Herbage Response to Grazing Systems and Stocking Intensities

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Abstract

A review of pertinent literature shows that grazing systems and grazing intensities both influence herbage production on Western ranges. Mean annual herbage production increased by 13% when grazing systems were implemented at a moderate stocking intensity. Increases were larger (35% and 27%) when continuous livestock use was reduced from heavy to moderate, and moderate to light, respectively. This suggests that adjustments in livestock numbers have a greater effect on herbage production than do grazing systems.

Grazing systems are being implemented on Western ranges by land management agencies. These agencies use studies by Hormay and Talbot 1961, Hormay and Evanko 1958, Merrill 1954, Reardon and Merrill 1976, Martin 1973, and Hickey and Garcia 1964, among others, to support this action. These grazing system studies report better livestock distribution, greater herbage and livestock production, and improved range condition. However, literature reviews (Hickey 1968; Heady 1961; Herbel 1971; and Shiflet and Heady 1971) also summarize grazing system studies which report nonsignificant forage responses, reductions in livestock production, and cost increases. Some researchers (Heady 1961; Mathis and Kothmann 1968; Cook 1966; and McMeekan 1956) feel that vegetation is affected more by grazing intensity than by grazing systems.

One objective of this paper is to review and analyze data from grazing system and grazing intensity studies. The second objective is to determine whether livestock adjustments have a greater effect on herbage production than do grazing systems.

Methods

We have compared specialized grazing systems to continuous grazing. Heady (1961) treated rotation, deferred, rest rotation, and deferred rotation systems as specialized systems and considered seasonlong and yearlong grazing to be continuous use. This approach is logical because differences between vegetative types and periods of use and nonuse make it difficult to compare one specialized system to another.

Herbage production data are the most reliable measure of grazing management procedures (Klipple 1964). Consequently, grazing studies were reviewed to find those which compared herbage production data under continuous use and specialized grazing systems. Results were used only from studies describing use at a moderate level (40-60%). Herbage production under the respective systems was tabulated from each of 18 studies and the difference in productiveness between the grazing systems and continuous are determined. An average difference for all studies was calculated. An average difference was also calculated for the four geographic regions. These means were compared by an analysis of variance. We have used these average differences as a measure of the vegetal response that can be expected when a specialized grazing system is implemented.

Differences in herbage production under light, moderate, and heavy livestock use were also tabulated from 14 studies. Results were used only from studies describing use at a comparable level as follows: heavy, 60-80%; moderate, 40-60%; and light 20-40%. Average differences between production at the three use levels were calculated. An average difference was also calculated for two geographic regions. These means were compared by an analysis of variance. We have used these average differences as a measure of the vegetal response which can be expected when livestock use is reduced from heavy to moderate, and from moderate to light, respectively.

Results and Discussion

Herbage Response to Grazing Systems

Herbage production averaged 13% higher when livestock use was controlled by a specialized grazing system, rather than being continuous (Table 1). Two of the studies (Hamilton et al.

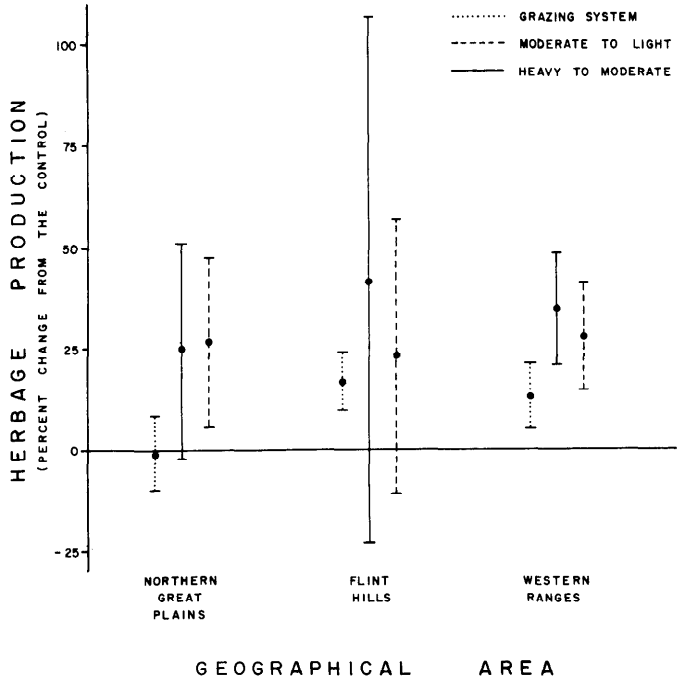

Fig. 1. *Herbage production response for three geographical areas under different grazing intensities (heavy to moderate, moderate to light and under grazing systems. Nodes represent means and confidence intervals at 95%.*

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Table 1. Herbage production (lb/acre) under grazing systems and continuous use, and mean differences in production for 18 studies in 6 geographical areas.

Author Geographic Area	Production: Grazing System	Production: Continuous Use	Percentage difference
Northern Great Plains			
Black et al. 1937	—No difference—		0
Black et al. 1942	—No difference—		0
Campbell 1961	1350	1163	16
Hubbard 1951		Higher	−12
Lodge 1970	−301	−261	−13
Smoliak 1960	489	465	5
			$\bar{X}=-.7\%, S=11, S\bar{x}=4$*
Flint Hills			
Herbel et al. 1959			
Ordinary upland	1952	1744	12
Limestone breaks	1996	1499	33
Clay upland	1346	1116	21
Owensby et al. 1973			
Loamy upland	4521	4218	7
Breaks	3564	2898	23
Clay upland	4311	3657	18
Smith et al., 1978	2759	2604	6
			$\bar{X}=17, S=10, S\bar{x}=4$*
Texas			
Kothmann et al. 1975			
Deep upland	1532	1233	24
Deep upland	1227	955	28
Rolling hills	1287	723	39
Rolling hills	1054	788	34
Keng et al. 1960	Higher		25
Reardon et al. 1976	1188	481	147**
			$\bar{X}=30, S=6, S\bar{x}3$*
Southwest			
Martin 1970	220	550	−60
Martin 1973	89	64	39
Martin et al. 1976			
Site I	551	394	47
Site II	195	175	11
Site III	357	387	−8
			$\bar{X}=6, S=61, S\bar{x}=27$*
Pacific Northwest			
Hamilton 1945	Higher		9
Skovlin et al. 1976			
Grassland	+51	+21	143**
Forest	−108	−134	19**
Colorado			
Klipple 1964	−298	−35	−750**
Average for Western Ranges			$\bar{X}=13, S=23, S\bar{x}=5$*

[1] Confidence interval of the mean was calculated at a 95% level.
[2] Treated as outliers, and not included in the analysis.

Table 2. Herbage Production (lb/acre) under two grazing intensities and mean differences in production for 14 studies in 9 geographic areas.

Author	Production: Heavy	Production: Moderate	% Change
Northern Great Plains			
Hanson et al. 1970	1752	2092	19
Johnson et al. 1951	1262	1571	25
Lewis et al. 1956			
Ridges	1069	1009	−6
South slopes	1098	1300	19
North slopes	1188	1343	13
Draw	2509	2231	−11
Rauzi 1963	727	1574	117
Reed et al. 1961	314	381	21
			$\bar{X}=25\%, S=40, S\bar{x}14$***
Flint Hills			
Herbel et al. 1959			
Ord. upland	1318	1749	33
Limestone break	1528	1499	−2
Clay upland	505	1116	121
Launchbaugh 1957	1096	1245	14
			$X=42\%, S=55, S\bar{x}=28$***
Colorado Seeded Range			
Currie et al. 1970			
Agropyron cristatum	1082	1270	17
Bromus inermis	555	755	36
Ager and Brin	1189	1578	33
Agropyron intermedium	477	894	87
			$\bar{X}=43\%, S=30, S\bar{x}=15$***
New Mexico			
Valentine 1970	49	77	57
Oklahoma			
Hazell 1967	3172	3767	19
Colorado			
Smith 1967	−203	+85	142*
Wyoming			
Pond 1961			
Granitic soil	.48	.74	54**
Sedimentary soil	1.18	1.48	25**
Utah			
Cook 1971	−45%	−11%	76
Pacific Northwest			
Skovlin et al., 1976			
Grassland	+9	+57	533*
Forest	−122	−128	−5
Average for Western Ranges			$\bar{X}=35\%, S=37, S\bar{x}=8$***

[1] Treated as outliers, and not included in the analysis.
[2] Measured in grams per plant.
[3] Confidence interval of the mean was calculated at a 95% level.

1975; and Campbell 1961) investigated tame pastures, the remainder native ranges. Reardon and Merrill's (1976) study was omitted from the analysis because the continuous use pasture was grazed at a higher stocking intensity. The study of Skovlin et al. (1976) was omitted because utilization averaged 38% for the five key species. Klipple's (1964) datum was omitted because it was a statistical outlier (Li 1964).

Herbage response to grazing systems differed by geographical area (Table 1, Fig. 1). For example, when herbage response under specialized grazing systems was compared to that under continuous use, mean herbage production decreased 0.7±9%, increased 17±7%, and increased 30±6% in the Northern Great Plains, Flint Hills, and Texas, respectively. The three studies (Martin 1970; Martin 1973; Martin and Ward 1976) from southern Arizona suggest that mean herbage response will increase by 6±41% when grazing systems are implemented in the Southwest. It is unrealistic to predict mean herbage responses in the shortgrass prairie of Colorado or the Pacific

Northwest because of the restricted number of studies. The analysis of variance showed the means were not significantly different. However, Table 1 suggests that responses in the Flint Hills and Texas regions are similar, and that these are different from the responses in the Northern Great Plains. The data also suggest that additional research is needed in the Southwest before geographic differences can be fully analyzed.

Variation measured on different range sites at or near the Santa Rita Experimental Range (Martin and Ward 1976); in the Flint Hills region (Herbel and Anderson 1959); and in the Texas region (Kothmann et al. 1975) is similar to the variability between geographical regions. Therefore, the 13±8% increase is a realistic estimate of mean herbage response to grazing systems on Western ranges.

Herbage Response to Grazing Intensity

Herbage responses are fairly consistent when livestock numbers are reduced on Western ranges (Tables 2 and 3). Mean herbage production increases 35 and 28% when use is reduced from heavy to moderate, and from moderate to light, respectively. Currie and Smith (1970) studied seeded pastures, the remainder native ranges. Cook's (1971) study was omitted from the analysis because he used a clipping technique to simulate livestock grazing on seven plant species. Data from Smith (1967) and Skovlin et al. (1976) were not analyzed because their utilization levels were lighter than those considered in this analysis.

Only two geographic regions had enough studies to permit comparison on native ranges (Fig. 1, Tables 2 and 3). The analysis of variance showed no significant difference. However, the response from reducing livestock use from heavy to moderate in the Flint Hills (42±65%) was higher than it was in the Northern Great Plains (25±27%). But the response from reducing livestock use from moderate to light was greater in the Northern Great Plains than in the Flint Hills. The differential response may reflect the interplay of short-, mid-, and tall-grass species.

Variation between range sites measured in South Dakota (Lewis et al. 1956) and in the Flint Hills (Herbel and Anderson 1959) is similar to the variability between geographical regions. Therefore, the 35±14%, and the 28±13% increases are realistic estimates of mean herbage response to livestock adjustments that reduce use from heavy to moderate, and moderate to light, respectively.

Management Implications

Tables 1, 2, and 3 can be interpreted to predict herbage response to grazing management procedures on Western ranges. Herbage production can be expected to increase an average of 13±8% when grazing systems are implemented. Federal land management agencies could also use the 13±8% increase as a basis for associated livestock and socio-economic predictions in their environmental impact statements.

Geographically, herbage response to grazing systems was most variable in the Southwest. This variation (6±41%) makes it difficult, if not impossible to predict consistent herbage response. Therefore, it appears that livestock adjustments become increasingly important as a management tool in this region. In contrast, herbage response to grazing system implementation is less variable in Texas. Thus, it becomes a more feasible management tool in this region.

It is not possible to evaluate grazing system implementation at a light stocking intensity. Gibbens and Fisser's (1975) study

Table 3. Herbage production (lb/acre) under two grazing intensities ar mean differences in production for 12 studies in 8 geographic area

Author	Production		% Change
	Moderate	Light	
Northern Great Plains			
Hanson et al. 1970	2092	3700	77
Johnson et al. 1951	1571	2046	30
Lewis et al. 1956			
Ridges	1009	1059	5
South slopes	1300	1289	−1
North slopes	1343	1389	3
Draw	2231	2885	29
Reed et al. 1961	+381	+564	48
			$\bar{X}$=27%, S=28, $S\bar{x}$=11**
Flint Hills			
Herbel et al. 1959			
Ord. upland	1749	2080	19
Limestone break	1419	1916	28
Clay upland	1116	968	−13
Launchbaugh 1957	1245	1963	58
			$\bar{X}$=23%, S=29, $S\bar{x}$=15**
Colorado Seeded Range			
Currie et al. 1970			
Agropyron cristatum	1270	1264	0
Bromus inermis	755	787	4
Ager and Brin	1578	1479	−6
Agropyron intermedium	894	907	2
Elymus junceus	638	885	39
			$\bar{X}$=8%, S=18, $S\bar{x}$=8***
New Mexico			
Valentine 1970	77	159	106
Colorado			
Smith 1967	+85	+18	−79
Wyoming			
Pond 1961			
Granitic soil	.74	.9	22**
Sedimentary soil	1.48	2.58	74**
Utah			
Cook 1971	−11%	+17%	255*
Pacific Northwest			
Skovlin et al. 1976			
Grassland	+57	+43	−25*
Forest	−128	−108	16*
Average for Western Ranges			$\bar{X}$=28%, S=33, $S\bar{x}$=8***

Treated as outliers, and not included in the analysis
Measured in grams per plant.
Confidence interval of the mean was calculated at a 95% level.

on a big sagebrush range is most applicable. They felt that a ligl stocking rate was the reason vegetal cover did not sho differences between rest rotation, deferred, or seasonlon grazing.

It is possible to compare the alternatives of implementing grazing system at moderate use or of reducing livestoc numbers to a light level. For example, in the Northern Gre Plains, herbage response will increase by 27±21% whe livestock use is reduced from moderate to light. Herbag response to grazing systems averages −0.7±9%. In this sitt ation, livestock adjustments may be more economically feasibl for an individual operator (Klipple and Bement 1961). But lan management agencies must consider social, economic, an

other factors before they decide to adjust livestock from moderate to light, implement grazing systems, or do a combination of both alternatives.

Land managers are also confronted with the situation of implementing grazing systems and simultaneously reducing livestock use from a heavy to moderate level. Tables 1, 2, and 3 can be used to evaluate the alternatives. For example, livestock adjustments result in a 35% and grazing systems a 13% increase in herbage production. These values can be adjusted proportionately to account for the total herbage response. It is assumed this would be an additive effect, resulting in the total response. Thus, livestock adjustments, from heavy to moderate use, would account for 73%, and grazing systems for 27% of the total herbage response when both are implemented simultaneously.

Conclusions

Results from a number of controlled grazing studies show that mean herbage production will increase by 13±8% when grazing systems are implemented, at a moderate use level on Western ranges. This is a smaller response than is obtained when livestock use is reduced from heavy to moderate, or from moderate to light. These livestock adjustments cause herbage production to increase by 35±14% and 28±13%, respectively. This suggests that land managers should place more emphasis on proper stocking intensity, and less on grazing system implementation.

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