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VEGETATION OF THE EOLIAN PLAIN AND ASSOCIATED
COASTAL FEATURES OF SOUTHERN TEXAS

DISSERTATION

Presented to the Faculty of the Graduate School of
The University of Texas in Partial Fulfillment

of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

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about 27 miles east of Laredo, whence it swings and runs another 80 miles northeastward to Nueces River. It reaches its maximum elevation of almost a thousand feet east of Laredo, but is actually not as prominent there as it is a little to the south and to the northeast, for the Aguilares plain has not been eroded as much in that vicinity and thus offers less relief. The elevation of the cuesta decreases somewhat south of Laredo but not as much as it does to the northeast toward Nueces River, where it becomes low and indistinct.

South of the latitude of Kingsville and Laredo, an enormous sandy plain slopes gently eastward from the cuesta for 85 or 90 miles to Laguna Madre. This plain has essentially no streams, is unbroken by cuerdas, and virtually all its relief is due to the work of wind: in short, this is the eolian plain of southern Texas. It includes all of Kenedy and Brooks counties, northern Hidalgo County, and parts of Jim Hogg, Starr, Willacy, Kleberg, Duval, and Jim Wells counties. It is a country of large ranches, rich in oil and potable water and (except in droughts) grass. It owes its value as ranching land largely to the fresh water in the Goliad formation, to tap which wells must now reach down as much as a thousand feet near the coast. On the south, near Rio Grande, the eolian plain merges with an area of silt and clay, in Cameron

County, much of Willacy County, and the southern part of Hidalgo County, except for the southwestern corner. The surface of silt and clay has not been changed as much by the wind as has the eolian plain to the north, into which it grades. But most of Willacy and Hidalgo counties shows at least some wind reworking, and some of the most important relief features in coastal Cameron and Willacy counties are clay dunes. The northern boundary of the eolian plain is as indistinct as the southern, if not more so. One characteristic of the terrain north of the latitude of Baffin Bay stands out in striking contrast to that southward: many creeks drain the area. In Duval County, though the indications of wind reworking are most obvious in the southern fourth of the county, they can be found near the eastern boundary of the county as far north as San Diego. In Jim Wells County reworking is evident as far north as Alice or farther, though it is obvious only in the southern third of the county. Clay dunes and sand dunes are present in Kleberg and Nueces counties. But, in general, evidence of windwork progressively decreases northward from Baffin Bay.

This paper contains the data gathered in a preliminary reconnaissance of the vegetation of the eolian plain and its associated coastal features in southern Texas south of Nueces River. It is based on more than four years of research, and incorporates data gathered in an earlier study of the vegetation of eastern Cameron County. Although many statistical

BOTANICAL HISTORY

In 1895, A. A. Heller commented that botanists knew practically nothing of the region between Corpus Christi and Brownsville (Heller, 1895:5). J. K. Small remarked, only 27 years ago, that coastal southern Texas had remained almost a virgin botanical field (1927:136). So far as published information is concerned, Heller's and Small's remarks could be repeated today with considerable accuracy.

Several early botanists visited the study area, the earliest of whom, Berlandier, botanized in the extreme southern portion of Texas and adjoining Mexico for several years between 1830 and 1850. Though most of Berlandier's collections are from the southern extreme of the area, a few are labelled as being from between Rio Coloral [= Arroyo Colorado] and Rio de las Nueces. For a fuller account of Berlandier's career, see Geiser (1948).

From the time of Berlandier until Vernon Bailey's excursion in 1900, no botanist collected between Arroyo Colorado and Baffin Bay, in the very heart of the study area. During this time, however, several men collected at Corpus Christi at the northern extremity, and along Rio Grande at the southern extremity. In 1847 Dr. Josiah Gregg

botanized along Rio Grande (Torrey, 1858). In the interval 1850 through 1856 a Dr. Poselger collected cacti on the lower Rio Grande and at Corpus Christi (Geiser, 1936). In the fall of 1853 Arthur C. V. Schott collected along Rio Grande starting at its mouth (Torrey, 1858). Prior to 1858 a Dr. Edwards botanized at Corpus Christi (Torrey, 1858:179). For several years during and after the Civil War, botanists were not active in the study area. In the fall of 1879, Dr. Edward Palmer collected near Corpus Christi (Watson, 1883, 1883). Apparently C. C. Parry accompanied Palmer. In the interval 1879-1883 S. B. Buckley botanized in the "lower Rio Grande valley" (Britton, 1884). In the interval 1888-1892 G. C. Nealley collected in the study area, spending a total of about five weeks near Corpus Christi and about 14 weeks along Rio Grande in Cameron and Hidalgo Counties (McVaugh, 1946). In 1888 C. G. Pringle collected a few specimens in Cameron and Hidalgo counties (Coulter, 1890). In 1890, J. M. Coulter published on Nealley's collections, and, in the interval 1891-1894, he published the Botany of western Texas, a manual of vascular plants known in Texas west of 97th meridian. In 1894, A. A. Heller spent eight weeks collecting at Corpus Christi (Heller, 1895). In the spring of 1900 Vernon Bailey made 62 collections in the study area,

including 22 numbers between Arroyo Colorado and Baffin Bay. Bailey's collections were available to J. K. Small in the preparation of his monumental Flora of southeastern United States, a manual of plants known to occur east of 100th meridian (Small, 1903).

Following the completion of the railroad from Kingsville to Brownsville in 1904, and at an accelerating rate since completion of the highway in 1941, many botanists have visited the area, and a few have collected intensively. Robert Runyon, a resident of Cameron County since 1910, has made the most valuable and most nearly complete collections ever obtained from southern Texas. Seven species in the study area bear his name. Other names high on the list of collectors are Tharp, Lundell, Clover, Chateau, Walker, Sinclair, and Davis. The handful of valid new species collected in the area in the last 50 years are mainly from the long-inaccessible sandy plain in the central and coastal part of the area. It is safe to say that the pioneer period of exploration is over, though the whole field of taxonomic revision of the flora is scarcely touched. The phase of research involving plant sociology, detailed geography, and the related applied field of range management, is just beginning.

Aside from several general accounts of the physiognomy of the vegetation, the first serious attempt to distinguish

broad phytogeographic⁹ areas in southern Texas was by Tharp. He mapped his coastal prairie associates as far south as Nueces River along the coast, and he mentioned the encroachment of brush as far north as San Patricio County (1926). He later included most of the present study area in his Mesquite-Chaparral Region, except for a strip of sand hills, supporting live oak and grasses, and stretching across Kenedy, Brooks, and Jim Hogg counties; and he mapped his Coastal Prairie as extending south to Baffin Bay (1939). Later he repeated this mapping but enlarged the sand hill area, which he designated the Coastal Mainland Dunes Region (1952). This mapping is applicable, if one realizes, as Tharp does, that the boundaries are often indefinite and do not lend themselves to close delineation.

Clover (1937) explored Cameron, Willacy, Hidalgo, Starr, and Zapata counties, and mapped and described the vegetational types which she distinguished. She mapped a narrow coastal strip of salt grass (*Spartina spartinae*)

⁹Zoologists have attempted broad regional mappings of "biotic provinces." Dice (1943) included the study area in his "Tamaulipan Biotic Province." Blair (1950, 1952) attempted to refine Dice's boundaries, and described the "Matamoran Biotic District" which included Starr, Hidalgo, Willacy, and Cameron counties. Attempts to fathom the subtleties of the whole biota on the basis of terrestrial vertebrates are hazardous.

community). Along Rio Grande she mapped a narrow wooded strip; northward from that a broad varied zone of brush of several types; and north of that in northern Hidalgo and Willacy counties an area of sandy prairie.

A very small part of the area, the palm groves southeast of Brownsville, received intensive study in 1940-1942 by Mrs. A. M. Davis and Mr. L. I. Davis. The study culminated in the writing of a thesis on the vegetation of the palm groves by Mrs. Davis (1942). The thorough examination by the Davises of this previously well-collected small area turned up at least two new species and four new distribution records for the United States.

Before field work for the present study began no botanist had ever undertaken a thorough reconnaissance of the vegetation of the ranch country in Kleberg, Kenedy, Willacy, and Brooks counties. Most of the field work upon which the present study is based was conducted in those counties on large ranches, especially the King, Sauz, and Kenedy ranches.

with essentially no clay fraction, a retarding of brushing over is evident from the lower degree of coverage and the lower species diversity of brush on the looser soil. Such a gradient can be explained as a simple lag phenomenon; that is, it may be postulated that not sufficient time has elapsed to allow mesquite to occupy the looser soil. However, the constant repetition of such gradients may tend to invalidate such a postulation. Considering the rapidity of dispersal of mesquite, and the abundant chance it has had to be dispersed, it might seem that by now the mesquite would have occupied all the area which is favorable to it.

2. Live oak scrub

This community is almost completely dominated by live oak (Quercus virginiana and/or Q. oleoides quaterna). Live oak scrub is confined to loose sandy soil and occupies only the higher terrain not too greatly subject to salt spray. There is no evidence that live oak scrub is ever replaced by any other community. It is considered to be an edaphic climax.

Loose sandy soil apparently suitable to live oak is distributed in the central part of the study area in the eolian plain in Kenedy, Brooks, central Jim Hogg, northern Willacy, northern Hidalgo, northern Starr, and extreme southwestern Kleberg counties, and in a narrow coastal strip in

Kleberg and Nueces counties: Live oak is actually distributed on this soil only in Brooks, Hidalgo, Willacy, and Kenedy counties, and in the coastal strip of Kleberg and Nueces counties.

In Kleberg and Nueces counties live oak covers practically all the coastal strip of loose sand back of the beach ridge, being absent only in swales. Live oak scrub in these counties differs from that south of Baffin Bay in being shorter, generally less than three feet tall, and so sparse as to allow many loose sand prairie species to grow (see Plate XVI). Rarely within the short scrub occur mottes as much as ten feet tall, and approach the density and degree of shading found in mottes south of Baffin Bay (see Plate XVII). The short live oak scrub of Nueces and Kleberg counties is also distinct in containing several shrubs and robust perennial herbs not found to the south, including: Ilex vomitoria, Persea Borbonia, Myrica cerifera, Vaccinium arboreum, Sabal minor, and Monarda punctata maritima. Grasses and forbs found in this short scrub, but not south of Baffin Bay are Muhlenbergia capillaris and Strophostyles leiosperma.

South of the latitude of Baffin Bay, the live oak scrub is generally taller, sometimes approaching 25 feet in height, but generally about 15 feet tall, and usually produces conditions of shading unfavorable to the growth of most loose sand

PLATE XVI

An expanse of live oak scrub about 3 feet tall,
on loose sand near the coast in Kleberg County.
In the right background is a barely visible swale
covered with prairie rather than scrub.

21

1941
JAN
1941

prairie species (see Plate XVIII). Some stands of live oak scrub are continuous over large upland areas in Kenedy and Brooks counties, being replaced only in swales, some of which are completely surrounded by the scrub. But in northeastern Kenedy County and near the coast in southeastern Kenedy and northeastern Willacy counties the stands of live oak take the form of mottes surrounded by loose sand prairie (see Plate XIX). In the shade of the scrub are found the usual "motte-grasses," including: Vaseyochloa multiner-vosa, Sporobolus purpurascens, Trichoneura elegans, Paspalum ciliatifolium, Digitaria texana, and Cenchrus pauciflorus. On the live oaks are the usual epiphytes: Tillandsia Baileyi, T. recurvata, and T. usneoides. Vines occurring in the scrub are Metastelma barbigerum, and Vitis mustangensis. Other plants growing in the shade are: Malvaviscus Drummondii, Wissadula amplissima, Pterocaulon virgatum, Mentzelia texana, Tradescantia hirsutiflora, Hybanthus verticillatus, Solanum verbas-cifolium, Sclerocarpus uniserialis, Cnidoscolus texanus, and Schrankia latidens. Three scarce woody species growing with live oak in Kenedy County are Yucca Treculeana, Bumelia lanuginosa, and Sapindus Drummondii. A few areas in Kenedy County have a low open type of live oak scrub in which the loose sand prairie species are not shaded out.

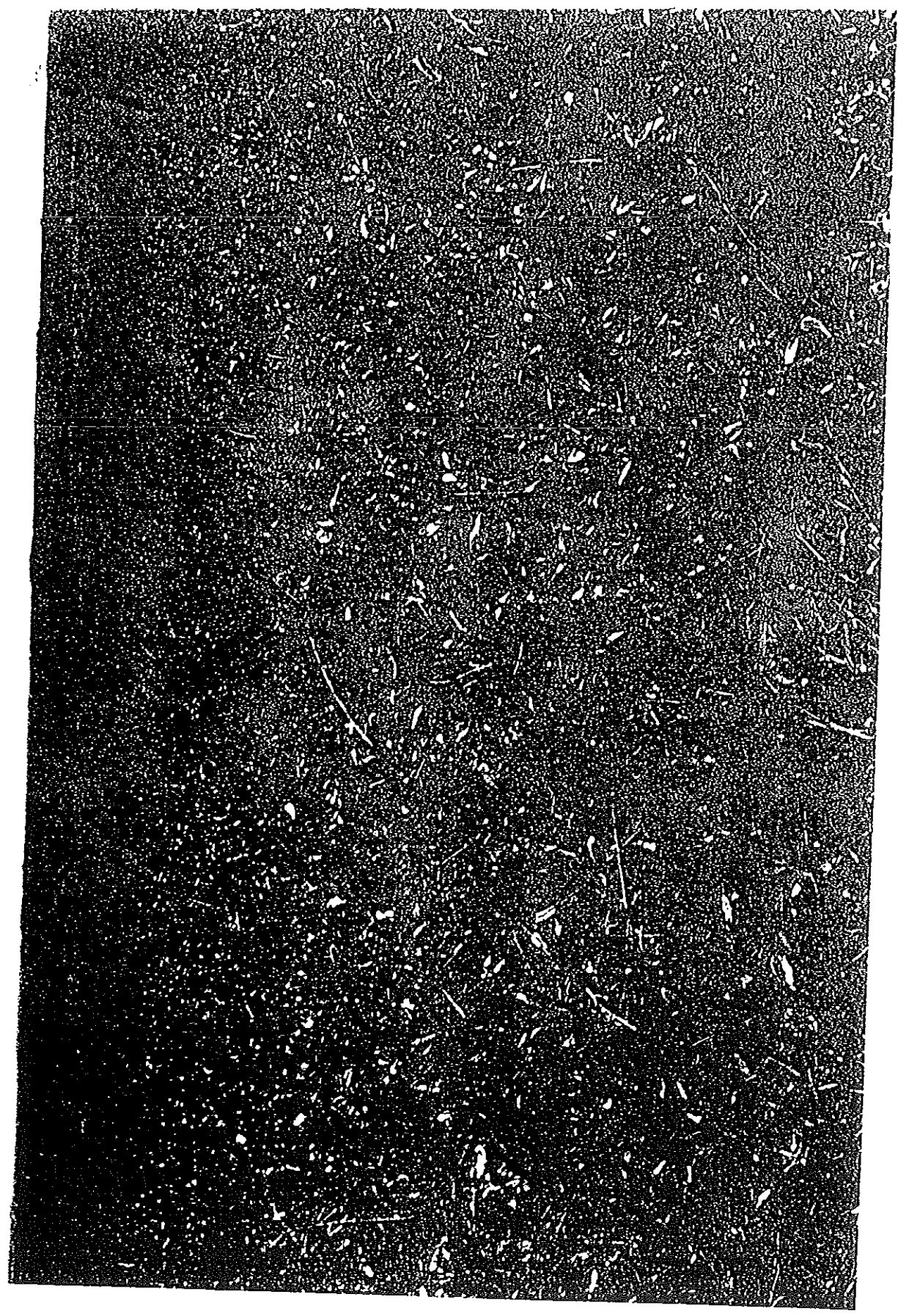
An evaluation of the importance of the plants known to occur in live oak scrub will be found in Column E, Table VI.

63

PLATE XVII

Live oak scrub about three feet tall on loose sand near the coast in Kleberg County. The taller darker motte is of Persea Borbonia. Eastward across Laguna Madre on the horizon is Padre Island.

62a



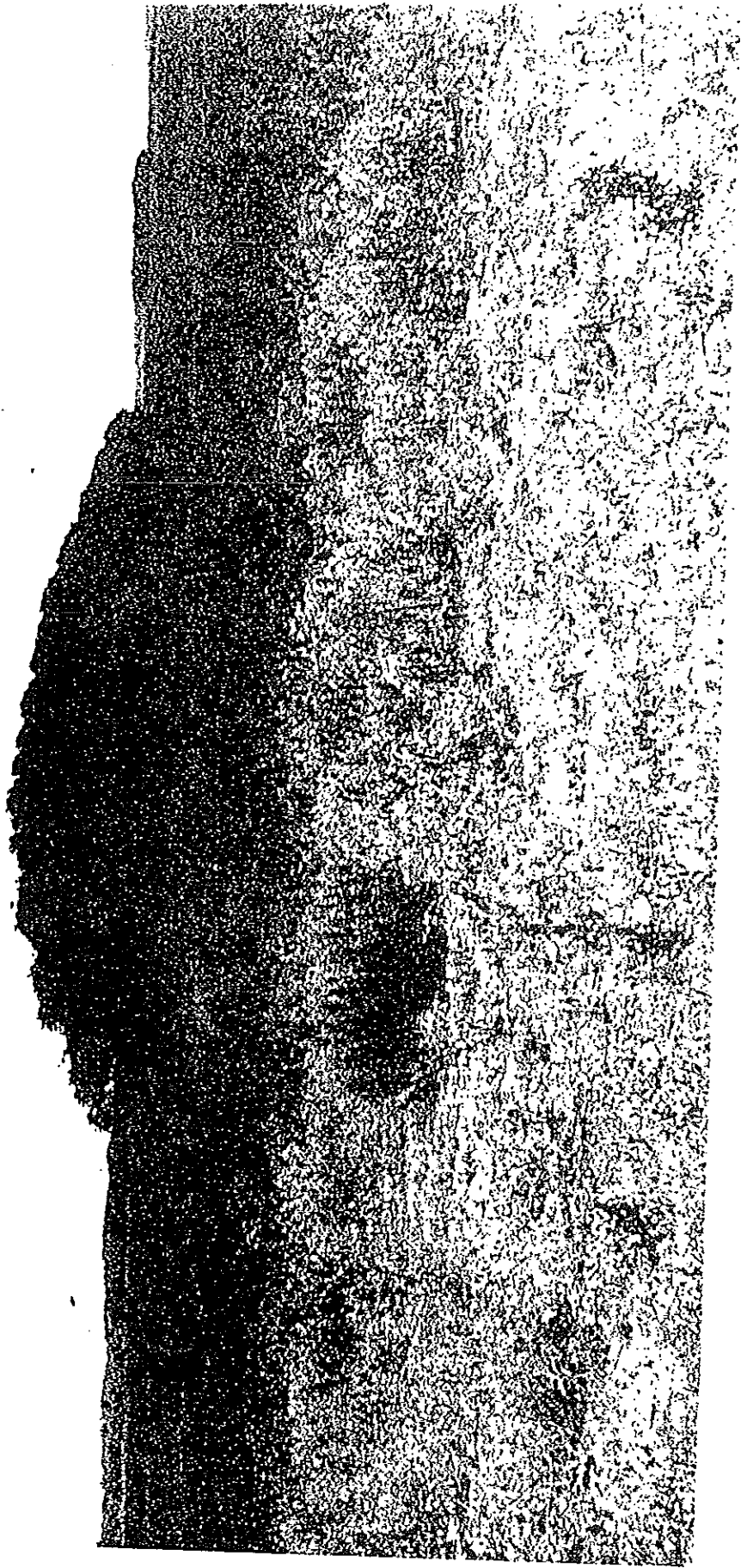
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PLATE XVIII

Interior of a large live oak motte in south-central Kenedy County, after a long drought. The nearly leafless (but still living) live oaks are about 15 feet tall, and are the only woody plants in the motte. The apparent absence of grasses and forbs indicates severe drought and grazing.

PLATE XIX

A small live oak motte in loose sand prairie in north-central Kenedy County. The taller central live oaks are about 15 feet tall. Severe overgrazing of the prairie is evident from the virtual absence of grass and the abundance of coarse weedy forbs.



1111

3. Loose sand prairie

This type of vegetation occupies loose sand uplands not dominated by brush or by live oak scrub. It is considered to constitute a fire climax, but, near the coast, is also apparently a salt spray climax. On slopes of loose sand it is in contact with live oak scrub on higher ground, and with *Spartina spartinae* community on lower ground. The presence and coverage of species in three stands of relatively undisturbed loose sand prairie are given in Table IV, column A. The community might suitably be called the *Andropogon littoralis* community, since that species in large well-developed bunches covers an average of almost a third of the area of the sample plots. The rest of the stands is covered by over 40 other perennial grasses and forbs, together with several annuals. Little or no ground is bare. In the relatively undisturbed stands the grasses are about 3 feet tall at the most, except for *Panicum virgatum* whose flowering culms stand as high as 6 feet in the fall. Large irregular bunches or colonies, each composed of a single species of perennial grass, form a loose mosaic. The mosaic covers about half the ground. Species composing the mosaic include *Andropogon littoralis*, *Panicum virgatum*, *Paspalum plicatulum*, *P. ciliatifolium*, *P. monostachyum*, *Elyonurus tripsacoides*, *Brachiaria ciliatissima*, *Cenchrus pauciflorus*, and *Chloris cucullata*. Most of the forbs

present are not robust, but send long spindly stems up to the light. The grasses achieve their maximum height after the fall rains; at anthesis they are overtopped by a few robust annuals which germinate in the spring, including Cassia fasciculata, Helianthus debilis cucumerifolius, and a few Croton Engelmannii. Of the three stands of relatively undisturbed loose sand prairie mentioned, one is coastward from the limit of live oak; the other two are not. Studies of these three stands and of other only slightly more disturbed stands both coastward and inland from the limit of live oak indicate that the composition of the relatively undisturbed loose sand prairie is not greatly influenced by salt spray.

Most prairie, in contrast to that described above, shows evidence of more or less severe grazing disturbance. Much of it is brushed (see Plates XIII, XIV, XV). The open prairie now remaining is mostly near the coast (see Plates V, VII, XIX, and XX). The grazed prairie shows great reduction in coverage by perennial grasses; Andropogon littoralis is virtually absent. Much of the ground is bare. The community of the grazed prairie is more varied and the species mostly less constantly present in the sample areas than in relatively undisturbed stands. Several forbs attain greater coverage under grazing, and several species apparently rare

PLATE XX

Open, severely grazed loose sand prairie near the coast in southeastern Kenedy County in August. Note that much of the ground is bare. The large weeds are pistillate plants of Croton Parksii standing two or three feet high (the species was described as a shrub though it is annual). The jackrabbit constitutes a conspicuous element of the biota.

or even lacking in the undisturbed stands assume importance upon disturbance. The seasonal changes of overgrazed prairie on loose sand are much more spectacular than those of relatively undisturbed stands. The grasses are short and sparse, rarely over two feet in height, in small tufts (not in bunches), and locally inconspicuous to the vanishing point. The species of forbs (both annual and perennial) which provide much of the coverage in the community severally flourish and bloom each in its own season. They furnish continuous color through much of the year. The spring bloomers are mostly low and bright. As the season progresses the coarse herbs which start growth in the spring arrive at anthesis. Some of the coarse annual herbs are robust and surpass all other species in height and conspicuity in the summer and fall. Among them are Cassia fasciculata and the several species of Croton. The structure and composition of the disclimax prairie seems to be influenced by salt spray. Columns B and C of Table IV show presence and coverage in disclimax loose sand prairie respectively inland from and coastward from the coastward limit of live oak.

As has been described before, a ridge of loose sand-and-shell hash fronts Laguna Madre in some places. This ridge supports a community similar to that of the rest of the overgrazed loose sand prairie near the coast, but the lower part of its windward slope also supports species not noted growing.

together elsewhere except just leeward from the Gulf beach, including: Sesuvium Portulacastrum, Ipomoea stolonifera, Croton punctatus, Oenothera Drummondii, and, rarely, Uniola paniculata, Panicum amarulum, and Sporobolus Tharpii.

A type of loose sand prairie is peculiar to the bottom of shallow swales. The proximity of the water table to the surface is perhaps one of the factors influencing the composition of the prairie; but the bottoms are sufficiently well drained to allow the development of prairie rather than of *Spartina spartinae* community. While plants characteristic of these swales are never truly aquatic nor hydrophytic, they are favored by the greater moisture available to them. Many plants of the upland prairie are present in the swales. Cephalanthus occidentalis grows as scattered shrubs just below the level of upland loose sand prairie in some swales, being more common north of Baffin Bay. Other plants found in the swales but not present in the upland prairie, are listed:

Chloris *petraea*
Panicum *sphaerocarpon*
Cyperus *aristatus*
Dichromena *colorata*
Fimbristylis *castanea*
Scirpus *americanus*
Juncus *polycephalus*
J. marginatus *setosus*
Nemastylis *purpurea*
Rorippa *Walteri*
Mimosa *strigillosa*
Linum *rigidum* *Berlandieri*

Limnoscium *pumilum*
Eustoma *Russellianum*
Lippia *incisa*
Verbena *Halei*
Gerardia *strictiflora*
Stemodia *tomentosa*
Pluchea *purpurascens*
Cirsium *horridulum*
Conoclinium *betonicum*
Erigeron *myrionactis*
Coreopsis *cardaminaefolia*
Flaveria *oppositifolia*.

North of Baffin Bay, in similar swales, the species listed above are present as well as several which were not observed south of Baffin Bay, including:

Juncus brachycarpus
Ascyrum hypericoides
Lechea divaricata
Gnaphalium purpureum

Silene antirrhina
Helianthemum Bicknellii
Chrysopsis pilosa
Krigia occidentalis.

The formation of blow-outs in loose sand removes sand from the root zone. Movement of the sand leeward from the blow-outs buries some plants. In these two ways the prairie plants are killed by eolian activity, leaving bare sand surfaces. During times of fairly abundant moisture, when the wind is not actively blowing the sand, the bare dune surfaces are the sites of seres. Often these seres are interrupted by resumption of blowing, but doubtless in the past some have progressed to the point at which the sand is stabilized by plant cover. Among the early species to become established are:

Annuals

Heliotropium convolvulaceum
Amaranthus arenicola
Helianthus debilis cucumerifol-
ius
Polypteris Hookeriana

Perennials

Salix migra
Eragrostis oxylepis
Aristida Roemeriana
Cenchrus pauciflorus
Galactia canescens
Xanthoxylum Clava-Herculis
Oenothera Drummondii
Lantana horrida

Apparently the dune sere leads to the development of loose sand prairie and perhaps eventually to brush or live oak scrub.

Table IV

Species of prairie on loose sand and sandy loam

In each column the left-hand figure is presence and the right-hand figure coverage.

- A - Relatively undisturbed loose sand prairie.
- B - Overgrazed loose sand prairie inland from the coastward limit of live oak.
- C - Overgrazed loose sand prairie coastward from the limit of live oak.
- D - Overgrazed prairie on sandy loam.

Andr
Cenc
Chlc
Brac
Erag
Spor
Pani
Pasp
Elyc
Pani
Bout
Digi
Aris
Erag
Aris
Pasp
Vase
Spor
Pani
Pasp
Hete
Aris
Erag
Aris
Pani
Pasp
Andr
Pasp
Erag
Erag
Erag
Bout
Aris

Tric
Trip
Spor

Table IV

Species of Prairie on Loose Sand and Sandy Loam

<u>Perennial grasses</u>		A	B	C	D
Andropogon littoralis.	100 30				
Cenchrus pauciflorus	100 5	100 5	100 5	100 5	100 5
Chloris cucullata	100 5	71 5	11 +	67 5	
Brachiaria oiliatissima	100 5	15 +	8 +	12 +	
Eragrostis oxylepis	100 +	100 8	100 9	88 10	
Sporobolus cryptandrus	100 +			36 +	
Panicum firmulum	67 5	30 +	3 +	15 +	
Paspalum ciliatifolium	67 +	30 +	8 +		
Elyonurus tripsacoides	67 +	11 +		9 +	
Panicum virgatum	67 +	7 +	3 +		
Bouteloua hirsuta	67 +	4 +		12 +	
Digitaria texana	67 +	4 +	3 +	9 +	
Aristida Roemeriana	33 +	61 +	61 10	88 15	
Eragrostis sessilispica	33 +	28 +	8 +	45 +	
Aristida Wrightii	33 +	13 +		3 +	
Paspalum monostachyum	33 +	6 +			
Vaseyochloa multinervosa	33 +	2 +			
Sporobolus purpurascens	33 +	2 +		3 +	
Panicum nodatum	33 +	2 +			
Paspalum plicatulum	33 +	2 +			
Heteropogon contortus	33 +	2 +		6 +	
Aristida purpurascens		7 +			
Eragrostis Swallenii		2 +		3 +	
Aristida longiseta				3 +	
Panicum ramisetum				3 +	
Paspalum debile		2 +		3 +	
Andropogon saccharoides				3 +	
Paspalum propinquum				6 +	
Eragrostis lugens				9 +	
Eragrostis curtipedicellata				9 +	
Eragrostis Tracyi				12 +	
Bouteloua filiformis				12 +	
Aristida purpurea		2 +	3 +	18 +	
<u>Annual grasses</u>					
Trichoneura elegans	33 +				
Triplasis purpurea		6 +	3 +		
Sporobolus pulvinatus				6 +	

Table IV

Perennial forbs		A		B		C		D	
<i>Lotoxalis Berlandieri</i>		67	+	21	+	71	+	79	+
<i>Polygala alba</i>		67	+	6	+	11	+	12	+
<i>Thelesperma filifolium</i>		33	+	28	+	5	+		
<i>Opuntia Allairei</i>		33	+	22	+	58	+		
<i>Cassia aristellata</i>		33	+	22	+	18	+	12	+
<i>Euphorbia innocua</i>		33	+	2	+	45	+	3	+
<i>Galactia canescens</i>		33	+	9	+	8	+		
<i>Monarda fruticulosa</i>		33	+	15	+	3	+		
<i>Oxybaphus albidus</i>		33	+	7	+				
<i>Tetragonotheca ludoviciana repanda</i>		33	+	4	+				
<i>Stylosanthes viscosa</i>		33	+	4	+				
<i>Ditaxis pilosissima</i>		33	+	4	+				
<i>Zornia diphylla</i>		33	+	2	+				
<i>Centrosema virginianum</i>		33	+						
<i>Sida cordifolia</i>		33	+	2	+	3	+		
<i>Convolvulus incanus</i>		33	+	2	+	13	+	3	+
<i>Meriolix serrulata</i>		33	+	15	+	50	+	6	+
<i>Matelea parviflora</i>		33	+	4	+			6	+
<i>Sida Lindheimeri</i>		33	+	35	+	3	+	15	+
<i>Rhynchosia americana</i>		33	+	85	5	79	5	42	+
<i>Croptilon divaricatum</i>				22	+	53	+		
<i>Cnidoscolus texanus</i>				21	+	3	+		
<i>Eupatorium compositifolium</i>				13	+	5	+		
<i>Gaillardia lanceolata</i>				7	+	5	+		
<i>Senecio Riddellii Parksii</i>				2	+	11	+		
<i>Samolus ebracteatus alyssoides</i>						21	+		
<i>Baptisia laevicaulis</i>						16	+		
<i>Stillingia sylvatica</i>									
<i>Dalea aurea</i>				11	+				
<i>Richardia brasiliensis</i>				7	+	3	+		
<i>Aeschynomene viscidula</i>				7	+	3	+		
<i>Yucca constricta</i>				4	+	5	+		
<i>Neptunia pubescens</i>				4	+				
<i>Ratibida peduncularis</i>						5	+		
<i>Sphaeralcea Lindheimeri</i>						5	+		
<i>Petalostemon obovatum</i>				4	+	3	+		
<i>Houstonia nigricans</i>				2	+	3	+		
<i>Phaseolus atropurpureus</i>						3	+		
<i>Prunus texana</i>						3	+		
<i>Liatris elegans</i>				2	+				
<i>Evolvulus sericeus</i>				2	+				
<i>Tephrosia Lindheimeri</i>						3	+	3	+
<i>Croton argyranthemus</i>				2	+			3	+
<i>Indigofera miniata</i>				2	+			3	+
				2	+	16	+	3	+

Table IV

<u>Perennial forbs (continued)</u>				
A	B	C	D	
Schrankia latidens	6 +		6 +	
Zornia bracteata	7 +	5 +	6 +	
Evolvulus alsinoides	2 +	16 +	6 +	
Acalypha radians	22 +	79 +	18 +	
Commelina erecta angustifolia	7 +	13 +	21 +	
Lygodesmia texana			3 +	
Chrysopsis Berlandieri			3 +	
Aphanostephus Riddellii			3 +	
Aphanostephus ramosissimus			3 +	
Verbena Cloveri			3 +	
Lantana horrida			3 +	
Lithospermum incisum			3 +	
Funastrum cynanchoides			3 +	
Asclepias Emoryi			3 +	
Echinocereus angusticeps			3 +	
Mentzelia stricta			3 +	
Waltheria americana			3 +	
Sida tragiaefolia			3 +	
Callirhoe involucrata			3 +	
Hoffmanseggia caudata			3 +	
Cooperia Drummondii			3 +	
Acacia Greggii			3 +	
Acacia angustissima			3 +	
Clematis Drummondii			3 +	
Cocculus diversifolius			3 +	
Melampodium cinereum			3 +	
Cassia texana			6 +	
Ditaxis humilis			6 +	
Sphaeralcea pedatifida			6 +	
Sideranthus spinulosus			6 +	
Dalea nana			6 +	
Galactia Grayi			12 +	
Desmanthus virgatus depressus			42 +	
Hymenopappus artemisiaefolius				
(biennial)	2 +	8 +	6 +	
<u>Winter annual forbs</u>				
Verbena bipinnatifida			9 +	
Verbena ciliata	4 +	3 +		
<u>Spring annual forbs</u>				
Phlox Drummondii glabriflora	100 +	97 +	100 +	93 +
Aphanostephus skirrhobasis	67 +	37 +	37 +	49 +
thalassius	33 +	19 +	50 +	61 +
Coreopsis nuecensis				

Table IV

Spring annual forbs (continued)				
	A	B	C	D
<i>Sisyrinchium</i> spp.	33 +	13 +	50 +	3 +
<i>Petalostemon emarginatum</i>	33 +	19 +	37 +	12 +
<i>Pyrrhopappus multicaulis</i>	33 +	37 +	45 +	30 +
<i>Sabbatia campestris</i>	33 +		18 +	3 +
<i>Brazoria arenaria</i>		6 +	11 +	
<i>Psoralea rhombifolia</i>		7 +	13 +	
<i>Eurytaenia texana</i>		2 +	5 +	6 +
<i>Linum rigidum</i>		2 +	8 +	9 +
<i>Plantago Hookeriana inflexa</i>		2 +	3 +	18 +
<i>Lobelia Berlandieri</i>		7 +	21 +	30 +
<i>Senecio ampullaceus</i>		6 +		3 +
<i>Vicia Leavenworthii occidentalis</i>		7 +		6 +
<i>Polypremum procumbens</i>		7 +		12 +
<i>Descurainia pinnata</i>				3 +
<i>Phacelia laxa</i>				3 +
<i>Amblyolepis setigera</i>				6 +
<i>Linum multicaule</i>				6 +
<i>Verbena quadrangulata</i>				6 +
<i>Evax multicaulis</i>				6 +
<i>Castilleja indivisa</i>				9 +
<i>Corydalis micrantha</i>				9 +
<i>Verbena pumila</i>				9 +
<i>Phacelia patuliflora</i>				9 +
<i>Oenothera laciniata</i>				15 +
Summer annual forbs				
<i>Gaillardia pulchella</i>	33 +	35 +	45 +	30 +
<i>Chamaesyce missurica</i>	33 +	6 +	3 +	
<i>Dyssodia tenuiloba</i>		22 +	16 +	
<i>Cristatella erosa</i>		11 +	26 +	
<i>Chamaesyce ammannioides</i>		7 +	16 +	
<i>Paronychia Drummondii</i>		11 +	8 +	
<i>Houstonia subviscosa</i>		11 +	5 +	
<i>Diodia teres</i>		6 +	3 +	
<i>Chamaesyce cordifolia</i>		4 +	3 +	
<i>Sclerocarpus uniserialis</i>		2 +	3 +	
<i>Heliotropium convolvulaceum</i>		6 +		
<i>Richardia scabra</i>		6 +		
<i>Rudbeckia serotina</i>		2 +	8 +	3 +
<i>Scutellaria muriculata</i>		6 +	39 +	6 +
<i>Polypteris rosea</i>		13 +	5 +	9 +
<i>Phyllanthus abnormis</i>		7 +	5 +	30 +
<i>Heliotropium texanum</i>		9 +		15 +
<i>Gaura odorata</i>				6 +
<i>Gaura brachycarpa</i>				9 +
<i>Xanthisma texanum</i>				9 +
<i>Portulaca pilosa</i>				18 +
<i>Nama hispidum</i>				21 +

Table IV

<u>Summer and fall annual forbs</u>		A		B		C		D	
Cassia fasciculata		100	+	100	15	97	10	100	13
Helianthus debilis cucumerifolius		67	5	28	+	3	+	21	+
Croton Engelmannii		33	+	100	5	100	5	100	8
Croton Parksii				100	15	92	10	61	+
Croton (sp. undetermined)				37	+	21	+		
Croton glandulosus				11	+	3	+	18	+
<u>Fall annual forbs</u>									
Polypteris Hookeriana				7	+				
Froelichia Drummondii				8	+			6	+
Eriogogonum multiflorum				37	+			30	+

4. Prairie on sandy loam

A type of prairie quite different from that on loose sand occurs on sandy loam. Sandy loam has a clay and silt fraction (except in a thin layer at the top) great enough to prevent it from becoming loose even during dry weather. But in wet weather the clay fraction is not sufficient to make the sandy loam sticky or plastic. A practical criterion for recognition of this soil is used by the ranch people who drive over it: sandy loam can be driven over with no danger of getting stuck in either wet or dry weather. In contrast to this, the loose sand is difficult to drive through in dry weather and clay soils are difficult to drive through in wet weather. Obviously every gradation exists between the loose sand on the one hand and clays on the other. Of the species which occur in prairie on the several soil types, far more are common to the loose sand and sandy loam than are common to the sandy loam and clay.

A great deal of the prairie on sandy loam has become brushed over, i.e., replacement of prairie by brush has begun (see Plate XII). The pioneer brush plants are isolated or in mottes. This replacement ultimately results in complete elimination of the prairie.

The prairie on sandy loam persists in small areas mostly at the margins of areas which have been described as

supporting loose sand prairie and live oak scrub. These small areas are in southwestern Kleberg County, extreme southern Jim Wells County, extreme western Willacy County, and northern Hidalgo County, and in scattered patches in northeastern Starr, southeastern Duval, and eastern Jim Hogg counties. In general, the higher the clay fraction in the soil, the more completely has brush covered the ground; conversely, the closer the approach to loose sand, the more frequent are the areas of relatively open prairie (where the brush plants and mottes are more widely spaced). No area of sandy loam was found in the entire study area which did not have a mesquite at least every fifty yards (except where these had been bulldozed or plowed).

A study of the very few relatively undisturbed stands of prairie on sandy loam indicates that the fire climax, if one is identifiable, is a complex prairie community in which few species are constantly present, and in which annuals are important.¹⁶ Andropogon littoralis was not found on sandy

¹⁶It should be emphasized that, though not all stands of prairie on sandy loam exhibit the same degree of disturbance, none shows a degree of seral progression comparable to that exhibited by the three stands of loose sand prairie represented by the data in Column A of Table IV. Thus, in order to compare loose sand prairie with prairie on sandy loam by use of the data in Table IV, it is much more significant to compare Column D with Column B than with Column A.

loam. The presence and coverage of perennial species which occurred in 33 stands of grazed prairie on sandy loam are given in Table IV, Column D. The grasses and most of the forbs are short and sparse. In many places coverage is so low that during droughts the ground appears to be bare (see Plate XII). Not all stands show such severe disturbance. As in the case of prairie on loose sand, a decrease in coverage by perennial grasses is correlated with increased severity of overgrazing. During favorable seasons the annual herbs assume great importance in the prairie. During the spring the sparse grass and herbaceous cover is rarely over a foot tall. As the season progresses the coarse annual forbs which germinate in the spring overtop the other plants and assume aspect dominance; among these are Cassia fasciculata and several species of Croton.

Some swales in prairie on sandy loam are tight-bottomed with a sufficiently high clay fraction to be sticky and to hold water, thus promoting the growth of pond plants, the most conspicuous of these being Sesbania Drummondii, which forms large shrubs with a trunk diameter of up to four inches at the base. Many swales, however, do not hold water for more than a few days after rains, and have a modified type of prairie, with several species not found in the sandy loam uplands, including the following:

Mimosa strigillosa
 Stemodia tomentosa
 Soliva anthemifolia
 Rorippa Walteri
 Eustoma Russelianum
 Verbena Halei

Coreopsis cardaminaefolia
 Trichocoronis Wrightii
 Nemastylis purpurea
 Limnosciadium pumilum
 Lippia incisa

5. Clay prairie.

No stands of clay prairie found were considered to be even relatively undisturbed. No areas of the highly disturbed clay prairie available for study were free of mesquite (see Plate XI). On the other hand, the clay prairie is somewhat more easily delimited geographically, and its components are entirely different from these of the vegetation of any coarser soil. The clay prairie is scattered in patches in the brush on the black, tight, sticky calcareous clay or silty clay loam, mapped as "Victoria" clay loam, between Alazan Bay and Callo del Grullo, north of Baffin Bay in Kleberg County; similar terrain extends north and east, including most of Nueces County, but north of Kleberg County the clay is practically all in cultivation and clay prairie could not be studied except at a few isolated points along railroads.

Table V lists the 10 perennial species found in more than three of the 34 stands of clay prairie, showing presence and coverage.

SUMMARY

The area is the extreme southern part of the Gulf coastal plain of Texas coastward from the Goliad cuesta. It lies in a warm temperate region with erratic rainfall averaging about 25 inches a year; it has only two or three frosts each winter, and occasional winters are free of frost. It is in general low and flat, rising from the coast westward to only about 525 feet in elevation over a distance of 85 to 90 miles. The eastern part of the entire area, near the coast, receives much salt borne inland by the prevalent onshore winds, either from spray picked up over the Gulf and Laguna Madre, or from dust picked up in the marginal tidal flats. A vast plain of fine sandy soil stretches from the coast to the western margin and slightly beyond, occupying most of the area. Stabilized and active sand dunes up to 30 feet high and interdune shallow sandy swales are the common geomorphs in large areas within this eolian plain. Other features are caliche-sand eolian ridges at the lee margins of wind-scoured caliche-bottomed cayos. The sand of the eolian plain is rarely more than 35 feet deep; beneath it is a hardpan (not everywhere indurated) which is calcareous, argillaceous, and locally saline with evaporational residues, and usually impervious, so that it supports perched ground water over large areas. The hardpan (or caliche) undulates gently, sloping coastward at about the

same average rate as the surface, but not paralleling that surface, being much deeper under sandhills than under swales. It is even exposed by wind scour in cayos. In the absence of streams water percolates down through the sand to the water table and drains slowly coastward, accumulating salts on the way. On both the north and south the sandy mantle of the eolian plain becomes thinner, the soil more loamy, and the dune topography less marked. These changes are gradual. Increasing clay fraction is noticeable in swales before it is in uplands. Baffin Bay and its arms, Cayo del Grullo and Alazan Bay, mark more abrupt changes in soil texture, and receive drainage from a number of creeks. Between Baffin Bay and Corpus Christi Bay, along the mainland shore of Laguna Madre, is a strip of loose white fine sand of dune topography. West of Alazan Bay and the Oso is a large plain of clay loam, almost unworked by wind, and steeply trenched by a few creeks. West of Cayo del Grullo the topography again is undulating and the soil sandy, creek valleys alternating with rolling sandy uplands showing some dune topography. At about the latitude of Baffin Bay this merges southward with the typical eolian plain, the sand becoming deeper and looser, and the creeks fewer. In Duval County, on the other hand, the soil is reddish sandy loam and only a little of it has been reworked.

The loamy area into which the eolian plain grades to the south is much less extensive than that to the north, and is virtually undrained by creeks. South of it are the floodplain and delta of Rio Grande, the soils of which are mostly poorly drained clays except on the higher and more loamy natural levees. Arroyo Colorado (the only natural erosional channel of any consequence south of Olmos Creek) is a natural floodway of Rio Grande trending northeast through Cameron County. The marginal clay flats of Laguna Madre and many other low lying clay flats on the deltas of Rio Grande and Arroyo Colorado, and at the margins and heads of bays farther north, have served as source flats of clay dunes, the larger of which rise as much as thirty feet above the flats and are the most conspicuous relief features of the coast.

Of the vegetation, in summary, it may be said that the upland climax formations in the study area are brush and liveoak scrub. Live-oak scrub is topo-edaphic climax on loose sand upland. Deep brush is probably climatic climax on upland soils of any texture except on loose sand already pre-empted by live-oak. In the past, evidently because of repeated burning which favored the existence of dense prairie, these climax formations were not nearly as extensive as they are now. Herds of horses and cattle depleted the fire climax

to such an extent that it no longer supported extensive fires. In the absence of fire, live oak and brush have been, and probably still are, spreading at the expense of the grazed prairie. The depletion of the dense grass cover also reduced competition on the part of prairie species, thus increasing the chances of survival of the invading woody seedlings. The means of dispersal of the seeds of mesquite, a pioneer brush species, in the droppings of horses and cattle, also has made for rapid brush spread.

Brush and live oak scrub are upland climaxes. In low ground, near the coast and in swales and other low areas inland, species of these two formations do not invade, even in the absence of fire. Several different herbaceous communities occupy the ground unfavorable to brush and live oak scrub. The communities occupy zones at fairly definite elevations on the slopes of swales, and on the ground sloping to the coast. The zone occupied by any one of the herbaceous communities is not necessarily at exactly the same elevation either on different slopes or on different profiles of the same slope. But the sequence of communities has fundamental similarities on all slopes.

At strandline occurs the *Batis-Salicornia-Suaeda* community.

Above strandline and juxtaposed to the *Batis-Salicornia-suaeda* community on the inland side is the *Borrichia-Batis-*

Monanthochloe community; a similar community not in contact with strandline also occupies swales inland. It is never in contact with any other community on ground lower than itself except at strandline.

A *Spartina spartinae* community occurs on ground just above and juxtaposed to that occupied by *Borrichia-Batis-Monanthochloe* community. It also occupies many inland swales where it is not directly in contact with *Borrichia-Batis-Monanthochloe* community.

The vegetation of the next highest zone, above the *Spartina spartinae* community, is not the same on all slopes. On clay soil it can be clay prairie but is more frequently brush; on loose sand the upland vegetation above the *Spartina spartinae* community is frequently (or everywhere near the coast) loose sand prairie, but infrequently is deep brush. On loose sand, above the more or less brushy prairie, occurs live oak scrub. Live oak scrub is never in contact with *Spartina spartinae* community.

All the zones tend to have definite lower boundaries. Grazing disturbance results in a decrease in the definition of the zonation. This decrease is the result of weedy invasion of higher zones by species of lower zones. Rarely the movement is toward lower ground.

The zonation pattern can be explained on the basis of salinity tolerances of the species, and can be related to the salinity of both the soil and the subsoil. In general, as the elevation decreases, the salinity of the soil increases; yet degree of salinity is not correlative over the whole area with elevation above sea level, but is apparently closely correlative with depth of the alkaline saline water table. This water table in places well inland is high enough above sea level to favor a *Borrichia-Batis-Monanthochloe* community in swales at elevations greater than those at which live oak or brush species occur on uplands nearer the coast. But the sequence of communities on any one slope is always the same.

Relating the climaxes to geomorphology and soils, it may be said that the most extensive formation in the area is brush, which covers most of the sandy eolian plain and most of the areas of loam to the north and south of it, as well as the caliche and gravel hills to the west of it. Brush covers all distributary ridges and clay dunes. Live oak scrub covers a large area of upland loose sand in the eolian plain. A small area of upland clay loam and a more extensive area of sandy soil is occupied by prairie. Of these prairie areas it may be said that virtually all are severely overgrazed, and some are still being replaced by

brush or by live oak scrub. But near the coast and in a few swales, the upland prairie persists except in low areas sufficiently saline to be dominated by Spartina spartinae. A Spartina spartinae community also occupies large low clay flats of the delta of Rio Grande. Still lower saline areas of both sand and clay near the coast, and rarely inland, are occupied by a Borrichia-Batis-Monanthochloe community. The lowest and most saline ground, at strandline, is occupied by Batis-Salicornia-Suaeda community.

Small, well-watered (or formerly seasonally flooded) areas near Rio Grande and Nueces River are occupied by short timber.