Rodent Control on California Ranges

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BECAUSE the grazing resource of this country is important to us all, it is desirable that those who are interested in conservation or range management acquaint themselves with some of the interrelationships of rodents and grazing on rangelands, and to determine for themselves the value of existing control measures designed to reduce or eradicate these animals locally. Few people believe that all field rodents should be protected; on the other hand, not many demand the complete extermination of any species of rodents. But there is considerable difference in current viewpoints on the degree of either protection or control that is desirable in different localities. As a result of this disparity in opinions, it is imperative that each situation be considered independently. We must avoid generalizations such as "All ground squirrels should be destroyed," or "The organized trapping or poisoning of any of these animals must be prohibited."

Material in this article is largely based on observations and data stemming from investigations conducted at the San Joaquin Experimental Range, O'Neals, California, maintained by the U. S. Forest Service in cooperation with the University of California (Hutchison and Kotok, 1942). The article has been prepared at the request of the editor, Joseph F. Pechanec.

As a result of the combined efforts of many investigators since 1934, including personnel from a number of departments in the University of California, U. S. Forest Service, U. S. Fish and Wildlife Service, California Department of Fish and Game, and others, the relation of rodents to the fauna and flora of this foothill rangeland is perhaps as well understood as any comparable area. There are more than 60 publications from the Range pertaining to zoological studies and about the same number on livestock operations and forage investigations.

Rangeland Concepts

Judgment as to the propriety of controlling rodents is a relative matter, for species that become a household or agricultural pest to one person may provide another with recreation or sport. For example, most people, including farmers, find pleasure in seeing ground squirrels on top of fence posts along roads, unless one finds their presence resulting in a depletion of his barley crop. A pocket gopher pushing its excavated soil into a mound is fascinating to observe, unless the scene is in the middle of one's lawn. To some, the main value of ground squirrels and jack rabbits is as targets for their .22 rifles. This disparity in viewpoints holds for other animals as well. It is conceivable that some city and suburban nature lovers may want all wild animals protected—except, of course, ants and mice that get into their houses, pigeons and starlings that deface their buildings and sidewalks, or moles and gophers that take up residence in their lawns. Thus, it is clear that with rodents and other animals which at times become pests, it is necessary to weigh the evidence carefully before passing judgment, and to be tolerant and considerate of other people's relation to the situation.

Some confusion about different phases of rodent natural history stems from a widespread misunderstanding of the term, the balance of nature. Too often the term is thought to imply that there is some mysterious balancing force which maintains a sensitive and uniform population density of each species in a community. On the contrary, there is a regular oscillation in abundance of species; but, once the so-called natural balance becomes established, the fluctuations only occasionally bring about an extermination of a species, even locally, unless man is participating. Man, however, is part of the current balance as his influence is felt in varying degrees throughout the land and on much of the sea. He interferes with the balance by altering the oscillating pendulum and creating new situations that require additional adjustments between species. This alteration of the environment provides conditions suitable for new arrivals, causes the local extermination of others, and frequently changes the population density of many species, either by permitting them to increase or by bringing about a reduction in individuals. There is no chance of establishing the original climax types (actually man is trying to develop better types) and the former balance, unless man is completely removed. We approximate the former status in our national parks and primitive areas (although we extinguish natural lightning fires), but cannot begin to accomplish the preservation of original plants and animals on land where man lives, travels, or produces food and other materials. In fact, as the human population pressure increases it becomes necessary to alter the former balance more and more, in order to establish a set of conditions which will be even more responsive to man's needs.

A few examples of game animals will be used to show how man affects the population density of other kinds of animals as well as of rodents. Most of the former marsh habitats of ducks in the Sacramento Valley have been drained for agricultural purposes. On the other hand, much of the Pacific Flyway has been maintained because man plants large sections of this land to rice. In the same area agricultural development has brought about a considerable reduction in valley quail. But the introduced ring-necked pheasant has taken its place as a successful game bird on these lands, which have been converted to rice and other cultivated crops. The mourning dove is now more abundant in the state than it was before extensive agricultural development took place (Leopold, 1951). Too often it is overlooked that man is responsible for great increases in numbers of some kinds of animals—as well as reductions in density of other forms—whether they be game animals or those species that often become pests. Remedial measures are frequently necessary to increase the number of desirable species unfavorably affected by man's influences, or to reduce the increased numbers of the undesirable forms.

It is important to note that an increase in certain kinds of rodents is likely to occur whenever land is used, and *not* just when it has been abused by man. Plants are basic items of animal food chains and, since grazing and cultivation alter the composition and density of forage, a change in the fauna inevitably follows land use. On cultivated land all of the native forage is often lost, and a dense stand of one or more alien plants is established. But even light to moderate degrees of grazing will cause some and often a considerable change in the original plant cover.

Many agricultural practices indirectly bring about an increase in abundance of certain kinds of wild animals. The planting of alfalfa or irrigated pastures often causes a manyfold increase in numbers of pocket gophers and meadow mice but at the same time eliminates a number of other rodent species. The increased density of these two kinds of rodents does not indicate either that the land has been abused or over-grazed; nor does it indicate that it is a waste of money to control the pests, for many a farmer has lost his crop by failing to control these animals when they became too numerous on otherwise properly managed land. Likewise, there is no reason livestock should not be raised on ranges where grazing stimulates an increase in numbers of ground squirrels and other rodent species. If a gopher should happen to move into our bed of tulips, I doubt if any of us would consider planting more tulips so that there would be ample for our needs as well as those of the gopher. On the contrary, we would more likely become greatly upset until the rodent was poisoned or trapped. Similarly, why should a rancher reduce his herd whenever rodents increase? After all, such high populations of rodents frequently would not be able to exist if they were not so well adapted to grazed ranges. If it were shown that a particular species would not become a pest unless the land was grazed too closely, this would of course be another thing. However, it is usually a relative matter in such instances, the rodent or rabbit species involved merely becoming more numerous the closer the land is grazed. And the presence or absence of certain rodent or rabbit species is not a good indicator of range condition, for wildlife numbers fluctuate greatly from year to year because of other causes than grazing intensities.

Sometimes it is difficult to know when control of a rodent species, such as ground squirrels, is justified. On most cultivated lands it has proved necessary to eradicate ground squirrels to protect crops; otherwise they become so numerous that little if any of the crop is left to harvest. If a squirrel or gopher burrow diverts precious irrigation water, an individual rodent can be costly. Not only in cultivated areas but also on ranges, it is becoming increasingly evident that livestock men cannot afford high squirrel populations, and that often it is good conservation and an economically sound practice to control these animals where they have locally become pests or "animal weeds."

The opinions most of us have regarding the beneficial or detrimental value of rodents and also predators, as well as other wild animals, are essentially determined by the manner in which the animals affect our livelihood or compete with our recreational or esthetic interests. Opinions on the interrelationships of rodents and their predators on grazed ranges are often expressed too strongly, apparently because little data are available. This is partly due to the fact that such data are not easy to obtain. The less the amount of evidence there is regarding conservation subjects, however, the more biased and emotional we seem to become over the issues. In fact, at present the "armchair" research in the literature about rodent control on rangelands greatly exceeds that based on field data.

For the protection of agricultural crops in California, ground squirrels, pocket gophers, meadow mice, rabbits, kangaroo rats (Storer, 1949), and rats and mice (Storer, 1952) all require control measures. Where it has been demonstrated that disease-bearing rodents are involved in close proximity to human populations, the numbers of ground squirrels, chipmunks, and peromyscus are also reduced by control operations. Most rodent control baits consist of grains and strychnine, Compound 1080, zinc phosphide, thallium sulfate, or Warfarin.

Ground squirrels receive considerable attention in California because of their economic significance, although effective control measures now place squirrels second to pocket gophers as California's most important field rodent pest. The Annual Report of the California Department of Agriculture (40: 228–237) states that, in 1951, various official agencies in the state treated almost four million acres in economic control of ground squirrels. Approximately $300,000 was expended by all agencies on squirrel control, which amounts to about 7.5 cents per acre. The cost of the predator control over 56 counties, which included 6,252 coyotes, amounted to $385,000. For purposes of comparison, the annual grazing fees on this land during the same year ranged from $2.50 per acre on the better but still untilled ranges to one dollar per acre on steeper, rockier, brushier pastures.

Human population pressure has destroyed most of the original wild lands and forced us to manage rodents along with predators and game as a branch of agriculture. One might say that rodents and other kinds of wildlife are not really allied to agriculture, but rather a competitor with it. Many, in fact too many, examples of such competition can be found. Deer may damage vineyards, orchards, or even pasturage. Pheasants may destroy tomatoes. Ducks often deplete yields of rice and sometimes compete with lambs for pasturage, and even locally do considerable damage to vegetable crops. But many of the more recognized forms of agriculture also compete with each other. Livestock have to be fenced from row crops; chemical sprays occasionally are blown astray and damage other crops or kill bees being used for pollination or honey production. It is merely a matter of proper management and awareness of the economics of the situation, rather than competition between game and other types of farming. But, since there are forms of wildlife, such as rodents, that frequently become pests to agriculture, it is even more necessary to regard wildlife management as a division of agriculture, just as economic entomology, plant pathology, and weed control are intimately associated with agriculture.

Forage and Soil Relationships

Constant changes and adjustments between the different factors of environment, accelerated by grazing, result in a considerable upset in the former balance of nature. Selective pressure by herbivorous animals has undoubtedly operated in the balance before the advent of man by preventing more palatable forage species from evolving naturally on ranges. The same type of selection by wild animals of the more preferred vegetation is operating today. For example, in the interior of California it usually is considered impossible to grow dryland alfalfa unless pocket gophers are artificially controlled. (The reason gophers are not quite so serious with irrigated alfalfa is that flooding destroys many individuals, and the greater forage yields will support more gophers.) On rangelands, where attempts are underway to artificially establish more palatable forage species, wildlife frequently destroy many of the alien plants (Howard, 1950). The animals are especially attracted to some of the introduced perennials after the annual plants have become dry if the seeds and seedlings survived their depredations.

How does cattle grazing at the Experimental Range alter the swing of the pendulum in the balance of nature to such an extent that some species of wildlife increase in numbers and become pests? This happens partly because livestock prefer certain species of forage plants to others. This results in an increased survival of the less desirable plants. But a more important reason is that there is less litter on grazed ranges, which in turn favors germination of broad-leafed plants, which are more desirable to rodents.

Experiments at the Range have shown that the quality of forage, which is essentially an annual-plant type, deteriorates when completely protected from grazing. If ungrazed, the forage cover tends to progress for an indefinite period through annual grass stages to become dominated by tall grasses, such as ripgut brome (*Bromus rigidus* Roth) and slender wildoats (*Avena barbata* Brot.) (Talbot and Biswell, 1942). These species are coarse and relatively unpalatable to livestock. "Under light to close utilization by cattle, an earlier stage of succession is maintained with a more desirable mixture of species, including clovers and filarees" (Bentley and Talbot, 1948). Observations on the natural area at the Range, which has not been grazed by cattle since 1934, indicate that rodents and other wildlife are unable to maintain this earlier stage of succession without the assistance of cattle except on low-productive sites of shallow soil and around the margins of brush plants.

Not only does grazing by livestock affect the forage composition, but it also brings about conditions that result in an increase in number of squirrels and some other kinds of rodents. Linsdale (1946) found that ground squirrels disappeared after an area was protected from grazing but remained on adjacent grazed pastures. They appear to do better on grazed ranges also at the Experimental Range. Regardless of whether grazing is light or close, alteration of plant species and density of the forage cover by grazing often leads to an increased ground squirrel population. And this increase in number of squirrels may compete seriously with stock for forage. Some rodents respond differently, on the other hand, as there are fewer pocket gophers (*Thomomys bottae*) and almost no meadow mice (*Microtus californicus*) in pastures grazed by cattle as compared to areas protected from grazing at the Experimental Range. But the deermouse (*Peromyscus maniculatus*) and kangaroo rat (*Dipodomys heermanni*) seem to thrive best on grazed areas (Quast, 1948). Quast also found that the brush mouse (*Peromyscus boylei*) was least disturbed by cattle grazing. The species that were unfavorably affected or reduced in numbers by grazing were pinon mouse (*Peromyscus truei*), harvest mouse (*Reithrodontomys megalotis*), and possibly two species of pocket mice (*Perognathus californicus* and *P. inornatus*). Reynolds and Haskell (1949) found that the highest population of Price and Bailey pocket mice occurred in ungrazed stands of perennial bunchgrass. Others have shown elsewhere that grazing often brings about an increase in the numbers of certain rodents and rabbits (Bond, 1945; Buechner, 1942; Grinnell and Dixon, 1918; Kalmbach, 1948; Moore and Reid, 1951; Norris, 1950; Parker, 1938; Phillips, 1936; Reynolds, 1950; Taylor, 1930; Taylor and Lay, 1944; Taylor and Loftfield, 1924; Taylor *et al.*, 1935; and Vorhies and Taylor, 1933).

Just how rodents compete with the livestock for herbaceous forage is not entirely known. Evidently it is not merely the amount of food they consume, but rather the type of food and the time of year when they take it. A stomach full of seeds certainly is not equivalent in food value to the amount of forage such seeds could have produced if they had been allowed to germinate and grow to maturity. Annual plants are prolific seed producers, but rodents may still reduce the forage yield of annuals by depleting the seed supply in numerous small areas that are only an inch or two across. Also, rodents and most other forms of vertebrate wildlife feed extensively on newly germinated forage. And again, the seedlings it takes to fill a stomach are nowhere near equal to the amount of forage that would be produced if those plants were allowed to mature. After many of the plant species once get a good start they can withstand a certain amount of cropping, but it appears that rodents thin and stunt excessively, hence reducing the total yield. Perhaps the rodents kill many of the plants by cutting below their growing points. Branson (1953) has shown that "... in general, the grasses in which the growing points reached a height that permitted their removal by grazing decreased as intensity of utilization increased, but grasses with growing points at the ground level usually increased." Rodents can graze at the ground surface.

Ground squirrels exert the greatest competition with livestock for herbaceous forage at the Experimental Range from shortly after the forage germinates until the peak of the growing season, for then there is surplus feed for all animals (Fitch, 1947 and 1948b; Horn and Fitch, 1946). Fitch and Bentley (1949) found that six ground squirrels caged in a one-half-acre enclosure annually reduced the yield of forage an average of 1,058 pounds per acre of dry material, more than ten times the amount the squirrels might actually have eaten. When they calibrated how much forage each ground squirrel, pocket gopher, and kangaroo rat ate or prevented from maturing in the enclosures, the data suggested that the natural field population of these three species which occurred in other pastures on the Range might be reducing the total annual herbaceous crop by more than one-third. To verify these findings not only by forage clippings on grazed areas but also in pounds of beef produced on poisoned and unpoisoned pastures, an additional seven-year, cooperative study on a pasture scale was started at the Experimental Range in 1948.

More studies are needed to determine the advisability of rodent and rabbit control on different grazed ranges (Fichter, 1953), and to determine whether it is a valuable conservation practice that should be accelerated in many areas where control is not now utilized in the range-management operations. Anyone interested in the animal ecology of rangelands cannot help but wonder if there are not some beneficial effects of rodents on ranges. From a practical viewpoint, however, their value can hardly be considered significant in the light of the known facts. Unfortunately, it is difficult to test experimentally the effects of burrowing rodents; it is easier to point out their shortcomings. Nevertheless, the relationships of rodents to soil cultivation, water percolation, soil fertility, soil aeration, destruction of insects, and control of weeds is at least of academic interest to most individuals concerned with range problems.

In California pocket gophers are the chief burrowing rodent. They probably excavate more soil annually than all the other 88 or so California species of rodents combined. Ground squirrels, even though their burrows are more conspicuous than those of gophers, usually occupy old established systems and dig relatively little. With regard to the burrowing activity of these and other rodents, it appears that particularly plant roots, and the myriad of bacteria, protozoans, worms, crustaceans, arachnids, insects, and other small animals in the soil accomplish a more desirable form of tilling than rodents. From a geological standpoint, the pocket gopher may actually have a prior claim to the land where he is now so unwelcome. In his never-ending burrowing beneath the surface of the earth he has contributed to the building up of great agricultural valleys, such as the highly productive San Joaquin and Sacramento Valleys in California (Grinnell and Storer, 1924). On the other hand, he has contributed to the erosion of many acres of rich farm lands and man is also endeavoring to stop erosion of mountains.

The principal manner in which the burrowing activity of rodents seems to increase percolation of water is by channeling or draining the water through one of their burrows. In most instances when the surface runoff flows down burrows, it adds little additional water to the surrounding soil but reappears at some lower elevation. This condition too often results in extensive subsurface erosion, followed by cave-ins of the ground surface and the formation of gullies (Crouch, 1942; Gunderson and Decker, 1942; Longhurst, 1940). Many gullies in California on both tilled and untilled lands originated as a consequence of water being channeled down squirrel or gopher burrows. After such rodent tunnels become enlarged, the tops eventually cave in and deep gullies often result. It is important to note that this kind of erosion occurs under dense stands of herbaceous forage and is not necessarily brought about by grazing. The removal of woody vegetation on some soils, unaccompanied by rodent control, may promote these conditions. Once a gully gets started, it may be extended farther up hill by subsequent rainstorms. The above is not meant to imply, however, that rodent burrows are responsible for the formation of all gullies. Many result from other causes, such as cultivation of too steep slopes, automobile tracks, and livestock trails.

Forage ordinarily destroyed by squirrels, gophers, and other native species, if protected and made available to livestock, would be returned to the soil as fertilizer in much the same manner as by rodents. Many visitors to the Experimental Range notice the rank herbaceous growth in the vicinity of rodent burrows and harvester-ant mounds and, therefore, wonder if it would not be desirable to have more of these animals. The entire picture is difficult to show, however, for one cannot see all the potential forage that these animals have destroyed elsewhere to account for the concentration of waste products of seeds and other plant parts about the entrances of their homes. Likewise it appears questionable that rodents can be too important in controlling objectionable insects or weeds, but careful observations on these matters should be continued.

In an experiment to test the need for ground squirrel (*Citellus beecheyi*) control at the San Joaquin Experimental Range when feeding supplements to livestock, 900 pounds (2,180) of surplus potatoes were scattered on the range to sun-dry before being fed to the cattle (Howard and Wagnon, 1951). Within 18 days approximately 18 squirrels had removed every potato. Few potatoes were lost in a control pasture, however, where the squirrels had been poisoned.

The game manager as well as the farmer is interested in ground squirrels. In the valley quail investigations at the Range, Glading (1938) showed that ground squirrels destroyed more quail eggs than all other predators combined.

When he controlled squirrels, their chief predator, he demonstrated that a greater harvest of quail by sportsmen was possible. If quail are not being hunted, however, squirrel control is of little value in quail management, because any additional birds resulting from squirrel poisoning usually will disappear from other causes anyway. Increased production resulting from squirrel control (properly prepared poison squirrel bait will not harm quail) is of greatest value when the annual crop of birds is being harvested by man, as then the hunter can shoot the increased quail production resulting from squirrel control. With an increase in take of quail and control of squirrels, there is an increase in production of the birds.

Predator Relationships

A logical presumption regarding the question of reducing the number of ground squirrels might be to leave coyotes unmolested so that they would control the squirrels. Unfortunately this does not happen in California. Instead of uncontrolled coyote populations keeping ground squirrels at such a low level that they are no longer pests, it appears that squirrel populations which build up following grazing have merely extended the range and increased the number of coyotes, At least, according to Grinnell *et al.* (1937), certain ranges of coyotes in California have been extended by agricultural practices. These predators may feed extensively on ground squirrels, but they take only a fraction of the annual increase; the remaining are eliminated by various factors, including many other kinds of predators. And in areas where predators are not controlled, the combined influence of all the predators does not keep the density of squirrels at a low level on either cultivated fields or rangelands. Enough squirrels to compete seriously with agricultural interests often survive even the combined effects of all the different kinds of predators.

It is suspected that coyotes may exercise a greater influence on jack rabbit numbers than on squirrels, although there are no data to support this view known to the author. As with squirrels, the population of jack rabbits often increases when an area is grazed or put to certain other agricultural purposes and must be controlled.

Studies carried out at the Experimental Range provide some interesting information about the coyote-ground squirrel relationship. The material is not being presented as an example of the merits of coyote control, but rather to show what happened to the squirrel population when the coyotes were controlled. In 1936, when it was found necessary to reduce the coyote numbers on the Range to protect the calf crop (Fitch, 1948a; Wagnon *et al.*, 1942), 35 of these predators were removed. About 30 were trapped during each of the next three years. During 1939–1940 and 1940–1941 thirteen coyotes were removed each year. On subsequent years only a few individuals have been taken. The low population of coyotes presumably is now largely due to their being killed from eating ground squirrels that have been poisoned with 1080. But before the effective reduction in number of coyotes occurred, Fitch (1948b) estimated that about one coyote per 300 acres was present in 1939–1941. (It would make little difference, as will be pointed out in the discussion to follow, even if there had been several times this number of coyotes.) Fitch also showed that ground squirrels (*Citellus beecheyi*) made up about one-third of the diet of the coyotes.

Up to this point the data give the impression that the partially reduced population of coyotes existing on the Range in 1939–1941 might have been important in regulating squirrel numbers; but it happens that the same ground squirrel population had a potential annual increase of about 5.8 squirrels per acre (Fitch, 1948b). Using Fitch's information as a basis, the coyotes were removing only 0.4 of the 5.8 squirrels or only about seven per cent of the annual increase. If there had been several times as many coyotes, they still would have destroyed only a small percentage of the squirrels. The red-tailed hawks, on the other hand, were removing almost eight per cent. Fitch found the rattlesnake to be the most important predator of ground squirrels at the Range. They were annually taking about two squirrels per acre or 34 per cent, which is five times the amount removed by the coyotes.

Even the combined effect of the three most important predators of ground squirrels at the Range—rattlesnakes (Fitch and Twining, 1946; Fitch and Glading, 1947), red-tailed hawks (Fitch *et al.*, 1946), and coyotes (Fitch, 1948a)—accounts for the destruction of only one half the annual increase of squirrels (Fitch, 1948b). Additional predators, disease, and unknown factors apparently were responsible for the disappearance of the remaining number of these rodents. It is obvious that if predators were able to eliminate completely one of their prey species, such prey would naturally become extinct. And if predators were able to keep their important prey species at low population levels, few predators would be able to survive. Coyotes merely remove some of the surplus individuals of their favored prey species. When conditions change and favor a prey species, both the prey and its predator species increase in number. The prey animals would of course become even more abundant if there were no predators, as has happened in Australia and New Zealand. But what the author wishes to emphasize is that even though the predators are a help, they often are not adequate, and artificial control of rodents is still necessary.

After the coyote population at the Experimental Range was materially reduced and maintained at so low a level that none or only a few could be trapped each year instead of 30 or more, there was no corresponding increase in squirrels. Instead, during some years ground squirrels and especially kangaroo rats and cottontails actually decreased appreciably in numbers. This reduction in the rodent and rabbit population density was not the result of coyote control, but is presented here as an example to show that other environmental factors are more important than coyote numbers in determining the density of squirrels present. Fitch (1948b) writes with regard to the Range, "... the available evidence suggests that coyote predation is not a determining factor in the trends of ground squirrel, cottontail, kangaroo rat, and gopher populations in this type of habitat, despite the fact that these small mammals comprise the bulk of the food and are taken in great numbers. Relations with range cattle are generally harmonious, but individual coyotes, which learn to kill small calves, may cause serious damage at times."

With regard to the coyote-ground squirrel relationships on the San Joaquin Experimental Range, the size of the coyote population is probably more dependent on the number of squirrels present than vice versa. This is because ground squirrels make up about one-third of the diet of the coyotes—a major part of their food—whereas the coyotes destroy but a small fraction of the annual increase of squirrels. Coyotes, in areas the writer has seen, cannot hold the density of ground squirrels at so low a level that they will not compete seriously with man's interests. In most instances the squirrels have become numerous because of man's activities; hence they need to be controlled as do weeds in a garden. And the ground squirrel, as an agricultural pest in California, certainly is not the result of the coyote-control measures that have been practiced. This should not be interpreted as meaning that the coyote and other predators do not help man check rodent numbers, for they do provide valuable assistance, especially where man does not have sufficiently effective means of control for a particular rodent or rabbit species. They are not especially helpful with ground squirrels, however, for man has developed control methods for these animals that are more effective than predators, much as flyswatters and chemicals are used to control flies instead of just encouraging more birds and other predators of flies. There is no evidence known to the author to support the view that rodents and rabbits serve as buffers between certain predators and domestic animals, except for the brief period following the initial effective control of the rodents or rabbits that served as prey species.

There is a need of revaluation of the effects and methods of predator control in California and elsewhere. If the objectives of control were clarified and supported with an unbiased factual study over a number of years, there surely would be instances where more effective control measures could be adopted and others where certain practices could be modified with a saving of funds and better results. The subject of rodent and predator control can afford to be reexamined from the viewpoints of not only livestock and game interests but also those of conservation organizations which are attempting to preserve wildlife for its own sake. Such a study should be rewarding to conservationists as well as to agriculture and sportsmen.

In conclusion, our goal is good land management through maximum sustained yields from rangelands both in livestock and game. Original fauna and flora will have to be preserved in places such as national parks. Since man alters the balance of nature when he uses land, he has to introduce remedial measures to counteract the undesirable consequences of his disturbance of the former balance. An important step toward initiating these measures would be to eliminate the emotional stigma frequently associated with the words poison or control, as rodent control is often a good *conservation* practice to be adopted on ranges. Is it not possible that when we strongly oppose the artificial control of certain kinds of rodents and rabbits on rangelands in the interest of conservation, we are our own worst enemy? Another barrier to a more rapid acquisition of answers to the relationships of rodent control to land management stems from those few who are so dogmatic that they will not tolerate organized rodent or predator control anywhere. They object to control even though man may have been responsible for causing the increased numbers of animals that require abatement. It appears that by such zealous attempts to improve ranges by protecting all wild animals, we fight against the very thing we think we are fighting for. Basic research on the fundamental biological functions of animal ecology of rangelands is sorely needed, but a common impediment stems from a hesitation by some to be associated with worthy but "practical" problems in control. Instead of criticizing without evidence current range rodent control practices, let's be constructive by encouraging more research to put the subject on a better factual basis and to reduce the emotional convictions to a minimum.

Summary

Much of the material under the section on range concepts pertains to a philo-

sophical interpretation of rodent control on rangelands.

Plants are basic items of animal food chains and, since cultivation or even light to moderate degrees of grazing alter the composition and density of forage, a change in rodent populations inevitably follows land use. Some species decrease in density and even disappear locally, while others, such as ground squirrels, frequently increase in numbers and seriously compete with livestock for forage.

Sometimes pocket gophers or ground squirrels become abundant on slopes and cause gullies when water gets channeled down their burrows, causing subsurface erosion followed by cave-ins of the ground surface. Plant roots and microorganisms perhaps do a better job of soil cultivation than do rodents.

A partially controlled population of coyotes at the San Joaquin Experimental Range, one-third of whose diet consisted of ground squirrels, actually only killed about seven per cent of the annual increase of squirrels. Rattlesnakes accounted for almost five times as many.

In most instances, the type of research needed for zoological range-management problems is basic ecology or natural history, but whenever agricultural or practical interpretations are drawn from such studies the investigations are too often demurred. Consequently, teachers and graduate students alike are not attracted to this important field of research.

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RANGE PLANT IDENTIFICATION CONTEST

At the Seventh Annual Meeting of the American Society of Range Management in Omaha, Nebraska, January 26 to 29, 1954, a range plant identification contest will be conducted similar to the contests at each of the past three meetings.

Competition is becoming tougher; the school producing the winning team this year will have to be on its toes.—*H. W. Cooper*, Chairman, Contest Display Committee.