# Root Systems of Four Desert Grassland Species on Grazed and Protected Sites[1]

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## Highlight

**Root systems of species of *Aristida*, *Bouteloua* and *Trichachne* were restricted to the upper 7 inches of soil, with depth penetration of roots influenced by characteristics of the soil. Grazing affected root development by reducing the amount of branching of first-order roots and, in 2 species of *Bouteloua*, by decreasing total root density. Root diameter was not affected.**

The root system of a plant represents almost one half of the total material produced by that plant, and must be taken into account when the effect of environmental factors on plant development are studied.

Several early clipping experiments (Biswell and Weaver, 1933; Robertson, 1933; de Peralta, 1935) found that root development was affected by defoliation and reduction of photosynthetic surface. Crider (1955) observed root growth directly and noticed a cessation of growth for a period of time dependent on the severity of the clipping treatment. Troughton (1957) reviewed the literature on underground organs of herbage grasses and listed many other studies on the effects of defoliation on root development. A recent study by Schuster (1964) showed that heavy grazing reduced total root weight, depth of penetration and branching of the roots of several grass species growing under natural conditions in Colorado.

The present study investigated the effect of grazing on the root development of four species of native grasses of the southwestern United States, excavating grass plants growing in the field under natural conditions but subjected to different grazing pressures. The species studied included threeawn (*Aristida glabrata* (Vasey) Hitch.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), slender grama (*Bouteloua filiformis* (Fourn.) Griffiths) and Arizona cottontop (*Trichachne californica* (Benth.) Chase).

### Study Area and Methods

The field work was carried out at the Santa Rita Experimental Range, about 25 miles south of Tucson, Arizona, with an average annual precipitation of 16 inches. A soil survey of the region (Youngs et al., 1955) classifies the soil at the study site as Tumacacori coarse sandy loam, a soil which "absorbs and holds moisture well, releases it readily to plants, and is sufficiently rich in humus and nitrogen to support vigorous plant growth."

The study site was located at Parker Station, 4300 ft above sea level. An enclosure protecting vegetation from grazing by livestock had been established there in 1935, within which a good stand of grama grasses was found. The area outside the enclosure had been grazed by cattle under varying intensities during the history of the experimental range, but the presence of a cow path along the edge of the enclosure indicated fairly constant presence of cattle in the area whenever the pasture was in use. Measurements were made on root systems of at least 10 individual plants of 4 species, both within and outside of the enclosure to detect any differences which could be attributed to differences in past grazing pressures.

To expose the roots, a method developed by van Breda (1937) was adopted. Soil was removed from around the plant roots by means of a jet of compressed air, provided by a portable air compressor. In some areas of compacted soil, an ice pick was used to loosen the soil before blowing. Fig. 1 shows the root system of a grass plant after excavation by this method.

The density of the exposed root system was estimated by counting the number of roots which passed through a 1 x 2-inch wire frame, held within 3 inches from the base of the plant; a total of 4 counts were made for each plant. An independent estimate of root density was made by counting the number of secondary branches along the first 6 inches of main root, making 4 or more counts per plant, depending on the amount of variation within each species. Root diameter was measured on 20 main roots of each plant, cut within one inch from the base of the plant and mounted on scotch tape for easier handling.

All measurements were restricted

[1] *This study was supported by a fellowship from the Charles Lathrop Pack Forestry Foundation during 1957-58.*

FIG. 1. Roots of *Bouteloua filiformis* excavated by the compressed air method to depth of 30 inches.

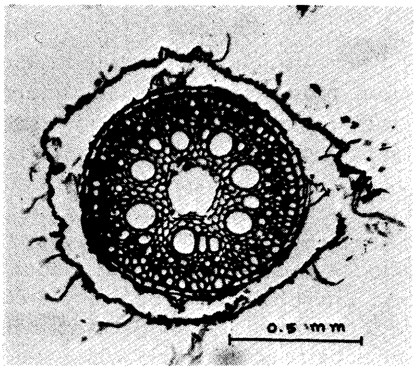

FIG. 2. Cross section of a root of *Aristida glabrata* showing the loose enveloping sheath characteristic of all species of *Aristida* found on the study area.

to the upper part of the root systems, in the top 7-inch soil layer. My prior root excavations in the same general area had shown that most of the root development of the grass species concerned took place at this shallow depth. Deeper root penetration appeared to be closely related to soil type and no attempt was made to determine the influence of grazing on extreme rooting depths.

### Root Development

The general descriptions of root systems in this section are based on more complete root excavations along deep trenches, both within and outside of the enclosure and at other sites within the experimental range. The additional species mentioned were closely related to the grasses studied, but were not available both within and outside of the enclosure for comparison.

Besides *Aristida glabrata,* three other species of threeawns were encountered on the study area, poverty threeawn (*A. divaricata* H. & B.), spidergrass (*A. ternipes* Cav.) and *A. hamulosa* Henr.; all showed similar characteristics in root development. The genus was typified by a very shallow root system, almost wholly restricted to the upper 4 inches of soil, with little depth penetration. The individual roots were of large diameter, averaging 1.12 mm, and showed little branching. The most characteristic feature of the roots of the threeawns was the presence of a light-colored sheath enveloping the stele. A similar sheath was described by Price (1911) for some Saharan species of this genus. Miscroscopic examination of cross-sections of threeawn roots showed the sheath as an external cell layer, in which root hairs and particles of sand were embedded. The intermediate cortical region below the epidermis had disintegrated, leaving the stele and endodermis as a loose central column (Fig. 2).

The genus *Bouteloua* was characterized by a very finely divided root system, with much branching. In slender grama, hairy grama (*B. hirsuta* Lag.) and Rothrock grama (*B. rothrockii* Vasey), the root diameter averaged 0.35 mm, but the taller sideoats grama had coarser roots, averaging 0.75 mm in diameter. Superficial root development was restricted to the upper 7 inches of soil, but downward extensions to depths of 36 inches were observed in coarse-textured deep soils.

The roots of Arizona cottontop were similar to those of the gramas in lateral spread and depth of penetration. The roots were not as much branched, however, and average root diameter was 0.61 mm. Cell walls were heavily lignified and a concentration of main xylem vessels was found in the center of the stele, making these roots strong and difficult to break.

**Table 1. Effects of grazing on root development.**

| Species[1] | Branch 1st 6 in | No. roots per sq in | Diam. mm |
|---|---|---|---|
| Agl | | | |
| prot. | 14.0* | 9.5 | 0.92 |
| grazed | 8.5* | 9.5 | 1.32 |
| Bcu | | | |
| prot. | 100.5* | 15.5* | 0.83 |
| grazed | 84.3* | 11.7* | 0.83 |
| Bfi | | | |
| prot. | 86.0* | 29.0* | 0.36 |
| grazed | 53.0* | 11.2* | 0.37 |
| Tca | | | |
| prot. | 80.0* | 14.0 | 0.66 |
| grazed | 32.0* | 10.5 | 0.57 |

*Significant difference at 0.05 confidence level

[1] Agl = *Aristida glabrata;* Bcu = *Bouteloua curtipendula;* Bfi = *B. filiformis;* Tca = *Trichachne californica.*

**Effects of Grazing and Discussion**

The amount of branching was the parameter of root development most consistently affected by grazing (Table 1). Statistical analysis of the variation around the mean, and a simple t-test, showed significant differences in all cases at the 5% confidence level.

Number of roots/in$^2$ was only affected in the highly-branched root systems of the grama grasses; in *Aristida glabrata* the number of branches relative to the number of main roots was too low to show any reduction in total number of roots near the base of the plants; while in Arizona cottontop the observed decrease in number of roots was too variable to show up significantly.

Root diameter was highly variable and no significant differences were observed between protected and non-protected plants. The lack of observable differences in some species may also have been due to their relative unpalatability and light use even under unprotected conditions.

The fact that defoliation results in a reduction in the total root mass of the plants so treated, has by now been documented in several studies and with various species. The results of this study show that much of this reduction comes from a tendency towards less branching of the main roots. Such secondary branches in general are short and their loss does not always show up in a reduction of root density expressed as number of roots passing through an arbitrary surface area. But as these smaller branches present a relatively larger surface area in contact with the soil, their reduction could seriously restrict the potential of the plant to obtain moisture and nutrients from the soil.

**LITERATURE CITED**

BISWELL, H. H., AND J. E. WEAVER. 1933. Effect of frequent clipping of grasses. Ecology 14:368-390.

BREDA, N. G. VAN. 1937. An improved method in the study of root bisects. So. Afr. J. Sci. 34:260-264.

CRIDER, F. J. 1955. Root growth stoppage resulting from grass defoliation. U.S.D.A. Tech. Bull. 1102. 23 p.

PERALTA, F. DE. 1935. Some principles of competition as illustrated by sudan grass, *Holcus sorghum sudanensis* (Piper) Hitch. Ecol. Monog. 5:355-404.

PRICE, R. S. 1911. The roots of some North African desert grasses. New Phytol. 10:328-333.

ROBERTSON, J. H. 1933. Effect of frequent clipping on the development of certain grass seedlings. Plant. Physiol. 8:425-447.

SCHUSTER, J. L. 1964. Root development of native plants under three grazing intensities. Ecology 45: 63-70.

TROUGHTON, A. 1957. The underground organs of herbage grasses. Commonwealth Bur. Past. and Field Crops Bull. 44. 91 p.

YOUNGS, F. O., A. T. SWEET, A. T. STRAHORN, T. W. GLASSEY, AND E. N. POULSON. 1931. Soil survey of the Tucson area, Arizona. U.S.D.A. Bur. of Chem. and Soils, Ser. 1931, No. 19.