

Studies Show Grazing Stimulates Range Plants

RENO (Special) — A Nevada range plant grazed at judicious levels may produce as much as 80 per cent more plant material than one completely protected!

Studies conducted by scientists in the College of Agriculture, University of Nevada for more than 10 years indicate that range plant health is related to grazing and browsing stimulation.

Contrary to what some people may think or believe, plants grazed at relatively intense degrees though not to the point of abuse are healthier and more productive than those which have had no use.

"The cessation of all grazing on a Nevada range could be as harsh or harsher treatment and impact on the range than that of over grazing," said Dr. Paul T. Tueller. Dr. Tueller is a professor of range science and management at the University and has been involved in studies of Nevada range lands now for more than 14 years.

In light of recent interest around the state in Nevada's public domain range lands and how they may be used, Dr. Tueller commented about some interesting facets of range ecology that might not be generally known.

"Nearly all of the plants in the State of Nevada have developed over thousands of years with the pressure of browsing or grazing by wild animals and later livestock." He added, "Our work has shown that if plants don't

receive the annual stimulus of grazing or browsing at a judicious level they may become what is called "stagnated." Dr. Tueller explained that in this condition the plants become less vigorous, show symptoms of poor health, and can become considerably less productive.

In the course of Dr. Tueller's studies, Three-Phase Range Enclosures were used and located at various areas in Nevada. One part of such an enclosure is surrounded by a high fence which prohibits access by either domestic animals, deer or other wildlife and may be protected at the bottom from rodents. Adjacent to this is an enclosure with a lower fence that keeps out livestock, but lets deer in (by jumping) and finally there is a third area where all species may graze or browse.

Plants within the totally protected area and which have been protected for a number of years were compared to those in the outside areas. Special temporary enclosures were used so that a season's growth of a browsed or grazed plant could be accurately measured. In some cases, the continuously browsed or grazed plant, protected only through one growing season as a means of comparison produced up to 80 per cent better than the fully protected plants.

Enclosures studied were located at Paine Springs in Duck Creek Valley of White Pine County, at White Rock between Lincoln and White Pine, on the Morey Bench in Nye County and at Fort Ruby on the south end of the Ruby Mountains in Elko.

On a measurement of bitterbrush, as an example, browsed plants produced 33.7 pounds of feed per acre on the Morey Bench compared to 7.3 pounds for fully protected plants on the inside of an enclosure.

Interestingly, one often sees such enclosures or pictures of them where the plants like bitterbrush look large and bountiful on the inside of the enclosure while they look beaten down hedged and grazed or browsed low on the outside. Yet closer examination may show that the hedged or grazed plants might have a healthier more vigorous color, may have more new growth or leader per stem and more leaves per leader. This compares stagnation with browse stimulation.

Dr. Tueller says that most plants respond accordingly. Upon enclosing an area, the grass at first shows extreme vigor, grows high and healthy and looks very good. However, growth the following growing season may be seriously hampered by crowding and stems of the old, unused grass. Plants measured in the enclosure studies included grass, forbs, bitterbrush, big sagebrush, desert peach, rabbitbrush, service berry, horsebrush and others.

"It would appear that over many years plant communities have developed in tune with certain levels of grazing and that changes in such relationships to any great degree could be expected to be at least as detrimental as beneficial," Dr. Tueller noted. He concluded by saying that data pertinent to such study is now in the process of being compiled for publication.

Vegetation Stagnation in Three-Phase Big Game Enclosures

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Abstract

The allocation of range forage for deer and livestock is an important range management problem. Utilization of the three-phase enclosure technique for such evaluations is complicated by the response of plants to nonuse. Protection from browsing can cause "stagnation" to occur as early as the second year after the enclosure is established. **Nonuse of bitterbush resulted in an average reduction in production of 70%.** Temporary enclosures moved each year are required for accurately determining annual forage production.

Resource managers lack methods that will give reliable estimates of site productivity and its relationship to carrying capacity for either livestock or big game. One procedure often followed for partitioning forage has been the use of three-phase enclosures.

This paper reports a 6 year study to determine site productivity (i.e., pounds of vegetation produced per hectare) through the use of three-phase enclosures and temporarily erected movable enclosures. Production refers to the total annual dry matter increment of grasses, forbs, and browse. Effects of different species, plant density and dispersion characteristics, vegetation stagnation caused by lack of grazing, and site differences within three-phase enclosure all tend to confound range production and utilization data. Factors considered to influence these results are precipitation, past utilization, condition and trend of the vegetation, and the period of protection from grazing. *Stagnation* can be defined as the

reduction in productivity of range plants resulting from a lack of grazing.

Use of enclosures for rangeland evaluation has received wide acceptance. Daubenmire (1940) defined the enclosure as any experimental area which is protected from the activities of a particular class of animal by a barrier such as a fence or screen. They have some drawbacks, such as the barrier effect which will influence wind movement, precipitation, and seed collection. Three-phase enclosures were used as early as 1932, to discover and demonstrate the food preferences of animals (Young 1955). Each phase should be 1 acre (.405 hectare) or larger to have the least effect on the probability that deer will enter and should be located so that all phases are located on a single vegetatively homogeneous and representative part of the rangeland (Young 1958). Jones (1965) and McMahan (1966) have used the enclosure technique to study relative utilization, cover and compositional changes, and other effects.

Methods

Four important Nevada deer ranges and corresponding enclosure sites were selected for this study. Paine Springs, White Rock, Morey Bench, and the Fort Ruby sites were selected on the basis of vegetal homogeneity among enclosure phases and because they represent important deer winter range habitat-types.

The Paine Springs enclosure, built in 1962, is located in the Duck Creek Basin, near McGill in White Pine County within an *Artemisia tridentata/Purshia tridentata/Poa secunda* plant community at 2,073-m elevation. The White Rock enclosure, near White Rock Peak in Lincoln County, is situated in an *Artemisia tridentata/Purshia tridentata/Poa secunda* plant community at approximately 2,190-m elevation and was constructed in 1965. Morey Bench is in Hot Creek Valley east of Tonopah in Nye County. A three-phase enclosure was built there in 1965 situated in an *Artemisia tridentata/Purshia glandulosa/Prunus andersonii* plant community at the base of Morey

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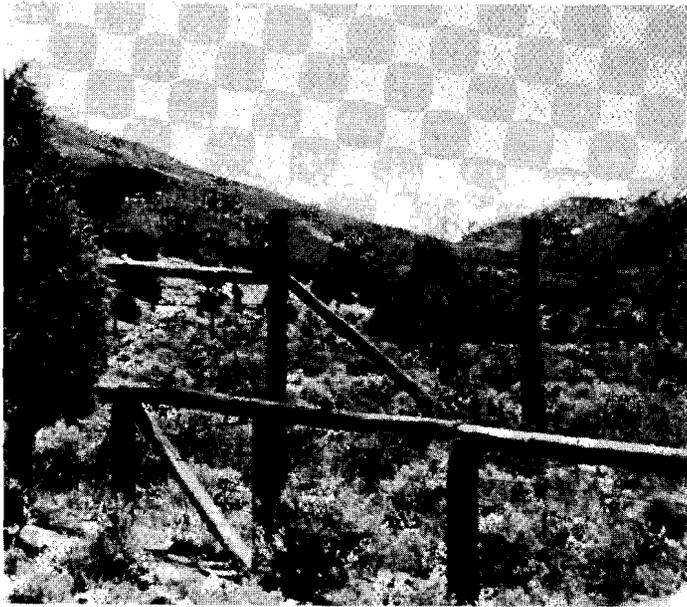


Fig. 1. The Three-Phase Enclosure: Phase A (high fence) and Phase B (low fence).

Peak (2,072 m). The Fort Ruby enclosure, constructed in 1959, is located at 1,920 m elevation just south of the Ruby Marshes in White Pine County. The boundaries of the latter enclosure encompass an ecotone comprised of the *Pinus monophylla*/*Juniperus osteosperma*/*Artemisia nova* and the *Artemisia nova*/*Chrysothamnus viscidiflorus*/*Purshia tridentata* plant communities.

All enclosure areas consist of three phases (Fig. 1), each encompassing .405 hectares (1 acre): one phase is fenced to exclude all foraging (Phase A); a second fence excludes livestock but allows deer foraging (Phase B); the third is unfenced and allows both livestock and deer foraging (Phase C). The following assumptions are made: highest production, a measure of site potential, is achieved in Phase A; deer utilization is represented by the difference in production between Phase A and Phase B following the foraging season; livestock utilization is derived from Phase B production after grazing less Phase C production after grazing.

Vegetation at each site was originally described using a modification of the method described by Poulton and Tisdale (1961) including cover and density. Ten transects each of ten contiguous frequency quadrats were employed to determine frequency. Twenty- or 30-inch (50.8 or 76.2 cm) square quadrats were used. During the summer of 1969, cover data were obtained from individual clip plots of both temporary and permanent enclosures. Height in meters to the highest point and density measurements of selected shrub species were taken within the 20 ft by 20 ft (6.1 × 6.1 m) clip plots.

Annual Forage Production

Production data were obtained by the clip before-and-after method. Bitterbrush was clipped on plots 20 ft by 20 ft (6.1 × 6.1 m). Sagebrush and other shrub species were clipped from a 10 ft by 10 ft (3.05 × 3.05 m) plot, and production of grasses and forbs was determined by clipping a plot 4 ft by 12 ft. Both latter plots were nested within the larger plot. Five 20 ft by 20 ft (6.1 × 6.1 m) clip plots were located at random from among the total of 100 in each phase. By restricting the randomization, new plots were clipped each year.

Grasses and forbs were clipped at ground level. Bitterbrush and serviceberry were clipped of all current year's twig growth. On sagebrush current annual growth is difficult to determine. Therefore, new shoot length was estimated before being clipped. Data represent total annual vegetative yield and not necessarily available forage. However, it is felt that all material clipped in this study was available to the grazing animal. Clippings were oven dried at 70° for 48 hr., weighed, and the weights converted to kilograms/hectare.

Five temporary enclosures square in shape, each encompassing an area of 400 ft² (37.16 m²), were located within Phase C at each enclosure site during the summer of 1968. Five older temporary enclosures of the same dimensions were erected at the Paine Springs and Morey Bench sites in the summer of 1966.

The temporary enclosures were used to supply a better estimate of site potential than that obtained from Phase A, or the continuously protected area. They provide protection from grazing for one growing season only, and were moved each year. Total annual production was measured on the vegetation within these structures and compared to that taken from Phase A. By this comparison the effect of stagnation can be quantified.

Employment of the temporary enclosure technique makes possible the assessment of the effects of stimulation provided by grazing on forage production. This technique eliminates the influence due to "stagnation" and gives a better estimate of the annual potential production of a particular site.

Shrub yields were corrected on the basis of volume-of-area occupied per species in an effort to overcome the problems of vegetation heterogeneity among phases. Harniss and Murray (1976) have shown that the dry leaf weight production of sagebrush can be estimated from height and circumference measurements. Their literature review showed that shrub production can be related to crown diameter, stem diameter, foliage cover and basal area and known volume. Similar relationships held true for certain grasses (Pasto et al. 1957; Evans and Jones 1958; Frakes 1959; Reppert 1962; Payne 1974; Uresk et al. 1977).

A multiple linear correlation analysis was used to test the relation of cover, height and density to yield. The relation of each sampled parameter to yield was determined for sagebrush and bitterbrush taken from each sample plot. If the correlations were found to be significant, the standard partial regression coefficients were computed and used as measures of the relative importance of each independent variable on yield. In this manner, a weighted index using the standard partial regression coefficients of each independent variable can be used to correct the yield data of each phase of the enclosure to that recorded from the temporaries. This constitutes a correction to a level of production that could be expected if stagnation had not been a factor.

The formula derived to correct yields of the various enclosure phases to that taken from the temporaries is:

Estimation of Deer Use

Relative deer use among the enclosure phases was tested (a *t*-test for paired plots) by comparing counts taken from each phase of the enclosure system. Pellet groups were counted in ten 0.01-acre (0.004 ha) plots in each phase. These values were divided by 13, the average pellet groups/day/deer, in order to convert the data to deer-days use per acre (Smith 1964). Counts were not significantly different at the 0.05 level of probability, and deer use between Phase C and Phase B was considered equal.

Results

The protected areas must produce the same quantity as the browsed and grazed vegetation if the three-phase enclosure is to provide information on deer-livestock competition as computed from differences in utilization. Data from our four study sites show that the effect of vegetation stagnation precludes this capability.

Paine Springs

Production data (Table 1) were too variable for any conclusions concerning deer-livestock competition or for comparisons of the vegetation production among enclosure phases. However, the erection of temporary enclosures provided data on total vegetation production. Cover, height and density were significantly related to the corresponding yield of bitterbrush in simple and multiple linear regression analysis (Table 2). The standard partial regression coefficients have been weighted

Table 1. Yields expressed in kilograms/hectare of oven-dry forage at four study sites.

Study site	Phase	Year	Paine Springs				White Rock				Morey Bench			Fort Ruby			
			Artr	Putr	Grass	Forbs	Artr	Putr	Grass	Forbs	Artr	Pugl	Forbs	Arno	Putr	Grass	Forbs
A	1964	101.5	54.0	74.0									75.2	2.0	3.6		
	1965	112.3	37.8	91.5		239.2	69.6	48.9		3.0	57.4	23.1	67.4	3.7	7.2		
	1966	46.7	1.2	140.8	11.2	79.5	63.9	52.5	5.9	329.1	643.7	18.3	23.2	2.9	10.3	5.8	
	1967	402.3	56.1	129.2	11.5	371.1	52.5	37.7	50.2		439.1	34.2	102.4	5.1	26.9	57.4	
	1968	78.1	11.1	191.4	7.9	73.2	10.1	216.4			176.4		39.0	2.4	33.4	23.6	
	1969	157.4	16.1	167.2	22.6	436.2	52.5	79.5	14.9		8.2		96.3		91.5	100.3	
B	1964	85.9	38.4	79.4									48.2	1.7	5.8		
	1965	41.4	66.1	139.9		223.6	36.9	40.9		8.4	33.7		58.6	0.7	13.4		
	1966	65.4	5.7	45.4	2.6	299.8	33.5	41.4	14.5	32.7	569.6	10.8	101.2	3.9	7.1		
	1967	63.9	53.9	123.3	16.7	324.1	106.5	52.2	19.7		611.5		94.9	14.9	31.9	88.9	
	1968	136.7	30.1	174.3	0.6	231.2	18.3	27.2			204.2		73.9	1.1	23.8	1.6	
	1969	173.8	8.7	117.4	2.4	478.3	114.3	73.2			29.9		191.4	6.0	36.8		
C	1964	97.6	11.2	36.7									52.1	0.3	0.9		
	1965	110.3	17.3	36.4		157.3	22.2	44.4		8.0	13.4		24.7	0.4	6.3		
	1966	32.3	4.5	19.7	3.0	115.7	19.2	18.9	10.0	15.7	394.5		46.7	3.8	2.6	2.6	
	1967	137.6	90.8	102.6	30.5	234.4	121.3	42.5	18.9		592.7		193.6	3.6	28.7	4.9	
	1968	84.2	28.6	53.9	1.6	222.4	10.8	25.0			135.6		99.4	1.9	0.6		
	1969	140.2	18.9	62.7	5.9	396.1	83.9	33.6			21.0						
Old temporaries	1967	284.1	105.7	98.6	13.8							426.3	89.7				
	1968	81.1	84.5	244.9	55.3							26.2					
	1969	208.6	102.9	181.7	11.2							31.4					
New temporaries	1969	277.8	40.8	110.7	17.9	450.9	181.4	88.1	1.0			97.4	432.1	6.9	49.2	20.7	

Artr - *Artemisia tridentata*
 Arno - *Artemisia nova*
 Putr - *Purshia tridentata*
 Pugl - *Purshia glandulosa*

44.1% for cover, 26.1% for height, and 29.8% for density.

For the 1969-1970 period, potential production of bitterbrush in the temporary exclosures was 40.8kg/ha while yield from the completely protected area was only 16.1 kg/ha. Hence, Phase A produced only 39% of its potential in 1969, and stagnation has accounted for a 61% reduction in production following protection for 8 years. A correction of yield in the A phase based on the weighted index shows that without the effect of stagnation the production of bitterbrush based on cover, density, and average height of plants should have been 41.56 kg/ha.

Cover percentages of *Artemisia tridentata* from the temporary exclosures and Phase A were 10.43% and 10.94%, respectively (Table 3). However, sagebrush in Phase A has produced only 59% of that recorded from the temporaries. For rabbitbrush (*Chrysothamnus viscidiflorus*), the temporaries produced approximately one-third of that recorded in Phase A. For grasses, the results were variable. The old temporaries had higher yields in 1968 and 1969 but not in 1967. This is explained in part by the effect protection from grazing has on plants previously subjected to heavy utilization. Although basal cover estimates for grasses were approximately equal, yield was greater in plots protected for 8 years. Perhaps the stagnating effect expressed by shrubby species allows for a "release" of previously suppressed grass species so that growth and subsequent yield are increased. Data from the control plots (Phase C) indicate that stagnation has, indeed, occurred for shrubs. Shrub species show a large reduction in productivity as a result of continued protection from grazing. Whenever the B or C phase outproduces the A phase, some irregularity in the technique is indicated. On the other hand, grasses and forbs show a definite increase in total forage produced due to protection from grazing, even though production outside is greater during a good year. These data suggest that the area is not presently being grazed at

its potential. Yield figures from two different sets of temporary exclosures show potential forage production from all plants to be greater than 448 kg/ha of oven dry forage.

Comparisons of the data obtained from the temporary and existing exclosures indicate that protection from grazing has caused a sizable reduction in the amount of browse production. Both bitterbrush and sagebrush were at a static low level of production due to the lack of utilization. Results from the old temporary exclosures show that 100% simulated utilization for those two species over 3 years, a measure of site productivity, produced yields that were greater than from those plants receiving "normal" grazing at the Paine Springs site. This suggests that the "normal" grazing patterns were not sufficient to provide the annual grazing stimulus required to give optimum browse production at some judicious utilization rate.

White Rock

Initial results appeared favorable for the prediction of the relative use by wildlife and livestock for bitterbrush and sagebrush (Table 1). However, the effects of stagnation were obvious after less than 2 years.

The standard partial regression coefficients calculated from the analysis of cover, height and density (Table 2) were rated 39.94%, 19.76%, and 42.30%, respectively. Phase A could have produced 172.6 kg/ha of bitterbrush under similar treatment and is comparable to the site potential obtained from the temporaries, where 181.4 kg/ha of bitterbrush was recorded. Stagnation is thought to be responsible for the phase A production of only 52.5 kg/ha of bitterbrush, or 30% of its potential. Stagnation has accounted for a 70% reduction in production from site potential after 5 years of continued protection from the annual stimulus of grazing.

Stagnation caused less reduction in sagebrush production. Cover percentages for sagebrush show that the A phase and the

Table 2. Simple and multiple linear correlations of vegetative parameters from bitterbrush at four study sites.

Variables				Paine Springs		White Rock		Morey Bench		Fort Ruby	
X ₁	X ₂	X ₃	Y	r	r ²	r	r ²	r	r ²	r	r ²
C			Yield	.919 ^b	.845	.816 ^b	.666	.878 ^b	.771	.841 ^b	.707
H			Yield	-.778	.605	.467	.218	-.246	.058	.196	.038
D			Yield	.890 ^b	.792	-.802 ^b	.643	.654	.428	-.070	.005
C	H		Yield	.974 ^a	.949	.816 ^b	.666	.878 ^b	.772	.869 ^b	.755
C	D		Yield	.930 ^b	.865	.878 ^a	.771	.963 ^a	.928	.977 ^a	.954
H	D		Yield	.898 ^b	.806	.813 ^b	.661	.665	.442	.206	.042
C	H	D	Yield	.997 ^a	.994	.901 ^a	.812	.991 ^a	.982	.988 ^a	.977

C = cover; H = height; D = density; ^a = significant at .01; ^b = significant at 0.1; r = regression coefficient; r² = coefficient of determination

temporaries are almost equal. Yields from 1969 show production in Phase A to be slightly less (436 kg/ha) than that taken from the temporary exclosures (451 kg/ha) (Table 1). Likewise, differences between the temporaries and B and C phases of the exclosure show no statistical significance.

Grass in the A Phase had a greater cover percentage but a lower density than that recorded from the temporary exclosures. Yields for the 1969 season showed production to be approximately equal and only slightly higher in the temporary exclosures when compared to the A and B phases. Yield was much lower for the C phase, indicating that production was greater in the temporaries possibly due to vigor brought about by the first years of protection from grazing. Protection from grazing for one growth season and favorable growing condition appear to be responsible for the increase in production of the grasses previously subjected to heavy annual utilization by cattle at this site. Our test was not sensitive enough to predict the effect, if any, stagnation may have had on the grass inside the completely protected area.

The differences in forb yields appear to be simply a function of frequency of occurrence and cover percentages in each phase. Forb cover in the temporaries is barely more than a trace and

frequency of occurrence is less than half that in the A phase (Table 3).

Protecting the vegetation for only one growing season accompanied by favorable precipitation showed that potential forage production at the White Rock exclosure can be much greater than the level of the production represented by the control area. The temporary exclosures produced approximately 721 kg/ha of oven-dry vegetation during an average precipitation year (1969) and thus probably is a good representation of site potential.

Morey Bench

The Morey Bench exclosure was constructed in January of 1965 and the first year's production and utilization data yielded a computed 77% utilization of desert bitterbrush (Table 1). However, by 1967 stagnation was noticeable. Cover and height alone may not adequately weight the index for correcting the production yields (Table 3) at this site. The added influence of density in the computation of the correlation coefficients showed a higher level of significance than that recorded for cover times height on yield. Therefore, density measurements from within the A phase the the temporary exclosures were used

Table 3. Vegetation parameters for sagebrush and bitterbrush on four Nevada deer range in 1969.

Study Site	Phase	Paine Springs		White Rock		Morey Bench		Fort Ruby	
		Artr	Putr	Artr	Putr	Artr	Pugl	Arno	Putr
Cover (percent)	A	10.94	10.87	15.45	10.31	6.57	16.20	11.04	
	B	12.09	5.14	21.11	9.40	3.98	17.95	17.61	0.91
	C	10.46	10.24	14.19	9.49	4.51	14.01	16.02	0.29
	Temporaries	10.43	9.94	15.30	7.88	5.37	25.34	16.62	0.62
Frequency (percent)	A	75	20	86	36	27	35	71	3
	B	61	18	76	29	23	34	74	14
	C	73	15	69	50	6	27	73	4
Height (meters)	A		0.75		0.54		1.15		0.26
	B		0.72		0.56		1.13		
	C		0.67		0.32		1.07		
	Temporaries		0.64		0.43		1.19		0.39
Density (plants/hectare)	A		1453		3499		1507		1550
	B		1238		3121		1292		
	C		1507		6944		1184		
	Temporaries		1829		6027		2422		10979

Artr - *Artemisia tridentata*
 Putr - *Purshia tridentata*
 Arno - *Artemisia nova*
 Pugl - *Purshia glandulosa*

in the computation of the index (Table 3). The standard partial regression coefficients have been weighted 48.59% for cover, 17.9% for height, and 34.22% for density.

Production in Phase A for 1969 showed bitterbrush had produced only 22% of that recorded from the temporary exclosures (8.2 kg/ha). The site could have potentially produced 37.8 kg/ha. Stagnation apparently accounted for a 78% reduction in production of the site potential in bitterbrush due to 5 years of protection from grazing. The sparse distribution of herbaceous species and the high variability of occurrence of the other shrub species among exclosure phases made analysis difficult.

An increase in precipitation during 1966 above that received in 1965 (a low precipitation year) brought a corresponding increase in yields. An even greater increase in precipitation during 1967 showed a proportionate increase in bitterbrush yields from the B and C phases. In contrast, Phase A not only produced less bitterbrush in 1967 than in the drier year of 1966, but was also outproduced by both the B and C phases during 1967, suggesting that stagnation had occurred after 2 years of protection. The potential of this site is greater than any other site studied (Table 1). The site may produce as much as 426.3 kg of bitterbrush per hectare in a good year. Forage plants protected for annual utilization by wildlife and livestock exhibited stagnation, accounting for a sizable reduction in yield. Plants hand clipped 3 successive years to simulate 100% utilization of the annual growth produced over four times as much plant material as the plants protected from grazing for 5 years and then clipped to simulate the same 100% utilization.

Results suggest (Table 1) that present utilization of the area by livestock and deer is reducing bitterbrush production. Past and present use has reduced both the average height and number of individuals per hectare in the control area (Table 3).

Fort Ruby

Bitterbrush plants were few in numbers at this location (Table 3). Black sagebrush was the dominant shrub. Forage potential for grass species was generally low due to the high proportion of low volume producers such as *Poa sandbergii*.

The standard partial regression coefficients have been weighted 55.88% for the cover, 9.96% for the height, and 34.16% for the density of *Artemisia nova* based on the regression results (Table 2). Ten years of protection from the stimulus of grazing has accounted for a 65% reduction in site productivity in terms of black sagebrush production (Table 1). Results from the previous sites show that stagnation may have occurred within 2 to 3 years after protection.

Phase A produced 96.3 kg/ha of black sagebrush during the 1969 growing season but could have produced 270 kg/ha of black sagebrush under similar treatment. Black sagebrush produced only 35% of its potential.

For rabbitbrush (*Chrysothamnus viscidiflorus*) the relative cover percentages of Phase A and the temporaries were 2.66% and 3.43%, respectively. A comparison of yields shows 92 kg/ha of rabbitbrush from the temporaries and 30.1 kg/ha from Phase A. It is doubtful that a 1% greater canopy cover of rabbitbrush can account for almost a three-fold increase in yield. It appears that stagnation has occurred in this species, also. Observations during the collection of spring clippings confirmed deer utilization of rabbitbrush.

The response of grasses and forbs to continued protection from grazing was similar to that observed on other sites. Grass and forb cover in Phase A was only slightly higher than in the temporaries. Yet grass production in the completely protected

area was approximately twice that recorded from the temporary exclosures in 1969. Forb yield is almost 100.9 kg/ha in phase A as compared to 20.2 kg/ha recorded from the temporaries.

The effect of continued heavy utilization on grass and forbs becomes apparent when yields from the temporary exclosures are compared to past yields recorded from the B and C phases subject to utilization by wildlife and livestock (Table 1). Protection for 1 growth season allowed a marked increase in vegetation production. The higher production of grasses and forbs in Phase A for 1969 is not explained by the data but may be due to the higher cover of forbs and slightly higher cover of grass (Table 3). Precipitation recorded at the exclosure site since 1965 shows that favorable growing conditions prevailed during the 1969 growing season. Results from the erection of temporary exclosures at this site provide evidence that continued protection from the stimulus of grazing has a strong influence on the shrubs. The data are not clear cut for the grass and forb components and may be partially masked by the favorable growing conditions in 1969. Additional years would be required to determine whether stagnation occurs in grass and forb species.

Discussion

Utilization of the three-phase exclosure technique for rangeland evaluation is complicated by the responses of plants to nonuse. Garrison (1953) found shrubs unclipped and/or lightly clipped generally produced the least forage. Bitterbrush plants protected for 9 years produced 71% less than those that were browsed annually (Martinson 1960). Browsing tends to remove the apical bud resulting in an increase in twig numbers due to lateral branching. The initial imbalance in the shoot-root ratio due to severe removal of top growth creates an abundance of soil moisture and nutrients which favour new shoot growth (Ferguson and Basile 1966). Twig growth on spring-pruned mountain mahogany increased from less than ½ inch annual growth before pruning to an average of 2.8 inches annual growth after pruning (Thompson 1970). Others have shown similar relationships with shrubs (Lyon 1966; Gibbens and Schultz 1962; Ferguson 1968). The utilization of course must be judicious. For example, removal of greater than 50% of the desert shrubs in late spring and summer for 3 years reduced yields, while 90% removal of current growth killed many of them (Cook 1971). However, browse production increased in many species including bitterbrush, when 25 or 50% of the current year's growth was removed in fall or winter (Lay 1965).

This study has shown that nonuse in the fully protected area (Phase A) of an exclosure system causes vegetation stagnation of shrubs to occur as early as the second year after the exclosure is established. This condition was maintained for at least 8 years and, presumably, lasts indefinitely. Potential browse production in the A phase was reduced, depending on the site, from 3 to 78% of the average annual productivity of shrubs receiving the annual stimulus of browsing. **Nonuse of bitterbrush resulted in an average reduction in productivity of 70%. For big sagebrush the figure was 36%.**

Exclosure sites previously subjected to heavy utilization of grasses and forbs by livestock show that continued protection favors good growth and high yields of these species. Grass plants protected from grazing for several years produced up to 100% more vegetation than plants protected for only one growing season. The proper season and degree of use may be beneficial to be grazed grasses by increasing tillering, number

of leaves and percent ground cover (Jameson 1963; Laude et al. 1968; Heady 1975, p. 19). In this study forb production was 20% higher in the fully protected areas than in the temporary exclosures. Stagnation exhibited by the shrub species probably contributed to the increased grass and forb yields by providing a release of moisture and nutrients to the forbs and grass. This is substantiated by the fact that basal area of grasses and forbs was the same in fully protected and the temporary exclosures. It must also be considered that grasses and forbs within the exclosures may be competing with the shrubs, thus contributing to the stagnation.

However, on some sites there is evidence to suggest that grass production, while higher in those areas protected for several years, is still lower than it might be with the annual stimulus of grazing. There is limited evidence that saliva from grazing animals adds thiamine to grasses and stimulates these plants to greater growth (Reardon et al. 1972). Grass plants inside phase A were usually large with numerous culms, many of which were dead, giving them a much different appearance than the grazed plants. It appears that the plants were unthrifty due to the many dead culms.

The effect of stagnation in exclosures can be quite vivid. This is a noteworthy value of constructing such exclosures. Much useful information can be derived from exclosures by the agencies involved with range management if they are interpreted correctly. The stagnation effects on vegetation caused by lack of grazing are often not considered when exclosures are used for demonstration.

Some level of stagnation probably exists on any site that is not receiving at least a moderate degree of annual grazing or browsing. **Data from this study indicate that stagnation is also evident in the portion of the exclosure systems utilized by deer only.** Yield recorded under this condition would account for the fact that the control, or C phase of the exclosure site, produces more than the B phases. This masking effect on yield serves as a great source of error in computing the relative utilization of forage by wildlife and livestock.

The three-phase exclosure technique can only be sensitive and supply reliable data in areas receiving moderate to heavy utilization (35-65%) and only when used in conjunction with temporary movable exclosures so that reliable information on annual forage production can be obtained.

Large, profound year-to-year differences in production can be attributed to weather variation. Differences in forage productivity of up to 12 times from one year to the next have been measured (Tueller and Monroe 1975). These variations may supercede or mask the effects of stagnation, or at least make it extremely difficult to measure.

The corrections used in this study to adjust yield data from clipped plots have application in providing a more accurate method of measuring the degree of relative forage utilization from within the B and C phases of the three-phase exclosure system. Smith and Urness (1962) have pointed out that relative utilization figures alone, without some index of production, cannot indicate the pounds of forage utilized by either game or livestock. However, they do reflect the pressure exerted on the range. Production data obtained in this study in conjunction with information on food preferences provided by the exclosure system justify the use of such tools in rangeland evaluation.

Such exclosures may also serve as excellent training grounds for students.

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