VEGETATION ON GYPSUM SOILS OF THE JORNADA PLAIN, NEW MEXICO

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The small number of plant species and their sparse distribution on gypsum is a real problem on many ranges in the southwest. Herrick ('04) states that the great Jornada del Muerto plain is evidently underlain at no great depth by deposits of the Red Bed series, a gypsum bearing formation extending from New Mexico into Texas, Oklahoma and Kansas. The White Sands in New Mexico, now mostly within a national monument, is a spectacular gypsum formation, with both active and stabilized dunes containing from 96 to 98 per cent hydrous calcium sulphate (Cockerell and Garcia, '98; Coville and MacDougal, '03; Macbride, '05). Just a few miles west over the San Andres Mountains on the Jornada Experimental Range,[1] several thousand acres is occupied by gypsum soils, or by sandy soils underlain by gypsum at shallow depths. Regular observations of these two soil types from 1925 to 1934, with available climatic, vegetative, and grazing records, constitute the basis for this report.

Factors Influencing Vegetation

The Jornada plain ranges from 4,000 to 4,600 feet above sea level, has no permanent stream, and no surface outlet to the Rio Grande, 10 miles to the west. The San Andres mountains to the east consist of low sandstone foothills, and a higher limestone mass, underlain by granite. The soils of the plain or mesa are largely Quaternary alluvium with older sands and gravels. The Manzano group described by Talmage and Wootton ('37) applies to the Jornada plain, and contains gypsum beds as much as 100 feet thick. Soils, climate and biotic factors are all important to the vegetation.

The gypsum earth, sometimes called gypsite, commonly has a thin veneer of grayish silt or very fine sand. At the top the gypsum has disintegrated into a soft floury mass, and the rock gradually becomes harder or more coarsely crystalline with depth.[2]

An adjacent soil type is sand underlain by gypsum at shallow depths. The sand is reddish, medium in texture and loose. It rests upon a bed of soft

[1] A branch of the Southwestern Forest and Range Experiment Station; headquarters are maintained in Tucson, Arizona, in cooperation with the University of Arizona.

[2] Soil descriptions were adapted from a typewritten report (1918) by J. O. Veach, of the then Bureau of Soils, U. S. Department of Agriculture, based upon his soil survey of the Jornada range.

whitish rock, mainly gypsum, with a sharp contact, at depths of a few inches to 2 or 3 feet. In places the sand has been drifted into mounds with windswept spaces between, with the gypsum bed partly exposed. A bed of crystalline gypsum more than 8 feet thick was found in one place. It seems probable that this soil type, like the first, is a chemical precipitate formed during the desiccation of old lakes, rather than a soil caliche, which is mainly calcium carbonate.

Analyses of gypsum soils from the Jornada range by the Bureau of Chemistry and Soils showed from 65 to 76 per cent soluble salts, with about 60 to 65 per cent calcium sulphate. There were small amounts of Mg, Na, K, Cl, and HCO_3, but no CO_3. NO_3 was lacking both in the surface .5 inch, at 6 inches and at 12 inches in depth.

Both soil types here considered ranged within the comparatively narrow alkaline limits of pH 7.8 to 8.2 in samples collected down to a depth of 12 inches.

The climate on the Jornada range is representative of a large area of the semi-desert southwest. The temperatures at the headquarters from 1914 to 1930 vary from a mean minimum in January of 21.2° F. to a mean maximum of 94.7° in July. In general, minimum temperatures are about 40° F. or higher from early April until late October, and permit growth during that period. The average annual precipitation from 1914 to 1934 inclusive was 8.98 inches, of which 51 per cent came during July, August, and September; although less than 2 inches of rain fell during the summer of 1934. Wind movement and evaporation are considerably higher during the spring months than after the rainy season starts.

The native fauna associated with the plant life differs considerably on the two soil types under consideration. Few rabbits or kangaroo rats were observed on the gypsum outcrops, a condition similar to that previously reported for clay soils (Campbell, '31). The shallow sands underlain by gypsum, however, are inhabited by comparatively large numbers of jack rabbits, cottontails, kangaroo rats and wood rats, a condition found on other loose sandy soils of the Jornada mesa. A herd of pronghorned antelope grazes the herbage on both the gypsum and the shallow sand types.

Cattle also range over both soil types, but in general prefer vegetation on the sandy soil to that on the gypsum.

Vegetation on Gypsum Outcrops

The number of plant species that occur on the gypsum soils of the Jornada range is more limited than on any other soil type. The list observed over a ten year period includes only two grasses, *Sporobolus nealleyi* and *Pappophorum wrightii;* five other herbaceous plants, *Galpinsia hartwegi, Gaura coccinea, Sartwellia flaveriae, Dicranocarpus parviflorus* and *Solanum jamesii;* and one shrub, *Ephedra torreyana.* This is the type locality of the moss *Moenkemeyera littlei* discovered in 1934 growing on shaded vertical walls of gypsum sinks (Williams, '36; Little, '37). Crustose lichens also occur occasionally. Ordinarily only the *Sporobolus* and *Ephedra* are present in any great abundance, with the grass clearly predominant (fig. 1). In years when the precipitation is considerably above average, such as 1926, the *Sartwellia* may occur in considerable abundance, and the other species listed are frequently observed. Only *S. nealleyi, G. coccinea* and the Moenkemeyera appear to be limited to the gypsum soils.

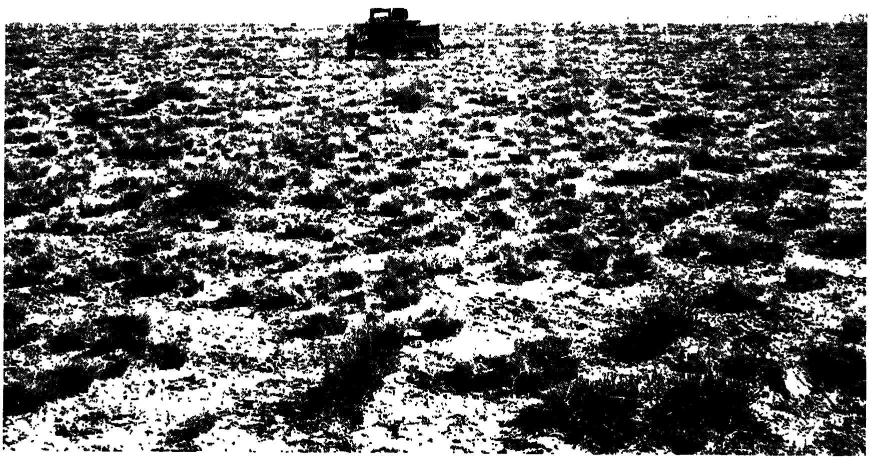

FIG. 1. *Sporobolus nealleyi* and *Ephedra torreyana* growing on gypsum soils on the Jornada range. Note typical ring growth of the grass tufts.

The eight flowering plants listed above are the same or closely related to those on the White Sands but far fewer in number than the 62 species reported there by Emerson ('35). The Jornada gypsite supports a denser and more uniform vegetation than the gypsum dunes or alkali flats of the White Sands, but even so, when compared with black grama (*Bouteloua eriopoda*) range, it is only too obvious that the range forage production of the *S. nealleyi* type is extremely low. Under good management it usually would require 30 to 35 surface acres to support a cow for a month as compared to about 3 acres per cow per month on the best black grama sites. The density of vegetation is about 0.1, the plants are widely spaced, short, and mature slowly.

The *S. nealleyi* tufts grow in the ring or nest shape characteristic of several other grass species in the region. The slow growing panicle is enclosed within a membranous sheath, which often remains unbroken, so that in many years the seed are not disseminated even if they mature. One seed sample required examination of 1,600 florets to secure 100 cleaned seeds. In addition the tough seed coat prevents ready germination, although some seed remained viable for five years. The following tabulation summarizes germination tests of clean *S. nealleyi* seed collected in three different years, Retests were made on new lots of seed from the same samples.

Seed collected	Initial test germination		Retest germination	
year	*year*	*per cent*	*year*	*per cent*
1928	1929	20.5	1934	0
1929	1930	10.0	1934	8.0
1931	1933	14.0	1934	20.0

With the combination of scant seed, poor germination and compact soil, very few *S. nealleyi* seedlings appeared. Furthermore, the stand of this grass was materially reduced by the 1934 drought. It decreased from 655 sq. cm. on a square meter quadrat in 1931 to 10 sq. cm. in 1935, charted at 1 inch above the ground. Of the 7 tufts of this grass on the plot in 1931, only 1 was alive in 1937.

The Ephedra spreads only very slowly. It survived the 1934 drought much better than the grass, as very few individual shrubs died.

Although considerable work has been done with applications of gypsum to other soils, yet little has been attempted toward working out the reason for the lack of productivity of gypsum itself under range conditions. Some authors suggest that some chemical property of gypsum soils inhibits plant growth; others propose a physical explanation. Both reasons probably contribute to the scarcity of plant life on these soils. Hilgard ('06) states that few naturally gypseous soils are very productive although gypsum apparently is not hostile to plants, since it is used extensively as a commercial fertilizer. Cockerell and Garcia ('98) found that wheat and peas grew in soils from the White Sands as well as in ordinary soil under laboratory conditions. However, in the field Emerson ('35) found no growth water at 6 inches under the surface of the dunes. Furthermore, he inferred that all water absorbed by roots in the gypsum sands must be taken from a practically saturated solution of calcium sulphate, a condition which undoubtedly holds in the Jornada gypsum outcrops. The lack of nitrates and probably the limited quantities of essential minerals also would be expected to retard plant growth.

Both Hilgard ('06) and Widtsoe ('11) indicate that the fine, uniform particles of gypsum and associated heavy clay soils become so closely packed that pore space is exceedingly small. This condition makes the soil unusually difficult to prepare for cultivation. In nature as well as from commercial treatment gypsum may form a sort of plaster—a medium most unsuitable for plant growth. Furthermore, the chemical and physical properties of gypsum soils so limit the plants which do grow that they are subject to more severe wind erosion and desiccation than are individuals in denser stands.

Shallow Sands Underlain by Gypsum

The flowering plants on the loose sands where gypsum is within a few inches of the surface include all of those on gypsite. In addition, there occurs in moist years a dense stand of *Franseria acanthicarpa,* a tall annual ragweed. Grasses which come in include giant and mesa dropseeds, *S. giganteus,* and *S. flexuosus.* Later in the succession even black grama may come in, but it is easily killed out by close grazing or trampling on this site. *Yucca elata* and *Prosopis glandulosa,* shrubs typical of the mesquite-sand dune type, also appear. In fact the vegetation on these areas where the gypsum is completely covered with several inches of sand in general resembles that previously described for typical mesquite sand dunes (Campbell, '29). The best types now growing on these soils on the Jornada range still have a long way to go before they compare favorably with the better black grama areas on compact sandy or gravelly soils. The sands underlain by gypsum now afford a grazing capacity of approximately 15 to 20 surface acres per cow month, as compared to about 3 surface acres per month on the best black grama.

Undoubtedly many of the unfavorable factors responsible for sparse vegetation on the gypsum outcrops continue to operate in the shallow sands, for the gypsum is still within easy reach of the plant roots. This whole situation is one which could easily mislead the range examiner. A superficial inspection of the shallow sandy type might lead one to attribute the sparsity and poor quality of vegetation to overgrazing, when actually the presence of gypsum close to the surface greatly retards plant succession, which is slow at best in the semi-desert southwest. In this case the poor range production is much the same regardless of the distance from stock watering places. The occasional gypsum outcrops indicate its proximity to the surface, and the loose surface sand characterizes a soil type not yet stabilized. Talbot '38 points out that there are several places in the Southwest where small denuded areas supporting little or no herbaceous vegetation may not indicate range abuse, but rather a heavy concentration of gypsum or other salts unfavorable to plant growth. It is necessary in sound range management to recognize this and similar unusual situations, and limit the grazing of the area to the season and intensity that will bring about its gradual improvement under existing soil conditions.

Summary

Gypsum soils of the Jornada plain in southern New Mexico are of two types: (*a*) Gypsite or gypsum earth, 60 to 65 per cent calcium sulphate, lacking in nitrates, and (*b*) loose quartz sands a few inches in depth, underlain by gypsum.

Both soil types are comparatively unproductive, probably owing to a combination of chemical and physical properties of the gypsum, and to

the effect of continued wind erosion on the soil and on the sparse vegetation.

Range inspection and range management require careful observation and analysis of soil conditions in order to arrive at a proper interpretation of the reasons for forage production, and plan for forage utilization that will favor range improvement.

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