Soil Depth-Vegetation Relationships on a Shallow Limy Range Site in Western Kansas[1]

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Highlight

Soil depth heterogeneity within the shallow limy range site in western Kansas results in differences in range composition and production. Deep soils produce more forage than shallow (< 4″) soils. Such variations in production within an apparently uniform range site should be considered when evaluating range condition and establishing stocking rates.

The Mixed Prairie, extending from southern Canada through the Great Plains to southern Texas, is variable in vegetation composition and forage production. When Clements (1916) classified plant communities in North America, he relied on climax vegetation being a product of the climate. Subsequent research has explained the variability of plant communities in greater detail. Soil texture (Richard and Davis, 1964), calcareous nature of the soil (Linnell, 1961), parent material (Smith, 1963), soil types (Lunsford, 1963), and slope-exposure (Glover et al., 1968) contribute to the variability of the Mixed Prairie.

Range managers utilize such research to divide large range areas into units called range sites. Soils have been used as a criterion for classifying range sites along with climax vegetation, climate, and topography. One such unit in western Kansas is the shallow limy range site (USDA, 1968), a site typified by shallow soils but having considerable vegetation and soil heterogeneity.

Weaver and Clements (1938) and Tomanek (1963) have expressed the idea that soil depth influences vegetation heterogeneity. The purpose of the present investigation was to ascertain what correlations existed between soil depth, basal cover, and the production within the shallow limy range site.

Study Area and Procedure

Two sampling areas were used in this project. Two-hundred samples were taken from a 320-acre grassland (W ½ S27, T14S, R22W). The remaining 260 samples were taken from an 80-acre tract of land (W ½ SE ¼, S ½ NE ⅕, NE ⅕ NE ¼, S 1, T15S, R22W). The areas are similar in topography and vegetation, and were in excellent range condition in 1951 and have not been grazed since that time.

The shallow limy range site is characterized by relatively shallow soil on topography varying from nearly level to very steep. Soils on this site are usually less than 20 inches deep and possess only an A and C horizon. The soil profile often contains numerous rock fragments and is calcareous to the surface. Many midgrasses and tallgrasses are found growing here, usually forming an open cover. Little bluestem (*Andropogon scoparius*), big bluestem (*A. gerardi*), side-oats grama (*Bouteloua curtipendula*), and blue grama (*B. gracilis*) are the major grasses. The vegetation and soils found on this site have been reported by Hulett and Tomanek (1969).

In an effort to minimize the influence of soil factors other than depth, sampling criteria were: (1) transects placed on the contour to minimize effects of slope position and (2) slope and exposures chosen that were nearly the same.

Samples were taken at 1 m intervals along the transects described above. The samples were quadrats 2 dm² and were used to estimate percent basal cover, percent composition, production of vegetation, and soil depth.

The vegetation was clipped to ground level in each quadrat and separated according to tallgrass, midgrass, shortgrass and forbs. Clippings were dried in a forage drier at 75 C and then weighed to determine production.

A hand auger drilled until bedrock was struck, was used to determine soil depth within each quadrat. If doubt existed as to correct depth reading, a spade was used.

Total correlation coefficients, partial correlation coefficients, and analysis of variance were calculated according to Bailey (1959). Duncan's multiple range test (Duncan, 1955) as modified by Kramer (1956) was applied to those variables exhibiting a significant F-value to test for specific mean differences.

Scientific and common names of plants are according to Anderson (1961).

Results and Discussion

In an attempt to ascertain if soil depth was correlated to various attributes of the vegetation, 14 variables were chosen for correlation analysis (Table 1).

Sixty-four of the total correlation coefficients were significant at either the 5% or 1% level. Some of the coefficients in the matrix, such as the correlation between total basal cover and total production, are of minor ecological consequence but are reported since they aid in the interpretation of the coefficients contained in the top line of the matrix, which represents the correlation coefficients found between soil depth and the remaining 13 variables.

Positive correlations were found between soil depth and total production, soil depth and total basal cover, and total production and total basal cover. Examination of the total correlation between soil depth and total production indicated that an increase in total production resulted from increases in soil depth. However, total basal cover, which was also positively correlated to both total production and soil depth, was responsible for the

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Table 1. Correlation coefficients between the 14 variables analyzed on the shallow limy range site.

	Total Production	Total Basal Cover	Production of Forbs	Production of Grasses	Basal Cover of Blue Grama	Basal Cover of Buffalo Grass	Basal Cover of Hairy Grama	Basal Cover of Big Bluestem	Basal Cover of Little Bluestem	Basal Cover of Side-oats Grama	Production of Short Grasses	Production of Midgrasses	Production of Tall Grasses
Soil Depth	.153**	.186**	NS	.179**	.137**	.385**	–.219**	–.185**	–.247.**	.101*	.250**	.123*	–.151**
Total Production		.374**	.292**	.914**	NS	NS	NS	.152**	.227**	.212**	NS	.750**	.213**
Total Basal Cover			NS	.404**	.576**	.330**	NS	–.210**	NS	.292**	.507**	.219**	–.150**
Production of Forbs				–.104*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Production of Grasses					NS	NS	NS	.196**	.258**	.235**	NS	.809**	.254**
Basal Cover of Blue Grama						.214**	–.116*	–.192**	–.261**	–.196**	.674**	–.296**	–.157**
Basal Cover of Buffalo Grass							–.120*	–.135**	–.147**	–.319**	.546**	–.242**	–.108*
Basal Cover of Hairy Grama								NS	NS	NS	.171**	–.108*	NS
Basal Cover of Big Bluestem									NS	–.239**	–.185**	–.139**	.898**
Basal Cover of Little Bluestem										–.262**	–.221**	.364**	NS
Basal Cover of Side-oats Grama											–.363**	.489**	–.201**
Production of Short Grasses												–.329**	–.141**
Production of Midgrasses													–.144**

* r-value significant at 5% level.
** r-value significant at 1% level.

correlation between soil depth and total production. The partial correlation coefficient between soil depth and total production was non-significant indicating that total production was not directly affected by soil depth but that soil depth affected total basal cover which in turn influenced total production.

The total correlation coefficients also indicated that the production of grasses increased with an increase in soil depth. Since the production of grasses was also correlated with total basal cover, partial correlation coefficients were again computed to determine if the correlation between production of grasses and soil depth was real. The partial correlation coefficients were all significant, indicating that production of grasses was affected by both soil depth and total basal cover.

Three grass species had higher basal cover on deeper soils: blue grama, buffalograss and side-oats grama. Two of these species, blue grama and buffalograss are related to the significant positive correlation between soil depth and production of short grasses. However, a third shortgrass species, hairy grama, is also included in this correlation. Although the basal cover of hairy grama was negatively correlated to soil depth, the production of short grasses was still positively correlated to soil depth. Both blue grama and buffalograss yield considerably more than hairy grama, thereby offsetting the negative effect of hairy grama on the correlation. On soils less than 20 inches in depth, the basal cover of buffalograss was lower while blue grama remained about the same. Therefore, buffalograss was principally responsible for the significantly higher production of shortgrasses on soils deeper than 20 inches.

The production of shortgrasses increased as soil depth increased (Table 2) in the same manner as total production. The 20+ inch category had the highest production of shortgrasses.

Total basal cover increased as soil depth increased and a close relationship between basal cover and total production existed (Table 2). The shortgrasses influenced the total basal cover because of their growth habit. The highest basal cover was found on soils over 20 inches in depth and again buffalograss was responsible, since its cover was significantly reduced on soils shallower than 20 inches. In depth categories ranging from 4 inches to 20 inches no significant differences in

Table 2. Analysis of variance tables and multiple range test for selected vegetation attributes at four soil depth categories. Basal cover (BC) is given as a percentage.

Total Production

Source	SS	DF	MS	F
Depths	258.32	3	86.10	6.80**
Error	5775.05	456	12.66	—
Total	6033.37	459	—	—
Depth	0–4	12–20	4–12	20+
Mean gr/4 dm²	3.77	4.87	5.32	6.22

Total Basal Cover

Source	SS	DF	MS	F
Depths	2710.42	3	903.47	14.13**
Error	29158.06	456	63.94	—
Total	31868.46	459	—	—
Depth	0–4	12–20	4–12	20+
Mean bc/plot	25.84	27.42	28.66	31.11

Total Grass Production

Source	SS	DF	MS	F
Depths	257.86	3	85.95	7.44**
Error	5266.09	456	11.55	—
Total	5523.95	459	—	—
Depth	0–4	12–20	4–12	20+
Mean gr/ dm²	2.82	4.37	4.57	5.34

Buffalo Grass Basal Cover

Source	SS	DF	MS	F
Depths	6652.10	3	2217.37	59.75**
Error	16920.21	456	37.11	—
Total	23572.31	459	—	—
Depth	0–4	12–20	4–12	20+
Mean bc/plot	1.28	6.29	7.92	19.46

Short Grass Production

Source	SS	DF	MS	F
Depths	145.21	3	48.40	18.98**
Error	1161.19	456	2.55	—
Total	1306.40	459	—	—
Depth	0–4	12–20	4–12	20+
Mean gr/4 dm²	0.57	1.02	1.21	2.36

Blue Grama Basal Cover

Source	SS	DF	MS	F
Depths	2418.93	3	806.31	7.79**
Error	47180.93	456	103.47	—
Total	49599.86	459	—	—
Depth	0–4	12–20	4–12	20+
Mean bc/plot	12.52	18.15	19.37	19.73

Tall Grass Production

Source	SS	DF	MS	F
Depths	64.22	3	21.41	8.08
Error	1206.35	456	2.65	—
Total	1270.57	459	—	—
Depth	20+	12–20	0–4	4–12
Mean gr/4 dm²	0.00	0.13	0.43	0.83

Side-Oats Grama Basal Cover

Source	SS	DF	MS	F
Depths	1759.03	3	586.34	6.03**
Error	44370.44	456	97.30	—
Total	46129.47	459	—	—
Depth	0–4	20+	4–12	12–20
Mean bc/plot	15.34	17.56	18.81	21.95

Note: Means underscored by the same line are not significantly different.

cover of buffalograss were found. Side-oats grama seemed to be particularly well adapted to soils 12 to 20 inches deep and may have been competitive in reducing the cover of buffalograss on these particular soils.

Basal cover of blue grama did not differ significantly on soils deeper than 4 inches but was significantly reduced on soils shallower than 4 inches.

The production of midgrasses increased as soil depth increased. Side-oats grama, the major midgrass, increased in basal cover on deeper soils while little bluestem decreased in basal cover as soil depth increased. Since side-oats grama had a greater yield than little bluestem, a positive correlation was found for the production of midgrasses. Another factor contributing to this positive correlation was the entry of two other midgrasses, red-threeawn (*Aristida longiseta*) and purple-threeawn (*A. purpurea*) in sample plots with deeper soils.

Side-oats grama was the major midgrass found in the sample areas, with a highest basal cover on the 12 to 20 inch depth soils. This species is most commonly found on areas of medium depth, where the soils are calcareous. Soils deeper than 20 inches in the study area are not calcareous, and thus might not be as suitable for the best development of this species. Conversely, side-oats grama seems to be somewhat excluded from shallow soils, which may represent the competitive effect of little bluestem.

The basal cover of big bluestem, the most abundant tallgrass on the area, decreased as the soil depth increased, as shown by the negative correlation coefficient and resulted in decreased production of all tallgrasses as the soil depth increased. The production of tallgrasses was significantly higher on the shallower soils (Table 2), a phenomenon related to the growth of big bluestem on such soils.

The production of forbs was not significantly correlated to soil depth. Although a large number of forbs was found on shallow soils, such morphologically large species as slimflower scurfpea (*Psoralea tenuiflora*), found growing on deeper soils, produced a greater amount of forage, compensated for the few forbs species on deeper soils and resulted in a non-significant correlation coefficient.

Total production (grasses and forbs) generally increased as soil depth increased (Table 2). The lowest production was found on the 0 to 4 inch and 12 to 20 inch depth categories and the highest production on soils deeper than 20 inches. There was no significant difference in grass production on soils deeper than 4 inches. This may indicate that any difference in total production between soil depth categories deeper than 4 inches was the result of differential forb production, although the data on forb production do not support this conclusively. When the soil was shallower than 4 inches, the production of grasses was significantly lowered.

Although some soils samples were deeper than 20 inches, they are classified as shallow limy range sites, since their extent is so limited that technically they would have to be considered as deep soil inclusions within the shallow limy site. Such soil heterogeneity gives rise to production variability that must be recognized in range condition evaluation.

An important aspect regarding the effect of soil depth on vegetation is the rooting habits of the species involved. A thorough study of the root habits of many prairie plants growing in rock-filled soil was made by Albertson (1937). He found that the roots of little bluestem and side-oats grama, though relatively fine, penetrated only to about three feet. Those of big bluestem extended one to two feet deeper. The fine roots of hairy grama, blue grama, and buffalograss were usually confined to the surface 18 inches. He further pointed out that although the roots may be confined to shallower depths on rock soil, at times the roots penetrate soil-filled fissures in the rocks, making it possible for the root systems to develop to greater depths. Such differential rooting may result in competitive advantages to the plants that are ultimately manifested in variations in composition and production.

Conclusions

(1) Total forage production increased as soil depth increased, with soils over 20 inches in depth producing significantly more forage than any other depth categories. (2) Total basal cover increased as soil depth increased, showing the same significant ranges as total production. (3) Production of grasses did not differ significantly on soils deeper than 4 inches indicating that increases in total production beyond this depth were the result of increased forb production. (4) Basal cover of buffalograss was significantly reduced on soils shallower than 20 inches. (5) Production of shortgrasses increased as soil depth increased, the highest production being on soils deeper than 20 inches. (6) Basal cover of side-oats grama increased as soil depth increased, the greatest basal cover being on the 12 to 20-inch category, being significantly higher than all other categories. (7) Soil heterogeneity within a recognized range site can produce significant variability in range composition and production.

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