Significance of Reduced Plant Vigor in Relation to Range Condition[1]

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Highlight

In Southwestern North Dakota, forage yields were much higher on ranges in excellent than on those in good condition; differences in forage yields between ranges in good and those in fair condition were smaller. Reduced yields were due mainly to reduced vigor of midgrasses, as reflected by plant height, and not to loss of plants.

Range managers and technicians commonly use relative production by species as part of the "departure-from-climax" method as described by Dyksterhuis (1949) to estimate condition and feasible stocking rates of rangeland. Technicians, using this method, have prepared quantitative guides for their respective areas.

The purpose of the research described here was to investigate factors affecting forage production in southwestern North Dakota and test the Range Technician's Guide prepared for the Soil Conservation Districts of southwestern North Dakota within the 15- to 19-inch precipitation zone.

Procedure

In 1960, twelve native grassland areas, representing four range sites in southwestern North Dakota, as recognized by the U.S.D.A. Soil Conservation Service (1956) were selected for study: (1) Clayey (e.g., Morton clay loam soil—a soil of rolling uplands), (2) Sandy (e.g., Flasher sandy loam soil —a soil of rolling uplands), (3) Shallow (e.g., Farland loam, gravelly substratum phase—high terrace soil), and (4) Silty (e.g., Havre silt loam soil—low terrace soil). The range condition of each study area was estimated by using the U.S.D.A. Soil Conservation Service Technician's Guide to Range Sites (1956). The numerical value for each condition class was determined on the basis of ovendry weights of clipped grasses and forbs.

Between 1960 and 1962, botanical composition of the vegetation, yield, and vigor (as measured by leaf heights) were determined annually on each area. The composition of the cover was determined with a 10-point inclined point frame (Smith, 1959), using 3,000 points per area to give a sample with a mean error of 10% (Whitman and Siggeirsson, 1954). The "basal-contact" system was used, where only basal contacts of vegetation are recorded as "hits."

Herbage yields were taken from 2.5 × 5-ft quadrats clipped at ground level within 3 × 6-ft cages at the end of the growing season. There were 10 systematically distributed quadrats for each of the 12 study areas. Tall grasses, short grasses, midgrasses, annual forbs, and perennial forbs were ovendried and weighed separately. Species composition was estimated in the field at the time of clipping. At the same time, leaf heights of five plants of each species were measured on each quadrat giving 50 height measurements per species per study area. Height measurements were averages of the highest portion of leaves in their natural resting state.

In calculating forage yields, it was assumed that 70% of tall and midgrass herbage and 50% of short grass herbage was forage. These percentages are based on the premise that cattle can graze to a 1-inch (2.5 cm) stubble and that 60% of the shortgrass and sedge herbage and 85% of the mid- and tall-grass herbage is above the 1-inch height (Payne, 1958) and 80% of that material is palatable (U.S.D.A. Soil Conservation Service, 1937).

Annual precipitation for the 3-year study period averaged 15.5 inches. The 1961 season was the driest: during the April–July period there were 7.5 inches of precipitation, compared to 8.8 inches in 1960 and 14.1 inches in 1962 (U.S. Weather Bureau, 1960, 1961, and 1962).

Results and Discussion

Forage Production

The better the range, the greater the forage yield. Forage yields on some ranges in excellent condition were 50 to 60% more than yields on ranges in good condition, and 56 to 82% more than yields on ranges in fair condition (Table 1). Forage yields—indication of grazing capacity—of range sites in different condition classes did not correspond with recommended stocking rates in the Range Technician's Guide (U.S.D.A. Soil Conservation Service, 1956).

The Range Technician's Guide specifies that stocking rates of range sites should change in direct proportion to changes in range condition; i.e., a 25 or 40% reduction in range condition rating should mean a 25 or 40% reduction in recommended stocking rate regardless of range site. This gives the guide great flexibility, but perhaps not the right kind of flexibility to allow for large differences among sites. For example, our data suggest that the reduction of stocking based on a 25% decrease in forage yields on silty and clayey range sites in good condition should be more than 25% possibly 50%, while the 25% reduction would be satisfactory on sandy range sites. A reduction of only 25% on silty and clayey range sites would have resulted in much more intensive use than on the sandy site, and possibly deterioration of the range.

The differences in forage yield between the less productive range sites—shallow and sandy—were more in line with the reduction of stocking rates as suggested by the Technician's Guide. However, the forage yield on the sandy range in fair condi-

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Table 1. Herbage production (lb/acre, ovendry), forage production (lb/acre, ovendry),[1] and range condition ratings on four range sites of southwestern North Dakota.

Site	Range condition rating		Difference[2] (%)	Herbage yield	Forage yield	Difference (%)
	Descriptive	Numerical				
Silty—Havre						
silt loam	Excellent	92	0	1,714	1,169	0
	Good	72	–22	1,123	572	–51
	Fair	48	–48	1,273	667	–43
Clayey—Morton						
clay loam	Excellent	78	0	1,595	956	0
	Good	58	–26	1,326	576	–40
	Fair	32	–59	1,700	536	–44
Shallow—Farland						
loam, gravelly substratum phase	Excellent	76	0	1,223	644	0
	Good	57	–25	1,020	450	–30
	Fair	48	–37	732	370	–42
Sandy—Flasher						
sandy loam	Excellent	75	0	996	564	0
	Good	66	–12	719	394	–30
	Fair	40	–47	1,010	460	–18

[1] Forbs excluded.
[2] Refers to magnitude of difference stepwise from excellent to good and excellent to fair.

tion was higher than expected in relation to yield on ranges in good condition.

Range deterioration from excellent to good condition appears to be more serious economically than deterioration from good to fair condition, and hence, probably should receive more attention. A drastic deterioration of cover leading to irreparable soil loss on ranges in fair condition, of course, would require immediate attention. However, we found no losses of total basal cover associated with deteriorated range condition.

Vegetation Composition Based on Cover

Plant basal cover gave a more realistic estimate of plant composition than herbage yield by weight. Determining species composition using basal cover often requires exhaustive sampling (Whitman and Siggeirsson, 1954), but does provide a reliable basis for checking changes in plant groups.

Basal cover was low for the most productive species, the midgrasses—mainly *Agropyron* sp., *Stipa* sp., and *Koeleria cristata* (L) Pers. Tall grasses—mainly *Andropogon* sp. and *Calamovilfa longifolia* (Hook) Scribn.—contributed only a small percentage to total cover, though their forage yields were appreciable on sandy range site (Table 2). On some soils, midgrass cover varied only slightly between excellent and good ranges (Table 3). However, midgrass forage yield was much less on the good range. Obviously, much of this reduction is the result of reduced vigor of the individual plants, rather than reduction in basal cover. This is important in determining the responsiveness of these ranges to grazing management. In order to increase production on these ranges, conditions favoring restoration of vigor should be established, not necessarily conditions needed to restore the species in the cover.

A rest-rotation system of grazing similar to that advocated by Hormay and Talbot (1961) might give plants the rest needed to restore vigor and

Table 2. Forage production (lb/acre, ovendry)[1] by plant group in relation to range condition on the various range sites of southwestern North Dakota.

Plant group and range condition	Range sites			
	Silty	Clayey	Shallow	Sandy
Excellent condition				
Tall grasses	0	0	0	225
Midgrasses	1,147	616	315	200
Short grasses	22	340	329	142
Total cover	1,169	956	644	567
Good condition				
Tall grasses	0	46	0	128
Midgrasses	385	274	71	96
Short grasses	188	256	379	170
Total cover	573	576	450	394
Fair condition				
Tall grasses	0	0	0	0
Midgrasses	104	106	69	76
Short grasses	563	430	301	384
Total cover	667	536	370	460

[1] Forbs excluded.

Table 3. Basal cover (%) of vegetation in relation to range condition on four range sites in southwestern North Dakota.

Range condition and plant grouping	Range sites			
	Silty	Clayey	Shallow	Sandy
Excellent condition				
Tall grasses	0	0	0	2
Midgrasses	11	6	4	6
Short grasses	1	22	32	23
Forbs	18	0	1	1
Total cover	30	28	37	32
Good condition				
Tall grasses	0	2	0	1
Midgrasses	6	8	3	4
Short grasses	8	24	43	37
Forbs	19	3	2	1
Total cover	33	37	48	43
Fair condition				
Tall grasses	0	1	0	0
Midgrasses	4	2	4	2
Short grasses	26	47	41	33
Forbs	8	5	0	1
Total cover	38	55	45	36

also restore species if necessary; these authors stressed that selective grazing of the vegetation is the prime cause of range deterioration. They pointed out that selective grazing cannot be prevented, but its harmful effects may be overcome by resting the range at intervals. Their interpretations are strengthened further by Johnson's (1965) investigations in Wyoming.

The increase in total basal cover found on deteriorated ranges was due to the increase in basal cover of short grasses, primarily blue grama (*Bouteloua gracilis* (Michx. Torr.)), (Table 3). Basal cover of short grass species increased more than the midgrasses decreased, indicating that short grasses not only replaced some of the midgrasses, but also occupied part of the area not previously occupied by plants. Perennial and annual forbs made up only a small portion of the basal cover on most range areas regardless of condition.

Leaf and Plant Heights

The small changes in cover between ranges in excellent and good condition do not explain the large difference in forage yields on these ranges. Consequently, this indicates that some condition other than composition and cover is responsible, and this logically would be plant vigor.

Plant height (leaf or seed stalk) has been used as an indication of plant vigor (Hanson, 1950; Brown, 1954; Parker, 1954; Short and Woolfolk, 1956; and Cook and Goebel, 1962). Even so, leaf height measurements must be confined to a few key species in order to provide sufficient numbers to detect differences due to grazing. Leaf heights are probably more useful in grass studies than stalk heights because production of seed stalks varies greatly in relation to season as well as grazing use.

On most study areas average leaf heights were obtained for four midgrasses—western wheatgrass (*Agropyron smithii* Rydb.), prairie Junegrass (*Koeleria cristata* (L.) Pers.), needleandthread (*Stipa comata* Trin. and Rupr.), and green needlegrass (*S. viridula* Trin.). The reductions in leaf heights of the midgrasses, while somewhat variable, were generally greatest between excellent and good condition ranges with only small differences between the average leaf heights on good and fair condition ranges (Table 4).

Table 4. Average leaf heights (cm) of four major midgrasses and the major short grass and two sedges under different range condition classes on four range sites in southwestern North Dakota.[1]

Species and condition	Range sites			
	Silty	Clayey	Shallow	Sandy
Major midgrass				
Agropyron smithii				
Excellent	38	31	29	29
Good	29	23	24	28
Fair	25	24	22	—
Koeleria cristata				
Excellent	—	13	14	10
Good	—	12	7	8
Fair	—	13	5	—
Stipa comata				
Excellent	31	20	26	24
Good	22	20	14	16
Fair	18	16	11	16
Stipa viridula				
Excellent	43	—	—	—
Good	29	—	—	—
Fair	—	—	—	—
Major short grass and sedges				
Bouteloua gracilis				
Excellent	13	10	13	6
Good	8	10	7	6
Fair	9	10	4	6
Carex eleocharis				
Excellent	—	10	9	14
Good	—	8	8	9
Fair	—	8	9	8
Carex filifolia				
Excellent	—	11	14	12
Good	—	12	8	8
Fair	—	—	8	8

[1]A dash in data columns means species did not occur in appreciable amount on the site.

The short-grass heights are more difficult to interpret and less reflective of lower range conditions compared to midgrass heights. However, where reduction in leaf heights was discernible, it was greatest between excellent and good ranges. This was true of blue grama on the silty and shallow sites, terrace soils; needleleaf sedge (*Carex eleocharis* Bailey) on clayey and sandy range sites, rolling upland soils; and threadleaf sedge (*C. filifolia* Nutt.) on the less productive sites, shallow and sandy range sites (Table 4).

Therefore, average leaf heights of the major midgrasses would be a good supplementary measure to use in determining the condition of ranges of the types studied, particularly in the good and excellent classes. However, measurement of standard heights for ungrazed plants by species, year, and site would be necessary to separate effects of weather and grazing.

The major perennial and annual forbs were shorter on the poorer ranges. Since the forbs were grazed only lightly or not at all, the effects of grazing must have been indirect.

Therefore, leaf or plant height of midgrasses may be a more sensitive measure of the first stages of range deterioration and would be a better guide than plant composition for scheduling rest periods.

Conclusions

These data suggest: (1) the departure-from-climax method of measuring range condition records definite changes in plant composition, but refinements are needed and possible for recommended short-term stocking rates as set forth in the Range Technician's Guide (U.S.D.A. Soil Conservation Service, 1956) for range sites in southwestern North Dakota; (2) plant vigor as measured by leaf height was more indicative of the first stages of range deterioration than was plant composition and hence may be a better guide for scheduling rest periods; (3) sustained maximum forage production may not be possible under *continuous* season-long grazing due to selective grazing by animals and its effects on plant vigor of preferred species, but may be possible with a deferred-rotation system of grazing.

Literature Cited

Brown, D. 1954. Methods of surveying and measuring vegetation. Brit. Commonw. Bur. Pasture, Field Crops, Bull. 42. 223 p.

Cook, C., and G. J. Goebel. 1962. The association of plant vigor with physical stature and chemical condition of desert plants. Ecology 43:543–546.

Dyksterhuis, E. J. 1949. Condition and management of rangeland based on quantitative ecology. J. Range Manage. 2:104–115.

Hanson, H. C. 1950. Ecology of the Grassland II. Bot. Rev. 16:283–360.

Hormay, A. L., and M. W. Talbot. 1961. Rest-rotation grazing—a new management system for perennial bunchgrass ranges. U.S. Dep. Agr. Prod. Res. Rep. 51. 43 p.

Johnson, W. M. 1965. Rotation, rest-rotation, and season-long grazing on a mountain range in Wyoming. U.S. Dep. Agr. Forest Serv. Res. Pap. RM-14, 16 p. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.

Parker, K. W. 1954. A method for measuring trend in range condition on National Forest ranges with supplemental instructions for measurement and observation of vigor, composition, and browse. U.S. Dep. Agr., Forest Serv. 37 p. (Administrative studies.)

Payne, W. D. 1958. A study of methods of determining percentage utilization on native grass ranges in western North Dakota. Masters thesis, North Dakota State University. 103 p.

Short, L. R., and E. J. Woolfolk. 1956. Plant vigor and a criterion of range conditions. J. Range Manage. 9:66–69.

Smith, J. G. 1959. Additional modifications of the point frame. J. Range Manage. 12:204–205.

U.S.D.A. Soil Conservation Service. 1937. Palatability table-grasses, weeds, trees and shrubs. Soil Conserv. Serv. in Tech. Coop. with Bur. of Indian Aff., Pap. 388.

U.S.D.A. Soil Conservation Service. 1956. Technician's guide to range sites, condition classes and recommended stocking rates in Soil Conservation Districts of North Dakota within 15–19" precipitation belt. 5 p.

U.S. Weather Bureau. 1960, 1961, 1962. Climatological data. N. Dak. Annu. Sum. 1960, 69:180–189; 1961, 70: 188–196; 1962, 71:178–186. U.S. Dep. Commerce, Asheville N. C.

Whitman, W. C., and E. I. Siggeirsson. 1954. Comparison of line interception and point contact methods in the analysis of mixed grass range vegetation. Ecology 35: 431–436.