Effect of Soil Depth on Plant Production[1]

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Highlight

Soil depth is an important factor to consider when evaluating forage production on range soils. Three soils with different soil depths produced different kinds and amounts of vegetation. The Bakeoven cobbly silt loam (5 inches to basalt bedrock) produced 158.7 lb/acre. The Kuhl silt loam (12 inches to basalt bedrock) produced 620.0 lb/acre. The Anders silt loam (25 inches to basalt bedrock) produced 869.4 lb/acre.

The purpose of this study, started in 1967, was to determine some effects of soil depth on the kind and amount of native vegetation produced each year. Hulett et al. (1969) found that forage production increased as soil depth increased. Mason et al. (1967) discovered that of two soils in a relict area in Utah, the deeper soil produced more forage than did the shallow soil. Anderson (1962) shows that different soils have distinctive plant communities.

The three soil series selected for this study are all underlain by basalt bedrock. These series, in order of increasing soil depth, are: Bakeoven, Kuhl, and Anders.[3] A soil series consists of a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and from a particular type of parent material (USDA, 1951).

Procedure

The study area is located 4.4 miles west of Davenport, Washington, and 0.7 miles north of State Highway No. 2 along county road No. 220 on Mr. Walt Kik's farm. The study area is located on a point of untilled land that protrudes into a fallow wheat field. This area has not been grazed since 1932, and has an excellent or near-climax vegetative cover. A fire burned the area in 1946; however, little, if any, damage could be noted in the plot sampling areas. There was no soil deposition on the study area from the adjacent cropland. The Bakeoven site sample area is 10 yards west of the county road, the Kuhl is 130 yards southwest of the Bakeoven, and the Anders is 40 yards south of the Kuhl.

To eliminate as many variables as possible, care was used to select the sampling areas within the three selected study sites so that seven factors were kept uniform. The first was uniformity of soil depth. Soil depth on the Bakeoven site ranged from 4 to 9 inches, on the Kuhl site from 10 to 16 inches, and on the Anders site from 21 to 29 inches. This uniformity was accomplished by selecting the central point and determining the outer limits of the area by digging from five to eight holes with a bucket-type soil auger. Soils with underlying basalt bedrock were selected because effective rooting depth ends abruptly and soil depth can be accurately measured. The second factor requiring uniformity was soil texture; therefore, all soils studied were silt loams. The third, fourth, and fifth factors—climate, elevation, and topography—were kept uniform. This was accomplished mainly by locating all the study sites within an area roughly 200 yards. Climatic data, for the area was recorded at the weather station at Davenport, Washington, showed the mean annual temperature from 1931 thru 1955 to be 46.1 F. Precipitation from 1931 thru 1965 was 16.81 inches. During the study period, 1967–1968, the two-year average was 13.71 inches. Elevation at all three study sites is about 2,400 feet, with less than a 5-foot difference between any of the sites sampled. The topography is relatively smooth, with all slopes less than 5 percent. Although these slopes are at the lower end of the slope phases for each of the mapping units as indicated in the soil description, this was necessary so that the other requirements of uniformity could be met. The sixth factor was aspect; therefore, all sampling areas were selected on south-facing slopes. The seventh and final factor was finding climax or near climax plant communities. This posed a problem, but fortunately a suitable area was located adjacent to a wheat field that had not been grazed since 1932. Although the area burned in 1946, little if any damage was noted, and an excellent or near-climax vegetative cover was present.

Soil depths were checked around each site-sampling area with a soil auger. Next a soil pit was dug (4′ × 2′ × depth to bedrock) in the center of each site-sampling area. The soil profile was then described in standard nomenclature as used by the USDA Soil Conservation Service, and 2-quart soil correlation samples were taken of each horizon. A horizon is a soil layer having distinct qualities that differentiate it from both the layer above and the layer below (USDA, 1951).

Three 9.6 ft^2 circular plots, designed to determine the total annual yield and composition by weight of the potential (climax) vegetation associated with each soil depth, were randomly located around each soil pit distances ranging from 3 to 80 feet.

The previously determined variations in soil depths to be allowed within each study area limited the radial distances at which the 9.6 ft^2 plots would adequately sample the vegetation.

When the plot ring was placed, a numbered stake was driven into the center of the ring so that the plots could be easily found at a later date. Each species was individually clipped to ground level, except for minor annuals which were grouped and then placed in labeled paper bags and weighed. Several days later, after the samples had been air dried, they were reweighed and the dry weight converted to pounds per acre.

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[3] Tentative series. Recommended for establishment, but not approved as yet.

FIG. 1. Bakeoven cobbly silt loam, 0 to 15 percent slopes. Notice the way the basalt bedrock, in the lower foreground, undulates over short distances. Bedrock is at 5 inches.

FIG. 2. Kuhl silt loam profile. Notice abrupt contact between the soil and the basalt bedrock. Bedrock is at 12 inches.

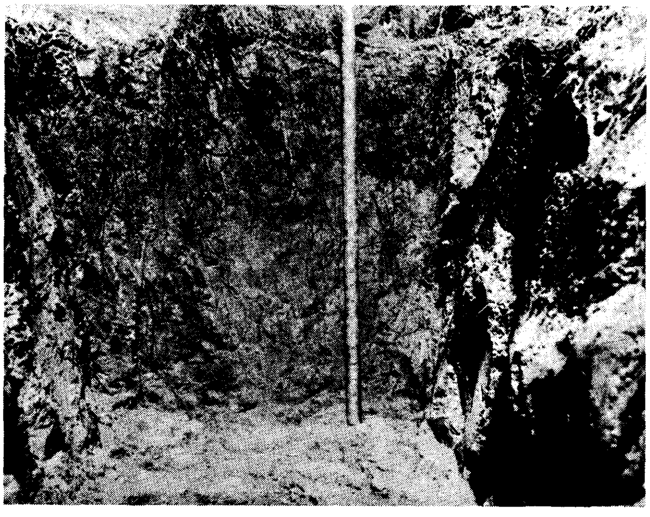

FIG. 3. Anders silt loam profile. Bedrock is at 25 inches.

Results

A brief, semi-technical description of the three soils used in this study as described by the soil scientist with soil colors given using the Munsell (USDA, 1951) notations are:

Bakeoven cobbly silt loam, 0 to 15% slopes (Fig. 1).

Surface layer, 0–1½ inches	Brown (10YR 5/3) cobbly silt loam; weak very fine granular structure; slightly hard, very friable, nonsticky, and nonplastic; common roots; neutral reaction.
Subsoil, 1½–5 inches	Light yellowish brown (10YR 6/4) gravelly silt loam; moderate medium subangular blocky structure; hard, very friable, sticky and slightly plastic; common roots; neutral reaction.
Substratum, 5 inches +	Consolidated basalt bedrock.

Kuhl silt loam, 0 to 15% slopes (Fig. 2).

Surface layer, 0–7½ inches	Brown (10YR 5/3) silt loam; moderate fine subangular blocky structure; slightly hard, very friable, slightly sticky, and slightly plastic; many roots; 1% gravel; neutral reaction.
Subsoil, 7½–12 inches	Brown (10YR 5/3) silt loam; moderate fine subangular blocky structure; hard, friable, sticky, and plastic; common roots; 1% gravel; neutral reaction.
Substratum, 12 inches	Consolidated basalt bedrock.

Anders silt loam, 0 to 15% slopes (Fig. 3).

Surface layer, 0–11 inches	Grayish brown (10YR 5/2) silt loam; weak medium subangular blocky structure; slightly hard, very friable, nonsticky, and nonplastic; many roots; neutral reaction.
Subsoil, 11–25 inches	Brown (10YR 5/3) very fine sandy loam; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky, and nonplastic; common roots; neutral reaction.
Substratum, 25 inches	Consolidated basalt bedrock.

The first clipping of the vegetation in 1967 was taken on June 5, and then on July 11 the plots were revisited to see if there had been any regrowth. It was necessary to reclip one Kuhl plot

FIG. 4. Stiff sagebrush and Sandberg bluegrass are the native vegetation on the Bakeoven cobbly silt loam soil.

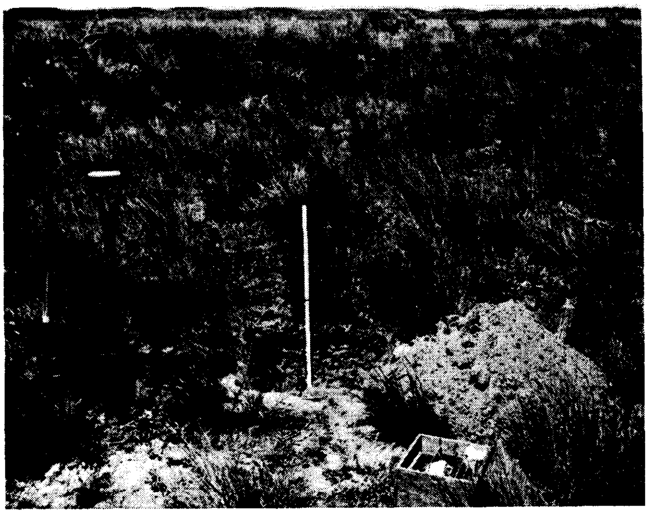

FIG. 5. Native vegetation on the Kuhl silt loam is primarily bluebunch wheatgrass. Soil pit and sampling equipment in foreground.

FIG. 6. On the Anders silt loam soil, Idaho fescue and threadleaf sedge are the dominant plants.

Table 1. Forage production (lb/acre, air dry) on the Bakeoven, Kuhl, and Anders soils. Data are average of the three plots clipped each of 2 years.

Plant Names	Bakeoven cobbly silt loam	Kuhl silt loam	Anders silt loam
Grasses and Grass-like			
Sandberg bluegrass (*Poa sandbergii*)	59.9	46.6	
Bottlebrush squirreltail (*Sitanion hystrix*)	14.9		
Bluebunch wheatgrass (*Agropyron spicatum*)		341.8	16.6
Japanese brome (*Bromus japonicus*)		16.6	
Cheatgrass brome (*Bromus tectorum*)		6.6	
Idaho fescue (*Festuca idahoensis*)			283.3
Threadleaf sedge (*Carex filifolia*)			308.3
Western needlegrass (*Stipa occidentalis*)			63.3
Sixweeks fescue (*Festuca octoflora*)			8.3
Big bluegrass (*Poa juncifolia*)			5.0
Forbs			
Biscuitroot (*Lomatium* spp.)	9.9	8.3	T[1]
Littleflower collinsia (*Collinsia parviflora*)	6.6	11.6	
Other annual forbs	13.3	52.0	43.3
Wyeth eriogonum (*Eriogonum heracleoides*)		120.0	3.3
Blue-eyedgrass (*Sisyrinchium* spp.)		4.9	31.6
Larkspur (*Delphinium* spp.)		3.3	
Salsify (*Tragopogon* spp.)			31.6
Lupine (*Lupinus* spp.)			28.3
Common comandra (*Comandra umbellata*)			13.3
Astragalus (*Astragalus* spp.)			6.6
Phlox (*Phlox* spp.)			8.3
Death camas (*Zigadenus* spp.)			T
Fleabane (*Erigeron* spp.)			10.0
Agoseris (*Agoseris* spp.)			8.3
Shrubs			
Stiff sagebrush (*Artemisia rigida*)	54.1		
Big sagebrush (*Artemisia tridentata*)		T	T
Threetip sagebrush (*Artemisia tripartita*)		8.3	T
Gray horsebrush (*Tetradymia canescens*)			T
TOTAL PRODUCTION	158.7	620.0	869.4

[1]T in table indicates a quantity less than 1.

and all three of the Anders plots on the later date. After that time no appreciable regrowth was noted. In 1968, the plots were first clipped on June 11 and revisited on July 10 to be reclipped, but there was no regrowth, probably because of the drier than normal year. In 1968 plots were taken on different areas from those clipped in 1967 but still within the bounds of the original plot study area.

A distinct difference in plant community was found on the three soils. The plant community on Bakeoven cobbly silt loam (Fig. 4) was dominated by stiff sagebrush[4] and Sandberg bluegrass; on Kuhl silt loam (Fig. 5) by bluebunch wheatgrass; and on Anders silt loam (Fig. 6) by Idaho fescue and threadleaf sedge. A marked difference in forage production between the three soils was also noted: Bakeoven cobbly silt loam produced 158.7 lb/acre; Kuhl silt loam produced 620 lb/acre; and Anders silt loam produced 869.4 lb/acre (Table 1).

Conclusions

From the results of this study, it seems apparent that differences in soil depth do have an effect on the kind and amount of vegetation produced. Soil depth should be considered when evaluating the forage production potential of range soils. It is planned to continue this study for several more years so that ranges in yields in both favorable and unfavorable years can be obtained. Consideration should be given to extending this type of study into other climatic areas and onto other kinds of soils.

No special attempt was made to regulate conditions, so inch-by-inch differences in soil depth can be interpreted as differences in plant community or production. However, these observations were made: On the Bakeoven soil the plant community is composed mainly of stiff sagebrush and Sandberg bluegrass, and the yields are very low. On the Kuhl soil the yields are much higher than on the Bakeoven soil, and the plant community changed markedly to basically bluebunch wheatgrass. The Anders soil does not reflect the striking contrast in production over the Kuhl soil that the Kuhl has over the Bakeoven soil. However, there was a difference in yield, but more important, the plant community is dominated by Idaho fescue and threadleaf sedge.

[4] Botanical names of species mentioned are found in Table 1, as according to Hitchcock et al. (1969).

Literature Cited

ANDERSON, E. WILLIAM. 1962. Behavior of forage yields on some range sites in Oregon. J. Range Manage. 15: 245–252.

HITCHCOCK, C. LEO, ARTHUR CRONQUIST, MARION OWNBEY, AND J. W. THOMPSON. 1969. Vascular plants of the Pacific Northwest. Univ. of Wash. Press, Seattle. Parts 1–5.

HULETT, G. K., G. L. VAN AMBURG, AND G. W. TOMANEK. 1969. Soil depth-vegetation relationships on a shallow limy range site in western Kansas. J. Range Manage. 22: 196–199.

MASON, LAMAR R., HORACE M. ANDREWS, JAMES A. CARLEY, AND E. DWAIN HAACKE. 1967. Vegetation and soil of No Man's Land Mesa relict area, Utah. J. Range Manage. 20:45–49.

USDA. 1951. Soil survey manual. USDA Handbook No. 18. 503 p.

SECOND CALL FOR PAPERS

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each proferred paper to the appropriate subcommittee for review and final selection. Acceptance will be based on a review of submitted material, relevance to the theme and to suitability for inclusion in a program session. Authors will be notified of acceptance after September 1, 1970. Abstracts of preliminary abstracts may be revised in a uniform style for publication in the program of the 1971 meeting.

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Program chairman for the 1971 meeting is:

C. M. McKell
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Abstracts and supporting information should be mailed to Dr. McKell to arrive no later than June 20, 1970.