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NON-GRAZING AND GOPHERS LOWER BULK DENSITY AND ACIDITY IN ANNUAL-PLANT SOIL

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Abstract: The effects of non-grazing on Ahwahnee coarse sandy loam were studied at the San Joaquin Experimental Range in central California. An exclosure, on which there had been no livestock grazing for 34 years, had a lower surface bulk density and lower acidity than an adjacent range that had been grazed. Bulk density averaged 1.08 gm./cc. on the ungrazed range, and 1.43 gm./cc. on the grazed range. The pH values were 6.15 for the ungrazed area, and 5.65 for the grazed area.

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Since the days of the early Spanish settler, the influences of livestock use have altered the character of California's rangelands. Native perennial bunchgrasses were replaced by annuals introduced at the Spanish missions[1] and soil properties have changed—particularly bulk density.[2]

Mature cattle exert static ground pressures equal to those of heavy wheel tractors—around 24 pounds per square inch of hoof-bearing area.[3] Trampling compacts the upper few inches of soil, increasing soil bulk density and reducing porosity and moisture storage capacity—especially when soils are moist.

In a study at the San Joaquin Experimental Range, in central California, we sought to determine whether surface soil bulk density where grazing had been absent for a number of years differed significantly from that where grazing had been continued. We also investigated the reaction of soil acidity under the two conditions. These kinds of information have not been available for soil in the granitic zone of annual-plant rangeland. We found that the absence of livestock grazing resulted in lower soil bulk density and lower acidity in the soil.

STUDY AREA

Two areas—an exclosure and an adjacent area *(fig. 1)*.—on the same site on the Experimental Range were selected for study. Each test area was 50-feet square. The site is classed as open-rolling with a southern exposure and a slope of 6.5 percent. The soil, an Ahwahnee coarse sandy loam, is common on the Experimental Range and much of the land nearby.

No livestock have grazed inside the exclosure since 1936. The exclosure also excluded squirrels but not gophers. The adjacent area has been moderately grazed from the first of February to early June since 1960. This is the season with adequate green forage and abundant soil moisture.[4]

Figure 1—*The exclosure (fenced area) and adjacent (lower boundary indicated by marker stakes) study areas on the San Joaquin Experimental Range.*

Within the exclosure, the vegetation was mostly ripgut brome *(Bromus rigidus)*[5] with smaller amounts of soft chess *(Bromus mollis)* and slender wild oat *(Avena barbata)* mixed in. Only a few forbs were present. Outside the exclosure, ripgut brome and soft chess were present. We also found annual fescues *(Festuca* sp.*)*, an abundance of broad-leaf filaree *(Erodium botrys)*, and several other forb species.

METHODS

Both inside and outside of the exclosure, five equally-spaced lines were drawn. This restriction to randomization was used to assure ample coverage of both areas. Along each line, 10 sampling points were randomly selected from a possible 40, providing for 50 observations per area.

A soil core of known volume (117.3 cc.) was removed at each point. The depth of sampling (6.5 cm.) was governed by the cylinder length of our field density sampler. The cores were dried at 105°C. for 24 hours and then weighed to the nearest one-tenth gram. From the oven-dry weights and volume, we computed the bulk density of each core.

The pH for each core was determined using the spot-plate technique. Values of pH were converted to their arithmetically equivalent values before analysis.[6]

For both values, bulk density and pH, the hypothesis of equality was tested by using Student's t test with 98° of freedom.

RESULTS AND DISCUSSION

The means in bulk density and pH values and their differences were:

	Bulk density (gm./cc.)	*pH*
Range:		
Grazed	1.43	5.65
Ungrazed	1.08	6.15
Difference	.35	.50

The differences were statistically significant at the 5 percent level of probability.

We found that the soil within the exclosure was soft and friable. On the grazed area it was hard, requiring much greater effort to collect the cores. The soils were also noticeably different in structure. Soil within the exclosure was granular; on the grazed area it had a coarse platy appearance.

Hence it came as no surprise that soil bulk density inside the exclosure averaged 24 percent less than on the grazed area. These findings on bulk density corresponds with those reported by Liacos for annual grassland in California.[2] His data were from the hills east of San Francisco Bay and a soil developed on sandstone.

Many diverse but co-acting factors were responsible for loosening the soil inside the exclosure. They include: (a) freezing and thawing of the soil surface, (b) residues and mechanical effects of plant roots, (c) the byproducts and activities of the soil microflora and fauna, and (d) the presence of a thick mulch layer to break the force of raindrops. But probably the most important factor was the cultivation of the soil and resultant mixing of mineral particles and organic matter by gophers.

Among the rodent species on the Experimental Range, the pocket gopher *(Thomomys bottae mewa)* is the most important soil cultivator.[7] In spring, gophers work the upper soil layers, extending their burrow systems which are usually 6 to 8 inches below the surface. Normally they will throw up one or more mounds daily, and in a single year gophers may turn over large portions of the surface.[8] Thus their effect on bulk density is largely a mechanical loosening of the soil.

Gophers had equal access to both the ungrazed and grazed areas. However, the period when gophers are most active near the surface is also when the soil is most easily compacted. Trampling by cattle recompacts the mounds, and their hoofs may break into the surface burrows. Therefore, trampling offsets soil cultivation by gophers. No trampling by cattle for the past 34 years combined with the cumulative effects of gopher activity was, therefore, the primary reason for the difference in soil structure and lower bulk density within the exclosure.

Soil within the exclosure averaged three times less acid than on the grazed area. However, both the lowest (pH 7.8) and the highest (pH 4.7) acidity were found on the grazed area. The lesser variation and less acid condition within the exclosure were likely the combined result of: (a) the absence of grazing which unevenly removes the predominantly basic grass residues; and (b) the absence of uneven fertilizing effects resulting from cattle feces and urine.

How rapidly soil is loosened in the absence of livestock and how rapidly soil becomes compacted after livestock are allowed to graze remain to be learned. We also need to learn whether different grazing management practices and range fertilization affect gopher populations.

NOTES

[1]Talbot, M. W., and A. W. Sampson. *The range in California. In,* The yearbook of agriculture. Washington, D. C. p. 575-582. 1948.

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[4]Bentley, J. R., and M. W. Talbot. *Efficient use of annual plants on cattle ranges in the California foothills.* U.S. Dep. Agr. Circ. 870, 52 p. 1951.

[5]Scientific plant names follow Munz, P. A., and D. D. Keck. *A California flora.* Berkeley: Univ. Calif. Press. 1959.

[6]Daubenmire, R. F. *Plants and environment–a textbook of plant autecology.* New York: John Wiley and Sons, Inc., p. 45-57. 1953.

[7]Horn, E. E., and H. S. Fitch. *Interrelations of rodents and other wildlife of the range.* Calif. Agr. Exp. Sta. Bull. 663. p. 113-115. 1942.

[8]Storer, Tracy I. *Controlling field rodents in California.* Calif. Agr. Exp. Sta. Ext. Serv. Circ. 434, p. 27. 1953.

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The Station's range-wildlife environmental research unit, headquartered at Fresno, California, is developing the scientific base for multiple-use management of central California ecosystems. This report adds a facet of knowledge for the ecosystem of the Sierra Nevada foothills.