# An Evaluation of Some Common Factors Affecting Utilization of Desert Range Species

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The variable utilization made of a range forage species under different plant associations and intensities of grazing has been a puzzling problem since scientific management of ranges began. The palatability rating or preference index for a particular species is not constant but is highly variable. This variability is a result of relative abundance of the species in the flora, the intensity of grazing on the area, and the presence of other forage species. To the knowledge of the author, no study has ever been undertaken to determine the degree of influence each factor might exert upon the utilization of a particular species in various situations.

The present study was made to evaluate some common factors

known to influence degree of utilization of a given species under variable plant expression and grazing intensity normally encountered on desert ranges in Utah. Multiple regression and correlation techniques were used in analyzing the data.

### Procedure

During a four year period, 1954-1958, fifty desert areas were studied to determine per cent species composition and degree of utilization by sheep during the winter grazing seasons. The areas were located in three broad valleys averaging about 15 miles wide and 30 miles long (Figure 1). The fifty areas represented many variable expressions of vegetation and range condition in west central Utah.

Species composition for each study area was calculated from weight estimates of each species in thirty randomly selected plots. Another thirty plots were randomly selected in each area following grazing by herded sheep to determine the utilization of each species. Degree of utilization on each species in the plot was determined by ocular estimate. The utilization on the areas varied from light to heavy intensity. Average utilization for each area was weighted by quantity of each species present. Average utilization for groups of desirable and undesirable species was obtained by calculating simple mean values from the number of species in each group.

The species found on the study areas are listed in Table 1. The seven most common species were selected for analyses. Three species — galleta grass, Indian ricegrass, and winterfat — were readily eaten on all areas. Four species — three-awn-grass, sand dropseed, snakeweed, and yel-



FIGURE 1. One of the broad valley basins in the northern desert-shrub association where the study was conducted.

lowbrush — were relatively unpalatable and were eaten only sparingly on most areas. The first three species were termed desirable and the latter four undesirable.

Average composition and utilization for the seven selected species on the fifty study areas are presented in Table 2. Average utilization for all species on the study areas was 32.2 percent, and average percent utilization of the desirable and undesirable species was 49.7 and 15.6 percent, respectively. Average percent browse on the study area was 60.9 and average percent grass was 35.4.

The data from the fifty areas were analyzed by multiple regression and correlation. The average percent use for each of the seven chosen species was termed the dependent factor (Y). The independent factors for each species were as follows: weighted average percent utilization of the area  $(X_1)$ , average percent utilization of the more palatable species  $(X_2)$ , average percent utilization of the less palatable species (X<sub>3</sub>), average percent species composition for the individual species being evaluated (X<sub>4</sub>), average percent of the species present/average percent composition of the more palatable species (X5), average percent of the species present/average percent composition of the

less palatable species (X $_6$ ), average percent browse present (X $_7$ ), and average percent grass present (X $_8$ ).

Regression analyses were made by calculating standard partial regression coefficients  $(b^{\circ}_{y1} \dots )$ . These differ from ordinary partial regression coefficients  $(b_{y1} \dots )$  in that they are expressed in terms of units of standard deviations change in the dependent factor (Y) for every change of one standard deviation in the independent factor (X<sub>1</sub>). Therefore, these values for the independent factors are indicative of the relative influence each dependent factor has upon the dependent factor. The ordinary partial regression coefficients are expressed in units of measurement for Y and X<sub>1</sub>, respectively.

The standard partial regression coefficients are sometimes referred to as the direct effect of a factor when all factors except the Y and  $X_1$  in question are held constant.

Another method of expressing the influence of an independent factor upon a dependent factor is by means of simple correlation coefficients (r). The simple correlation coefficient expresses the general nature of the relation-

Table 1. List of plants encountered in fifty study areas by forage classes and palatability groups.

	Scientific Name	Common Name
Browse		
Desirables	Artemesia nova Artemesia spinescens Eurotia lanata Atriplex confertifolia Atriplex canescens Grayia spinosa	Black sage Bud sage Winterfat Shadscale Four-wing-saltbush Hop-sage
Undesirables	Ephedra nevadensis Gutierrezia sarothrae Artemesia tridentata Chrysothamnus stenophyllus Tetradymia spinosa	Jointfir Snakeweed Big sage Yellowbrush Horsebrush
Grasses Desirables	Bouteloua gracilis Oryzopsis hymenoides Hilaria jamesii Sitanion hystrix Stipa comata Agropyron spicatum	Blue grama Indian ricegrass Galleta grass Squirreltail grass Needle-and-thread grass Blue bunch wheatgrass
Undesirables	Aristida longiseta Sporobolus cryptandrus Bromus tectorum Tridens pilosa	Three-awn-grass Sand dropseed Downy bromegrass Hairy triodia
Forbs		
Desirables	Sphaeralcea grossulariaefolia	Mallow
Undesirables	Salsola kali var. tenuifolia Eriogonum supp.	Russian thistle Desert buckwheat

Table 2. Average composition and utilization on fifty study areas in desertshrub range.

Species	Composition	Utilization
	<u> </u>	ent) <u> </u>
Galleta grass	16.8	23.7
Indian ricegrass	8.6	47.7
Sand dropseed	12.5	12.7
Three-awn-grass	1.8	10.4
Snakeweed	3.9	15.6
Winterfat	22.5	51.5
Yellowbrush	23.9	15.1

ship, but  $r^2$  multiplied by 100 expresses the percent of variation in the dependent factor (Y) accounted for by the independent factor (X<sub>1</sub>) when all other independent factors are ignored in the calculation. This is sometimes referred to as the total effect of the independent factor on Y.

For a more complete interpretation of causal relations among the independent and dependent factors when all factors studied are considered, it is necessary to calculate components for each independent factor considered in the coefficient of multiple determination  $(\mathbb{R}^{2_{y_{1}}}, \ldots)$ . The component for each independent factor is the product of the simple correlation and the standard partial regression coefficient (rb<sup>°</sup>y<sup>1</sup> . . .). This, when multiplied by 100, expresses the percent variation in the dependent factor (Y) accounted for by the independent factors  $(X_i)$  when all factors are considered in the calculation.

The coefficient of multiple correlation  $(R_y \ . \ .)$  measures the combined effect of the independent variables on the dependent variable. The coefficient of multiple determination  $(R^2_y \ . \ .)$  multiplied by 100 measures the total percent of variation in Y accounted for by the combined effect of all of the independent factors.

In most multiple regression analyses the independent factors are intercorrelated, and either increasing or decreasing the number of independent factors considered changes the value of all the remaining partial regression coefficients and the coefficient of multiple determination.

### **Results and Discussion**

The influence of each independent factor upon the dependent factor (Y) will be discussed under separate headings.

#### Weighted Average Percent Utilization of the Area X<sub>1</sub>.

The overall intensity of grazing on an area naturally would seem to have considerable influence on the utilization of most of the species present. As shown in Table 3, the overall utilization of each area significantly influenced the intensity of use of four of the seven species studied. Three of these were in the group of species readily eaten and one in the group eaten sparingly.

The significant  $r^2$  values indicate that percent utilization of the areas may account for variation in Y ranging from 9.66 to as much as 24.64 percent. Weighted percent utilization of the area as a component of the multiple coefficient determination or as the joint effect of X<sub>1</sub> in the overall combined influence of all factors considered together, however, was not significant in any case.

# Average Percent Utilization of the More Palatable Species $X_2$ .

The independent factor  $X_2$ was positively associated with the degree of use of each of the seven species except yellowbrush (Table 3). In most cases, as degree of utilization of the desirable species increased, the utilization of individual species increased. For yellowbrush, however, increased utilization of desirable species among the study areas decreased the degree of use made of this species.

By analyzing the relationships of the independent factors, it was found that as desirable plants decreased in quantity on the areas, the utilization of desirable species increased. It was also noted that as desirable plants decreased in quantity, the presence of yellowbrush increased. Thus, as the degree of utilization of desirable species increased, the degree of utilization of yellowbrush decreased.

The average utilization of the desirable species was the most influential factor measured affecting degrees of use of the individual species studied. Generally this was true, regardless of the palatability of the individual species evaluated. This factor alone accounted for over 60 percent of the total variation in Y for some species. The correlation coefficient for this relationship was statistically significant for five of the seven species studied.

The joint effect or the component of influence in the multiple correlation of determination ranged from 6 to more than 50 percent of the variation in Y. This joint influence of percent utilization of any single species in the flora was statistically significant for four out of the seven species (Table 3).

# Average Percent Utilization of the Less Palatable Species $X_3$ .

In most cases the percent utilization of desirable species  $(X_2)$  and the percent utilization of undesirable species  $(X_3)$  were significantly correlated. Therefore, as would be expected from the previous discussion, the average percent utilization of the undesirable species on an area influenced the degree of utilization of any single species in the area.

independent factors $(\mathbf{X}_i)$ , and multip	le coefficier	nt of def	erminati	(zH) uoi	tor seven	common d	esert ra	nge speci	es.			
				And the second	DESI	RABLE S	PECIES					*
		Gallet	a grass		I	ndian rice	grass			Winter	rfat	
Independent factors		% va acco	riation j	in Y for		% va acci	riation j punted f	n Y or		% va acc	rriation i ounted f	n Y or
Xı	$b^{\circ_{yl}\dots j}$	Jointl rb°x1(	y 1 00 r <sup>2</sup>	Alone vix100	b° <sub>y</sub> i1	Jointl rb°x10	y 0 r <sup>2</sup> , A	lone ix100	b° <sub>y</sub> i J	Joint rb°x1	ly 00	Alone 2 <sub>vi</sub> x100
% Utilization of the area X <sub>1</sub> % Itilization of desirable species X <sub>0</sub>	0.14	4.67	**	11.36* 23.60**	0.15 0.62**	47.81 47.81	*	9.66 0.25**	0.20 0.64**	6.8 50.3	4 **	12.02* 31 40**
$\%$ Utilization of undesirable species $X_3$	0.44	23.9(	**	30.21**	0.16	7.47	*	2.15**	0.10	4.3	4	18.06*
$\%$ Composition of individual species $X_4$ $\%$ of the species present/ $\%$ composition	0.53	-6.19	•	1.37	-0.08	-0.38		0.20	-0.57	6.2	6	1.19
of desirable species $X_5$ % of species present $\%$ composition	0.24*	4.8	**	3.90	0.11	3.16		7.92	0.61	0.7	1	0.01
of undesirable species X <sub>6</sub>	$0.14^{*}$	-0.9	~	0.46	-0.03	0.57		4.33	0.09	-2.4	5	6.98
$\%$ Browse present $X_7$	-0.06	-0.0	_	0.00	-0.10	0.26		0.06	-0.23	6.4	5	8.08
% Grass present X <sub>8</sub>	-0.06	-0.1		0.06	-0.20	0.73		0.13	-0.19	-4.1	7	4.56
R <sup>2</sup> x 100		41.31	*			64.35	*			68.3	7**	
					UNDES	SIRABLE	SPECIE	ß				
	Sand	dropseed		Thr	ee-awn-gr	ass	Ye	llowbrush		Ñ	nakewee	F
	%	variation	in Y		% variatic	n in Y	0	% variati	on in Y		% variat	ion in Y
	а	ccounted	for		accounte	ed for		accounte	ed for		accoun	ted for
Independent factors X,	$\mathbf{b}^{*}$	ointly $I$	Alone	b°*11	Jointly rb°x100	Alone $r^{2}_{vix100}$	b°vi 1	Jointly rb°x100	Alone $r^{2_{vi} \times 100}$ ]		Jointly rb°x100	Alone r <sup>2</sup> x100
% Utilization of the area X <sub>1</sub>	-0.37	3.42	0.88	-0.04	-1.98	24.64	0.04	0.01	0.00	0.11	2.52	5.06
$\%$ Utilization of desirable species $X_2$	0.73	36.60*	24.78*	0.24	5.76	5.67	-0.22	7.82	$12.49^{*}$	0.35	14.04	16.06
% Utilization of undesirable species X <sub>3</sub>	0.10	6.60	43.66** 2.66	0.07	1.92	8.19*	0.17	-1.55	0.81	0.78	59.60*	59.04**
% Composition of individual species X4 % of the species present/% composition	- 20.2	03.02	07.0	1.83	-06'T/	15.41*	-0.04	1.76	17.03*	0.92	-10.52	1.32
of desirable species $X_5$	-2.75*	$65.71^{*}$	5.73	-1.58	-46.67	8.72	-0.18	5.05	7.93	-1.02	7.87	0.60
$\%$ of the species $\operatorname{present}/\%$ composition												
of undesirable species X <sub>6</sub>	-0.25	12.93	$26.01^{*}$	0.13	7.33	30.99*	-0.31	11.22	12.97*	0.12	-2.18	3.19
$\%$ Browse present $X_7$	$2.12^{**}$	8.15	0.16	0.84	-26.24	9.66	0.30	1.34	0.20	-0.14	2.98	4.31
% Grass present X <sub>8</sub>	2.37**	11.39	0.23	0.88	42.62	$23.44^{**}$	0.20	0.69	0.12	-0.41	0.25	0.00
R <sup>2</sup> x 100		81.78**			54.70*			26.34			72.04	

Table 3. Standard partial regression coefficients (b<sup>o</sup>vi . . . j). percent variations in Y (percent utilization of single species) accounted for by each of eight

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\* Significant at the .05 level of probability. \*\* Significant at the .01 level of probability.

For six of the seven species the correlation coefficients showing the causal influence of percent utilization of undesirable species upon the percent utilization of a single species were statistically significant (Table 3). Heavier use of the undesirable species among the areas had no appreciable influence on the degree of use made of yellowbrush. The variation in percent utilization of a single species accounted for by considering only factor X<sub>3</sub> varied from 18 to 30 percent for the three more palatable species and from 1 to 59 percent for the four less palatable species (Table 3) . The joint influence of average percent utilization of undesirable species upon percent utilization of a single species in the flora when all factors are considered was somewhat less, generally. The variation in Y accounted for by X<sub>3</sub> jointly, ranged from 4 to 23 percent and from -1.5 to 59 percent among the individual desirable and undesirable species, respectively (Table 3).

The effect of average percent utilization of the undesirable species  $(X_3)$  upon the percent use of each of the more palatable species—galleta grass, Indian ricegrass, and winterfat—was not as influential as the average percent utilization of the desirable species  $(X_2)$ . The influence of  $X_3$  and the influence of  $X_2$ upon the percent use of each of the four less palatable species were about equal (Table 3).

# Percent Composition of the Species in the Flora X<sub>4</sub>.

The relative abundance of a species in the flora would commonly be considered an important factor affecting the degree of utilization that it would receive. However, in the present study this factor significantly influenced the utilization of only two of the seven species studied. These two species—three-awngrass and yellowbrush—were eaten only sparingly on most areas. Nevertheless, this factor  $(X_4)$  was of major importance in determining the utilization of both of these species. The causal effect of relative abundance of a species upon its utilization was negative for some species and positive for others (Table 3). This was true for species in groups of both high and low palatability.

The  $r^2$  values multiplied by 100 showed a significant influence for  $X_4$  on the percent utilization of yellowbrush and threeawn-grass. In each case, respectively, 17.03 and 15.41 percent of the variation in Y was accounted for by  $X_4$  alone (Table 3). For yellowbrush the relationship was negative and for three-awn-grass it was positive. Thus, as the abundance of yellowbrush increased. utilization of it decreased; but as the abundance of three-awn-grass increased, the utilization of it increased.

The effect of abundance of three-awn-grass on utilization of it accounted for 71.96 percent of the variation in Y as a component part of the multiple regression determination. A similar comparison for the other six species showed no significant joint effect for this factor as a component of the multiple regression determination (Table 3).

# Percent of the Species Present/Percent Desirable Species X<sub>5</sub>.

In discussing the effect of this ratio, it should be pointed out that as the quantity of desirable species increases, the quantity of the undesirable species decreases. Moreover, as the quantity of an unpalatable species increases in the flora, there is a high probability that the total undesirable species likewise increases, and the same is true for a palatable species with respect to total desirable species. Thus, a slight increase of a less palatable species would widen this ratio markedly; but a marked increase in a more palatable species would be necessary to widen this ratio even slightly.

The  $X_5$  factor, when considered alone (r<sup>2</sup>), was not significant for any of the seven species. It should be noted, however, that the relationship was positive for the three desirable species, but it was negative for three of the four less palatable species. This indicates that as the proportion of a palatable species increases relative to total palatable species, its utilization increases, but as the proportion of a less palatable species to total palatable forage increases, its utilization decreases.

The standard partial regression coefficients for factors  $X_5$  and Y were significant only for galleta grass and sand dropseed. For each of the species, respectively, this factor accounted for 4.83 and 65.71 percent of the variation in Y (Table 3).

## Percent of the Species Present/Percent Undesirable Species X<sub>6</sub>.

The abundance of undesirable species in relation to the abundance of any single species significantly affected the percent utilization of only three species —sand dropseed, three-awngrass, and yellowbrush-when considered alone as a single factor. Abundance of three-awngrass in proportion to other undesirable species was positively associated with the degree of use made of this grass and accounted for 7.33 percent of the variation in Y as shown by the value of the correlation coefficient squared multiplied by 100 (Table 3). The influence of factor X<sub>6</sub> on the dependent factor Y, when considered alone, accounted for 12.97 and 26.01 percent, respectively, for yellowbrush and sand dropseed. This relationship was negative for both species, thus indicating that as the quantity of each of these species increases in proportion to the abundance of total undesirable species, the utilization of them decreased.

Only one species had a positive r value for the relationship between  $X_6$  and Y. This suggests that as the quantity of a species decreases in proportion to the total undesirable species the utilization of it increases regardless of its palatability.

The standard partial regression coefficient was significant for factors  $X_6$  and Y for only one of the seven species studied. The percent of the variation in Y accounted for by factor  $X_6$  in the multiple regression analysis was small in most cases.

### Percent Browse in the Flora X<sub>7</sub>.

The percent browse present was never a significant factor affecting percent use of any of the seven species studied when this factor was considered alone (Table 3). Only for sand dropseed was the standard partial regression coefficient significant for factor  $X_{7}$ .

### Percent Grass in the Flora $X_8$ .

When the influence of percent grass present was considered alone and jointly, it had a significant influence on the utilization of only three-awn-grass and sand dropseed (Table 3).

The correlation coefficient for factor  $X_8$  and utilization of threeawn-grass was 0.48 and accounted for 23.44 percent of the variation in Y when considered alone (Table 3). The standard partial regression coefficient for factors  $X_8$  and Y for sand dropseed was 2.37, and jointly this factor accounted for 11.39 percent of the variation in Y (Table 3).

# Multiple Coefficients of Determination.

The multiple coefficient of determination for the eight independent factors was statistically significant for five of the seven species studied. From 54.70 to 81.78 percent of the variation in Y was accounted for in these five cases. This indicates that, for the most part, the eight independent factors measured account for most of the variation associated with the utilization of any single species in the flora.

#### Conclusion and Summary

During a four year period, from 1954-1958, fifty individual desert areas used for winter grazing in west central Utah were studied to determine the influence of some common factors on degree of utilization of seven abundant range plants. The data was analyzed by multiple regression and correlation to evaluate the factors affecting degree of utilization of the individual species. The average percent utilization for each of the seven species was termed the dependent factor (Y) and the independent factors included weighted average percent utilization of the area  $(X_1)$ , average percent utilization of the more palatable species  $(X_2)$ , average percent utilization of the less palatable species (X<sub>3</sub>), average percent species composition for the individual species being evaluated  $(X_4)$ , average percent of the species present/average percent of the more palatable species  $(X_5)$ , average percent of the species present/average percent of the less palatable species  $(X_6)$ , average percent browse present  $(X_7)$ , and average percent grass present  $(X_8)$ .

The influence of each independent factor  $(X_i)$  upon Y when considered alone was measured by r<sup>2</sup>100 and by rb<sup>°</sup><sub>yi</sub>...100 when operating jointly with all factors considered in the calculations.

The percent use for each of the three more palatable species was significantly influenced by  $X_1$ ,  $X_2$ , and  $X_3$  when these were considered alone and by  $X_2$  when they were operating jointly. The percent use of three of the four less palatable species was significantly influenced by either  $X_2$  or  $X_3$  or by both when the factors were considered alone or jointly.

The other factors,  $X_4$  to  $X_8$ , were equally as important as  $X_1$ ,  $X_2$ , and  $X_3$  for some species, but in most cases they were significant for only one to three of the seven species studied.

The quantity of each of the species present was of major importance in determining the utilization of two of the less palatable species, three-awn-grass and yellowbrush.

The data indicate that when the quantity of a palatable species increases in proportion to the other palatable species, the utilization of it increases, but as the quantity of an unpalatable species increases in proportion to the total palatable species, the utilization of it decreases.

The quantity of a species present in proportion to the total quantity of unpalatable vegetation significantly influenced the degree of utilization only for three rather unpalatable species. In six out of seven species studied, this relationship was negative.

Multiple regression coefficients using all eight independent factors were significant for five of the seven species studied. The coefficients showed that these eight factors, when considered together, accounted for as much as 82 percent of the variation in Y.

Each of the independent factors significantly influenced the degree of utilization of at least one or more of the seven species studied, but the influence for any one factor varied widely among species.

Even though the influence of each of the independent factors upon utilization of a species varied widely among the seven species, some were of sufficient importance to account for more than 30 percent of the variation in Y for most of the species studied.