Dependence of standing crop on range condition rating in New Mexico

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Abstract

The Sandy Ridge Site of southern New Mexico was studied to determine the dependance of total standing crop and components of standing crop on range condition rating. Total standing crop which included mesquite (*Prosopis glandulosa* Torr.) decreased, but total standing crop minus mesquite increased as range condition rating increased. These relationships were found to be highly significant ($P \leq 0.01$) by regression analysis. Very low R-square values for these models indicate that the often assumed positive linear relationship of standing crop to range condition rating is not reliable. Prediction of standing crop from range condition ratings using linear or quadratic models was found to be unreliable for the Sandy Range Site in southern New Mexico.

Key Words: ecological status, trend, forage production, biomass

Range condition classification has become the basis for adjusting stocking rates and revising management plans, a procedure which has resulted in considerable controversy. One commonly used procedure, developed by Dyksterhuis (1949), assumes that forage production increases as range condition increases. This study was conducted to determine if this relationship applies to a rangeland area classified and mapped as the Sandy Range Site in southern New Mexico.

With the Dyksterhuis method, rangelands in early stages of secondary succession are classified poor while those in climax stages are excellent. The procedure is based on estimating the percentage of the present plant species composition by aerial cover or weight that is considered to be part of the climax stage of succession for the site.

Four condition classes are:

Poor	0 to 25% of climax
Fair	25 to 50% of climax
Good	50 to 75% of climax
Excellent	75 to 100% of climax

The Range Inventory Standardization Committee (1983) proposes that the term range condition be replaced with ecological status and the classes of poor, fair, good, and excellent be replaced with the classes of early seral, mid seral, late seral, and potential natural community, respectively. The plant species composition in the potential natural community (often called climax) of a "Range Site" is determined by using areas subjected to minimal disturbance that have been excluded from grazing for long periods of time (relic areas).

Many range managers recommend or set lower stocking rates on poor condition range relative to good condition range based upon the assumption that forage production is lower in lower condition classes (Dyksterhuis 1949, USDA 1976). This assumption was supported by Goebel and Cook (1960) in southern Utah. They found that poor condition range had lower forage production with less palatable forage than good condition range. Infiltration rates

of water into the soil were also the lowest on the poor condition range. Other studies conflict with this assumption. Cook et al. (1965) found slightly more total forage produced on range in the poor condition class than range in the good condition class.

Smith (1979) found that the method used to rank range by condition classes is inadequate and proposed that it be modified. His assertion was that range condition based on climax composition may not be meaningful in terms of management and that climax or near-climax condition classes may not be as desirable to the land manager's goals as the lower condition classes. For example, on range where sagebrush (*Artemisia tridentata* Nutt.) has been destroyed, forage production is usually higher but condition rating is lower than excellent condition range where sagebrush remains as part of the climax plant community. Modifications to current condition concepts have been suggested by the Range Inventory Standardization Committee (1983). The state-and-transition model (Westoby et al. 1989) is an alternative to the range condition model. It emphasizes management for transition to desired stable states rather than adjustment of stocking rate toward succession along a gradient towards climax as practiced under the range condition model. The objectives of our study were to:

a) determine if there is a dependence of various components of standing crop on range condition rating (i.e., if forage production increases as range condition rating increases),

b) quantify the amount of change in standing crop for a given change in range condition rating, and

c) determine how accurately estimated standing crop can be predicted from range condition rating using a simple linear model (the model most commonly applied).

Study Area

Field sampling was conducted from 18 August to 22 October 1977, on the New Mexico State University's Agricultural Experiment Station Ranch, 20 km north of Las Cruces. The climate is arid with the mean annual precipitation for a 40-year period of 215 mm, most of which falls during the growing season (July, August, and September). June is the warmest month of the year with an average maximum temperature of 34° C. January is the coolest month of the year with an average of 13° C. The precipitation in 1977 during this study period was slightly above normal in August and October, but only 15% of the normal for September (U.S. Department of Commerce 1977).

Data were collected from 2 similar areas, each containing areas varying from poor to good condition. Previously in 1967, one of the areas was fenced into 3 pastures to separate the predominantly good condition range designated pasture 3N, (451 ha); fair condition range, pasture 3W, (668 ha); and poor condition range, pasture 3S, (526 ha). The 3 pastures had been grazed under a seasonal suitability grazing system (Beck 1978). The other area, pasture 15 (1,348 ha), was continuously grazed.

The study area is classified as semidesert grassland with the vegetation varying from homogeneous stands of black grama (*Bouteloua eriopoda* Torr.) to nearly pure stands of mesquite. Extensive sand dunes have developed where mesquite has invaded these sandy soils. The study area is described and mapped as

Methods

One hundred twenty transects were sampled in the study area using ten 0.89-m² quadrats per transect. Fifty six, 24, 20, and 20 transects were randomly located in pastures 15, 3W, 3S, and 3N respectively. Standing crop green weight of each species in a quadrat was estimated in the field according to the methods developed by Pechanec and Pickford (1937) and tested by others as summarized by Cook and Stubbendieck (1986). Standing crop was the total amount of living plant material in aboveground parts, expressed on a per unit area basis at a given point in time. Field personnel were trained by estimating, then clipping and weighing practice plots prior to actual sampling. Estimated plots were occasionally clipped during sampling to verify and if necessary modify estimates. Plants of each species were harvested monthly, weighed green, then air dried each month to develop conversion factors to convert green weights to air-dry weights on a monthly basis. Woody material from previous years' growth was not included in the estimates.

Range condition ratings were determined for each sample transect according to the Dyksterhuis (1949) method as currently used and modified by the SCS (USDA 1976). With this method, the species composition of the potential plant community (Table 1) was compared to the species composition of the plant community of each sample transect. Range condition rating was determined by the summation of the percentage values of species or categories of species common to both plant communities. As described by USDA (1976), the range condition rating is an expression of the relative degree to which the plant species composition of the sample community resembles the presumed climax plant community for the Sandy Range Site. Of the 120 transects, 35, 49, and 36 were classified according to this method as poor, fair, and good condition, respectively.

Regression analysis of 120 sample values was used to determine the dependence of various components of estimated standing crop (y) on range condition rating (x) for the type of rangeland in southern New Mexico classified and mapped Sandy Range Site.

We evaluated not only total standing crop but also various components of total standing crop because some plant species such as mesquite or broom snakeweed (*Xanthocephalum sarothrae* (Pursh) Shinners) are not useful as forage for livestock in this study area (Rosiere et al. 1975), which directly impacts carrying capacity. The relationship of range condition rating and carrying capacity, was evaluated by comparing range condition rating to (a) total standing crop, (b) total standing crop minus mesquite and (c) components of total standing crop. Components of the total standing crop were total grasses, perennial grasses, annual grasses, perennial forbs, annual forbs, black grama, and a number of individual plant species.

Simple linear models were used to test these relationships. Data transformations and quadratic models were used to further evaluate the dependence of standing crop on range condition rating.

Results and Discussion

Significant linear relationships ($p \leq 0.05$) were determined by regression analysis between various components of standing crop (y) and range condition rating (x). A highly significant negative linear relationship was found between total standing crop and the range condition rating. Although significant, the R-square value (0.43) for the linear model is low, only explaining 43% of the total variation. The quadratic model $y = 965.9 - 28.4x + 0.2x^2$ had a much better fit, explaining 57% of the total variation (Fig. 1).

These data are interpreted as showing that as the composition of climax species increases (i.e., as range condition improves) the total nonwoody standing crop of the Sandy Range Site decreases. However, most of the total standing crop from the poor condition rangeland is from the unpalatable mesquite. The greatest percentage dry weight of the total standing crop is mesquite with an average of 58% for the 120 transects (Table 2).

Table 1. Composition of the potential plant community for the Sandy Range Site. Approximate percentage of total annual herbage yield expressed in air-dry weight (lb) per acre (USDA 1979).

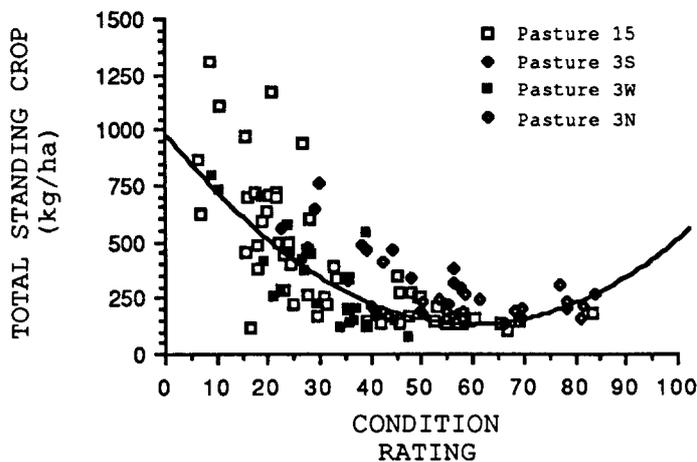| Grasses & grasslike		Woody (Shrubs, half shrubs, vines and trees)		Forbs	
	70–75%		10–15%		10–15%
Black grama	20–30	Soaptree yucca Longleaf ephedra	5–10	Croton Wild buckwheat Globemallow Euphorbia spp.	3–5
Mesa dropseed Sand dropseed Spike dropseed	15–20	Sand sagebrush Fourwing saltbush Winterfat Broom dalea	1–5		
Bush muhly	5–10			Spectaclepod Desert baileya Filaree	3–5
Plains bristlegrass	1–5	Cacti Broom snakeweed	1–3 1–3		
Arizona cottontop Cane bluestem	5–10			Threadleaf groundsel Desert holly Astragalus spp.	
Tobosa	1–5			Horsenettle Russian thistle Lambsquarters Tansymustard	1–3
Threeawns	5–10				
Fluffgrass Annual grasses Blue grama	1–5			Other annuals Other perennials	1–5

Fig. 1. Total standing crop (kg/ha) in relation to condition rating. Regression curve is best fit quadratic equation: $y = 965.9 - 28.4x + 0.2x^2$, $R^2 = 0.57$, $P \leq 0.01$.

A proper evaluation of range carrying capacity as related to range condition must be directed toward that portion of the vegetation considered useful as forage for livestock or wildlife. A positive rather than negative relationship is found between standing crop and range condition rating when the unpalatable mesquite is eliminated from the total standing crop. Although the regression of total standing crop minus mesquite ($y = 94.9 + 0.9x$) has a significant positive relationship to condition rating, it explains very little, only 8% ($R^2 = 0.08$) of the variation. An extremely low R^2 value implies that y has virtually no linear dependency on x (Lewis-Beck 1986). This relationship is low, negative, or nonsignificant when tested within each pasture.

The relationship of grass standing crop to condition rating was positive ($y = 15.4 + 1.1x$) and significantly correlated ($R^2 = 0.34$) when tested across all pastures. The relationship was either low ($R^2 < 0.16$) or nonsignificant when tested within each pasture except 3N, ($y = -5.2 + 1.5x$, $R^2 = 0.34$), the pasture with the highest mean condition rating (62.6).

The relationship of perennial grass standing crop to condition rating was positive ($y = 17.8 + 1.0x$) and significantly correlated ($R^2 = 0.30$) across all pastures but was low ($R^2 < 0.30$) or nonsignificant when tested within each pasture. Mesa dropseed (*Sporobolus flexuosus* (Thurb.) Rydb.) and black grama had the greatest percent composition by weight of the grass species present (10.4% and 3.5% respectively, Table 2). Separate regression analyses were done on these species. Mesa dropseed had a low but significant correlation ($R^2 = 0.03$) to condition rating. This relationship was not significant across any of the regressions for the separate pastures.

The linear relationship of perennial grass to condition rating was mostly attributed to the black grama standing crop, the second most abundant grass. Black grama had a positive significant correlation ($R^2 = 0.32$) to condition rating with the linear model $y = -13.3 + 0.6x$ but an even better correlation ($R^2 = 0.48$) with the quadratic model: $y = 15.3 - 1.1x + 0.02x^2$. The black grama linear relationship was significant for separate pastures 15 ($y = -7.6 + 0.6x$, $R^2 = 0.28$) and 3N ($y = -64.0 + 1.6x$, $R^2 = 0.43$). This relationship was not analyzed for pastures 3W and 3S, since black grama was present in only 5 transects within these pastures. The relationship of the annual grass portion of standing crop to range condition rating was also low but positive ($y = -2.3 + 0.1x$) and significant ($R^2 = 0.24$). This relationship is not significant for the separate pastures except pasture 3N ($R^2 = 0.20$). Neither total forbs, perennial forbs, nor annual forbs were significantly related to condition rating. The separate analysis of Russian thistle (*Salsola kali* L.), a species contributing the greatest percentage of the annual forb standing

Table 2. Average percent species composition by estimated dry weight for 120 transects, and percent species frequency of occurrence for the Sandy Range Site. Species lower than 0.1% composition are not listed.

Species	% Composition by dry weight	Percent frequency of occurrence in 120 transects
Perennial grasses		
Mesa dropseed (*Sporobolus flexuosus*)	10.4	91
Black grama (*Bouteloua eriopoda*)	3.5	39
Fluffgrass (*Erioneuron pulchellum*)	1.7	75
Spike dropseed (*Sporobolus contractus*)	1.0	24
Threeawns (*Aristida* spp.)	0.5	52
Sand dropseed (*Sporobolus cryptandrus*)	0.2	8
others	0.2	
Total Perennial grasses	17.5	
Annual grasses		
Sixweeks threeawn (*Aristida adscensionis*)	0.3	23
Needle grama (*Bouteloua aristidoides*)	0.2	27
Sixweeks grama (*Bouteloua barbata*)	0.2	33
others	0.1	
Total annual grasses	0.8	
Perennial forbs		
Leatherweed croton (*Croton pottsii*) var. *Pottsii*	1.2	57
Wooly paperflower (*Psilostrophe tagetina*)	1.2	28
Twoleaf senna (*Cassia bauhinoides*)	0.9	56
Fendler bladderpod (*Lesquerella fendleri*)	0.4	18
Scarlet globemallow (*Sphaeralcea coccinea* var. *elata*)	0.3	24
Silverleaf nightshade (*Solanum elaeagnifolium*)	0.2	57
Trailing rushpea (*Hoffmanseggia incarnata*)	0.2	38
Indian rushpea (*Hoffmanseggia glauca*)	0.2	40
others	0.3	
Total perennial forbs	4.9	
Annual forbs		
Russian thistle (*Salsola kali*)	4.0	70
Goosefoot (*Chenopodium* spp.)	1.6	57
Wooly tidestromia (*Tidestromia lanuginosa*)	0.4	36
Wislizenus spectacle pod (*Dithyrea wislizeni*)	0.2	22
Purslane portulaca (*Portulaca oleracea*)	0.2	14
Rocky Mountain zinnia (*Zinnia grandiflora*)	0.2	24
others	0.2	74
Total annual forbs	6.8	
Woody species		
Honey mesquite (*Prosopis glandulosa*)	58.0	74
Broom snakeweed (*Xanthocephalum sarothrae*)	4.7	98
Longleaf ephedra (*Ephedra trifurca*)	3.2	25
Soaptree yucca (*Yucca elata*)	3.2	73
Fourwing saltbush (*Atriplex canescens*)	0.4	3
Mescat acacia (*Acacia constricta*)	0.3	3
Prickly pear cactus (*Opuntia* spp.)	0.2	4
Total woody species	70.0	

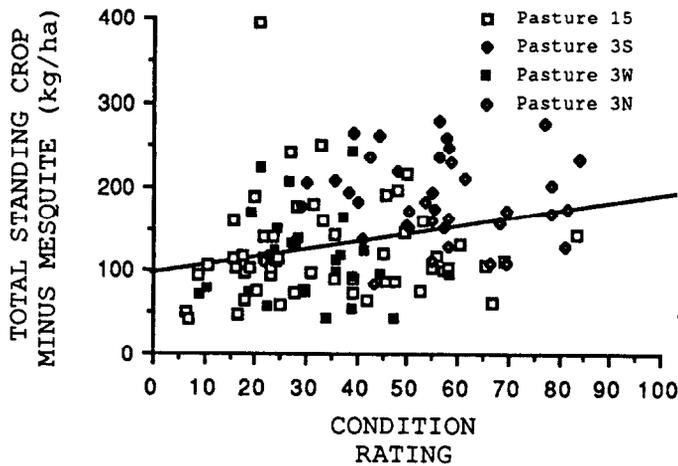**Fig. 2. Total standing crop minus mesquite (kg/ha) to condition rating. Regression curve is the best fit linear equation: y = 94.9 + R² = 0.9x, R² = 0.08, P≤0.01.**

crop, did not show any significant pattern.

In this study where a large number of samples were collected, data were insufficient to reliably quantify a difference in forage production as related to the Dyksterhuis (1949) method of range condition rating. No reliable relationship was found that could be used to quantify increased forage as succession approached climax.

The results of this study are not in conflict with the range manager's goal to improve range condition. A manager could justify low stocking rates on poor condition range on the assumption that low rates are necessary to improve range condition. However, the results of this study do not support the practice of quantifying the difference in total forage production between range condition classes. The amount of forage production from poor condition range at this site is not sufficiently low to justify recommending lower stocking rates.

Dyksterhuis (1949) pointed out that forage production is generally only a reflectance of range condition and was opposed to the view that range condition be measured directly in terms of forage production as proposed by Humphrey (1947). Lower stocking rate recommendations on poorer condition range were simply guides based upon local experiences to bring about rapid improvement in range condition.

Reduction of stocking rate for reasons to improve condition does not appear justifiable for mesquite-infested range in Southern New Mexico. On the nearby Jornada Experimental Range, complete exclusion of livestock on 259 ha since 1933 has not improved range condition, and by 1963, the amount of mesquite cover increased from about 50% to 100% of the area (Buffington and Herbel 1965). On the other hand, reduction of stocking rate for reasons that less forage may be available on poor condition range is justifiable.

Conclusion

We found a positive linear relationship for range condition

rating and total standing crop minus mesquite, and a negative linear relationship for range condition and total standing crop. The 2 relationships are significant and in the direction expected. However, the subject of importance is the current carrying capacity. Neither model is useful for quantifying carrying capacity as reflected in the correlation coefficients for the linear models. Estimated standing crop could not be accurately predicted from range condition ratings. The relationships were found to have more of a quadratic shape than linear.

The method of rating range condition by species composition as most commonly used appears to be reliable for neither assessing range condition as demonstrated by Anderson (1985), nor quantifying carrying capacity as demonstrated in our study for the Sandy Range Site. Revised methods of condition rating need to be developed that are dependable in assessing range condition. If forage production does in fact increase with increased condition, the method should be useful in quantifying carrying capacity.

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