VEGETATION AND CLIMATE OF COAHUILA, MEXICO

Cornelius H. Muller

Introduction

Like much of Mexico, Coahuila has never received sufficient attention to make known the diversity of its physiography, climate, and vegetation. The extreme physiographic diversities of the state occupy a relatively small proportion of its total area. Much of Coahuila's surface is characterized by the Basin and Range type of topography; that is, by relatively isolated mountain ranges scattered on a nearly continuous series of undrained bolsones or desert plains. It is therefore possible to travel great distances in Coahuila without ever climbing above the level of the desert. Many biologists and climatologists passing within sight of the mountains seem to have been not at all impressed by their climatic and vegetational features. The principal travel routes in Mexico are largely confined to the level plains, and this is in large part responsible for the erroneous notion of vegetational and climatic homogeneity in Northern Mexico. It is the purpose of this paper to record observations within the mountains of Coahuila as well as on the plains and to present evidences of the existence of climatic diversity.

This study is based upon the division of the area into "natural regions," using as criteria topography, elevation, substratum, vegetation, and history. The important characters of a natural region vary less than those between any two natural regions. Essentially the same method was employed in a discussion of the vegetation and climate of Nuevo León (Muller, 1939).

Homogeneity of climate is an important character of a natural region, but the present state of our knowledge of the meteorology of Coahuila is very poor. A few scattered observatories, all of them located on the desert plains, give no clues to the climatic diversity of the mountainous areas. The close dependence of vegetation upon climate, other factors being accounted for, permits one to approximate an expression of the climatic types of areas in which the vegetation is known. In Coahuila, for instance, several meteorological observatories with relatively long records give us a fairly accurate picture of the climates of the several plains regions of the state. The vegetation of these plains is consistently one phase or another of Chihuahuan Desert Shrub in the Central Plateau Region or of Tamaulipan Thorn Shrub in the Coastal Plain Region. Departures from these vegetation types are confined to the high elevations and abrupt topographic features that favor increased rainfall and reduced temperature. A pine forest, for example, may be regarded as a definite indication of a climate of greater precipitation and lower temperature than that of the desert shrub.

Madroño, Vol. 9, No. 1, pp. 1–32. January 27, 1947.

Treatments of Vegetation and Climate of Coahuila

Until recently only incidental and fragmentary reference to the vegetation of Coahuila could be found in the literature, although several historic botanical collections were made within its limits. Gregg and Wislizenus were the earliest, but neither left any published record of the vegetation beyond casual mention of the widespread desert shrub. Pringle (1888) described the desert shrub in a few of its phases on the Central Plateau and the pine forests and chaparral of the mountains in the same region. He made no effort to indicate the distributions of these vegetation types. Merriam (1898) in mapping the distributions of his life zones credited northern and southeastern Coahuila with rather extensive areas of the Transition Zone, but he did not indicate the source of his information. The forests he intended to include in the Transition Zone are actually not nearly so extensive as his map indicates. Contreras (1942b) mapped the vegetational formations of Mexico in a general way, recognizing steppe, desert shrub, succulent desert shrub, and thorn shrub in Coahuila but not distinguishing them from similar but quite unrelated vegetation in other regions.

Treatments of the vegetation and climate of adjoining states give some clues to the nature of Coahuilan vegetation and climate. Palmer (1928) and Muller (1937) each gave brief descriptions of the vegetation of the Chisos Mountains in western Texas, which constitute one of the links between the Sierra Madre of Nuevo León and the Rocky Mountains of New Mexico. The Chisos area has proved to parallel the Sierra del Carmen of adjacent Coahuila in many respects. The eastern border of Coahuila is characterized in the treatment of Nuevo León by Muller (1939), and the western border is described in a paper on the vegetation of Chihuahua by Shreve (1939) and in one by LeSueur (1945). More recently Shreve (1942a,b) has described the desert and grassland vegetation of Coahuila in studies of more extensive areas.

The climates of Coahuila have been treated only incidentally to more extensive classifications. Sanchez (1929) and Thornthwaite (1931) both allowed only two climatic types within the state. Sanchez named these "Clima de Estepas" and "Clima Desertico" (steppe and desert climates). Thornthwaite's divisions are similar; he called them "semiarid, mesothermal, and [with] deficiency of rainfall at all seasons" (DB'd)[1] and "arid, mesothermal, and [with] deficiency of rainfall at all seasons" (EB'd). Page (1930) mapped the rainfall of Coahuila and indicated an area of low precipitation conforming roughly to Sanchez' and Thornthwaite's desert climates. He also credited the extreme southeastern and northeastern portions with a greater rainfall, a

[1] These formulae are those used by Thornthwaite and derived from his system.

feature clearly indicated by the vegetation of those areas. Ward and Brooks (1936) followed Page and Sanchez rather closely in their work on the climates of northern Mexico. An anonymous Mexican publication (1936) follows Thornthwaite closely. Contreras (1942a,b) recognized a temperate climate throughout the state, but did not indicate a humidity greater than "semiarid." Shreve (1944), utilizing meteorological records and physiographic diversity, mapped the rainfall of the northern half of the republic. His results conform much better to the observable landscape than do earlier attempts.

Physiography and Soils of Coahuila

As has been noted, the physiography of Coahuila is characterized by Basin and Range topography. This form occupies all the area lying west of the Rocky Mountain–Sierra Madre axis that, in Coahuila, is represented by the Sierra del Carmen. This axis runs from the Sierra del Carmen in north-central Coahuila to the Sierra Madre in southeastern Coahuila. Thayer (1916) regarded these elevations as the escarpment of the Central Plateau, but they are really a range of mountains, some of whose peaks reach 3,000 meters and rise considerably above the plateau, which itself ranges from about 1,000 to 1,500 meters. There are two major breaks in this mountain range, one east of Saltillo where the plateau has the eroded remnant of a true escarpment and one east of Monclova where the Rio Salado has eroded a wide pass through the mountains and projected the head of its valley beyond Monclova, forming an area of low elevation incising the plateau.

The mountains west of the Carmen axis are mostly isolated and scarcely continuous, but some of them are oriented in definite directional trends and are so nearly contiguous as to exercise a positive influence on the climate. Just west of the Carmen axis the Sierra de la Madera at Cuatro Cienegas, the Sierra del Fuste, and the Sierra del Pino project northward in a nearly unbroken range. Along the western border of Coahuila the Sierra Mojada, Sierra de Almagre, and Sierra de Hechiceros run north almost to the valley of the Rio Grande. These north-south trending ranges together with the northern half of the Sierra del Carmen axis effectively divert winds coming from the east coast of the continent and are responsible for much of the rain that falls in the mountains of northern Coahuila. Furthermore, the wide basins separating these mountains are open to the north and allow the free entrance of extra-tropical cyclonic storms during the winter season. Across extreme southern Coahuila the Diamante-Carneros and Parras ranges form an axis that links that region with the highlands of both the Sierra Madre Oriental of Nuevo León and the Sierra Madre Occidental of Durango. In addition to these major ranges of the plateau, there are many scattered minor ones which are much less effective as wind barriers or in inducing precipitation and lower temperatures.

In summary, the northern three-fourths of the Central Plateau portion of Coahuila is characterized by several relatively contiguous north-south trending ranges as well as by numerous scattered minor ranges. The southern portion, on the other hand, lacks major north-south trending ranges, has only scattered minor ranges, and is bounded to the south by discontinuous east-west trending ranges.

The northeastern quadrant of the state lies on the Atlantic slope of the continent. It consists of a plain ranging from about 200 to 500 meters in elevation, lying east of the Sierra del Carmen. It includes an extensive mountain mass, the Serrano del Burro, whose highest peaks reach about 2,300 meters altitude. In the north this eastern plain is essentially identical with the desert plains of the Central Plateau and the upper Rio Grande Plain, but toward the south it merges with the Eastern Coastal Plain and the Piedmont areas of Nuevo León.

Soils in Coahuila fall roughly into four classes. These are stony immature soils, dark loam soils, light desert soils, and alkaline desert soils. Dune sands are of only local occurrence. These groups and their effects on vegetation are easily recognized and evaluated. The characteristics of the soil are a possible source of error in evaluating the relationship of climate and vegetation. It is necessary to determine that soil is not responsible for differences in vegetation ascribed to climate.

The stony soils sometimes are confusing in their effect upon the vegetation. It is not difficult to recognize the effect of stony outcrops in an area of soil derived from the same substratum. However, where limestone and igneous stony soils alternate in a semiarid region, the igneous areas take on a much more mesic appearance than the limestone areas. It is often a temptation to regard the well-developed grasslands of granitic areas as indicative of a less arid climate than the adjacent desert shrub of limestone areas. Only by careful consideration of alternating limestone and igneous outcrops can this source of error be avoided.

The influences of chemical differences in soil, such as salinity and presence of gypsum, are readily recognized by the presence of indicator species, as described by Johnston (1941) in the case of gypsum. Where such factors are operative over wide areas, they may themselves serve in some measure as indicators of climate.

It is well known that heavily saline soils develop and persist only under extremely arid conditions. In the mature soils, disregarding entirely the stony immature types, arid regions are characterized by light gray soils and red soils lacking in humus, while mesic regions develop dark loams with relatively high percentages of humus. Some of the more densely vegetated plains east of the mountains have dark loam soils, but on the plateau west of the mountains this group is confined to the higher elevations where greater precipitation permits the development of more mesic vegetation.

Climatic Influences

Before attempting to classify the vegetation types of Coahuila and to map their distributions, it is necessary to consider some of the major physical influences that control climate and therefore the distribution of vegetation. First is the position of our area on the continent. Coahuila lies in the broader end of Mexico and just east of the center of the continental mass. Its western border (the Coahuila-Chihuahua line) marks roughly the continental center at this latitude. The presence on the north of the desert and semi-desert regions of Trans-Pecos Texas and southern New Mexico further accentuates the continental influence upon the climate of Coahuila. The continental influence is largely limited to the Central Plateau. It is made possible by the presence of the Sierra del Carmen axis which effectively excludes winds from the Atlantic Ocean and Gulf of Mexico. On the west the Sierra Madre Occidental similarly reduces the effectiveness of any winds from the Pacific Ocean and the Gulf of California. This rain shadow phenomenon was encountered in the Sierra Madre Oriental of Nuevo León where it is strikingly clear. West of the Sierra del Carmen in Coahuila and east of the Sierra Madre Occidental in Chihuahua secondary and lesser ranges add to the effect of the major ranges so that as one approaches the centrally located Coahuila-Chihuahua line, one finds the climate increasingly arid.

West of Saltillo an east-west directed lowland crosses the state. It is bounded on the north by the discontinuous mountains of central Coahuila and on the south by the more nearly continuous uplands of the Saltillo-Parras axis. The Eastern half drains onto the Coastal Plain, while the western half is an undrained basin. This basin, open more or less to the easterly winds, is not less arid than the great protected basins of northwestern Coahuila. In fact, rainfall records show that the southwestern basin is more arid than the northerly ones. This is in part caused by a partial blocking of the easterly winds by the Saltillo highlands and in part by the low altitude of the basin. The effect is similar to that of the low altitude of the valley of the Rio Grande in northern Coahuila.

The trend toward an arid climate from east to west is not confined only to the general climate (of the plains). The local climates of higher elevations, such as the increased precipitation and lower temperature induced by a mountain range, become less and less extreme toward the west as general aridity increases. The most extreme influence is seen in the Sierra del Carmen, the first mountains encountered by the easterly winds. West of this the succeeding ranges are not quite so high, but there are several of comparable height, notably Sierra de la Madera and Sierra Mojada. The former range lies in central Coahuila and bears a well developed though depauperate pine forest. This forest,

though not quite so mesic, is essentially comparable to those of the Sierra Madre Oriental in Nuevo León and the Sierra del Carmen of northern Coahuila. The Sierra Mojada, on the other hand, lies in western Coahuila and bears no pine forest. It is said to have been forested at one time, but it has been denuded, and the xeric climate does not permit reseeding of forest species as is so evidently occurring in the Sierra de la Madera. The present vegetation of the Sierra Mojada is largely chaparral and clearly reflects the drastically reduced precipitation in the paucity of its herbs, which do not readily survive the summer drought.

The latitudinal position of Coahuila places it partially within the subtropical high-pressure belt or the belt of subtropical calms, a fact to which it owes much of its aridity. The Coastal Plain and Rio Grande Plain portions of the state lie in the path of the northernmost trade winds, but these are much less effective here than in Nuevo León. The principal evidence of their influence is seen in the much more humid nature of the east slopes of the eastern mountains than is noted on their western slopes.

Convectional storms which center about the scattered mountain masses account for the greater part of the summer rainfall in the interior portions of Coahuila.

Vegetation Types

In the following discussion a general description of the major vegetation types is presented. In those cases where intensive local analytic studies have been made, the details are omitted in order to avoid distortion of the picture of the whole area. The vegetation types are mapped in text figure 1.

1. Chihuahuan Desert Shrub. The plains and basins of the southern, western, and northern three-fourths of the state of Coahuila are characterized by many variants of a general vegetation formation which is strictly desert in all its attributes (pl. 3, fig. 1). This was previously described in Nuevo León as Central Plateau Desert Scrub, but Chihuahuan Desert Shrub, a variant of Shreve's term (1942b), seems preferable. Low, sparse perennials and ephemeral annuals make up this polymorphic vegetation. The most characteristic species is *Larrea tridentata* (DC.) Cov., and the structure and composition of the variant types may best be considered from the standpoint of the species that are associated with *Larrea* or that occasionally replace it. Not all of the area occupied by *Larrea* and its associates is true desert, for the various species range more or less widely into adjacent areas of a more mesic nature. In such cases, however, the function of the desert species is not the same as on the true desert; they not only do not dominate the site, but their physiognomy and spacing are much changed.

Most widely associated with *Larrea* are *Flourensia cernua* DC., *Acacia vernicosa* Standl., *Fouquieria splendens* Engelm., and *Prosopis*

velutina Wooton. In addition to these, the following species, listed approximately in order of decreasing importance, are common associates:

Condalia lycioides (A. Gray) Weberb.
Koeberlinia spinosa Zucc.
Coldenia Greggii (Torr.) A. Gray
Parthenium incanum H.B.K.
Lycium Berlandieri Dunal
Celtis pallida Torr.
Condalia spathulata A. Gray
Opuntia imbricata (Haw.) DC.
Opuntia leptocaulis DC.
Opuntia spp. (Platyopuntia)
Yucca australis (Engelm.) Trel.
Yucca Torreyi Shafer
Acacia constricta Benth.
Rhus microphylla Engelm.
Citharexylum brachyanthum A. Gray
Microrhamnus ericoides A. Gray
Sericodes Greggii A. Gray
Hilaria mutica (Buckl.) Benth.

The habitat type on which the typical phase and minor variants of this association develop is characteristically a plain, bajada, or outwash plain of more or less gentle declination. The soil is usually rather shallow and stony, but it might be quite deep and covered by a "desert pavement" of small stones. Edaphic variations are responsible for major changes in the vegetation irrespective of homogeneous climatic conditions.

A very deep soil in well-drained situations is usually characterized by an abundance of *Flourensia* which may even exclude *Larrea. Prosopis, Koeberlinia, Condalia spathulata,* and *Parthenium* are often more abundant in such situations. Small catchments of deep soil are frequently considerably more moist than the surrounding plain, and these usually develop a very dense stand of the common shrubs in which *Acacia vernicosa, Rhus microphylla,* and *Yucca australis* are apt to be quite important. Parts of such areas are sometimes covered by a sod of *Scleropogon brevifolius* Phil. or *Hilaria mutica* or both. Such a thicket, with or without the grass sod, is locally termed a *mogote* (pronounced mo-gó-tay), a very useful word meaning "island" that should be accorded recognition in ecological literature along with chaparral, encinal, and other words of Spanish and Mexican origin that are more expressive than any corresponding English words.

The larger basins may have a more or less well-developed laguna or lake bed surrounded by a nearly flat playa and the gently sloping bajada. If accumulation of water is frequent in the laguna, its center may be quite bare and may have a ring of *Sporobolus Wrightii* Munro encircling the bare center where occasional flooding prevents the growth of other species. If the bolson receives little runoff from the surrounding mountains and hills, its playa may be very limited in extent. Such a playa is usually

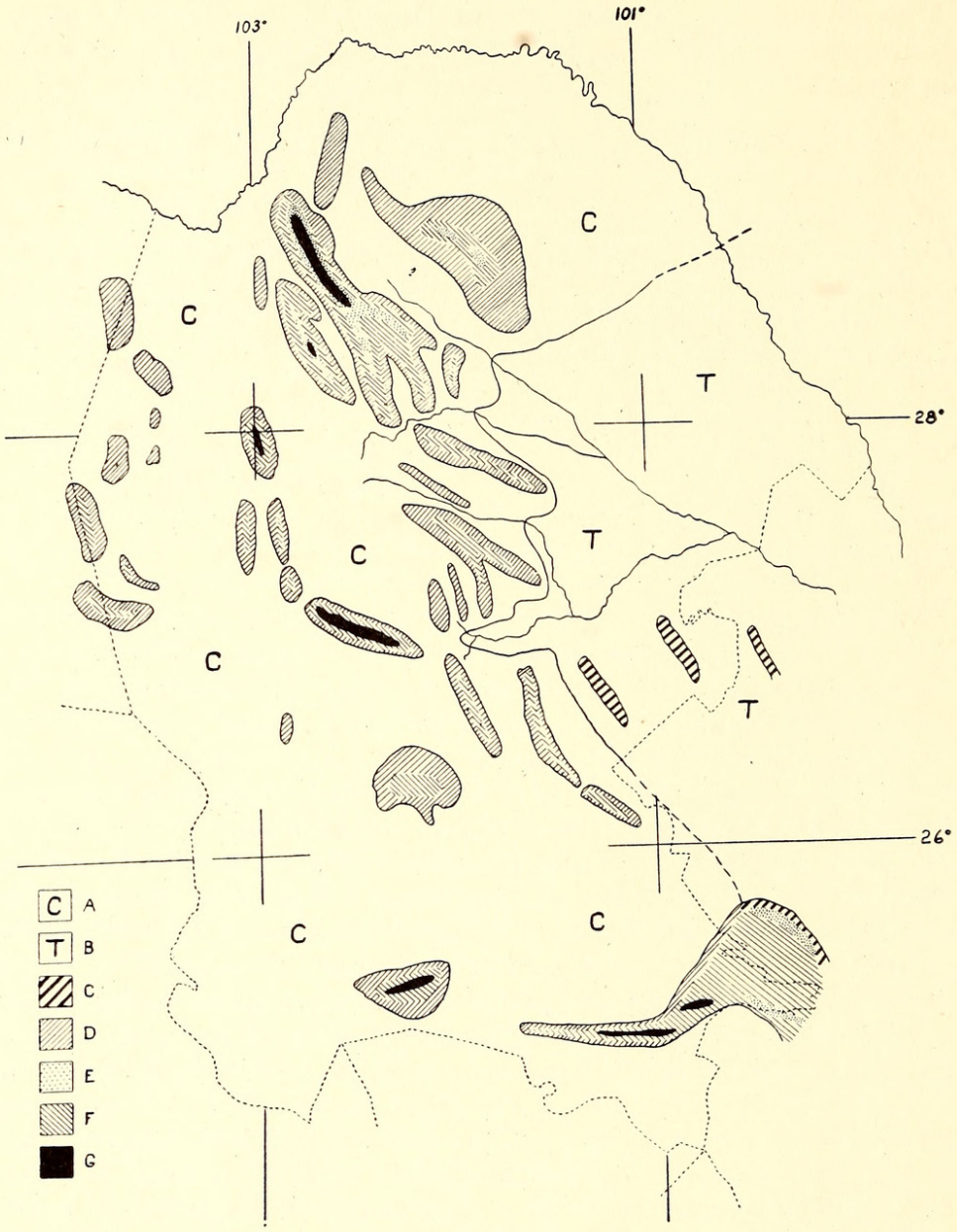


Fig. 1. Distribution of vegetation types in Coahuila. A, Chihuahuan Desert Shrub; B, Tamaulipan Thorn Shrub; C, Piedmont Shrub; D, Grassland (and Grassland Transition); E, Montane Low Forest; F, Montane Chaparral; G, Montane Mesic Forest.

covered by a nearly pure stand of *Hilaria mutica.* These tobosa flats, however, are not invariably of small extent.

More saline lagunas or salt lakes are surrounded by *Atriplex* spp., *Allenrolfea* sp., *Suaeda* sp., *Prosopis velutina,* and *Sporobolus* (pl. 3, figs. 2, 3). The larger playas may develop rather broad zones of somewhat saline soil bearing *Prosopis* and *Atriplex canescens* (Pursh) Nutt. These are especially prominent in southwestern Coahuila.

The undrained basins are confined to the southern and western half of the state, the Basin and Range country west of the Sierra del Carmen and Sierra Madre.

The low elevations of the bolson grassland and the fact that it is always overlooked by the surrounding desert shrub was regarded by Shreve (1942a) as evidence of the desert nature of the tobosa llanos. He points out that this vegetation is a response to soil conditions on the desert and is not to be regarded as part of the climatic grassland formation.

A few of the basins have local beds of sandstone from which small areas of dune sand have developed. Where these have become more or less stabilized, they bear a sparse cover of *Prosopis, Yucca elata* Engelm., *Ephedra Torreyana* S. Wats., *Atriplex canescens, Gutierrezia* sp., and *Heliotropium Greggii* Torr.

Another and very important variation of the desert shrub vegetation is the development in two poorly delimited areas of succulent desert types. The extensive low limestone hills in northern Coahuila, especially in the low altitude zone of the Rio Grande Valley bordering northern Coahuila, exhibit a particularly rich flora of succulent species, including *Euphorbia antisyphilitica* Zucc., *Jatropha dioica* Sesse, *Agave lecheguilla* Torr., *Hechtia* sp., *Opuntia* spp., and various species of *Echinocactus, Echinocereus, Mamillaria,* etc. In the central-southwestern quarter of the state, rocky hills above the desert plain develop a similar variant of the desert in which *Grusonia Bradtiana* (Coult.) Britt. & Rose is abundant. Such succulent desert types are confined to rocky slopes of shallow soil (pl. 3, fig. 4).

2. Tamaulipan Thorn Shrub. East of the Sierra del Carmen and Sierra Madre Oriental the foothills of these ranges gradually give way to the Gulf Coastal Plain which, in Coahuila, is of relatively high elevation, averaging perhaps 400 meters. This merges in the north with the upper Rio Grande Plain, which is predominately true desert. East-central Coahuila, however, has little in common with the desert of central and western Coahuila; it is rather much more closely related to southern Texas, northern Nuevo León, and northern Tamaulipas. The vegetation of this area, including the well-known "brush country" of southern Texas, is a formation equal in rank to the desert shrub vegetation of the Chihuahuan Desert in western Chihuahua and eastern Coahuila. Shreve (1917) recognized this vegetation as distinct from all other types in the United States and separated it under the name "Texas Semi-Desert." The term chaparral is locally applied to this vegetation by the natives, and the term was adopted by Clover (1937) in southern Texas. This use of the term seems objectionable from both an etymological and practical standpoint. The original Spanish meaning of chaparral is a growth of low, evergreen oaks. The word was thus correctly applied to the oak-dominated scrubby

broad-sclerophyll vegetation of California, and it is applied for the same reason to the closely related broad-sclerophyll vegetation of Nuevo León and Coahuila. Its application, then, to a semi-desert thorn shrub vegetation is unfortunate and misleading. This thorn shrub was described in Nuevo León under the name Eastern Coastal Plain Scrub. In order to describe and locate the center of its development, it is here proposed to apply to the Eastern Coastal Plain Scrub the term Tamaulipan Thorn Shrub. The more luxuriant and arborescent developments of this general type in extreme southern Texas and especially in Tamaulipas may be termed Tamaulipan Thorn Forest.

The Tamaulipan Thorn Shrub occupies an area of plains and low hills similar in many respects to the topography of the Chihuahuan Desert Shrub west of the mountains but with the three important differences of lower elevation, greater rainfall, and exposure to winds from the Gulf of Mexico. These habitat differences are correlated with the development of a vegetation characterized by a higher preponderance of thorny species, a greater abundance of grasses, and a more luxuriant and denser growth of shrubs. Characteristic species are much more numerous than in the desert, the flora is much richer in total species, and the number of variants or phases of the vegetational formation are correspondingly higher. No attempt will be made to classify these variants except in so far as this is required by the description of the most prominent Coahuilan phases. This should not be regarded as a characterization of the entire Tamaulipan Thorn Shrub formation, a task that will require a separate treatment.

Although many species characteristic of the Tamaulipan Thorn Shrub and even locally dominant in that formation are also common in the desert shrub, the thorn shrub is distinguished clearly by several very distinctive constituents. Among these are the following:

Acacia amentacea DC.
A. Berlandieri Benth.
Leucophyllum frutescens (Berl.) Johnst.
Porlieria angustifolia (Engelm.) A. Gray
Karwynskia Humboldtiana (Roem. & Schult.) Zucc.
Prosopis glandulosa Torr.
Cordia Boissieri DC.
Schaefferia cuneifolia A. Gray
Cercidium floridum Benth.
Lippia ligustrina (Lag.) Britt.
Parkinsonia aculeata L.
Acacia Farnesiana (L.) Willd.
Castela texana (Torr. & Gray) Rose
Colubrina texensis (Torr. & Gray) A. Gray
Lantana Camara L.

Outstanding among species important in both formations are *Celtis pallida, Opuntia leptocaulis, Condalia lycioides, Jatropha dioica,*

Koeberlinia spinosa, Opuntia imbricata, Agave lecheguilla, and *Microrhamnus ericoides.* Even *Larrea* and *Flourensia* filter onto the Coastal Plain from the upper Rio Grande Plain and across the mountains where these are broken by erosion systems. Also commonly associated with the Tamaulipan Thorn Shrub are the following species:

Lycium Berlandieri Dunal
L. pallidum Miers
Eysenhardtia texana Scheele
Sophora secundiflora (Ortega) Lag.
Bernardia myricifolia (Scheele) S. Wats.
Condalia obovata Hook.
Bumelia lanuginosa (Michx.) Pers.
Diospyros texana Scheele
Forestiera angustifolia Torr.
Citharexylum Berlandieri Robinson
Salvia ballotaeflora Benth.
Leucophyllum minus A. Gray
Viguiera stenoloba Blake
Yucca australis (Engelm.) Trel.
Y. rostrata Engelm.
Opuntia Lindheimeri Engelm.

Grasses are quite abundant, and often the vegetation assumes characteristics of well-developed grassland, but this is not so evident in Coahuila. *Bouteloua trifida* Thurb., *Hilaria Belangeri* (Steud.) Nash, and *Aristida purpurea* Nutt. are most abundant. Locally *Andropogon scoparius* Michx., *A. saccharoides* Swartz, *Chloris virgata* Swartz, *Buchlöe dactyloides* (Nutt.) Engelm., and others are important. Perennial herbs are much more obvious here than in the desert shrub, composites, *Croton,* and *Verbena* being particularly abundant.

The phases of thorn shrub observed in eastern Coahuila include the transition from desert shrub, in which both *Larrea* and *Flourensia* are important on either rocky or deep-soiled areas, as well as several phases of the true thorn shrub (pl. 4, figs. 1, 2, 3). On shallow soils overlying limestone *Acacia Berlandieri, A. amentacea, Leucophyllum frutescens, Porlieria angustifolia, Opuntia* spp., and *Jatropha dioica* are amongst the outstandingly obvious species. On deep clay soils a dispersed sod of *Bouteloua trifida* and *Hilaria Belangeri* alternates with *Prosopis, Opuntia, Castela,* and some of the species listed above. Deep alluvial soils, especially adjacent to streams, may bear a richer grass flora forming a more dense sod on which the shrub and small tree species appear as a savanna. On very rocky sites the shrubs may be quite as stunted as those of the desert, while at higher elevations the luxuriance of the shrubs and the introduction of additional species tend to develop the Piedmont Shrub described below.

3. Piedmont Shrub. Along the eastern base of the mountains that bound the western limit of the Tamaulipan Thorn Shrub is a poorly defined zone of large shrubs and small trees that occupies the irregular piedmont topography of this region as well as some

outlying small mountains on the Coastal Plain. Although this type is best developed and most extensive in Nuevo León, where is has been described as Piedmont Scrub, it is distinctly present in southeastern Coahuila, and evidences of it may be seen north of Muzquiz at the base of the Sierra del Carmen in north-central Coahuila. Its northward extension covers too narrow a band to be mapped on a small scale.

The first evidence of change from Tamaulipan Thorn Shrub to Piedmont Shrub is a greater density and luxuriance of thorn shrub species as they ascend to higher elevations. The eventual introduction of non-thorny and more tree-like species accomplishes the transition. The principal characteristics of the Piedmont Shrub are the preponderance of this life form, the abundance of low suffrutescent species, and the aestivation of herbaceous species during the rigorous drought of midsummer. In the following list the characteristic species are named approximately in the order of decreasing importance:

Quercus fusiformis Small
Diospyros texana Scheele
Bumelia lanuginosa (Michx.) Pers.
Sophora secundiflora (Ortega) Lag.
Bauhinia lunarioides A. Gray
Quercus invaginata Trel.
Quercus sinuata var. breviloba (Torr.) C. H. Mull.
Quercus Mohriana Buckl.
Rhus virens Lindh.
Vauquelinia corymbosa Correa
Leucaena glauca (L.) Benth.

Common shrub associates are *Colubrina macrocarpa* (Cav.) Don, *C. Greggii* S. Wats., *Rhus trilobata* Nutt., *Eysenhardtia texana, Ptelea trifoliata* L., and *Amyris madrensis* S. Wats. Along waterways in the hills *Juglans rupestris* Engelm., *Celtis reticulata* Torr., *Acacia Farnesiana,* and *Ungnadia speciosa* Endl. are characteristic, while very mesic ravines often bear *Quercus Muehlenbergii* Engelm. and *Ulmus multinervosa* C. H. Mull.

The evident part played by *Quercus sinuata* var. *breviloba* and *Q. Mohriana* in the narrow strip of Piedmont Shrub in north-central Coahuila is very suggestive of the Edwards Plateau of

---

Explanation of Figures, Plate 3.

Plate 3. Vegetation of Coahuila.[2] Fig. 1. Chihuahuan Desert Shrub with *Larrea, Fouquieria,* and *Opuntia* sp. Fig. 2. Laguna de Leche, an undrained desert lake bed intermittently inundated. Fig. 3. Saline phase of Chihuahuan Desert Shrub at the edge of an undrained basin, with *Prosopis velutina, Opuntia* sp., and *Atriplex* spp. Fig. 4. Chihuahuan Desert Shrub, succulent phase, with *Agave lecheguilla, Hechtia* sp., *Grusonia Bradtiana,* and *Euphorbia antisyphilitica* associated with *Larrea, Fouquieria,* and *Acacia vernicosa.*

[2] For the photographs in plates 3, 5, 6, and 7 the author is indebted to Mr. B. Y. Morrison who permitted their use from the collection of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, where they had been filed by the author.

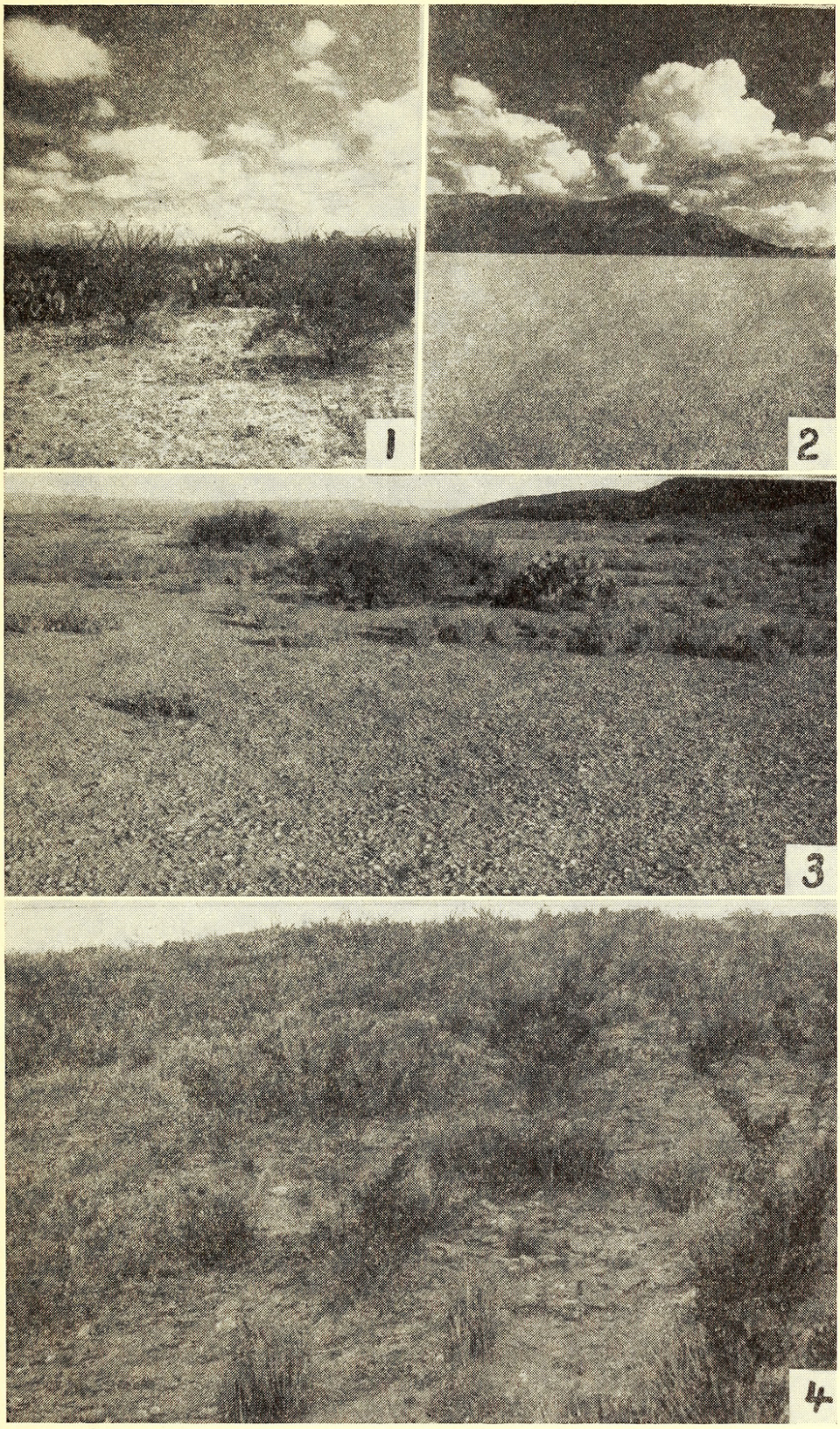


PLATE 3. VEGETATION OF COAHUILA.

Texas as well as similar shrub zones beneath the lower or dry limits of forest and woodland in western Texas.

In several broad canyons of the Piedmont on the east flank of the Sierra del Carmen occur open forests of *Brahea bella* Bailey associated with Piedmont Shrub. This arborescent palm is equally at home on the flat, grassy valley floor or the steep cliffs of the lower mountain slopes and canyon walls. It appears in Coahuila principally about the headwaters of the Rio Sabinas, but at the base of the Sierra Madre in Nuevo León it is more extensive.

The Piedmont Shrub is to some extent climatically coextensive with grassland transition and replaces this transition over much of the lower east slope of the mountains.

4. Grassland. True climatic grassland is not extensive in Coahuila. The greater proportion of the grass-covered area never develops much beyond a transition between desert shrub and grassland, further development being terminated by failure of elevation or by the development of chaparral (pl. 5, fig. 1). Since grassland requires an area of relatively deep, flat soil and a considerably more mesic climate than that of the desert plains, it is to be sought only at higher elevations on gently sloping hills and plateaus. Such situations in Coahuila are found only in the northwestern quarter of the state where the Sierra de las Cruces, Sierra de Hechiceros, and (locally) the Sierra del Carmen present these conditions. The latter locality is partially a granitic area on the gentle east slope, and the development of a true grassland there may be partly edaphic, but a neighboring grassy limestone slope is indicative of climatic effect. Grassland Transition, by contrast, is very widespread, occurring about the flanks of most of the mountain ranges. A few of the broader canyons of the Sierra del Carmen are covered by grassland, but these areas are too small to be mapped on a small scale.

True Grassland is largely dominated by *Bouteloua gracilis* (H.B.K.) Lag. with *B. curtipendula* (Michx.) Torr., *Andropogon saccharoides, Lycurus phleoides* H.B.K., *Stipa eminens* Cav., *Aristida glauca* (Nees) Walp., *Buchlöe dactyloides,* and *Muhlenbergia monticola* Buckl. locally abundant or even dominant. Associated with the dominants are numerous species of perennial herbs, the Compositae, Asclepiadaceae, and Scrophulariaceae being especially well represented. Rocky prominences in such an area are apt to

---

Explanation of Figures, Plate 4.

Plate 4. Vegetation of Coahuila. Fig. 1. Tamaulipan Thorn Shrub consisting of *Condalia lycioides, Opuntia leptocaulis, O. Lindheimeri, Acacia amentacea,* and various grasses. Fig. 2. Tamaulipan Thorn Shrub with *Karwinskya Humboldtiana, Leucophyllum frutescens, Acacia amentacea, Yucca rostrata, Condalia* spp., and various grasses. Fig. 3. Tamaulipan Thorn Shrub, savanna phase, with *Koeberlinia, Opuntia leptocaulis, Cercidium texanum,* etc. on a sod of *Bouteloua trifida, Hilaria Belangeri,* and *Aristida purpurea.*

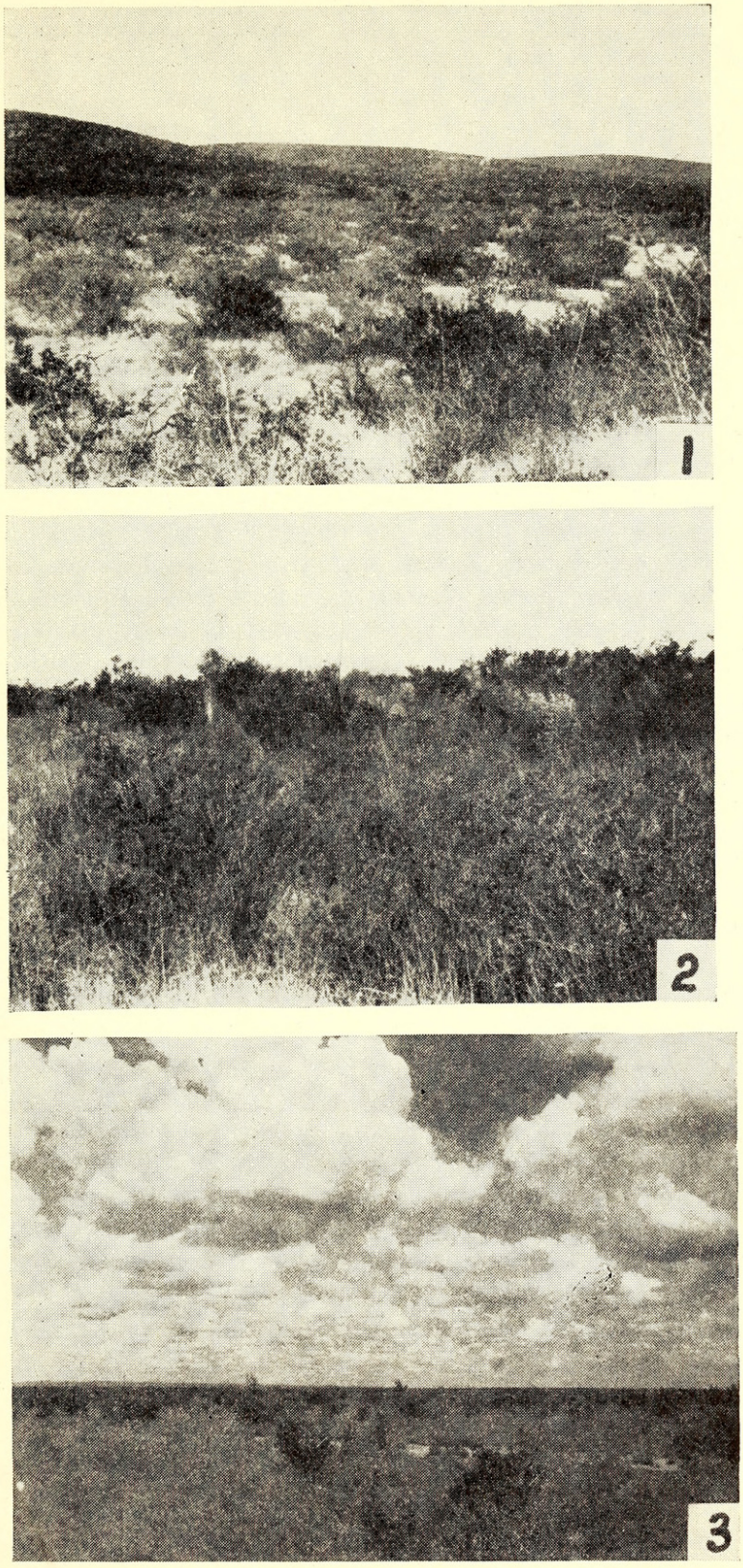


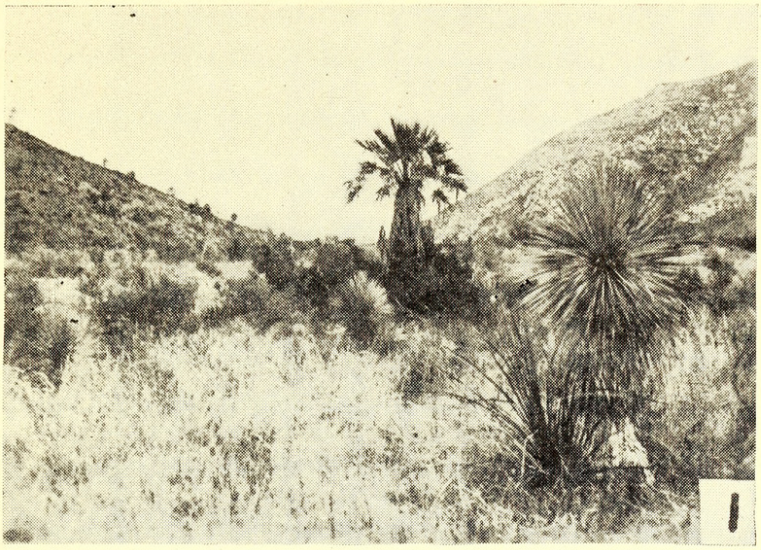
PLATE 4. VEGETATION OF COAHUILA.

bear oaks, junipers, *Dasylirion, Nolina,* and *Yucca,* and these plants also occur sparsely on the grassy slopes.

Grassland Transition subtends the upper limits of the desert shrub as it ascends the foothills from the plains and bajadas. At first the desert species become denser and larger, simultaneously as the grassland species begin to appear. *Larrea, Flourensia, Fouquieria, Parthenium incanum, Viguiera stenoloba, Agave lecheguilla, Yucca australis, Y. Torreyana,* and *Dasylirion* sp. are amongst the more common woody species of this transition zone. As the grasses take over a greater percentage of the available space and form a more continuous sod, the woody species become more sparse but do not suffer diminution in size. Their eventual exclusion from the Grassland, here as elsewhere, is purely the result of competition under conditions more favorable to grasses and less favorable to shrubs. *Nolina* spp. persist with *Dasylirion* and *Yucca* after *Larrea, Flourensia,* and *Fouquieria* have been eliminated. At this stage the vegetation is entering the phase of true Grassland. Over much of the area of the Grassland Transition on limestone hills there occur more or less dense stands of *Parthenium argentatum* A. Gray (guayule), a species that competes poorly with both the grasses and the desert shrubs. Of the several characteristic transition species, it is the most obligate member of this vegetation type.

5. Montane Low Forest. Above the Piedmont Shrub on the east slope of the Sierra del Carmen there occurs a vegetation type essentially equal to that which has been described in Nuevo León as Montane Low Forest. This vegetation type is the regional equivalent of the Encinal described by Shreve (1939) in Chihuahua and the well-known oak-pinyon-juniper zone of the southwestern United States. It is not intended to suggest that these widely separated vegetational zones are identical but only that they are vicarious representatives of one another. The Montane Low Forest of Nuevo León and southeastern Coahuila is the most aberrant of the several types; that of northern Coahuila (which is also identical with the equivalent zone in the Chisos and Davis Mountains of Trans-Pecos Texas) is intermediate in character between the Nuevo León and southeastern Coahuila type and the oak-pinyon-juniper of farther north. The Coahuilan woodland is therefore not homogeneous, some stands suggesting the Nuevo León Montane Low Forest while others are very similar to the oak-pinyon-juniper woodland. A third phase clearly indicates a relationship with the low forest of the escarpment of the Edwards Plateau in west-central Texas. In such transitions between divergent vegetation types are clearly illustrated the dangers of naming widespread plant associations and regarding them as identical throughout. Perhaps even the claim of equivalence is too great in such cases.

The principal characteristics of the Montane Low Forest in



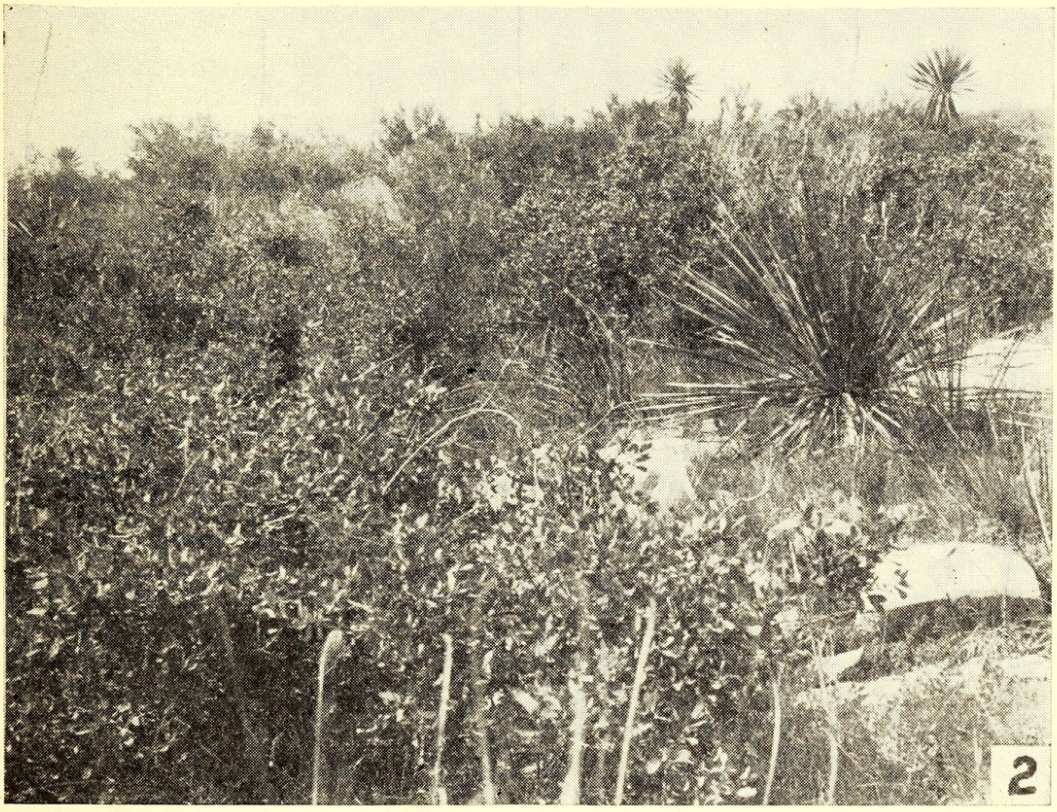


PLATE 5. VEGETATION OF COAHUILA. FIG. 1. Grassland Transition on the eastern slope of the Sierra del Carmen with *Andropogon scoparius, A. saccharoides, Bouteloua curtipendula,* and *B. gracilis. Dasylirion* and *Brahea* are prominent. FIG. 2. Montane Chaparral with *Quercus intricata, Q. invaginata, Dasylirion, Yucca carnerosana, Ceanothus Greggii, Cercocarpus mojadensis,* and various grasses.

Nuevo León, Coahuila, and southern Trans-Pecos Texas are an open stand of low trees with rounded crowns, usually gnarled branches, and trunks less than one foot in diameter, the development of a copious grass cover, and the presence of one or more species of *Agave* of the *Applanatae* relationship. The tree layer is usually dominated by oaks, while pinyon and junipers may be prominent (although these are nearly absent from this zone in Nuevo León). Several tree species characteristic of this zone are also prominent in the next higher one, the Mesic Forest zone. In the Montane Low Forest these adopt the characteristic low round crowns and gnarled branches of that zone. The distinction between the two vegetation types is to some extent based upon the physiognomy of the vegetation and to some extent upon the floristic composition.

The principal tree species of the Coahuilan Montane Low Forest are named approximately in the order of decreasing importance in the following list:

Quercus Gravesii Sudw.
Pinus cembroides Zucc.
Juniperus pachyphloea Torr.
Quercus hypoleucoides A. Camus
Quercus Laceyi Small
Juniperus flaccida Schlecht.
Quercus arizonica Sarg.
Quercus sinuata var. breviloba (Torr.) C. H. Mull.
Quercus Mohriana Buckl.
Arbutus xalapensis H.B.K.
Fraxinus cuspidata Torr.

Associated with these are many shrub species of which *Salvia regla* Cav., *Garrya ovata* Benth., *Rhus trilobata, Vitis arizonica* Engelm., *Ptelea trifoliata, Bumelia lanuginosa,* and *Cercocarpus breviflorus* A. Gray are the more prominent. Nowhere does one encounter all these species combined in a single forest.

The east slopes of the Sierra del Carmen, and to lesser extent those of the Sierra Madre farther south, are dominated principally by *Quercus Laceyi, Q. Gravesii, Q. sinuata* var. *breviloba,* and *Q. Mohriana* with which *Bumelia, Vitis, Ptelea,* and *Rhus* are associated. The presence in arroyos in this zone of *Cercis reniformis* Engelm., *Smilax bona-nox* L., *Rhus virens,* and *Ungnadia speciosa,* in the light of the identity of the oak species, is particularly suggestive of the woodland of the escarpment of the Edwards Plateau, especially toward its southwestern quarter. Grasses in this phase are rather sparse, partly perhaps because they are heavily grazed.

Explanation of Figures, Plate 6.

Plate 6. Vegetation of Coahuila. Fig. 1. Montane Chaparral consisting of *Quercus intricata, Q. invaginata, Dasylirion, Yucca carnerosana, Ceanothus Greggii, Rhus virens,* and *Cercocarpus mojadensis.* Fig. 2. Meadow of *Bouteloua hirsuta, B. gracilis,* and *Stipa eminens* lying between pine forest and the more elevated chaparral of the background.

PLATE 6. VEGETATION OF COAHUILA.

Lycurus phleoides, Stipa eminens, Muhlenbergia monticola, and *Aristida* spp. are the principal species. Herbs, and particularly suffrutescent species, are strikingly abundant, legumes and composites being the most evident.

At higher elevations in the Sierra del Carmen there occurs a phase of the woodland much more suggestive of the oak-pinyon-juniper association. The dominant tree species are *Quercus hypoleucoides, Q. Laceyi, Q. arizonica, Pinus cembroides, Juniperus pachyphloea,* and *J. flaccida.* Associated with these are *Salvia regla, Garrya ovata, Agave Havardiana* Trel., and *Arbutus xalapensis.* The open stand of trees permits a heavy cover of *Muhlenbergia Emersleyi* Vasey, a very course bunchgrass, with *Lycurus phleoides,* and other lesser species. This vegetation is very similar to that of the Chisos and Davis Mountains with the oustanding difference that *Quercus Emoryi* Torr. and *Q. grisea* Liebm. are both absent from the Coahuilan phase.

The arroyo forest at this elevation includes, in addition to the above species, *Pinus arizonica* Engelm. and *Acer brachypterum* Woot. & Standl. This, and the somewhat more closely spaced trees with straighter and taller trunks, indicate a transition to the Mesic Forest, the next higher zone.

6. Montane Chaparral. On the west slope of the Sierra del Carmen and equivalent climatic zones of the more westerly mountains, the Montane Low Forest is replaced by a shrubby vegetation type that has much in common with the broad-sclerophyll vegetation of California. This has been described in Nuevo León where it is well developed on the major west slopes of the Sierra Madre. This zone may replace the grassland or it may lie between a well-developed grassland and the pine forest of higher elevations or variously alternate with these. On deep-soiled sites grassland and pine forest meet and mingle, but shallow, stony soils at the same general elevation are invariably covered by chaparral. This dependence of chaparral upon shallow soils is closely paralleled in the Californian type where deep soils are grass covered (pl. 6, fig. 2).

The Coahuilan chaparral is very well developed on the upper slopes of Sierra de la Madera and Sierra del Pino (pl. 5, fig. 2; pl. 6, fig. 1). The type is dominated by several species of oak, including *Quercus intricata* Trel., *Q. invaginata* Trel., *Q. Pringlei* Seemen, *Q. Laceyi,* and *Q. hypoxantha* Trel. Of these only *Q. Pringlei* and *Q. Laceyi* are deciduous. Associated with these are

---

Explanation of Figures, Plate 7.

Plate 7. Vegetation of Coahuila. Fig. 1. Meadow of *Andropogon Gerardi, Monarda* sp., and various Compositae with pine forest in the background. Fig. 2. Montane Mesic Forest of *Pinus arizonica* with *Juniperus pachyphloea* and *Quercus Gravesii* as an understory and a sod of *Andropogon scoparius, A. saccharoides,* and *A. Gerardi.*

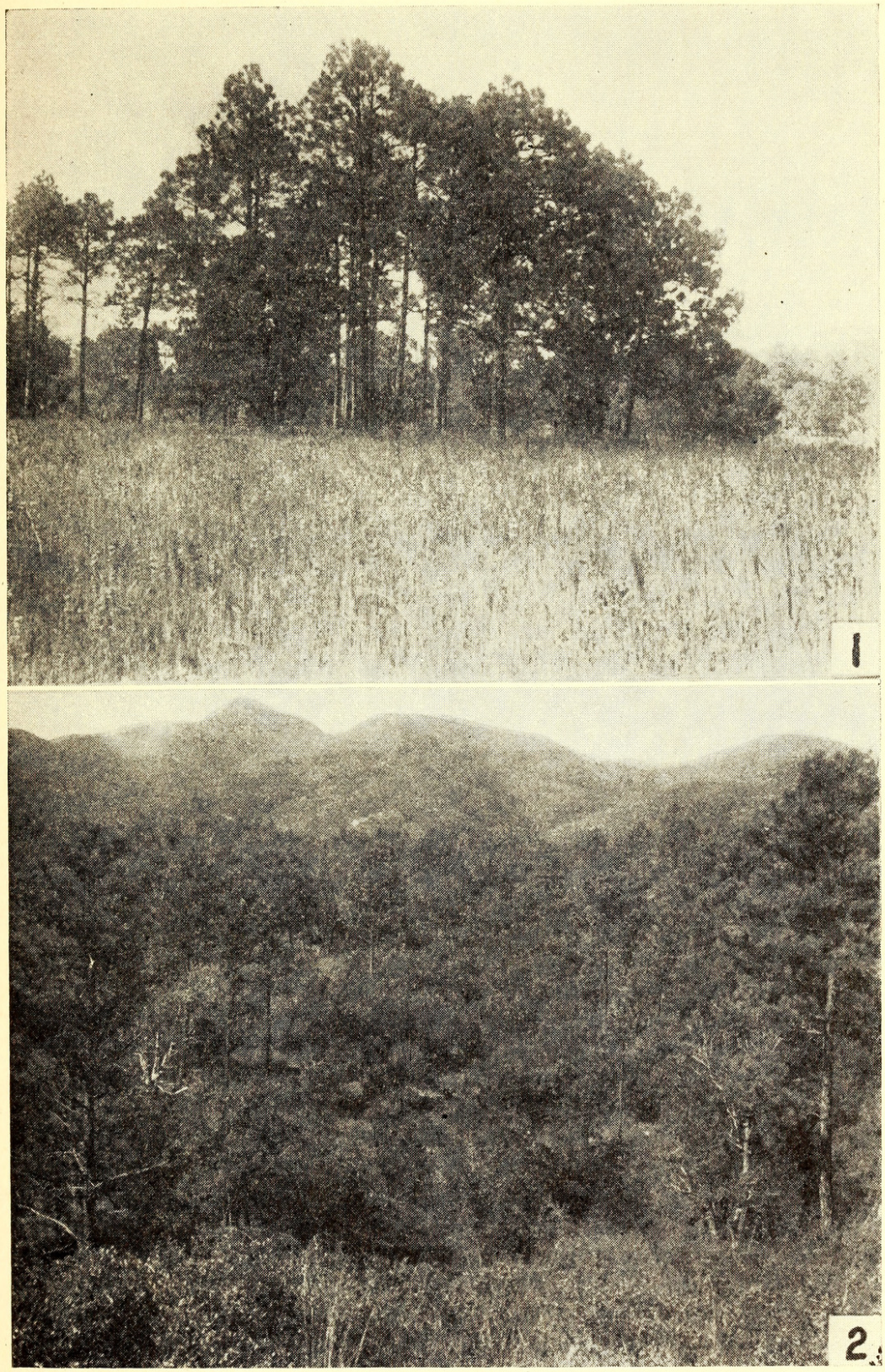


PLATE 7. VEGETATION OF COAHUILA.

the following species listed approximately in the order of decreasing importance:

Garrya ovata Benth.
Rhus virens Lindh.
Cercocarpus mojadensis C. Schneid.
Cercocarpus sp.
Microrhamnus ericoides A. Gray
Berberis trifoliolata Moric.
Cowania plicata D. Don
Arctostaphylos pungens H.B.K.
Ceanothus Greggii A. Gray
Amelanchier denticulata (H.B.K.) Koch
Arbutus xalapensis H.B.K.
Fraxinus Greggii f. nummularis (Jones) C. H. Mull.
Ceanothus lanuginosus (Jones) Rose
Rhus trilobata Nutt.
Rhus microphylla Engelm.
Nolina erumpens (Torr.) S. Wats.
Dasylirion sp.
Yucca carnerosana (Trel.) McKelvey

The very high preponderance of evergreen species and the many genera common to both this chaparral and that of California clearly indicate the close relationship of the two. Just as in California and Arizona the more easterly stands of chaparral closer to the desert influence show a paucity of true chaparral species and an influx of desert species, so also the westerly mountains of Coahuila, more subject to the continental influence, bear only a depauperate chaparral and a high percentage of thorny shrubs. Grasses are much reduced in this phase of the chaparral. Sierra Mojada and Sierra Almagre, near the Coahuila-Chihuahua line, both exhibit this depauperate association. *Quercus intricata, Q. Pringlei, Q. pungens* Liebm., *Lindleyella* sp., *Rhus virens, Cercocarpus* sp., *Ceanothus Greggii, Arctostaphylos pungens, Acacia Greggii* A. Gray, and *Mimosa biuncifera* Benth. are the principal woody species. *Dasylirion* sp. occurs but sparsely, and both *Yucca* and *Nolina* are absent. *Fraxinus cuspidata, Rhus microphylla, Ptelea trifoliata, Juniperus flaccida,* and *J. pachyphloea* occur only along arroyos. This xeric chaparral is exceedingly dense. The only grasses of any importance are *Bouteloua gracilis, B. hirsuta* Lag., and *B. curtipendula,* and these occur only in small clearings.

The upper slopes of Sierra Mojada are said once to have borne timber, principally *Juniperus pachyphloea* and *Pinus arizonica,* which has since been cut clean for use in nearby mines. This must undoubtedly have been a relic stand, for reseeding has not progressed.

7. Montane Mesic Forest. Above the Montane Low Forest and the Montane Chaparral in the higher and more massive mountain ranges there occurs a forest type of definitely mesic nature. The principal characteristics of this type are dominance by *Pinus arizonica* and its associated species, close spacing, tall straight

trunks, a closed canopy of crowns, and poor development of both shrub and grass layers except in clearings (pl. 7, figs. 1 and 2). Only strictly shade-tolerant species comprise the lower layers. The surface soil of this zone, unlike that of the Montane Low Forest, has well developed humus and duff layers, and its moisture content remains high or moderate throughout the summer so that aestivation does not occur.

In the better developed stands of Montane Mesic Forest, such as the upper elevations of Sierra del Carmen, the following species comprise the vegetation:

Pinus arizonica Engelm.
Pseudotsuga taxifolia (Lam.) Britt.
Cupressus arizonica Greene
Quercus Gravesii Sudw.
Quercus hypoleucoides A. Camus
Quercus Muehlenbergii Engelm.
Populus tremuloides Michx.
Acer brachypterum Woot. & Standl.

The principal shrubs are *Lonicera pilosa* (H.B.K.) Willd. and *Ceanothus coeruleus* Lag. *Stipa tenuissima* Trin., *Piptochaetium fimbriatum* (H.B.K.) Hitchc., and a few lesser species are the only grasses. Dicot herbs are common but by no means so abundant as in the lower zones.

In the Sierra Madre of southeastern Coahuila the same type is dominated by *Pinus arizonica, P. teocote* Schlecht. & Cham., *P. montezumae* Lamb., *Quercus affinis* Scheidw., *Q. Endlichiana* Trel., *Cupressus arizonica, Pseudotsuga taxifolia,* etc. *Pinus ayacahuite* Ehrenb. occurs in the highest and most moist sites of both localities, and the Sierra de la Madera of Central Coahuila bears in addition stands of *Abies coahuilensis* Johnst. A similar forest appears on the Sierra de Parras.

The lesser mountain ranges and those more subject to the continental influence bear a much more depauperate pine forest. In the Sierra del Pino, for instance, *Quercus Gravesii, Juniperus pachyphloea, Arbutus xalapensis,* and *Prunus capuli* Cav. are the principal tree species associated with dominant *Pinus arizonica.* The ground cover consists principally of *Andropogon scoparius* Michx., *Bouteloua curtipendula, Elymus canadensis* L., *Muhlenbergia Emersleyi,* and several dicot herbs, of which *Monarda* sp., *Erigeron* sp., *Aster* sp., and additional composites are the more prominent. Although the entire flora is depauperate, the forest is not a relic stand in these mountains, for regeneration is obviously taking place. The climate here is not sufficiently favorable, however, for the development of so rich a forest as that of the Sierra Madre of Nuevo León, for instance.

Apparently no mountains in Coahuila very closely approach the condition described in Nuevo León as subalpine. The rich

meadows and subalpine forests are only suggested by the occurrence of *Pinus ayacahuite* and *Abies coahuilensis,* and a timberline is never reached.

Conclusion

The obvious variations in climate throughout the mountainous area of Coahuila are not reflected in the available data from the few meteorological observatories on the lowlands and plains. These data adequately represent the climates of their respective vicinities and perhaps give an index to the climates of the plains in general.

The area in Coahuila that clearly exhibits vegetational and soils evidence of climates more mesic and cooler than those of the lowlands and plains equals about ten percent of the total area of the state. That this was not recognized in published maps of the climatic types of Coahuila is illustrated in Table I. The climates of Sanchez (1929) in the second column are essentially equal to those of Thornthwaite (1931) and of Ward and Brooks (1936). It will be noted that the five more mesic and temperate vegetation types have no counterparts in the existing classifications of climates in Coahuila.

Table I. Vegetation Types and Climatic Types of Coahuila

Vegetation types	Climatic types of Sanchez
1. Chihuahuan Desert Shrub	Clima Desertico
2. Tamaulipan Thorn Shrub	Clima de Estepas
3. Piedmont Shrub	.....
4. Grassland	.....
5. Montane Low Forest	.....
6. Montane Chaparral	.....
7. Montane Mesic Forest	.....

Biologists cannot rely upon existing climatic classifications for significant geographic data. However, biologic data offer a valuable check upon the accuracy of climatic classifications, especially where such gross areal discrepancies exist as here illustrated. These discrepancies represent biologic, geographic, and economic deviations of considerable importance.

University of California,
Santa Barbara.

Literature Cited

Anonymous. 1936. Apéndice sobre un estudio preliminar de climas llevado a cabo en el Servicio Meteorológico, de acuerdo con la nueva classificación de C. Warren Thornthwaite, y publicado con la colaboración del Instituto Panamericano de Geografía e Historia. Méx. Sec. Agr. y Fom., Dir. Geogr. Met. e Hidrol., Serv. Met. Publ. 37: 1–6. Illus.

Clover, E. U. 1937. Vegetational survey of the Lower Rio Grande Valley, Texas. Madroño 4: 41–66, 77–100.

Contreras, Arias A. 1942a. Estudios climatológicos, Areas geograficas de dispersion: Parthenium argentatum, Hevea brasiliensis, Castilloa elastica. Méx. Sec. Agr. y Fom., Dir. Geogr. Met. e Hidrol. Pp. 1–112. Illus.

————. 1942b. Mapa de las provincias climatológicas de la República

Mexicana. Méx. Sec. Agr. y Fom., Dir. Geogr. Met. e Hidrol., Inst. Geogr. Pp. vii + 54. Illus.

Johnston, I. M. 1941. Gypsophily among Mexican desert plants. Jour. Arnold Arb. 22: 145–170.

LeSueur, Harde. 1945. The ecology of the vegetation of Chihuahua, Mexico, north of parallel twenty-eight. Texas Univ. Publ. 4521. Pp. 1–92.

Merriam, C. H. 1898. Life zones and crop zones of the United States. U.S.D.A., Div. Biol. Surv. Bull. 10: 1–79.

Muller, C. H. 1937. Vegetation in Chisos Mountains, Texas. Texas Acad. Sci. Trans. 20: 3–31.

———. 1939. Relations of the vegetation and climatic types in Nuevo León, Mexico. Am. Midland Nat. 21: 687–729.

Page, J. L. 1930. Climate of Mexico. U. S. Monthly Weather Rev. Sup. 33: 1–30.

Palmer, E. J. 1928. A botanical trip through the Chisos Mountains of Texas. Jour. Arnold Arb. 9: 153–173.

Pringle, C. G. 1888. The forest vegetation of northern Mexico. I–X. Gard. and For. 1: 70 et seq.

Sanchez, P. C. 1929. Estudio de climatología comparada con applicaciones a la República Mexicana: classificación provisional de sus climas. Méx. Sec. Agr. y Fom., Dir. Estud. Geogr. y Climatol. Publ. 19: 1–13. Illus.

Shreve, Forrest. 1917. A map of the vegetation of the United States. Geogr. Rev. 3: 119–125.

———. 1939. Observations on the vegetation of Chihuahua. Madroño 5: 1–13.

———. 1942a. Grassland and related vegetation in northern Mexico. Madroño 6: 190–198.

———. 1942b. The desert vegetation of North America. Bot. Rev. 8: 195–246.

———. 1944. Rainfall of northern Mexico. Ecology 25: 105–111.

Thayer, W. N. 1916. The physiography of Mexico. Jour. Geol. 24: 61–94.

Thornthwaite, C. W. 1931. The climates of North America according to a new classification. Geogr. Rev. 21: 633–655.

Ward, R. de C., and C. F. Brooks. 1936. The climates of North America, in W. Köppen and R. Geiger, Handbuch der klimatologie 2 (pt. J): J9–J79.

VLADIMIR L. KOMAROV, 1869–1946

Early in 1946, in Moscow, Russia, Dr. Vladimir L. Komarov, President of the USSR Academy of Sciences and an eminent botanist, died at the age of seventy-six. To American botanists Komarov is known chiefly as the author of the "Flora of Manchuria," published in three volumes in 1901–1907 by the St. Petersburg Botanic Garden. Besides the "Flora of Manchuria," Komarov published many other botanical works. His "Flora of Kamchatka," which was the result of his travels in 1908–1909, was almost ready for publication at the time of the Revolution of 1917, but most of the proof sheets were lost. The "Flora of Kamchatka" (918 pages) was finally published in 1927–1930.

In 1912 Komarov submitted to the Moscow State University his doctor's thesis, "An introduction to the flora of China and Mongolia." He had in mind the gigantic task of publishing a "Flora of China and Mongolia," and shortly after his doctoral