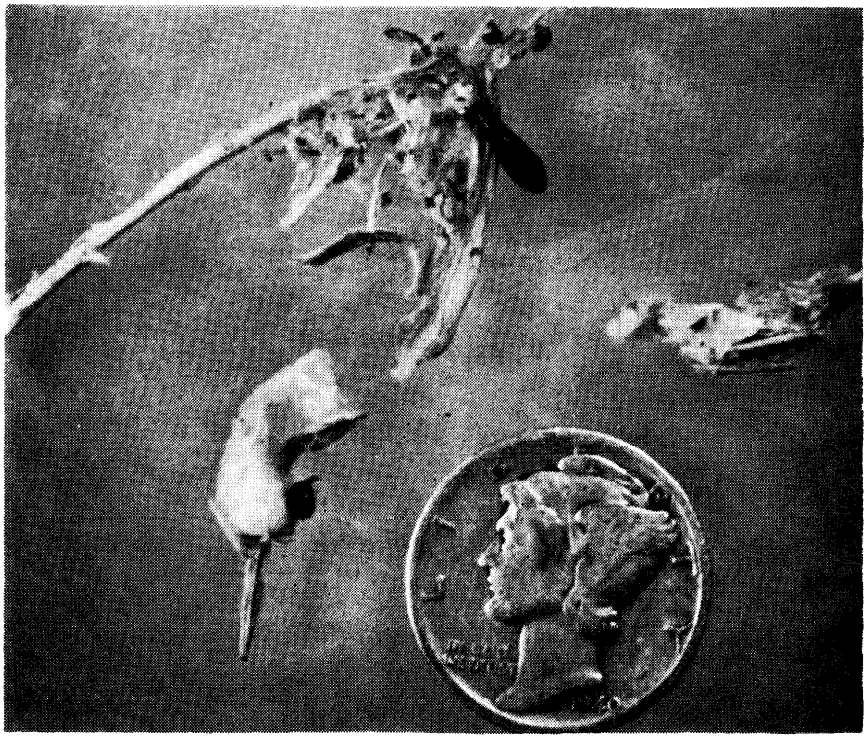

FIGURE 2. Pupa of *Aroga websteri*, Clark at top. Eggs enclosed in webbing at lower left. (Photo by R. R. Kindschy, BLM).

Aroga in some samples is approximately 50 to 70 percent. There appear to be two types of parasites; one works on the larva and the other works on the pupa. The effects of the parasites on the *Aroga* population for 1964 and subsequent years is unknown.

This widespread infestation of *Aroga* and subsequent damage to sagebrush has important ecological and range management implications. In areas of heavy sagebrush where desirable understory species are lacking, a heavy sagebrush kill may result in an increase of less desirable weeds.

Where there are sufficient understory grasses to take advantage of the removal of the sagebrush, nothing but good should come as a result of removal of sagebrush. Such areas should be managed to take maximum advantage of the sagebrush removal. However, on areas without sufficient desirable forage grasses as understory, the removal of the sagebrush may result in more serious range deterioration. Range seedings should be given major consideration where possible. The Bureau of Land Management has recognized the management and improvement implications of this *Aroga* infestation. Private land operators are being advised to do so.

LATE-SPRING HERBAGE PRODUCTION ON SHORTGRASS RANGELAND[1]

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Herbage production on the shortgrass plains varies from year to year. Thus it is difficult either to predict herbage production or to recommend stocking rates that are not detrimental, especially in drought years. The amount and time of precipitation, other climatic conditions, and grazing use have definite influences on the kinds and amounts of herbage produced.

Dahl (1963), found on a sandhills range in Colorado, that grass yields in the spring were significantly influenced by the total precipitation of the previous two years. Also, the amount of grass produced by early August could be predicted from the depth of moist soil on April 15. At the Manyberries Range Experiment Farm in southeastern Alberta, Smoliak found that the May-June precipitation was highly correlated with annual forage production and that pre-seasonal precipitation was not significantly correlated with range forage production. Rogler and Haas (1947) found that the amount of soil moisture from the preceding fall and precipitation during the current season were important factors affecting the yield of a native mixed prairie in North Dakota. Thus the amount of native herbage produced may be influenced not only by the current season's precipitation, but by the previous year's rainfall as well.

Native vegetation on the shortgrass plains consists principally of perennial shortgrasses and midgrasses with some annual grasses as well as annual and perennial forbs. The midgrasses generally obtain most of their growth in the early spring and summer. The shortgrass species start growth in late spring and continue through the summer if moisture is not limiting.

Range readiness in the spring is usually judged by observing indicator plants or the general appearance of the range. To determine the amounts and kinds of vegetation present in late spring on native shortgrass rangeland, a study was initiated in the spring of 1959 at the Archer Substation near Cheyenne, Wyoming. The results for a 5-year period are reported herein.

Study Area

The major soil on the upland site of the experimental pastures is Altvan fine sandy loam. The native vegetation is characteristic of the shortgrass plains. The principal shortgrass species are blue grama *(Bouteloua gracilis)* and buffalograss *(Buchloe dactyloides)*. Western wheatgrass *(Agropyron smithii)* is the principal midgrass. Sixweeks-fescue *(Festuca octoflora)* is the dominant annual grass. Other cool-season grasses and forbs are minor.

Approximately 75 percent of the annual precipitation is received dur-

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ing the April 1 to September 30 growing season. Precipitation during the growing season varies from less than 6 in. to over 17 in. The 50-year average annual and seasonal precipitation is 14.93 and 11.72 in., respectively.

Procedure

The upland site on two native shortgrass pastures was studied. One had been moderately grazed since 1945. The other had been heavily grazed from 1945 to 1954 and lightly grazed thereafter. The animals used on these pasutres were ewes and their lambs from the Experiment Station flock. The moderately grazed pastures had been stocked at the rate of 2.40 acres per ewe and lamb; the lightly grazed units at 3.70 acres.

Caged plots 2 ft. square, harvested the previous fall for determining current year's herbage production were clipped in the spring. Thus only the current spring growth was harvested. The herbage was clipped at ground level; separated into midgrass, shortgrass, annual grass, and forbs; air-dried; weighed; and computed on a per-acre basis. The average leaf heights of 10 randomly selected blue grama and western wheatgrass plants were measured. Clipping and leaf-height measurements were initiated on May 27, 1959, and thereafter during the month of May except in 1961, when these measurements were made on June 6.

Results and Discussion

The kind and amount of herbage harvested in late spring varied. Only traces of annual grass and forbs were present in 1959 and 1963. During the other three years (1960, 1961 and 1962) annual grass and forbs accounted for 6 to 19 percent of the total vegetation produced on the moderately grazed pasture and from 2 to 9 percent on the lightly grazed pastures. Six-weeks-fescue, the principal annual grass, appears to be correlated with the abundance of fall moisture. Hylton and Bement (1961) state that the density of six-weeks-fescue may be predicted by careful examination of temperature and moisture conditions during August, September, and October preceding the summer growing season. They also found that the density of six-weeks-fescue was slightly influenced by grazing intensities.

During the 5-year period the amount of perennial grass averaged 286 and 231 pounds per acre, respectively, on the moderately and lightly grazed pastures (Tables 1 and 2). This difference was not significant, but the difference in the amount produced in different years was significant at the 0.05 level of probability.

Difference in the amount of midgrass produced between the moderately and lightly grazed pastures was statistically significant at the 0.01 probability level. The 5-year average shows nearly three times more midgrass on the moderately grazed pasture than on the lightly grazed. This difference may be accounted for in that the lightly grazed pasture is still recovering from past heavy grazing use.

There was no significant difference between the amount of shortgrasses produced on the moderately and lightly grazed pastures, but there was a statistically significant difference at the 0.01 level for the amount of shortgrasses produced among years. Averages of 158 and 184 pounds per acre of the shortgrass were produced on the moderately and lightly grazed pastures, respectively, over the 5-year period. The slightly greater amount of shortgrass on the lightly grazed pasture is accounted for by the abundance of buffalograss, which had resulted from the 10-year period of heavy grazing (Lang, et al., 1956).

Average leaf heights of blue grama and western wheatgrass for the moderately grazed pasture are shown in Table 3. They were 1.1 in. for blue grama and 4.5 in. for the western wheatgrass. Heights of both grasses were greater in 1961, the later date of measurement.

The greatest amount of herbage produced in the spring was not always associated with the best moisture conditions between April 1 and date of harvest; this indicated that the previous year's fall moisture was an important factor (Table 4). Herbage production among years was

Table 1. Air-dry herbage from moderately grazed pasture, Archer Substation 1959-1963.

Year	Harvest Date	Mid Grass	Short Grasses	Annual Grasses	Forbs	Total
		(Pounds per Acre)				
1959	5/27	52	172	T[1]	T[1]	224
1960	5/23	72	208	11	7	298
1961	6/6	148	93	46	11	298
1962	5/25	197	190	28	5	420
1963	5/17	170	127	T[1]	2	299
[1]Trace	AV.	128	158	17	5	308

Table 2. Air-dry herbage from lightly grazed pasture. Archer Substation 1959-1963.

Year	Harvest Date	Mid Grass	Short Grasses	Annual Grasses	Forbs	Total
		(Pounds per Acre)				
1959	5/27	59	135	T[1]	T[1]	194
1960	5/23	24	256	8	20	308
1961	6/6	38	142	6	9	195
1962	5/25	87	264	7	1	359
1963	5/17	26	120	T[1]	2	148
[1]Trace	AV.	47	184	4	6	241

Table 3. Leaf height of blue grama and western wheatgrass on moderately grazed pasture in spring, Archer 1959-1963.

Year	Harvest Date	Blue Grama	Western Wheatgrass
		(Inches)	
1959	5/27	1.1	4.0
1960	5/23	1.2	4.8
1961	6/6	1.5	5.8
1962	5/25	1.0	4.6
1963	5/17	0.7	3.5
	AV.	1.1	4.5

Table 4. Effect of precipitation and time of harvest on herbage produced (air-dry) on moderately grazed pasture, Archer 1959-1963.

Year	Fall Harvest Caged Plots	Left, end of Season	Produced in Spring	Precipitation
	— — (pounds) — —			(inches)
1959	357	256	224	2.37
1960	388	192	298	2.70
1961	786	310	298	7.38
1962	620	328	420	1.54
1963	564	411	299	0.82
AV.	543	299	308	2.96

highly variable and appeared to be dependent upon the interaction of several factors. From 30 to 164 percent more herbage was harvested in the fall than in the spring. In 4 of the 5 years more than half of the herbage was produced by late spring.

The five year study period was too short for obtaining reliable correlations and regression equations for predictive purposes. Seventeen years (1947-1963) of precipitation and clipping data were available from the pastures moderately grazed. From these data correlations and regressions were determined.

The May-June precipitation when correlated with perennial grass yields gave a highly significant correlation coefficient of 0.675. This compares to 0.859 found by Smoliak (1956). The April through August precipitation when correlated with perennial grass yield resulted in a highly significant correlation of 0.745, which is higher than that for May-June precipitation and grass yields. Although statistically significant, only 46 and 56 percent of the variation in perennial grass yields is accounted for by variation in precipitation.

The regression equations derived from the relationship of perennial grass yield to the May-June and April through August precipitation are $Y = 195 + 57.77\ X_1$ and $Y = 70.18 + 43.54\ X_2$, where X = May-June and X_2 = April-August precipitation (Figure 1). Also shown for comparison is the regression line developed by Smoliak.

A test of homogenity of the regression coefficients calculated by Smoliak and for the moderately grazed pastures at the Archer Substation showed no significant difference. Thus, a given increase of May-June or April through August precipitation results in a comparable increase of herbage at both locations.

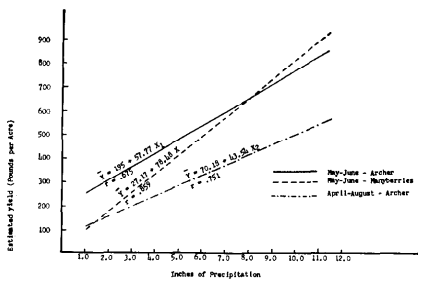

FIGURE 1. Estimated yield for various amounts of precipitation, perennial grasses at Archer and total herbage at Manyberries.

On the basis of yield from the caged plots from the moderately grazed pasture, 39 to 73 percent of the annual herbage produced was left at the end of the grazing season. This indicates that the rate of stocking for the upland site was approximately moderate four years out of the five, if the rule of thumb—leave half and graze half—is observed. The criterion used for the proper degree of utilization was to leave an average of 1.2 and 0.9 in. of height on blue grama at the end of the grazing season on the lightly and moderately grazed pastures, respectively.

Summary

A study to determine the kinds and amounts of native vegetation present in late spring on native shortgrass rangeland was conducted at the Archer Substation in Wyoming during the years 1959 through 1963. Clipping studies were conducted in late May on a pasture moderately grazed since 1945 to 1954 and lightly grazed thereafter.

Nearly three times more midgrass was produced on the moderately grazed pasture than on the lightly grazed pasture. Recovery of the pasture grazed lightly since 1955, previously heavily grazed, is slow and not reflected in the clipping data. Observations show that midgrasses are increasing, but the abundance of buffalograss and prevailing climatic conditions have not been conducive to the rapid reestablishment of the desirable species. There was no significant difference in the amount of short or warm-season grasses produced between the moderately and the lightly grazed pastures.

During the 5-year period there was wide variation in the amount of herbage produced and amount of precipitation. Average total herbage for the 5-year period was 308 and 241 pounds per acre, respectively, for the moderately and lightly grazed pastures.

May-June and April-through-August precipitation when correlated with yields gave highly significant correlation coefficients of 0.675 and 0.754, respectively. Regression equations developed from the moderately grazed pasture data were not statistically different from the equation developed by Smoliak at Manyberries in Alberta, Canada.

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SILVER SAGEBRUSH IN EASTERN NORTH DAKOTA

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The range of sagebrush (shrubs of the genus *Artemisia)* is usually shown to include only the Southwest part of North Dakota as roughly limited to the north and east by the Missouri River. Only two shrub species of this important rangeland genus occur in the state, namely *A. tridentata* Nutt. (big sagebrush) and *A. cana* Pursh (silver sagebrush). Silver sagebrush has the wider distribution of the two species.

Outliers of silver sagebrush have