

and mammalogy. The response of the students for classes of this type exceeded all expectations and he found himself swamped with students who were eager to enroll in his classes.

In the mammal classes George taught the students the rudiments of classification, ecology, field collecting techniques, and skin preparation, and in spite of gas rationing, tire rationing, and other wartime obstacles, he managed to get into the desert and collect quantities of kangaroo rats so that his students could learn to prepare mammal skins. George Willett's personality coupled with his vast field experience soon made the bird and mammal classes the most popular of the museum group—and once again we see a glowing example of his ability to understand and endear himself to those with whom he came in contact.

George Willett's contributions and influence in the world of science have terminated far too soon, but his was a full life overflowing in experience and wilderness adventure. In the history of American ornithology, his name stands as one of the great. What he did in American mammalogy, while being significant, is far overshadowed by what he influenced others to do, and his guidance and teachings will be reflected in the mammalogy of the western United States for years to come.

Los Angeles County Museum, Exposition Park, Los Angeles, California.

A STUDY OF THE DEER AND ELK HERDS OF ROCKY MOUNTAIN NATIONAL PARK, COLORADO

BY FRED MALLERY PACKARD

Among faunistic studies undertaken by the writer for the National Park Service in Rocky Mountain National Park, Colorado, between March 1939 and December 1940, was a survey of the status and condition of the herds of Rocky Mountain mule deer (*Odocoileus h. hemionus*) and elk (*Cervus c. canadensis*). This paper is based upon reports made to the National Park Service at the conclusion of the investigation.

THE RANGE

In summer, the deer and elk inhabiting the park are to be found scattered throughout the area, especially at the higher elevations where excellent forage is abundant. In winter, however, they concentrate mostly in the lower meadows and ponderosa forests, the principal winter range being located in the long parks east of the divide between 7,800 feet and 8,500 feet near Estes Park village. The deterioration of this winter range has been the subject of many reports since 1930. The more important of these may be summarized as follows:

The first annual spring wild life report in 1929 (Anonymous, 1931) announced the winter range to be in very poor condition because of overuse, and located the critical area as the central district near Estes Park. The browse plants were then in better condition than the grasses, and the deer, more numerous than ever before, wintered better than the elk. Most

of the wintering areas were on private lands. Serious barking of aspens by elk was reported for the first time.

Mr. Dixon's report (1931) verified the inadequacy of the amount of winter range under the jurisdiction of the National Park Service, and recommended the purchase of certain areas by the government. Of these, Beaver Meadow and Horseshoe Park and part of Moraine Park have been bought.

The January 1932 range report (Anonymous, 1932) divides the central range into five areas and classifies the forage plants on each. The southernmost, Mill Creek, was then little used by game, and was in better shape than the others. Moraine Park was even then seriously abused by livestock, and the Deer Mountain area was suffering from overgrazing by game and domestic animals. The Beaver Creek area (Beaver Meadow) was then a moderately grazed hay meadow, invaded by various weeds not necessarily harmful to game. Horseshoe Park, the site of private ranches, was badly overgrazed, fifty percent of the ground cover having been destroyed in places, and weeds were replacing better forage. This damage was due primarily to livestock. The plants adversely affected were *Purshia*, *Prunus* and *Amelanchier*. Indicators of overuse, such as *Artemisia frigida*, *Eriogonum* and *Geranium*, were present.

Thompson (1933) reported that the barking of aspen by elk was as serious as at Yellowstone; that the *Purshia* was producing but half the normal amount of forage; and that sagebrush and *Ribes*, secondary deer foods, were severely overused. He pointed out that although the winter range was well covered by grass and similar plants, abuse had resulted in porcupine grass (*Stipa minor*) becoming the prevalent species, accompanied by dense growths of *Chrysothamnus*, both inferior to the forage species they had replaced.

Subsequently, Wildlife Technician Merlin K. Potts' several reports, and other reports by investigators associated with him, indicated a continuing deterioration of the range, especially in the Mill Creek, Moraine Park, and Deer Mountain areas, the browse plants being affected more than the grasses in spite of beneficial rainfall and snow.

Dixon (1939) submitted a report on the conditions confronting the elk herd. Although it was true that the grasses had been doing well during the previous eight years, compared with the browse plants, he found that the grasses were not in nearly as good condition as they had been in 1931. He believed that the carrying capacity of the range had been exceeded, and that the range was being destroyed through overuse.

Ranger Harold M. Ratcliff, in his report in May 1939 on winter range conditions, reached similar conclusions, and presented a comprehensive discussion of the status of the range plants. This report is the most complete study available of the botanical aspects of the situation and I depended considerably on it in making my own faunistic study of the deer and elk herds.

THE DEER HERD

History.—Little information is available regarding the number of deer that inhabited the present park previous to 1900. Several Indian tribes hunted there, and doubtless found deer an important staple. Deer were moderately plentiful in the Estes Park region when the valley was settled in the 1860's, and the pioneers, too, utilized them for food and clothing. The advent of market hunting almost immediately thereafter affected the deer population nearly as disastrously as it did the elk and those bighorns that inhabited easily accessible places. Deer became scarce, escaping the fate of the elk probably because they are less gregarious, and smaller, hence less productive of marketable meat. At the same time, accelerated occupation of their range by domestic stock, and other factors less easily determined, resulted in a reduction of the deer population to a very low figure. This decline continued apparently into the early 1900's.

What factors caused the initial revival of this small population, and what the relative influence of each was, are speculative.

Beneficial Factors. The removal of elk as a competitive species before 1900 was doubtless of benefit to the deer. There are no reports that the range was over-utilized by game in the early days, but the reduction of the number of animals using it permitted the maintenance of the luxuriant growth of browse and grass that then existed over much of the area. This benefit was somewhat offset locally by the introduction of livestock on the range.

The constant destruction of predators, especially of coyotes and cougars, throughout the region probably did not markedly affect the deer until it had been continued for some time, and not until the herd had already been reduced seriously by hunting.

Forest fires usually exact some toll from wildlife, but probable the most influential fire of which there is record was the Bear Lake fire of 1900. It burned hundreds of acres of conifer forest, where certainly a number of deer had been summering, and may have killed some of them. Following a period when the area was unsuited for use by deer, ground cover began to replace the scar, a process that has barely commenced today at the higher elevations, but which is well advanced below 10,000 feet. This new cover is mostly herbs, grasses, shrubs and aspen, much more valuable as food for deer than the conifer forest it replaced. It is probable that the production of browse plants on this and other burns, and in those areas where the forest cover was otherwise removed, has been a factor of some importance in the perpetuation of the deer in this region.

The withdrawal of the park area from hunting in 1915, the addition to it of adjacent sections of the range from time to time since, and the establishment of the Rocky Mountain Game Preserve ensured the survival and increase of the herd thenceforth. At first, the increase was moderate, and it was not until 1930 that indications of over-population appeared.

Adverse Factors.—While these and probably other factors were restoring the deer population to a higher level, other influences were even then opposing this increase, and additional ones have been added since. Thus, the reduction of predators possibly benefited the deer when the herd was low, but as the herd increased, their absence may have encouraged the spread of disease through the deer; also, they were not available to reduce the elk properly when that species was restored to the area. A large forest fire, suitably located, may kill some deer, but may result in herd increase by restoring browse plants. It is beginning to appear that various climatic conditions affect differently the relative abundance of parasites in animals, influenced probably by even other complex factors; but the effect on the host species may be quite the reverse of the effect on the parasites.

Most important of the adverse factors was doubtless the continued encroachment of man, his constructions and his domestic stock on the aboriginal deer range. The early decline was partly the result of early settlement, but once the herd had decreased, this factor probably became less effective. When the deer did begin to recover, there was still a large range available, much of which they

used in conjunction with domestic stock. Just at the time (1932) the detrimental effects of multiple use of the range became conspicuous, some large tracts were added to the park and the competition of domestic stock was removed as much as possible.

The establishment of ranches on the winter range was accompanied by the need for increased lines of communication. Roads began to spread over the open pine-brush country that formed the best part of the deer range. Some of them were used only periodically, but as Estes Park became popular, incursions of tourists and commercial people augmented their use. Consequently, several new factors appear: exotic grasses and other plants, such as foxtail, Russian thistle, dandelions, etc., were introduced; the Wyoming ground squirrel (*Citellus r. elegans*) entered the region and spread rapidly over all of the lower meadows; automobiles traveled the roads in increasing numbers, levying toll of wildlife, including deer.

Fences bounding private property have some effect in the reduction of the herd. Adult deer and yearlings appear to have no difficulty jumping wire stretched fifty inches above the ground. If the strands are higher, they usually crawl between them. When alarmed, however, they sometimes leap frantically against the barriers, and may become tangled in the wires. This type of accident occurs most frequently near roads, where the deer are trying to escape automobiles. Near settled areas, dogs often chase deer through fences, resulting in broken legs for the latter. Coyotes, too, probably chase deer in the same way.

Poaching remains a factor difficult to evaluate, but certainly of some effect. Poaching of deer centers around Estes Park village, and usually occurs outside the boundaries of the national park out of season. The constant vigilance of the ranger force has greatly reduced the importance of this illegal activity.

Elk, once removed as a competitive factor, were reintroduced in 1913. They increased even faster than the deer and, although they prefer grasses, their utilization of browse hastened the deterioration of those plants. At present, they are serious competitors of the deer for browse species, while there is reason to believe that the deer are now eating more grasses in spring than they formerly did.

Control measures applied against predators until 1926 reduced the number of game deaths, but at the same time they removed the benefits to the herd as a whole that would have resulted from the natural elimination of the unfit. Predators have been protected in the park since 1926 and are increasing, in spite of their continued destruction near the park boundaries. The moderate restoration of the predatory species, especially coyotes and cougars, before the overpopulation of deer became evident through the deterioration of the range, probably has been beneficial in preventing the spread of infectious diseases through the overcrowded herd.

Too few autopsies of park deer have been made by pathologists trained to detect evidence of inconspicuous diseases to permit definite evaluation of the health of the herd. Opinion agrees that the animals now appear to be in poorer condition in spring than they were at the same season in former years, but other evidence indicates that as yet disease is not seriously prevalent in the herd.

Feces from the range examined by Dr. F. X. Gassner, Colorado State College of Agriculture, were found to be entirely free of parasites. Field autopsies performed by Ranger Ratcliff and the writer revealed no evidence of disease, although there are a few records of a condition diagnosed as necrotic stomatitis in the park files. Isolated cases of hemorrhagic septicemia and other sickness have been reported.

Lungworms have been found in autopsied deer on several occasions, presumably *Protostrongylus macrotis*, which is the form that has been recovered from deer elsewhere in the state. A tapeworm of the genus *Monodelzia* was recovered from a doe. Although other parasitic worms and coccidia have been found in park bighorns on the same range, they have not been discovered in any of the deer or elk examined.

Botfly larvae (*Cephalomys* sp.) were frequently found in the pharynx and trachea of park deer, less often in the nasal cavities. The pharyngeal bots often are expelled by coughing or sneezing. Nasal bots have been known to cause fatal suffocation. Bots, like most parasites, become increasingly active when the host is suffering from malnutrition, an inevitable concomitant of over-utilized range; so the potency of these parasites as lethal factors may be considered to be increasing.

Older residents reported that many years ago some deer showed evidence of scabies. Whether the occurrence of this disease in deer can be correlated with its virulent appearance in the bighorns at the turn of the century is not certain.

Several external parasites are known to be present on park deer. Two forms of tick (*Dermacentor andersoni* and *D. albipictus*) have been found heavily infesting deer of all ages and both sexes, but probably have no lethal effect.

As far as could be ascertained, the most lethal factor operating against the continued increase of the park deer at present is the legal hunting near the park boundaries. During the fall of 1939, nine checking stations were located at strategic places in the Roosevelt National Forest. Most of the deer and elk that were killed on that part of the forest and other lands proximal to the central winter range of the park were checked through two stations at Lyons and in Big Thompson Canyon where 296 deer and 23 elk were counted. District Forest Ranger Blackmer estimated that about half of these deer were resident on the forest, while the other half had migrated to it from their summer and early fall range within the park. It may be assumed, then, that 150 bucks of the park herd were shot legally during the 1939 season. It is believed that all of the elk listed above spent part of the year within the park.

Sex-Age Counts.—Analysis of the data on legal kills and carcasses found dead in the park, revealed the following proportion of losses during the year: 167 bucks, 28 does, 14 fawns, 15 adults of unknown sex, and 23 deer of unknown sex and age. Therefore, 12 bucks were killed for every two does and for every fawn; or, excluding the 150 bucks shot in season outside of the park, 16 does died in the park for every 10 bucks and 8 fawns. These figures include 207 adults and 14 fawns, a ratio of 15 adults to one fawn. The reliability of this ratio is questioned because young carcasses disintegrate or are destroyed more quickly than those of adults.

The number of deer in the park varies with the season, there being more in summer than in winter. On the basis of counts made annually in spring, just before the migration to the higher fawning grounds, there were about 1400 deer in the park in 1939. Rutter (1937) estimated a 20 per cent annual increase through the production of young, indicating an annual birth of 280 fawns. Other investigators have considered this figure somewhat low, their estimates placing it nearer 28 per cent, which would result in the birth of 390 fawns. The writer favors the higher figure.

The important conclusion to be drawn from these statistics is that in 1939 the known rate of loss (about 18 per cent of the herd) was slightly less than the estimated rate of increase (20 to 28 per cent). Reduced hunting and travel during the war years have undoubtedly affected the survival rate of the deer and elk, but definite data are lacking. Investigators studying game conditions in other parts of Colorado believe that the optimum production of a deer herd with favorable conditions on its ranges is approximately 33½ per cent. The state, however, is primarily interested in obtaining the maximum number of game animals that can be supported properly by its ranges, whereas the park is more concerned with the restoration of its winter range.

It is evident, then, that natural and artificial checks had operated by 1940 to slow the former rapid increase of the park deer herd to a point where the rates of production and loss nearly balanced, so that the population was more or less static. They had not succeeded in establishing that balance at a figure low enough to warrant belief that the depleted range would henceforth recover without additional help. In other words, the deer herd still apparently exceeds the carrying capacity of the present forage on the winter range, and the range may be expected to deteriorate further.¹

THE ELK HERD

History.—During the 19th century, the region now designated as the national park and the adjacent mountain forests supported a large population of elk, either as permanent residents or as migratory bands inhabiting the region several months of the year. No definite information is available on which to base an estimate of the actual number, but the estimate that 20,000 elk occupied Moffatt and Routt counties in 1880 supports the belief that probably as many elk utilized the region then as today, and possibly more.

Hunting by the pioneers for food, sport, and market had drastically reduced the elk population by the end of the century. The few elk left were scattered and unable to rebuild the herds. By 1912 the Routt and Moffatt counties herds had been reduced to 120 animals, and fewer than a dozen were known to remain on the Roosevelt National Forest. There is little question that the species would have disappeared completely within a few years had not steps been taken to restock the region by plants from other areas. Five plantings were made by the

¹Recent reports from the park indicate that following moderate arbitrary reduction of the deer and elk herds between 1940 and 1945 the range has improved considerably, and that in 1946 it was in better condition than it had been for many years.

U. S. Forest Service in the Roosevelt Forest and the present national park as follows:

YEAR	NUMBER	AREA
1913	25	Estes Park
1913	3	Nederland
1914	24	Estes Park and Lyons
1915	25	Nederland and vicinity
1917	47	Rollinsville

The 1913 planting at Estes Park apparently was unsuccessful.

These introduced elk multiplied rapidly. Following are the official counts and estimates of the number of elk within the park during the succeeding years:

YEAR	ELK	YEAR	ELK	YEAR	ELK	YEAR	ELK
1915	30	1926	200	1931	430	1938	645
1917	27	1927	200	1932	335	1937	785
1918	60	1928	200	1933	335	1938	865
1919	80	1929	300	1934	375	1939	900
1920-25	Increase	1930	330	1935	550		

The count in 1939 indicated that about 900 elk utilized the park during all or part of that year. The Roosevelt Forest supports an estimated 600, of which about half may be considered as additional to the park population, making a total of 1200 individuals.

Beneficial Factors.—The factors benefiting the elk, once they were re-established, were similar to those that enabled the deer to thrive. Primary, probably, was the protection from hunting afforded by the national park and the Rocky Mountain Game Preserve while the numbers of elk were low. Until the growing herd of deer began to destroy the browse, the elk suffered little competition from them. Elk are more secure against the attacks of predators than deer, and few predators were present on the winter range until recently. Adult elk can jump ordinary fences, and are not so likely to be injured as are deer when chased by dogs or coyotes. Although livestock on the ranches in the lower meadows competed with elk for grasses in early years, there was forage enough for all, and the elk were encouraged to visit the hay ricks on the ranches until they increased enough to become a nuisance.

Adverse Factors.—Fewer influences affected the elk adversely than were operative against the deer herd. The advent of the automobile had little direct effect on the elk, except to frighten them from their pastures from time to time: elk are seldom hit by cars, although it sometimes happens. There is no evidence that the park elk have ever been seriously diseased. The early wildlife reports comment upon the scrawny appearance of the elk in spring, which some observers were inclined to attribute to disease rising from winter privation. However, the same elk were reported to be in excellent condition in October, and it is probable

that the observers did not realize how ragged a healthy elk can look in spring. The elk doubtless suffer some privation in winter, and grow thin; but the winters in the park are relatively mild and actual starvation is not common.

As the herd increased, competition with livestock became somewhat serious, but in 1932 domestic animals were removed from all of the winter range within park, except in Moraine Park. Deer, at first of minor competitive effect, have increased their consumption of grasses with the loss of much of their natural browse. They eat grass especially heavily in late winter, when both deer and elk are at their lowest vitality.

Some elk, probably old nonbreeding bulls, remain through the winter on open stretches of alpine meadow and are subjected to rigorous climatic conditions their migratory fellows do not have to endure. A severe storm may cause the death of such individuals directly, or by decreasing their defense against predators. There is an odd report of an elk that fell off a cliff and landed in a tree somewhere along the Thompson River, there to die of injuries or starvation. The mating battles of elk sometimes end fatally for one or both of the contestants, but certainly are not a detrimental factor to the increase of the herd.

Disease appears in the elk as isolated cases, not as a condition common to the herd. Occasionally an elk may be seen suffering from leg injuries which reduce its ability to obtain forage, and may thus starve. A young elk observed and later killed by Game Warden Grady Young was suffering from what appeared to be a brain disorder, similar to encephalitis. Internal diseases are not known from park elk, and the only serious external parasites appear to be wood ticks.

The remains of twelve elk were found that had died between July 1, 1939 and July 1, 1940. Twenty-three bull elk were checked through the Lyons and Big Thompson checking stations during the 1939 season, which probably all belonged to the park herd. This produces a total of 34 elk known to have been lost from the park herd during the year.

The increase of the park herd in 1939 was officially computed to be 29 percent, but the rangers believed that figure to be much too low, some expressing the opinion that it should be as high as 50 per cent. It has been shown that the average yearly increase since the elk were restored to the region has been about 45 percent. Whatever the actual birth rate of the elk in the park, it is apparent that it exceeds the mortality rate considerably. In spite of a number of natural and artificial checks, the elk herd is increasing rapidly, and already exceeds the optimum carrying capacity of the winter range.

Sex-Age Counts.—Detailed sex-age counts of the bands present on the winter range during the rutting season are not available, but observations indicated that one breeding bull will normally gather a following of between 25 and 40 cows, yearlings and calves. The average size of such bands was one bull to 31 others, of which about 12 would be breeding cows. The "proper" sex-age ratio of elk on a range in good condition does not appear to have been determined. It is not known whether the ratio above is suitable for a range suffering from overpopulation.

Spring counts, made between February 6 and April 24, 1940, when the adult

bulls were no longer with the other elk, produced a ratio of 3 spike (non-breeding) bulls to 12 adult females to 8 non-breeding yearlings to 13 calves on the park ranges. The hunting season outside the park probably destroys as many adult bull elk as is good for maintaining the sex balance of the herd.

SUMMARY

A review of previous reports on the range problem in Rocky Mountain National Park demonstrates a serious deterioration of the forage plants on the lands of the district where deer and elk concentrate in winter. Although browse plants show the greatest damage, there are indications that forage grasses are seriously and adversely affected also. This depletion has progressed, in spite of fairly good climatic conditions, until the range has reached a condition requiring remedy.

The basic cause of range depletion is the overpopulation of deer and elk. A review of the natural and artificial influences operating upon the herds reveals that the annual birth rate and mortality rate of the deer approximately balance, so the herd has reached a more or less static level. This number, however, is above the optimum carrying capacity of the range. The birth rate in the elk herd greatly exceeds the mortality rate, so that elk are continuing to increase rapidly.

LITERATURE CITED

- (Unpublished reports in the files of Rocky Mountain National Park)
- ANONYMOUS. 1931. First annual spring wild life report, June 15, 1931. 11 pp. photographs.
- . 1932. Report on Condition of Portions of Elk and Deer Winter Range in Rocky Mountain National Park, January 15, 1932. Tables, map.
- DIXON, JOSEPH S. 1931. Report on needed winter range for big game in Rocky Mountain National Park, June 30, 1931. 2 pp. photographs.
- . 1939. Special Report on the Elk Problems at Rocky Mountain National Park. December 16, 1939. 41 pp., photographs.
- THOMPSON, BEN H. 1933. Memorandum to the director. Re: Elk and deer winter range in Rocky Mountain National Park. September 23, 1933.
- RUTTER, JOHN A. 1937. Report on the carrying capacity of the winter range of Rocky Mountain National Park. January 5, 1937.

34 Randolph St., Passaic, New Jersey.