1975

Effects of Grazing on Desert Vegetation

B. E. Norton

1974 PROGRESS REPORT

EFFECTS OF GRAZING ON DESERT VEGETATION

B. E. Norton
Utah State University

US/IBP DESERT BIOME
RESEARCH MEMORANDUM 75-50

in

REPORTS OF 1974 PROGRESS
Volume 1: Central Office, Modeling
Resource Management Section, pp. 1-6

1974 Proposal No. 2.4.3

Printed 1975

Citation format: Author(s). 1975. Title.
US/IBP Desert Biome Res. Memo. 75-50.
Utah State Univ., Logan. 6 pp.

Ecology Center, Utah State University, Logan, Utah 84322

ABSTRACT

Current year's plant production on the grazed pastures of the Desert Experimental Range in 1973 ranged from 125 to 363 pounds per acre. These values are based on weight estimates taken in October. The Desert Experimental Range is an experiment station operated by the USDA Forest Service to study the impact of grazing on salt-desert shrub vegetation. The experimental pastures are dominated by salt-desert shrubs such as *Ceratoides lanata* and *Atriplex confertifolia*. Under conditions of severe grazing impact, annual forbs can contribute more than 50% of the current herbage crop. The effects of heavy grazing on *Ceratoides lanata* appear to be a reduction in average plant size, a decrease by about one-third in plant cover and a slight thinning in plant density.

INTRODUCTION

The Desert Experimental Range (D.E.R.) is located in Millard County of southwestern Utah, about 75 km west of the township of Milford. This station is operated by the U.S. Forest Service as a unit of the Intermountain Forest and Range Experiment Station. The original reason for setting aside the area as an experimental facility was to study major aspects of winter-range management. The D.E.R. occupies approximately 225 km^2 in Pine Valley, a typical basin-and-range graben running north-south between the Wah Wah Mountains and the Halfway Hills. The elevation ranges from 1550 to 2012 m, with the grazed experimental pastures falling between 1555 and 1753 m.

The vegetation is typical of about 180,000 km^2 of winter grazing lands in the Great Basin that are generally referred to as northern desert shrub or salt-desert shrub communities. The dominant perennial shrubs on the experimental pastures are *Ceratoides lanata*, *Atriplex confertifolia* and *Artemisia spinescens*. Perennial grasses include *Sporobolus cryptandrus*, *Oryzopsis hymenoides* and *Hilaria jamesii*. A more detailed description of the area may be found in Hutchings and Stewart (1953) and Holmgren (1975). The perennials are dependent upon spring snow-melt to provide soil moisture for the growing season. Average precipitation over the months of November through March is only 45.2 mm; another 31.8 fall during the spring months of April and May, on average. The three summer months represent the wettest period (mean of 52.5 mm), but the high temperatures at this time of year and the nature of the rains (storms) make this input of questionable value to the perennial species. Mean total annual precipitation is 157 mm.

This area, and many others like it in the intermountain region, is traditionally used for winter grazing -- largely sheep grazing. The livestock arrive from their summer ranges in the mountains in October or November and stay on the shrub-desert vegetation until April or May. When the Experimental Range was established in 1933, overgrazing was evident on much of this type of sheep range (McArdle et al. 1936) due to unrestricted grazing (Stewart et al. 1940). The Taylor Grazing Act of 1934 placed winter ranges on public land under government management. The general purpose of the D.E.R. was therefore to determine the best stocking rate on the winter range and the least detrimental period for grazing. This broke down into several specific objectives (Hutchings and Stewart 1953, p. 4), of which the principal objectives were to determine the utilization of forage species by sheep, the effect of grazing intensity on forage yields and the effect of precipitation on herbage production.

Twenty experimental pastures were set aside near one end of Pine Valley; sixteen of these are 130 ha, the other four are 97 ha. The treatments applied to these pastures comprised combinations of early winter, middle winter and late winter (early spring) sheep grazing with light, moderate and heavy stocking rates. Two enclosures of 0.4 ha were fenced in each pasture (with some exceptions), with two corresponding grazed plots marked in matching vegetation. Plant production was measured in October on 18.6-m^2 plots by a weight-estimate method (Pechanec and Pickford 1937a). Forage utilization was estimated at the end of the grazing season using the ocular method described by Pechanec and Pickford (1937b). The experimental design and methods adopted are discussed in detail by Hutchings and Stewart (1953).

Herbage production estimates were taken every year from 1935 to 1945, and again in 1947. These 12 years of production and utilization records were sufficient to determine the proper stocking rate and to establish trends in the vegetation due to season or intensity of utilization (Hutchings and Stewart 1953). Subsequent estimates of production were undertaken in 1957 and 1958, and again in 1967; also, further interpretative work has been pursued (e.g., Holmgren and Hutchings 1972).

The intention of the Forest Service to continue annual estimates of herbage production after 1967 was not realized until an agreement was reached with the IBP Desert Biome to conduct the October field estimates again in 1973. The interest of the Biome program was principally directed toward the development and testing of a computerized simulation model of vegetation change under grazing as experienced at the Desert Experimental Range. The structure of this model has been discussed in earlier Biome reports (Wilkin 1973, Wilkin and Norton 1974). In addition to the modeling aspects, the Biome was interested in succession as a desert vegetation phenomenon, and hoped to help explain the processes by which the observed changes in community composition were occurring.

METHODS

Herbage Production

Estimation of herbage production was carried out in October of 1973 using the same method that has been employed on the experiment station since 1937. The procedure is based on the technique described by Pechanec and Pickford (1937a). In each pasture, 64 permanent plots (48 in the four smaller pastures) are marked with steel pegs. These pegs are regularly spaced circa 100 m apart in rows of eight pegs, with 200 m between rows. The permanent steel peg serves as the center of a circular quadrat 18.6 m^2 (200 sq. ft.) in area which is described by a marking peg arcing at the end of a radial chain. A trained observer inspects the plot and notes every species within the perimeter. He then records his estimate of the weight in grams of air-dry plant material from the current year's production for each species present. Estimates of percent cover are also made for the major species on the plot. These observers collected these estimates for each pasture. The data are analyzed in a fashion which provides the production per acre in pounds of plant material in keeping with the traditional practice in this long-term experiment. The observers spent 10 days to 2 weeks in a training session prior to working on the permanent plots.

Plant Density and Dimensions

To supplement the kind of data being collected on plant production by the weight-estimate method, plant density and dimension measures were undertaken in the summer of 1974. The procedure for plant density was the point-centered quarter method as described by Cottam and Curtis (1956). The sampling points (160) were located in each pasture sampled; these were located at 5-m intervals along four transect lines spaced 200 m apart. This permitted an effective sampling area of 205 x 610 m (one-eighth of a square kilometer). Pastures were sampled in matched pairs, each pair consisting of one pasture showing signs of heavy impact from grazing and the other with evidence of light impact. [These pairs are pastures 6 and 11, 9 and 18, 14 and 16, 7 and 17.] The two sampling areas in a pair were located directly opposite one another and on either side of the fence separating the two pastures. The transects began 10 m from the fence and proceeded normal to it. The location of each pair was the result of deliberate selection to minimize variability due to inherent site differences and to highlight the fence-line contrasts due to the different grazing treatments.

This sampling program for plant density was applied to three shrub species: *Ceratoides lanata*, *Artemisia spinescens* and *Atriplex confertifolia*. At each of the 160 points per pasture, distance measures were taken in the four quadrants for all three species, giving a potential of 12 measures per point and 640 measures per species per pasture. Plant density was calculated as N/ha by squaring the mean distance measure for a species (which gives mean area per plant) and dividing it into the area of a hectare.

In addition to the distance measures, the height, width and length of each plant were recorded. Percent cover was determined by taking the average of width and length, calculating plant area from this mean radius and multiplying by size class numbers to give species area per hectare. Forty plants of each species were randomly selected from the 640 identified in each pasture and the above-ground growth harvested for subsequent separation into biomass components.

RESULTS AND DISCUSSION

Herbage Production

The results of the weight estimates of current year's production by species are given in Table 1 for each pasture and summarized in Table 2 by plant group. The data are listed in units of pounds per acre to conform with the procedure adopted for similar estimates taken over the last forty years.

The detailed listing in Table 1 can be discussed most usefully in relation to production estimates taken in other years, rather than in terms of a pasture-by-pasture comparison for the one point in time. Preceding estimates were obtained from 1935 to 1945 inclusive, 1947, 1957 and 1958, and 1967. The pastures were also assessed in October of 1974 and 1975. A between-year comparison will be undertaken for the next progress report.

There are several interesting points to be observed in an examination of the summary in Table 2. Annual grasses and perennial forbs are insignificant components of the vegetation in terms of annual production. Annual forbs, on the other hand, can be responsible for more that half the year's plant growth (64% in pasture 18, a heavily grazed pasture stocked in late winter), although they generally contributed less than 25% in 1973. Overall, shrubs are the dominant constituent of these grazed communities.

Plant Density and Dimensions

The density and dimensional characteristics of winterfat are contrasted for two adjacent, but differentially grazed, pastures in Figure 1. For the two pastures represented (14 and 16), winterfat is the dominant species present. Plant density has apparently decreased under the heavier grazing; the density of 4.47 plants/m^2 for pasture 14 is slightly less than the density of 4.83 plants/m^2 just across the fence in pasture 16. Plant cover, however, shows a much more dramatic contrast: 13.7% for the heavier grazed pasture 14 compared to 21.4% in pasture 16. The difference is reflected in the frequency distribution of size classes by radial dimension. The mean radius is 10.5 cm in the less severely impacted pasture, and 8.5 in pasture 14. The plants are on average smaller; this is not due to an increase in the fraction of the population at the small end of the scale with plant radius of less than 4 cm, but rather to virtual elimination of the very large plants (22 to 27 cm radius) and severe reduction in the numbers in size classes with radii greater than 15 cm.

Table 1. Record of current year's herbage production in air-dry pounds per acre as determined by the weight estimate method in October 1973 on the 20 experimental pastures

Species	Pasture number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PERENNIAL GRASSES																				
Aristida fendleriana	.27	1.05	1.30	.62	.92	1.52	.49	.69	.46	.53	1.09	.07	.19	.29	1.82	.06	.60		.97	.06
Bisphardaonna kingii	.02	.08	.09	.11	.31	.64	.21	.15	.11	.19	.19	.02					.03		.01	
Bouteloua gracilis	5.25	3.74	5.18	1.51	3.38	.63	.08	.21		.15	2.38						1.05			.05
Hilaria jamesii	23.52	22.91	25.83	31.57	21.98	21.29	10.85	7.45	16.64	11.83	9.15	3.46	46.46	9.55	27.28	16.65	6.84	4.60	19.65	17.16
Oryzopsis hymenoides	3.51	7.36	3.06	5.82	10.32	9.60	10.76	3.85	2.64	4.34	9.91	5.14	9.82	2.13	10.87	5.46	21.47	6.52	5.29	2.40
Stipa hymenoides	.11		.13	.07	.33	.06	.01	.04		.07	.30		.03							
Sporobolus contractus		.82	.09	.74			2.35	.26	.41			.89	.10				5.38	1.74		.21
Sporobolus cryptandrus	50.46	32.86	29.86	16.75	18.79	31.28	46.48	31.31	24.12	29.67	33.47	22.66	3.35	1.39	3.20	.46	21.99	9.55	2.00	3.54
Poa secunda					.03															.07
Stipa comata															.51					
Stipa coronata						.01														
Tridens pulchella						.01														
ANNUAL GRASSES																				
Bromus tectorum		.05		T		.01			.01		.04	.01	.04		.07	.01				.11
Bouteloua barbata	.02	.05			.01	.05	.01	.07	.02									.01		.01
Munroa squarrosa	.18	.19	.08	.09	.19	.70	.60	.40	.39	.70	.63	5.31			.03	.01	.09	1.23	.05	.60
PERENNIAL FORBS																				
Aster aramosus										.05										
Astragalus (two spp.)	.01	.08					.09						.07				.11		.06	
Brickellia oblongifolia	1.07	.03	1.41	.25	1.42	.05	.13		1.55								2.98			
Gnyptantha (two spp., one annual)				.04	.01	.01					.04									
Encelia frutescens						1.03														
Hermidium alipes				.01	.02	T	.01	.01	.02	.01		.07							.01	
Hymenopappus lugens						.10														
Hymenoxis acaulis						.03														
Machaeranthera pattallii			.06	.08	.22	.26		T		.02		.01								.04
Oenothera spp. (at least three spp., two annual)	.01		.03		.05	.24				.01	.17	.12								.04
Sphaeralcea grossulariaefolia (and *S. caespitosa*)	2.12	2.11	.85	2.39	2.85	1.90	1.68	2.89	1.45	1.04	2.03	2.43	5.95	2.90	5.32	2.04	3.07	.75	1.79	1.19
Yucca baccata						.64														
Haplopappus sp.						.04														
ANNUAL FORBS																				
Ambrosia acanthocarpa																			.03	
Amaranthus sp.													.04							
Caulanthus pilosus																			.07	
Chaenactis macrantha	1.77	1.70	2.74	1.85	1.09	1.49	.33	.23	.66	1.76	1.38	.79	.04	.03	.11	.08	.22	.04	.05	.47
Chenopodium spp. (maybe three spp.)	.11	.02				.01	.18	.03			.03	.07	10.04	.31	2.37	.59	.26	1.27	1.72	.89
Descurainia pinnata	.34	.83	.37	.37	.05	.11	.92	.17	.22		.72	.20	.66	5.32	1.23	4.87	.41	.10	.53	3.36
Eriogonum spp. (two spp. annual, one perennial)	.32	.33	.18	.06	.19	.35	.21	.02	.22	.11	.21	.26	1.98	.56	4.43	1.64	.90	.13	4.99	1.01
Euphorbia sp.	.05	.01	.01	.03	.02	.23		.06	.04	.06	.33	.01			.02		.12	T		.03
Gilia (two spp.)	.11	.16	.03	T	.09		.22	.01	.08		.08	.40	1.99	.82	2.23	.56	2.03	3.19	2.77	.74
Halogeton glomeratus	27.06	6.69	3.59	4.00	1.11	.56	15.45	5.94	.23		.47	4.29	3.33	11.05	4.67	4.85	48.82	156.00	36.79	14.53
Lappula redowskii	4.93	2.86	2.19	3.37	2.83	1.56	4.48	4.87	4.32	2.82	1.15	6.34	6.47	2.27	4.47	1.50	2.90	7.05	4.83	3.42
Lepidium montanum (and *L. densiflorum*)	1.10	1.41	1.55	2.66	3.97	.50	2.81	4.42	4.38	3.27	3.72	6.83	.76	.60	.39	.43	.49	2.52	1.17	3.02
Machaeranthera canescens (sometimes biennial)	2.42	1.63	.06	.26	.04		.77	.13				.79	.67	8.27	2.33	.43	2.28	2.19	.06	1.45
Montnella albicaulis													.17		.13					
Phacelia crenulata	7.06	12.29	8.96	8.45	10.93	7.06	3.92	9.98	12.83	14.53	11.91	6.29	5.97	6.21	6.82	.21	1.48	.57	5.07	5.68
Salsola kali	3.41	.17	.88	.07		T	4.47	1.66	.69		.18	12.61	35.99	1.64	42.95	26.08	55.65	52.05	43.96	7.93
Townsendia florifer	.52	.27	.36	.57	.87	.70	.20	.56	.26	.53	.72	1.11	.14	.44	.37	.25		.20	.23	.21
SHRUBS																				
Artemisia bigelovii					.37															
Artemisia frigida					.01	.11						.02						.81	.03	.01
Artemisia spinescens	.42	.69	.08	1.36	2.72	.01	.58	4.94	5.52	.18	2.36	2.13	1.90	.11	.11	1.30	.07	.02	.03	.09
Atriplex canescens			.66	.70			.54								.40		.01	.31	.12	
Atriplex confertifolia	18.00	22.44	26.77	47.59	52.37	22.94	4.98	64.36	52.80	43.12	4.78	64.41	55.09	96.82	63.56	68.96	26.60	36.63	22.99	95.97
Ceratoides lanata	10.99	16.15	19.89	16.23	4.08	1.45	54.18	56.76	20.78	.06	.11	23.03	92.46	189.83	60.96	221.46	36.35	62.97	155.21	125.31
Chrysothamnus nauseosus latisperma	.16	.03	.83	6.60	2.95	.08	1.09	.37	1.89	2.13	4.92		.50		.17				.31	.27
Chrysothamnus viscidiflorus stenophyllus		.17	1.78	4.75	6.38	5.28	.38	.40	.10	1.93	8.69	.13	11.91	.95	14.88	5.03	6.97		22.26	4.74
Ephedra nevadensis	3.37	6.01	4.56	7.10	2.66	5.96	.17	.30	2.71	4.02	7.05	.57			.28		.46	.21		
Gilia pungens	.13			.03			.06										.07			
Gutierrezia sarothrae	.60	.14	.32	.97	2.02	3.37	1.56	1.85	.93	1.39	3.68	.63					.32		.05	.13
Haplopappus sp.		.01																		
Kochia vestita			.18	.10	.24	2.39													.27	
Polygala subspinosa	.02				.24	.06				.05		.04								
Pyrrocoma fasciculata	4.03		1.23	1.24	1.11	.63	.28		.23	.41	3.35	.17	2.30							.73
Tetradymia glabrata				.43	.11					.71	.25				.58					
Tetradymia spinosa				.04							.21									
CACTI																				
Coryphantha vivipara					.02	.02														
Opuntia pulchella	.18		T	.01		.06				T		T			.01					
Opuntia sp.	T	.63	.97	.08		.23	.02	.04			.01		.10	.16	.37	.03		.07		

Table 2. Summary of herbage production by plant groups -- derived from Table 1

Totals	Pasture number																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual Grasses	.20	.29	.08	.09	.20	.76	.61	.47	.42	.70	.67	5.32	.04		.10	.02	.09	1.24	.05	.72
Annual Forbs	49.20	28.37	20.91	21.69	21.19	12.57	33.96	28.08	23.93	23.08	20.90	39.98	68.25	37.52	72.52	41.49	115.96	225.31	102.27	42.74
Total Annuals	49.40	28.66	20.99	21.78	21.39	13.33	34.57	28.55	24.35	23.78	21.57	45.30	68.29	37.52	72.62	41.51	115.65	226.55	102.32	43.46
Perennial Grasses	83.14	68.80	65.54	57.19	56.06	65.04	71.23	43.96	44.38	46.78	56.49	32.24	59.95	13.36	43.68	22.63	37.36	22.41	37.92	23.49
Perennial Forbs	3.21	2.22	2.35	2.77	4.57	4.30	1.91	2.90	3.02	1.13	2.24	2.63	6.02	2.90	5.32	2.04	6.16	.75	1.86	1.27
Total Perennial Herbs	86.35	71.02	67.89	59.96	60.63	69.34	73.14	46.86	47.40	47.91	58.73	34.87	65.97	16.26	49.00	24.67	43.52	23.16	39.78	24.76
Shrubs (including Cacti)	37.90	46.27	57.34	87.23	75.28	42.59	63.84	129.02	84.96	54.00	35.41	91.13	164.26	287.87	141.32	296.78	70.85	101.02	201.27	227.25
Total Perennial Herbs and Shrubs	124.25	117.29	125.23	147.19	135.91	111.93	136.98	175.88	132.36	101.91	94.14	126.00	230.23	304.13	190.32	321.45	134.37	124.18	241.05	252.01
Total Vegetation	173.65	145.97	146.16	168.97	157.30	125.26	171.55	204.43	156.71	125.69	115.71	171.30	298.52	341.65	262.94	362.96	250.02	350.73	343.37	295.47

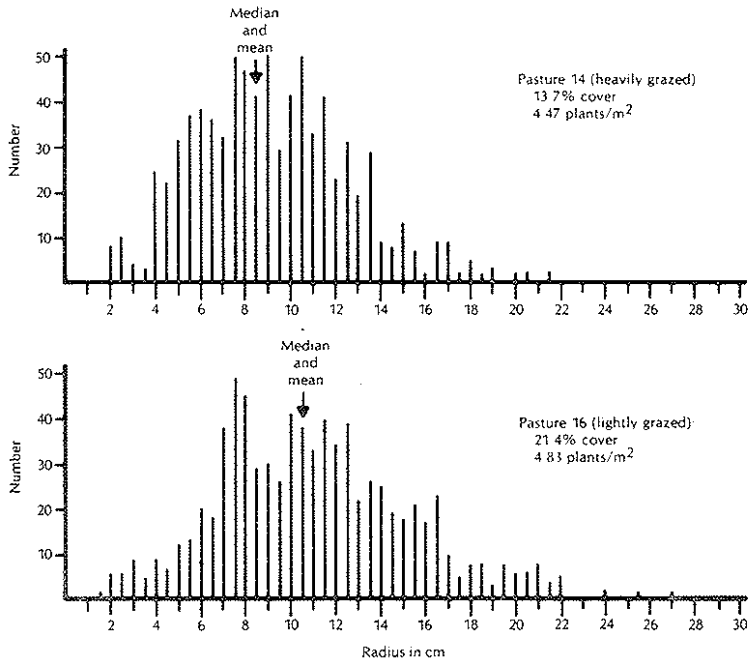

Figure 1. Frequency distributions for *Ceratoides lanata* by plant radius size classes in 0.5-cm increments for a heavily grazed pasture (#14) and a slightly grazed pasture (#16). N = 640 in each case. Plant density and percent cover of *C. lanata* in each pasture are listed on the figure.

It is interesting to speculate that turnover of the winterfat population is occurring a little more rapidly under heavy grazing, provided there is some correspondence between size and age. West and Gun (1974) have reported a decrease in mean life span of winterfat due to grazing at the D.E.R. An association between plant size and age for winterfat has not been established, however, and the shift in the spectrum of plant radii shown in Figure 1 may be simply due to a smaller growth habit adopted under grazing, with a more contracted distribution of perennating buds. The frequency distribution suggests a narrower curve with a higher peak for pasture 14, but this has not been tested statistically to determine whether the heavily grazed pasture has a more uniform plant population than the lightly grazed pasture.

Data on other species and other pasture comparisons were not ready for presentation at the writing of this report. The remaining analysis will be included in the next progress report.

EXPECTATIONS

The next report will concentrate on the following areas:
1. Plant production through time in relation to grazing pressure, season of grazing, climate and site characteristics.
2. The effects of grazing on plant density and plant size.
3. The distribution of biomass in these grazed communitieis, both above- and below-ground.
4. Successional behavior in the communities.

ACKNOWLEDGMENTS

The author wishes to acknowledge the cooperation and support provided by Dr. Neil Frischknecht and Mr. Ralph Holmgren of the Intermountain Forest and Range Experiment Station, USDA Forest Service. The Forest Service contributed one person to the team of three observers conducting the weight estimates of herbage production, and the IBP is grateful for this cooperation. Facilities were kindly provided by the Forest Service at the Desert Experimental Range for overnight accommodation. The maintenance of the grazed pastures with regard to fencing, access roads and livestock arrangements, to which the studies reported herein are indebted, is carried out entirely by the USDA Forest Service. Relations with Forest Service personnel concerning fieldwork and sharing of data have been very friendly.

LITERATURE CITED

COTTAM, G., and J. T. CURTIS. 1956. The use of distance measures in phytosociological sampling. Ecology 37:451-460.

HOLMGREN, R. C. 1975. The Desert Experiment Range: description, history, and program. Pages 18-22 *in* D. N. Hyder, ed. Arid shrublands - Proceedings of the Third Workshop of the U.S./Austral. Rangelands Panel. Soc. for Range Manage., Denver, Colo.

HOLMGREN, R. C., and S. S. HUTCHINGS. 1972. Salt desert shrub response to grazing use. Pages 153-164 *in* C. M. McKell, J. P. Blaisdell, and J. R. Goodin, eds. Wildland shrubs -- their biology and utilization. USDA Forest Serv. Gen. Tech. Rep. INT-1. Intermount. Forest and Range Exp. Sta., Ogden, Utah.

HUTCHINGS, S. S., and G. STEWART. 1953. Increasing forage yields and sheep production on Intermountain winter ranges. USDA Circ. 925. 63 pp.

MCARDLE, R. E., D. F. COSTELLO, E. E. BIRKMAIER, C. EWING, B. A. HENDRICKS, C. A. KUTZLEB, A. A. SIMPSON, and A. R. STANDING. 1936. The white man's toll. Pages 81-116 *in* The Western Range. Sen. Doc. 199, 74th Congress. U.S. Govt. Print. Off., Washington, D. C.

PECHANEC, J. F., and G. D. PICKFORD. 1937a. A weight estimate method for determination of range or pasture production. Amer. Soc. Agron. J. 29:894-904.

PECHANEC, J. F., and G. D. PICKFORD. 1937b. A comparison of some methods used in determining percentage utilization of range grasses. J. Agr. Res. 54:753-765.

STEWART, G., W. P. COTTAM, and S. S. HUTCHINGS. 1940. Influence of unrestricted grazing on northern salt desert plant associations in western Utah. J. Agr. Res. 60:289-316.

WEST, N. E., and C. GUNN. 1974. Phenology, productivity and nutrient dynamics of some cool desert shrubs. US/IBP Desert Biome Res. Memo. 74-7. Utah State Univ., Logan. 6 pp.

WILKIN, D. C. 1973. Model of response of a desert shrub community to sheep grazing. US/IBP Desert Biome Res. Memo. 73-59. Utah State Univ., Logan. 19 pp.

WILKIN, D. C., and B. E. NORTON. 1974. Predicting utilization of forage species on Great Basin Desert winter range. US/IBP Desert Biome Res. Memo. 74-65. Utah State Univ., Logan. 7 pp.