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DAMAGE TO RANGE GRASSES BY THE ZUNI PRAIRIE DOG.

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INTRODUCTION.

That native rodents cause heavy losses both in cultivated crops and in forage plants on the pasture and range has long been recognized. Indeed, after a careful calculation, the Biological Survey has conservatively estimated the losses in crops in the United States at $150,000,000 annually, and in forage plants on the open range at a like sum—a total annual loss of $300,000,000 from this source (Nelson, 1918, p. 2, and 1919, p. 5; Taylor, 1920, p. 283; Bell, 1921, p. 423).[1] Determinations under controlled conditions of the actual damage done by rodents, either in cultivated crops or on the open range, are, however, almost wholly lacking. The first paper dealing in a precise manner with such damage is that of W. T. Shaw (1920),[1] who made a determination of the destruction of wheat by the Columbian ground squirrel (*Citellus columbianus* Ord) in eastern Washington. No comprehensive published results dealing quantitatively with rodent damage on the open range have been seen.

The difficulties in the way of this kind of experiment, while not small, are by no means insurmountable; and it is believed that esti-

[1] Literature references and numbers in parenthesis refer to citations in "Literature Cited," page 15.

NOTE.—This bulletin is a report on a cooperative undertaking between the Biological Survey, the Carnegie Institution of Washington, the Forest Service, and the Arizona Agricultural Experiment Station to ascertain quantitatively the destructiveness of prairie dogs to stock ranges. It is for the information of stockmen and others interested in the control of rodent pests of the range.

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mates of damage will be more accurate and convincing when based on controlled field tests. The difficulties include lack of information regarding the life histories of the animals concerned; necessity for evolving new methods of fencing, organization, and administration; expense of adequate fencing and inspection; and remoteness of the field of operations from headquarters.

The most important of the species of rodents which narrow the margin of profit of the farmer and stockman in the Western States are prairie dogs, ground squirrels, pocket gophers, and jack rabbits. Among these, none does greater damage to range grasses than the prairie dog, referred to more than 20 years ago as "one of the most pernicious enemies to agriculture" (Merriam, 1902, p. 263). Hollister (1916, p. 7) writes: "Prairie dogs are unquestionably responsible for great annual damage to crops and pasturage. In certain areas the destruction amounts to virtually the entire forage. Crops of grain and cultivated hay are often entirely ruined unless drastic preventive measures are taken." But "in other out-of-the-way places the animals do not interfere in the least with the operations of man."

Almost anyone who has had opportunity for observation will have been impressed with the destructive effect of the prairie dog on the forage grasses in the vicinity of its "towns," especially during dry years. Charles Springer, who, during the World War, was chairman of the executive committee of the New Mexico council of defense, writes (letter of January 6, 1919):

> Regarding the extent of damage done to the range by prairie dogs, opinions differ, and, of course, it depends upon the degree of infestation. In the 50,000-acre unit now being investigated and treated in the Moreno Valley, in Colfax County, the prairie dogs destroyed nearly all the grama grass, and I believe the damage to that range amounted to 75 per cent. Generally the damage done by prairie dogs in the infested areas with which I am familiar ranges from 40 or 50 per cent to 100 per cent. I have seen in Rio Arriba and Sandoval Counties, and in some of the other counties, large areas rendered practically worthless for grazing purposes by these pests. It is safe to estimate that the annual damage to ranges in New Mexico has amounted to destroying the grass on more than 6,000,000 acres of the very choice grazing land of the State, the areas selected and infested by prairie dogs being generally the best grama-grass flats and draws.

In order to determine quantitatively the damage done by prairie dogs to forage grasses under different conditions, three sets of experimental areas were established during the year 1918 in northern Arizona (at Coconino, near Grand Canyon; at Williams; and at Seligman) by the Bureau of Biological Survey, the Carnegie Institution of Washington, and the Forest Service. Some of the results thus far obtained are discussed here.

The prairie dog found in northern Arizona and concerned in the experiments here reported is the Zuni prairie dog (*Cynomys gunnisoni zuniensis* Hollister). This subspecies is of wide distribution, being found in central, northern, and eastern Arizona, in central and northwestern New Mexico, and in southwestern Colorado. Its destruction of forage grasses may be regarded as fairly typical of the activities of prairie dogs in general.

The procedure in the conduct of the experiments was either to fence in the prairie dogs on a particular infested tract, or (as at Seligman) to permit free entry of prairie dogs while excluding cattle; to inclose also a contiguous area of similar size, so that it

could be held under total protection from cattle as well as prairie dogs; and then, by means of permanent meter vegetation quadrats, and in other ways, to obtain quantitative information as to the vegetation actually destroyed under grazing (1) by prairie dogs alone and (2) by cattle alone (or cattle and prairie dogs together) in comparison with (3) the amounts produced under total protection. This was accomplished by actually measuring the grasses under total protection, under grazing by prairie dogs, and under grazing by cattle; by mapping the areas on the quadrats occupied by the grasses; and by fall clipping and weighing all vegetation from certain quadrats in the areas under the different conditions.

ORGANIZATION AND AUSPICES.

The project has been cooperative from the beginning. Dr. Frederic E. Clements, of the Carnegie Institution of Washington, has given valuable assistance and advice relative to the organization and prosecution of the experiment and has made provision for the charting of the vegetation. Former supervisors Ira T. Yarnall and James A. Scott, of the Tusayan National Forest, extended many courtesies in connection with the work; and the present supervisor, George W. Kimball, has continued quarterly inspection of the areas and assisted in other ways. Dr. Chas. T. Vorhies, of the University of Arizona, charted the quadrats in the spring of 1919; and D. A. Gilchrist, Biological Survey rodent-pest director for Arizona, assisted by Ben E. Foster, supervised the fencing of the areas, made check-counts of the prairie dogs in the inclosures at different times, inspected the areas at intervals, arranged for the capture and reintroduction of prairie dogs, and provided for necessary eradication. The writers have participated in the organization and conduct of the experiment from its inception and have inspected the areas at least once each year, checking up on the rodent relations, measuring the grasses, charting the vegetation quadrats, and clipping, weighing, and photographing the grasses from the clip quadrats.

VEGETATION AFFECTED.

The region in which prairie dogs are chiefly found is in the western part of the Great Plains formation, called by Clements (1920) the mixed prairie. This consists of two components, a tall grass and a short grass. Over the greater part of the area occupied by this formation the two occur mixed, but toward its eastern border the short grasses become of minor significance, while on the western they are of major importance. The "tall grass" is characterized by the presence of wheat grass (*Agropyron*) and porcupine grass (*Stipa;* usually the needle-and-thread grass *Stipa comata*), and the "short grass" by blue grama (*Bouteloua gracilis*). There are several additional associates of both components, but only those occurring in northern Arizona are of particular interest here.

The areas covered by this investigation are in the extreme southwestern extension of the Great Plains formation already mentioned. The vegetation through most of this section is of the short-grass type and consists of blue grama associated with ring grass (*Muhlenbergia gracillima*) and black or woolly-foot grama (*Bouteloua crio-*

poda). The short-grass type is of greatest importance from the forage standpoint when the blue grama is present in quantity, and of least importance when it is associated with much ring grass. The woolly-foot grama is a characteristic desert grass and is therefore of increasing importance toward the west and south, disappearing altogether at higher elevations and toward the east.

The tall grasses have nearly all disappeared from vast areas in northern Arizona as a result of heavy overgrazing, the sand dropseed (*Sporobolus cryptandrus*) being the only one which is still widespread and which will come back readily if conditions permit. In certain favorable areas the western wheat grass (*Agropyron smithii*) is still predominant, and such areas are of great importance, because of the excellent quality and large quantity of the forage produced. This wheat-grass type is especially important also because wheat grass withstands grazing and trampling by cattle very well in the situations where it has survived, and because the type contains sand dropseed, which recovers quickly if given opportunity.

The two types of grassland mentioned (the tall grass, characterized by the western wheat grass; and the short grass, characterized by blue grama) are the most important of those found grazed by prairie dogs in this region. The other types occur in washes which flood to such an extent that prairie dogs can not colonize them, on rocky hills where these rodents can not dig burrows, or in parks in the upper plant formations where the animals can not live. The short-grass and tall-grass forage types belong essentially to the same formation and were originally much more closely associated. The coming in of man with his herds of grazing animals has caused them to segregate and form distinct consociations, or forage types (Clements, 1920; Loftfield, 1924).

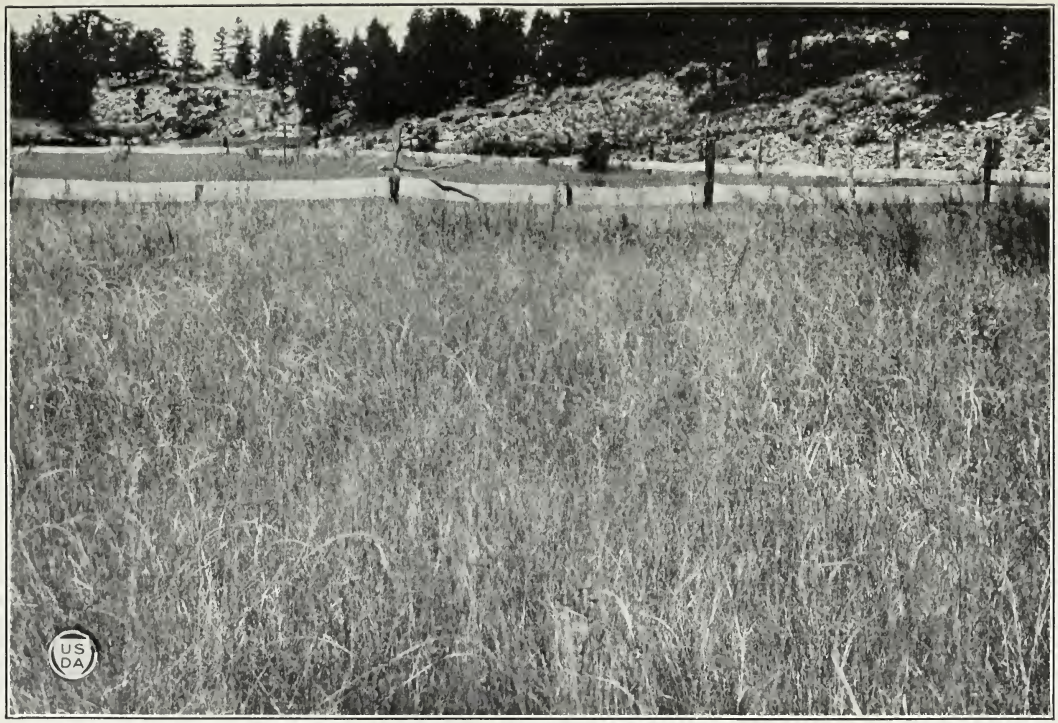
The experimental areas were established during the early spring of 1918 by the writers, assisted by D. A. Gilchrist. After an extensive survey, the Coconino area was selected as a typical representation of the tall-grass type, and the Seligman area of that form of the short grass most commonly found in northern Arizona. Another tract was considered in the type where blue grama is associated with ring grass, since this was more nearly representative of the short grass as it occurs generally in the Western States. An additional installation was made possible in a tract located in the short-grass type and established under Mr. Gilchrist's direction on the Tusayan National Forest, near Williams.

Summarizing, the Coconino areas are representative of conditions in the tall grass; Williams, those in the short grass; and Seligman, of the zone of transition between the Great Plains and Desert associations of the grassland climax. Results to 1922 from the Coconino and Williams areas are presented, data from the Seligman areas being omitted because experimental difficulties have so far prevented the securing of significant data on rodent damage.

THE COCONINO EXPERIMENT.

THE AREA.

The Coconino experimental tract is situated near Coconino, Ariz., in the northern division of the Tusayan National Forest, 1 mile east of the Williams-Grand Canyon road, and about 8 miles by road from



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FORAGE CONDITIONS, COCONINO, NEAR GRAND CANYON, ARIZ., OCTOBER 24, 1922.

Plot of mixed wheatgrass (*Agropyron smithii*) and dropseed (*Sporobolus cryptandrus*) under total protection from grazing by livestock and prairie dogs. No ground is visible in his lot. For conditions grazed by prairie dogs and by cattle, see Plate II, Figures 1 and 2, respectively.

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FIG. 1.—PRAIRIE-DOG PLOT.

The grass here is noticeably shorter and thinner than that shown in Plate I, and the ground is easily visible in several places, as a result of grazing by prairie dogs.

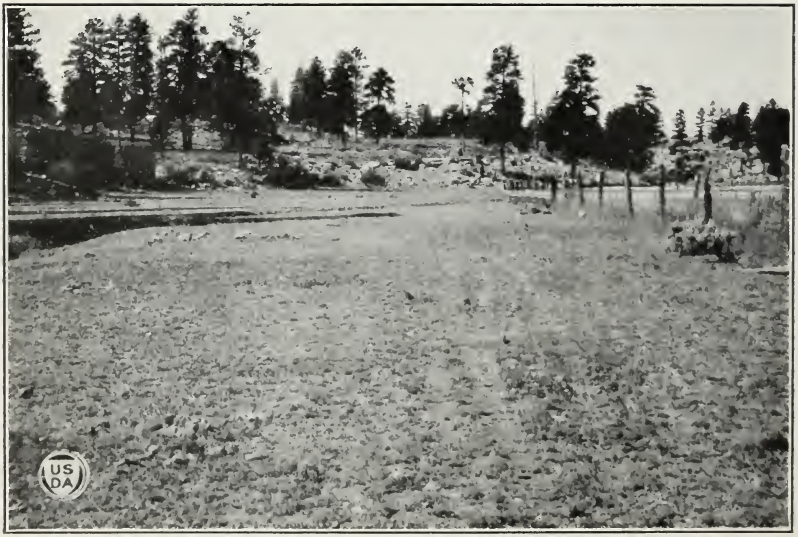

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FIG. 2.—CATTLE-GRAZED PLOT.

Very little grass is in evidence outside the fenced plots, where the forage is freely grazed by cattle.

FORAGE CONDITIONS, COCONINO, ARIZ., OCTOBER 24, 1922.

(See also Plate I.)

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FIG. 1.—UNDER TOTAL PROTECTION.

The difference in the number of fruiting heads under protection and under rodent grazing indicates the difficulties of propagation by seeds when prairie dogs are present.

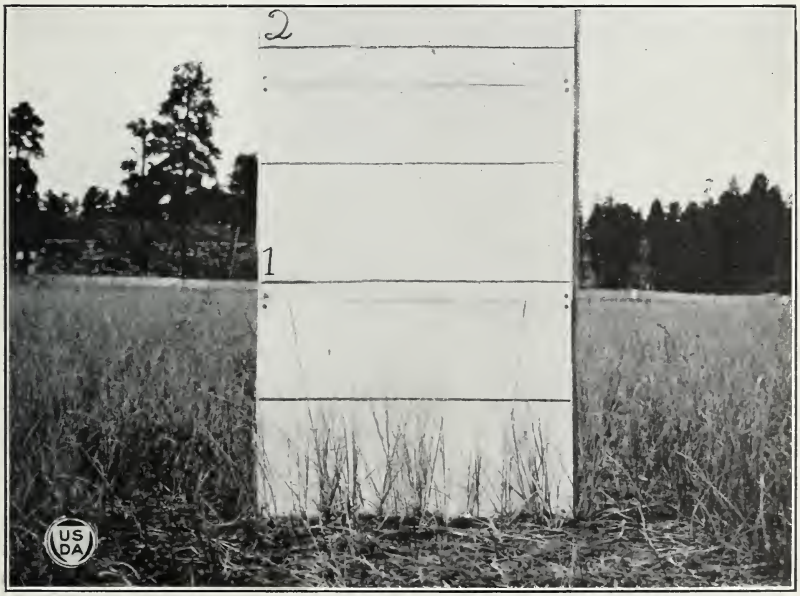

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FIG. 2.—UNDER GRAZING BY PRAIRIE DOGS.

The grass is thinner and poorer than under protection from the rodents. The background in this figure and in Figure 1 is numbered in feet.

WHEATGRASS (AGROPYRON SMITHII) UNDER TOTAL PROTECTION AND UNDER GRAZING BY PRAIRIE DOGS, COCONINO, ARIZ., OCTOBER 29, 1920.

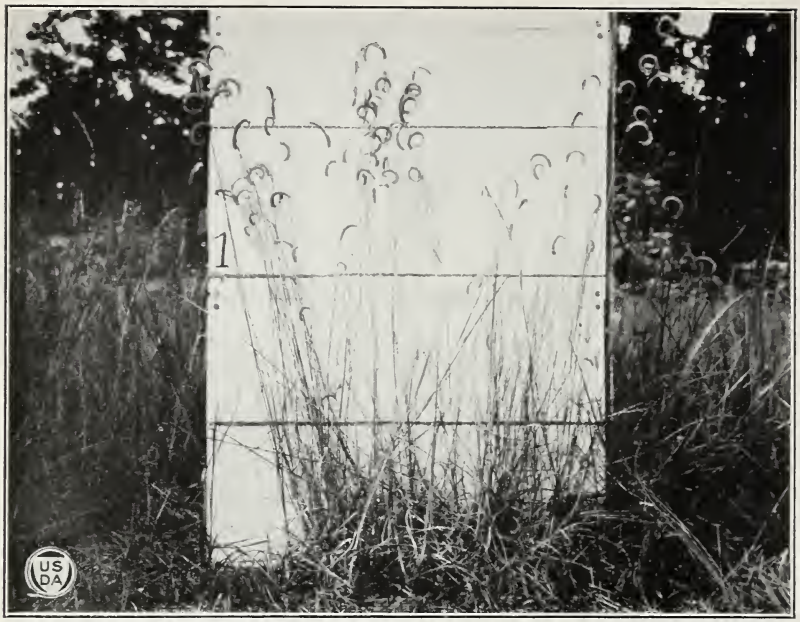

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FIG. 1.—UNDER TOTAL PROTECTION.

In the plot from which prairie dogs and stock were excluded tall stems and fruiting heads developed. (Measurements in the background are in feet.)

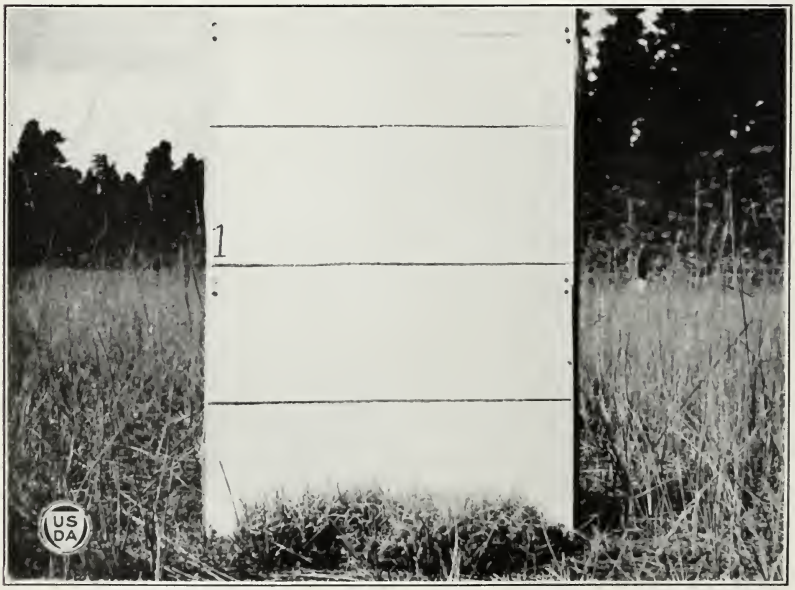

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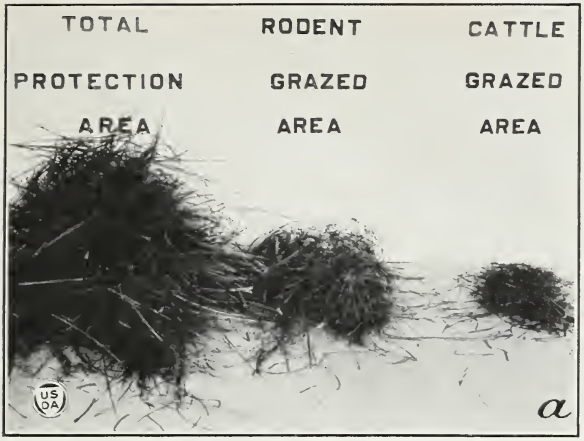
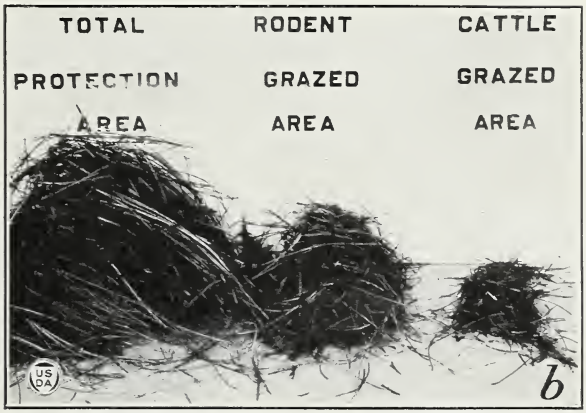
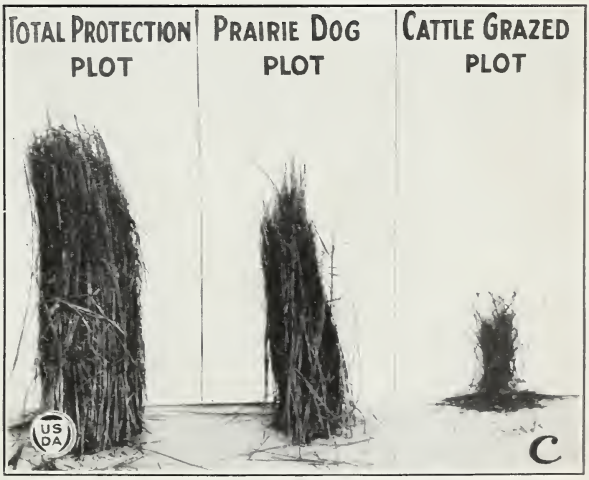
FIG. 2.—UNDER GRAZING BY PRAIRIE DOGS.

Grazing by prairie dogs usually reduces this grass to the form of a close-set turf, with few or no tall stems and frequently no fruiting heads whatever.

BLUE GRAMA (BOUTELOUA GRACILIS) UNDER TOTAL PROTECTION AND UNDER GRAZING BY PRAIRIE DOGS, COCONINO, ARIZ., OCTOBER 29, 1920.







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WHEATGRASS (AGROPYRON SMITHII) FROM CLIP QUADRATS, COCONINO, ARIZ.

Cuttings in *a*, *b*, and *c* made after summer grazing in the years 1919, 1921, and 1922, respectively.

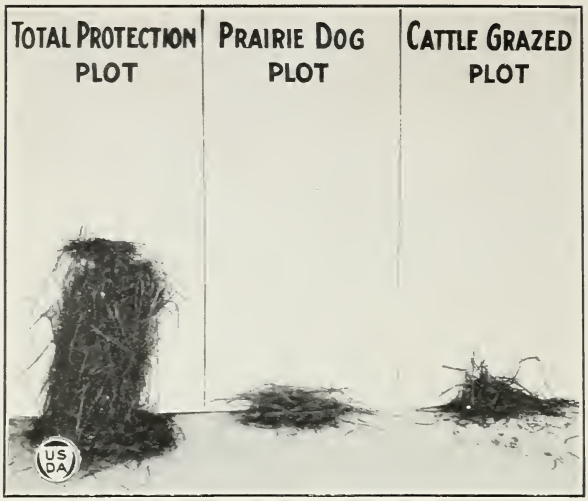

FIG. 1.—DROPSEED (SPOROBOLUS CRYPTANDRUS) CLIPPINGS MADE IN FALL AT COCONINO, ARIZ.

Prairie dogs here had grazed this grass even more closely than had cattle.

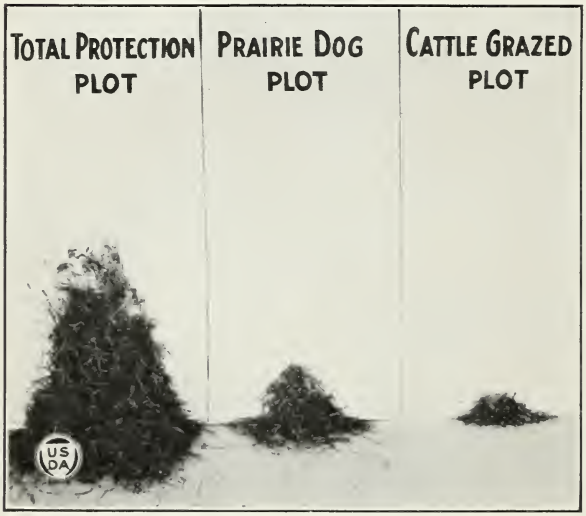

FIG. 2.—FALL CLIPPINGS OF BLUE GRAMA (BOUTELOUA GRACILIS) MADE AT WILLIAMS, ARIZ.

The piles labeled "cattle grazed plot" are from the open areas, where both cattle and prairie dogs grazed.

DROPSEED AND BLUE GRAMA FROM CLIP QUADRATS, 1922.

Grand Canyon post office. The place selected is in the "wash," which is best described as a water-made park in the yellow-pine forest which forms a broad belt along the south rim of the Grand Canyon at this point. The characteristic vegetation of the area (Pls. I and II) is the western wheat grass (*Agropyron smithii*) (Pl. III), sparsely dotted with bushes of the true sagebrush (*Artemisia tridentata*). The wheat grass is predominant, but where some protection permits it to produce seed the sand dropseed (*Sporobolus cryptandrus*) is of nearly equal importance. Blue grama (*Bouteloua gracilis*) (Pl. IV) is present also, but thus far has been of minor importance. Several other grasses, such as the June grass (*Koeleria cristata*), occur but are rare and of little economic importance.

Two plots were measured off on April 14, 1918, each approximately three-fourths of an acre in extent (132 by 247.5 feet). One quadrat was staked out and charted in each of the plots and another outside. The plots were fenced on May 27, 1918. To exclude stock, four strands of barbed wire were utilized. For the prairie-dog inclosure a strip of 1-inch-mesh galvanized wire 3 feet wide was used in addition, the lower 6 inches being buried in the ground, leaving 2½ feet above the surface as a barrier to the rodents.

Careful counts indicated the infestation of prairie dogs in this region to be about 25 individuals to the acre. A like proportion, or 18 or 20 animals, were found to have been fenced in the inclosure. Prairie dogs in the total-protection area and outside the inclosures were eliminated by thorough poisoning. Some difficulty was experienced in retaining the rodents where needed and in excluding them from "protected" areas, and this constituted a source of error in the experiments, but these, tending to minimize rather than exaggerate the results, show the damage as less extreme on the areas than probably would otherwise have been the case.

Two quadrats, one in each fenced plot, were added to the first three on May 19, 1919, by Doctor Vorhies, who charted the quadrats at that time. These, and the one outside, were clipped at the end of the growing season that year and each year thereafter, the results being shown in Table 1 on page 8.

PROGRESS OF THE EXPERIMENT.

When the inclosures were first fenced on May 27, 1918, the grasses, under the combined grazing of stock and rodents, had been cropped off short throughout the region, so short, in fact, as to make identification of the different species difficult. By November 13, 1918, however, certain noteworthy changes had taken place. The grasses under total protection were knee high. The forage in the rodent inclosure was in good condition also, though plainly showing the effects of rodent work. Around one series of burrows within this inclosure a circular area about 40 feet in diameter had been almost entirely grazed off by the rodents. Fifteen or twenty feet seemed to be about the average radius of intensive prairie-dog damage, though it was evident that some rodent grazing had been done over the entire area. Outside the fences, where stock had been grazing freely, the grass was cropped short, resembling its condition when the fences were first installed.

Changes in the vegetation were measured quantitatively by means of five permanent quadrats, two in each of the fenced areas and one outside. These were charted every year at the end of the growing season and one quadrat in each of the three plots clipped at that time and the crop of grass weighed by species. The results thus measured were striking, and show in a very marked manner not only the differential effects of rodent and cattle grazing, but the responses of each of the grasses to such grazing (Pls. V and VI).

In 1918, when the first three quadrats were installed, the sand dropseed (*Sporobolus cryptandrus*) was almost extinct, appearing in only one of them. This was due largely to its great palatability, both cattle and prairie dogs seeking it and grazing it to the ground at all times. The established plants were holding on in some measure by producing a crop of short leaves close to the ground in the manner characteristic of the blue grama, which enabled them to survive in spite of close grazing by cattle. But plants near the prairie-dog burrows were utterly destroyed, for the rodents had grazed the grass down to the tops of the roots, rarely leaving so much as a bud to reestablish the plant.

The chief result noted after the growing season of 1918 was the first appearance of seeding plants of dropseed in the totally protected plot. Such plants occurred in the prairie-dog inclosure also but only at some distance from the group of burrows. Very few of these plants were seedlings; in fact, nearly all may be said to have been established plants, permitted by protection to produce their first real crop of seed.

As a result of this crop, the fall of 1919 showed dropseed plants everywhere on the whole area, and from that time on this grass has been of almost equal importance with wheat grass on and around the plots. This was due to the great amount of seed produced in the protected plots scattering over the entire area and reestablishing plants where grazed out. The plants were grazed down by cattle outside the plots, however, and in the rodent inclosure, were grazed down and gradually killed so that while these plots showed at times nearly as many plants per square meter as in the protected area, clipping in fall showed little forage left.

In the spring of 1918 the wheat grass (*Agropyron smithii*) plainly showed the effects of overgrazing. This grass does not produce short leaves close to the ground as does blue grama (and also dropseed when forced to it), but sends up leafy stems which, when grazed closely, have no photosynthetic surfaces left. Such plants must draw upon stored food-material to send up short shoots which may escape and permit food supplies to be in some measure replenished. The habit of the wheat grass of spreading by rhizomes, however, is distinctly in its favor. Seeding is always a precarious means of reproduction under grazing conditions, while spreading by rhizomes permits pooling of the food produced by the few shoots which escape for the use of all shoots arising from the rhizome. The tougher texture and scabrous leaves of the wheat grass make it less palatable than either grama or dropseed, hence a few shoots at least are apt to remain untouched. When heavily grazed for some years, however, the rhizomes become starved, and

fewer shoots are produced each season. Under such conditions, sagebrush (*Artemisia*), rabbitbrush (*Chrysothamnus*), snakeweed (*Gutierrezia*), and finally annual weeds come in and tend to replace the wheat grass. All these were present on the areas during the spring of 1918. Under grazing conditions not so destructive the wheat grass is slowly replaced by blue grama. This had apparently in some measure occurred here.

Under total protection the wheat grass increased to a remarkable extent the first two years, but very slowly afterward. By 1919 a stable relationship had apparently been reached between the number and size of shoots of all grasses and the amount of water available. The year's rainfall was unusually favorable and the total amount of forage has not increased much since that time, but has fluctuated with the season. The wheat grass, however, has made consistent gains as a result of successful competition with the dropseed. Very little change has taken place in the wheat grass on the cattle-grazed area during the period of the experiment, a gradual increase occurring until 1919, probably as a result of eradicating the prairie dogs, after which time the growth fluctuated with the rainfall. In the rodent-grazed area, however, this grass showed a consistent decrease until 1922, when the amount of it practically doubled as a consequence of lessened rodent infestation.

Blue grama (*Bouteloua gracilis*) occurred in small quantities on the areas in 1918. On the cattle-grazed portion it has shown a slow consistent increase each year. In the protected plot and in the rodent-grazed plot this grass more than doubled in quantity by the end of the growing season of 1919. This, as in the case of the other grasses, was the result of protection against cattle grazing and the decrease in number of prairie dogs in the inclosure. The grama showed little change in the protected area during 1920 and decreased somewhat in 1921 and 1922, as a result of competition with the other grasses. In the rodent inclosure it continued to increase somewhat, since rodent grazing favored this grass by comparison with the others.

In 1922 (October 24) sand dropseed (*Sporobolus cryptandrus*) was found growing in the prairie-dog area somewhat more abundantly than before, indicating a decrease in grazing by prairie dogs since the last preceding inspection (fall of 1921). Needle-and-thread grass (*Stipa comata*) was found on the areas for the first time, there being an older plant surrounded by a considerable number of younger but seeding individuals as well as several seedlings. June grass (*Koeleria cristata*) was commoner this year than on former occasions. Six-weeks grama (*Bouteloua procumbens*) appeared in quantity for the first time this year as an annual, principally outside the fences. In general, the grasses did not look so well in 1922 as on previous inspections, because the rains were late. The plot under total protection was becoming weedy from lack of grazing and trampling.

TABLE 1.—*Quadrat study, giving weights of grasses clipped each fall from permanent meter quadrats under the different conditions as stated, to indicate the amount of forage destroyed by prairie dogs at Coconino, Ariz., 1919–1922.*

Kind of grass.[1]	Total-protection area.	Rodent-grazed area.	Cattle-grazed area.	Quantity destroyed by rodents.[2]
Western wheat grass:	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1919	100.0	36.8	6.6	63.2
1920	117.1	24.3	8.7	92.8
1921	138.8	22.6	6.7	116.2
1922	161.1	77.2	6.7	83.9
Sand dropseed:				
1919	164.6	[3]	4.6	164.6
1920	32.8	[4]	[4]	32.8
1921	81.9	[4]	6.4	81.9
1922	38.7	3.7	6.1	35.0

[1] Blue grama did not occur in sufficient quantity to be taken into account.
[2] Obtained by subtracting amounts under rodent-grazed conditions from those under total protection. The rodents concerned are chiefly prairie dogs; a negligible quantity of forage may have been taken by others.
[3] Trace.
[4] None.

It is to be recalled that the figures in Table 1 were obtained under controlled conditions, by actual weights, and that the amount shown as destroyed by rodents is undoubtedly somewhat less than would be the case had it been possible to keep a full number of prairie dogs in the rodent inclosure and to exclude them completely from the total-protection area. The figures indicate in very general but impressive terms a potential rate of damage which may be expected where rodent grazing takes place in the wheat-grass forage type under conditions similar to those of this experiment. The following statement (Table 2) presents some of the results obtained under these conditions:

TABLE 2.—*Annual production of forage and its reduction per acre by prairie dogs.*

Forage.	Production in pounds.	Destroyed by prairie dogs.	
		Pounds.	Per cent.
Western wheat grass	1,153	794	69
Sand dropseed	709	701	99
Total	1,862	1,495	80

The annual forage loss on a section of land in this forage type at the rate shown in Table 2 would be the impressive total of 479 tons. Nowhere on the range, however, is this type the continuous vegetation cover, and in most of the region it occurs as comparatively small islands in the surrounding types. It should be pointed out also that the quantity of forage destroyed by rodent grazing does not necessarily represent the quantity actually consumed. Part of the loss is due to the reduction of vigor of many grasses through early spring grazing, which inhibits their growth and prevents them from producing the quantity of forage they otherwise would. Unfortunately, no satisfactory quantitative data are as yet available which indicate the amount of this loss. Continuous clipping of the

quadrats through the season did not yield reliable results, though check quadrats show that clipping reduces the forage and starves out the plants far more than does grazing by cattle. Trustworthy methods are now being worked out, however, which, to date, indicate that growth inhibition effects have been exaggerated. Nevertheless, allowing the 35 pounds of dry forage per day per cow, and estimating that plants weakened by average rodent grazing produce only a 50 per cent crop, the forage saved by extermination of rodents should suffice to support 37 head of cattle additional per section if forage of this type formed a continuous ground cover and if it were possible to utilize the forage when in a condition such as at the time of clipping. Of course, no extensive areas of western range afford such forage, but the figures are indicative of the quantitative reduction due to these rodents that may be expected in the best forage types, which are the ones most affected. A corresponding reduction may be expected in more typical forage.

THE WILLIAMS EXPERIMENT.

THE AREA.

The experimental tracts at Williams, Ariz., which were installed in the spring of 1918 shortly after the Coconino field test was inaugurated, are situated near the Sweetwood Ranch, 3½ miles north of the town, near the point at which the Red Lake Colony road crosses the Grand Canyon Railroad. They are in typical blue grama (*Bouteloua gracilis*) forage areas on a tract of land which slopes gradually to the west. This forage type is one of the most widely distributed in the country, being found in abundance from north of the Canadian boundary south to the tableland of Mexico and from east of the one hundredth meridian westward to the Rocky Mountains and beyond, particularly across New Mexico and Arizona. Hence the results of this experiment should be especially suggestive and of broad applicability.

A short distance from the experimental tracts is the lower edge of the juniper-pinyon formation, so that they are not far from the upper border of the grassland proper. Although this border is more favorable than the lower areas for grass maintenance, overgrazing has progressed so far that the grasses are more than half replaced already by various shrubs, as snakeweed (*Gutierrezia*) and rabbit brush (*Chrysothamnus*). The soil is composed of a fine silt produced largely from the weathering and decomposition of basalt; it is a deep reddish brown and very stony. The effects of washing are quite noticeable, the grass tufts often having half an inch or more of their roots exposed. This washing renders the grasses unusually susceptible to damage by grazing.

The Williams plots are smaller than those at Seligman and Coconino, yet large enough for the purposes of the experiment. The fenced part is 148 feet square and is divided by another fence, so that two plots each 148 by 74 feet have been inclosed. The north plot (planned for a prairie-dog inclosure) was first fenced with galvanized net wire, 1 inch mesh, 3 feet high, buried about 4 inches underground and topped with a 6-inch strip of galvanized iron, strung

around on barbed wire. Above the galvanized net wire were three barbed wires at 6 to 8 inch intervals. The south area (planned for a total protection tract) was inclosed with 6 barbed wires and with galvanized net wire, 1-inch mesh, to exclude prairie dogs. Installation was by the Biological Survey and the Forest Service jointly.

It seemed to be well-nigh impossible to confine prairie dogs in the inclosure successfully, even though an apron of galvanized net wire was later installed inside and buried in the ground in an attempt to prevent their escape; they either found some way to get out, perished from natural causes, or became the prey of predatory animals or birds. It was then concluded to try a different plan, and the north inclosure was retained as a total-protection plot instead of a prairie-dog inclosure, and by removing the galvanized net wire, the south plot was so arranged as to permit free grazing and colonizing of prairie dogs from the outside, though cattle were excluded by the barbed wire as before.

This arrangement, according to which no attempt was made to confine the prairie dogs, was found much more satisfactory than the previous one. Meter quadrats were installed on November 6, 1919, one in each of the plots, and one outside of the fences. Additional quadrats were measured off and typical quadrats were clipped for the first time on October 18, 1922, this being the first year when reliable and significant results could be obtained in this way.

PROGRESS OF THE EXPERIMENT.

The failure of earlier attempts to retain prairie dogs in their inclosure and to stop their invasion of the total-protection area prevented the obtaining of results of much value in regard to the effect of rodents on forage until the season of 1922, when (as observed during the month of October) contrasts were marked. The blue grama (*Bouteloua gracilis*) (Pl. VI) showed many seeding heads in the total-protection area, though very few were noted in the prairie-dog plot or outside. Many clumps of a tall grass, bottlebrush squirrel-tail (*Sitanion hystrix*), and a few of sand dropseed (*Sporobolus cryptandrus*) were observed in the total-protection area, while neither grass was in evidence either in the prairie-dog plot or outside the fences.

It is obvious that these grasses were enjoying far more favorable opportunities for seeding in the total-protection area than in the prairie-dog plot. The prairie dogs evidently not only destroyed an appreciable quantity, by weight and bulk, of the best forage plants, but also attacked them at their critical seeding period, thus having a markedly detrimental effect on their reproduction. The infestation of prairie dogs in the plot appeared to be about the same as, or in some cases much less than, the average infestation in the open country round about. It is felt, therefore, that the figures given are a conservative statement of actual destruction of this type of forage by prairie dogs under the prevailing conditions in the vicinity.

TABLE 3.—*Quadrat study, giving weights of grasses clipped in fall from permanent meter quadrats under the different conditions as stated, to indicate the amount of forage destroyed by prairie dogs at Williams, Ariz., 1922.*

Kind of grass.	Total-protection area.	Rodent-grazed area.	Cattle and rodent grazed area.	Quantity destroyed by rodents.[1]
	Grams.	*Grams.*	*Grams.*	*Grams.*
Blue grama	43.7	7.3	2.6	36.4

[1] Obtained by subtracting amounts under rodent-grazed conditions from those under total protection. The rodents concerned are chiefly prairie dogs; a negligible quantity of forage may have been taken by others.

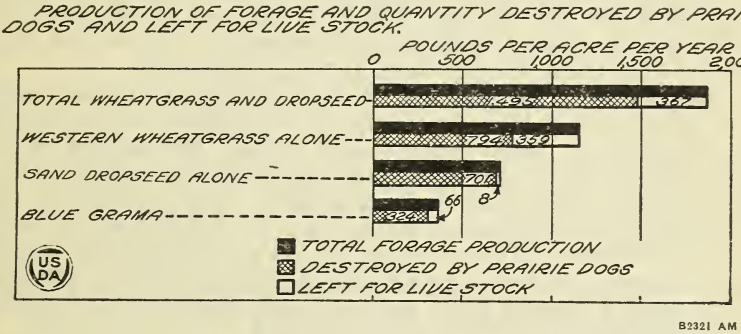

FIG. 1.—Quantitative destruction of forage by prairie dogs. Composite record from experiments of four years at Coconino, Ariz., and of one year at Williams, Ariz.

The figures in Table 3 show that under the conditions of this experiment prairie dogs destroyed the forage at the rate of 324 pounds of the 390 pounds produced on an acre in the year; or, putting it another way, rodents reduced the available stand of the blue grama—the most important forage grass in the region—by 83 per cent.

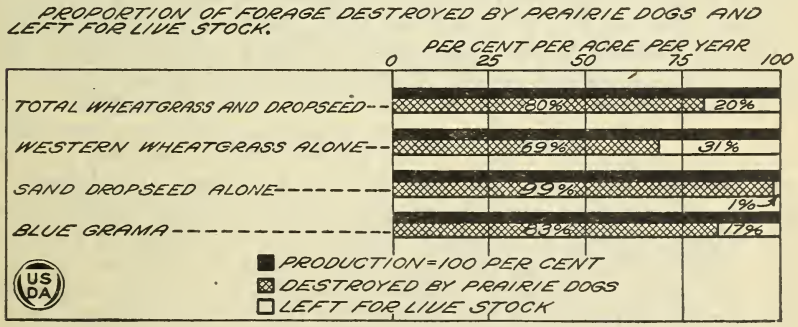

FIG. 2.—Percentage destruction of forage by prairie dogs. Composite record from experiments of four years at Coconino, Ariz., and of one year at Williams, Ariz.

SOME GRAZING RELATIONS OF PRAIRIE DOGS.

It is not the intention to imply that the rates of damage here shown actually prevail throughout the areas of the forage types here considered wherever prairie dogs are at work, for there are

many modifying conditions in different localities which may operate to increase or diminish the amount of damage. Accurate generalization covering an entire forage type can only be based on quantitative experiments carried over a period of years in several representative localities. But at the rate of damage indicated by the measured results here given, the grazing capacity of the range would almost inevitably be reduced even in a favorable year, and in a drought year the effect of rodent grazing would be critical.

Prairie dogs tend to congregate into "towns" or communities, which are occupied continuously until the vegetation is used up. The range in and around the town is severely grazed at all times, and sometimes, particularly in dry years, the grasses are grazed not only to the ground, but all the buds and even the tops of the roots are eaten, the grasses being thereby utterly destroyed. When the damage reaches this point it is spectacular and impressive.

In many localities through the Western States there exist great areas of choice range land on which the vegetation has been completely destroyed by these rodents, and usually the margin of the affected area shows a series of prairie-dog towns gradually encroaching toward the untouched grassland. The animals do not readily abandon their burrows, not in fact until the distance to the grazing area becomes too great for safety. In consequence the heavily overgrazed tracts are gone over again and again, so that by the time they are deserted there is often not one small shoot left to form the nucleus from which the range can be reseeded.

The denuded areas are sometimes wholly bare in dry season, but are usually occupied by stands of weeds altogether unfit for grazing either by stock or by prairie dogs. With the slow movement of plant succession in desert or semiarid regions, particularly under present range-control conditions, recovery from prairie-dog grazing must necessarily be slow. Complete eradication of the entire rodent population and proper grazing management does, however, give the grasses a chance to move back into the denuded area, and gradually to restore the range. It is obvious that quantitative determination of present damage to the range must be based on experiments conducted in the grassland border of an occupied prairie-dog town or in some colony where the grass has not been entirely destroyed.

It is not improbable that, under original conditions prevailing within the geographic range of the prairie dog, a practical equilibrium between the grass and the rodents had been established, so that the prairie dogs and the grasses rather constantly maintained their ranges, subject, of course, to fluctuations in climate and certain other possibly modifying factors. The coming on the scene of man, with his herds of grazing domestic animals, has completely upset this original balance and has turned the tide toward destruction of the forage plants. The killing of coyotes and other predatory animals, fully justified on certain areas where they do more damage to species of wild game and to livestock than they do good in destroying rodents, has removed one of the normal checks upon the prairie dogs and has tended still further to upset the balance. As an offset for these two modes of interference with the natural equilibrium, the Biological Survey and various cooperating agencies have undertaken systematic campaigns for the extirpation of the rodents. If utter

destruction of the range grasses over great areas is to be prevented, these campaigns must be increased in scope and number.

Careful attention to the plants eaten in the tall-grass and short-grass forage types at Coconino, Williams, and Seligman, Ariz., has shown conclusively that prairie dogs here consume only the plants eaten by cattle and do not touch plants which cattle find unpalatable. Hence these rodents compete directly with cattle for the usual forage plants of this region.

Not only do the rodents eat the same grasses, but they take them in the same order of preference that cattle do. At Coconino, for example, both eat the grasses in the following order: Dropseed, wheat grass, blue grama. At Seligman both cattle and prairie dogs grazed the Russian thistle (*Salsola pestifer*) when it was young and tender, but when old and tough neither would touch it. Prairie dogs can graze the forage much more closely than cattle, and, therefore, are able to subsist where cattle can not and are far more destructive to valuable range plants.

As previously suggested, the prairie dog does much more damage to the range during seasons of drought than at other times. Wholesale poisoning of the rodents may well increase the forage in certain instances sufficiently to permit the cattleman to carry his stock through the dry period without loss.

So far as these experiments now indicate, the prairie dog does not possess a single beneficial food habit; nor is there any argument, so far as available facts or figures indicate, against its complete eradication on all grazing ranges. The data here presented show conclusively that the comparatively small expense of eradication is more than justified.

In many overgrazed areas, apparently, total eradication of prairie dogs and reduction in the number of cattle per unit area will be necessary if the forage crop is to continue profitable. Almost anyone can realize the serious damage done when the forage plants are utterly destroyed and vast areas rendered worthless; but many stockmen do not properly appreciate the constant heavy losses to which they are subjected by prairie dogs through decreased carrying capacity of the range, even where the grass appears to be maintaining itself.

SUMMARY AND CONCLUSIONS.

To determine quantitatively the character of prairie-dog damage to the range in northern Arizona and the principal forage types affected, two sets of experimental inclosures have been established, one near Coconino, in the wheat-grass forage type; the other near Williams, in the blue-grama type. Three plots were selected in each: (1) One subject to cattle (or cattle and prairie-dog) grazing; (2) one to prairie-dog grazing only; and (3) one protected from all grazing. Grasses from meter quadrats on the plots were measured, charted, clipped, and weighed each year.

Results of four years' experiments at Coconino show that prairie dogs destroy 69 per cent of the wheat grass and 99 per cent of the dropseed, or 80 per cent of the total potential annual production of forage. Results of one year's experiments at Williams show that the

rodents destroy 83 per cent of the blue-grama crop, the most important forage grass of the region. These experiments were made under conditions where the vegetation is at present maintaining itself; in many areas the prairie dogs destroy 100 per cent of the forage and have to move out themselves. Such extreme destruction favors the growth of unpalatable weeds, makes range recovery difficult, and opens the way for soil deterioration through erosion. The prairie-dog has not been shown to have a single beneficial food habit.

Prairie dogs and cattle come into direct, and, in times of drought, deadly, competition. The evidence from these experiments indicates that these rodents do not eat anything that cattle do not and that the two eat the grasses in the same order of preference; sand dropseed (*Sporobolus cryptandrus*) is preferred to western wheat grass (*Agropyron smithii*) and, when present with these, blue grama (*Bouteloua gracilis*) appears to be third in order of preference. The wheat grass apparently endures grazing by both prairie dogs and stock better than the dropseed.

The impressive total of forage that may be destroyed by prairie dogs clearly indicates the constant losses suffered almost unconsciously by stockmen who utilize the open range in places where the rodents have not been eliminated. The possible destruction of 80 per cent of the forage, or even of a far smaller proportion, is serious enough at any time, but in periods of drought it is likely to be calamitous, especially if in normal years the range is stocked to capacity. In some overgrazed areas the total eradication of prairie dogs, as well as the reduction of the number of cattle per unit area, apparently will be necessary if the forage grasses are to continue in profitable quantity.

The original equilibrium between prairie dogs and grass has been upset by man in his grazing of cattle and other livestock and in his extermination of coyotes and other predatory animals. As an offset the Biological Survey and its cooperators have undertaken systematic campaigns for the destruction of injurious rodents. Extension of such campaigns is necessary if the prairie dog is to be eliminated as a strong factor in the destruction of forage upon vast areas of good stock ranges and in reducing profits of the livestock industry there.

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