Influence of Climatic Conditions on Forage Production of Shortgrass Rangeland

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This study was initiated to determine the influence of climatic factors upon range forage production, which in turn determines the production of livestock on the range. By determining the relationships that exist between certain climatic conditions and forage yield, it may be possible to make accurate forecasts on the productivity of the range. Such forecasting could aid in developing good management practices in relation to proper grazing of native rangelands.

Methods of forecasting crop yields of important commercial crops in advance of harvest have been developed. Rogler and Haas (1947) have worked on the production of the range in relation to soil moisture and precipitation. They found that soil moisture for the preceding fall had a highly significant positive relationship with yield. Factors other than soil moisture had a pronounced effect on yield, one of these being current season precipitation. Clarke, Tisdale and Skoglund (1947) related annual fluctuations in forage production with climatic factors and found a fairly close relationship with the precipitation-evaporation ratio for the growing season. Moisture from rains of the previous fall or from winter snow did not appear to be so important as precipitation during the growing season.

Clarke *et al.* (1947) also found a fairly close association between rising soil temperatures and increased growth rate from the time growth began till the end of April. There was a fairly close relationship between available soil moisture and growth during May and June. The end of the period of active growth coincided with the date soil moisture became exhausted, usually during the middle of July.

The present study was conducted at the Manyberries Range Experimental Farm in southeastern Alberta in shortgrass prairie. Principal forage species include needle-and-thread (*Stipa comata*), western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and June grass (*Koeleria cristata*), in order of decreasing yield. Blue grama predominates in basal area.

The correlations found in this work have application to the area studied and will not necessarily hold true for other vegetational types in the prairie of southern Alberta and Saskatchewan.

Procedure

Meteorological records for the period of the study reported herein were accessible at the Farm. Although two different fields were used, climatic conditions on each were assumed to be similar to those at Farm headquarters. During the period 1930 to 1943, 36 four-square-yard plots were clipped annually on protected areas. In 1947 and 1948, 15 meter-square plots were clipped in protected areas. During 1949 to 1953, 15 yard-square cages were used in three fields, and these were clipped annually. All plots were clipped with hand shears after the forage was mature. Thus annual yields could be considered as being influenced primarily by climatic conditions during the growing season.

Experimental Results

Detailed data showing years of study, yields in pounds per acre and meteorological data are given in Table 1. A correlation analysis was conducted involving the different variables, the results of which are given in Table 2. A test

Table 1. Meteorological data and yields of forage for twenty years.

Year	Forage	Seasonal precipitation*	Evaporation (seasonal)	Mean. temp. (seasonal)	Hours of sunlight (seasonal)	Wind mileage (seasonal)	May-June Ppt.
	(lbs./acre)	(in.)	(in.)	(°F)			(in.)
1930	229	5.43	21.4	56.4	1050.8		3.39
1931	250	5.82	22.8	56.4	1055.4		2.81
1932	365	7.67	17.1	56.3	994.3		4.43
1933	263	6.31	23.9	55.7	1087.5		4.58
1934	220	4.59	22.0	57.2	1189.4		3.85
1935	290	5.21	19.7	52.7	1057.2		1.82
1936	163	2.63	26.9	59.7	1140.7	34,600	1.76
1937	250	3.80	19.8	57.0	1106.4	37,971	2.39
1938	387	6.21	14.7	55.8	967.6	29,048	3.79
1939	312	5.09	22.7	56.5	1003.4	33,842	3.53
1940	396	7.32	20.2	55.4	929.5	29,562	3.22
1942	825	11.46	21.2	54.0	909.8	29,732	9.62
1943	225	4.02	19.5	55.0	909.0	34,372	2.53
1947	306	4.28	22.3	56.2	1099.4	32,225	3.19
1948	190	6.18	13.3	54.9	1005.8		3.22
1949	90	4.45	21.2	58.2	1117.2	34,548	2.56
1950	270	5.83	19.1	52.8	930.3	35,252	3.81
1951	420	6.10	16.2	53.2	1015.6	34,324	5.18
1952	410	5.21	19.4	55.1	1054.6	34,468	3.19
1953	488	8.40	14.0	51.3	940.7	33,479	5.11
Aver.	317	5.80	19.9	55.5	1028.6	33,340	3.70

*April to July, inclusive

for linearity showed the relationships to be linear, within the range studied.

Table 2. The relationship of climatic factors to range forage production as shown by multiple correlation analysis.

Variables	r	Variables	r	Variables	r	Variables	r
ab	0.845**	ak	0.182	be	−0.630**	bf.d	−0.637*
ac	−0.246	al	0.859**	bf	−0.611*	be.d	−0.434
ad	−0.526*	am	0.657**	ab.e	0.847**	af.de	−0.487
ae	−0.572**	an	0.208	df.e	0.447	ae.df	−0.059
af	−0.566*	ao	−0.088	af.e	−0.384	ad.ef	0.098
ag	0.204	ed	0.642**	ad.e	−0.253	bf.de	−0.529
ah	0.047	fd	0.155	ae.d	−0.359	a.def	0.768**
ai	0.683**	fe	0.518	af.d	−0.577*	bd.def	0.866**
aj	0.701**	bd	−0.549*	fe.d	0.553	a.bdef	0.877**

**Highly significant ($P = 0.01$)
*Significant ($P = 0.01$)

a—Forage production (lbs. per acre)
b—Seasonal precipitation (ins.)
c—Seasonal evaporation (ins.)
d—Mean temperature (°F) (seasonal)
e—Hours of sunlight (seasonal)
f—Wind mileage (seasonal)
g—Seasonal precipitation previous year (ins.)
h—April precipitation (ins.)
i—May precipitation (ins.)
j—June precipitation (ins.)
k—July precipitation (ins.)
l—May plus June precipitation (ins.)
m—Annual precipitation (ins.)
n—Previous year's annual precipitation (ins.)
o—Pre-seasonal precipitation (Oct. to March) (ins.)

Discussion

May precipitation and June precipitation were both significantly correlated with annual forage production; the May-plus-June precipitation was more closely related to forage production than any other factor studied. The coefficient of determination (0.738) shows that about 74 percent of the variation in the yield of forage can be accounted for by the differences in the May-plus-June precipitation.

Pre-seasonal precipitation was not significantly correlated with range forage production.

Clarke *et al.* (1947) found a fairly close relationship between the precipitation; evaporation ratio and forage production. The present study, based on 20 years' data, showed a correlation coefficient of 0.694 which was highly significant. A low insignificant negative relationship existed between forage production and seasonal evaporation.

Seasonal mean temperature, hours of bright sunlight, and wind mileage were all significantly negatively correlated with forage production.

The regression equation derived from the relationship of yield to May-plus-June precipitation is $Y = 27.17 + 78.48\,X$, where Y = estimated yield of forage in pounds per acre and X = May + June precipitation (Figure 1). This equation may be used as an estimate of annual forage production as early as July 1 each year. Assuming a 50 percent carryover (or that 50 percent of the forage produced by the important forage plants will be utilized); and assuming that a 1,000-pound beef cow requires 660 pounds of forage per month (dry weight basis), a curve representing number of acres required per 1,000-pound cow per month is included in Figure 1. Hence, if 3 inches of rainfall are recorded during May and June, approximately 233 pounds of forage may be expected to be produced. Reading directly off the curve, the estimated carrying capacity is approximately 5 acres per head per month.

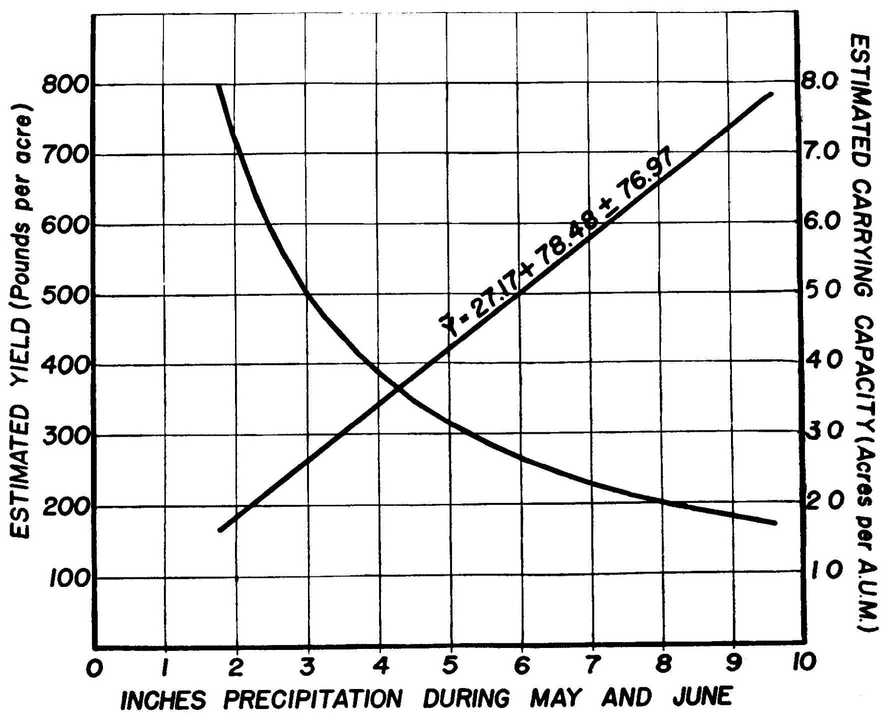

FIGURE 1. Estimated forage yield (straight line) and carrying capacity (curved line) for various amounts of precipitation.

Summary

In a study to determine the influences of climatic factors upon range forage production, correlation coefficients were determined for numerous variables. May-plus-June precipitation when correlated with yield gave a highly significant correlation coefficient of 0.859.

Seasonal mean temperature, hours of bright sunlight, and wind mileage were all significantly, negatively correlated with forage production. A low insignificant negative relationship existed between forage production and seasonal evaporation.

The stocking rates depicted by the graph represent a basis for conservative stocking rates over a period of years. In a year of high precipitation and consequently high forage yield, additional livestock numbers may be grazed during the summer and fall, or the grazing season may be extended to a greater length than usual. In event of drought, livestock numbers may be reduced by selling more than the usual number of livestock, culling more strictly, or shortening the grazing period and extending the winter feeding period. Until more is known about proper levels of utilization, the proposed graph may serve the purpose of adjusting stocking rates as deemed necessary.

A regression equation $Y = 27.17 + 78.48\,X$, where $Y =$ estimated yield of forage in pounds per acre, and $X =$ inches of precipitation in May plus June, was developed. This equation may be used to estimate forage production as early as July 1 each year. Assuming that a mature beef cow (1,000 pounds) requires 660 pounds of forage (air-dry basis) per month an estimate of carrying capacity is determined for the varying amounts of forage production estimated.

The data presented may be of considerable value in forecasting range production and stocking rates within certain limits. In years of high precipitation, the forage production may be high and the carrying capacity may consequently be increased. In event of drought, livestock numbers may be decreased to cope with reduced production.

LITERATURE CITED

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