamy subsoil, were higher than yields on Altvan, Cascajo, or Larim Variant, as were the single-year yields 1975–1978 (Table 2). Needleandthread made up less of the herbage production on Ascalon than on Altvan or Cascajo, and western wheatgrass occurred more frequently on Ascalon than on Altvan or Larim Variant (Table 1).

Although Ascalon and Altvan are both classified as loamy range sites, they differ more in herbage production and composition than do Altvan and Cascajo, which are, respectively, loamy and very shallow sites. Site classifications based only on surface texture must be interpreted cautiously.

The range in May–September precipitation across the 15 study area gauges was as large as 20% of the mean in 1975 and as small as 8% in 1979 (Table 2). When 1975–1979 mean precipitation was calculated for each gauge, the range in these means was 11% of the overall mean. For single intense storms, the range could be much larger; 78% of the mean on 14 July 1975 and 73% on 31 July 1979. Distribution varied with storms and years; no correlation between topography and distribution was apparent.

Herbage production was more variable within each year than was May–September precipitation. The range was as high as 72% of the mean on Altvan, Cascajo, and Larim Variant in 1978, to as low as 30% of the mean on Ascalon in 1976 (Table 2). Within years and soil groups, herbage production was not significantly correlated with May–August precipitation; no r^2 exceeded 0.17. This reflects in part the small variation in precipitation relative to the variation in production. Any differences in herbage production among pastures were assumed not to be caused by differences in precipitation.

Among years, herbage production on Altvan, Cascajo, and Larim Variant, including 1982 and 1983 data, was not correlated with May–August precipitation (Table 3). Because the network of rain gauges had been taken down at the end of 1979, we could correlate only mean production with precipitation records from the headquarters gauge. However, correlation of herbage yield with March–April precipitation was high (r^2 = 0.86), and multiple

Table 2. Precipitation and herbage production on two groups of soils.

Measurement		1974	1975	1976	1977	1978	1979	1981	1982	1983
Precipitation, mm										
March–April[1]		—	45	56	78	37	77	—	18	250
May–September[2]	Mean	—	210	285	253	254	308	—	426	286
	Range, percent of mean	—	20	11	19	9	8	—	—	—
March–September		195	225	341	331	291	385	376	444	356
Herbage Production, kg/ha										
Ascalon	Mean	—	1120	1090	1240	1080	1020	—	1140	1240
	Range, percent of mean	—	57	30	43	48	46	—	—	—
Altvan Cascajo,	Mean	—	860	880	850	860	980	—	950	1430
& Larim Variant	Range, percent of mean	—	39	31	36	72	48	—	—	—

[1]Headquarters gauge.
[2]Study area gauges 1975–1979, headquarters gauge 1974 and 1981–1983.

Table 3. Regression of annual herbage production (H, kg/ha) on precipitation (P, mm) in different periods at Headquarters rain gauge.

Soils and regression equations	r^2 or R^2
Altvan, Cascajo, and Larim Variant	
$H = 772 + 2.49\ P_{Mar-Apr}$	0.86**
$H = 831 + 0.49\ P_{May-Aug}$	0.03
$H = 273 + 1.89\ P_{Mar-Aug}$	0.76**
$H = 497 + 2.61\ P_{Mar-Apr} + 0.92\ P_{May-Aug}$	0.95**
Ascalon	
$H = 1083 + 0.60\ P_{Mar-Apr}$	0.32
$H = 1155 - 0.086\ P_{May-Aug}$	0.01
$H = 1001 + 0.35\ P_{Mar-Aug}$	0.17
$H = 1079 + 0.60\ P_{Mar-Apr} + 0.013\ P_{May-Aug}$	0.32

correlation with March–April and May–August precipitation accounted for 95% of the variation in yield. Correlation with March–August total precipitation was not as high as with March–April and May–August separately in multiple regression, nor even as high as with March–April precipitation. The high correlation of annual herbage production with early-season precipitation has been noted by other researchers. Rauzi (1964) found that May–June precipitation accounted for nearly as much of the variation in production as did April–August precipitation. Murphy (1970) reported that rainfall from 1 to 20 November was the best predictor of forage yields from California winter annual range; adding precipitation from the preceding season did not increase the coefficient of determination significantly. On Ascalon, the relationships of production and precipitation were similar, but the correlations were not significant, and coefficients in the regression equations were much smaller than could be accounted for by higher production.

Correlation of production with precipitation was good on soils with sandy subsoils and therefore little water storage capacity; plants growing on such soils were dependent on current rainfall. On a soil with loamy subsoil and higher water storage capacity, current rainfall was less important and stored water from past rains had some impact. On such soils, a more complex water-balance model (Wight and Hanks 1981) might be needed to predict herbage production. Much of the variation in production must have come from differences within soils in water holding capacity, as determined by texture and depth of soil horizons, and from differences in plant communities.

Even though spatial variation in May–September precipitation had little impact on herbage production, it may be important in determining runoff and soil loss. Osborn et al. (1980) noted that runoff volume was strongly correlated with total rainfall, and Johnson and Smith (1978) found that runoff and sediment yields increased not only with increasing total annual precipitation, but with increasing precipitation from individual storms.

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