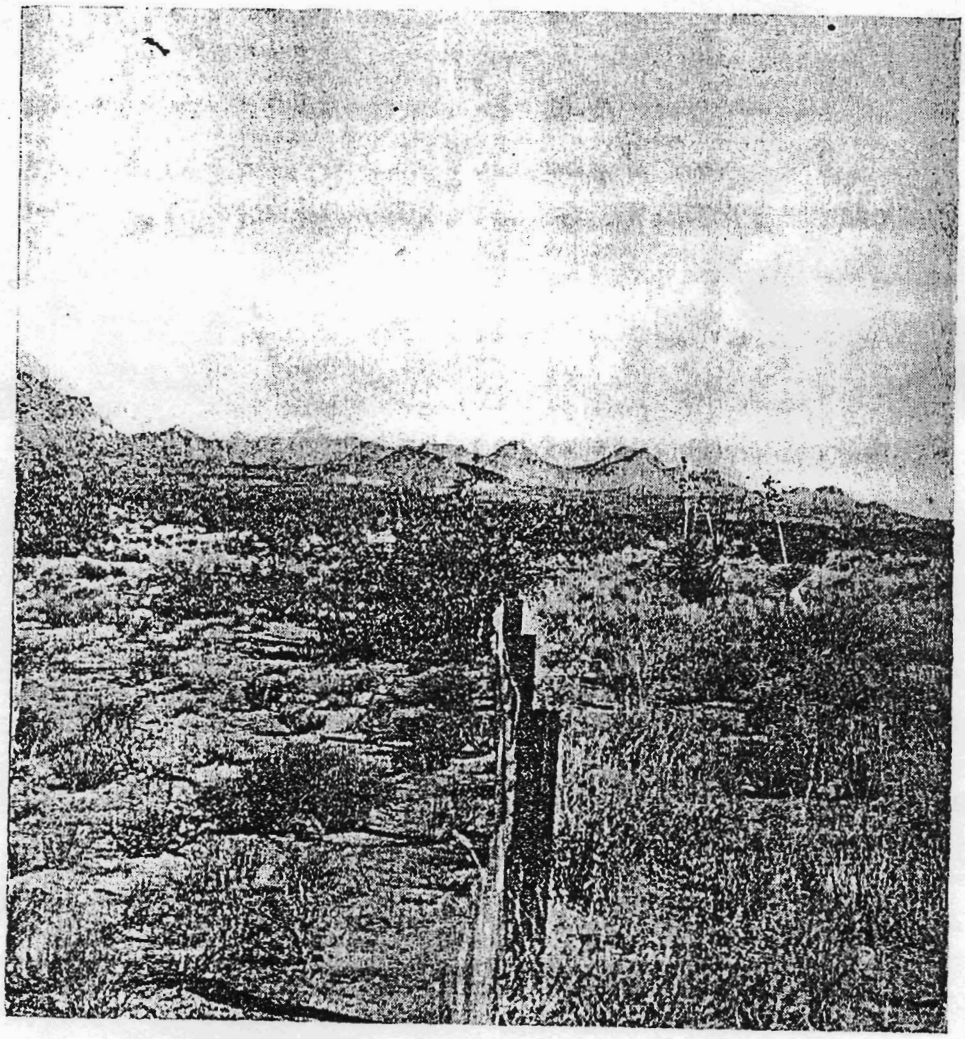
Bulletin 353 *January 1950*

Effect of Rodents, Rabbits, and Cattle on Two Vegetation Types in Semidesert Range Land

J. J. Norris



Agricultural Experiment Station
New Mexico College of Agriculture and Mechanic Arts

Summary

This bulletin reports results of an 8-year study on the effect of rodents, rabbits, and cattle on two vegetation types in semidesert grassland.

In mesquite-snakeweed types, rodents and rabbits alone exert sufficient grazing pressure to practically eliminate vegetation improvement. Exclusion of these animals can bring about striking improvement in the stand of valuable grasses. Production of perennial grass forage in this type can be increased 4 to 5 times by protection from rodents and rabbits together, and 1½ to 3½ times by protection from only rabbits. These increases amount to 300 pounds more grass forage per acre through protection from both rodents and rabbits, and 70 pounds more through protection from only rabbits.

These figures might lead one to believe that control of rodents and rabbits is worthwhile. Rodents and rabbits, however, normally inhabit deteriorated, brushy types, and control may extend as far as removal of brush, along with continuous poisoning or other measures. More information is needed on rodent and rabbit populations, methods of control, time required for residual populations to build up, and the rate at which these animals return to areas from which they have been completely removed. During this study, continual poisoning was necessary to maintain control even in supposedly rodent-proofed plots. Such continuous work is costly and soon overbalances any profit from increased forage production. It is believed that, in spite of the increased grass forage resulting from rodent and rabbit protection in mesquite-snakeweed types, the profits will not offset control costs.

In well preserved black grama grassland, no appreciable benefits result from rodent and rabbit protection. This is not surprising, since population studies indicate that rodents and rabbits are seldom numerous in well managed grassland.

About the Cover:

The area on the righthand side of the fence has been closed to rodents and rabbits since 1936. The condition on the lefthand side shows how these small animals can damage mesquite-snakeweed type of vegetation.

Effect of Rodents, Rabbits, and Cattle on Two Vegetation Types in Semidesert Range Land

J. J. NORRIS[1]

The relationship of rodents and rabbits to range conservation is controversial. Some think that rodents and rabbits are responsible for the deteriorated condition of ranges, and opinions extend all the way from that view to the opposing one, that an abundance of these animals is a result of overgrazing by domestic livestock. It has been recognized that rodents and rabbits retard the natural revegetation of severely depleted ranges. Furthermore, it is known that rodents, and particularly jack rabbits, have contributed largely to the failure of some artificial reseeding projects.

These facts have led to the belief that rodent and rabbit control is an important range conservation measure. However, such control is expensive and the benefits are of questionable value. It appears that rodent and rabbit control should be based on economic benefits which will accrue from the work. Such benefits can be determined only by a detailed analysis of conditions existing in the region in question.

This report is based on the results of a study conducted from 1939 to 1948 on the New Mexico Agricultural Experiment Station ranch to determine the effect of rodents and rabbits on semidesert range land in southern New Mexico.

Review of Literature

Much has been written about the relationship of rodents and rabbits to range vegetation; however, many of the references are expressions of opinions and comparatively few are the result of detailed investigation. The following is a review of some of the more important of these opinions and investigations.

As early as 1899, Smith (25)[2] was emphasizing the damage done by rodents to the range and urging the systematic extermination of prairie dogs. Since that time other writers (7, 13, 22) have stated that rodents, particularly prairie dogs, ground squirrels, and pocket gophers, contribute to the destruction of vegetation and induce erosion. Taylor and Loftfield (29) state that prairie dogs and cattle come into direct and, in times of

[1]Credit is due K. W. Parker, J. H. Knox, J. O. Bridges, and K. A. Valentine for planning and conducting the early part of the work, and to the Division of Grazing, United States Department of Interior, and Soil Conservation Service, United States Department of Agriculture for installing rodent plot fences and making initial rodent counts.

[2]Numbers in parentheses refer to Literature Cited on page 22.

drought, serious competition. They found that the Zuni prairie dog in certain areas could destroy as much as 80 percent of the total annual forage production of wheat grass and dropseed and up to 83 percent of blue grama production. Arizona studies (34) showed that consumption of vegetation by rodents, chiefly jack rabbits, amounted to 28.7 percent of all vegetation present and 38.8 percent of the valuable forage grasses. Parker (19) in New Mexico found that jack rabbits may destroy as much as 99.4 percent of perennial grass forage on depleted range, and that worthless snakeweed increased on areas grazed by rabbits. He stressed the importance of considering jack rabbit control on artificial revegetation projects, and stated that rodents alone can keep former grassland in deteriorated condition with snakeweed the principal cover. California workers (14) determined that ground squirrels and kangaroo rats took 15 percent or more of the forage produced, and pointed out that large rodent or rabbit populations consume great quantities of forage which would otherwise be available for livestock. This last statement has been made by many other persons concerned with rodent-range interactions.

Most investigators appear to agree that rodents are more often a result of range deterioration rather than a primary cause of it. Studies on jack rabbits (2, 28, 30, 34), kangaroo rats (16, 17), wood rats (15, 33), and other rodents (20, 23, 24), all indicate that these animals increase as overgrazing progresses, and that none are of importance in well managed grassland areas. Hawbecker (12) in California concluded that kangaroo rats appear to actually benefit the local sheep industry because he found five times as much annual filaree and bromegrass on rat dens as on the areas between the dens. He refers only to annual forage and not to the more valuable perennial forage plants. On the other hand, Fitch (6) believes that the Tulare kangaroo rat in California competes with livestock for the sparse annual vegetation. Several articles (8, 9, 10, 26) mention that animals benefit the soil by mixing and deepening it, adding nutrients and vegetable matter to it, and aiding the entrance of air and water into it. Bond (5), in an excellent review, strongly suggests the possibility that some range rodents under certain conditions may speed up plant succession and assist the recovery of depleted areas by a differential pressure on plant species typical of the early successional stages.

Taylor (27) aptly sums up the situation by stating that no benefits can result from rodent control unless livestock pressure is also reduced. Allen (1) goes back to the economics of rodent control and stresses the importance of careful study of costs and values followed by selection of control methods which are economically practical and of permanent value.

Description of Experimental Area

The New Mexico Agricultural Experiment Station ranch is in Dona Ana County and lies party on the Jornada Plain, partly in the Dona Ana Mountains and partly on the breaks of the Rio Grande. The elevation of the ranch varies from about 4,000 feet along the river to 5,800 feet at the highest point in the Dona Ana Mountains. The general level of the portion of the ranch lying on the Jornada Plain is 4,300.

The climate of the area is semiarid. Records for the Jornada Experimental Range, which is on the same plain and at the same general elevation as the experimental ranch, show the average annual precipitation for the 34-year period, 1914-47, to be 9.38 inches (11,32). A shorter (17-year) average from three stations on the experimental ranch is 9.06 inches. Years of departure from the average are frequent and the departure is often great. The precipitation for April, May, and June is so low and evaporation so great that there is usually very little plant growth during this period. Therefore, these months are excluded from the growing season which is July 1 to October 31. Average growing season precipitation at the Jornada for the 1914-47 period is 5.81 inches. Growing season precipitation for the experimental ranch during the 17 years on record was 5.53 inches. The slightly lower precipitation on the experimental ranch may be due to the difference in length of records.

Recorded temperatures are moderate with a yearly mean temperature of around 60°F. Extremes of 0°F. to 105°F. are sometimes reached.

The vegetation of the ranch consists in general of three main types: black grama[1] grassland, creosote bush, and mesquite. The portion of the ranch lying on the Jornada Plain is largely grassland. Creosote bush dominates on rougher areas and mountain footslopes. The mesquite type occurs on the slightly elevated and sloping borders of the plain where it forms mesquite sand dune areas and from which it is invading the grassland. Considerable areas are dominated by threeawn-fluffgrass; and snakeweed occurs throughout, often dominating in certain portions. In addition, there are limited areas of tobosa grass, burrograss, and tarbush.

Soils are generally light. Grassland soils are sands or sandy loams, often underlain by a layer of caliche at from 6 inches to 3 feet. Soils of the creosote bush type are mostly gravelly in texture, although they are sometimes of a chalky impervious nature. Mesquite dune areas have a fine sandy soil underlain

[1]Scientific names of all plants are listed in Appendix 1.

by a stratum of heavier, more compact material. Tobosa, burrograss, and tarbush normally occur on rather heavy clay soils.

Wildlife of Experimental Area

The following species of wildlife occur in or near one or more are located: jack rabbit[1], cottontail rabbit, spotted ground of the various vegetation types in which the experimental plots squirrel, grasshopper mouse, hoary wood rat, white-throated wood rat, banner-tailed kangaroo rat, Merriam kangaroo rat, Ord kangaroo rat, Baird's pocket mouse, brush-tailed pocket mouse, and big-eared harvest mouse (4, 18, 21).

Predatory species include the coyote, badger, bobcat, Arizona gray fox, Swainson's hawk, marsh hawk, red-tailed hawk, prairie falcon, golden eagle, and occasionally the burrowing owl.

Populations of rodents are known to vary widely from year to year and even from one season to the next. Availability of of food, predators, and disease are partially responsible for these wide fluctuations, and there are other causes about which little is known. These variations in rodent populations make it difficult to obtain accurate data which can be used in studies of rodent influence on ranges.

Detailed rodent population studies on the experimental ranch have not been made during the progress of the study; however, some useful information is available. Pinto (21), in an extensive faunal survey of the ranch in 1937, made den counts of rodents in each vegetation type. His data are presented in table 1.

TABLE 1. Average Numbers of Rodent Dens per Acre in Various Vegetation Types on the Experimental Ranch, 1937. Pinto (21)

Rodent	Grassland	Mesquite Sandhills	Other Types[1]
Kangaroo Rats[2]	1.7	13.7	2.1
Miscellaneous Mice[3]	1.8	17.2	4.4
Ground Squirrel	0.9	2.0	1.4
Wood Rat	0.2	0.5	0.5
Total Small Rodents	4.6	33.4	8.4

[1]Other types include snakeweed-grass, fluffgrass-threeawn, and creosote bush. All are sites of low productivity.

[2]All species of Kangaroo Rats.

[3]Grasshopper mouse, harvest mouse, and pocket mouse.

Den count data do not show actual numbers of small rodents; however, they do bring out the relative population densities in

[1]Scientific names of all animals are listed in Appendix 1.

various vegetation types. The survey showed a wide variation in den count between the different vegetation types, ranging from a low of 4.6 total dens per acre in grassland to 33.4 total dens per acre in mesquite-sandhills.

Additional small rodent den counts are available from the work plan developed in 1939 at the beginning of this study (18). A summary of these data show 17.7 total rodent dens per acre in black grama grassland, 22.0 dens per acre in fluffgrass-threeawn grass type, and 23.5 dens per acre in mesquite-sandhills. These variations are not so marked as those shown in table 1, however, they do show lower numbers of rodents in grassland with increases in the mesquite-sandhill types.

Comparison of 1939 den count data with that of 1937 brings out the variation in rodent populations from year to year. For example, in the grassland, the 1937 counts showed 4.6 dens per acre and the 1939 counts showed 17.7 dens per acre.

Other limited information on small rodent populations in the region is available from trapping work by Trowbridge in 1941-42 (32), on the Jornada Experimental Range, adjacent to the experimental area. His results from trapping 5 nights with 7 lines of 10 traps each are summarized in table 2.

TABLE 2. Small Rodent Populations on the Jornada Experimental Range, 1941-42. From Trapping Counts by Trowbridge (31)

Rodent	Vegetation Type		
	Black Grama Grassland	Snakeweed-Grass Types	Mesquite-Sandhills
Kangaroo Rats	44	55	131
Miscellaneous Mice[1]	0	4	1
Ground Squirrel	1	0	1
Wood Rat	2	3	18
Total Small Rodents	47	62	159

[1]Miscellaneous mice include grasshopper mouse, harvest mouse, and pocket mouse.

Trowbridge's findings are similar to those presented earlier in that populations of rodents are lowest in grassland, they increase in the less productive snakeweed-grass types, and are highest in mesquite-sandhills. This is in agreement with the reports of other workers who state that rodent populations are higher on deteriorated sites than they are on good grassland. These findings favor the theory that small mammals tend to increase following range deterioration.

Counts were not made on jack rabbit populations on the experimental areas; however, data from the Jornada Experimental Range appear to be applicable. Trowbridge (31), in numerous automobile counts during the summers of 1941-42, estimated rabbit populations in various vegetation types. His results are summarized in table 3.

TABLE 3. Rabbit Populations by Vegetation Type on the Jornada Experimental Range from Automobile Counts, 1941-42. Trowbridge (31)

Vegetation Type	Jack Rabbits per Section	Cottontails per Section
Black grama grassland	11	28
Snakeweed-grass	83	106
Tobosa flats	96	18
Snakeweed-mesquite-grass	65	88
Snakeweed-mesquite-yucca-weeds	59	48
Mesquite sandhills	118	295
Weed types	272	307

As with the small rodents, jack rabbits are fewest in the climax grassland and highest in weed types of low carrying capacity. The distribution of cottontails according to vegetation type is similar. Arnold (3), summarizing Trowbridge's data, reports an increase of jack rabbits from 1941 to 1942 of 11 to 33 in black grama grassland and 96 to 260 in tobosa flats. He further states that rabbit populations have dropped since 1936 but appear to be increasing since 1942. This statement is borne out by general observations both on the experiment station ranch and the Jornada Experimental Range.

It seems safe to state that rodent and rabbit populations in southern New Mexico are higher in deteriorated vegetation types than in good grassland, and that numbers vary widely from year to year. These factors must be considered in the selection of economically sound control methods.

Experimental Methods

Installations

In the fall of 1939, exclosures were built to exclude cattle only; cattle and rabbits; and cattle, rabbits, and small rodents. These exclosures were located in two different vegetation types: deteriorated mesquite-snakeweed and high-grade black grama grassland. A series of three exclosures, one of each of the above types, was constructed in each vegetation type. In addition, a check plot, open to all grazing, was established at each site.

In the black grama grassland, the exclosures and check plot were contiguous. In the other vegetation type, the exclosures were separated by a distance of 330 feet or more, and the check plot adjoined the exclosure fenced against cattle and rabbits, open to rodents. Each exclosure and check plot was 330 feet square and enclosed 2½ acres. Exclosures against cattle, rabbits, and small rodents were fenced with standard 3-foot, ¼-inch mesh hardware cloth, buried 8 inches in the ground and surmounted by 3 standard barbed wires. Exclosures against cattle and rabbits but open to small rodents were similar except for the substitution of 1-inch mesh chicken wire for the ¼-inch mesh hardware cloth. Cattle exclosures were fenced with four barbed wires. Open check plots were staked with angle iron pegs at each corner.

Rabbits and small rodents were removed from cattle, rabbit, and small rodent exclosures by trapping, shooting, or poisoning. Rabbits only were removed from the cattle-rabbit exclosures. At times these animals returned to exclosures from which they had been removed and continual poisoning was necessary. No other control of rodents and rabbits was permitted within 2 miles of the exclosures.

Sampling

A sampling area 200 feet long was staked out within each exclosure and check plot leaving a border strip 65 feet wide between any fence and any sampled area. The sampling area was then subdivided into 64 parts, 25 feet square. Temporary quadrats 1 meter square were located at random each year in each of the 64 parts. On the quadrats, the basal area of all perennial grasses was measured with a listing square. Crown spread of all shrubs and half-shrubs, including mesquite, snakeweed, and yucca, was measured on an area 4 meters square, of which the initial quadrat was one quarter. Weight of all perennial grasses in each quadrat was measured by clipping the grass to a height of 1 inch, air-drying it, and weighing it in grams. Samples were taken in April and May of each year before the rainy season; therefore, grass production measurements in any one year were mainly the result of the previous year's rainfall. All data were converted to square inches of basal area or crown spread per square yard and total pounds of grass per acre.

Samplings were made in 1940, 1941, 1942, 1947, and 1948.

In addition to the series of exclosures established in 1939, studies have been made on a rabbit-proof exclosure established

in 1936 in snakeweed-mesquite type. This exclosure was sampled by means of four quadrats, each 1 meter square, and compared with three quadrats of the same size outside the exclosure.

Experimental Results

Mesquite-Snakeweed Type

1939 Exclosures. The pasture in which these exclosures were located has been closed to cattle since 1935, therefore no cattle use has occurred. Because of this, data are presented for the check plot and only two exclosures—one excluding both rabbits and rodents, the other excluding rabbits.

Reconnaissance estimates of the vegetation on the area in the fall of 1939 showed 11 percent density consisting of 59 percent snakeweed, 27 percent mesquite, 12 percent dropseed, and minor amounts of fluffgrass, tobosa, black grama, bush muhly, threeawn grasses, plains bristlegrass, yucca, and various perennial weeds.

Rainfall on the area during the 1939-47 period, as shown in table 4, was slightly above the 34-year average of 9.38 inches for the Jornada Plain. While there were 2 years of low rainfall, precipitation during the period as a whole was definitely good.

TABLE 4. Seasonal and Annual Precipitation (Inches) on the Mesquite-Snakeweed Site, 1939-47[1]

	1939	1940	1941	1942	1943	1944	1945	1946	1947	9-year avg.
Seasonal precipation[2]	4.96	5.05	11.36	7.13	3.32	5.00	5.65	7.70	2.90	5.89
Annual precipitation	8.01	9.08	18.66	9.61	7.47	8.78	6.05	11.02	6.39	9.45

[1]Precipitation by months for the 1939-47 period is presented in Appendix 2.
[2]Seasonal precipitation is for July, August, September, and October.

Stand and yield of all perennial grasses and crown spread of snakeweed are the only measurements used for comparison, since, excepting mesquite, they are the only important vegetation. Mesquite measurements were subject to such large experimental errors that they were not considered satisfactory. Data on usable perennial grasses are presented in table 5.

The stand of grasses as determined by basal area measurements was similar on all plots in 1940 except that Plot C (open to rodents and rabbits, closed to cattle) showed a stand 2½ times greater than that on any other plot. This difference is highly significant. Beneficial effects of protection from rodents and rabbits alone on the stand of grasses became apparent after

only 1 year. Plot A (closed to rodents and rabbits) increased to a stand 4 times greater than that on Plot B (closed to rabbits, open to rodents) and 40 times greater than that on Plot C. These differences are highly significant and the stand on Plot A continued to be significantly greater than that on Plots B and C throughout the study. After the first year of the study, the stand on Plots B and C decreased. No increase in stand appeared until 1947, after 7 years of protection, at which time the stand on Plot B was greater than that on Plot C. This difference in favor of Plot B is more striking when one considers the significantly greater stand on Plot C at the beginning of the study. It is evident, then, that rodents and rabbits together, and even rodents alone exert sufficient grazing pressure in deteriorated mesquite-snakeweed types to severely limit vegetation improvement even though the range is not used by cattle.

TABLE 5. Stand and Yield of Usable Perennial Grasses[1] Under Three Degrees of Protection in Mesquite-Snakeweed Vegetation Type, 1940-48

Year	Plot A: Closed to rodents, rabbits and cattle		Plot B: Closed to rabbits and cattle, open to rodents		Plot C: Open to rodents and rabbits, closed to cattle	
	Stand[2]	Yield[3]	Stand[2]	Yield[3]	Stand[2]	Yield[3]
1940	0.73	3.35	0.55	0.42	1.57	3.21
1941	1.17	82.27	0.30	0.42	0.03	0.84
1942	1.08	98.69	0.30	9.90	0.05	1.25
1947	6.31	425.27	2.44	172.12	2.20	104.85
1948	3.86	370.30	1.65	140.54	0.77	68.35

[1]Usable grasses include dropseed, threeawn, plains bristlegrass, tobosa, black grama, and bush muhly.
[2]Basal area of grasses in square inches per square yard.
[3]Yield in pounds of grass per acre to 1-inch level.

The yield data, shown in table 5, presents a similar picture, with yields significantly higher in Plots A and B. Per-acre yields, after 7 to 8 years of protection, are four to five times greater under protection from rodents and rabbits together and one and a half to three and a half times greater under protection from rabbits alone than on the unprotected plot. This amounts to over 300 pounds per acre more total grass under protection from both rodents and rabbits and about 70 pounds more total grass under protection from rabbits alone.

These differences are large and might lead to the conclusion that rodent and rabbit control in this type may be profitable. However, large populations of these animals normally occur

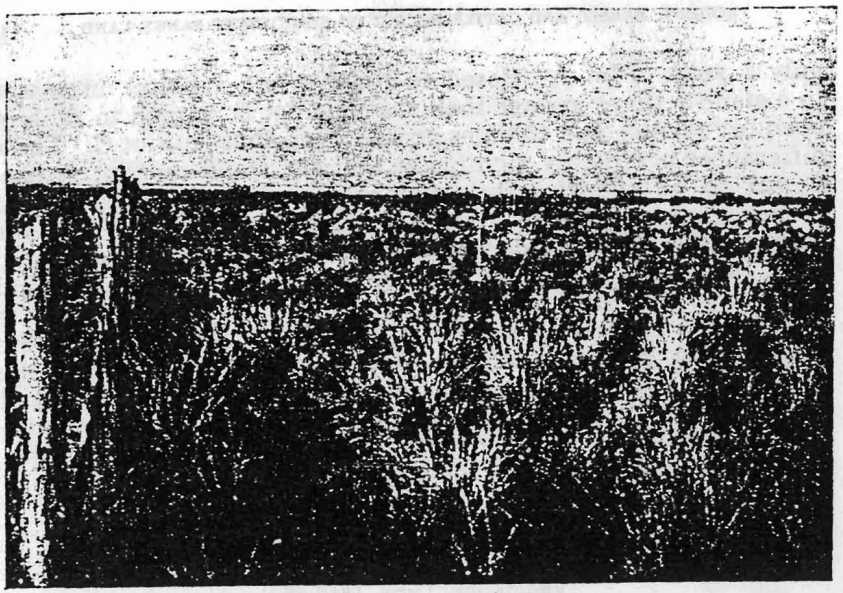


Fig. 1. Mesquite-snakeweed type. 1939 exclosures. Plot A, after 6 years protection from rodents, rabbits, and cattle. Compare with figure 2.

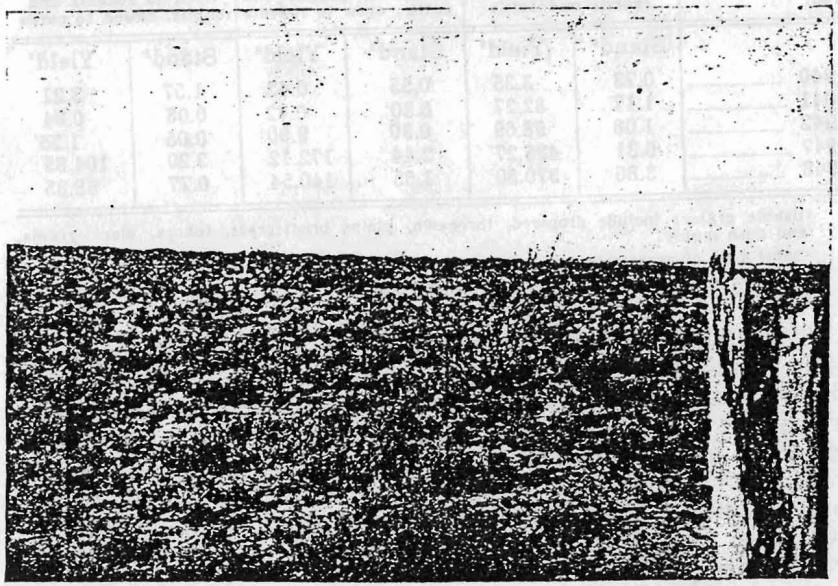


Fig. 2. Mesquite-snakeweed type. 1939 exclosures. Outside Plot A. This area is open to rodent and rabbit use. No cattle have been in the pasture. Note that the principal cover is snakeweed. Compare this with figure 1.

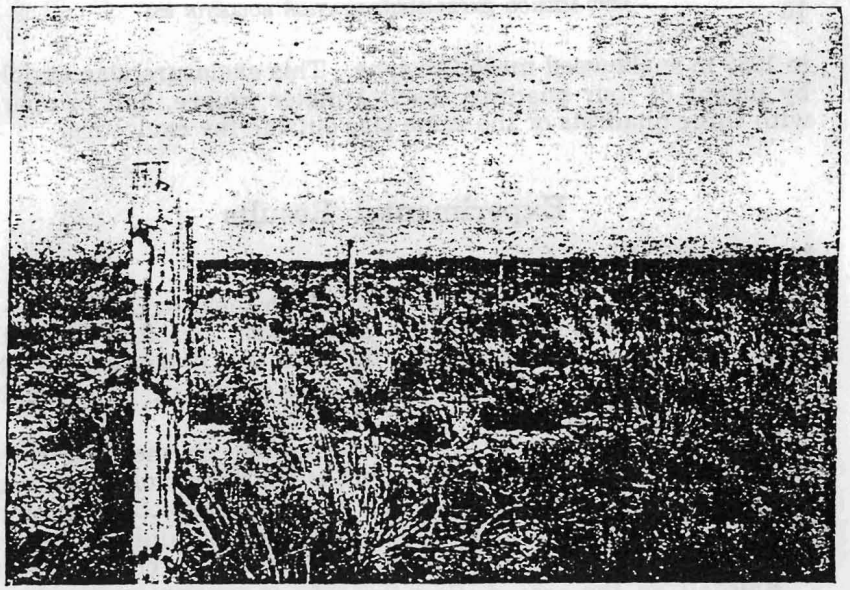


Fig. 3. Mesquite-snakeweed type. 1939 exclosures. Plot B, after 6 years protection from rabbits and cattle, but open to rodents.

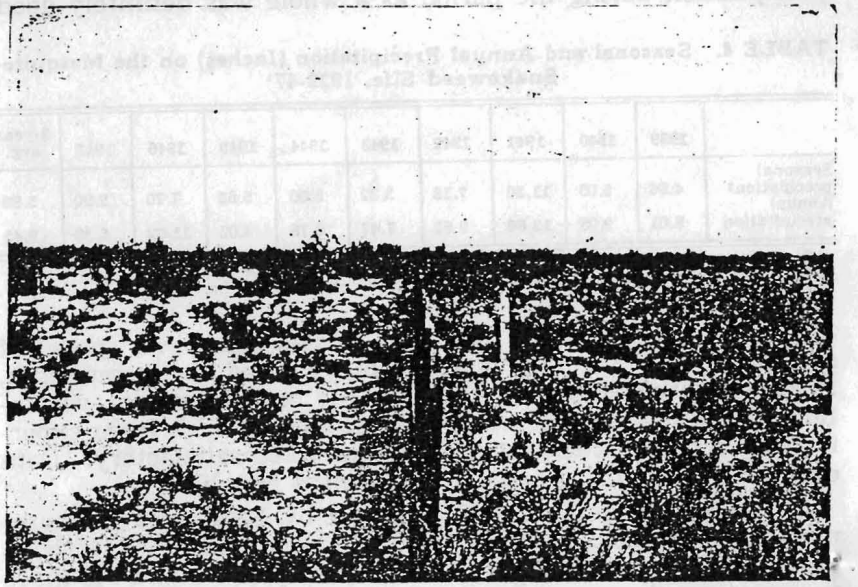


Fig. 4. Mesquite-snakeweed type. 1936 exclosure after 12 years protection from rodents and rabbits. Note that snakeweed is principal cover on the unprotected area (left), and that grass dominates inside the exclosure (right). No cattle use in the pasture.

in deteriorated brushy types, and control may involve brush removal and cattle protection for several years, both of which are costly. Experience during the course of this study indicates that complete control of rodents in the site as it exists is impossible with present methods. Rodents returned to the rodent exclosure each year, and poisoning three or four times yearly was necessary to maintain control. Anything short of complete kill of all rodents over large areas is of doubtful value, since populations can build up rapidly from low residual numbers. Rate of return by rodents to depopulated areas is not sufficiently well known in this region to determine complete control costs.

Crown spread of snakeweed as measured on plots of 4 square meters and converted to square inches per square yard are presented in table 6.

TABLE 6. Crown Spread of Snakeweed (Square Inches per Square Yard) in the Mesquite-Snakeweed Type, 1940-48

Year	Plot A Closed to rodents, rabbits and cattle	Plot B Closed to rabbits and cattle, open to rodents	Plot C Open to rodents and rabbits, closed to cattle
1940	47.12	40.04	44.80
1941	140.87	155.70	136.76
1947	18.58	4.32	30.39
1948	3.68	5.76	12.41

In 1942 measurements on the crown spread of snakeweed were made on plots of 1 square meter rather than 4 square meters. These measurements were subject to errors too great to be used, hence, the 1942 data were omitted.

Variability of the results indicates that rodents and rabbits exert little influence on the crown spread of snakeweed. There is a slightly larger decrease in snakeweed on Plots A and B than on the Plot C. This is probably due to the fact that rodent and rabbit pressure on perennial grasses reduces competition with snakeweed. This differential grazing pressure tends to prevent restoration of grasses, and favors snakeweed on the plots subjected to rodent and rabbit use.

It should be pointed out that snakeweed in this area is influenced markedly by seasonal variation. For example, comparison of snakeweed data with rainfall records for the site show that the 1941 data were collected in an unusually favorable spring following a growing season only slightly below average. The heavy stands of snakeweed on all plots are due to favorable

rainfall. Again, the 1948 snakeweed growth followed a season much below the average, which resulted in a decrease.

1936 Exclosure. In April 1936, a rodent and rabbit exclosure 200 feet square, or approximately 1 acre in area, was established in the mesquite-snakeweed type. The protected area was sampled by charting, with a pantograph, four quadrats of 1 square meter each. Three quadrats of the same size, but outside the exclosure, were similarly charted. Preliminary results were reported by Parker (18). While definite conclusions cannot be drawn from mapping such a limited number of quadrats, the results are indicative and serve to substantiate results reported for the 1939 exclosures. Averages of the plots inside and outside the rodent-rabbit exclosure for each year charted are presented in table 7.

TABLE 7. Vegetation on Protected and Unprotected Meter Square Quadrats Established in 1936[1]

Vegetation	Closed to rodents and rabbits					Open to rodents and rabbits				
	1937	1940	1941	1943	1948	1937	1940	1941	1943	1948
Perennial grasses[2] ...	160.7	297.0	240.0	337.5	701.8[3]	118.0	10.3	7.7	5.5	207.0[4]
Snakeweed	293.5	282.2	1567.8	1340.5	94.0	906.6	1978.7	4282.0	1448.3	148.0

[1]All data expressed as square centimeters per square meter.
[2]Perennial grasses include dropseed, black grama, tobosa, Hall's panicum, and fluffgrass.
[3]No fluffgrass present.
[4]Forty-four percent of this figure is fluffgrass.

These data bear out the results reported for the 1939 exclosures in that the stand of perennial grasses improved under protection from rodents and rabbits, and showed no improvement without protection. The stand of grasses on the closed plot in 1948 was three times as great as on the open plot in the same year. Moreover, the fact that the stand on the open plot consisted of 44 percent fluffgrass while there was none on the closed plot is noteworthy. Fluffgrass is a short-lived perennial grass of practically no forage value and might well have been excluded. Omitting the fluffgrass leaves a stand of perennial grasses six times greater under rodent and rabbit protection. Snakeweed data present a similar picture to that reported for the 1939 exclosures.

Black Grama Grassland

The three adjoining exclosures and an open check plot in this type of vegetation were located in a pasture which has been grazed by cattle since 1939 at an average rate of 7 animal units per section yearlong. Reconnaissance estimates of the vegetation in the fall of 1939 showed a density of 22 percent, with

73 percent black grama, 24 percent mesa dropseed, 2 percent snakeweed, and the remaining 1 percent consisting of yucca, mesquite, senna, croton, and longleaf ephedra.

Average rainfall on the area during the 1939-47 period as shown in table 8 was almost one-half inch above the 34-year average for the Jornada Plain. The average, however, is misleading since one year received exceptionally high rainfall, and five years were decidedly below the average. Growing season rainfall during the period has generally been favorable so that growth conditions have been fairly good.

TABLE 8. Seasonal and Annual Precipitation (Inches) of the Black Grama Grassland Site, 1939-47[1]

	1939	1940	1941	1942	1943	1944	1945	1946	1947	9-year avg.
Seasonal Precipitation[2]	4.67	4.82	12.37	6.12	3.87	7.23	7.31	6.79	4.74	6.44
Annual Precipitation	7.82	9.28	20.09	8.32	7.64	11.13	7.60	9.04	7.88	9.86

[1]Precipitation by months for the period 1939-47 is presented in Appendix 3.
[2]Seasonal precipitation is for July, August, September, and October.

Stand and yield of perennial grasses are the only measurements used for comparisons between treatment plots since other vegetation is unimportant in the composition. These data are presented in table 9.

While these data show some variations from year to year, they generally indicate little or no beneficial results due to protection from rodents and rabbits. Slight increases in stand and yield of grasses occurred from 1940 to 1941 because of the unusually favorable spring season of 1941. Stands fluctuate somewhat between plots, but generally were highest in 1941 with a continual decrease through 1948. Yields generally show

TABLE 9. Stand and Yield of Usable Perennial Grasses[1] Under Four Methods of Treatment in Black Grama Grassland

Year	Plot A — Closed to rodents, rabbits, and cattle		Plot B — Closed to rabbits and cattle, open to rodents		Plot C — Closed to cattle, open to rodents and rabbits		Plot D — Open to rodents, rabbits and cattle	
	Stand[2]	Yield[3]	Stand[2]	Yield[3]	Stand[2]	Yield[3]	Stand[2]	Yield[3]
1940	12.06	204.78	13.27	119.93	10.28	88.78	11.25	70.94
1941	14.94	707.33	13.12	626.31	13.61	588.92	12.06	397.07
1942	13.62	769.61	13.39	570.89	11.16	595.07	10.04	435.71
1947	9.25	965.65	8.69	851.97	8.08	1203.62	5.92	533.86
1948	4.29	754.35	3.68	646.92	3.64	678.59	3.74	293.66

[1]Usable grasses include black grama, dropseed, threeawn, bush muhly, and Hall's panicum.
[2]Basal area of grasses in square inches per square yard.
[3]Yield in pounds per acre.

a continued gain to 1947, dropping in 1948. This increase in yield is due, in part, to accumulation of the previous year's growth rather than current production. The decrease in yield from 1947 to 1948 is probably due to the poor season of 1947 followed by a poor spring season in 1948.

Plot D (open to rodents, rabbits, and cattle) is definitely lower than other plots because of cattle use. This use has been greater than normal for the pasture since the plots are located within one-half mile of water and the continuous fences tend to cause cattle to drift across the unfenced plot. For example, utilization checks on the unfenced plot in 1948 showed 44.6 percent use as compared to 25 percent use in the pasture as a whole.

Table 10, showing the increases in yield from year to year and the increase after 8 years on all plots, indicates more clearly that protection from rodents and rabbits was of no benefit.

TABLE 10. Increase (Pounds per Acre) in Yield of Grasses by Years in Black Grama Grassland

Period of Growth	Plot A — Closed to rodents rabbits, and cattle	Plot B — Open to rodents, closed to rabbits and cattle	Plot C — Open to rodents and rabbits, closed to cattle	Plot D — Open to rodents, rabbits and cattle
1940-41	502.55	506.38	500.14	326.13
1941-42	62.28	-55.42[1]	6.15	38.64
1942-47	196.04	281.08	608.55	98.15
1947-48	-211.30[1]	-205.05[1]	-525.03[1]	-240.20[1]
8-year Increase	549.57	526.99	589.81	222.72

[1]Minus before the figure indicates a decrease in yield from the preceding year.

Fluctuations in yield, shown in table 9, are more pronounced in table 10; however, the over-all increase in production under three degrees of protection from grazing is essentially the same. The fact that Plot C (open to rodents and rabbits) showed a slightly greater increase after 8 years of protection from cattle than did the plots receiving protection from rodents and rabbits as well as cattle indicates that no benefits resulted from protection against rodents and rabbits. Plot D (open to rodents, rabbits, and cattle) showed less increase since the grass was grazed off each year by cattle, and was allowed little accumulation beyond current growth. It has been pointed out that rodent and rabbit populations are normally not high in well preserved grassland, and also that rabbit populations have been low during the course of the study. A longer study, running through a period of high rabbit numbers, might show some benefit from rabbit protection. These data, however, lead to the conclusion that control of rodents and rabbits in well managed grassland is neither necessary nor worthwhile.

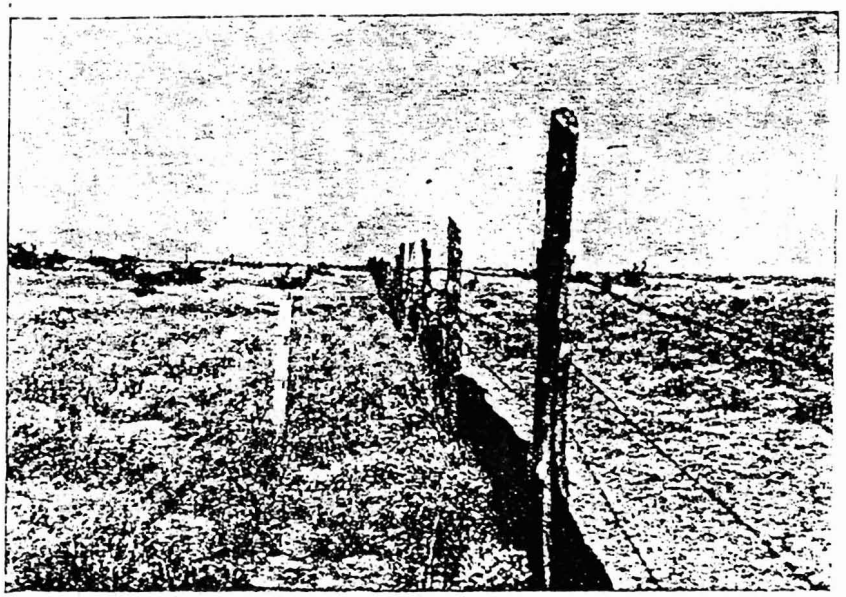


Fig. 5. Black grama grassland type. Plot A (left), after 8 years of protection from rodents, rabbits, and cattle.

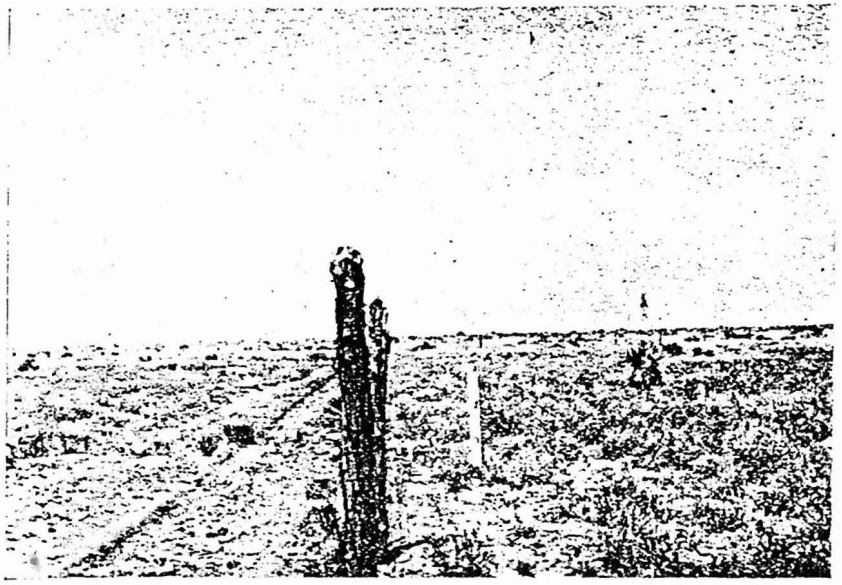


Fig. 6. Black grama grassland type. Plot B (right), after 8 years of protection from rabbits and cattle, but open to rodents.

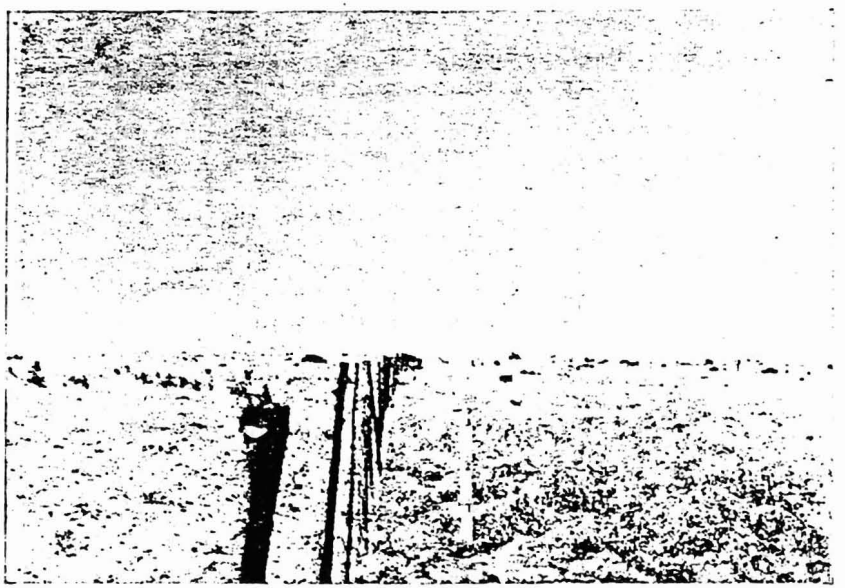


Fig. 7. Black grama grassland type. Plot C (right), after 8 years of protection from cattle, but open to rodents and rabbits.

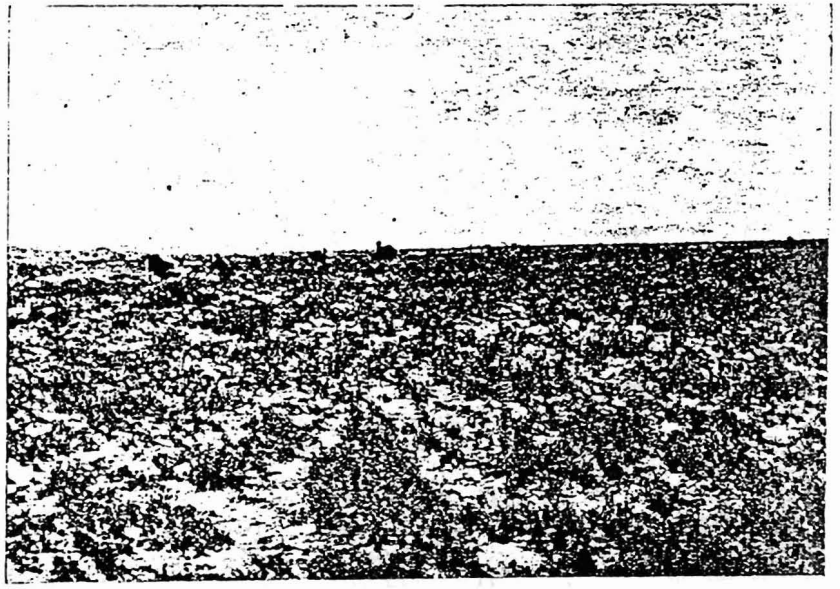


Fig. 8. Black grama grassland type. Check plot, open to rodents, rabbits, and cattle. Note grass density is similar to that in figures 5, 6, and 7.

APPENDIX 1. List of Common and Scientific Names of Plants and Animals Mentioned in the Text

Plants:

Black grama grass	*Bouteloua eriopoda* Torr.
Burrograss	*Scleropogon brevifolius* Phil.
Bush muhly grass	*Muhlenbergia porteri* Scribn.
Creosote bush	*Larrea divaricata* Cav.
Croton	*Croton corymbulosus* Engelm.
Fluffgrass	*Triodia pulchella* H. B. K.
Hall's panicum	*Panicum halli* Vasey.
Longleaf ephedra	*Ephedra trifurca* Torr.
Mesa dropseed	*Sporobolus flexuosus* (Thurb.) Rydb.
Mesquite	*Prosopis juliflora* var. *glandulsoa* (Torr.) Cockrill
Plains bristlegrass	*Setaria macrostachya* H. B. K.
Sand dropseed	*Sporobolus cryptandrus* (Torr.) A. Gray
Senna bean	*Cassia bauhinioides* A. Gray
Snakeweed	*Gutierrezia sarothrae* (Prush.) Britt and Rusby.
Tarbush	*Flourensia cerna* DC.
Threeawn grass	*Artistida* sp.
Tobosa grass	*Hilaria mutica* (Buckl.) Benth.
Yucca	*Yucca elata* Engelm.

Rodents and Rabbits:

Baird's pocket mouse	*Perognathus flavus flavus* Baird
Banner-tailed kangaroo rat	*Dipodomys spectabilis baileyi* Goldman
Big-eared harvest mouse	*Riethrodontomys megalotis megalotis* Baird
Brush-tailed pocket mouse	*Perognathus penicillatus eremicus* Mearns
Cottontail rabbit	*Sylvalagus auduboni* subsp.
Grasshopper mouse	*Onychomys torridus torridus* Coues.
Hoary wood rat	*Neotoma micropus canescens* Allen
Jack rabbit	*Lepus californicus* subsp.
Merriam kangaroo rat	*Dipodomys merriami merriami* Mearns
Ord kangaroo rat	*Dipodomys ordii ordii* Woodhouse
Spotted ground squirrel	*Citellus spilosoma macrospilotus* Merriam
White-throated wood rat	*Neotoma albigula albigula* Hartley

Predatory Animals and Birds:

Arizona gray fox	*Urocyon cinereoargenteus scottii* Mearns
Badger	*Taxidea taxus berlandieri* Baird
Bobcat	*Lynx rufus baileyi* Merriam
Burrowing owl	*Speotyto cunicularia hypogaea*
Coyote	*Canis latrans* subsp.
Golden eagle	*Aquila chrysaetes canadensis*
Marsh hawk	*Circus hudsonius*
Prairie falcon	*Falco mexicanus*
Red-tailed hawk	*Buteo borealis* subsp.
Swainson's hawk	*Buteo swainsoni*

APPENDIX 2. Precipitation (inches) by Months for the 1939-47 Period on the Snakeweed-Mesquite Site

year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Total[1]	Annual Total
1939	.98	.01	.67	.27	.00	.28	1.07	1.85	1.44	.60	.38	.53	4.96	8.01
1940	.02	.91	.09	.28	.69	.70	1.41	1.24	1.72	.68	.77	.57	5.05	9.08
1941	1.86	.64	1.14	1.20	.97	.46	2.11	2.35	5.62	1.28	.19	.84	11.36	18.66
1942	.31	.37	.00	.65	.00	.10	1.52	3.13	1.53	.95	.00	1.05	7.13	9.61
1943	.35	.00	.18	.00	.05	1.72	1.56	.40	1.36	.00	.88	.94	3.32	7.47
1944	.38	.77	.01	.00	.53	.21	1.63	.67	1.21	1.49	1.23	.65	5.00	8.78
1945	.21	.06	.08	.00	.00	.05	2.33	.86	.03	2.43	.00	.00	5.65	6.05
1946	1.20	.00	.00	.37	.40	.33	.97	1.99	3.07	1.67	.36	.66	7.70	11.02
1947	.56	.00	.42	.05	.79	.43	.80	2.00	.00	.10	.81	.43	2.90	6.39
9-year average	.65	.31	.29	.31	.38	.45	1.49	1.61	1.78	1.02	.51	.63	5.89	9.45
34-year average[2]	.46	.37	.35	.22	.50	.54	1.72	1.75	1.44	.91	.50	.62	5.82	9.38

[1]July, August, September, October.
[2]From long-time records on Jornada Experimental Range

APPENDIX 3. Precipitation (inches) by Months for the 1939-47 Period on the Black Grama Grassland Site

year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal Total[1]	Annual Total
1939	1.03	.01	.60	.26	.00	.30	1.22	.98	2.12	.35	.41	.54	4.67	7.82
1940	.02	.91	.09	.28	.69	.70	1.41	1.24	1.72	.68	.77	.57	5.05	9.08
1941	1.82	.89	1.06	1.18	.83	.79	1.73	3.41	5.93	1.30	.37	.78	12.37	20.09
1942	.19	.32	.00	.45	.00	.41	1.07	2.74	1.50	.81	.00	.83	6.12	8.32
1943	.35	.00	.09	.02	.07	1.07	.99	1.30	1.58	.00	.96	1.21	3.87	7.64
1944	.38	.60	.08	.00	.50	.09	2.93	1.65	1.39	1.26	1.63	.62	7.23	11.13
1945	.20	.02	.02	.00	.00	.05	3.10	1.08	.64	2.49	.00	.00	7.31	7.60
1946	1.18	.00	.00	.02	.34	.17	1.69	.69	3.41	1.00	.18	.36	6.79	9.04
1947	.57	.00	.43	.04	.41	.48	1.19	3.13	.12	.30	.73	.48	4.74	7.88
9-year average	.64	.32	.26	.24	.27	.55	1.75	1.78	1.98	.92	.59	.56	6.44	9.86
34-year average[2]	.46	.37	.35	.22	.50	.54	1.72	1.75	1.44	.91	.50	.62	5.82	9.38

[1]July, August, September, October
[2]From long-time records on Jornada Experimental Range.

LITERATURE CITED

1. Allan, P. F.
1942. Defensive control of rodents and rabbits, Jour. Wildlife Mgt. 6 (2): 122-132.
2. Arnold, J. F.
1942. Forage consumption and preferences of experimentally fed Arizona and antelope jack rabbits. Ariz. Agr. Expt. Sta. Tech. Bul. 98. 35pp.
3. Arnold, J. F.
1946. Jack rabbits and their effects on grazing lands. Field Day Program. N. M. Agr. Expt. Sta., N. M. Ext. Serv., and S. W. For. and Range Expt. Sta. Mimeo.
4. Bailey, Vernon
1931 Mammals of New Mexico. U. S. D. A. Bur. Biol. Surv., North American Fauna No. 53. 412 pp. illus.
5. Bond, Richard M.
1945. Range rodents and plant succession. Trans. North American Wildlife Conf. pp. 229-234.
6. Fitch, H. S.
1948. Habits and economic relationships of the Tulare kangaroo rat. Jour. Mammalogy. 29 (1): 5-35.
7. Gabrielson, I. N.
1938. Thomomys the engineer. Am. Forests. 44 (10): 453-454, 478-479.
8. Greene, R. A. and Charles Reynard.
1932. The influence of two burrowing rodents *Dipodomys spectabilis* (Kangaroo rat) *Neotoma albigula albigula* (pack rat) on desert soils in Arizona. Ecology 13 (1): 73-80.
9. Grinnell, J.
1931. Editorial. Condor 33: 131-132.
10. Grinnell, J.
1933. Native California rodents in relation to water supply. Jour. Mammalogy 14: 293-298.
11. Hardy, E. L., J. C. Overpeck, and C. P. Wilson.
1939. Precipitation and evaporation in New Mexico. N. M. Agr. Expt. Sta. Bul. 269. 68 pp. illus.
12. Hawbecker, A. C.
1944. The giant kangaroo rat and sheep forage. Jour. Wildlife Mgt. 8(2): 161-165.
13. Hollister, N.
1916. A systematic account of prairie dogs. U. S. D. A. Bur. Biol. Surv., North American Fauna No. 40. 37pp. illus.
14. Horn, E. E. and H. S. Fitch
1942. Interrelations of rodents and other wildlife on the range. Calif. Agr. Expt. Sta. Bul. 663 pp. 96-129.
15. Horton, J. S. and J. T. Wright.
1944. The wood rat as an ecological factor in Southern California watersheds. Ecology 25 (3): 341-351.
16. Monson, Gale
1943. Food habits of the banner-tailed kangaroo rat in Arizona. Jour. Wildlife Mgt. 7(1):98-102.

17. Monson, Gale and W. Kessler
1940. Life history notes on the banner-tailed kangaroo rats, Merriam's kangaroo rat, and the white-throated woodrat in Arizona and New Mexico. Jour. Wildlife Mgt. 4 (1): 37-43.
18. New Mexico Agri. Expt. Sta. and U. S. D. A. Soil Conservation Service, Work Plan for a Cooperative Rodent Field Test. Unpub.
19. Parker, K. W.
1938. Effect of jackrabbits on the rate of recovery of deteriorated rangeland. N. M. Agr. Expt. Sta. Press Bul. 839. 3pp mimeo.
20. Phillips, P.
1936. The distribution of rodents in overgrazed and normal grassland in Oklahoma. Ecology 17(4): 673-679.
21. Pinto, H. T.
Wildlife Management. Report of extensive faunal survey of the State College Ranch, Rio Grande Division, Soil Conservation Service. Unpub.
22. Renner, F. G.
1936. Conditions influencing erosion on the Boise River watershed. U. S. D. A. Tech Bul. 528. 32pp. illus.
23. Smith, C. C.
1940. Biotic and physiographic succession on abandoned farmland. Ecol. Monog. 10(3): 421-484.
24. Smith, C. C.
1940. The effect of overgrazing and erosion upon the biota of the mixed grass prairie of Olkahoma. Ecology 21(3): 311-325.
25. Smith, J. G.
1899. Grazing problems in the Southwest and how to meet them. U. S. D. A., Div. of Agros. Bul. 16.
26. Taylor, W. P.
1935. Some animal relations to soil. Ecology 16(2): 127-136.
27. Taylor, W. P.
1936. Some effects of animals on plants. Sci. Monthly 43: 263-271.
28. Taylor, W. P. and D. W. Lay
1944. Ecologic niches occupied by rabbits in eastern Texas. Ecology 25(1): 120-121.
29. Taylor, W. P. and J. V. G. Loftfield
1924. Damage to range grasses by the Zuni prairie dog. U. S. D. A. Dept. Bul. 1227. 15pp. illus.
30. Taylor, W. P., C. T. Vorhies and P. B. Lister
1935. The relation of jack rabbits to grazing in southern Arizona. Jour. Forestry. 33(5): 490-498.
31. Trowbridge, A. H.
Report on a preliminary study of the relative populations of rodents and rabbits on the Jornada Experimental Range, New Mexico. Unpub.
32. U. S. Weather Bureau
1939-1947. Climatological Data: New Mexico Section. Monthly reports.
33. Vorhies, C. T. and W. P. Taylor
1940. Life history and ecology of the white-throated wood rat, *Neotoma albigula albigula*, Hartley, in relation to grazing in Arizona. Ariz. Agri. Expt. Sta. Tech. Bul. 86. 74pp. illus.
34. Vorhies, C. T. and W. P. Taylor.
1933. Life history and ecology of jack rabbits, *Lepus alleni* and *Lepus californicus*, ssp, in relation to grazing in Arizona. Ariz. Agr. Expt. Sta. Tech. Bul. 49, 117pp. illus.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

Board of Control

Board of Regents of the College

Frank Light, President ..... Silver City, N. M.
J. A. Sweet, Secretary and Treasurer ..... Mesquite, N. M.
J. Minor Beene ..... Las Cruces, N. M.
Albert Gonzales ..... Santa Fe, N. M.
Austin Brooks ..... Clovis, N. M.

Ex Officio Members

Hon. Thomas J. Mabry, Governor of New Mexico ..... Santa Fe, N. M.
Hon. Charles L. Rose, Superintendent of Public Instruction ..... Santa Fe, N. M.

Officers

J. W. Branson, M. S. ..... President of the College
H. R. Varney, Ph. D. ..... Director
A. S. Curry, B. S. ..... Associate director
Annette Harlan, B. S. ..... Assistant to the director

Staff

Agricultural Economics

P. W. Cockerill, M. S. ..... Agricultural economist
H. B. Pingrey, M. S. ..... Associate agricultural economist
Morris Evans, M. S. ..... Associate agricultural economist
W. K. Snyder, M. S. ..... Assistant agricultural economist
C. R. Hall, M. S. ..... Assistant in marketing
W. P. Stephens, M. S. ..... Assistant in farm management

Agricultural Engineering

C. T. Bourns, M. S. ..... Agricultural engineer
A. E. Stewart, M. S. ..... Assistant agricultural engineer

Agronomy

J. C. Overpeck, M. S. ..... Agronomist
G. N. Stroman, Ph. D. ..... Agronomist
H. E. Dregne, Ph. D. ..... Agronomist
Glen Staten, M. S. A. ..... Associate agronomist
C. W. Chang, Ph. D. ..... Associate agronomist
J. E. Chapman, M. S. ..... Assistant agronomist
Sherman Paur, M. S. ..... Assistant agronomist
Marvin Wilson, M. S. ..... Assistant in agronomy

Animal Husbandry

J. H. Knox, M. S. ..... Animal husbandman
P. E. Neale, M. S. A. ..... Animal husbandman
W. E. Watkins, M. S. ..... Nutrition chemist
J. W. Benner, D. V. M., M. S. ..... Associate animal husbandman
Marvin Koger, Ph. D. ..... Associate animal husbandman
K. A. Valentine, M. S. ..... Associate animal husbandman
J. J. Norris, M. S. ..... Assistant animal husbandman
C. B. McConnell, B. S. ..... Assistant animal husbandman

Biology

R. F. Crawford, M. S. ..... Biologist
J. R. Eyer, Ph. D. ..... Entomologist
P. J. Leyendecker, Jr., Ph. D. ..... Associate plant pathologist
L. R. Faulkner, M. S. ..... Assistant entomologist

Chemistry

Peter Duisberg, Ph. D. ..... Assistant chemist

Dairy Husbandry

W. I. Tretsven, Ph. D. ..... Dairy husbandman
S. R. Skaggs, M. S. ..... Associate dairy husbandman
C. B. Reeves, M. S. ..... Assistant dairy husbandman

Home Economics

Edith Lantz, M. A. ..... Research specialist
Helen Gough, M. S. ..... Assistant home economist

Horticulture

J. V. Enzie, M. S. ..... Horticulturist
R. E. Harper, M. S. ..... Associate horticulturist
Kenneth W. Hench, M. S. ..... Assistant in horticulture

Poultry Husbandry

L. N. Berry, B. S. ..... Poultry husbandman

Publications

V. W. Johansen, B. A. ..... Editor

Sub Stations

John Carter, Jr., B. S. A. ..... Superintendent, Plains Substation
H. D. Jones, B. S. A. ..... *Superintendent, Middle Rio Grande Substation*
D. R. Burnham, B. S. (Coop. USDA) ..... Superintendent, Northeastern Substation
David H. Williams, M. S. ..... Associate agronomist, Northeastern Substation

Cooperators

F. A. B. MacKeil ..... Cotton statistician, USDA, El Paso, Texas
A. M. Leding ..... Agronomist, USDA
L. R. Lytton ..... Senior agricultural aid, USDA
D. S. Hubbell, Ph. D. ..... Soil conservationist, USDA
J. L. Gardner, Ph. D. ..... Soil conservationist, USDA
H. J. Maker, B. S. ..... Soil scientist, USDA
Marvin L. Seal, M. S. ..... Soil scientist, USDA
Eldon G. Hanson ..... Irrigation engineer, USDA