

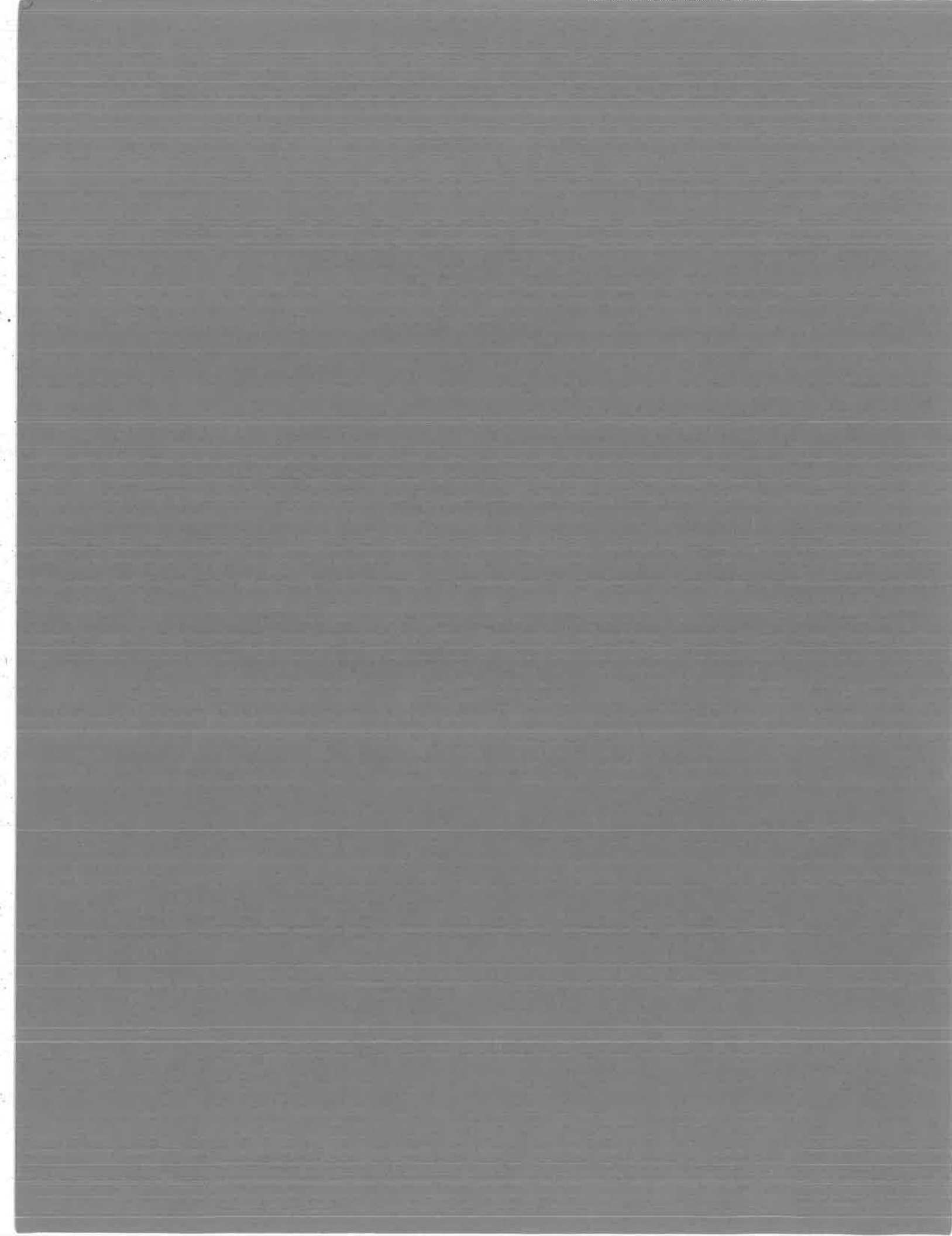
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WILLIAM A. CREED

A CONTRIBUTION
OF THE GREAT LAKES
DEER GROUP

RESEARCH FOR DEER MANAGEMENT IN THE GREAT LAKES REGION





FOREWORD

This analysis of research needs has been prepared by a committee of The Great Lakes Deer Group, an organization of wildlife management and research specialists from the Great Lakes Region - Ontario, Michigan, Wisconsin, and Minnesota. The Group was formed to promote the interchange of information on research and management of deer and deer range. It has met each year since 1951. In addition to exchanging information, the Group is dedicated to (1) the collection, dissemination, and more efficient use of basic knowledge of deer and range; and (2) the development of a basic program of deer and deer range management and research in the Region.

The Group feels that the deer research effort should be directed in two ways: (1) reasonable amount of fact finding - for fact finding's sake, the so-called pure research never knowing what will be found out; and (2) the major effort should be either directly or indirectly aimed at providing more recreation for our customers.

The discussions contained in this report are intended to briefly summarize the state of our knowledge on each topic as of early 1964; they are not intended to be a complete exposition of all known facts. Likewise literature references are not cited, since the committee assumes that readers wishing to use this report will have at least some familiarity with published information on deer. In addition, much information cited herein has not been published.

This report should be used as a source of ideas to guide future programs. It is not intended as a long-range plan for any agency or area.

By delineating the general areas of research need, and by recommending priority projects, the Great Lakes Deer Group hopes to assist the research planning of individual agencies, and to encourage productive inter-agency cooperation in deer and deer-range research.

Laurits W. Krefting
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SUMMARY APPRAISAL OF RESEARCH NEEDS

Each section of this research program analysis contains suggestions for needed research concerning deer in the Great Lakes Region. Some of these needs are for basic knowledge; some are for immediate use in management programs; some have wide interest and importance; others are of importance only locally. In considering all the stated needs, it is apparent that an appraisal of their priorities must be made to complete the perspective on deer research this program analysis intends.

Discussions within the Great Lakes Deer Group have resulted in the definition of 16 problem areas of highest priority for future research.

These are problems common to the Great Lakes Region. However, since the needs and programs of participating agencies vary greatly, it is not possible to rank these programs in an order acceptable to all agencies concerned. Therefore, the list of major research needs presented below are to be considered of greatest importance, but in no particular order of priority for the program of any state or province. No obligation is implied that any participating agency must accept these recommendations.

The research priority list is necessarily expressed in general terms. Even though these are problems of common interest, there are still differences in deer populations, habitat status, and management programs within the Great Lakes Region that make it impractical, if not impossible, to propose research projects in detail. However, inter-agency cooperation in establishing projects on these topics is not only possible but also highly desirable. The coordination of such joint research efforts in the interest of getting the most from the available deer research dollars is a prime function of the Great Lakes Deer Group.

In preparing this priority list, some members of the Group have expressed regret that there are no really new or revolutionary needs and ideas presented, and that the same 16 priority needs would probably have resulted from a similar analysis 15 years ago. There is no question that this is true. However, this point in itself is highly significant. It emphasizes that while deer research has made progress rapidly in recent years, there is still much to be learned about the basic biology of whitetails and their habitat. In addition, the increasing sophistication of deer management programs, and the integration of deer management with other land-use programs have made the need for more detailed solutions to familiar problems a pressing one. For example, harvest regulations and habitat management now require that specific numbers of deer be related to specific areas of specific habitats. It is no longer satisfactory (nor publicly acceptable) to base management programs only on the status of winter range. The unknowns about deer-habitat relationships are somewhat fewer than they were 15 years ago, but they are still large enough to warrant priority attention today. The same general relationships hold for all priorities on the list.

PRIORITY RESEARCH NEEDS

1. Methods of determining the carrying capacity of deer ranges.
2. Methods of determining deer populations prior to hunting seasons, especially for small areas, that can be used to determine the size of the surplus and to set regulations for the removal of these surplus deer.
3. Better techniques for measuring hunting kills and losses from disease, parasites, starvation, poaching, predation, and infant mortality.

4. Assessment of the reliability of present aging techniques, and development of new aging techniques.
- * 5. Methods of measuring deer productivity for important forest-cover and soil types.
6. Behavior characteristics of deer as they relate to mobility and management.
7. Effects of weather on survival and distribution of deer.
8. Basic knowledge of deer anatomy, physiology, and diseases (etiology, pathological effects, transmission, possible control).
9. Nutritional requirements of deer, nutritive values of browse plants, and means of improving nutritively poor range.
10. Life-history studies of the important deer browse species, with emphasis on propagation in relation to deer browsing.
- * 11. Development and appraisal of silvicultural techniques to integrate deer habitat improvement with timber production.
- * 12. Relationships between summer-range types and deer population levels.
13. Tests of range-survey methods, silvicultural techniques, and deer harvest methods on large research and management demonstration areas.
14. Methods for determining public attitudes toward deer management programs, and methods for convincing the public and conservation agency personnel of the need for managing deer on a scientific basis.
15. Determination of all economic values of the total deer resource.
16. Determination of all recreational uses of deer.

RESEARCH NEEDS FOR DEER MANAGEMENT

IN THE GREAT LAKES REGION

INTRODUCTION

The Great Lakes Region has a gross area of 562,000 square miles. About half of the human population resides in four large metropolitan centers - Detroit, Milwaukee, the Twin Cities of Minneapolis and St. Paul, and Toronto. The Region is also easily available to large centers of human population in Indiana, Illinois, Iowa, and Ohio.

The white-tailed deer is the most important big game animal in the Great Lakes Region. Annually more than 1,000,000 deer hunters purchase licenses and kill more than 300,000 deer. With an increasing human population accompanied by increasing leisure time and the resulting demand for more recreation, deer hunting as a sport is almost certain to increase.

In parts of the Great Lakes Region the deer-carrying potential of the range has reached its maximum and in some major areas is rapidly decreasing, carrying the herd down with it. This increasing use of a decreasing resource makes it imperative that habitat be kept in the best possible condition to produce optimum herds, and that the entire annual huntable surplus be efficiently utilized. To attain this goal, up to date and accurate information must be available to the deer managers and to the administrators. Furthermore, public understanding and support is essential for an effective management program.

The information in this report is presented for the express purpose of guiding the programming of future studies and management plans by private and public agencies toward the goals of maximum production and sustained adequate harvest.

IMPORTANCE OF DEER IN THE REGION

General History of the Herd

The forested area of the Great Lakes Region furnishes the raw material for important wood-using industries, plus the opportunity for a large part of the nation's outdoor recreation, particularly hunting and fishing. Deer hunting is a major sport. The region supports an estimated 1-1/2 million white-tailed deer, about one-third of the total United States population.

During the past two centuries major ecological changes have taken place in the forests of the region as a direct result of settlement, fires, and logging. Farming, logging, and fires destroyed the virgin forest leaving large and small openings and producing browse more favorable to deer. The deer population increased rapidly with the abundant supply of good browse. Today, however, the forest has advanced on the logged and burned areas. Tilled fields have been abandoned and the forest has grown up. Browse plants important to deer are less abundant and winter habitat, severely overbrowsed during the period of peak deer populations, has not recovered.

Ontario

The history of deer in southern Ontario is one of range extension after early logging, followed by a build-up and then a decline of the deer population.

Before the opening of the mature forest, deer probably were not found very far north of a line from the southern tip of Georgian Bay to the Ottawa River and paralleling Lake Erie, Lake Ontario, and the St. Lawrence River. They were first seen on the north shore of Lake Huron in the

vicinity of Manitoulin Island and Sudbury in the 1870's and the 1880's. It is possible that some may have crossed from Michigan into the areas around Sault Ste. Marie. The herds continued to build up until about the 1920's, when the highest densities were probably reached. Since that time, with a decrease in logging activity, the forest has gradually closed in again.

The decline in deer numbers has not been a steady one, but rather a series of downward steps following winters in which snow depths were extreme. After each bad winter it seemed that the herd did not recover its former numbers.

In western Ontario, deer crossed into the Fort Frances area in the 1870's. There was a rapid increase and good populations were present as early as 1910. The peak population probably came in the 1940's, largely as a result of widespread fires in 1936 and a drastic fire in the Fort Frances area in 1937.

The first major die-off of deer occurred in the winter of 1949 and was responsible for the start of the deer research program in Ontario. A second die-off occurred in 1955-56. These were both due to deep snow. Recent winters have been mild in western Ontario and deer are again abundant.

Minnesota

In Minnesota the deer range is more widespread than in the past. About 1900, deer were present but not abundant in the conifer forest of the middle and northern parts of the state. With the opening of the forest by fires and logging, the deer population increased and by 1930 deer were common over most of the state. Although conditions improved in the north

after 1900, the situation in the south was different. Land clearing, intensified farming, and severe hunting made the deer scarce by 1880. Drastic changes in the deer population and distribution within the state have taken place since that time. Deer are now found in all of Minnesota's counties and the total population has been estimated at 500,000 animals.

Wisconsin

The original distribution and density of the deer in Wisconsin was directly related to the original habitat. The virgin forest that covered much of the northern part of the state was made up largely of big timber. Under these stands deer food was sparse. Probable deer densities, prior to 1800, were 10 per square mile in the northwest, 10 to 15 per square mile in the northeast and 20 to 50 per square mile in oak-maple forest in the southern half of the state.

Soon after 1800 the fur trade began to decline and the white settlers turned to agriculture. They hewed farms out of the virgin forest that also furnished necessary lumber and fuel. The oak stands in southern Wisconsin were the first to go and soon the huge white stands followed. The peak year for lumber production was 1899, and by 1920 many virgin stands of hemlock and hardwoods had been cut. Logging changed the environment drastically and was followed by an era of uncontrolled forest fires.

Between 1850 and 1900 the expanding deer habitat produced an early deer population peak. Then, between 1900 and 1910, the uncontrolled fires and market hunting caused the deer herd to decline. Law enforcement, predator control, fire protection, and hunting season restrictions all began about 1915. The deer population increased slowly at the start but by 1930, overbrowsed range was evident and deer began to damage farm

crops. Deer are now found in all counties. Growing public acceptance of scientific management principles is slowly leading toward sustained-yield deer harvests and minimum range damage.

Michigan

In the Upper Peninsula of Michigan little is known of the history of deer prior to 1850. Logging had not begun and it is probable that deer were relatively scarce. In many areas of Upper Michigan they were considered to be fairly common by 1870 but by about 1900 deer were at a low point because of market hunting. Logging and fires soon opened up the forest and produced favorable habitat. Also, restrictive hunting regulations and better law enforcement permitted the herd to expand in the improved habitat.

In the northern part of the Lower Peninsula, early habitat conditions were more favorable for deer. Soon after 1850 the herd increased with logging to the point where deer were abundant between 1870 and 1880. This was followed by a period of market hunting during which over 100,000 animals were shipped from the region in one year. Fires and market hunting decimated the herd so that by 1900 it was at a low level. Soon thereafter market hunting was outlawed, fire control improved and the deer population was on the increase again by 1920. The "buck law" became effective in 1921 and hunting was much improved by 1925. A deer irruption was soon underway and by 1930 parts of the range were overstocked. Starvation was rampant in portions of the region by 1936.

In the southern part of the Lower Peninsula, Michigan's agricultural and industrial region deer were plentiful in primitive times. At the start the deer population increased with agriculture but by 1870 more intensive

agriculture and market hunting depleted them. Between 1885 and 1920 deer were considered scarce but by 1930 were on the increase. By 1943 deer were found in every county of the state.

Extent of the Range

Climate

The mean annual precipitation ranges from about 20 inches in northwestern Minnesota to about 36 inches at the southern border of Michigan. Extremes in temperature range from 50 degrees below to 105 above zero. The average frost-free growing season extends from about 100 days to 180 days.

Forest Resources

About 45 percent of the total land area in the Lake States is forested. These forests once covered 104 million acres or nearly 85 percent of the land. At present, approximately 53 million acres are considered commercial forest and the rest non-commercial. About 10 million acres are non-stocked, 10 million acres are covered with softwoods, and about 32 million acres are commercial hardwood forest lands. The forest cover types are as follows: aspen-birch, 15 million acres; northern hardwoods, 8 million; oak-hickory, 5-1/2 million; elm-ash-cottonwood, 3 million; jack pine, 2-1/2 million; spruce-fir, 2-1/2 million; black spruce, 2 million; and white cedar, 1-1/2 million. Types with less than a million acres each include white pine, red pine, and tamarack.

The Lake States has approximately 50 billion board feet of live saw-timber and a growing stock volume of about 26 billion cubic feet. Although the Region has about 10 percent of the forest area of the country, it has less than 5 percent of the growing stock volume and less than 3 percent of

the sawtimber. Twenty percent of the commercial forest area is non-stocked and another 30 percent is poorly stocked. There are about 5,700 primary wood-using plants, ranging from large pulp mills to small sawmills.

The Province of Ontario is characterized by three major forest regions: The Boreal, the Great Lakes-St. Lawrence, and the Deciduous. The Province has a total land area of approximately 219 million acres, of which 199 million acres are forested and 20 million acres are non-forested. A little more than half of the forested area is classified as productive. The primary growing stock consists of 61 percent coniferous species and 39 percent hardwoods. The volume of this growing stock is nearly 151 billion cubic feet. Present forests can sustain an allowable annual cut of 2.7 billion cubic feet.

Harvest

The Lake States supported an estimated 1,500,000 white-tailed deer in 1960. The Province of Ontario also has a fairly large deer herd but population data are not available. Since the total United States white-tailed deer population has been estimated at 4-1/2 million in 1957 and 5-1/2 million in 1958, approximately one-third of the total are produced in the Lake States.

In 1955 the Lake States kill was about 172,000 deer (possibly 30,000 more in Ontario) and this harvest increased to about 328,000 in 1959. Since the total United States kill was 981,865 deer in 1959, the Lake States accounted for 30 percent of all the deer harvested. During a six year period, 1955 to 1960, the total Lake States kill was about 1-1/2 million animals. In 1963 the Lake States kill was 301,000. Ontario bagged an additional 29,400 deer in 1963.

The National Survey of Hunting and Fishing in the United States (1960) shows that 4,414,000 people hunted big game in 1955 and the number increased to 6,277,000 in 1960 at which time these hunters spent a total of \$345,994,000 (\$55 each). One billion dollars was spent for all kinds of hunting in 1960. That year the number of deer hunting licenses sold in the Great Lakes Region was about 1,100,000. If each hunter spent \$55, the total deer hunter expenditure in the region approximated 60 million dollars. Applying this same \$55 to the Great Lakes Region that hunted in 1963 places the annual expenditure at 64 million dollars.

Conflicts With Other Resource Uses

Forest and Agricultural Damage

Because of the liberal deer hunting seasons and the occasional severe winters, forest damage by deer is not a problem in Ontario, save in Algonquin Park where yellow birch reproduction has practically been eliminated. Field and orchard crop damage is minor in southern Ontario.

In southern Minnesota crop damage complaints by farmers were not numerous until 1940 but by 1943 had reached serious proportions. By 1946, the deer herd had increased to the point where it was possible to open the southern part of the state to hunting. This aided in reducing damage. In southeastern Minnesota, apple growers have suffered winter damage by deer since about 1947. Several state parks and refuges and federal refuges have been open to hunting to alleviate damage to pine plantations and other trees and shrubs.

Damage by deer in Wisconsin through trampling and browsing agricultural crops and orchards has been and continues to be a costly problem. Localized

summer damage to forest reproduction also occurs. This is the only state in the region that makes payments for agricultural crop damage.

Between 1932 and 1963, about 613,000 dollars was expended in settlement of deer damage claims. Wisconsin has taken a realistic point of view as to what constitutes deer damage to forest tree reproduction. Trees not needed for forestry purposes cannot be damaged by deer browsing and not all deer browsing can be classified as "damage."

Michigan suffers moderate deer damage in all classifications: agriculture, fruit, forest. No payment is made for losses, but permits are issued to farmers to kill marauding animals. Forest damage is spotty, and significant only in certain localities. Crop damage is increasing rapidly as the herds build up in the major southern farming territories but has leveled off under recent liberalized kills in the fruit country and the scattered farms of the north.

Competition With Other Wildlife

Competition between the white-tailed deer and other forest game has not been investigated thoroughly. Several kinds of wildlife which may interact competitively with deer include: snowshoe hare; moose; ruffed grouse; elk; and cottontail rabbit. Severe competition for food is limited to snowshoe hare, moose, and elk. Usually the damaging effects of deer and hares are local and closely related to food abundance in a particular area.

Concurrent use of range by moose and deer is limited to northern Minnesota and to parts of Ontario where both species utilize many of the same kinds of browse plants. Elk competition is limited to a small area of Lower Michigan. The competition between ruffed grouse, sharp-tailed grouse and deer for food is relatively unimportant. However, high deer populations

may influence the amount and distribution of cover for all kinds of forest game. In some areas deer browsing tends to keep the forest in a brushy stage and thereby make it more favorable to the sharp-tailed grouse.

Hazard on Highways

As early as 1937 the highway mortality in Wisconsin was 192 deer. For the four years, 1951 to 1954, a total of 1,700 was reported and by (8000+ in 1964) 1963 the total annual road kill increased to 5,995 deer.↑ In addition it is probable that many deer are struck by automobiles that die later and hence are not reported. Minnesota highway kills rose from 882 in 1956 to 2,150 in 1961, and the total kill for this 8-year period was about 10,350 deer. Highway kills in Michigan increased from 1,900 in 1954 to 4,800 in 1963. Only a small number of deer are killed on the highways of the Province of Ontario.

Reservoir for Parasites and Diseases

Whitetails have many kinds of parasites. Nevertheless, pathological studies show that most deer are at least as healthy as most deer hunters. In Michigan and Wisconsin, the liver fluke which has its definitive host in the deer produces fatal infestations in sheep and makes livers of cattle in some local areas unmarketable. Anaplasmosis, a serious blood parasite among cattle and found to occur in deer in some sections of the United States, has not been investigated to any extent in the Great Lakes Region.

Deer are host to a long list of infectious diseases, only a few of which warrant concern from the standpoint of the welfare of deer and of deer serving as reservoirs of infections to humans and domesticated animals.

Brucellosis, leptospirosis, and tuberculosis have received considerable attention in recent years. Brucellosis and tuberculosis are rare and of minor importance in deer of Wisconsin and Michigan. The incidence of leptospirosis appears high throughout most of the Great Lakes Region, but its significance has not been determined. Q fever, which is generally a mild disease among humans, has been reported in deer. Again, its status in deer, as a public health problem, has not been investigated thoroughly.

RESEARCH FACILITIES AVAILABLE

Facilities for research in deer ecology may be of three kinds: (1) land on which control over both herd and vegetation is possible, (2) pens and enclosures for restraining animals and conducting controlled experiments, and (3) laboratory facilities for studying anatomy, digestion, disease, and nutritive value of browse. Most research facilities now available are under state or provincial control.

Facilities in the Upper Peninsula of Michigan operated by the Michigan Department of Conservation include a mile-square enclosure, pens, and a laboratory building known as the Cusino Wildlife Experiment Station. In the Lower Peninsula, the Department maintains large and small pens for studies in deer nutrition and physiology which are located at the Houghton Lake Wildlife Experiment Station. Good laboratory facilities are also available there. Research involving farmland deer is conducted by the Rose Lake Wildlife Experiment Station near Lansing. The State of Michigan controls a portion of Beaver Island and smaller islands in Lake Michigan suitable for deer and

*Lots
of facilities
in Michigan*

other wildlife research. The George Reserve, a two-square mile fenced area 25 miles northwest of Ann Arbor, is owned by the University of Michigan. This enclosure provides a place for research in deer behavior and herd dynamics in the farm fringe area.

The Minnesota Department of Conservation maintains a laboratory at the Carlos Avery Wildlife Area north of St. Paul. This laboratory has facilities for holding animals and for limited anatomical and physiological studies. The Veterinary School of the University of Minnesota cooperates in anatomical and disease research. The Carlos Avery Area and associated public hunting areas provide an opportunity for study of animals with and without hunting pressure. Camp Ripley, a large National Guard installation where access is closely regulated, provides a favorable spot for trapping, banding, and observing animals.

The Wisconsin Conservation Department does not maintain any facilities specifically for deer research. Laboratory facilities at Conservation Department area headquarters such as those at Spooner, Woodruff, and Madison can be used for deer research. The Sandhill Wildlife Demonstration Area, a state-owned 14-square mile fenced area formerly used for commercial deer production is used for testing management techniques. The Veterinary Science Department of the University of Wisconsin has deer holding pens and laboratory facilities for deer disease studies. The Ontario Department of Lands and Forests has research facilities at the Southern Research Station at Maple; these include an office, laboratory, and a cooperating pathology laboratory equipped for work on parasites. Close integration among Branches of this Department makes aerial photographs, aircraft, and other equipment readily available for field operations. Diseases involving

bacterial and viral agents are studied at the Ontario Veterinary College at Guelph. A field station in Algonquin Park is located in a wilderness area set aside specifically for research.

Some deer research has been conducted at the University of Minnesota's Cloquet Forest Research Center. This station, however, is primarily devoted to study of ruffed grouse and forest management.

Research facilities are also available in the Wildlife Departments at the University of Michigan, Michigan State University, University of Minnesota, University of Wisconsin, the Ontario Agricultural College and other colleges and universities.

PRESENT KNOWLEDGE AND RESEARCH NEEDS

Physical Characteristics of Deer

Anatomy

Minnesota has been involved in a study of the anatomy of the white-tailed deer. The forelimb was the first region to be examined in detail. This study included the peripheral nervous system, structures, and musculature. Much of the remaining portions of the deer have been dissected and examined. The hindlimb has been studied and described. Cooperators in these studies were the Division of Veterinary Medicine, University of Minnesota, and the Minnesota Division of Game and Fish.

Anatomical information from normal animals is essential as background for studies in nutrition, behavior and disease. Investigations urgently needed include:

1. Detailed gross and microscopic study of the normal central nervous system, particularly the brain.
2. Studies on anatomical development of the rumen:

- a. From birth to adult
 - b. Capacity of the rumen at different ages
 - c. Factors influencing development papillae
3. Studies on the skeleton:
 - a. Determination of hereditary, environmental, and nutritional factors influencing skeletal size.
 - b. Study of the skeleton to develop a better aging method.

Taxonomy

All deer within the Great Lakes Region are considered to belong to the subspecies Borealis. This does not rule out the possibility of local genetic variations, but it does reduce the urgency for taxonomic research.

A taxonomic study of deer in the Great Lakes Region using physical characteristics and serological methods would be desirable. Such information should provide an understanding of the animal we are trying to manage. If any real differences become evident, the following applications of the knowledge would seem likely:

1. Some of the differences in aging criteria which have been discovered might be due to genetic differences. If the areas in which the differences occurred were outlined, the applicability of the aging criteria would also be known.
2. Local differences in growth rate and reproductive rate might be discovered. Such findings would have immediate management implications.
3. There might be differences in deer habits within the region. These could include such things as varying shelter requirements for winter.

Because there are no known sub-specific differences in the Great Lakes Region this taxonomic problem is not urgent. On the other hand, it should be easy to make the comparisons which would indicate whether any genetic differences did, in fact, exist.

Taxonomic background is necessary as part of our basic biological knowledge of deer. Even if differences were turned up which proved to be environmental rather than genetic, such knowledge would prove useful in the field of deer management.

The Herd

Census Methods

Accurate herd census is one of the most important and difficult of all management activities. For deer, indirect census methods have been most successful, although direct counts have been used on occasion.

Pellet Counting

The pellet-group survey is currently the best indirect deer census method available and is applicable to both large and small units. Michigan has used pellet group counts routinely over large areas annually since 1953. The entire major deer range has been included since 1959. In some years mortality surveys have been combined with the pellet surveys. Eleven surveys have been held on the George Reserve and 5 on the Cusino deer enclosures, both small areas where the size of the deer herd was known.

Wisconsin conducts pellet surveys over large areas and currently makes counts on several management units annually. Each unit has been surveyed about once in five years. Minnesota has used pellet counts experimentally on small areas. Ontario combines pellet counts with dead deer surveys in major yarding areas. The U. S. Bureau of Sport Fisheries and Wildlife has developed the multiple random-start systematic sampling technique and it has been tested on many areas.

The pellet-group technique is capable of providing estimates very close to actual populations, but refinements are necessary. There is a definite

need for the determination of the proper plot size to be used in sampling. At the present time there is a wide variation in plot sizes used by the different agencies, and even within agencies. These vary from 100 sq. ft. to 1/50 acre in size. It is doubtful that pellet groups are randomly distributed in any vegetation type and therefore the proper plot size may vary between types and with deer use of a particular type. Sampling techniques which can withstand valid statistical analysis need to be developed and improved. Refinements are also badly needed in: (1) pellet age determination, (2) leaf fall dates, particularly in oak, conifer, sedge and grass, and bracken fern stands, and (3) defecation rates.

We have study on Pellet aging.

Michigan has done work on counting errors and defecation rates and studies of pellet aging are now in progress in Michigan, Minnesota, and Wisconsin. Accurate determination of new pellet groups is the biggest problem with this method, especially where leaf cover is sparse (i.e. marshes etc). The rate of aging varies with season, climatic conditions, and diet of the animal.

Air Counts

Aerial census of big game animals in the United States began as early as 1931 when airplanes were used to count elk in Utah and Wyoming. Since that time, aerial deer counts have been more or less successfully conducted by many states including Texas, Colorado, Minnesota, and North Dakota. Michigan had less success in brief experiments. Moose, elk, sheep, antelope, and African ungulates have also been censused by airplane.

Few agencies have used photos extensively, relying rather on visual observations. However, recent developments in photographic techniques may produce more accurate results.

The Michigan Department of Conservation has made brief experiments

using a helicopter and aerial photographs to census dead deer but with inconclusive results thus far. Michigan has also used helicopters to a limited extent in attempts to census live deer and elk.

Many of the studies cited above have apparently been related to ground counts as a standard to determine their accuracy. In northern hardwoods and marshes in Minnesota a 25% aerial coverage during the winter of 1962-63 corresponded favorably with pellet group counts the following spring.

Problems which warrant further study are the following:

1. Methods of sampling - strips: blocks; natural geographic units; best altitudes.
2. Intensity of sampling for efficient work.
3. Index factors to adjust for variability in counts caused by time of day, season, snow on ground, cover type and density, and weather conditions. In conjunction, determination of acceptable conditions for aerial census.
4. Determination of sexes and ages of animals. This would appear to be of very great potential use in determining herd composition and structure, total population, and especially success of fawn production for making harvest recommendations.
5. Types of equipment best suited to aerial census including use of helicopter for low speed, low altitude work.
6. Census of dead deer by aerial methods.
7. Use of photographs: black and white, color, strip photos, stereoscopic exposures, ultrasensitive films, photography at night, and through dense cover with infra-red or heat detecting equipment.

Study of these problems will suggest many others. Aerial census methods for big game animals, because of their possibilities of cheap, rapid, and extensive coverage, could be developed into a much more useful tool in game management and research. However, in the northern forests there are many problems to be resolved.

Track and Bed Counts

Track and bed counts have been the subjects of intermittent investigation and use over the years. Attempts have been made to convert them to absolute deer numbers, but these have not been successful because of variables inherent in the methods and lack of accurate population estimates by other means against which to judge results. At best, such counts give only an index to population numbers, and can be used only to identify trends.

For track counts, the most acceptable current technique, at least as used in Minnesota and Wisconsin, is to make morning counts of deer tracks on segments of sand or dirt roads which have been dragged the afternoon before to eliminate old tracks. This is usually done in summer, and has been applied largely where oak and pine stands make standard spring pellet-group counts difficult. The Wisconsin Conservation Department has also used track counts to determine seasonal use of forest types.

The Michigan Department of Conservation checked track counts against other population measurements without consistently accurate results. The Wisconsin department found in the sandy central portion of the state that track counts indicated annual changes in numbers that were subjectively consistent with other population indicators. The Minnesota Department of Conservation considers track counts useful for determining trends in deer numbers at Camp Ripley. Track counts are being tested as a method to evaluate the effectiveness of Camp Ripley as a refuge. The U. S. Forest Service considers the technique as an adequate summer index. Ontario used tracks to count movements in and out of study areas, but not as a population index.

Not
just
"subjectively
consistent,"
now have
statistical
correlation
of several
methods

Unsatisfactory attempts have been made by several states in the past to use bed counts in both summer and winter as a population measurement. Bed counts have little potential as a population census method. Their main use seems to be the identification of bedding cover types at different seasons of the year.

*We have
this in
progress now*

Research is needed to evaluate the track counts on areas where deer populations can be determined by other means. Track counts should be further tested as a technique in determining relationships between deer movements and range types.

Deer Drives

The deer drive as a method for censusing deer was developed in the early days of the Civilian Conservation Corps program, and was widely used during the years 1934 to 1941 in all three Lake States, utilizing the abundant manpower and organized leadership in both State and Federal CCC Camps. About 300 drives covering some 200,000 acres were made annually in these three states during the height of this program.

With this wealth of practical experience, the technique of successfully conducting a census has been well developed. Instructions for laying out deer drive areas and the precautions to be taken in organizing and conducting the drive are available.

This census method has been largely replaced by the pellet group method. It still is and will continue to be used on a more limited basis where special needs or favorable conditions of manpower occur. Special needs are often associated with research projects, such as the Cusino and George Reserve fenced enclosures in Michigan or other limited areas where census information is needed. Deer drives have public relations value and are well adapted to use by sportsmen, Boy Scouts and other youth groups as a public service project. Conservation-camp programs of State and

Federal agencies are now supplying some manpower for deer drive censuses, and the amount of this type of organized manpower may increase.

There are opportunities to further simplify and improve this census method. Suggested approaches to be evaluated are:

1. Use of field radios in execution of drives.
2. Eliminating counters by substituting:
 - a. Electronic counting devices.
 - b. Track counts in snow or prepared roads and trails.
3. Effectiveness of silent vs. noisy drives.

Other Methods

Several means of appraising the relative abundance of deer have been developed which do not depend on total counts of deer on selected units or on sample counts of deer sign.

Conceivably, population estimates on small areas can be obtained by use of Lincoln-Index computations on data from sightings of conspicuously marked and unmarked deer. The Minnesota Department of Conservation has trapped and marked deer since 1959 with collars bearing "Scotchlite" symbols permitting field identification of individual deer. The Michigan Department of Conservation experimented with self-attaching collars of several solid colors and began large-scale field use in the winter of 1961-62. Radio transmitters attached to deer will soon be used to identify specific deer in Michigan.

Population estimates derived from sex-age kill data are being used in Michigan and Wisconsin to provide supplementary information. The sex and age structure of the harvest is obtained from examination of a sample of the legal harvest at checking stations. Sex and age information is then combined with accurate harvest data to generate population estimates for previous years.

Wis
STUDIES

The Michigan and Wisconsin Conservation departments have been obtaining counts of deer by field personnel for a number of years. The Minnesota department used similar counts in the past but discontinued them in 1953. Michigan has combined these with other population indices--legal harvest data from firearm and bow and arrow seasons, and records of deer known to have been killed by cars--to form a "Combined Deer Population Index." The method of combination depends essentially on bringing the several sources of data to a common scale by transformations and weighting each by the square root of the sample size. Wisconsin summer counts are not interpreted for census purposes but are used as an index to productivity changes.

SUMMER
COUNTS

Sex and age data from examination of a sample of the kill can be used to estimate survival rates. If logarithms of frequencies by age class are plotted, the slope of the line drawn through these points is equal to the logarithm of the survival rate. This curve will be a straight line, barring chance sampling deviations, if there is equal recruitment to the herd and uniform survival each year. Few wild deer populations can satisfy these conditions entirely because hunting pressure, fawn production, fawn survival, and vulnerability may vary from one year to the next. In over-browsed deer range, many yearling bucks may not grow antlers large enough to be legal in Wisconsin or Michigan buck seasons. Still, unless there are extreme fluctuations, this method provides approximate measures of survival.

Work needs to be done in determining the most efficient ways using and combining the various population indices, converting the combined index value to actual population estimates, evaluating relative precision of the estimates, and finally adjusting differences in index values from area to area. Quantitative plant

studies are needed to determine if an index to populations may be developed.

Aging Methods

Tooth Wear

Severinghaus' method for aging deer by tooth replacement and wear is used almost universally. The outstanding advantages of the method are:

1. It is rapid and applicable to large-scale deer checking operations;
2. The age of a deer is determined on the spot and the information is immediately available;
3. Use by experienced biologists, it is accurate for deer through the 2-1/2 year age class.

The method has serious faults attributable to variations in tooth wear and in the skill required of the biologist. Additional disadvantages are the teeth cannot be examined when deer are frozen or because of the manner in which deer are tied onto cars or at hunting camps. Trophy deer can seldom be examined properly for age determination.

There is evidence that the tooth pattern may vary with deer from different areas due to conditions of environment, nutrition and, perhaps, genetics.

The Michigan Department of Conservation has deer of known age and prepared a revised aging criteria from a series of known age jaws. The Wisconsin Conservation Department reported closer agreement with the Michigan revised method than with Severinghaus' original description of New York Deer.

There is an urgent need for more sets of known-age jaws of wild deer from other areas so that the method may be refined to fit deer of different environments.

Lens Weight

Since the eye-lens method of aging wild game was proposed in 1959, it has proved very useful in determining the ages of several species of animals. Work is currently being done at the Illinois Natural History Survey to modify the results obtained in 1959 on deer lenses. Michigan has also made an extensive collection of deer lenses.

The results to date from both Michigan and Illinois show substantial variation in weight of lenses from older animals. The findings obtained from the lenses taken from the deer harvested at the George Reserve in 1961 are equally unsatisfactory when compared with the data obtained by the tooth wear method. There was excellent separation between lens weights of fawns and yearlings. However, there was considerable overlap in the lens weight from deer judged to be 1-1/2, 2-1/2, and 3-1/2 years by tooth wear. These are the age classes between which good separation is most desirable.

It may not be possible for any one group of investigators to obtain a sufficient number of known-age animals to develop an adequate lens weight growth curve. If several research groups use a standard technique, it can be determined whether regional or other differences exist. It is important that lenses be collected from "known-age deer" which have grown up under essentially natural conditions.

With deer having only a limited breeding season, one adult lens weight growth curve should suffice, but it is possible that two adult curves may be needed. Does which were initially bred as fawns may not fit a curve based on does which were first bred as yearlings. This physiological relationship between lens growth and breeding activity is in need of study.

Sex, location, year, and diet did not seem important in respect to lens growth in rabbits and may not be variable factors in deer.

Other Aging Methods

Aging by sectioning incisors has been developed for mule deer and should have possibilities for white-tails.

Another method having possiblility is the sectioning of the lower jaw. This has been done for some marine mammals and should be investigated for deer.

Research may reveal an aging method based on ossification of the frontal bone but its usefulness would be limited by the toothwear method of aging.

Productivity

For a number of years the Michigan Department of Conservation has autopsied does statewide during the period of normal pregnancy for information on reproduction. Information has been obtained on more than 3,000 does since the start of the project. Ovaries collected have been analyzed for ovulation rate and fertilization success. Fetuses were aged and yearly breeding and parturition dates were calculated.

The Michigan department reported on the determination of pregnancy in live deer by means of radiographic examination. The study showed that pregnancy and number of young could be determined with considerable certainty at 100 days of fetal development. It is anticipated that considerable use will be made of this technique for appraising reproduction. Michigan has also prepared a field key for determining the age of deer fetuses recovered on autopsy.

Badly needed is a more precise method for aging fetuses. Michigan is testing a field key developed from Ruth Armstrong's paper on fetal growth of New York deer. It may be erroneous to assume that Great Lake deer fit the growth curve of New York deer. In addition, studies show that fetal size is influenced by the plane of nutrition of the mother, hence

characters in addition to size of the fetus should be included in any aging key. It would be desirable to acquire a complete series of fetuses to establish growth curves known to be reliable for the Great Lakes Region. Additional research needs include information on time of the beginning of fawning, height of fawning, late fawning dates, and duration and peak of the rut. The use of radio active isotopes for marking fetuses and for subsequent identification should be investigated.

Nutrition

Comprehensive experiments in deer nutrition were carried out in the late 1930's and early 1940's in Michigan and somewhat later in Wisconsin by the state conservation departments.

The main features of the studies were:

1. Controlled feeding experiments on penned deer to test many species of natural foods, as exclusive diets, and in various combinations, to measure palatability, relative nutritive value, and daily amounts required to sustain deer through a normal yarding period. In addition, artificial deer food as supplements to natural browse were tested.
2. Digestion trials on cedar and hard maple browse and clover and alfalfa hay and chemical analyses of many of the common browse species.
3. Palatability tests to rate the preferences of penned deer for different shrubs, herbs, and grasses. Observations on feeding habits and selection of plants by free-ranging, semi-tame deer.
4. Study the carrying capacity of various vegetative cover types by enclosing a known number of deer in specific areas.
5. Logging and other experimental cutting of swamp and upland habitat to determine benefits to deer and cost of the practice in a management program.

Additional extensive feeding trials using different browse species alone and in combinations to determine their relative value in carrying

deer through a yarding season were begun with penned deer in the late 1940's. Considerable study has been made concerning the feed value of aspen sprouts and acorns in supplementing browse. In Minnesota approximate food analysis was conducted by the Department of Conservation for red-osier dogwood, mountain maple, aspen, and balsam fir to determine the nutritive values of these species.

At Michigan State University rumen digestion in the deer was compared with that in a bovine by analyzing products of rumen fermentation, chiefly volatile fatty acids. Related studies at the University of Minnesota concerned the cycle of gastro-intestinal pressures of deer. Graphic data were obtained involving the mastication and pattern of rumen activity.

In a study of milk quality, chemical analyses were made on approximately 85 milk samples from about 50 does to determine normal characteristics of deer milk and whether the composition is influenced by the nutritional status of the doe.

Considerable study has been carried on with the blood of deer to determine the normal hematology and biochemistry as well as the possible effects of malnutrition on the blood picture.

Shelter Requirements

In winter, deer ordinarily select yarding sites high in shelter value in preference to areas with abundant available browse. This seeming paradox probably represents an instinctive habit to seek sites which provide the greatest physical comfort. Whether this behavior also is related to psychological security is not known. In a recent Maine study, penned deer fed submaintenance diets in sparse shelter declined no more in physical condition than did those in moderate or dense natural cover. Apparently the sparsely-sheltered deer have microclimates similar in

quality to those in the better sheltered pens. Results of a penned study by the Michigan Department of Conservation indicated, however, that when the diet was inadequate, protection from wind, at least, was essential for survival.

In view of the seemingly conflicting findings noted above, further tests of shelter requirements should be made on penned deer under highly controlled, properly designed experimental conditions. Under natural conditions, the various environmental (weather) and metabolic (nutrition) factors probably interact to the extent that the major influencing factors are difficult to separate. Ideally, future penned-deer studies should utilize weather-chambers wherein the climate may be regulated. In this manner each weather and nutritional factor can be appraised individually and in combination. Clinical evaluation of metabolic and physiological aspects should be an essential part of such basic research. Behavior patterns and possible physiological adaptation mechanisms which are invoked during periods of stress should also be investigated.

From a management standpoint, winter shelter may not be a limiting factor for deer, except under unusually severe weather and atypical feed conditions. Cover, however, may be an important influence on winter yarding activities, affecting distribution, concentrations, and movements of deer. Thus, properly interspersed optimum cover may be a useful tool in regulating habitat utilization because it naturally manipulates deer distribution. These aspects of deer cover require investigation.

Mortality

Gun

The ultimate goal of deer research and management, for the most part, is the production and maintenance of a herd of sufficient size to provide recreation for the hunter. In turn, the gun hunter provides the most effective means of harvest and herd control.

In the Great Lakes region, the legal season kill is influenced by restrictions on sex and age, weather during the season, weather during the previous winter, and hunter density.

In Michigan in 1963, a record high of 516,000 licenses were sold and 74,710 deer were taken during the regular season. An additional 49,360 were harvested under special-season permits. The total gun harvest of 124,070 deer was the highest on record since 1952. This was a success ratio of 24%. The total pre-season population based on pellet group surveys was estimated at 800,000. The take, therefore, was about 16% of the pre-season herd. The goal of management is to harvest the "hunnable surplus." This should be at least 25% of the fall herd. This would even allow for a sizeable illegal kill. In the Upper Peninsula, even bucks are considered to be underharvested. There is a dire need for substantially larger legal harvests of deer in Michigan. In 1959, the dead deer survey showed an estimated total of 34,500 shot deer lying the the woods -- this is a combination of illegal kills and crippling loss and amounted to 30% of the legal kill. On study areas, 46 of 85 carcasses found were illegally shot during the "bucks only" season indicating that illegally killed deer make up a substantial part of the animals found on dead deer surveys. The number of deer taken out of season in Michigan is unknown, but is believed to be sizeable in some areas.

In Ontario, Province-wide data are not available regarding populations and kill due to the tremendous areas which are relatively inaccessible. In 1960, 31,500 hunters checked reported shooting 6,500 deer for a success ratio of 21%. A success ratio of 24% was reported in 1959. In 1963, 120,600 hunters killed 29,400 deer for a success ratio of 24%. Severe winters have marked effects on subsequent hunting seasons. For the most part Ontario deer herds remain underharvested, and severe winter weather conditions are an

important population controlling factor.

In Wisconsin in 1963, 50,800 bucks and 14,200 does were taken during the legal firearms season for a total kill of 65,000 deer. About 19% of the licenced hunters shot deer. Hunter success was 16% in 1962, and the total kill was 45,800 deer. The killing of does is limited to special areas and seasons. Areas in the north continue to be underharvested due to legal restrictions and starvation occurs during severe winters.

During the 1964 spring dead deer survey in 18 management units which sustained a legal kill of 1.7 deer per square mile in 1963, an additional 1.9 deer per square mile were found dead due to illegal kill, crippling losses, and unknown causes. The winter was rated a mild one so losses from starvation were light. In 1962 in an area of 407 square miles in eastern Jackson county, only antlered bucks were legal targets and a registered kill of 4.7 bucks per square mile were tallied. A dead-deer survey showed that for every 100 deer shot, 48 were registered legally and 52 were left as illegal kills or crippling loss. In 1963 in the same area, antlerless deer were also taken by permit and the total registered kill rose to 8.8 deer per square mile. For each 100 shot, 63 were registered legally and 37 were left in the woods as illegals and cripples.

In Minnesota in 1963, 112,800 deer were harvested by 257,350 hunters for a success ratio of 43.8%. The highest success ratio of 52.7% was reached in 1959. In a population estimated at 500,000 animals, it is believed that the annual increment to the herd is being legally harvested in some areas of the southern and central counties. Here the kill ranges up to 10 deer per section. In the northern counties, however, the harvest is as low as one-half deer per section and in remote areas of the northeastern part of the state no deer are removed by hunting.

During severe winters the herd continues to suffer starvation losses which approach the allowable harvestable surplus despite legal kills of any deer.

No substantiated data are available statewide on crippling losses during the legal season, but hunter questionnaire surveys indicate that the loss may approach 20% of the harvest.

Following the 1960 bow and arrow firearms seasons in the Camp Ripley Military Reservation, dead deer surveys were conducted on 14 sample areas. During the November firearms season, 820 hunters killed 312 deer and reported crippling 53, or one for each six taken. No dead deer were found on eight 30-acre plots checked in November, and only one was found on six-acre plots in March.

There is less valid data on the number of illegal deer taken by the gun in and out of season, than by any other facet of annual deer mortality. Opinions range from "one deer poached for every legal deer taken" to the other extreme of "poaching take is negligible." It is entirely possible that both expressions are true on limited areas in the Great Lakes Region.

Methods of determining legal gun harvest are not a problem although the various methods employed may vary in accuracy. Registration of each kill as required in Wisconsin gives a high degree of accuracy, providing biases due to failure to register are recognized and considered. Apparent needs include methods of getting accurate kill data soon after the close of the season. If these were of equal validity, they could be used as a basis for kill comparisons. The Michigan Department of Conservation used both a traffic survey to get immediate kill data plus a later post card pull of deer licence buyers.

There is a serious need for accurate data concerning the out-of-season gun kill. The take by poaching remains the most important unknown in the annual life equation of the deer herd.

Information is also required regarding correlations of illegal kill and crippling loss with deer numbers and hunter density.

Starvation

One of the more spectacular results of the interaction of inadequate food supplies and severe winter weather is the direct loss of deer from malnutrition. The burden of this falls principally on the fawns. In some winters, perhaps a majority of the fawn crop will die in parts of the deer range. In terms of overall effects on the herd, this outright loss of deer is not nearly so important as lowered fawn production and range destruction, but it does provide a convincing argument for proper deer herd management.

Methods of ascertaining losses from malnutrition throughout the Great Lakes Region have ranged from estimates made by field personnel based on haphazard checks of deer yarding areas to statistically sound sample surveys. Large scale dead deer surveys were made by the Michigan Department of Conservation in 1955, 1956, 1959, 1960, and 1962, the last three in conjunction with pellet group surveys. In Wisconsin, dead-deer surveys were conducted by the Conservation Department together with pellet counts as early as 1958. The method used in both states can be satisfactorily adapted to large or small units and can provide estimates at varying levels of precision depending on the effort available.

It must be recognized that starvation may be the result of one or several events. A deer may starve because it cannot find enough good food to eat, is physically unable to eat, too sick to eat, or isn't able to efficiently utilize products of digestion (as in severe parasitism). Defective teeth, crippling and other physical handicaps may result in

starvation but these conditions usually are easily recognized. From experience and constant surveillance of the deer herd we know that chronic "wasting" disease and severe parasitism are extremely rare in the Lake States' deer.

Although autopsy findings must always be interpreted with care, starvation can generally be diagnosed with little doubt. Starvation is characterized by emaciation of the body. This can be recognized by absence of a fat layer just under the skin, in the membranes covering the abdominal organs and in other fat storage areas within the body, most notably about the kidneys. An additional fat storage area most useful in diagnosing starvation is the marrow of the long bones, especially the femur.

Frequently there is difficulty in establishing the cause of death where carcasses are almost entirely consumed by scavengers. Here, the condition of the bone marrow still serves as an indication of the nutritional state of the deer, but does not exclude the possibility that the deer was killed by a predator or had some other physiological abnormality. Additional diagnostic characteristics are required to more accurately determine cause of death in deer.

Diseases and Parasites

There is a great deal of published information on the occurrence of a wide variety of diseases and parasites found in white-tailed deer. Most of the published material is concerned with identification and frequency of occurrence of diseases and parasites. These aspects are fairly well covered at present.

What is lacking, however, are studies on the ecology of development and transmission of these diseases and parasites among deer and to man and domestic livestock.

Recent studies in the midwest on brucellosis, leptospirosis, hemorrhagic disease and liver flukes are examples of work accomplished in this regard. But in total the existing knowledge of the etiology, prevalence, methods of surveillance, and methods of control are quite rudimentary.

A possibility exists that deer herds could act as reservoirs for diseases and parasites dangerous to livestock and humans. Deer have not been incriminated in any outbreaks in the Great Lakes Region where people or domestic animals are involved.

Predation

It is only in parts of Minnesota and Ontario that wolves are present in sufficient numbers to be of importance. Studies by the Ontario Department of Lands and Forests have covered the general ecology of wolves, with specific emphasis on food habits. There is also an attempt to develop methods of determining wolf density and methods of effective control of wolf numbers. It has been found that wolves can maintain much higher densities when the major food species is deer than when it is moose.

High wolf densities appear to be about one animal per ten square miles.

It is likely that normal populations will run about one animal per twenty-five square miles. Past estimates of wolf densities in Ontario have apparently been very much too high.

Dogs are a problem in much of the region. Numbers of deer killed by dogs and the importance of these kills to the deer herd are poorly documented and poorly understood. There is some evidence to indicate that predation by dogs may be of considerable consequence locally. As an example, during March and April of 1962, deer losses attributed to dogs at the Carlos Avery Wildlife Area in Minnesota was considered to be most

severe. At least 43 deer were known to have been killed and an additional 16 injured on the approximately 35 sq. mile area.

Coyotes, although numerous, do not appear to be very effective predators on deer and it is doubtful if bobcats or lynx ever take more than an occasional animal.

Specific information is required concerning: the effects of wolves on deer numbers during severe winters, whether special relationships exist between wolves and deer when deer numbers are low, and the effects of the presence of alternate prey. It may be that wolves can turn to other prey, such as moose, when deer numbers drop and thereby maintain a sufficiently high population to decimate the deer.

An estimate of the total kill of deer by predators would be very useful especially if it could be expanded to establish the effects of such mortality on local deer populations. This would require a determination of the relative importance of predation as opposed to other causes of mortality. Fawn mortality, especially in the farm country where dogs are abundant, may be attributed at least in part to predation. This should be a part of future infant mortality studies.

Weather

The Great Lakes Region forms the northern extremity of the range of white-tailed deer. Anatomically and physically, deer are not well adapted to winter conditions along the northern fringes of their range and are therefore bound to suffer in years of unusual severity.

Northern winters are characterized by deep snow and low temperature. Deep snow cover ordinarily confines deer to forest types where the snow depth is the least, thereby limiting the extent of useful range. Deep snow cover also places added energy requirements on the deer when their food is scarest. Since 1953 the Ontario Department of Lands and Forests

has maintained a system of snow stations to investigate the effect of snow cover on survival of deer. Although this is necessarily a long-term study, it has already proved useful in predicting hunter success based on the previous winter's survival.

The direct effect of winter temperatures is poorly understood. There are no reliable data at hand applicable to the Great Lakes Region.

Research is needed to determine the possible effects of cold wet springs or summer droughts on the herd.

There is need of a coordinated system of snow stations established throughout the Great Lakes deer range to facilitate study of the effects of snow cover on survival and distribution of deer. Also, more emphasis should be placed on appraising effects of snow quality.

Studies are needed on temperature relationships, including effects of low temperatures, alternating extremes of temperature, levels of acclimation, and wind chill. These should be conducted both under controlled experimental conditions and also in the field.

Additional needs include a thorough evaluation of the shelter qualities of the common forest types in the Great Lakes Region and a study of the effects of weather on rutting behavior.

Other Mortality

Seven years of deer mortality records, 1956-1963, in Minnesota indicate a reported total loss resulting from miscellaneous, non-hunting causes of 10,350 animals.

Reported highway kills in Minnesota have increased from 882 deer in 1956 to 2,150 in 1963. In Michigan, the highway kills have increased from 1,900 in 1954 to 4,800 in 1963. Wisconsin reported 5,995 highway deer kills in 1963.

Wisconsin tops in road kills! 8,000 in 1964

There appears to be a correlation between the highway deer kill and

the deer population. In Michigan, the exact nature of the correlation appeared to vary from area to area because of the differences in traffic volume and number of roads; however, the changes in highway kill between years for the same area are probably indicative of population trends. Ohio has used such data to estimate their deer populations for some time. Losses are adjusted by a "travel-pressure factor" which is computed by dividing the total miles of roads of gravel surface or better located within a county into the total annual gasoline gallonage for the county.

Studies in Wisconsin, however, indicate that despite corrections for variations in traffic pressure, road-kill totals can be used as only a very general index of annual changes in the deer population.

The continued increase annually in highway deer mortality is considered due to the gradual increase in the deer herd, the greater abundance of roads and the increase in the volume and speed of vehicular traffic.

Greatest deer mortality occurs in fall and spring corresponding with the deer movement during the rut and the spring dispersion. During November the highway mortality ratio in Minnesota is two bucks to one doe, indicating the greater activity of the bucks during the rutting season.

Investigations are required to determine existing correlations between the extent of highway kills and the size of the deer populations, and to see if some devices can be adapted to repel deer from highways especially in the extremely hazardous areas.

Behavior

Studies of deer movement have been conducted by all member units of The Great Lakes Deer Group. Michigan began such work in 1929, with Wisconsin and Minnesota following in the mid-30's. In early studies of

deer movement, animal condition and survival, ear-tagging served as the sole means of identifying individual animals. With rare exceptions, data were obtained only when a tagged deer was recaptured during subsequent trapping operations or recovered by hunting, highway accidents, etc.

With increasing need for individually marked animals, ingenious capturing and marking methods have evolved. The use of the drug-carrying projectile syringe, capable of temporarily immobilizing an animal, is becoming more widely accepted, following improved injection mechanisms. Snares which automatically attach a self-locking colored collar have proved of considerable significance especially in Michigan.

In various stages of development and field trial are several promising radio-positioning devices. At present, cost of manufacture, limited range, and relatively short battery life restrict the use of these electronic marking units, but these limitations are only temporary and are certain to be overcome. As with many such discoveries of importance, a number of independent studies of a similar nature are being simultaneously conducted, resulting in duplication of effort and general inefficiency. More comprehensive and up-to-the-minute publication of results is advocated to keep workers informed of the progress in this field.

Deer which apparently have all the essential requirements of food and cover near at hand in forested areas commonly confine their movements to a cruising radius of approximately one-half mile. Less satisfactory habitat conditions prompt the deer to move over a larger area. Of course, the annual cruising radius of a herd is greater where the animals frequent distinct summer and winter ranges. The cruising radius of deer in and about a winter yarding area has received attention by all member units of the Great Lakes

Deer Group. Evidence of animal movement is relatively easy to observe under severe winter conditions.

Homing tendencies by deer are professed by some workers and are refuted or doubted by others. If homing tendencies do exist, there is certainly a limit to the distances involved. Sex and age factors are of significance in this regard. Knowledge of these factors under various conditions will enable the big game manager to exercise good judgment when considering the transporting of live trapped nuisance deer to a distant location for introduction or restocking purposes.

A knowledge of deer movements is essential to setting up certain regulations--i.e. in Michigan the law requires that antlerless deer be taken only from areas where there is a shortage of winter food or where deer are doing damage to crops. Hence the total range of deer damaging crops must be known in order that they be adequately harvested.

Of significance for management is the relationship of deer numbers and cruising radius of the animals to the size, number, and interspersions of refuge areas and management units. In the past, large tracts of forests have been regarded as essential to the welfare of a deer herd. Increased knowledge of the relatively small home range of deer has shown the fallacy of such thinking and large refuge areas are now being reduced in size or even abandoned entirely.

Deer response to forest cuttings, created as an emergency food supply or merely a side benefit resulting from normal logging operations, is of current interest. The distances deer will travel to such a food source serves as a guide to the degree of utilization which may be expected. Deer visibly marked, whether identifiable individually or only as one of a certain

group, offer a means of studying this facet in detail.

Information is needed on a herd's daily, seasonal, and annual movements and the manner in which these movements are influenced by naturally occurring forces and man-made factors such as fire, flooding, herd increase, and herd reduction, forest cutting practices, and changes in land use. Each of these factors require much detailed study. There appears to be no major phase of deer movement which is not being considered at the present time in The Great Lakes Deer Group. Hence it is suggested that impetus be given to movement studies now underway rather than striving for additional projects of this nature.

Competition

Intraspecific competition is a strong influence in regulating white-tailed deer populations in the Great Lakes Region. Where and how it operates is well documented. Losses of deer directly from starvation or indirectly as in the loss of fawns due to the severely weakened condition of the doe can be directly attributed to competition. The idea of too little food is merely the converse of the idea of too many animals--one idea implies the other.

Interspecific competition between deer and other species is much more subtle, and economic factors and vested interests often over-shadow the biological phenomenon of such competition between populations of game animals.

In the Great Lakes Region there are four esthetically or economically important species which may interact competitively with white-tailed deer. These are snowshoe hare, elk, moose, and the ruffed grouse.

Snowshoe Hare

Browse studies conducted in deer-proof and deer and hare-proof exclosures have yielded information illustrating the detrimental effect of deer and hare

browsing on seedling and shrub regeneration in various conifer and hardwood forest types. In specific areas, browsing by hares has been more detrimental to forest regeneration than deer browsing. This is especially true where hare populations are high. Certainly, there can be little doubt that this browsing activity places competitive stresses on both species.

Competition for food is not the only factor. When hare and deer populations are high, cover for the hare may be greatly reduced; and when food and cover are limited, a decline in snowshoe hare numbers is sure to follow. The ideal ecological situation for the hare occurs very early in the forest succession. Unless a factor such as fire, extensive insect damage, or lumbering enters in to alter the succession, deer browsing limits forest regeneration and thus limits the recovery of the hare population from low points in its cycle.

In the past, browsing by deer and snowshoe hares has been approached from the point of view of damage to the reproduction potential of the forest stand. Such browsing is without question an important factor; however, the present trend toward greater recreational use of our forest lands indicates a need for information concerning the effects of interspecific competition on the deer and hare population fluctuations.

Elk

Occurrence of white-tailed deer and elk on the same range is limited, in the Great Lakes Region, to isolated populations in northern portions of Michigan and Minnesota.

Although elk utilize a larger proportion of grasses in their diet than white-tailed deer, in rigorous winters both species are almost exclusively browsers. It is then that competition between elk and deer reaches its most serious proportions. In severe winters, the elk have a greater chance for survival because of longer legs and greater size.

In such areas as the Pigeon River State Forest in Michigan where white-tailed deer are abundant, the elk herd has increased and competition between these species has developed into serious proportions.

Moose

Joint utilization of range in the Great Lakes Region by moose and white-tailed deer is common in northern Minnesota and the Province of Ontario, with limited occurrences in Wisconsin and Michigan.

In Ontario, competition for food is the most important ecological relationship between white-tailed deer and moose. Only when both populations are well below carrying capacity is competition unimportant. Several species of plants are readily utilized by both deer and moose. These include mountain ash, red-osier dogwood, red maple, and various species of sumac.

The moose's greater size and ability to reach for higher browse give it a distinct advantage. However, the greater reproductive potential of the deer has allowed development of populations sufficiently large to keep regeneration of seedlings and shrubs at a minimum and thus adversely affect the food supply of moose.

Ruffed grouse

Ruffed grouse are found in almost every portion of the Great Lakes Region and are almost always found in forested areas frequented by white-tailed deer.

Due to food habits of the grouse, competition between them and deer for food is usually negligible. Probably the most limiting factor for grouse is cover, and the best grouse cover is that which has a high degree of diversity. Likewise, the white-tailed deer, wherever it is found, prefers

a habitat with an abundance of "edge" associated with brush land, woodlots, or small tracts of timber or forest land.

When deer populations are allowed to become too large and tree and shrub regeneration is impaired, cover for ruffed grouse is reduced. The levels of density of grouse and deer at which both populations can exist without damage to grouse cover should be determined.

The Range

The problem of range inventory involves determination of quantity and quality. Without knowledge of browse quantity, adequate regulation of harvests and understanding of population dynamics are difficult. Without knowledge of quality, as well as quantity, recommendations for range management cannot be made.

In the past, attention has been centered primarily on winter range conditions. Recent studies have indicated that the quality of summer and fall foods may have considerable bearing on productivity. Present knowledge of what constitutes good summer and fall range, or of the cover types that produce the most nutritious foods, is incomplete.

Forest type maps, on-the-ground checking, and aerial flights have been used to determine winter yarding areas. The site of the areas occupied usually varies with the severity of winter conditions. There are no special problems in classification, but reinventories are necessary periodically.

Once again, there are no special problems in determining quantity of summer range. However, there is need for knowing what constitutes range in semi-agricultural areas. In terms of the total problem regarding deer and management, this is minor.

It is generally agreed that openings are important to deer on both winter and summer range. However, the minimum requirement for openings and their optimum site, shape, and distribution is not well understood. Information is also lacking as to the influence of various changes in forest condition on the extent and quality of deer range.

To make intelligent land management recommendations for deer as well as forests, total range requirements for specific deer population levels must be understood. This information is essential if both forest management and wildlife objectives are to be met. Research in this field should receive high priority.

Methods of Evaluating Range

Evaluation of Cover

Cover for big game must reduce wind and temperature extremes, snow depth, and snow crust formation. In the Lake States Region winter cover is often the critical limiting factor for deer. Few studies have been made to evaluate the importance of cover.

Factors affecting cover values are: size of tree, species of tree, aggregation of stems into clumps, distribution of the clumps, and the proximity of cover to food.

Cover species may be listed in order of relative effectiveness: conifers the most effective, hardwood species the least. The arrangement of cover also appears important, with reasonably large clumps of trees being more effective than smaller ones, and with connected clumps more effective than isolated ones. The importance of the size of the clump and its distribution also needs study.

The kind of cover needs further evaluation to determine guidelines for both quality and quantity. The information can probably best be obtained by making intensive studies of deer and deer behavior in relation to various silvicultural practices. An evaluation of cover must consider available or potential food.

Browse Survey Methods

Methods for the evaluation of deer browse conditions are more highly developed than those for evaluation of cover, but refinements can still

be made. The survey objective is the most important single criterion to be considered in choosing a method; an extensive survey to show trends will require a different approach than a detailed comparison of small areas.

Browse conditions may be estimated ocularly by a trained and experienced observer or recorded in a quantitative form by counting the stems of browsable plants. Stem counts are used by Wisconsin and Michigan Conservation Departments in unit and state surveys for determining trends in browse conditions. To quantify the ocular observation, somewhat, a technique was devised for plot sampling winter range for moose and deer. Similarly, the Ontario Department of Lands and Forests refined the stem count by counting stems and twigs of browse in a long, narrow plot. Each of these methods generally is also used to estimate or record the utilization of browse by deer during the winter.

Several methods have been devised to give more exact data on browse production. Clipping and weighing browse from plots is most accurate, but also very time-consuming. Weight estimation is rapid but subject to both estimation and sampling errors. A newer method combines a twig count with a determination of average twig weight, thus giving results in pounds of browse. This method is also subject to sampling errors.

Plotless methods utilizing stem density have been tested and show some promise when combined with browse preference values. Browse sampling is made especially complex by the number of plant species involved and the differences in browse value to deer as well as by the nonrandom or aggregated distribution of the plants. In addition, browse production varies with light and moisture conditions and so is greatly influenced by the density of the forest overstory and the gradual changes involved in forest succession.

A major problem in browse evaluation is the portrayal of conditions over an extensive area of range. This has generally been accomplished by surveys, but it may be deduced from the knowledge of browse production in various forest types subject to normal silvicultural treatment. Up-to-date forest type maps are frequently available; hence, methods for determining levels of browse production for specific types are needed.

Past browse studies have shown what species are used and to what degree and have given us an estimate of density of browse stems and availability of food, especially in winter yards. To better evaluate the impact of various silvicultural systems and other human activity on the ability of the forest to support deer, detailed browse production measurements are essential. Techniques now available need further refinement, and new techniques are needed by management to follow changing range conditions and by research for detailed comparisons of silvicultural systems and evaluation of range improvements.

We know that measuring available browse is difficult. Measuring it in terms of how many deer it will carry is most difficult. Is not the number and quality of deer coming off a large area year after year a measure of the browse on that area. In other words the deer themselves are providing us with a bioassay of the food and cover, etc.

Browse Tolerance Studies

Clipping studies designed to simulate light, moderate, and heavy deer browsing have been carried on by the U. S. Bureau of Sport Fisheries and Wildlife, the Wisconsin Conservation Department, and others. Recent work by the Bureau showed that white cedar under 7 feet in height was found to produce well when 20 percent or less of the foliage was removed annually. If more than 20 percent was taken, the production decreased, the growth rate slowed down, and the trees dies. Large white cedar more than 7 feet tall may be browsed heavily below the 7-foot level without injury. Mountain ash, red-berried elder, and red osier dogwood could not tolerate heavy usage.

Black ash, willow, pin cherry, beaked hazelnut, paper birch, and mountain maple tolerated between moderate and heavy usage. In order to keep browse within reach of deer, most plants must be browsed at least moderately.

A browse tolerance study of mountain maple, started in 1952, has been conducted cooperatively by the Bureau of Sport Fisheries and Wildlife and the Minnesota Department of Conservation. For ten years, 50 test clumps of mountain maple have been measured each fall and remeasured in the spring to determine the amount of annual growth taken by deer. Various intensities of clipping designed to simulate deer browsing have been carried on in two exclosures. Recent analysis of the data demonstrate that various intensities of browsing by deer in winter have had no apparent direct effect on the annual growth produced the following growing season. The growth response to different intensities of clipping did not follow any definite pattern in regard to the intensity of the clip except for the 100 percent clip. The growth in 1962 for the 100 percent clip treatment was 83 percent of that in 1953. Only one clump was killed. This demonstrates mountain maple has a very high browse tolerance.

The Bureau of Sport Fisheries and Wildlife has also studied the effect of simulated snowshoe hare and deer damage on several conifers. Nipping was simulated by clipping nursery-grown stock of different age classes. Results, six years after treatment, show that the removal of one inch of the terminal growth by single or repeated clippings reduced survival and height growth. Resistance to damage varied by species and can be attributed to the inherent ability of each species to produce new leaders. The species ranked in descending order of sensitivity as follows: red pine, white pine, jack pine, and white spruce. Clipping had a greater effect on height growth

than on mortality and had no effect on tree form.

The effects of various intensities of simulated browsing on well established red and white pines were studied by the University of Minnesota. They found that up to 3 years of overbrowsing may be tolerated. Even short periods of severe clipping may not be ruinous to small trees.

Future research should include tolerance studies of well-established conifers such as jack pine and white pine under field planting conditions. For young conifer planting stock more severe clipping studies are needed to simulate snowshoe hare and deer damage. Among the hardwood trees and shrubs, research should be centered on: sugar maple, yellow birch, red maple, and species of ash, hazel, and dogwood. Once the tolerance level of each species is known, range appraisal work will have much more meaning.

Exclosures

In some forest types and local areas the effects of deer browsing may be either beneficial or damaging, or there may be no apparent effect on the vegetation. The same deer herd may cause undesirable changes in the forest vegetation in one locality, while in another the effect of browsing may be desirable. If the population is not too high, deer browsing may stimulate tree growth and thereby improve the quality of the trees. The beneficial effects may be the result of thinning out stands where the trees are too abundant or improving quality by browsing on the lower limbs. Deer may even retard the establishment of undesirable tree species and thereby maintain more desirable mixtures for the multiple production of deer and wood. Deer exclosures that keep deer and hares from browsing on tree plantations or other forest vegetation serve a dual purpose. The exclosure with an unfenced study area immediately adjacent to it demonstrates how the abundance of deer affects the growth of food plants. One of the primary

reasons for establishing exclosures is to provide demonstrations that show the effect of deer browsing on woody vegetation and also point out the need for controlling the number of deer in an area. Where detailed vegetation tallies were taken over a span of years the exclosures can also provide basic information on the effect of deer browsing and snowshoe hare clipping on tree growth and on natural plant succession.

A variety of kinds and sizes of deer exclosures have been used within the Great Lakes Region. However, since about 1950 the usual exclosure built was of the Lake-States type, 40 feet by 40 feet outside dimension enclosed with woven wire to a height of about 8 feet. Half of the area was made hare-proof using poultry netting 6 feet in height. This made a double exclosure that would exclude deer but not snowshoe hares on one side and both deer and hares on the other side. Where larger areas must be fenced to get an adequate sample of the vegetation, one-acre exclosures have been used. In recent years small exclosures, 10 feet x 10 feet, have been used primarily in research, since their size permits more valid sampling. Within the Great Lakes Region there are well over 100 deer exclosures of various sizes and kinds.

Little has been published on the deer exclosures in the Great Lakes Region. On the Argonne Experimental Forest in Wisconsin, the Bureau of Sport Fisheries and Wildlife and the Lake States Forest Experiment Station demonstrated that approximately 8 years of rather low deer population were needed in second-growth hardwood-hemlock stands to permit successful regeneration of sugar maple. In a northern Michigan study, the University of Michigan concluded overbrowsing in the northern hardwood-hemlock type will be disastrous for deer and forest, for pure maple stands will not support deer and will be

prone to disease attacks. The study indicated that the important consideration is not deer density but severity of browsing on desired species.

There is a need for more demonstration exclosures but good judgment must be used as to their location. Foresters and game biologists should establish them jointly. They must be on good sites, accessible to roads where sportsmen, civic groups, and the general public may make use of them. Signs explaining the purpose and findings of the exclosures are essential. Exclosures should be used as needed to determine the influence of deer on forest composition.

Exclosures

Deer enclosure studies are needed to determine the carrying capacity of different deer ranges. Also, other basic limitations of carrying capacity must be known if deer are to be managed properly.

In Wisconsin, the Ladd Creek deer enclosure was established by the Conservation Department in 1945. This was a four-acre fenced area subdivided into four one-acre pens. Information was gathered on the effect of browsing on the carrying capacity of these pens in terms of reduced deer-browse days. At the Cusino Wildlife Experiment Station in Michigan, an enclosure about a mile square has made it possible to measure deer productivity, to test various census methods, and to measure the effect of a known number of deer on the vegetation. The George Reserve in Lower Michigan, an 1,150-acre enclosure, has provided valuable information on deer herd dynamics, deer behavior, and sustained production. An average of 20 deer per section have been removed from this area each year for the past 20 years. This harvest included 43 percent antlered bucks and 57 percent antlerless deer. Removals averaged 41 percent of the fall herd annually.

There is a need for more large deer enclosures similar to the one at Cusino. Other parts of the Great Lakes Region deer range need intensive study areas with emphasis placed on range-carrying capacity and herd dynamics. The two most critical

areas are north-central Minnesota and the northern hardwood type in northern Wisconsin. Recently, Minnesota has established several enclosures of 100-by-100 feet for the purpose of testing the defecation rate of deer. In the same areas, it would also be helpful to establish unfenced areas where the range is studied and regular gun seasons are held.

Life History of Browse Plants

Knowledge of the life histories of browse species is lacking. Some information is available on the early growth of a few of the commercial tree species which serve as browse, but both foresters and game managers agree that much more is needed. Among important browse species some attention is now being given white and jack pine, aspen, white and yellow birch, sugar maple, and hemlock, while work on white cedar has been done in both Michigan and Wisconsin.

Studies on shrubs and noncommercial tree species have been few. The University of Minnesota and U. S. Bureau of Sport Fisheries and Wildlife together with Minnesota Department of Conservation personnel investigated responses of mountain maple to herbicides and to browsing. The University of Minnesota has also gathered important information on the life history of this species. A few years ago a study was begun on the life history of beaked hazel in Minnesota; this has not been completed. Other browse species have received only limited treatment; for instance, clonal relationships of sumac were studied by the University of Michigan.

Ecologists at Universities in the Lake States Region can provide considerable information on community relationships and site requirements of many browse species; but specific information on life history, browsing tolerance, response to chemicals and fire, and similar data are urgently needed if serious attempts are to be made to rehabilitate critical areas of deer range.

Shrubs and noncommercial species deserving of attention include the dogwoods, maples, alders, mountain ash, hazels, sumacs, and willows. Herbaceous species used for food in spring and summer are also in need of study.

Carrying Capacity

Knowledge of carrying capacity of deer range in the Great Lakes Region is an essential management tool on which practically no research has been done. Perhaps the chief reason there is so little management history on the establishment and management of deer herds at proper population levels is the marked changes which are still taking place in the deer range itself. As noted earlier, the primeval forests of the Great Lakes Region did not become first-rate deer range until logging, fires, and partial settlement improved food conditions. Fire protection and intensified forest management programs are presently restoring the high forests with a consequent reduction in low ground vegetation. As more of these forest stands become merchantable, they will be logged and the succession set back to productive range. Eventually, intensively managed forests should provide higher and more stabilized food supplies than most of them do at present. Until this stage is reached, establishment of carrying capacities will be especially difficult.

Carrying capacity as defined here is the maximum number of deer which a range will support each season over a period of years, without injury to the soil, forage plants, or watershed, and which permits a healthy deer herd and a forest condition not seriously modified by the browsing activities of the animals.

Carrying capacity in the Great Lakes Region is determined chiefly by the number of animals which the winter range will support. Primary winter

ranges are the areas which deer naturally prefer and select to use. It follows that secondary range cannot be included in determining carrying capacity if it means that these areas will not be used until the key areas have been damaged by overbrowsing. Carrying capacity of the secondary range can be included if specific management provisions are made to make it usable by deer. This might include planting conifers for travel lanes and cover or scheduling timber sales to attract deer to the area.

With increasing logging operations and multiple use coordination, the browse supply made available in cut trees can be included as a supplement to natural browse in determining carrying capacity. This assumes a planned program of winter cutting operations which will provide a dependable supplementary food supply over a period of several years.

Carrying capacity from a practical standpoint has to be considered in terms of rather large units of range. It is now generally accepted that State-or Province-wide uniform seasons cannot meet the needs of deer management and that unit management is necessary. With some exceptions the smallest practicable units will be in the neighborhood of 100 square miles. Carrying capacity should be expressed in terms of the total overwintering population these units can safely support. Hunting quotas would be based on the number of animals which can be harvested from the annual increase on these basic herds.

Carrying capacities will not remain static, and review and adjustments will be needed at approximately five-to ten-year intervals.

Deer biologists and foresters have had little difficulty in recognizing overpopulations and accompanying range deterioration and damage to forest reproduction. There are also examples where smaller deer populations create no range or forest damage problems. More recently there has been encouraging

progress in reducing the deer on overpopulated ranges to a level which appears to permit some range recovery and which may be close to carrying capacity.

The few examples available of deer herds which are being managed at carrying capacity on a sustained yield basis, such as at the University of Michigan's George Reserve, are generally too small for wider application. This one example illustrates the need for this type of management and the harvest potential possible under such intensive management.

The carrying capacity of the farm deer range of the Great Lakes Region will be determined primarily by crop damage and other factors and is not considered in this analysis. There it will be a question of how many deer the people want or will tolerate.

Management experience and research are sadly lacking in scientifically establishing carrying capacities and especially in appraising their accuracy in recognizing or even purposely providing changes in the habitat which would justify correcting these standards.

The principal research needs in determining carrying capacity are:

1. Development of criteria to define the suitable range within the management unit--the winter range on which carrying capacity should be based.
2. To develop browse production data, in pounds per acre, by timber types at various ages and under a variety of silvicultural conditions. Browse produced by logging as well as that available from growing plants should be considered.
3. To develop browse production survey methods and procedures for using browse production in management units in evaluation of carrying capacity.

HABITAT IMPROVEMENT

Control of Deer Populations

Long-term habitat improvement is impossible unless the size of the

overwintering herd is held at a level that permits adequate growth and reproduction of browse species in winter yarding areas. Public hunting is the only reasonable method of deer harvest and is essential to habitat improvement programs.

Proper deer harvests by legal hunting have been a major problem for years; and although improvements are slowly being made, difficulties will likely continue in the future. Several principles concerning this situation are generally accepted by states with deer overpopulation problems:

1. Hunting seasons must be considered as a part of the total forest land-management program rather than as a deer management tool only. The timber production, recreational uses, forest products industries, and local economies of deer-hunting areas all have a large stake in hunting seasons and their effects.

2. The reasons for a given hunting season and its expected effects need to be explained to and understood by the public and employees of conservation agencies. When agency personnel do not understand and accept these things it is not possible to sell hunting seasons to the public.

3. It is obvious that hunting is the most economical method now available to control deer numbers. It is also clear that a variety of seasons must be established in any one state or province to get hunters into specific areas in numbers that will insure a desirable harvest. This may complicate enforcement and publicity problems, but it is the best way to maintain optimum deer numbers. Variable seasons types that could be utilized include any deer with a bag limit of one or more, antlerless, party-permit or "camp" deer, spike buck, and closed to hunting. Various combinations of hunting zones, quotas, split opening dates, and postseason

extensions are usable.

4. State-wide hunting seasons do not provide adequate harvests, regardless of the type of hunting. "Bucks-only" seasons have always failed to reduce herds or prevent herd increases. "Any-deer" seasons help in some areas but not in others because hunters crowd into traditional hunting spots and generally ignore other large areas open to hunting.

5. The number of hunters per unit area of deer range is highly important. In Wisconsin, for example, if all deer hunters in 1961 had been spread evenly over the area open to hunting there would have been about 10 hunters per square mile. At present levels of hunting success, such pressure would not achieve desired harvests. Better dispersion of hunters can be realized, although the problem cannot be completely solved, by manipulating season openings and bag limits, good prehunting season publicity, and provision of good access roads for hunters. Despite the long series of consecutive any-deer seasons in Minnesota, overpopulations have developed in areas receiving light hunting pressure.

6. Hunting regulations can be greatly influenced by public opinion, legislative attitudes, and the attitudes of aggressive sportsmen. Agencies need a chance to demonstrate on a scientific basis free from political interference how different hunting regulations can effect harvests.

Research is needed to:

1. Determine what motivates public acceptance of harvest regulations.
2. Determine the relative success of the various possible hunting regulations in different forest types, with different herd levels, and under various hunting pressures.
3. Evaluate the effectiveness of small refuges

in preventing overharvests in high-kill, any-deer hunting areas.

4. Determine productivity and all mortality factors on units subjected to special hunting regulations; i.e. does legal doe-shooting cut down the in-season illegal kill.

5. Determine the pattern of hunter movements and hunting pressure with given hunting seasons and what can be done to influence them.

Range Management

Changes in the deer range of the Great Lakes Region have resulted from lumbering, agricultural development, fire, and other causes associated with the economic development of the area. Little thought was given to the needs of the deer herd. More recently, land management programs are considering modifications for wildlife needs. In addition, habitat deficiencies are being corrected through direct action programs. Continued progress requires much more information on deer behavior and on habitat requirements.

To be effective, forest range management for big game requires treatment of relatively large acreages of land. Thus, the best opportunity to achieve significant changes in deer range is through silvicultural practices. Limited funds for specific direct habitat improvements require that these projects be concentrated on correcting critical habitat deficiencies not susceptible to correction through regular forest management programs.

Range management is less critical in the farm fringe areas, where carrying capacity is governed largely by the amount of crop damage farmers will tolerate. The hazard created by deer on the public highways is rapidly becoming important in both farm-fringe and suburban areas. Habitat manipulation needs to be directed to reducing these

conflicts.

Coordination With Forestry

Forest management practices which reduce the overstory and thus stimulate the growth of understory vegetation are of primary importance in maintaining and increasing forage for deer. Timber harvest operations normally cover many acres and result in heavy reduction in the overstory. In addition, the browse from the tops of felled trees is an important direct contribution to the food supply during the winter period.

Cutting Practices

When logging is accomplished on a rotation basis, it produces a variety of different age classes of trees, and this usually results in a maximum amount of food and cover.

A recent Michigan Department of Conservation study revealed that cuttings benefited deer in three ways: First, the cut growth itself provided food when the cutting was done in winter; second, cuttings opened up the stands and resulted in an increase tree and shrub growth, as well as sprouts; and third, the openings in the stands created more edge, which, in turn, provided greater variation in the browse supply.

A second Michigan study has shown that deer yard cuttings in winter made enough browse available to increase the carrying capacity of the yards during that winter as follows: cedar swamps, five extra deer per acre; mixed hardwood-conifer, three extra deer per acre; and hardwoods, one extra deer per acre. An average deer yard cutting was believed to provide browse for 2.6 deer per acre.

Cutting can provide both food and cover, although one may benefit at the expense of the other. When pure hardwood stands are cut, browse is

produced as a result of the sprout growth, but the cuttings have no cover value. On the other hand, conifers such as spruce and balsam are of greater value for cover than as a source of browse. In general, it can also be stated that uneven-aged stands produce a variety of habitat conditions favorable to deer. Even-aged stands must be broken up with openings to be of appreciable value to deer. The openings and edges provide important browse plants and are also important as summer range.

In the Great Lakes Region, cutting practices designed for producing pulpwood are more beneficial to deer than those for other wood products. The benefits are greater because in a pulpwood economy the trees are cut on a shorter rotation, and the sprout or shrub stages make up a greater proportion of a rotation.

Work by the Michigan Department of Conservation in Lower Michigan indicates that aspen stands clearcut for pulp can produce from 250 to 1,800 pounds of winter browse per acre, the amount depending on age of the sprouts and intensity of browsing. In the stands studied, between 35 and 45 percent of the aspen sprouts were browsed to some extent. The study further suggested that one-half to three-fourths of the sprout growth could be eaten by deer, and the remaining stems would be sufficient to form a fully stocked stand. One problem is to obtain even distribution of the browsing. Browsing was often beneficial since it served to thin the stands.

A study by the U. S. Fish and Wildlife Service and the Lake States Forest Experiment Station in mixed conifer swamps in Upper Michigan examined browse production, winter cover characteristics, and deer use of different types of cuttings. Representative values for pounds of browse produced in the various cuttings were: control, 18; light selection cut, 46; clearcut block,

130; diameter limit cut, 134; clear-cut strip, 161; and shelter-wood cut, 184. Relative winter deer-use based on pellet groups per acre was 30 in the control, 60 in the light selection cut, 64 in the diameter limit cut, 94 in the shelter-wood cut. The clear-cut strip had 38 groups, the adjoining uncut strip 102, while the clear-cut block had 14 and the uncut blocks 18. The best combination of food and shelter seems to be provided by the shelter-wood and the strip cuts.

Field observations suggest that strip cutting was the best, as the uncut strips provided excellent cover adjacent to abundant browse. Because of snow depths, which have exceeded 5 feet during some years, the clear-cut strips should not exceed 75 feet in width; 66 feet in width is preferable. Clear-cut strips can also be improved for deer use by leaving narrow strips at various intervals to serve as travel lanes when snow becomes deep. The current trend in forest management of pulp stands seems to be toward various kinds of clearcuts. Studies show that strip cuttings also are good for timber production.

A cooperative study by the Wisconsin Conservation Department and the Lake States Forest Experiment Station showed that managed stands of second-growth hardwood with an overstory of 75 square feet of basal area per acre are producing 10-times as much browse as are uncut stands. This results from increased production per stem and a greater number of stems. The annual yield is still low (21 pounds per acre), and considerably heavier cuts are necessary to produce large amounts of browse. Clearcutting in strips is one method which shows promise for browse production (200-400 pounds per acre) and at the same time may be effective in stand regeneration.

The amount of white cedar browse made available to deer by logging an

all-aged, mature northern white-cedar stand was revealed by a Michigan study which showed that yield varied directly with intensity of cut. Clearcutting produced approximately 5,340 pounds of browse per acre, while cutting to a 10-inch minimum stump limit produced only 2,530 pounds.

In northeastern Wisconsin a study was made of the production of potential deer browse in newly felled trees in the northern hardwood-hemlock type. The northern hardwoods in pole- and sawlog-size stands produced an average of about 13 pounds of fresh browse, and hemlock 117 pounds per square foot of basal area. A clear-cut stand has a potential of providing about 2,340 pounds per acre if cut during the winter. Summer logging makes no direct contribution to food supply since browse is eaten only when fresh. ?

Research is needed to more effectively evaluate the influence of the above cutting practices on deer range and especially to point out modifications which improve the benefits or reduce conflicts, as follows:

1. Determine browse production from logging slash which may be anticipated in the several forest types under various cutting systems.
2. Determine browse production in seedlings and sprouts in various forest types in successive years following logging under various cutting practices.
3. Determine the browse utilization by deer which is permissible and yet permits establishment of forest reproduction of the species desired.
4. Develop practical requirements for the coordination of forest and wildlife management.
5. Evaluate animal use of the various cutting practices.

Other Practices

Tree planting and seeding affect deer habitat in several ways: (1)

ground preparation by discing, furrowing, burning, etc. can stimulate the growth of herbaceous and woody species for periods up to 10 years; (2) planted conifers can supply essential winter cover; or (3) the effect of reforestation can be detrimental by hastening the plant succession to a high forest.

Road construction, special use permits, water impoundments, and other land management programs can benefit or damage deer range and the deer herd. Each must be appraised and, if possible, modified to meet, as fully as possible, deer management needs. In many of the more remote areas access road construction is the only way of securing an adequate deer kill. The modern deer hunter is absolutely dependent on his 4 wheels.

Direct Improvement

Direct improvements are usually most useful in specific problem areas. Generally, they will be limited to the correction of limiting factors which cannot be dealt with through coordination with other forest programs.

Openings

The direct improvement of most general application is the creation and maintenance of openings to provide this essential component of summer range. Openings are used heavily both in late fall and early spring as well as in summer and appear important both in conditioning deer for the rigors of a restricted winter diet as well as to provide the first succulent vegetation for their rapid recovery to normal weight, growth, and fawn production in the spring. The value of forbs as deer food has not been appreciated. Studies of these values should be initiated.

During the past 25 years openings have provided easy planting chances for the establishment of conifer plantations. The practice has been so

intensive that some public forests have but few openings left. Game managers recognize openings as an essential part of good wildlife habitat.

WIS.
STUDY

The Lake States Forest Experiment Station and the University of Wisconsin have in progress a study of the vegetation of natural openings. This is coordinated with a Wisconsin Conservation Department study of the animal use of openings. These and future studies are intended to provide criteria for classifying openings and determining methods and specifications for maintaining and establishing openings for optimum habitat.

Guides for treatment of openings must be flexible and should be modified to fit the local needs. The Minnesota Department of Conservation guide, for example, suggests that areas of 5 acres or less should not be planted. Openings 5 to 10 acres in size and larger are planted, but border strips or small openings are left. Such criteria are tentative and should be modified as information becomes available.

Browse production has been provided by special treatments in situations where this cannot be accomplished by timber sales. For this purpose Michigan is using mechanical tree cutters at a reasonable cost in noncommercial stands. Sportsman groups have been organized to make special cuttings in situations where the browse supply has been critically low.

Phytocides

One promising technique for improving deer habitat is the use of phytocides for making new openings in forested areas or maintaining old ones, for increasing browse, and for establishing natural or planted cover patches.

Recent trials by the U. S. Bureau of Sport Fisheries and Wildlife, the University of Minnesota, and the Minnesota Department of Conservation in

northern Minnesota demonstrate that out-of-reach mountain maple, a highly preferred browse species, can be top-killed to induce regrowth within the reach of deer. Ground applications of 2,4-D esters at the rate of 12 pounds of acid per hundred gallons produced the most regrowth.

Also, current trials conducted by the U. S. Bureau of Sport Fisheries and Wildlife and the University of Minnesota with 2,4-D in northern Minnesota have shown much promise because of the selective action of the phytocide on American and beaked hazel and other low-preference browse species. The findings so far show that 2,4-D selectively reduces populations of the two species of hazel and increases both the proportion and the total abundance of more desirable deer browse species. Current chemical and aerial spraying costs indicate the technique has practical application, as sizable areas may be sprayed for about \$3.50 per acre. In other sections of the region, where hazel is an important food plant, other techniques are needed.

Planting Food

Planting natural browse holds little or no promise in the Lake States as a method of increasing the food supply for deer. Numerous field trials have shown that food planting met with failure because of overpopulations of deer. Even on areas with few deer, the high cost currently prohibits use of this technique. Where native browse species persist, phytocides and cutting practices are more effective and far less expensive.

Planting Cover

Planting for winter cover has some merit, but it also is expensive and has limited application if done for this purpose alone. In some instances, conifer planting may be used to establish winter yards in areas where none

existed before. Natural upland conifer stands sometimes serve as wintering areas. Cover planting also may be made to establish travel lanes and thereby permit better use of winter yards.

In northern Minnesota, a study by the U. S. Bureau of Sport Fisheries and Wildlife demonstrated that it was possible to successfully transplant large wilding balsam fir, black spruce, and white spruce. The best winter protection and use of the planting were obtained when they were at least one-tenth of an acre in size and the trees were spaced 4x4 feet. Balsam fir proved to be the best species to plant because the deer browsed on the lower branches and permitted earlier use for cover by ruffed grouse, moose, and deer.

Prescribed Burning

During the past two centuries, major ecological changes have taken place in the forest cover types of the Lake States as a direct result of logging, settlement, and wildfire. Much good deer habitat resulted from the wildfires.

In deer management, prescribed burning has been tested at various times during the past two decades. This selective use of fire has been employed as a technique to make openings in forest cover, to create more edge, to retard plant succession in order to maintain desirable food plants for deer, and to stimulate the growth of food plants.

Immediately after an area has been burned little food usually is available, and often nearby cover is lacking, especially if the burns are extensive. This condition is soon followed by a period of abundance of both woody and herbaceous plants. Usually the succulent regrowth, on burned areas, which is high in protein, is readily utilized by deer.

It is common knowledge that deer are usually associated with a subclimax

rather than with a climax forest. Often more deer are produced on burns because of the stimulating effect of fire on browse production. The beneficial effects may last for a period of only 10 to 15 years before the forest canopy closes, limiting browse production and lowering carrying capacity. The use of prescribed burning for forest regeneration may ultimately provide some improved habitat.

Burning seems to be particularly beneficial in areas that have been subjected to excessive deer populations of long standing. If the area is logged first and then burned, tests have shown that the sprout growth of some species may be doubled.

Several generalizations can be made regarding the use of fire. Wildlife problems and the use of fire are very complex, and the benefits or gains must be evaluated for individual species and on a local basis. The technique has limited value since it can be employed only on public or private lands dedicated to intensive deer management and may not be used where the market value of the timber is high. Also, while burns in general tend to favor some big game species such as deer and moose, they can be detrimental to other big game such as caribou.

Disking and Bulldozing

The effectiveness of disking to regenerate understocked stands of aspen and to establish other conifer species by natural seeding as a forest regeneration measure suggests that the technique may be equally effective for deer browse improvement. However, in Michigan, where about 3,000 acres have been disked in Conservation Department research projects since 1952, results have varied markedly and have not been encouraging. Burning and logging were believed to be better techniques for habitat improvement.

Nevertheless, it was recognized that disking may have value in areas incapable of producing commercial forest products.

Tests were made with a bulldozer in several plant communities. Much regrowth resulted from trials in sapling-pole sugar maple stands, particularly where staghorn sumac was common. However, since the treatment cost was \$22 per acre, it seems unlikely that technique will have wide usage. But mechanical cutting using heavy crawler tractors equipped with special tree cutting blades appears to be a good technique. It has proven economical in poor quality stands of pole-sized aspen, red maple, and scrub oak in Michigan where 6,500 acres were treated at a cost of \$6.00 per acre.

Other Practices

Water supplies in the Great Lakes Region have generally not been considered a limiting factor; practically no attention has been given to the analysis of the adequacy of this essential requirement.

Likewise, salting has been associated with poaching of deer; and little, if any, consideration has been given to the use of salt in management programs. The need for its use may become more important. Fewer salt licks are being established by isolated settlers, logging camps, or poachers. The increasing use of salt on highways for dust control and snow and ice removal may be an important factor in attracting deer to these roads and contributing to the growing problem of car-deer accidents. The need for various trace minerals in deer nutrition is not well understood, although the Michigan Department of Conservation has done some work on the use of various salt formulations at their Cusino Wildlife Experiment Station.

Research needs in respect to special methods of range improvement are many. In general, both the response of the vegetation and the response of

the animal to the site treatment should be studied. Specifically the following items are needed.

1. Criteria for classifying openings as to potential for animal use.
2. Use of forbs by deer and methods of increasing forb production in openings.
3. Methods for establishment and maintenance of openings as well as specific coordination instructions for retention of openings, their distribution, size, and shape.
4. Knowledge of the effectiveness of phytocides, especially in renovating old winter yard areas, in maintenance of openings, and in improvement of the deer habitat potential on rights of way.
5. Methods for the establishment of new wintering areas, particularly relative to the use of upland conifer plantations as winter yards.
6. Evaluation of the use of fire relative to deer management, especially in areas where logging is not commercially feasible. The effectiveness of fire in permitting the development of ground vegetation is also an important problem needing consideration.
7. Clarification of the part that minerals play in deer nutrition and reproductive productivity. The effect of highway salting on car kill should also be evaluated.

DEER AND HUMAN RELATIONS

Economic

Value of Herd

Many different bases have been employed for measuring economic value of natural resources, e.g., total money expended by ultimate consumer, income to primary producer, market value equivalent of total product, potential income based on maximum utilization, and others. There are data for the Great Lakes Region giving estimates of total expenditure by deer hunters,

estimates of expenditures per unit of range (in Ontario, hunters pay about \$500 yearly for the venison taken off each square mile of range), income to landowners (state and private) in certain small study areas, and, of course, records of public revenue from license sales.

The central problem, which must be solved before much progress can be made, is to select or invent a standard basis on which the value of all forms of natural resources can be compared. Estimates of deer values have often been unacceptable because they have been calculated in an unfamiliar way or expressed in unfamiliar terms rather than because they are not valid.

The second problem is the development of techniques to assess the value of ecological units of range for production of deer relative to other raw materials and wildlife, since in future multiple-use management the emphasis placed on deer management will necessarily be in proportion to the expected return.

Deer Damage and Control

The presence of deer on or near lands being used for agricultural or forest crops always raises the possibility of deer damage. All of the states and provinces have reported deer damage to agricultural crops. All have also experienced damage to forest reproduction, although the extent and severity of damage apparently varies widely.

Various deer repellents have been developed for the protection of agricultural crops. None has proven completely satisfactory. Among the points to consider in evaluating any repellent are: effectiveness, cost, ease of application, length of effective protection period. Very little has been done with systemic repellents. Fencing has been used successfully on rather small areas in Michigan and Wisconsin, but is too expensive for general application.

Wisconsin is the only state that makes payment for agricultural crop damage by deer. In the 1962-63 fiscal year, 145 damage claims totalling over \$20,300 were paid. Michigan has made limited use of a system allowing landowners to shoot the offending animals; the carcasses are turned over to various public institutions. Such a procedure always invites public criticism and is not a generally satisfactory solution.

There is a considerable difference in the tolerance with which farmers view deer damage in some areas as compared to others. Perhaps a study of the reasons for these differences would reveal some way of increasing this tolerance in some of the problem areas of each state.

Forest damage and control are much more intricate problems. Some of the difficulties are:

1. There is now no good method for assessing deer damage to forest reproduction.
2. There is limited knowledge as to deer population levels which can be tolerated in various forest types and age classes.
3. The mobility of deer prevents any manipulation of numbers except on rather large areas.

The Wisconsin Conservation Department has developed a reasonably good method for measuring acreages sustaining deer damage. However, the method only gives a picture of the past year's damage; it does not measure what deer may have done in the last twenty years. Also, there is no way of placing any dollar value on the damage. The one big difference between this survey and most past deer damage surveys, is that it does not call all deer browsing "damage." Unless a particular tree is needed for forestry purposes, it cannot be damaged by deer browsing. The present method

Wis
Study

recognizes this and has resulted in a more realistic appraisal of deer damage to reproduction.

The research needs are:

1. More effective repellents for agricultural crops and orchards.
2. More information and further development work on systemic repellents, and further investigation of other possible methods of keeping deer out of any given area.
3. A method of measuring deer damage to forest values in a dollar and cents fashion. Also needed is knowledge regarding how such damage would change with changes in deer population.
4. Development of cutting methods with more tolerance for "reasonable" deer populations.

Public Relations

If forests and deer could be managed as entities, the current problems of all people concerned with these resources would be simple. However, this cannot be done because the only practical deer-range management in most of the Great Lakes Region is dependent on forestry practices.

Many problems inherent in forest and wildlife management are not of a technical, biological nature but are concerned with people--their needs, motivations, knowledge, understanding, and desires. A great deal of information has been made available to the general public on deer management under public relations programs by state, federal, and industrial interests; but acceptance and support appear low.

A successful program of deer and forest-land management is dependent on first determining the values and management problems concerning these resources as precisely as possible and second obtaining acceptance by all land-use agencies, organized representatives of public interests, and

the general public on the methods of achieving equitable management.

Agreement on how to adequately manage deer and forests can be reached through a critical evaluation led by conservation agencies. Acceptance of the methods must be accomplished through education. The main problem here is to develop a means of disseminating information on deer management in relation to other public values--forest resources, farm crops, and recreational interests.

It is the responsibility of conservation agencies to obtain the necessary information to manage deer and to provide the public with this information. The responsibility of the public is to understand the problems and to accept deer management programs based on the best information available. It is most important to recognize that the effectiveness of even the best hunting regulations will be periodically offset by unfavorable weather during the hunting season. This condition will be temporary, and the public must accept hunting season kills that are periodically poor or mildly excessive.

Hunters' direct interest in deer is often limited, unfortunately, to having enough deer so that they see a great many during the deer season. But deer hunters are a part of the general public, and it is up to resource managers to point out that some of the public may require something less than a deer behind every bush.

All agency personnel must be made familiar with forest-deer management policies and programs. The correct interpretation and use of these policies are essential to the success of a management program. There will be a continued need to keep agency personnel and the public apprised of current management efforts and changing problems.

Methods of contacting the public on these matters should be set up

with the aid of professionals in the public relations field. Emphasis of education programs should be based on recognizing the entire public's stake in forest and deer resources. In the past, too much emphasis has been placed on "too many deer." Educational goals should be redefined to indicate that hunters will be furnished with the maximum number of high-quality animals consistent with good land-use principles.

Research needs are:

1. Methods of promoting the understanding of management programs within agencies.
2. Motivational research to find out what creates public attitudes toward agency programs. This should include sociology and psychology of deer hunting and other factors regarding the deer herd. It also should include approaches to how we can best sell good deer management, what makes a successful deer season, the importance of seeing deer to the tourist industry, and where and why hunters will go if a large portion of a state or province is opened to restricted hunting seasons. Research of this type should be done only by well-qualified public-relations experts assisted by agency I&E personnel and deer technicians in planning phases. As a general rule, public relations people know little about game management, and game managers know little about public relations. Neither group should attempt the job alone. However, the hard cold fact remains that deer management seems harder to sell than soap or white-walled tires.

Management Demonstration Area

Large segments of the public are not in a position to understand or evaluate much of the data obtained by research programs. Therefore, when accumulated findings indicate the desirability of drastic changes in management, violent public opposition often develops. For this reason

it is desirable to develop extensive demonstration areas where complete management programs can be applied and the results are readily evident to the public without the necessity of understanding all the technical background and where results can be measured accurately.

Small (one- or two-square mile) areas have been used for the purpose in the past, but the public (and some technicians) are nearly always skeptical that the same management program would get the same results when applied to regular, large segments of deer hunting territory. What is needed is an area sufficiently large (300-500 square miles) and so located to include enough of the various range factors and conditions to constitute a typical segment of deer range and deer hunting territory. It should encompass plains and hills, swamps and upland, conifers and hardwood, dense and sparse cover, timber of all ages and various species, farms and clubs, posted and unposted land, and state, federal, and private hunting grounds. The managing agency (Federal, State, Province) should have ample authority to apply the game and range management practices that could and should be applied to such an area and should apply such practices in a manner that would demonstrate the results gained thereby. This would be a practical deer and range management area which could and would stand on its own general management and production record but which, if necessary, could be backed by the full complement of research data. This is the sort of a demonstration the public can understand. Islands work well. On the other hand, every successful antlerless deer season is a demonstration in itself. More should be made of this.

