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RODENTS, RABBITS, AND GRASSLANDS

E. R. KALMBACH

A VARIETY of small mammals fall in the average man's ken of rodents. Among them are the rodents proper (*Rodentia*), mice, rats, squirrels, prairie dogs, gophers, and others. Hares and rabbits (*Lagomorpha*) are technically not rodents, but must be included in a consideration of the relation of small mammals to the range because sometimes they are of greater economic importance than the true rodents. Even the insectivorous moles are often associated with the rodents by those who have had to combat them.

Oddly enough there are many species of rodents whose feeding, life habits, or limited distribution make them individually of little significance as hazards in modern grassland agriculture. Some of them are even energetic destroyers of grasshoppers and other insects. With them we need not concern ourselves here; it is more expedient to indicate the few that do most damage.

On the long-grass and short-grass areas of the Plains and Intermountain regions of the West, extensive grazing under conditions of limited rainfall has aggravated the problem of balancing what Nature may produce as well as destroy with what man would like to utilize. In those areas we have spent our greatest efforts to control rodents and tip the balance in our favor.

Throughout those areas the primary problems arising from field rodents are those associated with prairie dogs (four species), ground squirrels (more than 20 species), pocket gophers (three genera and numerous species), and kangaroo rats (fully two dozen species classified in two genera).

Not all the varied species of these groups are of paramount importance economically, yet problems connected with any one are essentially the same in their basic causes and in the economics of remedial measures.

Occasionally difficulties are had with other groups of rodents in the management of grasslands, although transgressions by these species are connected usually with other agricultural and horticultural pursuits. Among these rodents are the meadow and pine mice, rice and cotton rats in the South and Southeast, woodrats in the Southwest, and—when their numbers increase inordinately—even the commensal house mouse and the attractive little deer mouse become liabilities under certain field conditions. Less is known about the effect on grasslands of such species as harvest mice (*Reithrodontomys*), pocket mice (*Perognathus*), jumping mice (*Zapus*), grasshopper mice (*Onychomys*), and other more obscure forms.

Indirectly the valued beaver may play a part in grassland agriculture through impoundment and flooding of pasture land. The muskrat and its close relative, the round-tailed muskrat or water rat (*Neofiber*), may have the reverse effect through their undermining or perforating of irrigation structures adjacent to agricultural land.

The hares and rabbits may enter

into grassland economy whenever their cyclic increase has aggravated their pressure on the range. This is true of both the black-tailed and white-tailed species that affect the range and cultivated crops, especially when drought or early spring growth has concentrated them in the well-vegetated sections. This is also true of the antelope jack rabbit of the Southwest, but the related snowshoe and arctic hares, though capable of inflicting damage to hay crops at high altitudes or in northern latitudes, seldom become pronounced range-land pests. The diminutive but abundant cottontails, and brush and swamp rabbits, though capable of inflicting damage to young orchards, forest plantings, and truck crops, likewise are not looked upon as outstanding liabilities to range lands or hay crops, and their compensatory value as game animals must always be considered.

Whereas rodents and the associated rabbits have affected grasslands since time immemorial, their role in the ecology of modern agriculture and range use is far from being fully understood. These numerous vegetarian mammals always have been and will continue to be an influence on the range and farm. Their preferences for plant species may vary, however, and in that manner they may exert an influence on the succession of vegetative growth. The result may be for good or harm when judged in the light of man's prevailing range use.

Inseparately associated with the rodent-range complex is the degree of livestock use to which the grasslands have been subjected. This factor in itself may vary the rodent problem, according to circumstances, from one of little consequence to one of transcendent importance. To approach sound range administration and particularly range rehabilitation by giving consideration merely to one of these two elements (rodents or livestock) may be likened to a person, who, for some unaccountable reason, persists in merely dressing a wound without attempting to remove the disease. To carry the simile a bit further, it may be pointed out that, in the opinion of many who have studied such problems, the primary infection usually has its origin and persistence in excessive use by livestock. This has left a lasting wound, which rodent populations may be keeping in a state of constant irritation.

Some present-day conditions of depleted range are the result of many years of overuse. Whatever may have been their basic cause, it is evident that changes in the vegetative pattern did not take place suddenly. Even under abuse Nature often reacts slowly, and now that we are trying to rectify the trends that are against our best interests, we must not overlook the fact that readjustment also may be a slow process. This is particularly true at high altitudes and in arid regions where the struggle for readjustments is confined to short growing seasons or brief periods of rainfall.

Whereas rather rapid readjustments have been observed in experimental plots from which all controllable pressure elements have been excluded, it must be remembered that this drastic remedial treatment is not attainable on ranges that are being used. On most private and public lands there will be a certain degree of range use by livestock and it is under such conditions that we must appraise the role of field rodents and the economy of their control.

Prairie Dogs

The colonial prairie dog has been fought ever since the competition for forage between it and livestock became a matter of concern. More success has been attained in controlling it than any other group of field rodents. Being gregarious, its pressure on the range was emphasized wherever it had decided to occupy the land, and for that reason it was vulnerable to control since survivors would segregate at some point within their original colony. Here they would again become subject to attack.

The economic and ecological role of these mammals under modern agriculture and range use has been the subject of study through the use of experimental range plots and through an analysis of their food by stomach examination.

One of the earlier attempts to appraise the effect of rodent pressure on the range was the study carried out by Walter P. Taylor and J. V. G. Loftfield on the damage inflicted to range grasses by the Zuni prairie dog in Arizona. At the time of the work (1918), the authors stated, "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."

To determine quantitatively the damage done by these rodents to forage grasses, experimental areas were established at three points and their maintenance and appraisal became a cooperative project of the Biological Survey (predecessor of the Fish and Wildlife Service), the Carnegie Institution of Washington, and the Forest Service.

Results of 4 years of study in a wheatgrass forage type indicated that prairie dogs destroyed 69 percent of the wheatgrass and 99 percent of the dropseed (*Sporobolus*), or 80 percent of the total potential annual production of forage. In a blue grama type of range the loss caused by the rodents was computed to be 83 percent of the annual production. From the experimental testimony the conclusion was drawn that "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."

That "the prairie dog has not been shown to have a single beneficial food habit," though doubtless a true statement at the time it was made, is subject to qualification by later studies of the food habits of this quite generally despised field rodent. Some 20 years after the afore-mentioned field studies, Leon H. Kelso, having examined more than 500 stomachs of three species of prairie dogs collected under a great variety of conditions, disclosed that plants of forage or crop value are not the only ones eaten by these rodents. They did, however, comprise more than 78 percent of the food of the three species and wheatgrasses were highest in preference among the grasses. Of the range plants less attractive to livestock but eaten by the prairie dogs are sage, saltbushes, and Russian-thistle.

Taylor's and Loftfield's work on the Zuni prairie dog is worthy of repetition in the case of the black-tailed and white-tailed prairie dogs under range conditions differing from those in Arizona. Not only is there need for appraising more extensively the role of the other species of prairie dogs on which so much has been and still is being spent in control, but experimental procedures on range appraisal have improved since that earlier work. One would not expect that such later studies would materially change the estimate of the prairie dog's direct relationship to forage production but there is reason to believe that important facts in the concurrent use of the range by these rodents and livestock are yet to be disclosed.

Ground Squirrels

The control of ground squirrels has received attention throughout the West, but studies of their life habits and ecological relations have been carried out largely in the West Coast States, particularly in California and Washington. A treatise by Joseph Grinnell and Joseph Dixon on the California ground squirrels brought together for the first time much of the scattered information on life habits and economic status. Greatest emphasis was placed on the Beechey ground squirrel and its close relatives, the Oregon, Fisher, and

Douglas ground squirrels which collectively comprise most of the "'squirrel problem" of the State.

These were problems primarily of crop lands and, later, those associated with the curtailment and suppression of plague. Whereas the ground squirrel in relation to grassland agriculture in the sense of range protection entered the picture under many situations, much of the earlier work was conducted with the view of conserving highly valued crops. These early studies did not include detailed appraisals of the effect of squirrels on the range through the use of experimental plots. Estimates of over-all forage consumption were made by computations based on conservative estimates of the number of squirrels and the quantity of forage each would normally consume.

Whereas this approach is not considered as reliable as the methods used in more recent times, the conclusion reached was: "If the entire range of the California ground squirrel be taken into account and be supposed to consist purely of grazing lands (and so of minimum land value) grazed to their fullest capacity, the squirrels of this species take the place of 160,000 cattle or 1,600,000 sheep. Of course, it is not likely that the squirrels come into actual close competition with livestock in ordinary years; but in extra dry years, such as that of 1917–18, when all the living things which depend on vegetation for support are hard pressed to maintain existence, then the squirrels cannot help but crowd the cattle interests of the country, which are of such vital human importance."

In later years, appraisal of the effect of ground squirrels on the range was given much attention in California, particularly on the San Joaquin Experimental Range where, during the period 1935–46, a series of enclosures confining rather closely regulated numbers of ground squirrels, gophers, and kangaroo rats were studied and the results compared with those obtained on a comparable control area from which all of these small mammals were excluded. Livestock was removed from the area.

According to preliminary findings, the heaviest toll on the forage was exerted in the spring when the digger squirrel population is at its highest. Broadleaf filaree, brome, and fescue grasses comprised the basis of their diet, but as the season advanced and vegetation dried, the squirrels turned increasingly to seeds, acorns, and tarweed. There also was great fluctuation in the abundance and character of their food because of variation in rainfall.

It is axiomatic that the effect of squirrels and other rodents on the range depends strongly on the density of population, which varies greatly from place to place and year to year. E. E. Horn and H. S. Fitch in 1934 computed the number of squirrels in one pasture on the San Joaquin range to be from 12 to 15 per acre. During subsequent years disease was prevalent among the rodents and a steady decline in numbers was noted until 1940, when it was estimated that not more than half the original number of squirrels was present.

In contrast with observations made elsewhere on the reaction of rabbits to intensity of grazing, the ground squirrels on the San Joaquin range appear not to be strongly affected by the extent of livestock use, and it was surmised that factors other than the degree of grazing pressure governed the density of squirrel population.

Although not directed toward an appraisal of the economics of the California ground squirrel, a recently published volume by Jean M. Linsdale outlines many fundamental reactions of this rodent that have a direct bearing on squirrel-grassland relationships. The studies cover the period 1937–44 and were carried out on the Hastings Natural History Reservation near the upper border of an area of grassland at the north end of the Santa Lucia Mountains in California.

A significant fact disclosed is similar to that observed in the case of rabbits; namely, that these rodents show a dislike for areas on which the vegetation is thrifty and tall enough to obscure their normal vision. A 100-foot square plot was created in 1937 as an observational area. At the time it was well populated with squirrels. With the removal of excessive grazing by livestock, vegetative recovery took place and the squirrels, still abundant enough in 1940 to permit adequate observations, decreased in number until in 1943 no squirrels could be found.

Dr. Linsdale commented, "This change has not been restricted to this one spot, but it has taken place generally over the protected parts of the Reservation. . . . It may be necessary to plow the land if we want to study this mammal in the future. . . . The ground squirrel thus exemplifies the notion that each species of animal has a type of habitat in which it survives permanently, but from which it spreads when population conditions are favorable to occupy other areas."

Generalizing on these findings, Linsdale stated: "The practice of agriculture in this region by white men involved changes which favored ground squirrels: the introduction and spread of new plants and an increase in the proportion of annuals resulted for the animals in a greater bulk of green forage in the spring and larger crops of seeds for storage. Repeated removal, by harvest, of the mat vegetation also improved the ground for squirrel settlement by permitting unobstructed daytime visibility and freedom to move over the ground."

It was clearly evident throughout these studies that in many instances the squirrels were so injurious to the cultivated crops that their summary removal was the only answer. It also was apparent that in other instances the presence of the squirrels was a symptom of excessive or unsuitable land use and with its correction squirrels may become less abundant. In fact, their presence was likened to that of weeds that do best on disturbed soil.

An example of the time needed to unravel the answer to some rodent-range relationships is that involved in studies now being conducted on Grand Mesa, Colorado. There, among stands of Englemann spruce at an altitude of about 10,500 feet, are grasslands that have been severely grazed for more than half a century and the original bunchgrass cover has given way largely to one of mixed weed type. The area also is heavily infested with pocket gophers on the control of which much effort has been spent with at best temporary relief following costly operations. Eventually the question arose: Is the control of pocket gophers on Grand Mesa economically sound from the standpoint of range rehabilitation and livestock production?

Pocket Gophers

Since no measurable appraisal had been made of the effect of gopher control on these particular high mountain pastures and no comparison of the benefits against the cost of gopher control had been drawn, a cooperative arrangement was effected in 1941 between the Rocky Mountain Forest and Range Experiment Station of the Forest Service and the Fish and Wildlife Service of the Department of the Interior to determine some of these facts.

Originally, 10 objectives were outlined, but several had to be dropped at the outbreak of the war and others could be carried through only on a restricted scale. One objective was to determine changes in volume, density, and composition of vegetative cover brought about through drastic control of pocket gophers.

The design of the vegetative studies involved four 1-acre plots replicated four times, once in each of four distinct vegetative type areas. Groups of the plots were well spaced over the 7,000-acre area on which gophers were to be generally controlled.

The treatments accorded the plots in each group may be defined by the following terminology: Gophers and cattle present; gophers present, cattle absent; gophers absent, cattle present; and gophers and cattle absent.

Of these, the plot with gophers absent and cattle present was the most significant from the viewpoint of translating experimental findings into range ecology and economics.

This plot most closely resembled the conditions that would prevail on used ranges where gopher control was practiced, a condition prevailing on many privately owned and public lands. Cattle were excluded by fencing; the gophers were removed by trapping and poisoning within the plots and for some distance around them. Unfortunately, the lack of adequate crews during the war to keep the gopher population of the surrounding areas within bounds permitted a certain invasion of the gopher-free plots. Although the removal of cattle from the stipulated plots was complete at all times, the absence of gophers was merely a relative matter which, however, improved as methods for their removal became more effective.

After 5 years of experimental treatment, when yearly clippings and measurements of the vegetation were made, followed in 1946 with a careful statistical appraisal of prevailing conditions, the following deductions were made:

"Analyses to date certainly do not point toward any marked vegetation changes following pocket gopher control. Neither do they reveal any great change due to protection from livestock grazing. However, the Grand Mesa area has been heavily grazed for 60 years, and is seriously depleted. Remnants of vegetation indicate the study area once supported dense stands of tall mountain bunchgrass; but now sneezeweed, lupine, needlegrass, etc., dominate the landscape. Gophers have riddled the area, leaving tons of bare soil exposed. Much top soil has been washed away. It is not surprising that more than 5 years of protection from both the cattle and the gophers may be needed before any prominent changes in vegetation occur."

The conclusions reemphasize that under some conditions of previous misuse vegetative regeneration, particularly at high altitudes, may be exceedingly slow, and the benefits from remedial measures may not become evident short of many years of application. If this proves to be the case when all possible curative measures have been used, it follows that the application of measures of relief singly or intermittently will fall still farther short of attaining the objective.

Because of their excessive and very evident movement of the soil, pocket gophers have been accused of playing an important part in soil erosion and hence range deterioration. When such erosive action has been the result of the undermining of dams or the banks of irrigation canals there is no doubt as to the sequence of cause and effect.

On open range lands, particularly at higher altitudes where gophers often are abundant, full appraisal of interlocking factors may lead to other conclusions. Lincoln Ellison studied the pocket gopher as an instigator of erosion on the Wasatch Plateau in Utah.

The gopher has been considered a factor in the general process of erosion. Its mounds of uncovered soil not only tended downwardly on the slope but they also exposed unprotected surfaces to the force of wind and water. Yet Dr. Ellison was convinced that action of gophers was not a primary cause of accelerated erosion; rather, it stemmed from excessive use by domestic herds, which created surface conditions highly conducive to erosion of all types.

Dr. Ellison found no evidence on the Wasatch Plateau "that tunnels of pocket gophers concentrate overland flow in a degree to create gullies, unless, possibly, abnormal surficial runoff is induced by other causes." Delayed infiltration, the cause of gully-cutting runoff, he learned, cannot be attributed to pocket gopher activities—on the contrary, loosening of and formation of minor irregularities on the soil surface by pocket gophers no doubt increase the rapidity of infiltration.

One of the earlier and more comprehensive appraisals of rabbits in relation to the range was made by Charles T. Vorhies and Walter P. Taylor in Arizona. They approached the problem through field observation, appraisal of fenced quadrats, and the analysis of stomach contents.

Rabbits

From their extensive field observations it became apparent that jack rabbits were not most abundant where the grass was best. The antelope jack rabbit (*Lepus alleni*) appeared in greatest numbers under conditions of moderate grass growth and was less abundant in the better, as well as in the extremely poor range types.

The California jack rabbit (*Lepus californicus*) was most common in the poorly grassed semidesert type. The men pointed out that the reasons for these findings were not entirely clear but they stated that jack rabbits may be "more partial to some of the weeds and herbs of the secondary successions that accompany overgrazing, than to an exclusive diet of climax grasses." They noted the possibility also that like so many rodents, the jack rabbits prefer open country with high visibility to areas where the grass prevents seeing far.

From their experimental plots Vorhies and Taylor deduced that rabbits and rodents were mainly responsible for holding the vegetation in a preclimax condition and the evident fondness of rabbits for grass, when available, greatly favors the encroachment on grass ranges of mesquite, cholla cactus, weeds, and other species. They also pointed out that jack rabbits exerted their most telling effect on the range during drought, a time when control operations were stressed.

More recently, R. L. Piemeisal made observations in Idaho on the effect of rabbits and rodents on abandoned lands that had been subjected to severe treatment through plowing, burning, or overgrazing.

A study conducted to disclose the history of plant succession on these abandoned fields in relation to the beet leafhopper revealed that even after all livestock had been removed there were variable and unexplained sequences in plant succession.

Experimental plots that had been free of fire, plowing, and all grazing by livestock, but accessible to rabbits, followed no uniform pattern of recovery even after 6 years of such protection. The establishment of downy chess, which was sought to combat the beet leafhopper, was irregular at best. However, within quadrats protected from rabbits and livestock, plant succession followed a regular course and finally terminated in stands of downy chess. Whereas some of the smaller rodents may have played a part in plant destruction, especially after a dense stand of chess was established, ample proof was disclosed of the persistent pressure applied to these severely abused lands by the jack rabbit population.

Significant in the history of the experimental plots was that, beginning in 1939 and continuing to the end of the experimental period (1944), a pronounced reduction occurred in the number of jack rabbits in the region.

This resulted in comparatively slight destruction of vegetation during the latter part of this period and a downy chess cover developed on the outside, although not to such a pronounced degree as inside the plots. What part these periodic reductions in rabbit populations have in the ultimate recovery of depleted ranges and what part they may have played in the pre-Columbian history of western grasslands is a matter for conjecture and a worthy subject of further study. The corollary of this, the need for control during peaks of rabbit population on range lands that have suffered depletion, requires little demonstration, provided, however, the economics of the particular situation indicate its soundness and if pressure from livestock also is kept within recognized range capacity.

Another area on which significant experimental work has been done to reveal the role of rabbits and certain rodents on southwestern ranges is the Jornada Experimental Range and the College Ranch in New Mexico.

On the College Ranch, exclusion plots were established first in 1936 on land from which livestock had been removed a year earlier. These plots were of three types, a small rodent-rabbit-livestock exclosure, a rabbit-livestock exclosure (open to small rodents), and a livestock exclosure (open to rabbits and small rodents). There also was a control area to which all of these mammals had access. After a few years significant vegetative changes had taken place in the plots protected from the feeding of rabbits while at the same time the areas that had been exposed to rabbits but protected from livestock showed little recovery from their previous depleted condition.

These facts led to the conclusion that severely depleted ranges may require relief from pressure from both livestock and small mammals before recovery may be effected.

Kangaroo Rats

Of the four groups of field rodents I have discussed, the kangaroo rats are the least important economically but even they are an element to be reckoned with in the Southwest, particularly during seasons of drought when pressure on the range becomes acute. Work by Charles T. Vorhies and Walter P. Taylor on the life history of the banner-tailed kangaroo rat (*Dipodomys s. spectabilis*) has brought together much of what is known of these odd rodents.

This rodent does not hibernate. It stores food against the time when the range becomes parched. These storage periods are during the growth period of spring and again in late summer and fall. Even so, during years of low vegetative growth these resourceful rodents may face starvation and, of course, it is in those same critical years when their effect on the range is most pronounced.

The fact that much of the stored food of the kangaroo rats consists of seeds of plants makes their effect on the range more pronounced than that exerted by species that feed largely on the vegetative parts of the growing plants. Among the seeds eaten are those of some of the more important forage plants of the Southwest, particularly grama and needlegrasses. In quantity this stored food varies greatly, ranging to more than 12 pounds.

Vorhies and Taylor concluded that in ordinary seasons the banner-tailed kangaroo rat was not of great economic significance, but that during periods of extreme drought it may be of critical importance from the standpoint of the carrying capacity of the range.

Horn and Fitch in California found that, in contrast with the banner-tailed kangaroo rat, the Heermann kangaroo rat did not store food so extensively—no doubt the direct result of an ample supply of food yearlong. During the growing season much of the vegetative parts of range plants was eaten, but during the dry season the food consists almost entirely of seeds. Soft chess and filaree, common foxtail, and fescues are regular items of diet.

Great fluctuation in rat numbers was observed over a period of years. Counts of only 2 or 3 to the mile of roadway were observed in the spring of 1937; similar counts on the same area during the previous fall revealed as many as 75 to the mile. This wide fluctuation in numbers, as yet not fully explained, had much to do with the economic significance of these rodents on the California range.

That kangaroo rats may exert an effect on the range quite at variance with the expected has been pointed out recently by Albert C. Hawbecker in California. Confirming earlier observations by Joseph Grinnell, he recorded that in the San Joaquin Valley the giant kangaroo rat (*Dipodomys ingens*) occupied areas (to which the name of "precincts" was given) which were well covered with a healthy growth of filaree and red brome. Beyond the limits of the precincts these two plants were much less thrifty. Close study of the prevailing conditions led Dr. Hawbecker to conclude that the better growth was due to the agitation of the ground surface by the rats, resulting in better water penetration and possibly the formation of a more effective seedbed. This cultivating action of the kangaroo rats led to a fivefold increase of the two plants and they remained green longer.

In Conclusion

The problems arising in this country from the management of prairie dogs, ground squirrels, pocket gophers, and kangaroo rats, and the upsurging populations of other rodents and jack rabbits are endless in their ramifications. To appraise the economic implications has taxed the abilities of our best ecologists. Even when the analysis has been restricted to a single species, confined to a uniform environment, the results have often left the investigators confronted with many facts still unknown and indeterminable.

On costly and highly developed agricultural lands rodent control is seldom a matter for debate; the economics of the matter usually is plain. On open range lands, some of very low value, we are often confronted with decisions which are harder to make and for which adequate experimental data based on modern conditions of grassland use are lacking.

There is little question but that most of our present rodent-range problems have stemmed from some earlier abuse of the vegetative cover. It is also recognized that some of these depleted ranges on which the power of vegetative regeneration has been severely lowered may actually be kept in a state of perennial suppression by the resident populations of rodents or rabbits. Under such conditions rodent control presents an intricate problem in economics as well as in range management, and the correct answer will rest with the factors in each case.

One consideration, however, appears obvious: Rodent control alone, without provision at the same time for reducing livestock pressure and, where feasible for reseeding or otherwise aiding the depleted range, may be merely a temporary palliative.

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HOW TO CONTROL NOXIOUS PLANTS

JOSEPH F. PECHANEC, CHARLES E. FISHER, KENNETH W. PARKER

NOXIOUS range plants rob the livestock industry in many ways. In Texas alone, the annual loss from mesquite and juniper has been estimated to be 20 million dollars.

Some, like big sagebrush, mesquite, or oak, are shrubby or treelike, produce little forage, and obstruct grazing use. Other noxious plants, such as cheatgrass and snakeweed, produce poor forage and lower grazing capacity.

Poisonous plants such as larkspur, orange sneezeweed, and bitterweed sometimes cause such serious losses among cattle and sheep that some kinds of livestock must be taken off the range.

Still other noxious plants, like dry cheatgrass where it is predominant on a range, have been estimated to increase the fire hazard 500 times.

Against all noxious plants the charge