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Effect of Water--Retaining and Water--Spreading Structures in Revegetating Semidesert Range Land

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Much of the range land of the semidesert type needs revegetation. It is among the most severely depleted types of the entire West, according to McArdle, et al. (7). Throughout the upper Rio Grande watershed in New Mexico, where a large part of the range land is semidesert, Cooperrider and Hendricks (4) found depletion of plant cover and destructive erosion widespread and severe.

Revegetation of these semidesert areas, either by natural or artificial means, is slow and difficult because rainfall is scanty and soil moisture low. Moreover, the sloping semidesert ranges, where the need for the moisture is greatest, do not benefit from the rain which falls during the growing season because it is torrential and much of the water runs off. Sparse vegetation cover, scarcity of litter, and low permeability of barren compacted soil serve to increase the loss of water through runoff.

These facts have led to the viewpoint that revegetation of depleted sites on sloping topography would be greatly aided if some of the rain falling on such sites could be held on them by artificial structures and if flood water from natural drainage ways could be diverted to them.

Review of Literature

A rather limited amount of experimental work in the field of water retention and water spreading on range lands has been reported. Very little has been done on semidesert ranges. Monson and Quesenberry (9) working with flood water irrigation of range land in Montana have shown benefits through grazing capacity increase of 50 percent and elimination of the need for feeding supplemental hay. Barnes and Nelson (1) in Wyoming found that construction of closely spaced contours and rowed "pits" or basins increased the grazing capacity 11 percent and gains of lambs 6 pounds per acre. Greater volume of perennial grasses remained after the grazing season on the treated pastures than on the untreated. This was on well vegetated productive short grass range land. Hubbell and Gardner (6) report a four-fold increase in forage production from flooding alluvial wash bottoms in a year of light flooding and a nine-fold increase in a year of heavy flooding. They report that the percentage of cover decreased because of the sedimentation brought about by the flooding, but they further indicate that percentage of cover increased after initial loss. Beutner (2) reports that a series of earthen diversion dams and brush and wire spreaders were effective in taking water from gully bottoms dissecting a broad alluvial flat and spreading it on the flat, where it brought about increased growth of valuable range grasses. Semple and Allred (10), reporting on the effects of water spreading in southeastern Colorado, state that this work was effective in checking enlargement of the main drainage channels and in producing abundant yields of forage on the lands receiving the diverted flood waters. Miles (8), reporting on flood water spreader structures in Quay County, New Mexico, states that these structures have been effective in diverting flood water to range land and resulted in increased forage production. This increase also was obtained on well vegetated grassland. Caird and McCorkle (3), working on the southern Great Plains, found that contour structures of various kinds aid in the recovery of depleted ranges, but do not continue to show advantages after a period of a few years.

Description of the Experimental Area

Location: Beginning in 1935, experimental work was undertaken on the New Mexico Agricultural Experiment Station ranch to determine the value of several types of water-spreading structures on the revegetation of depleted semidesert range land. The ranch is in Dona Ana County and lies partly on the Jornada Plain, partly on the Rio Grande Valley west of the plain and partly in the Dona Ana Mountains between the plain and valley. The elevation of the main part of the plain occupied by the ranch is shown by United States Geological Survey Maps (11) to be from 4300 feet to 4500 feet. The highest peak in the Dona Ana Mountains is about 5800 feet and the river valley west of the ranch is about 4000 feet in elevation.

Climate: The climate of the experimental ranch is semidesert. Climatic records for the Jornada Experimental Range headquarters, lying on the Jornada Plain about seven miles northeast from the ranch headquarters, show the average annual precipitation for the period 1914-1945 to be 9.44 inches (5) (12). Years of rainfall above and below average are not infrequent and departures from average, especially positive departures, are often great. Rainfall during the months of July, August and September generally accounts for a little more than 50 percent of the annual total precipitation, according to the Jornada record. Most of the annual growth of vegetation on the range is made during these months. The late spring and early summer months of April, May and June are normally quite dry and account for only 14 percent of the total rainfall. Little growth of vegetation is made during this period. Much of the rainfall coming in the summer growing season is characteristically of a torrential nature and produces considerable runoff from compact soils or sloping topography. Recorded temperatures are moderate. Summer temperatures generally reach 100° F. and in some years go as high as 105° F. Winter minimum temperatures occasionally go as low as 0° F. but these instances are uncommon.

Soil: The soil of that part of the ranch lying on the plain is largely a light sandy loam. At depths of from 8 inches to 3 feet or more, much of this soil is underlaid by a dense layer of caliche. A very restricted area of the plain is subject to intermittent flooding from surrounding areas and in consequence is occupied by a heavier soil containing much clay. The higher part of the plain, the foothills of the mountains and many parts of the river drainage are occupied by sandy loam containing coarse sand and gravel. Extensive areas on the river drainage are occupied by deep, loose, coarse, sandy loam.

Vegetation: The vegetation on the ranch consists mainly of three types: black grama (Bouteloua eriopoda) grassland, creosote bush (Larrea divaricata), and mesquite (Prosopis juliflora var. glandulosa) shrub types. Lesser areas of tobosa grass (Hilaria mutica), burrograss (Scleropogon brevifolius), snakeweed (Gutierrezia sarothrae), sotol (Dasylirion wheeleri), and Mormon tea (Ephedra trifurca) occur on the ranch. The black grama grassland occupies the nearly level sandy areas of the plain. The slightly elevated and sloping borders of the plain along its western and southwestern edge are occupied by the mesquite type, commonly called the mesquite sand hill or mesquite sand dune type. The creosote bush occupies the rougher, rockier parts of the ranch on the footslopes of the Dona Ana Mountains and on rough rocky hills in the river drainage.

Experimental Installations and Results

The following types of structures were used in the study:

Contour terraces

These were constructed in 1935 on a broad, open, north-facing slope at the foot of one of the main peaks in the Dona Ana Mountains. This slope is of a more or less uniform grade of about 3 to 5 percent and is unmarked by prominent drainage ways. Soil on this site is a compact gravelly clay loam underlaid by a heavier compact clay loam and in places by caliche at depths of 20 to 36 inches. At the upper end of the slope the surface is more gravelly and pervious than at the foot.

The vegetation on this slope consists of three subtypes: A fringe of black grama grassland about a quarter mile wide covers the top of the slope; a mixed type of Mormon tea and grass is at the foot of the slope; and a tongue-shaped creosote bush type almost entirely separates the black grama from the Mormon tea and grass. Although some grass grows in the lower-most subtype, it is for the most part a sparse stand of fluffgrass (Triodia pulchella), a short-lived perennial of low value in stabilizing the soil or in forming a permanent plant cover.

The terraces, made with a road grader, are about 8 feet across at the base and 16 to 20 inches high. All material used in construction was taken from the upper side of each terrace, leaving a broad shallow borrow pit 6 to 8 feet wide. The horizontal interval between contours varied from about 100 feet to 300 feet, the closer interval being used at the top of the slope where the grade is steeper than at the foot. In all, 21 such terraces, covering an area of about 210 acres, were constructed. As first constructed, the terraces were continuous without cross checks and without overflow outlets. Later when numerous breaks occurred because of lack of outlets, rock "weeps" were built at intervals along the terraces to allow water to percolate through without damaging them.

After construction, some of the terraces were seeded to various native and cultivated plants. One of these terraces which had no seeding above it is shown in figure 1. No livestock have grazed the terraced area in the eleven years since the terraces were constructed.

A series of eleven chart quadrats was established on the area—six in the bottoms of the basins above the terraces, which were completely barren, and five on the intervening undisturbed areas between terraces.

Rainfall on the terraced area during the eleven-year period, presented in table 1, was slightly above the long-time average for

Fig. 1.—View of a contour terrace (left foreground to middle background) showi volunteer stand of native grasses, mostly mesa dropseed and three-awns, in the ba above terrace (left) and sparsely vegetated, little-improved area below terrace (righ

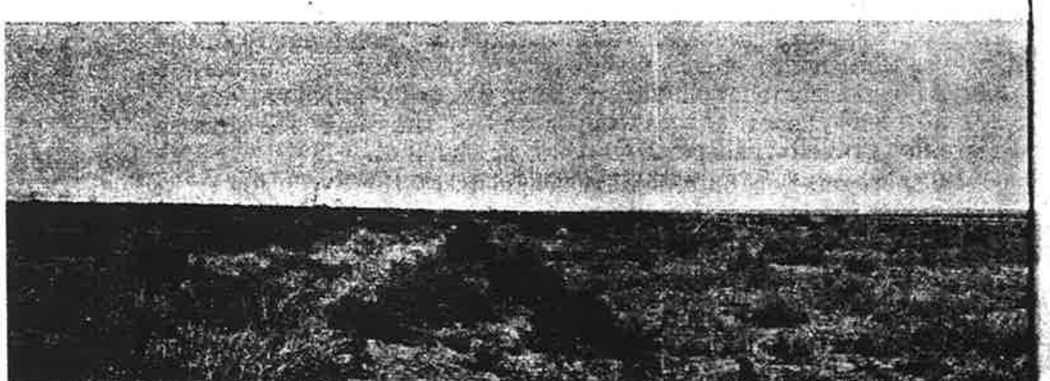


TABLE 1. PRECIPITATION ON TERRACED SLOPE, 1935 TO 1945

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Total[1]	Annual Total
						Month								
1935	.31	.35	.05	.15	.73	.21	1.53	2.21	1.57	0	1.10	.77	5.31	8.98
1936	1.10	.19	.07	.11	.65	.22	2.34	.46	1.21	.42	.96	.23	4.01	7.96
1937	0	.62	.47	0	.81	.96	.27	.35	1.65	1.10	0	.24	2.27	6.47
1938	.58	.57	.20	0	0	.86	2.94	.14	3.59	.15	.09	.95	6.67	10.07
1939	1.22	.01	.27	.18	0	.14	3.24	1.58	1.99	.49	.65	.75	6.81	10.52
1940	.02	.98	.01	.15	.76	1.79	3.27	.81	2.38	.88	.63	.48	6.46	12.16
1941	2.05	.61	1.02	1.10	.85	.98	.96	2.36	4.99	1.47	.06	.76	8.31	17.29
1942	.24	.35	0	1.18	0	2.25	1.02	3.52	1.25	.73	0	.88	5.79	11.42
1943	.26	0	.11	.04	.46	2.18	1.93	.43	1.01	0	1.13	1.01	3.37	8.56
1944	.46	1.05	.10	0	.49	.02	3.00	1.13	1.13	1.29	1.22	.69	5.31	10.63
1945	.34	.05	.04	0	0	.04	1.52	.53	.46	2.37	0	0	2.51	5.35
Average	.60	.43	.21	.27	.43	.88	2.00	1.23	1.93	.81	.53	.61	5.17	9.95

1. Seasonal rainfall is that occurring in July, August and September.

TABLE 2. AREA OF VEGETATION ON TERRACED SLOPE, 1937 to 1945

Tuft area of perennial grasses one inch above the soil surface and crown spread of shrubs, in square centimeters on square meter quadrats.

Quadrats on terraces	Year 1937	1938	1939	1940	1941	1942	1945
Quadrat 20							
Fluffgrass	52	122	47	0	12	0	0
Bush muhly	0	0	0	0	2	4	0
Total grasses	52	122	47	0	14	4	0
Snakeweed	525	217	4073	6693	4301	3178	0
Quadrat 21							
Fluffgrass	66	92	57	35	9	0	0
Snakeweed	1126	3738	4963	8400	7857	4842	21
Quadrat 22							
Fluffgrass	134	427	532	457	231	46	19
Snakeweed	0	32	202	1150	4585	6931	181
Quadrat 24							
Fluffgrass	186	370	142	170	83	44	0
Snakeweed	77	194	146	1536	5231	2643	0
Quadrat 28							
Fluffgrass	0	68	145	219	31	7	0
Snakeweed	485	1121	1886	3692	5589	5199	0
Quadrat 29							
Fluffgrass	65	257	110	55	124	35	0
Sand dropseed	0	0	2	4	0	0	0
Total grasses	65	257	112	59	124	35	0
Snakeweed	0	49	406	654	1549	2334	0
Creosote bush	0	0	10	85	341	0	0
Total shrubs	0	49	416	739	1890	2334	0
Quadrats between terraces							
Quadrat 23[1]							
Fluffgrass	0	0	70	246	8	7	—
Snakeweed	0	0	0	4	584	2417	—
Quadrat 25							
Fluffgrass	88	16	132	279	26	25	2
Snakeweed	0	0	0	0	38	580	81
Quadrat 26							
Fluffgrass	0	12	56	218	497	432	16
Mesquite	79	33	173	53	115	93	181
Quadrat 27							
Fluffgrass	246	63	210	546	581	182	6
Quadrat 30							
Fluffgrass	295	172	317	647	784	571	0
Sand dropseed	5	16	21	27	38	34	15
Black grama	28	44	45	47	61	77	41
Total grasses	328	232	383	721	883	682	56
Snakeweed	43	0	0	0	48	513	0

1. Quadrat 23 destroyed in 1944.

the Jornada Plain as observed at the Jornada Experimental Range headquarters. While there were two years of low rainfall, the period as a whole was definitely good in this respect. No records were kept on flood flows down the terraced slope but many flows have come down the slope since construction of the terraces and afforded water for flooding the terrace borrow pits. Some sedimentation above the terraces has occurred. This has varied from a fraction of an inch in some instances to 5 or 6 inches in others. This sedimentation is not considered to have been damaging since the better adapted grasses have persisted well under the degree of sedimentation existing.

Data obtained from the chart quadrats established in connection with the contour terraces are presented in table 2. The most pronounced change that took place was the great temporary increase in snakeweed on the quadrats immediately above the terraces. Snakeweed also exhibited a lesser increase on certain of the quadrats between terraces and this, too, showed a decline by the end of the period of observation. Fluffgrass increased about as much on both sets of quadrats but these increases were all offset by losses by the end of the observation period. These losses are not unlike those commonly observed on the range with respect to both these species. They are comparatively short-lived and areas supporting them often exhibit considerable fluctuations in cover if other species are not present to compensate for their loss by increased growth and spread. Black grama underwent a steady increase on the one quadrat between terraces on which it occurred. These black grama plants did not exhibit as high a degree of thrift, however, as black grama growing on better soil on the ranch under similar rainfall conditions.

Certain of the terraces were seeded to several range grasses. Those seeded to the grasses best adapted to the semidesert conditions exhibit good stands behind the terraces. The persistance of these stands affords reason to believe that had some of the longer-lived, well-adapted grasses become widely established above the terraces during the period of observation, the stand would now present a good condition instead of the poor condition which resulted from the loss of the snakeweed and fluffgrass that quickly occupied the terraces soon after their construction. While the terrace treatment has been effective in bringing about some improvement in amount and kind of vegetation cover, this has been of very limited extent. Little improvement that can be attributed to the terraces has taken place over the area in general.

Brush water spreaders

These structures were constructed in 1937 across a north and east facing slope of 2 to 4 percent extending from the foot of one of the main peaks of the Dona Ana Mountains to the Jornada Plain. The spreaders were made of brush gathered locally and were held down at about two-foot intervals by wire ties across the spreader. The knotted ends of the ties were driven into the ground 10 to 12 inches with a removable driving tool which had a notched end to carry the knotted end of the wire into the soil. The spreaders received water at stone dams across small gullies running down the slope and carried it across the slope at a grade generally not exceeding ½ percent. Some of the water passed through the spreader and down the slope all along its length.

Soil on the spreader area varies from place to place. Most of it is occupied by a surface layer, 6 to 10 inches deep, of sandy loam which contains much coarse sand and fine gravel. This is generally underlaid by a loose, incoherent coarse sandy loam, extending to a depth of 3 feet and more. One small part of the spreader area is occupied by a compact clay loam.

Vegetation on the area covered by the spreaders is varied. Part of the area is covered by a fairly good stand of black grama grass; part is covered by a good stand of black grama and tobosa grasses; part by a creosote bush type in which only a light stand of grass occurs; and part is covered by a very sparse stand of fluffgrass and annual grasses and forbs. A part of one of these spreaders constructed on this sparsely vegetated site is shown in figure 2.

The area covered by spreaders lies in two pastures, one of which has had no stocking for eleven years and the other of which is stocked lightly. Some of the spreaders were seeded by having the seed scattered in the brush after it was placed.

Ten chart quadrats were located in pairs along certain of the spreaders. One member of each pair was placed above the

Fig. 2.—View of brush spread[er] across a slo[pe] showing the ve[ry] sparse cover [of] the area and la[ck] of improveme[nt]

spreader where the effect of running or standing water did not extend and the other was placed a short distance below the spreader where it received the water which percolated through.

The spreaders were originally effective in carrying the water diverted from the gullies out across the slopes but after construction some of the dams in the arroyos became damaged by the flow of water and in later years did not deliver the full flow of the gullies to the spreaders; in fact, most of the small flows no longer go to the spreaders but pass through breaks and low parts of the dams.

Rainfall on the spreader area for the period 1940 to 1945 is presented in table 3. No gauge was operating on this site prior to 1940. However, the data for the terraced area, presented in table 2, are more or less representative of conditions on the spreader area. In fact, the spreader represented by quadrats 97 and 98 is closer to the terraced area gauge and is better represented by that gauge. The precipitation data indicate that the spreader area was favored by better-than-average rainfall for the locality. In 1945 precipitation during the growing season was low and little or no water was delivered to spreader areas.

Data collected from the water spreader quadrats are presented in table 4. These data for the most part reveal that no real difference developed between quadrats above and below the spreaders. Quadrats 107 and 108, established in a good mixed stand of tobosa grass, black grama and burrograss, exhibit a difference that is material. Some difference between these quadrats existed at the outset. This difference is not illustrative of a consistent similar difference all along this spreader, however, but pertains to the immediate area about these quadrats. Not infrequently the area above this spreader, not receiving flood water brought on the area by the spreader, exhibits the greater stand. In general it is impossible to identify any area either above or below the spreaders that have been benefited by them. This is true even of the area above the spreaders where the marks left by standing and running water give evidence that they were instrumental, at least occasionally, in bringing water to and holding it on these limited areas.

The very limited areas immediately adjacent to and within the spreaders did benefit somewhat in that they afforded places for seed of desirable grasses to lodge and germinate, and protection for the small plants in addition to the increased water. In places along the spreaders, desirable grasses have become abundantly established. Figure 3 taken near quadrats 80 and 81 illustrates the effect of a spreader in a light scattering stand of creosote bush and black grama grass eight years after construction of the spreader.

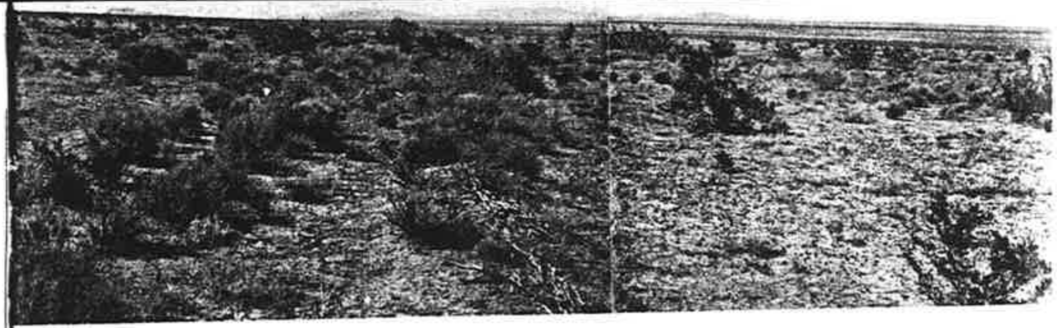
TABLE 3. PRECIPITATION ON BRUSH SPREADER AREA AND INTENSIVE CONTOUR AREA, 1940 TO 1945

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Total[1]	Annual Total
1940	—	.02	.01	.14	.62	1.85	2.98	.61	2.80	1.32	.75	.61	6.39	11.71
1941	2.00	.73	1.00	1.30	1.43	.65	1.79	2.37	5.87	1.76	.15	.90	10.03	19.95
1942	.18	.35	0	.95	0	2.24	.87	2.19	1.24	.88	0	.97	4.30	9.87
1943	.24	0	.16	0	.09	2.14	2.30	.43	1.10	.06	.99	1.37	3.83	8.88
1944	.56	.80	.04	0	.37	.15	2.21	1.35	1.14	1.38	1.47	.64	4.70	10.11
1945	.40	.05	.05	0	0	.05	2.18	.19	.31	2.18	0	0	2.68	5.41
Average	.56	.32	.21	.40	.42	1.18	2.06	1.19	2.08	1.26	.56	.75	5.32	10.99

1. Seasonal rainfall is that occurring in July, August and September.

TABLE 4. AREA OF VEGETATION ABOVE AND BELOW BRUSH WATER SPREADERS, 1937 TO 1945
Tuft area of perennial grasses one inch above the soil surface and crown spread of shrubs in square centimeters on square meter quadrats

Quadrats above brush spreaders	1938	1939	1940	1941	1942	1945	Quadrats below brush spreaders	1938	1939	1940	1941	1942	1945
Quadrat 80							Quadrat 81						
Black grama grass	47	74	103	63	47	53		46	35	50	36	42	22
Fluffgrass	9	191	412	145	89	0		71	159	347	341	174	0
Total	56	265	515	208	136	53		117	194	397	377	216	22
Quadrat 98							Quadrat 97						
Black grama grass	178	284	294	357	698	398		100	178	258	239	476	431
Fluffgrass	73	137	115	58	9	0		160	307	388	238	85	0
Total	251	421	409	415	707	398		260	485	646	477	561	431
Quadrat 107							Quadrat 106						
Black grama grass	34	137	119	130	192	30		33	108	134	146	264	150
Tobosa grass	66	98	107	85	172	26		64	143	138	134	170	101
Burrograss	74	154	204	107	122	8		77	116	77	91	137	57
Fluffgrass	1	52	177	172	46	0		61	242	346	269	147	0
Total	175	441	607	494	532	64		235	609	695	640	718	308
Quadrat 108							Quadrat 109						
Black grama grass	196	423	541	467	324	160		221	386	580	563	777	226
Fluffgrass	0	2	8	13	25	0		0	15	13	1	6	0
Total	196	425	549	480	349	160		221	401	593	564	783	226
Quadrat 112							Quadrat 111						
Fluffgrass	348	310	164	146	52	10		176	266	156	213	182	0



3.—View of a brush water spreader across a slope in a light cover of creosote bush black grama grass. No improvement in vegetation has followed construction of the ader.

Contour Channels

This type of structure consists of a flat bottomed trench about 6 inches deep and 24 to 30 inches wide, with the soil removed from the cut thrown up into ridges 6 to 8 inches high on the surface at each side of the trench. They were made with a road ripper which had a piece of steel fastened across the teeth. The channels were constructed on the contour at intervals of 25 to 75 feet on a slope varying from 2 to 3 percent. About 50 to 60 acres were treated with this type of structure in 1939.

The soil on this site is a loose sandy loam. Caliche appears near the surface in places and in hard cemented strata at depths of 30 inches or more in other places. Vegetation of the treated site consists chiefly of creosote bush, mesquite, and snakeweed, with some scattered patches of grasses, mostly mesa dropseed (Sporobolus flexuosus) and three-awns (Aristida spp.). Since the channels were constructed, no domestic livestock has been grazed in the pasture where they are located. No record of the vegetation on this site was made at the time of installation of the structures. A view of a part of one of the channels and of the site is shown in figure 4. Precipitation records from a nearby gauge are available for the treated area.

Rainfall data for this area are presented in table 5. Rainfall on the area has not been as good as on other parts of the ranch

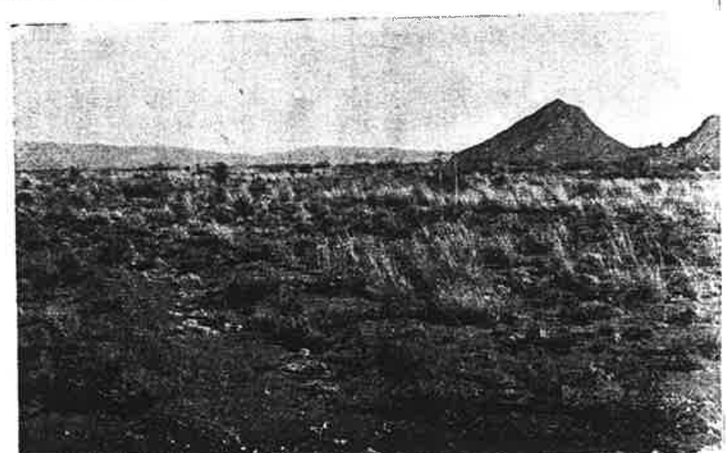


Fig. 4.—View of a contour structure. Vegetation such as appears in this picture also occurs off the treatment area and is therefore not considered to have resulted from concentration of the structure.

TABLE 5. PRECIPITATION ON CHANNELLED AREA, 1936 TO 1945

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Total[1]	Annual Total
1936	....	....	....	....	....	.13	2.41	.81	.66	.35	1.19	.09	3.88	5.64
1937	0	.71	.40	0	1.22	1.42	.22	.49	1.91	.95	0	.28	2.62	7.60
1938	.57	.46	.11	0	0	.80	4.32	.24	2.73	.05	.18	.93	7.29	10.39
1939	.98	.01	.67	.27	0	.28	1.07	1.85	1.44	.60	.38	.53	4.36	8.08
1940	.02	.91	.09	.28	.69	.70	1.41	1.24	1.72	.68	.77	.57	4.37	9.08
1941	2.05	.61	1.02	1.10	.84	.98	2.11	2.35	5.62	1.28	.19	.84	10.08	18.66
1942	.31	.37	0	.65	0	.10	1.52	3.13	1.53	.95	0	1.05	6.18	9.61
1943	.35	0	.18	0	.05	1.72	1.56	.40	1.36	0	.88	.97	3.32	7.47
1944	.38	.77	.01	0	.53	.21	1.63	.67	1.21	1.49	1.23	.65	3.51	8.78
1945	.21	.06	.08	0	0	.05	2.33	.86	.03	2.43	0	0	3.22	6.05
Average	.52	.44	.30	.27	.38	.59	1.86	1.20	1.82	.88	.48	.59	4.88	9.52[2]

1. Seasonal rainfall is that occurring in July, August and September.
2. Annual average computed from 9 year record.

during the period of study. The years 1943, 1944 and 1945 were especially dry. Despite the somewhat dry conditions revealed by the rainfall records, rainfall on the area has been sufficiently favorable to bring about improvement in plant cover where other factors have been favorable. This is evidenced by a marked improvement that has taken place within rodent and rabbit exclosures near the treated area during the period covered by the precipitation data. Certain restricted sites in the treatment area do present an improved condition in kind and amount of cover but similar improved sites are to be found off the treatment area. As a whole, the treated area is little if any different from the surrounding untreated area and it may be fairly concluded that the treatment has been ineffective in bringing about any improvement of the site. The sandy nature of the soil at this location has probably operated against the channels. Because the sandy soil possesses a high infiltration rate, runoff is not great and the channels do not receive much additional water.

Brush dams between mesquite dunes

These structures consisted of elongated piles of brush placed across the slope between mesquite-capped sand dunes. The brush piles were about 12 to 16 inches high and about 18 to 24 inches broad and were tied down by cross wire ties similar to those used on the brush water spreaders. Distance between these structures was about 10 to 30 feet. The slope is about 2 percent. An area of about 200 acres was treated by these brush dunes in 1937.

The soil on this site is a very loose sandy loam, much of it in uncompacted windblown drifts and held in place by low growing shrubby mesquite plants. Underlying the loose surface soil is a more compact sandy clay loam. In places this is exposed and presents a comparatively hard surface. Hard cemented caliche occurs in places at depths of 30 inches and more.

Vegetation on the site consists largely of mesquite with chamiza (Atriplex canescens) appearing in lesser amounts. The mesquite plants are embedded in the sand dunes which cover the area. The stems of each mesquite plant are many in number and project 12 to 24 inches above the dune surfaces. Little or no vegetation occupies the area between dunes on this site and as a consequence the erosive action of wind and water has full play upon the sandy soil.

The area covered by this type of structure lies in a pasture that has been stocked but grazing by livestock has been very light on the treated area. One of these structures and the type of cover in which they were installed are shown in figure 5. Detailed records of the condition of the vegetation cover were not made in connection with these plots. However, range survey

Fig. 5.—View of mesquit sand dune area showing brus "dams" constructed betwee dunes. This treatment wa not effective in bringing abou improvement of the area.

data for the area indicate that the vegetation density was very low before construction of the dams and consisted largely of mesquite with the interdunal areas almost barren. These structures have brought about only the slightest improvement and this is restricted entirely to the areas immediately beneath the brush dams. The interdunal areas remain as barren as at the outset of the work. The loose drifting soil at this site operates severely against the establishment and maintenance of the perennial grasses. Rodent and rabbit damage to the few grass plants that may appear is alone enough to prevent establishment and maintenance of these plants in the open interdunal areas.

Intensive contour structures

These structures installed in 1939 were of a more intensive nature than any described above and were constructed on a more limited scope, each type of structure being confined to a plot 330 feet square. The structures were all built on a gentle northeasterly facing slope which extends from the foot of the Dona Ana Mountains and averages 3½ percent. The plots in which the structures were made were laid out in two series—one open and one closed to rabbits. Both series were protected from domestic livestock.

According to surveys conducted by the Soil Conservation Service (13), soil to a depth of about 6 to 8 inches at the site of these structures is a dark brown sandy loam showing darkening by organic matter. Considerable coarse gritty material is present and carbonates are leached out of this surface layer. The subsoil to a depth of 24 inches is a light brown sandy loam containing much sharp grit. Calcium carbonate is abundant. The material is quite loose and incoherent. Below 24 inches the soil is coarse, loose sand containing much lime.

Vegetation on this site is a light stand of shrubs, grasses, and forbs. Soapweed (Yucca elata), creosote bush, snakeweed, and mesquite, make up most of the shrubs. The most common perennial grass is fluffgrass, and leatherweed (Croton corymbulosus), the most common forb.

The contour structures included in each series consisted of the following:

1. **Small single furrows.** These were made with a disc plow which threw the earth downhill. The furrow was about 6 inches deep and the ridge about 4 inches high. Horizontal interval between contours was from 4 to 6 feet.

2. **Medium double furrows.** These were made with the disc plow which passed twice in the same furrow and threw the earth downhill both times. The furrow was about 8 inches deep and the ridges about 6 inches high. Horizontal interval between contours was from 25 to 35 feet.

3. **Ridge contours.** These structures, consisting of two furrows and a ridge, were also made with the disc plow by throwing one ridge downhill and another ridge uphill onto the first from the second furrow. The furrows were 6 to 8 inches deep and the intervening single ridge about 8 inches high. These structures were made at horizontal intervals of 30 to 45 feet.

4. **Large ripper furrows.** These structures were made with a road ripper which had a broad flat blade welded across the teeth. This implement dug a broad flat bottomed furrow about 6 inches deep and 24 to 30 inches across and threw the earth up in ridges about 6 inches high at each side. Intervals between furrows were 10 to 12 feet.

5. In addition to the treatments, one plot in each group was left untreated. Sample plots 200 feet by 200 feet were laid out in each treatment plot and observations of perennial grasses, shrubs, and forbs were made on a set of belt transects in each sample plot.

A general view of the site on which these structures were installed is shown by figure 6.

A rain gauge was established in connection with the structures and a series of soil moisture sampling stations was established in connection with the group of structures within the rodent protection plot. Duplicate samples were taken of the 0-6 inch, 6-12 inch, and 12-24 inch levels at monthly intervals during the dormant season and at semi-monthly intervals during

Fig. 6.—General view of the site of the intensive contour structures. The small single contour furrow treatment plot of this series is

the growing season. In the spring of 1946 additional soil moisture sampling stations were established in connection with this phase of the experiment. One was located near the rodent exclosure on this site; another at a site on the ranch where reseeding experiments have been conducted on a deep sandy loam soil; and the third at a site in excellent black grama grassland. These stations were established to observe the retention of soil moisture from equal water applications at the three sites. A small area was enclosed by a low dike at each station and water added to a depth of 2 inches. Samples were taken at ten-day intervals at 0-6 inches, 6-12 inches, 12-24 inches, and 24-36 inches.

Rainfall data for the site on which these structures are located are presented in table 3. These data indicate that rainfall for the period of observation has been favorable for the growth of the native species. Rainfall on this site was slightly greater than the long-time average for this part of the Jornada Plain as recorded at the Jornada Experimental Range headquarters.

Data showing soil moisture percent for 1942, which was about average, are presented in figure 7. Values represent the average of duplicate samples, except in a few instances in which erratic values of one of the samples were excluded. It will be seen that there were no consistent advantages in soil moisture for any treatment. On July 1 all treatments showed a slight increase in soil moisture over the check in the 0-6 inch and 6 to 12 inch levels. At the same time all treatments exhibited less soil moisture than the check in the 12-24 inch level. Ten days later no material differences remained.

Vegetation on the plots exhibits a similar lack of response to the contour treatments, both under rabbit exclusion and where open to rabbits. A summary of the stand of perennial grasses on the plots is presented in table 6.

TABLE 6. STAND OF PERENNIAL GRASSES UNDER VARIOUS CONTOUR TREATMENTS

Measured on belt transects, 2 inches by 100 feet at ground level in square inches.

Contour structure treatment	Stand closed to rabbits	Stand open to rabbits
Small single furrows	1.09	0.78
Medium double furrows	1.40	2.66
Ridge contours	1.69	3.34
Large ripper furrows	0.92	1.93
Check, no treatment	1.58	0.98

Most of these differences are due to differences in fluffgrass which averages 75 percent of the cover on the 12 plots. As pointed out above, this grass does not form a stable cover

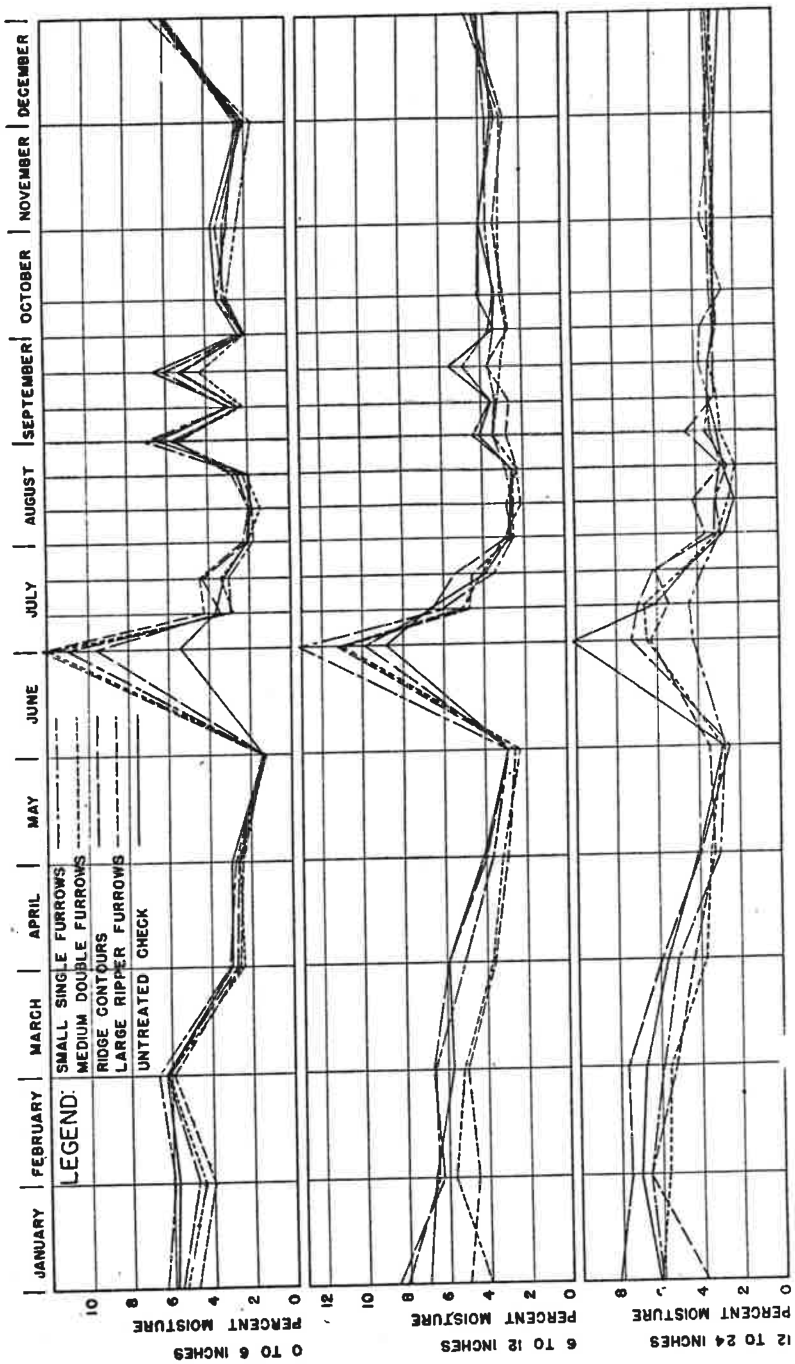


Fig. 7. Percentage of soil moisture in the intensive contour structure plots for 1946.

on these sites but fluctuates widely from time to time. Observations on the plot area and elsewhere on the general site reveal that this species has sustained a considerable death loss in some places over the past two or three years thus leaving sites all but devoid of any perennial grass cover. This characteristic of the grass serves to discount heavily any advantage that one plot may seem to show over another by virtue of abundance of the grass.

The lack of response of the perennial grass to the contour treatment is in accord with the soil moisture values observed for the various treatments. Failure of the plots to respond to the rabbit and rodent exclusion treatment is in marked contrast to the response obtained from protection against these animals at several other deteriorated sites on the ranch. At these sites protection against rabbits and rodents has brought about a pronounced improvement in the vegetation. Failure to obtain a like response at the site of the contour treatments indicates that rabbit and rodent damage is not the sole adverse factor on this site.

TABLE 7. PERCENT OF SOIL MOISTURE AVAILABLE AFTER TWO-INCH WATER APPLICATIONS ON SELECTED SITES.

Site	Soil type	Depth inches	Date watered	Percent soil moisture available Mar. 13	Mar. 23	Apr. 1	Apr. 22	May 2
Intensive	coarse	0-6	Mar. 11	2.8	0.5	0.0	0.0	0.0
contour	sandy	6-12		2.0	2.2	2.2	1.2	0.9
structures	loam	12-24		1.0	1.6	1.6	1.1	0.7
		24-36		0.0	0.0	0.0	0.0	0.0
Artificial	sandy	0-6	Mar. 16	....	1.5	1.0	0.0	0.0
reseeding	loam	6-12		....	3.2	3.9	3.0	2.0
site		12-24		....	3.7	3.4	3.0	2.8
		24-36		....	6.9	5.8	4.9	4.6
Excellent	sandy	0-6	Mar. 11	8.2	2.5	1.3	0.0	0.0
black grama	loam	6-12		10.6	7.0	5.8	6.5	6.7
grassland		(1)						

(1) A bed of hard caliche underlying this station prevents driving the sampling tube below 12 inches.

Data obtained from the stations at which equal water applications were made are presented in table 7. These data reveal that the soil at the site of the contour structures is deficient in its capacity to retain moisture over a period of time by comparison with other more productive soils on the ranch. Available water fifteen days after watering was considerably lower than at the other two stations and continued lower throughout the period of observation. No rain fell at any of the stations during the period of observation. The low water retaining property at the contour structures site is in conformity with the coarse texture of the underlying soil. These data reveal a serious deficiency in this site. Plants occurring on this area reflect the droughty nature of the soil through their appearance. The stand is sparse and almost no reproduction of the more desirable forbs and grasses takes place. The annuals are usually small and frequently die before fruiting or fruit only sparingly. Perennials exhibit appreciably less thrift and productivity than on the better soils on the ranch.

Summary and Conclusions

Five types of structures to check runoff water from semidesert range land were tested on the New Mexico Experiment Station's Experimental Ranch. These consisted of (1) widely spaced terraces; (2) small diversion dams with brush "hedges" placed to conduct the diversion water over depleted range land; (3) contour channels; (4) brush "dams" and (5) various smaller closely spaced contour earthen structures.

None of the types of structures used have been found to be effective in bringing about an improvement in vegetation cover on the sites where they were installed. Soil factors are thought to be chiefly responsible for the failure of these structures to bring about improvement. At some sites, the soil appears to be lacking in its capacity to retain sufficient moisture long enough to support establishment of seedlings and thrifty growth of older plants. At one site, the sandy nature of the soil prevents much runoff and consequently reduces the amount of water intercepted by the structure. At still another site, instability of the soil which is subject to severe wind, erosion and deposition operates against the effectiveness of the structures. Damage by rabbits and rodents has been partly responsible for retarding or preventing improvement on some sites.

Results obtained from this experiment indicate clearly that certain locations in semidesert range land are not susceptible to improvement through water retention and water spreading structures. The work also indicates that before extensive water spreading or water retaining works are constructed on any unproven site, an appraisal of the various factors should be made to determine whether certain factors operate critically against the success of the proposed structures. Pilot work on an exploratory scale is also indicated before extensive work is undertaken.

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