PROPERTIES OF SALINE RANGE SOILS OF THE RIO GRANDE PLAIN

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Highlight

Range conditions on saline soils are poor as a result of overgrazing. Reseeding plans need to consider species and drought-inducing effects of excess salts. Soil properties suggest that proper vegetative cover would enhance salt removal.

Vast acreages of rangeland within the Rio Grande Plain region of south Texas are seriously affected by soil salinity. The area with the greatest percentage of salt-affected soils occurs primarily on the Nueces, Frio and Rio Grande River watersheds (Figure 1). The region's climate is characterized by mild winters, long hot summers and erratic rainfall. Vegetation shown in Figure 2 is typical of the affected soils. Spined woody species dominate the ecological system.

In the early development of the region the only permanent sources of water were the Rio Grande and the Nueces Rivers on the south and north, respectively. Ranges near these water sources were heavily grazed and deteriorated to bare ground and brush. Since the 1860's fence building, ponds, and windmills have distributed grazing over the entire region. With the exception of isolated areas, the range has been overgrazed and reduced to low productivity.

FIGURE 1. Study area of saline rangelands in South Texas.

Historical data (Inglis, 1961) and well managed areas indicate that the climax vegetation was an open grassland with traces of low-growing woody vegetation. Large woody species were confined to overflow areas of the major streams. The effect of grazing pressure has been to reduce grasses and allow woody plants to increase. This effect is most pronounced on saline soils where the original grasses have almost disappeared and a woody

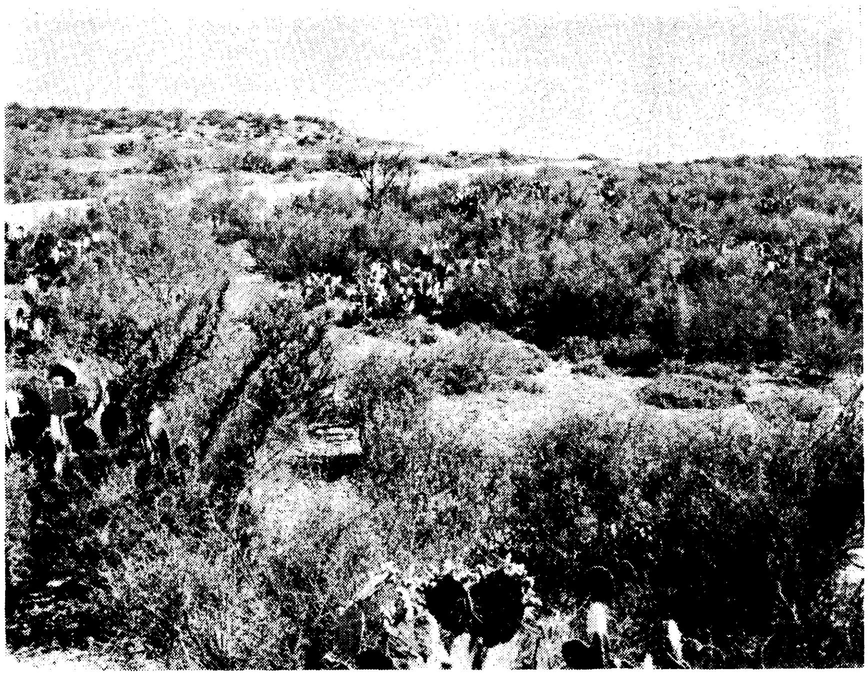

FIGURE 2. Maverick clay, saline phase.

plant aspect dominates the vegetative complex.

Ecological recovery on these soils is slow. Pastures deferred for 2 to 3 years often show little improvement. Recovery to the climax vegetation is delayed, particularly on the saline soils, because most of the more desirable salt-tolerant climax species have disappeared. Reduced range production has forced ranchers into brush control programs that include reseeding with introduced grasses as well as allowing for natural grass recovery. Consistent seeding failures on saline affected areas have pointed out the need for technical information about the properties of these soils.

Information about the chemical and physical properties of saline rangeland soils that occur in the region is meager and, for many of the properties, nonexistent. The saline soils are confined to three series: The Maverick, Montell, and Monteola. This study is an evaluation of properties common to these three soils and provides basic chemical and physical data for consideration in obtaining solutions to problems related to their ecology and management.

Procedures

Three locations representative of the morphological and ecological character of the saline phases of these soils were selected, and the soil profile sampled by horizons for laboratory analysis. The bulk density, necessary for determining the amount of water soil will hold, was measured using a volumetric sampler and the water intake rate at each sampling site was determined using double-ringed infiltrometers.

Analyses of the soil samples were made using procedures established by the U. S. Salinity Laboratory staff (1954). Extracts were obtained from a saturated paste and the samples analyzed for EC_e (electrical conductivity of the saturated soil extract) and water soluble ion composition. Other determinations were particle size distribution, plant available moisture retention, and percent sodium saturation of the soil ion exchange system.

In addition to analytical data, evaluations of current range grazing practices and their effects on vegetation have been made at numerous locations on both saline and nonsaline soils for a period of years.

Results and Discussion

The three soil series studied occur in nearly level to gently undulating landscapes comprised of low ridges and broad valleys. All three series are clay-textured calcareous soils. The Maverick soils (Figure 2) are shallow to moderately deep Regosols that occur on side slopes and convex ridges. The Monteola soils are dark gray Grumusols occurring on gently sloping areas. The Montell soils are similar to the Monteola but occur on nearly level areas or valley floors. Affected areas are variable in size from a few feet across to areas of several hundred acres.

Pertinent morphological characteristics of these soils are shown in Figure 3. The depth of the A horizon is a relative measure of the degree of maturity and reflects the effect of topography and parent materials on profile development. Each of the soils has visible salt accumulations as threadlike deposits or soft concretions at a relatively shallow depth and secondary gypsum accumulations deeper in the profile. Surface cracking with drying is a distinctive feature of all three soils. Cracks 2 to 3 inches wide that taper with depth but extend 2 to 3 feet into the profile are common.

Present vegetative cover on the soils is similar. In the example (Figure 2), woody plants are dominant. Species and composition vary considerably because of management and to a lesser extent because of topography. The following vegetative composition is typical and is based on observations made at the soil sampling sites.

Woody Plants	*Composition* %
Texas varilla *(Varilla texana)*	10
Pricklypear *(Opuntia lindheimeri)*	10
Mesquite *(Prosopis juliflora)*	5
Lote *(Condalia obtusifolia)*	5
Allthorn castela *(Castela texana)*	5
Blackbrush acacia *(Acacia rigidula)*	*trace*
Total	35
Grasses	
Curly mesquite *(Hilaria belangeri)*	40
Whorled dropseed *(Sporobolus pyramidatus)*	10
Red grama *(Bouteloua trifidi)*	5
Threeawn *(Aristida sp.)*	5
Total	65

The forage value and total production from these species is low. It is apparent in examining better managed sites that a potential for greater production exists. Reconstructions from narrative descriptions of the vegetation by members of expeditions in the country from 1820 to 1850 (Inglis, 1961) and observations at numerous affected sites indicate that the climax vegetation consisted primarily of grasses, all more palatable and higher forage producers than the present dominant species. The list of climax species includes alkali sacaton *(Sporobolus airoides)*, twoflower trichloris *(Trichloris crinita)*, Arizona cottontop *(Trichachne californica)*, lovegrass tridens *(Tridens eragrostoides)*, and white tridens *(Tridens albescens)*. All these species have been found as isolated plants on salt affected soils and better managed sites may contain one or more species in substantial quantities. Unfortunately no true relic area exists where quantitative data of their composition in a climax system can be obtained. Increaser grasses in the ecosystem have been curlymesquite, pink pappusgrass *(Pappophorum bicolor)*, tobosa *(Hilaria mutica)*, Texas bristlegrass *(Setaria texana)*, forbs, and woody plants.

A common management practice in the area to increase range production is to upgrade the present vegetative species through deferred grazing. Although the practice is effective on nonsaline rangeland, it hasn't been successful on salt affected soils because of the absence of desirable grass species. A procedure which has rapidly gained favor in the Rio Grande Plain is complete revegetation through brush

Depth Inches	Maverick	Montell	Monteola
	A Horizon Grayish brown clay strongly calcareous, blocky structure, few waterworn gravels.	A Horizon Dark gray, grading to gray clay, strongly calcareous, blocky structure.	A Horizon Dark gray clay, strongly calcareous, blocky structures, few waterworn gravels.
10	AC Horizon Light yellowish brown clay, strongly calcareous, blocky structure.		
20	C Horizon Light yellowish brown grading to brownish yellow clay, strongly calcareous, blocky structure, many salt threads.	ACsa Horizon Grayish brown grading to pale brown clay strongly calcareous, blocky structure, many slickensides, few salt threads.	AC Horizon Light brownish gray clay, strongly calcareous, blocky structures, few slickensides, few salt threads
30			
40		Csa Horizon Pale brown clay, strongly calcareous, blocky structure, many slickensides, about 10% by volume is composed of salt pockets and threads	Csa Horizon Very pale brown clay, strongly calcareous, blocky structure, distinct slickensides about 10% by volume is composed of salt pockets and gypsum crystals.
50	The lower portion of the horizon contains marine shell fragments and many gypsum crystals.		
60		C Horizon Light yellowish brown clay, strongly calcareous, blocky structure, gypsum crystals.	C Pale yellow shaley clay, many pockets of gypsum crystals.
70	C Olive yellow shaley clay, massive.	IIC Light gray soft weakly calcareous sandstone.	
80			

FIGURE 3. Selected profile descriptions of typical saline Maverick, Montell, and Monteola soils.

control by rootplowing and reseeding to high producing forage grasses. On nonsaline soils where grass establishment is successful, results are phenomenal. However, on sites where reseeding fails, or is not properly managed after establishment, pricklypear spreads rapidly, resulting in a range condition as undesirable as the original brush cover.

On saline soils reseeding attempts have been discouraging. The grass species and seeding techniques used have failed to establish stands. Several factors, however, give encouragement for revegetation success and increased forage production on these soils. The surface horizon is relatively salt free and has in the past supported more palatable species and greater plant density than the present sparse cover. However, because salts confine rooting depths, the amount of soil depth available for moisture storage is limited and the soils tend to be droughty. The problems of grass establishment on shallow droughty soils are universal. Successful establishment is primarily dependent on timely rainfall. In these respects, the soils studied differ little from other droughty soils. The net effect of salinity in these soils is to increase droughtiness in an area where it is already a serious management problem.

Analysis of soil extracts indicate the excess salts present in these soils to be primarily the chloride salts of sodium, calcium and magnesium. Soluble sulfates are present but are relatively minor contributors to the total salt concentrations. The EC_e values in Table 1 relate salt concentrations in the soil to the effects on plant growth. Commonly used guides proposed by the United States Salinity Laboratory staff (1954) are: salt concentrations greater than 4.0 mmhos/cm limits production of most forage crops; above 8.0 mmhos/cm, only moderately salt-tolerant species grow well; and above 12.0 mmhos/cm, only the most salt-tolerant species survive. The climax species which formerly occupied these soils include almost a complete spectrum of plants which range from species with low salt tolerance to alkali sacaton which is one of the more tolerant native forage plants.

The sodium saturation value indicates a possible complication when reseeding is considered. Soils which are intensively cultivated and have a saturation value above 15% have been found to be difficult to manage. They tend to puddle easily when wet and form severe crusts with drying. In soils such as these where the only disturbance is the reseeding operation, the problem may not develop. Crust formation, however, would be detrimental to grass seedling establishment.

The soluble salts in these soils could be removed if a supply of water for leaching were available. However, the only water available is rainfall that usually comes in high-intensity short-duration thunderstorms, a portion of which becomes runoff. Rain water moving through the soils, however, does carry soluble salts to the depth of penetration. Conversely, as the

Table 1. Analysis of a typical profile of saline Maverick, Montell, and Monteola soils.

Depth	EC_e	Sodium Saturation
Inches	mmhos/cm	Percent
	Maverick clay	
0-10	4.8	29.9
10-21	13.2	47.1
21-38	15.2	63.0
37-53	14.9	61.0
53-68	13.7	47.6
68-76	13.2	51.7
	Montell clay	
0-9	7.0	25.8
9-17	16.2	30.5
17-26	20.2	32.4
26-35	20.2	40.6
35-47	20.5	35.0
47-63	19.2	35.9
63-74	18.5	28.8
74-80	17.8	43.7
	Monteola clay	
0-10	.8	8.5
10-24	4.5	25.8
24-32	18.2	30.5
32-47	24.2	54.4
47-66	24.0	51.6
66-85	22.0	38.0
85-90	20.2	39.7

water returns to the surface in the drying cycle the salts are moved upward. With barren soils the salts are left in the soil surface as the water evaporates. Under a plant cover where roots are actively extracting water the salts are deposited in the soil at the point of the root contact. With a static salt supply and variable rainfall an equilibrium is reached between the upward and downward movement of salt. The depth of salt-free horizons in Figure 3 is an indication of this equilibrium system as it is modified by topography and runoff differences among the three soils. A heavy plant cover to reduce surface runoff and evaporation to a minimum should, in time, shift the equilibrium to a deeper depth. Conversely, the reduction in plant cover that has occurred with improper range management may have brought the equilibrium depth nearer the surface.

The equilibrium depth, or the depth of the salt-free surface soil, would be expected to be greater in those soils with low water-storage capacities. However, the depth to which a limited rainfall increment will penetrate and carry salts is not great because of the high storage capacities. The depth of wetting values (Table 2) calculated for a condition when ½ of the storage capacity is depleted indicates what can be expected under optimum conditions when no rain water is lost through runoff.

Rainfall runoff rates were not measured, but based on observations of surface drainage patterns and limited surface protection at the locations sampled, it is concluded that extensive runoff occurs. Runoff is modified by a number of variables, including surface protection, but it is primarily dependent on soil intake rates and rainfall intensities. The intake rate of a dry soil while cracks are being filled may be several times greater than the residual rate at saturated conditions. With the thunderstorms that are typical of the region, initial intake rates have more interpretative value than residual rates at saturated conditions. Intake rates did not vary appreciably among the three soils. At the sites sampled initial rates of 3.5 to 6.0 inches per hour were measured, but after 20 minutes the rates dropped rapidly to about 1 inch per hour and then gradually receded to a residual rate of about 0.5 inch per hour. With ample surface protection to control runoff, the initial intake rates measured are adequate to accommodate all of the rainfall from most of the thunderstorms which occur.

Table 2. Bulk density, available moisture storage capacity, and depth of soil wetted by a 2-inch rain for typical saline Maverick, Montell, and Monteola soils.

Depth	Bulk Density	Moisture Retention ⅓ Atm. Pressure	Moisture Retention 15 Atm. Pressure	Available Moisture Storage Capacity	Soil Depth Wetted by a 2-inch rain[1]
(Inches)	(g/cm)	(Percent)	(Percent)	(Inches)	(Inches)
Maverick clay					
0-10	1.22	33.9	19.0	1.6	
10-21	1.35	43.1	20.8	1.8	22.0
21-38	1.54	39.3	21.6	4.6	
38-53	1.40	43.3	24.5	2.6	
Montell clay					
0-9	1.22	31.5	19.7	1.3	
9-17	1.49	34.2	17.5	2.0	19.5
17-26	1.53	38.0	21.6	2.4	
26-35	1.36	36.6	21.3	1.9	
35-47	1.38	34.2	20.4	2.3	
Monteola clay					
0-10	1.38	41.4	24.2	2.4	
10-24	1.34	41.4	29.6	2.2	20.0
24-32	1.44	44.1	27.9	1.9	
32-47	1.48	42.7	26.5	3.8	

[1] Depth to which the soil would be wetted by a 2-inch rain if the soil contained ½ of the available moisture capacity.

The plant-available moisture-storage capacity values by depth increments (Table 2) are misleading and should be interpreted with consideration given to the EC_e values shown in Table 1. The water storage capacity is high, a desirable condition for plant growth, but root activity in the saline horizons is reduced because of high salt concentrations. Although roots may extend into the more saline subhorizons, osmotic effects and specific ion toxicities limit their growth and consequently the amount of water they can extract. Therefore, the plants growing on the sites must rely on moisture stored in the horizons above soluble salts. Plant species that subsist on these soils today are relatively salt tolerant and have an extensive shallow root system. Also, the combined effects of drought and improper range management have reduced the species present to those that are of relative low forage value. The water stored in these soils would be better utilized if the grass species covering them were high forage-value salt-tolerant species.

Summary

Range conditions on the saline soils of the Rio Grande Plain are poor as a result of over-grazing. The present sparse vegetative cover of short grasses and woody plants are of low forage value. The climax species remnants are sparse or have disappeared completely. Reseeding efforts will need to take into consideration proper species selections and drought-inducing effects of the excess salts.

The dominant salt in these soils is sodium chloride. The soil physical properties common to the three salt-affected areas suggests that proper vegetative cover would enhance salt removal and subsequently increased rooting depth and forage production.

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