VEGETATIVE SUCCESSION IN THE *PROSOPIS* SAND DUNES OF SOUTHERN NEW MEXICO

R. S. CAMPBELL

Jornada Range Reserve, U. S. Forest Service

PROSOPIS SAND DUNES

The Jornada Range Reserve, on which this study was made, was established in 1912, and has been conducted by the U. S. Forest Service as a range experiment station since 1915. It is a typical semi-desert range, adjacent to the Rio Grande valley in Doña Ana County, New Mexico, about 50 miles north of the Mexican boundary. There are about 145,000 acres (58,000 hectares) in the mesa portion, of which approximately one-fourth is covered by the *Prosopis* sand dune type, consisting of low, evenly distributed dunes occupied principally by mesquite (*Prosopis glandulosa* Torr.), with "blow outs" (wind formed hollows) in between the dunes.

The soils of the mesa are mostly Quaternary alluvium with older sands and gravels (Darton, '22), and the *Prosopis* type is always found in the loose, wind-blown phase of the more sandy soils. The community, as shown in Plate XII, 1, is rather extensive in southern New Mexico, although it is not mentioned by Watson ('12) in his description of the northern part of the state.

Results of Overgrazing

Jardine and Forsling ('22) have indicated that the ultimate result of injudicious grazing may be a transformation of grama grass (*Bouteloua eriopoda*) range to the *Prosopis* sand dune type. Evidence in favor of this statement is found in the occurrence of mesquite plants on the overgrazed and trampled area near wells, although the presence of *Prosopis* on trails and near watering places is often attributed to the dissemination of seed by grazing animals.

Because the *Prosopis* type is far inferior to *Bouteloua* grass range for grazing purposes, the study of the sand dunes is highly important. With proper handling, the deterioration of *Bouteloua* ranges may be checked, and under favorable climatic conditions the natural revegetation of the dune area may be accomplished. *Prosopis* plants are valuable as sand binders, and the large roots and thickened bases of the stems furnish the best fuel of the region. However, except for the beans and fresh growth in spring, the plants are comparatively poor forage; and, therefore, no opportunity should be overlooked for restoring *Prosopis* range to grass lands. For this reason, studies of the *Prosopis* sand dunes were initiated on the Jornada Range Reserve, and some preliminary findings are presented in this paper.

CLIMATE

Temperature

The climatic factors of the region are variable. The following temperature means, in degrees F., are taken from a 60 years' record at the New Mexico State Agricultural College (Linney, '25), about 25 miles south of the Reserve headquarters.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42.2	46.3	53.1	60.6	69.1	78.2	80.5	78.6	72.5	61.2	49.3	42.1

Temperature is a limiting factor only from October to the following April, but lack of moisture usually prevents the occurrence of a six months' growing season.

Precipitation

The precipitation is both irregular and spotted. There have been many drought years in the past, and even when rains do come, they are ordinarily local in character. Since 1915, the annual rainfall at the Jornada Reserve has varied from 3.54 inches in 1917 to 17.42 inches in 1926. The following precipitation means, in inches, taken from a 13 years' record at the Station, show why the growing season in southern New Mexico ordinarily includes only July, August and September. Over half of the total annual rainfall occurs during these three months.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.32	0.31	0.55	0.18	0.51	0.29	1.75	1.68	1.26	1.02	0.35	0.47

Mean seasonal, July, August and September, 4.69. Mean annual, 8.69.

Drought is one of the most important factors in the retrogression of southwestern range lands. During periods of low rainfall the detrimental effects of grazing and wind action become most pronounced. It has been found at the Jornada Reserve that continued drought may reduce the forage production 50 to 60 per cent, or even more, below the maximum (Jardine and Forsling, '22). Therefore, the range is easily overgrazed during drought, and the effects are all the more disastrous as a result of the weak condition of the vegetation.

Wind

Soil movement by wind is accentuated during drought and overgrazing, when there is less ground cover, and the sandy soils are in a loose condition. The most destructive effect of wind action is the erosion of soil away from roots, exposing plants to death from lack of moisture. While the soil particles are in transit, considerable direct damage is done to the vegetation by abrasion. Moreover, the windy spring season is a time of tremendous loss of soil moisture, because so much of the soil is moved into contact with the dry air, and its moisture content is brought below the wilting coefficient. Then, a final detrimental force is exerted when the sand is deposited, covering whole plants and causing further mortality, although it seems that plants recover more easily from sand deposition than from erosion.

Evaporation

Air movement is partly responsible for the increased evaporation during the spring and early summer, which is the most critical period in the life of the plants in this region. The following means, showing evaporation in

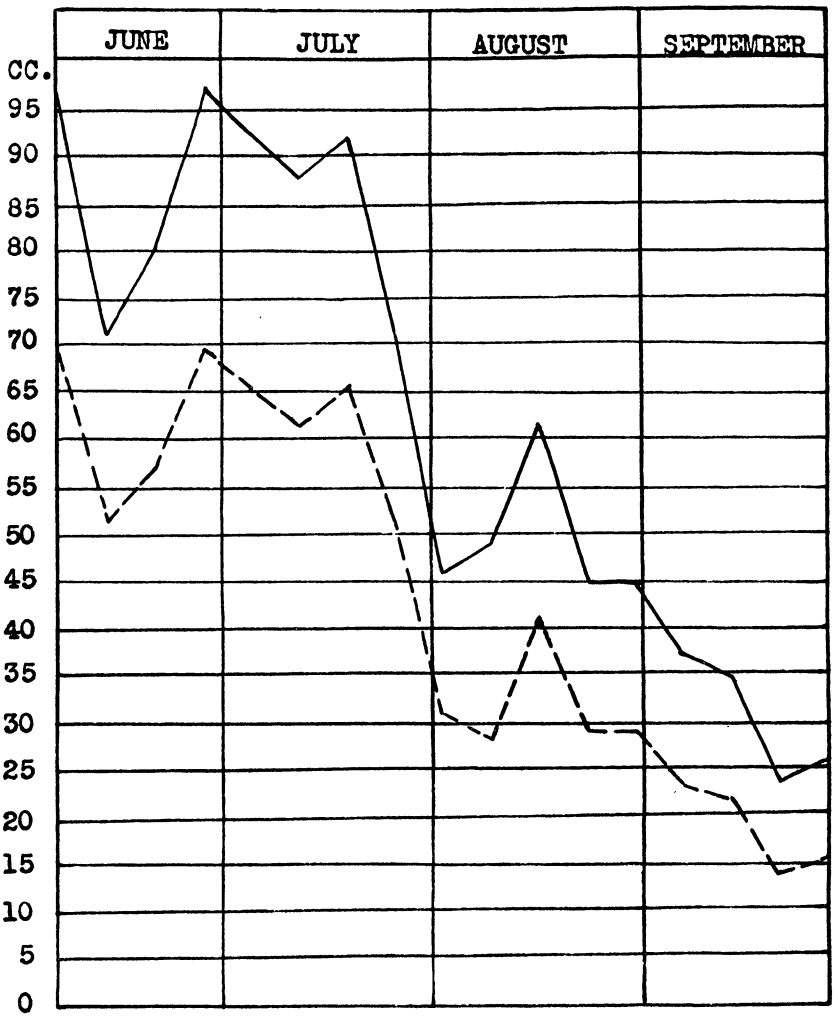


FIG. 1. Average daily evaporation rates, from Livingston atmometers, in the mesquite (*Prosopis*) sand dunes; summer, 1927. Solid line, bare spaces or blow outs; broken line, in the shelter of mesquite plants.

inches at the New Mexico Agricultural College (Linney, '19–'27), bring out the fact that the ratio of evaporation to rainfall is more than 10 to 1.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2.91	4.49	7.39	9.37	11.15	11.72	11.05	9.57	7.69	5.82	3.71	2.52

Mean annual evaporation, 87.39 inches

Figure 1 shows the average daily rate of evaporation during 1927 from standardized Livingston atmometers [1] in the *Prosopis* sand dunes. The high rate of evaporation in the blow-outs between the *Prosopis* dunes makes the bare spaces extremely dry.

Rodents

Nearly every *Prosopis* dune is infested with kangaroo rats, *Dipodomys spectabilis, D. merriami,* and *D. ordii.* These rodents burrow into all sides of the dunes, and feed to some extent upon the *Prosopis* beans. The first two species also collect and store grass and seeds for winter use, thus retarding the natural reseeding of the area. Jack rabbits and cottontails are also abundant in the dunes, and do considerable damage to the vegetation by nipping off leaves and gnawing the bark of the shrubs.

STAGES OF SUCCESSION

The stages of *Prosopis* sand dune succession occur on the Reserve at varying distances from water. The effect of overgrazing and trampling near water is clearly demonstrated by the fact that each higher stage in the series is found a little farther from water than the preceding one. Since the *Prosopis* clumps change rather slowly, the various stages are based on the plant succession which occurs in the space between dunes.

There are two general types of *Prosopis* dunes: the isolated clumps and the moving dune complex. The moving dunes are more difficult to arrest, and it is in the isolated dunes, especially on the protected northeast sides, that vegetation other than *Prosopis* begins to appear. The following plants occur in the *Prosopis* clumps, named in order of their abundance: *Yucca elata, Artemisia filifolia, Atriplex canescens, Ephedra trifurca, Parosela scoparia, Sphaeralcea incana, Gutierrezia* spp., *Helianthus* spp., *Aster* spp., *Sporobolus cryptandrus, Muhlenbergia porteri, Bouteloua eriopoda,* and some species of annual grasses. These plants are valuable as sand binders, as forage, and as seed plants to produce an annual supply of new seed for revegetation of the open blow-outs when favorable moisture conditions occur.

It is not without keen competition that plants other than *Prosopis* are able to grow in the dunes. Although *Prosopis glandulosa* seedlings have a distinct taproot, yet the root system of the mature plant is rather generalized, as Cannon ('11) has pointed out. The enlarged central root where water and nutrients may be stored, the vertical roots extending deeply into the sandy soil, the large lateral roots running far beyond the limits of the

[1] The atmometers were obtained through the courtesy of the Botany Department, University of Chicago.

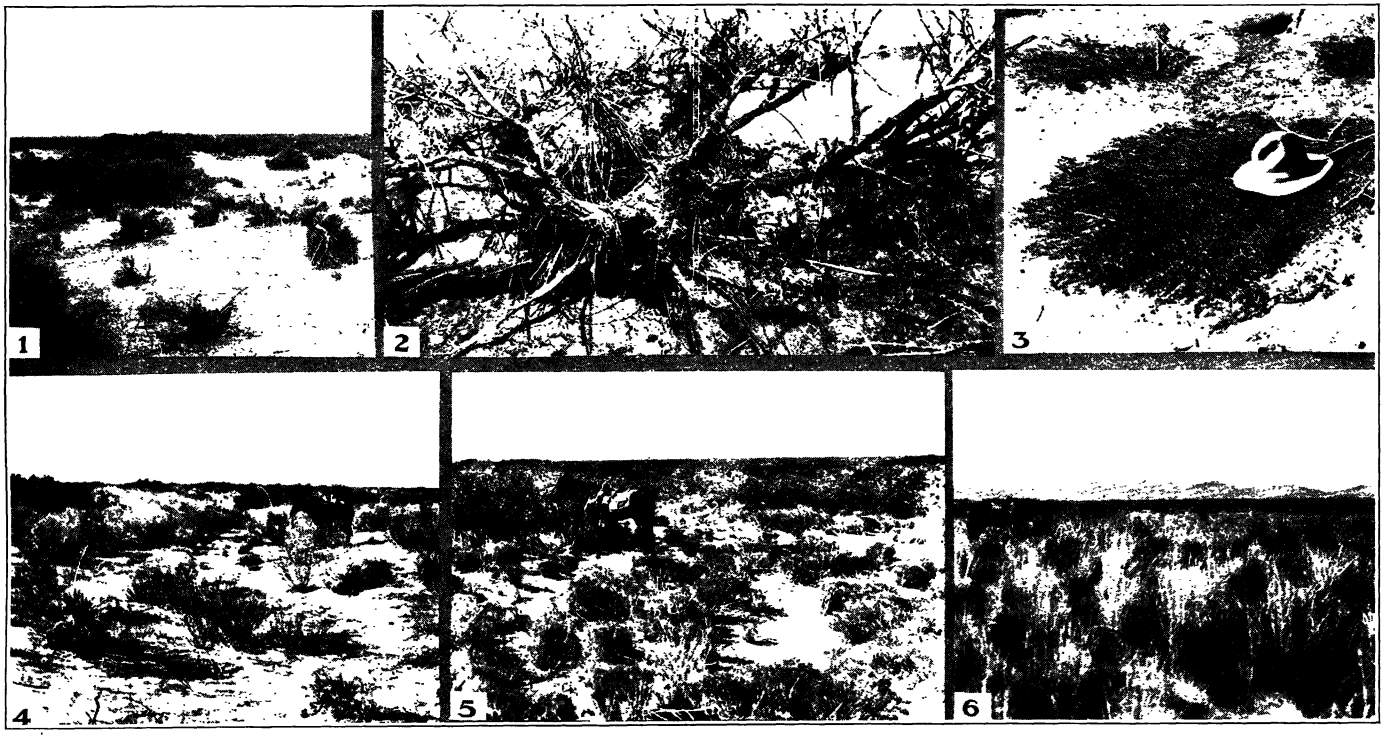
dune, and the great number of small shallow roots (Fig. 2, and Plate XI, 2), all aid *Prosopis* in its competition against incoming species, enable it to be one of the few plants to survive severe drought in the sandhills, and give it a tremendous endurance against overgrazing and wind erosion.

FIG. 2. A close up of the same mesquite plant as shown in Pl. XI, 2, after further excavation. Note the small surface roots of *Prosopis,* in direct competition with roots of grasses for available soil moisture.

Prosopis starts growth in the late spring, when most other perennials are practically dormant, and continues until late autumn. In fact, *Prosopis* is so well fitted to its habitat that it is only during a series of favorable years that other plants are able to thrive in the midst of the dunes, and for the stages of succession to develop in the "blow-outs."

The Mat Stage

When moisture conditions become favorable, surplus water accumulates in the "blow-outs," so that there may appear in the open spaces between the dunes several species of plants with a prostrate habit: *Chamaesyce revoluta, Parosela terminalis, Tribulus terrestris,* and others, all quick-growing, drought-escaping plants, shown in Plate XI, 3. This cover serves to obstruct and to hold the moving sands in place even after the end of the growing season, when all vegetation becomes dry, although most of the dry plant material is swept away by the strong spring winds.



1. *Prosopis glandulosa* plants with "blow outs" (wind formed hollows) between the dunes. 2. Bisect of a mesquite dune, showing the enlarged central root, and the extensive system of vertical and lateral roots of *Prosopis*. 3. The mat stage, showing the prostrate habit of *Chamaesyce revoluta*. 4. The ruderal weed stage, principally *Franseria*. 5. The *Gutierrezia* stage, thriving in a former blow out. 6. The *Sporobolus* association, just established in a *Gutierrezia* community at four miles from water.

Ruderal Weed Stage

When favorable moisture conditions continue for a sufficient length of time, a rank growth of large, coarse, annual and perennial "weeds" may start up and make the dune area a veritable flower garden during the summer period. The following forbs (Pl. XI, 4), named in order of their abundance, may come in either the same or the season following the mat stage: *Franseria acanthicarpa, Aster tanacetifolia, Reverchonia arenaria, Sophia ochroleuca, Sphaeralcea incana, Helianthus canus, Cucurbita foetidissima, Croton luteovirens,* and other coarse herbs, all with well developed root systems. They produce a gradual decline in the sand movement, even through the winter and dry windy spring months.

At the same time that the open spaces are being invaded with new vegetation, there is usually sufficient moisture in the mesquite clumps to permit a luxuriant growth of grasses and forbs.

The Gutierrezia Stage

When climatic and edaphic conditions permit, a heavy crop of *Gutierrezia* seedlings may appear, at first in the protection of *Prosopis* and other plants. Plate XII, 5, shows *Gutierrezia juncea* and other species in the *Prosopis* dunes. Other plants which occur in the type are: *Aristida purpurea, Baileya multiradiata, Panicum hallii,* and *Tidestromia lanuginosa,* as well as practically all of the plants mentioned in previous stages of succession.

The root system of *Gutierrezia juncea* is very adaptable to the conditions under which the plant happens to grow, as it ordinarily develops a strong taproot with several large laterals. When the plant grows in isolation, the development of lateral roots is much greater than when it is near or in contact with some other plant. Thus *Gutierrezia* possesses a generalized and adaptable root system which makes it very drought-enduring.

Although the *Prosopis* plants continue growth with unchecked activity, and the *Gutierrezia* stage brings no great increase in the forage production of the sand dune area, yet the establishment of a mature *Gutierrezia* community must be regarded as a marked upward step in the revegetation of the dunes. It is during the life of the *Gutierrezia* stage that excessive sand erosion is curbed, and leveling of dunes and deposition in the blow-outs is begun.

The Sporobolus Stage

After the *Gutierrezia* community is well established, various grasses may enter into the natural revegetation of the once bare spaces. During the second or third year of a continuous period of ample precipitation, the following grasses, listed in order of their abundance, become dominant: *Sporobolus cryptandrus, S. flexuosus, S. giganteus, Panicum hallii,* and *Aristida* spp. If there is sufficient moisture, nearly all of the species listed under preceding stages may be found, but grasses predominate where grazing is

not too heavy. During the third successive favorable year an excellent stand of *Sporobolus* was developed 3½ miles and farther from water (Pl. XI, 6).

The Bouteloua Climax

It is a far cry from the barren "blow-out" stage in the *Prosopis* sand dunes to a plains climax of the *Bouteloua* type, but such a succession may be brought about by proper handling of the range. Present studies at the Jornada Reserve indicate that, under proper grazing, *Bouteloua eriopoda* will eventually become dominant in *Gutierrezia* and *Sporobolus* types, providing the soil will support such a semi-desert climax.

SUMMARY

1. *Prosopis glandulosa* is a very drought-enduring plant, forming low dunes over large areas of western Texas, southern New Mexico, and southeastern Arizona.

2. During a period of three years of ample rainfall and conservative grazing the following stages in the natural revegetation of *Prosopis* sand dunes were observed at the Jornada Range Reserve: (*a*) Mat stage, low prostrate annuals. (*b*) Ruderal "weed" stage, large coarse annual and perennial forbs. (*c*) *Gutierrezia* stage, a very important step in revegetation. (d) *Sporobolus* stage, the beginning of new grasslands. (*e*) The grama grass, *Bouteloua eriopoda,* climax, highly valuable range land.

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