THE WHITE-TAILED DEER OF NORTH AMERICA

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By far the most popular and widespread of North America's big game animals is the deer, genus *Odocoileus*. Found from Great Slave Lake and the 60th parallel of latitude in Canada to Panama and even into northern South America, and from the Atlantic to the Pacific, the deer, including the white-tailed deer (*Odocoileus virginianus* ssp., see map.) and the mule deer, (*Odocoileus hemionus* ssp.) with, of course, the coast deer of the Pacific area (a form of *hemionus*), is characterized by a geographic range far more extensive than any other big game mammal of our continent.

Within this tremendous area the deer occurs in a considerable variety of habitats, being found in appropriate locations from sea level to timberline in the mountains, and in all the life zones from Tropical to Hudsonian. The whitetail is found in the swamps of Okefinokee, in the grasslands of the Gulf Coast, in the hardwood forests of the east, and in the spruce-fir-hemlock woodlands of the western mountains. It inhabits plains country, rocky plateaus, and rough hilly terrain.

The deer resembles the coyote, the raccoon, the opossum and the gray fox in its ability to adapt itself sufficiently to the settlements of mankind to survive and even to spread, within the boundaries of cities. It is one of the easiest of all the game animals to maintain. It is also one of the most valuable of all our species of wildlife,

whether from the point of view of commercialization in dollars and cents, or from the recreational, inspirational and esthetic aspects. Its graceful form, alert bearing, bright eyes, lordly antlers and harmonious movements have made it an object of appreciation, interest and genuine solicitude from the earliest times. As a source of food, clothing and utensils, as well as an item in religious rites and tribal customs, the deer was of enormous importance to the aborigines. When the European came along, it became similarly serviceable to him. Where there were deer, there went the pioneer. The marksmanship for which the American Revolutionary soldiers became famous was doubtless in part derived from experiences in deer hunting.

Right up to this date the deer is an important item in our recreational commercial structure. In at least half a dozen of our leading states, including Wisconsin, Minnesota, Michigan, New York and Pennsylvania, the capital value of the white-tailed deer ranges from half a billion to more than a billion dollars, based on the numbers of deer present, and the known expenditures by sportsmen in their pursuit. It is highly probable there are at least ten million deer in the United States at the present time, possibly more than at any previous period. Each million of deer, based on studies in Michigan and California, has a capital value of a billion dollars or more. It would probably be fair to set the total value of our deer, altogether, at well over ten billion dollars. And even this figure does not count the esthetic attractiveness of abundant deer in our woods, fields and coverts.

Where Our American Deer Fit in to the Deer Family. It is well-known that the artiodactyls, or even-toed ungulates, constitute the dominant ungulate order, far outnumbering all the others combined. Among the American representatives of this order, in addition to the deer, are the moose, caribou, and wapiti. The last-named three are closely related to Eurasian forms, from which they are derived. Indeed the moose, caribou, and wapiti are considered, on the basis of available evidence, to have been relatively recent immigrants to North America, having entered our continent not earlier than Pleistocene time, perhaps within 500,000 or at most a million years. All are northern in distribution, the moose and caribou particularly so, the wapiti or Canadian elk being found somewhat more southerly. In former times the moose, too, ranged farther south than at present. In strong contrast to the others, the subject of our present study,
Odocoileus, is a smaller deer than any of them, and is not nearly so closely related to any old world forms. Consequently our deer are thought to have had a very long American ancestry.

Speciation in Deer. Nature has performed two great natural experiments in the evolution of the deer, resulting it the white-tailed deer group on the one hand, and the mule deer-black-tailed deer group on the other. The white-tailed deer evolved in two important areas: in part in the vast forest and prairie expanses of northern, eastern, and middle America; and in part in the diversified terrain of portions of the West, especially in Mexico, Central and South America. The black-tailed deer and the mule deer, on the other hand, appear to have evolved in the rugged bad lands and mountains and valleys of the western United States.

The process of speciation in the deer was undoubtedly affected by the ice age. Both white-tailed deer and mule deer at this time lost a considerable part of their ranges. The ice front came at least as far south as the northern tier of the Great Plains and the Lake States, and in the west it reached the Columbia River. Both mule deer and white-tailed deer were represented in the isolated mountains and valleys of the southwestern parts of the continent, and here, in these relatively isolated areas, where the deer were not disturbed by the oncoming ice, time was allowed for differentiation to proceed, and consequently several races developed. Differentiation of the mule deer proceeded quite largely in the United States, while more than half of the 30 recognized races of the white-tailed deer arose in Mexico. It is of interest, in passing, to observe that, so far as known to the writer, there is no evidence of any sympatric evolution in deer. Of the 30 recognized races of the white-tailed deer 7 occupy extensive ranges in the more uniform north and eastern part of the continent; 7 are found in the southeast and south; and 16 are in the much dissected terrain of Mexico and central America.

It is of interest that north of the United States-Mexican boundary the white-tailed deer has reached the Pacific Coast in only one place, namely in western Washington and Oregon near the mouth of the Columbia River. At present this race of whitetail is nearly extinct, or at least is represented by very limited numbers. The whitetail has become extinct in the Yellowstone Park and in Colorado. It is very nearly non-existent in California, Nevada, Washington, and Oregon, and is often
scattered or scarce in other parts of the West. But in this same western country, the mule deer attains its maximum development, both in numbers and distribution. On the other hand the mule deer stock invades Mexico for only a relatively short distance, while the white-tailed deer penetrates throughout the Republic, and on down well into South America.

Some Characteristics of the Deer. The larger forms of the white-tailed deer are in the north and the smaller in the south. Maximum size is attained in those races occupying the region extending westward from the Atlantic Coast across southern Canada and the northern United States to the eastern slope of the Cascade Mountains. Weights of 400 pounds are on record. It will be observed that the deer support Bergmann's Rule, that warm-blooded animals from colder climates tend to be larger in size and hence to expose less surface in proportion to body-weight than do their relatives from warmer regions. The minimum size is attained by the white-tailed deer inhabiting Coiba Island off the Pacific Coast of Panama. While I have found no actual weights of this deer on record, Seton (*Lives of Game Animals*, 1937, vol. 3, p. 233) mentions that adult specimens of the Acapulco deer examined by Caton did not weigh over 30 or 40 pounds. This is easy for me to believe, as we have found full-grown deer in Texas (the Texas whitetail) weighing no more than 57 pounds. Smallest of the eastern races of deer is the Florida Key deer, which has been seriously reduced in numbers, probably principally by real estate development of the Florida keys which constitute its home.

All the deer authors agree that antler formation seems to correlate mainly with various physical factors, among which are size, maturity, and especially general physical condition. The larger northern races carry larger antlers with more numerous tines than do the smaller southern forms. In the Acapulco deer, for example, the antlers, even in fully mature bucks, may be reduced to single spikes. The size and shape and general development of the antlers usually are associated with degree of maturity, physiological condition, and general physical vigor.

In the northern white-tailed deer the antlers are shed annually, but in tropical Middle America the deer are characterized by short, gnarled, rugose antlers, with broadly expanding burrs, which seem to indicate that the time of shedding is indefinite, and that in some indivi-
duals the antlers even may be carried normally considerably longer than a year. This indefinite time of shedding may be traced to the relatively slight seasonal variation in temperature and consequent irregular breeding season, as a result of which fawns may be born during the northern winter, and, hence, may reach maturity at any time during the year. There is much evidence that this whole series of phenomena involving breeding, antler growth and shedding, molt of winter and summer coats, etc., reflects variations in the endocrine balance.

Breeding. Throughout most of the northern hemisphere the breeding season of the whitetail runs from December or January through April or May. Now the deer's food is limited to what is left of the vegetative or woody growth of the previous summer. On all ranges there is a relative shortage of food at this season, but much more of a crisis occurs on overstocked ranges. Since the season of pregnancy coincides with this period of shortage, the winter food supply becomes doubly important.

Does nutrition exercise any influence on the fertility of deer? CHEATUM and SEVERINGHAUS (Trans. 15th N. Amer. Wildlife Conf., pp. 170-190, 1950) raised this question and set about to answer it.

Five New York regions were defined quantitatively on the basis of their climate, topography, vegetation, land use, and deer populations on winter range. A progressive diminution in the average number of embryos per doe was broadly related to the estimated quality of the ranges.

For example, in the best western range, there were 1.71 embryos per doe; in the Catskill Periphery, 1.48; in the Central Catskill, 1.37; in the Adirondack Periphery, 1.29; and in the Central Adirondacks (the poorest range), 1.06 embryos per doe.

To one who has formed most of his notions of deer breeding from observations in the West, the frequency of fawn doe breeding, as reported by CHEATUM and MORTON (Jour. Mamm., 23 : 210-211, 1942) is nothing short of sensational. Through several years of collection (1939-1949) breeding data on 346 fawns were secured. Seventy-five of these bred at ages varying from 6 to 8 months. In the great majority of instances a single embryo was found, although occasionally twins were present. There was even a triple pregnancy with embryos nearing full term, found in a doe which was between 12 and 13 months of age when killed.

The above data applied to New York State as a whole.
The breeding of fawn does in the Adirondack region was very low (around 4 per cent) whereas in the western part of the state breeding in this age-class ran over 32 per cent. In a small sample secured in Massachusetts, SHAW (Proc. N.E. Fish and Wildlife Conf., Wilmington Del., p. 6, processed, 1951) found an even higher rate. These regional variations in fawn fertility appear to be related to differences in vigor and growth rate of fawn does.

The fertility not only of fawns, but of the New York deer generally corresponds broadly with evaluations of range quality. Between the high fertility of deer in the western region, (where range quality is higher) and the comparatively low fertility found in the central Adirondacks (where range quality is lower) there appear to be intermediate levels as exhibited by the does from the two Catskill sections and the Adirondack periphery.

« It seems likely that the relative adequacy of the animals' nutrition especially during the winter, may be a paramount factor governing such variations. »

As the authors indicate, « There is a large body of literature which conclusively demonstrates the important influence of diet on the reproductive physiology of domestic and laboratory animals as well as of man. »

A number of workers have reported on the low productivity apparently associated with over-browsed sections of deer range in Pennsylvania. On the George Reserve in Michigan it has been noted that the lowest fawn crops were produced during the period of greatest concentration of deer and most extensive forage depletion.

« It may be assumed », say these authors, « that the more heavily a deer range is browsed the less the deer occupying it will be able to satisfy their nutritional requirements. Conversely, a reduction in deer population density should reduce competition for the available browse supply and improve the nutrition of the deer involved. The taking of antlerless deer in addition to antlered bucks usually results in such a reduction. »

Additional evidence on this point comes from western New York. Eighty-eight does were collected in this part of the state during a period when the buck law was in force, (only bucks legal) so reduction in the deer herd was small. These does showed an average embryo count of 1.6 or 160 fawns per 100 does. Then some antlerless deer (does legal) seasons were held, which substantially reduced the deer population. Examination of 52 does taken following the antlerless seasons showed 1.9 embryos per doe, or at the rate of 190 fawns per 100 does.
That cutting down or thinning deer populations tends to result in higher reproductive rates in the deer which are left is evidenced widely throughout the deer range. So far as known, the facts support this conclusion without a single exception.

_Hormonal Relations to Breeding Cycle and Antler Development._ WISLOCKI, et. al. (Amer. Journ. Anat., 71: 371-415, 1942, and elsewhere) have demonstrated the intimate functional relations between sex glands and growth, maturing and shedding of the antlers. Shedding of the velvet is precipitated by a rise in testosterone, secreted by the testes. As the activity of the testes diminishes and testosterone is reduced, the antlers themselves drop off. Castration after shedding of the velvet, will cause antlers to drop.

In northern latitudes the new antler growth begins in April. This is a period of increasing daylight. WISLOCKI proposed that at this season a hormone that stimulates growth of antlers is released by the pituitary body. This small gland later releases another hormone which stimulates growth and activity of the testes. Activation of the testes and consequent increase in production of testosterone results, as before stated, in the shedding of the velvet.

« The breeding cycle of the buck is thus completed and it will be observed that hormones from at least two different sources may be actively involved in the sexual cycles, antler growth and development being a dramatic indicator of the hormonal balances prevailing at different stages of that cycle. »

Abnormalities in the seasonal rhythm of hormone production become manifest in the appearance of the antlers or other secondary sexual characters, and are reflections of impairment in hormone relations.

_Deer Breeding in Western New York._ Records were kept in New York of 2,831 does which went through the deer checking stations (1948-1950). These deer might have produced 2,355 fawns. No single age class above 3½ years produced as many fawns as did the fawn class itself (under 1½ years). Although the highest rate of fawn production (number of fawns per doe) was found in does of the 4½ to 7½ year classes, they were much fewer in number and hence their numerical importance to the herd as producing does was diminished. The total fawn production of all does 5½ years and older is only slightly more than the number anticipated from breeding fawns alone. The fawns produced 9 per cent of the anticipated
fawn crop; does from 5½ to 10½ plus years produced only 9.6 per cent of the fawns. More than 50 per cent of the fawns were produced by the fawns and the 1½ year old does together. This is the kind of age-composition and fawn production picture which is occurring in western New York where whitetails are heavily hunted with an annual buck season and also an antlerless deer season held about every other year. The importance in reproduction of the younger age classes is emphasized.

Triplet pregnancies are not unusual in well-nourished does and may occasionally occur in precocious fawns. Only four quadruplet pregnancies are known. AUDUBON and BACHMAN (The Quadrupeds of North America, vol. 2, p. 226, 1849) first reported quadruplet embryos in a Virginia whitetail taken in Carolina. Quadruplets were found in large doe killed by an automobile (1949) in Chautauqua, New York. This doe was killed April 26, and «...the fully developed fawns were in perfect condition. » Bartlett, in Michigan, reported a doe with quadruplet embryos in April, 1949. Several instances of quadruplet eggs being shed during a single estrous cycle were observed by Cheatum during analysis of deer ovaries, but in none of these cases had all four eggs been fertilized as would have been necessary for the birth of quadruplets.

When one or more of a litter of deer embryos die at some time during pregnancy the dead embryo or embryos are usually resorbed rather than aborted. This is in contrast to domestic ruminants in which abortion is the usual means of getting rid of the dead embryo.

Some sportsmen have been concerned lest overshooting of bucks would reduce the fawn crop. No evidence has come to light during the study which indicates that bucks anywhere have been cut down so low as to affect the size of the fawn crop.

There probably is wide variation in the number of breeding females a buck will serve. In close confinement in a corral a buck may serve many more does than he would or could under the dispersed conditions in the wild.

Gerstell in Pennsylvania (Penn. Game News 6 : 4, 20, 1936) maintained a 23 acre deer paddock, in which, one year, there were one buck and 20 does of breeding age. In November two of the does were shipped to a zoo and one was severely injured during the early winter. The remaining 17 does were bred by the buck and produced 21 or more fawns, showing that at least four females produced twins. Thus it is definitely known that the one buck successfully bred 17 does and may have
bred 20 does. The fawning period remained normal and extended over a period of less than 30 days.

These breeding results were secured under ideal conditions in captivity from a single buck. In the wild, 20 breeding does might be widely scattered over from one to ten square miles of land. Also, in the wild, all counts available indicate that a pre-hunting season sex ratio of one adult male to 7 or more adult females is highly improbable.

The doe is in heat and receptive to the buck for 24 hours or less. If conception does not take place, another period of heat occurs in 28 days. There may be four of these periods of heat in a single fall.

During the brief period when the doe is receptive the buck stays close by. The same buck may accompany the doe for two or three days after her heat period ends. Therefore, in the wild a buck that has found a doe that will soon be receptive may be out of circulation for four or five days.

The period of gestation is 196 to 203 days.

**Glands and Odors of the Whitetail.** There are four prominent glands on the whitetail: the preorbitals—located at the inner corners of the eyes; the metatarsals, in the outside of the lower hind legs; the tarsals, on the inside of the hind legs at the hocks; and the interdigitals, between the toes on all feet. The preorbitals are tear glands and their main function is to lubricate and clean the eye; the function of the metatarsal glands which secrete an oily substance which has a musky odor has not been ascertained. The tarsal gland is pear shaped with the small end upward. Whenever excited by fear or hostility, the animal elevates the hairs of the tuft marking the gland so that they stand out at right angles to the skin. The glands give out a penetrating odor of musk. As with the metatarsal glands their fundamental physiology is unexplained.

Nichol, working in Arizona (In Taylor, *The Deer of North America*, pp. 127-128, 1956), found that does discharge scent to call or warn fawns, bucks emit scent in the rut, all deer do so when frightened. Deer lost from the corrals and trying to find their way back were called to the herd in this way.

Unexplained is the deer's habit of urinating on its tarsal glands. While the most nervous deer were the ones emitting the musk odor, it was the least nervous which most frequently urinated on these glands.
The interdigital gland is more active than any of the others. It always contains a considerable amount of matter, which is about the consistency of the wax from human ear. This substance is of a grayish color, and gives off an odor which is strong and offensive to most nostrils. It is impossible for a deer to place its feet on the ground without leaving some of this scent, and it appears likely that their function has to do with locating themselves or other members of their species. Nichol found that does liberated from the corrals found their way back by trailing themselves. Deer depend first on scent, second on hearing, and third on sight.

Antlers. In his discussion of the phylogeny of the deer F. B. Loomis (Amer. Journ. Sci., 16 : 531-542, 1928) remarks that in the early Miocene some forms of the deer-like animals developed the bony process over the orbit to a greater extent than did the giraffes and the giraffe-like animals, and acquired the strange habit of having the major part of the bone die and become an exposed dead bone. This then began to be shed and a new one grown to replace it. This is the antler proper.

The growth and shedding of deer antlers is one of the strangest of animal physical characters. At first glance it seems almost preposterous that the sometimes huge rack of antlers, in some deer, as the moose, very heavy and ungainly, should be built up, and shed, every year. Yet such is the case. Seemingly, in the closely wooded country, such huge developments would be a handicap rather than a help, and one is not surprised to find P. L, du Nouy's assertion that the glacial period drove certain species of reindeer in northern Siberia which had developed very extensive antlers out of the steppes and into the closely packed forests of the south, where their antlers were such a handicap that the species finally died out. Whether this conclusion is sound or not, I do not know, but it is at least plausible.

It will be recalled that antler growth occurs in a cycle that is repeated year after year. For the northern white-tailed deer the growth has been well described by Wislocki who writes that the antlers begin to grow in April or May becoming hard by September when the velvet is shed. Mating ensues in October and November and the antlers are dropped in late December or January. This sequence of events is essentially the same for all the deer family in North America.

It is well known that the size of antlers is dependent upon the age of the individual, the quality and quan-
tity of forage available to it, and its hereditary background. The antler beam diameter increases in progressively older deer, within limits, and workers have often used this measurement for the determination of age. It is now known, however, that the increase proceeds only to the age of about 7½ years, then the antler beam diameter remains about the same or may even decline. Furthermore there is so much overlapping between different ages that the antler beam diameter is an unreliable indicator of age.

Within a given region it has been found that the antler beam diameter varies with the ability of the deer to find a sufficient quantity and quality of food. Where ranges are over-stocked the antler beam diameter is less. « The largest antler beam diameters in an age class were found », write Severinghaus and Cheatum, « where there was no overstocking of winter ranges and where the herd size was controlled by periodic antlerless deer seasons. »

The average number of points shows an increase with age up to 7½ years. But there is a good deal of variation in number of points associated with the nutrition and general physical well-being of the animal. After an average or severe winter in the central Adirondacks these workers found that about 50 per cent of the 1½ year old males, about 15 per cent of the 2½ year old males and perhaps 5 per cent of the 3½ year old males did not grow antlers 3 inches long, an important point in New York where antlers have to be 3 inches long to be legal. In western New York where the deer ranges were not overpopulated all yearling bucks had legal antlers (not less than 3 inches long) and only 14 per cent of these were unbranched. Among the other yearling bucks 43 per cent had 3 to 5 points, 40 per cent had 6 to 8 point racks, and 3 per cent had racks with 9 to 13 points. These were all in yearling bucks, remember. Thus on these even-aged yearling bucks the points varied from little bumps hardly half an inch above the skull to racks with 13 points.

SEVERINGHAUS and others (Trans. Fifteenth N. Amer. Wildlife Conf., pp. 551-570, 1950) have shown that the diameter of the antler beam similarly varies in yearling bucks from 7 to 30 millimeters. Among bucks 2½ years old the variation was from 13 to 38 mm, and in 3½ year old bucks from 18 to 43 mm. Apparently the nutrition of the individual is more important than age in influencing the number of antler points as well as antler beam diameter.

The frequency of deer with a certain number of points on both antlers is often of interest to hunters.
The most frequently encountered rack has seven or eight points. Next to this is a five or six, or a nine or ten point rack. An even, rather than an odd number of points is more typical, so that eight, ten and six point racks make up the majority. A rack with 11 or more points is only found on about 1 buck in 15 or 20; one buck in about 100 has 13 or more points, one in about 400 or 500 has 15 or more points and 1 buck in about 1,500 to 1,800 has 17 or more points.

Management. Seemingly among the very first concerns of the biologist or game manager should be the basic food species available under different conditions to the game, the abundance and distribution of these basic plants, their accessibility and their content of necessary protein and other foods. In part this will be indicated by their exposure to the vitalizing rays of the sun.

One complication in the evaluation of deer foods is that the deer consume a great variety of plants. It is easier, in some localities, to list the species of plants not used than those which are eaten. ATWOOD (Jour. Wildlife Mgt., 5 : 314-332, 1941) listed 614 kinds of plants known to be taken by the white-tailed deer in the United States. Numerically the seed plants, especially the dicotyledons, also grasses and sedges, and conifers, made up by far the greatest proportion of these. In fact only some 26 species of non-seed plants (algae, mushrooms, mosses, ferns, horsetails, club-mosses, etc.) are on the deer food list.

As HOSLEY points out (in TAYLOR, The Deer of North America, pp. 187-259, 1956), over most of the whitetail range the biggest management problems hinge around winter foods in one way or another. Climate and topography strongly affect the conditions under which deer winter. In the north the depth and duration of snow cover determine the animal's ability to reach foods. Temperatures affect the nutritional needs of the animal and hence its ability to winter on a given food. Size of plants has a great deal to do with availability. If browse is above the reach of deer, it will not be used. Also, large areas of young hardwoods without coniferous cover are unavailable for deer use.

According to Hosley the really outstanding winter deer foods of the northern forest region are comparatively few. Apple fruit is one of the most sought but its limited occurrence in the deer range of the Lake States makes it of little importance. White cedar is highly used and a very satisfactory deer food wherever it occurs.
The same is true of ground hemlock (*Taxus canadensis*). Hemlock (*Tsuga canadensis*), although not as nutritious as white cedar, is generally and heavily used all over the region. As a group the maples are most important. Mountain ash is heavily utilized and sumacs are favored.

Another group of 24 or more species of plants is heavily used in parts of the region. This group includes black ash, white ash, basswood, birch, black cherry, dogwoods, and others.

Some of the competitive relations of the deer with the moose and other animals within its range are of significance. Moose, for example, feed heavily on balsam, but for deer, balsam is a starvation food. Moose would not get along well, on the other hand, on a white cedar diet which would be top quality for deer. Mountain maple, paper birch and mountain ash are taken by both. It is of interest that in the Canadian life zone, which covers so much of Ontario and Canada generally, the deer is competing successfully with the moose, in fact the numbers of moose appear to be declining, while the numbers of whitetails are increasing. The case is otherwise in the Hudsonian zone, where the moose seems to be better adapted than the deer.

One does not ordinarily think of the deer as an enemy of small game. But in Pennsylvania, over large areas, heavy deer browsing resulted in the practical elimination of cottontails, snowshoe hares, ruffed grouse and wild turkeys.

*Habitat.* As with all animals, the habitat is important to deer welfare and productiveness. For the most part practical management is likely to be concerned more with the deer habitat than it is with the deer directly.

Hosley has pointed out how when the first settlers came to America, the deer herds were unquestionably very different from those of today. The northern forests had few deer, because there were almost no low-growing food plants to support them. The oak-hickory forests and those of the South had more generous deer populations. Then came a period of land clearing and settlement, starting in the East and progressing westward. Included in this was a wave of lumbering, which first covered the New England states and then moved across to the Lake States. As Hosley points out, the logging had two effects. As the old timber was opened up additional food plants became available for deer, and the animals followed the loggers into the "Northwoods." However, this was also the era of the professional market hunter.
who kept the logging camps supplied with venison. In 1880, 100,000 deer were sold on the market in Michigan (BARTLETT, Michigan White-tailed Deer, unpub. ms., typed, 1948). Following the logging came repeated and severe fires, which often left large areas barren. This combination of inimical factors led to virtual extinction of deer by the latter part of the 18th century over almost all but the northern parts of New England. In Pennsylvania the low point was reached somewhere around 1900, in Michigan between 1900 and 1915, and in Wisconsin in 1922, when the Game Commission stated « Deer are destined sooner or later to cease to be a game animal in Wisconsin » (SCOTT, Mich. Conservation, vol. 17, no. 11, pp. 6, 7, 12, 13, 1948). A widespread realization of what was happening stimulated efforts to maintain and increase the deer. There was some restocking in New England. A refuge system was established in Pennsylvania. Legal protection in larger measure was given the deer and made more effective. Jack lighting and market hunting were outlawed, open seasons were permitted on bucks alone where deer were still fairly plentiful and yearround protection was accorded them in areas where they were scarce. Doubtless of far greater importance were definite alterations in the habitat which took place about this time. There was widespread cutting of the second growth white pine and hardwoods in New England and Pennsylvania. This created a wealth of hardwood sprouts and seedlings on which deer thrived. Fire protection became effective and the young hardwoods were able to continue their development over larger areas. The herds were again on their way up. The swing went so far that in 1947 LEOPOLD, SOWLS and SPENCER (Jour. Wildlife Mgt., 11 : 162-177, 1947) listed more than half of the 48 states as suffering, more or less, from over-populations of deer. Given an animal of vigor and adaptability, a habitat improved through cutting, cultivating, or burning, so as to produce more deer feed, effective legal protection, and freedom from predatory animals, over-populations are inevitable unless the harvest of deer is increased to compensate for the artificially favorable factors.

Malnutrition. Wherever there is overcrowding of deer ranges there is starvation (under-nutrition or malnutrition). Since in many or perhaps in most cases deer die with their stomachs full of food of sorts, many writers prefer the term malnutrition to starvation. There isn't much, after all, to choose between the terms,
for at the end of the process the deer is as dead from malnutrition as it would have been from starvation.

The effects of malnutrition go deep, and may be briefly suggested.

(1) Malnutrition adversely affects the ovulation and fetal rates of deer.

Cheatum and Severinghaus (Trans. Fifteenth N. Amer. Wildlife Conf., pp. 70-190, 1950) found a progressive diminution in average number of embryos per doe to be broadly related to lower estimated quality of range. In the best western ranges the does averaged 1.71 embryos (171 per 100) each while in the central Adirondacks, where the range is relatively poor, the embryos averaged 1.06 each (106 embryos per 100).

(2) Malnutrition is the key to winter disease and die-off of deer. We have never encountered a widespread diseased condition in deer or the death of deer on an abnormal scale during the winter or summer which was not associated with deer that were hungry due to food shortage, in most cases the result of overcrowding of the range with deer or livestock or both.

(3) Malnutrition predisposes to parasitism, both internal and external. A deer that is undernourished or starving is almost certain to be the prey of greater numbers of parasites than is a well-fed, healthy deer. In some way, not as yet understood, the well-fed deer is more resistant to parasites. Perhaps the skin secretions of a healthy deer enable it to protect itself more effectively from parasites. In some cases the parasites or the disease may come first and make the deer poor regardless of the condition of the range. But we have never encountered a case where bad physical condition of deer was not associated with shortage of food, for one cause or another.

(4) Malnutrition cuts down the number of females that breed first at 1½ years (in the Northwest) or at 6-9 months (in the Northeast). These females then, often do not breed first until they are 2½ years old. « The reproduction rate goes down and the death rate of the young in their first winter goes up. Contraction takes place at both ends of the reproductive chain. » (Cowan, in Taylor, The Deer of North America, p. 561, 1956).

(5) Malnutrition cuts down the weight, size, and the antler development of the deer affected.
Deer removed from the over-populated Edwards Plateau in Texas and liberated in a more favorable range in the eastern part of the State increased in weight some thirty per cent in four years.

*What then can be Done?* Management of wildlife, including deer, consists largely of care for the habitat in such a way as to make and keep conditions favorable for the species under management. Under strictly natural conditions, with the complex of vegetation and animal life as it has built up through the ages, there are, perhaps, fewer difficulties. But man's pervasive influence has so modified most of the habitats of the animals and plants around him, that he must increasingly take a hand.

Out of this study come certain suggestions on how best to proceed. Here are some of them:

1. Hold deer populations down to the carrying capacity of the habitat at or near its minimum, that is, at the time of year when it can carry the smallest number of deer. This will reduce competition within the deer herd for food. In most instances the only effective way to secure this degree of regulation of deer numbers is to harvest both bucks and does.

2. Except where deer are seriously underpopulated as determined by adequate census by wildlife technicians, no predator control should be permitted on deer range.

3. Where practicable, so handle the deer habitat that food for deer will be produced. This may entail timber cutting, burning under careful regulation, or other practice. In ecological terms this usually will mean the maintenance of successional stages instead of the climax.

4. Manage the food supply of the deer so as to provide an abundance of palatable, nourishing food at all times, especially during periods of shortage. This often will mean cutting down the deer herd. If there are other game animals, or if there are domestic livestock on the range, full account must be taken of their food consumption, and provision made for all, again, more especially at the period of shortage. If this is done, the deer should be larger, their antlers will be better developed, their fawn crop, i.e. their increase, will be improved, they will be freer from disease and parasites.

While deer management is a complicated enterprise, embracing attention to the entire biotic community on a basis of each locality, it has been unflinchingly impressed on the writers of the Deer Book, individually and
collectively, that when things go wrong, malnutrition is more likely to be the villain than any other factor. As a corollary of this, the conclusion seems virtually unescapable that if the wildlife technician can keep the deer well-fed by natural means he will be spared many and indeed most of the troubles that otherwise go with the business.