

THE MANAGEMENT OF WILD HOOFED ANIMALS
IN THE UNITED STATES
IN RELATION TO LAND USE

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When the first colonists landed on the Atlantic Coast, there were ten species of native hoofed mammals (Table 1) within the borders of what is now the United States of America, excluding Alaska. Today all of these species still exist within the nation's limits. Of the original 53 American subspecies (HALL & KELSON, 1959), however, four have become extirpated within the nation's borders and three subspecies (two of elk and a form of the bighorn sheep) are extinct everywhere.

In Alaska, all seven of the original native hoofed mammal species still exist. The native subspecies of muskox was eradicated there, however, although it survives in Canada. The lost form of muskox was replaced, at least on Nunivak Island, by a different subspecies from Greenland.

All species, as defined broadly, have survived within American territory (including Alaska). But the numerical response of these species to civilization has not been identical. The bison, pronghorn, bighorn sheep, caribou, muskox, and javelina have become markedly reduced in total numbers. The mule and whitetail deer, on the other hand, have increased both their distributional limits and their abundance. The elk and moose display reduced geographic ranges and yet have increased within those restricted areas. The mountain goat and Dall sheep, have not changed much either in distribution or abundance.

The history of changes in abundance of the hoofed mammals in the United States is correlated largely with the land use changes which have taken place since settlement began. But it is also important that wild animals in the United States have never been in private

TABLE 1

Numbers and Satus of Subspecies of Ungulates Native to the United States (1).

SPECIES	United States proper		Alaska	
	Now Alive	Exterminated	Now Alive	Exterminated
Javelina (<i>Pecari tajacu</i>) (2)	2	0	—	—
Elk (<i>Cervus canadensis</i>) (3)	5	2	—	—
Mule deer (<i>Odocoileus hemionus</i>)	7	0	1	0
Whitetail deer (<i>Odocoileus virginianus</i>)	17	0	—	—
Moose (<i>Alces alces</i>)	3	0	1	0
Caribou (<i>Rangifer tarandus</i>) (4)	1	1	2	0
Pronghorn (<i>Antilocapra americana</i>) ..	4	0	—	—
Bison (<i>Bisonbison</i>)	2	0 (5)	1 (6)	0
Mountain goat (<i>Oreamnos americana</i>) .	2	0	1 (7)	0
Muskox (<i>Ovibos moschatus</i>)	—	—	0 (8)	1
Bighorn sheep (<i>Ovis canadensis</i>)	6	1 (9)	—	—
Dall sheep (<i>Ovis dalli</i>)	—	—	2	0
Totals.....	49	4	8	1

Notes :

(1) Numbers of subspecies are based on the distribution maps of Hall and Kelson (1959).

(2) Species names are those of Miller and Kellogg (1955) except for (4).

(3) The forms *merriami* and *nannodes* are classed as species (Miller and Kellogg, 1955; doubtfully so by Hall and Kelson, 1959, or as subspecies (Burt, 1952). *C. c. canadensis* and *C. c. merriami* are extinct.

(4) The barrenground and woodland caribous are lumped in the same species by Hall and Kelson (1959).

(5) Survivors of the original subspecies apparently were combined (Allen, 1942); mixed offspring may comprise present American herds.

(6) It is uncertain (Hall and Kelson, 1959) whether bison were native to Alaska in historic times. The species was introduced (Leopold and Darling, 1953) and is increasing at Big Delta.

(7) The form *kennedyi* is variously classed as a species (Miller and Kellogg, 1955); or as a subspecies (Burt, 1952; Hall and Kelson, 1959).

(8) The original subspecies was exterminated in Alaska by natives prior to about 1850. A Greenland subspecies has been established on Nunivak Island (Hone, 1934).

(9) *Ovis c. audubonii* is extinct. *O. c. californiana* and *O. c. cremnobates* within United States borders are certainly rare (Cowan, 1940), but increasing (Buechner, 1960).

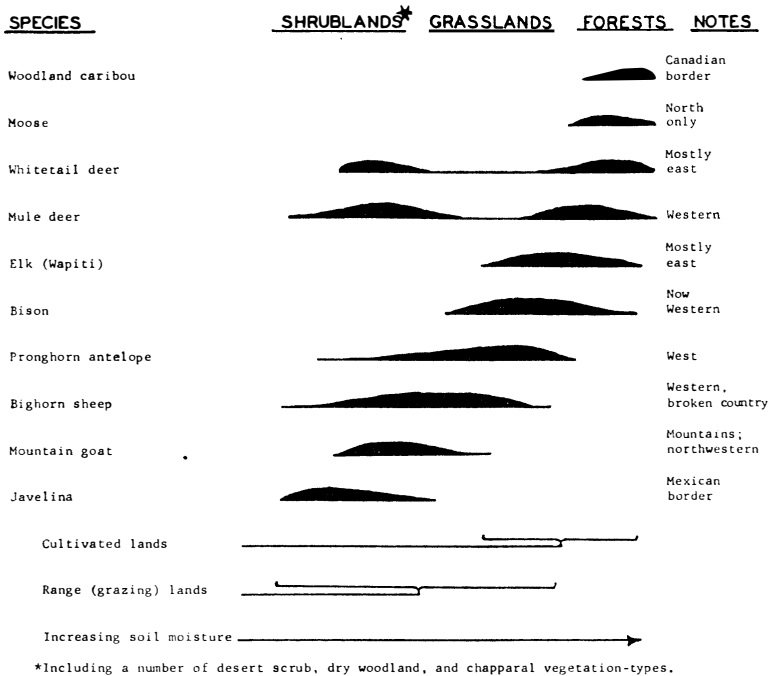


Figure 1. — Ecological distribution of principal hoofed Mammals of the United States.

ownership. Since the days of early settlement, the attitude of « free hunting for all » has dominated the American scene.

Since Alaska and its ungulates have been so thoroughly treated by LEOPOLD and DARLING (1953), emphasis hereafter will be on the transcontinental 48 states.

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DEVELOPMENT OF LAND USE AND GENERAL EFFECTS

Eastern Forest. At the time of the earliest European settlements, the land from Canada to the Gulf of Mexico and from the Atlantic to well west of the Mississippi River was largely timbered. Forest fires, torna-

does, hurricanes, and insect and disease attacks, however, were among the natural forces that acted at least occasionally, to create openings in the forest canopy. Some times large areas thus were reduced to sapling, shrub, or herbaceous stages of growth and community succession. Also, even before the coming of Europeans to America, the native Indians maintained grassy openings sometimes of large size (THOMAS, 1956), principally by burning.

Almost throughout the large forested areas of the eastern United States, with its openings and early successional stages, lived the elk (wapiti), bison (American buffalo), and whitetail deer. In northern forests, near the Canadian border, moose and woodland caribou (*R. t. sylvestris*) were found.

All available evidence indicates that the early forests, in general, were only moderately productive of these hoofed animals (SEVERINGHAUS and BROWN, 1956; DAHLBERG and GUETTINGER, 1956; TAYLOR, 1956; JENKINS and BARTLET, 1959). Where mature timber prevailed, canopies closed in overhead. Undergrowth was limited; vegetation within reach of grazing or browsing animals was relatively scarce.

Elk and, especially bison, eat much grass. In all probability, in the original forest they were most common in openings and early developmental stages of forest growth. Certainly, neither species was as common in the eastern states as on the plains and Rocky Mountains foothills (see ROE, 1951).

Deer and moose are primarily eaters of twigs and certainly were most abundant in old burns and other areas of shrubby growth. Of the five ungulates originally in eastern America, only the woodland caribou was adapted to survive in mature forests, perhaps not being able to compete with moose in more open areas (CRINGAN, 1957).

While the Indians used the ungulates for food, their primitive hunting methods are not known to have reduced the general levels of game abundance. With the coming of the European, however, the ungulates were hunted regularly and heavily with firearms. As settlement advanced, trappers and hunters spread in advance, living off the country. Nearer the agricultural districts, hunters were continually active in securing wild meat and selling it in the settlements (TAYLOR, 1956). Market-hunting, particularly in the nineteenth century, was a serious mortality factor on big game animals until federal

legislation in 1900 supplemented state regulations in forbidding the sale of game meat (WING, 1950).

In the early days, the forest was regarded principally as an obstacle to farming. Lack of knowledge caused many areas of low fertility as well as the better agricultural soils to be cleared for agriculture. Cutting and burning were a necessary part of land-clearing. Everywhere, downed timber and slash was set ablaze to clear the land for agriculture. In dry periods, fires often raged uncontrolled over large areas. As settlement proceeded westward, demands for lumber came from the East, adding impetus to forest reduction.

Especially on fertile lands, cultivation during the 1800s began to fill continuous extensive blocks of land, on which virtually all habitat for large game animals was destroyed. On such good soils, cultivation kept forest reproduction from surviving. On poor soils in many areas, the heat of fires destroyed soil organic matter and induced erosion. In parts of Michigan, for example, virtually no recovery of vegetation from these fires took place during the past century.

Three factors, then, successively reduced the abundance of hoofed ungulates in the eastern forest : (a) continuous hunting using all methods at all seasons, and often including shooting for the market, (b) widespread destruction of forests, often with severe burning of shrub and tree seedlings and even of soil organic matter, and (c) extensive agricultural settlement, restricting the habitats of many ungulate species.

Rangelands. These include all grasslands, shrublands, and desert scrub which may be used for livestock grazing. From long-grass prairie at the edge of the eastern forest to thick chaparral-bush in California, occurred bison, pronghorn antelope, elk, mule deer, and whitetail deer. Near rocky places throughout much of the rangelands, as well as in the higher mountains, the bighorn sheep lived. And in brushlands of the Southwest there was also the javelina, or peccary, a wild pig.

All of these species once occurred in teeming abundance, the wild ungulates of the American plains rivaling those of the grasslands of East Africa (PETRIDES, 1955). While bison and antelope were most numerous, deer, elk, and even bighorn sheep locally were not rare (KOCH, 1941; ROE, 1951).

Prior to European settlement, the native Indians preyed dependently on bison and other wild ungulates

and acted to extend the prairie, burning at the forest edge (THOMAS, 1956). Fires, both of natural and human origin, controlled invasion of the grassland by trees and shrubs (HUMPHREY and MEHRHOFF, 1958). It tended to improve the habitat for bison, antelope, and elk (in some areas) and to depreciate it for deer and, in the far south, javelina.

Invasion of the open plains by trappers, hunters, sheep and cattle grazers, and finally by settled farmers and ranchers led to heavy hunting (ROE, 1951) and caused many changes in the original vegetation that disturbed the habitats of wild ungulates.

Cultivation took over the long-grass soils and the moister portions of the short-grass plains. Intensive agriculture, furthermore, became the rule on floodplains of streams and in more recent years in other level areas suitable for irrigation.

Whereas originally the wild ungulates tended to move about permitting « rest years » of range recovery (THOMAS, 1956), the introduction of livestock began an era of increasingly intense forage depletion on the unplowed lands. Between 1830 and 1880 the open range became effectively occupied by fenced ranches (THOMAS, 1956). The fences isolated bands of antelope especially, and contributed to their reduction. Furthermore, as with grazers the world over, livestock herds were built up in wet years and overgrazing was frequent in dry ones. The replacement of highly-palatable climax bunchgrasses by less-palatable perennials and even by annual grasses and forbs became increasingly widespread.

Range destruction, due to overgrazing and also to improper cultivation, reached a peak during the great drought of the 1930's. Invasions of shrubs occurred over a long period throughout large districts in south Texas (CARTER, 1958), in southern Arizona (HUMPHREY, 1958), and elsewhere where overgrazing and the often consequent lack of range fires permitted the survival and spread of woody plants.

Western Forests. These forests are in areas of adequate rainfall along the several mountain ranges and near the Pacific coast. In these forests, sometimes moving to more open lowlands in winter, live mule deer (and less commonly, whitetail deer), elk, and moose. Mostly near timberline in high meadows are the mountain goat and bighorn sheep.

The original forests were mostly of tall coniferous trees with grassy openings on the shallower soils and

frequently thick undergrowth elsewhere. While wasteful lumbering occurred in some areas, many forests public and private, have been managed adequately for sustained timber yields. Considerable mature timber remains today.

Fires have always been frequent. Even today, with intensive protection, there are many small and occasional widespread burns. Following such blazes, browse production is enhanced in quantity (TAYLOR, 1956) and nutritive value (DEWITT and DERBY, 1955).

The abundance of ungulates in these areas in the early days is not well known. After crossing the grasslands, with their teeming herds of big game, wild animals in the mountain forests apparently seemed scarce to trappers and explorers. Yet records (as in KOCH, 1941) indicate that by modern standards hoofed animals were common.

There was a period following early settlement when moose became nearly extinct in the northern Rocky Mountains, the only western area in which they regularly occurred (DENNISTON, 1956). About 1875 (SMITH, 1954), bighorn sheep declined sharply apparently due to over-hunting, livestock competition, and epidemic diseases. It is likely that most other ungulates also became reduced in abundance at about that time as a result of widespread dependence on them for food by pioneers. As domestic foods became more available, however, and with the more common application of game laws, most species of wild ungulates again increased.

The general destruction of forests which took place in the East did not occur to the same extent in the West. Locally, destructive fires, overgrazing, and severe lumbering were followed by erosion and other harmful effects. In general, however, fires and lumbering merely increased browse production. Cultivation was mostly limited to lowlands but livestock grazing was undertaken in many of the drier and more open forests and extended above timberline in some regions.

The main long-term land use practice affecting wild ungulates in western forests has been livestock foraging. In winter, deer, elk, and moose tend to migrate away from the deep snows of higher elevations into traditional winter lowland ranges, now largely devoted to agriculture. Damage to haystacks and sometimes to orchards, grazing of livestock pastures, and occasional breakings of fences (MURIE, 1951; TAYLOR, 1956) have often resulted in efforts by landowners to kill, drive away, or fence off wild ungulates, or to legislate for heavier legal kills of them.

National Parks and Wildlife Refuges. As special forms of land use, these areas have had particular effects on wildlife. The establishment in 1872 of Yellowstone as a large protected area (eventually the first national park), mostly in northwest Wyoming, was particularly significant both in preventing overhunting and in preserving habitats. The most important nucleus of bison remaining in the United States was there and most remaining American herds are descendants of this group (ALLEN, 1942). Most transplants of elk, especially in the East, were of Yellowstone animals. Important populations of bighorn sheep, pronghorn antelope, and elk were saved in Yellowstone. It was the center of preservation of moose in the western United States. Of even greater significance was the precedent established in Yellowstone encouraging the preservation of public lands as national parks, national forests, and public grazing lands. (See also beyond).

SPECIES REACTIONS TO SETTLEMENT AND LAND USE

Efforts to maintain ungulate populations in the eastern United States were begun early (TAYLOR, 1956). In 1646, Rhode Island established a closed season on deer and other laws governing hunting were adopted gradually by the several colonies, and, later, states. Bounties on the timber wolf (*Canis nubilis*), a principal predator, were established early in colonial days, both for livestock protection and wildlife preservation.

Bison (American Buffalo). The ungulate most seriously affected by settlement and land use was the bison. It was an easy target; its meat and hides were valuable; its large size and herding characteristics required its removal from agricultural areas.

East of the Mississippi River, the last bison in Pennsylvania was killed about 1800 and in Wisconsin about 1830 (ROE, 1951).

On the range lands, it is estimated (THOMAS, 1956) that the bison herds numbered at least 50 million prior to 1830. Yet, by 1890 (ROE, 1951), it had been virtually exterminated. There can be no doubt that the bison was brought to the brink of extinction principally by the gun. It was the low point of America's regard for wildlife. The bison in the United States was saved in the Yellowstone reservation (ROE, 1951). The near extinction of this once-abundant symbol of America's frontier, however, gave impetus to the American conservation

movement later successfully promoted by President Theodore ROOSEVELT and other eastern residents. Our systems of national forests, national parks, and public grazing lands, are certainly due in large part to the public's reaction to the near loss of the once « limitless » bison*.

Bison herds now have been stocked in several localities in the West but the largest group is still the wild herds of Yellowstone National Park.

Elk (Wapiti). As a large and edible animal of openings in the forest and of the open plains, the elk was a food source for frontiersmen and undoubtedly a nuisance in crops.

The eastern elk (*Cervus c. canadensis*) disappeared so rapidly during the early 1800s (BAILEY, 1946), that only one museum skin was saved (ALLEN, 1942). In New Mexico and Arizona, the Merriam elk (*C. c. merriami*) also became exterminated on its isolated mountain ranges. Over-shooting seems likely but ALLEN (1942) believed that competitive grazing by livestock was an important mortality factor. The tule elk (*C.c. nannodes*) of the central valleys of California had its habitat preempted for agriculture, but was transplanted to other areas and fortunately still survives.

On rangelands, in the 1800s, elk were common on the open plains, as well as in the mountains. This was especially true in winter when they moved from higher elevations. The evidence (KOCH, 1947) indicates that the Great Plains' populations of elk were killed off by trappers, settlers, and probably the Indians once they secured arms. No further elk subspecies, however, were lost.

Today, elk have been reintroduced into Virginia, Michigan and other places, and are increasing despite competition from deer. In western forests and meadows, elk are so abundant as to cause problems. Almost everywhere the former lowland winter ranges of elk are occupied by ranches. In many cases, the ranch livestock also graze the high summer ranges of the elk. In

* Perhaps something on the order of a principle can be noted here : It is rarely the local resident in a wild area who values a permanent wildlife resource even though his livelihood may depend on it; it is usually people in settled areas some distance away who most realize its worth. The American Bison Society, first organized in the eastern United States (Allen, 1942), was instrumental in saving the buffalo. Whatever impetus there is for saving African big game displays similarly lies in the cities and settled areas of Africa and in world centers. (Petrides and Swank, 1958).

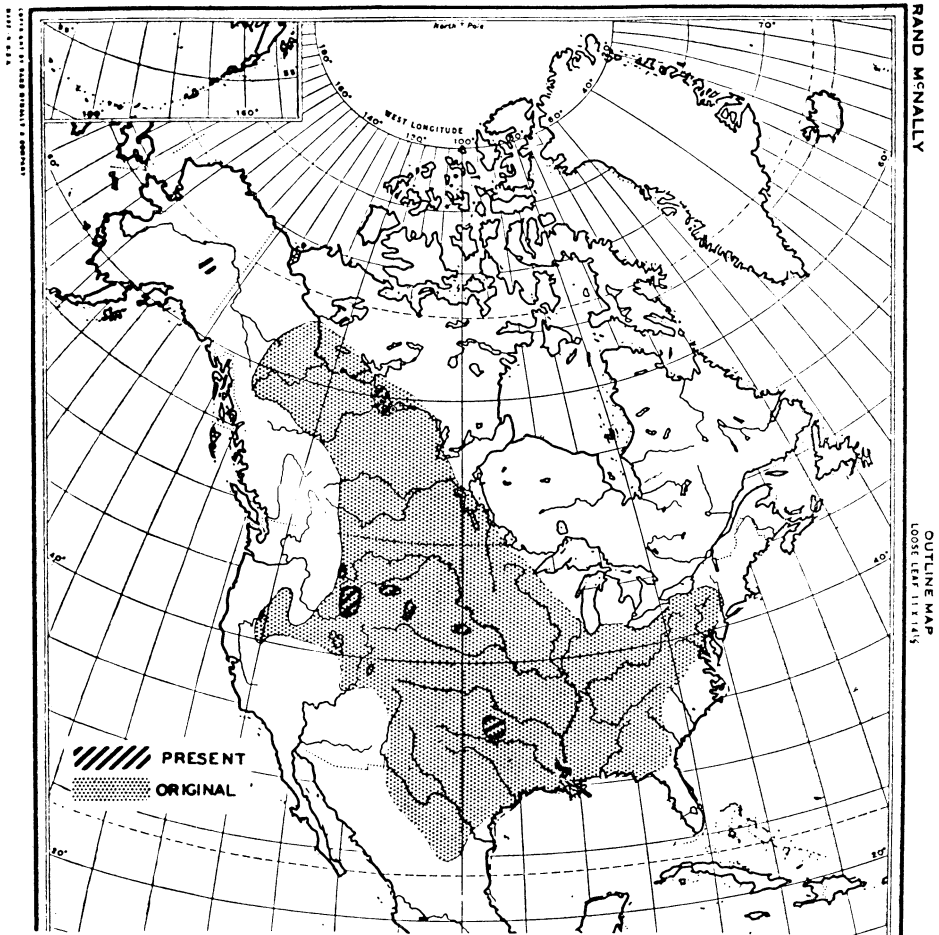


Figure 2. — Original and present distribution of the bison in North America (adapted from Hall, 1959 and Burt, 1952). The areas of present herds are considerably exaggerated in size.

some regions, furthermore, it is difficult to secure a hunting kill adequate to prevent increases in elk herd sizes (CRAIGHEAD, 1952). Where elk invade ranches (ANDERSON, 1958), they damage haystacks and sometimes fences and contribute to overgrazed pastures. In other areas, their heavy foraging may be serious competition for other wild ungulates (see beyond).

Moose. This large northern animal is quite vulnerable to unregulated hunting and disappeared, or vir-

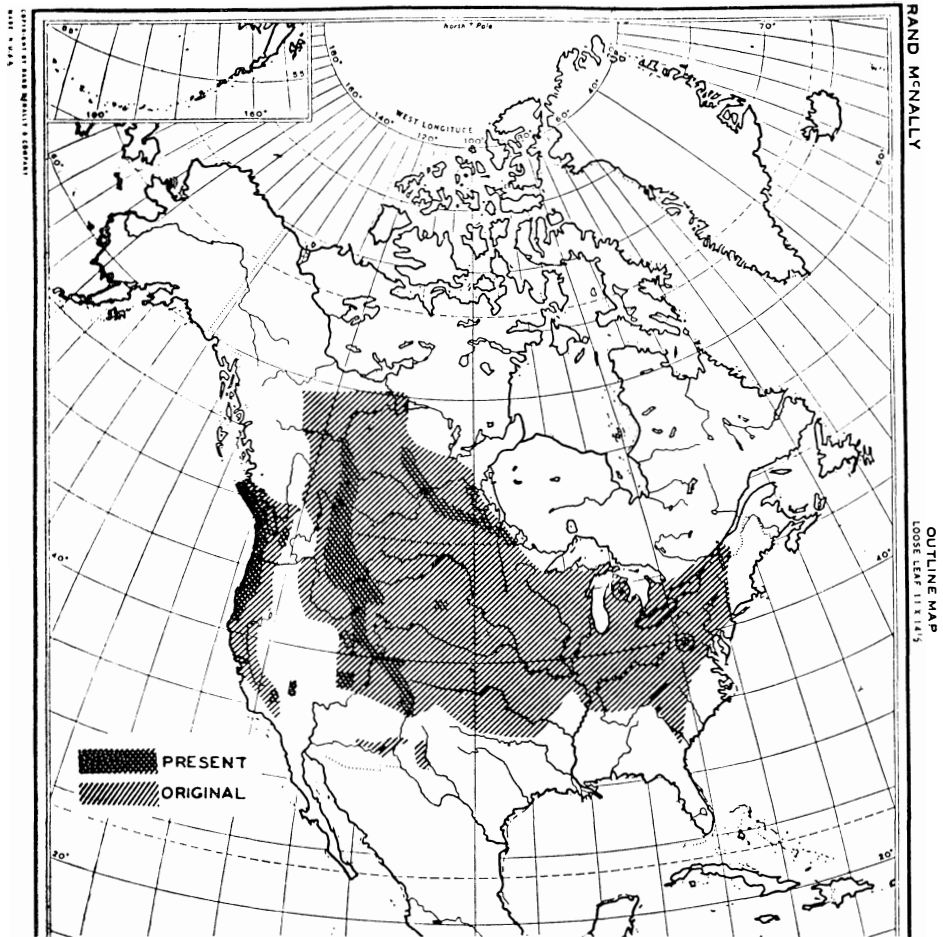


Figure 3. — Original and present distribution of the elk, or wapiti, in North America (after Murie, 1951 and Burt, 1952). Despite the reduction in range, this species is mostly over-abundant in its present locations.

tually so, from Massachusetts, New Hampshire, Vermont, New York, Pennsylvania, and Wisconsin in the early 1800s (PETERSON, 1955). They are now generally protected by law and are increasing in northern Maine, Michigan, and Minnesota. On Isle Royale, a large island in Lake Superior where a national park has been established, moose increased rapidly following a forest fire in 1936 which renewed their forage. Overbrowsing eventually

occurred, however, and a few years ago timber wolves were reintroduced in hope of restoring a predator-prey balance. The results are not yet known.

Moose are restored sufficiently to afford limited hunting in Wyoming and Montana. These states and Idaho largely comprise the original range in the West, and in all these areas moose are now increasing (PETERSON, 1955).

Caribou. The woodland caribou of the East requires mature northern forests and lichen foods which are difficult to restore, and it apparently has been eliminated from our area. The species occurred until at least 1943 (SWANSON *et al.*, 1945) and 1946 (PALMER, 1949) in the forests of northern Minnesota and northern Maine, respectively. Scattered reports may yet come in but at present the woodland caribou no longer seems to occur regularly outside Canada. Heavy illegal hunting seems to have contributed to its decline, but the loss of suitable habitat through logging, fires, and perhaps cattle grazing, has favored the whitetail deer and acted against the woodland caribou. The cause of the virtual extermination of the barren-ground caribou (*R. t. montanus*) in the northern Rocky Mountains has not been made clear. Perhaps 35 still exist in extreme northwest Idaho and adjacent Washington (LONGHURST, 1957).

Whitetail Deer. While this species ranges from Atlantic to Pacific, overlapping the range of the mule deer, it is much more widely distributed in the East. It is absent from much of the Great Basin region in the West and the most westerly subspecies (*O. v. leucurus*) is considered rare, being preserved largely on refuges (TAYLOR, 1956).

With the whitetail deer in the East and in parts of the West, an increasingly familiar pattern in modern wildlife preservation is evident. Although deer increased in some areas immediately following settlement, they were exterminated over large districts and became generally scarce during the latter part of the nineteenth century (TAYLOR, 1956). In the East, however, wherever agriculture was abandoned, which included large tracts on hilly and otherwise infertile soils, forest regeneration occurred. In Texas over large districts, overgrazing by livestock induced invasion of shrubs and small trees, and converted grassland to shrubland. Abundant deer forage returned on these and other timbered lands. The only possibly effective predators of deer have been eliminated, except from a very small part of the entire area, and

these cannot be restored because of potential livestock damage.

Because of low deer numbers, regulations restricting legal hunting to males became the symbol of a code of sportmanship designed to emphasize the values of the chase rather than the meat. Since deer have no restrictive mating patterns (TAYLOR, 1956), this discriminant shooting of males permitted an uncontrolled birth rate for the population. Improved law enforcement and the maintenance of many public and private refuge areas also encouraged rapid deer increases.

The combination of legal restrictions, refuges, and especially renewed forest vegetation led to a great increase in deer in many parts of the United States, first exclusively in the forested areas and now often also even in farmlands. This would be a gratifying situation were it not for the difficulty of halting the trend where this is necessary.

In areas of overpopulation, the too-abundant deer consume more browse than is produced and starvation is frequent in severe winters. This condition is aggravated, in the most eastern districts, by the maturation of second growth forests with consequent reduction of food within reach of the animals. Forest fires are rare now, too, and insects and diseases are mostly subject to control, so that natural regeneration of the forest is more or less limited to areas of windstorm damage or lumbering.

In some districts, damage to forest reproduction by deer is so serious that several plant species have been virtually eradicated and the seedlings of other important plants have very low chances for survival. Food scarcity causes in deer a lowered fecundity rate, a reduced survival rate, especially of the young, decreased body weights, a lowered ability to escape dogs and other normally-ineffective predators, higher incidence of disease and parasitism, and antlers often of such small size that they cannot easily be seen by hunters (for example, see JENKINS and BARTLETT, 1959). Thus, there is a serious deterioration of the deer themselves and especially of the deer habitat.

In the United States, wildlife agencies of federal and state governments are advisory bodies. They can pursue the policies they recommend only after the approval of the citizens' legislative representatives. It is essential now that the public be made to understand that in the absence of fire the deer herd in most areas now reproduces faster than the food supply can be regenerated,

and that properly-regulated hunting of both sexes is required to replace the mortality once caused by predators. Since the public was indoctrinated for many years with the idea that female deer should not be shot, it is difficult now to make a policy reversal.

Mule Deer. Deer occur throughout the rangelands, the mule deer being the more widespread species there. There are records of considerable slaughter of western deer during settlement days (TAYLOR, 1956), but killing was neither so intensive nor so closely accompanied by habitat reduction as in the East.

Where cultivation became intensive, deer were reduced through hunting and habitat changes, but probably even during early settlement range fires and livestock grazing had relatively little effect on the brushy vegetation of valley bottoms and canyons, in which mule deer made their headquarters. Through the years range fires have become infrequent. Wolves have become virtually exterminated and mountain lions (*Felis concolor*) and coyotes (*Canis latrans*) much reduced, principally due to demands of livestock owners. Deer may well have increased, at least locally, as a result of predator control.

While cattle may compete with deer for some foods, this is not likely to occur on properly stocked ranges (KIMBALL, 1957) and where domestic animals are overstocked they often induce an increase in shrubs which is beneficial to deer (SWANK, 1958).

In some parts of the rangelands, deer numbers may be restricted by low water supplies (ELDER, 1956; SWANK, 1958). But in numerous other areas, hunters do not harvest the annual increment and overpopulations result. Then the starvation sequence of lowered reproductive and survival rates ensues, with numerous deaths and habitat damage occurring during severe weather (TAYLOR, 1956).

There is some evidence (TAYLOR, 1956) that even under primitive conditions in some areas, hunting by Indians was essential to the welfare of deer through prevention of overpopulations. Hunting is even more necessary today where vegetative and land use conditions on rangelands encourage large annual increases in deer numbers.

Pronghorn Antelope. The pronghorn antelope is only one-tenth or less the size of the bison, but is has been estimated (THOMAS, 1956) to have been as abundant as the buffalo. It was depleted, over wide areas, however, and was nowhere common, even through the 1920s.

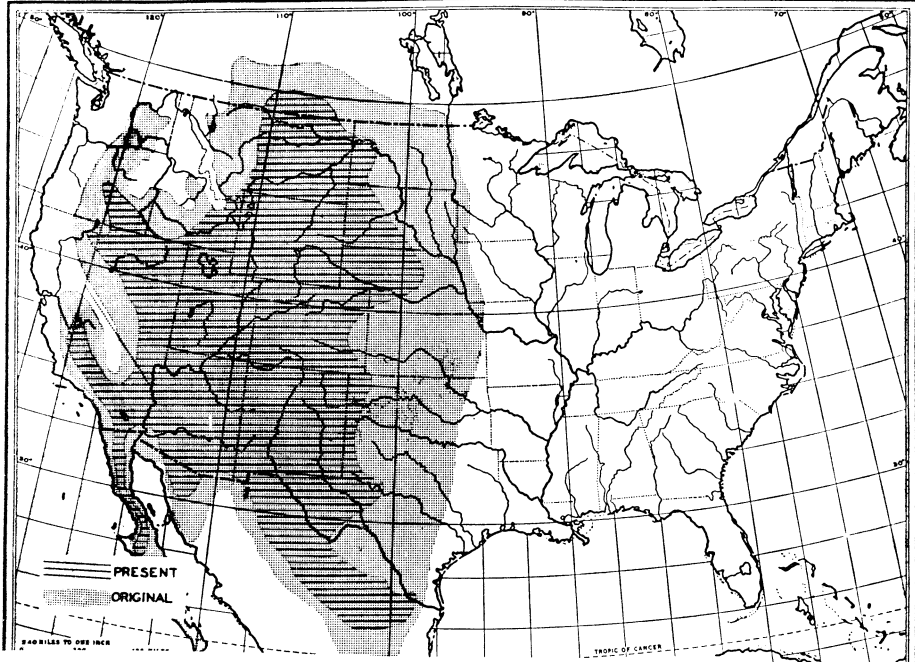


Figure 4. — Original and present distribution of the pronghorn antelope in North America (after Einarsen, 1948). Although the overall distribution of this species has not been much reduced, it is generally less abundant than formerly.

Pronghorns rarely jump fences and woven-wire or even taut barbwire fences serve as barricades, limiting their movement (BUECHNER, 1950). Numerous herds have been isolated within such barriers (BENSON, 1957). Pronghorns also have lost their habitat in areas of heavy shrub invasion and in pastures heavily grazed by cattle and especially sheep (BUECHNER, 1950). On the other hand, the provision of additional water supplies has been helpful to antelope in some areas.

Pronghorn antelope have been seriously preyed upon by coyotes (EINARSEN, 1940). Extensive control measures carried out against these predators have had favorable effects on pronghorn abundance in some districts (ARRINGTON, 1951).

In numerous areas, ranchers have felt that pronghorns compete for forage with cattle and have attempted to reduce their numbers. Also, limited damage to wheat

and alfalfa (lucerne) crops have caused some antagonism to the animals (COLE and WILKINS, 1958).

Especially during the early years of this century when the survival of the species was in doubt, the establishment of refuges for antelope assured that some areas were devoted to their survival. Male-only and short-season hunting regulations, and the restocking of trapped animals on predator-freed lands also proved beneficial. Though not everywhere numerous, the pronghorn is again becoming a common rangeland ungulate.

Bighorn Sheep. Originally, the bighorn sheep ranged throughout the western United States on steep slopes and in rocky country. According to the early literature (KOCH, 1941), bighorns were more abundant on stream-side cliffs and in rough country near prairie rivers than they were on the mountain slopes to which they are mostly now restricted. The Audubon bighorn, the subspecies once occurring on the northern plains, was totally exterminated during the early phases of settlement apparently principally by overhunting.

The bighorn sheep, of all American ungulates, has at present the least favorable status. Competition with domestic sheep and cattle, both on summer and winter ranges (HONESS and FROST, 1942; MCCANN, 1956) and also with elk and deer (HONESS and FROST, 1942; COUEY, 1950; SMITH, 1954) often results in poor nutrition. Infestations and deaths caused by lungworms, coccidia, and other parasites are frequent, and perhaps sometimes (ALLEN, 1942) but not necessarily always (PILLMORE, 1957), this is related to malnutrition.

In desert country, water may be the factor limiting bighorn numbers (JONES *et al.*, 1957). In such areas, the feral burro (*Equus asinus*) is an important competitor for forage and water (RUSSO, 1952; MCKNIGHT, 1958). Water-collecting tanks built for bighorns (RUSSO, 1952) and paved drainage basins for livestock (HUMPHREY and SHAW, 1957) may both aid wild sheep. But care must be taken that such water tanks do not induce overpopulations of livestock, and possibly of wild ungulates, with consequent overgrazing detrimental to all species (THOMAS, 1956).

Refuges for the bighorn in several states assist in preventing illegal hunting and serious livestock competition, and in providing water supplies and disease control.

Mountain Goat. The mountain goat has a restricted range but is common on high mountain slopes of north-

western states. In some parts of Idaho and Montana, its winter habitat is being damaged as a result of over-abundance (BRANDBORG, 1955). Successful introductions of this species have been made into several nearby states.

Javelina (Peccary). The javelina once was somewhat more widespread than now in Texas (JENNINGS and HARRIS, 1953) and Arizona (KNIPE, 1957) and perhaps in southwest New Mexico (HALL and KELSON, 1959). It has become restricted to the southern portions of these states, perhaps due mostly to shooting, because the small pigs sometimes kill sheep and ranch dogs. The javelina was not protected as a game animal in Texas until 1939 (JENNINGS and HARRIS, 1953).

It is now most abundant in areas of dense scrub, feeding principally on prickly-pear (*Opuntia* spp.). Since prickly-pear and other scrub is encouraged by overgrazing, heavy livestock grazing is beneficial. The species is increasing in such areas except where shrub-removal is practised.

CURRENT PROBLEMS

Overpopulations. Numbers of hoofed animals too great for their habitats during the winter (or less commonly, the dry) season, is the primary problem in ungulate management in the United States today. Whitetail deer, mule deer and elk are involved over wide areas. Locally moose and mountain goats are too abundant, and in a few localities, bison, pronghorns and javelinas may become overpopulated. Because of the damage they do to livestock, normal populations of large predatory animals can never be restored to most big game ranges. Complete harvest by hunting of surplus ungulate stock, rarely achieved heretofore in the United States, should be a normal management objective, and certainly must be undertaken wherever range damage indicates its necessity.

Shortages of winter ranges. Intimately involved in the overpopulation problem is the deficiency in winter (or dry season) habitats. In eastern forests, for the most part, winter habitat is now fully utilized and herd control is essential. In western areas where summer and winter ranges are more widely separated, much land otherwise available for wild animals in winter is occupied by livestock ranches, cultivation, and large reservoirs. At present, when meat and grain are being produced in surplus quantities, it would seem that increased efforts should be made to restore some key wintering lands to wildlife.

Where this has been done (MORSE, 1958), along with adequate hunting, not only have larger herds of game been maintained but damage to private property has been reduced. This is especially important in states where large reservoirs are becoming increasingly numerous, often submerging thousands of square miles of important bottomlands. North Dakota game biologists, for example, advise (in conversation) that one-third of that state's winter deer range has been destroyed by the several huge Missouri River dams.

Vegetation management. Of the ungulates now living in American forests, all are animals of early shrubby stage of forest succession. Where fires and plant diseases are controlled, lumbering is the main factor inducing forest regeneration. The shorter the cutting cycle and the more extensively the forest canopy is opened, the more beneficial to hooved wildlife. Forest management for pulpwood and chemical-wood production is more beneficial than sawlog culture, and clearcutting in blocks or strips is more helpful than light selective logging. Cutting on wintering areas is helpful if delayed until winter. The use of fertilizers to induce forest growth and forage production (KNOTT, 1956) may be either beneficial or harmful to ungulates, depending on their effects on succession.

Rangelands today are being modified on a wide scale. Over large districts, shrubs are being removed by machinery and by chemicals. This is detrimental to deer and javelinas, and to a lesser extent to pronghorn antelope. Range fertilization and reseeding with grasses will tend to be beneficial to wild grazing animals but the bison which would benefit most, is no longer present except locally. Properly controlled fires in California chaparral (TABER and DASMANN, 1958) benefit deer there.

National Parks; Refuges. Refuges once were useful in restricting the kill and in preserving the habitats of scarce animals. For ungulates in excess supply, however, the values of refuges as such have vanished. Sanctuaries still aid relatively rare forms of bighorns, elk, and white-tail deer. National parks while in fact refuges, serve larger purposes as living museums. More areas of this type are needed even in the United States, especially in rangeland vegetation types.

In American national parks, policies of no lumbering, no forest or range fires, no predator control, and no hunting are characteristic. In general, these are com-

mendable policies and should be followed unless conditions forbid. The first two policies in forest areas, however, for example, tend to result in old-age forest stands; they reduce forage for ungulates. At the same time, the no-predator control policy is of limited value since predators are rarely as abundant within parks as they originally were (PETRIDES and SWANK, 1958). The mountain lion and timber wolf are extinct, for example, in Yellowstone. Where predators are reduced, ungulates tend to increase. Yet, as seen, forage supplies tend to decrease.

High densities of hoofed mammals in many parks are creating difficulties in the preservation of the ungulates themselves, the vegetative habitat they occupy (which has important values aside from forage), and the other animals also dependent on that vegetation. Limited hunting is now permitted in a few areas and of necessity may become more common.

Pesticides. The use of chemicals to control undesirable organisms, particularly through aerial application to large areas, is a growing threat to wildlife. So far, poison sprays have not been of direct significance in ungulate management, but the potentialities for their concentration in food plants and water supplies require a watchful attitude. Where chemicals control diseases which might set back forest succession, they are helpful in forestry but detrimental to browse production that would otherwise naturally occur. With increasingly potent materials and more extensive methods of application, chemical « fallout » may well become an increasingly important problem in ungulate management.

Animal diseases. Brucellosis and leptospirosis are examples of diseases which can be transmitted between wild and domestic ungulates. While they have deleterious effects in themselves on the wild species, the greater danger exists that there may be public outcries for game destruction where wild ungulates can infect domestic stock or, possibly in rare cases, humans. Methods of disease control in wild animals are needed.

Restoration of species. Reestablishment of the woodland caribou, in parts of Maine, at least, is desirable if habitat conditions permit. Restoration of the barren-ground caribou in localities within its original American range would be desirable, but it does not seem essential since it is mainly a Canadian and Alaskan animal. Replacement of sample populations of typical species in depleted areas, however, such as the bighorn sheep in the prairie badlands, certainly should be undertaken.

Introduced species. A number of Old World deer, antelopes and sheep, and the European boar have become established in parts of the United States. Some are becoming abundant locally. Especially on rangelands, habitats may be available for suitable imported species without undue danger of competition with native ungulates. There are esthetic objections, but the integration of disease-free additional imports into the American land use pattern seems likely to continue at a slow rate.

Public Education. The mechanisms of interacting forces and the ways they act on wild animal populations must become better understood by the public, if preservation and management is to be more successful. Among public ideas which require modification in North America are the viewpoints that (a) the more animals there are, the better their status, (b) shooting is the main factor limiting the size of game animal populations, (c) shooting female big game is « wrong », (d) fires are harmful to ungulate populations, (e) predators necessarily should be controlled, and (f) preservation of flora and fauna is assured without management in national parks.

Flexible Policy for Wildlife Management. These ideas, and others, may indeed be true in some situations and even in many situations; on other occasions, however, they may be quite wrong. The public must be brought to understand that a wildlife policy that may be entirely proper in one area or with one species may or may not be the correct policy in another area or with another species. Proper wildlife management depends upon adequate diagnoses of specific problems and then on the application of procedures judged to be most suitable for each specific situation.

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