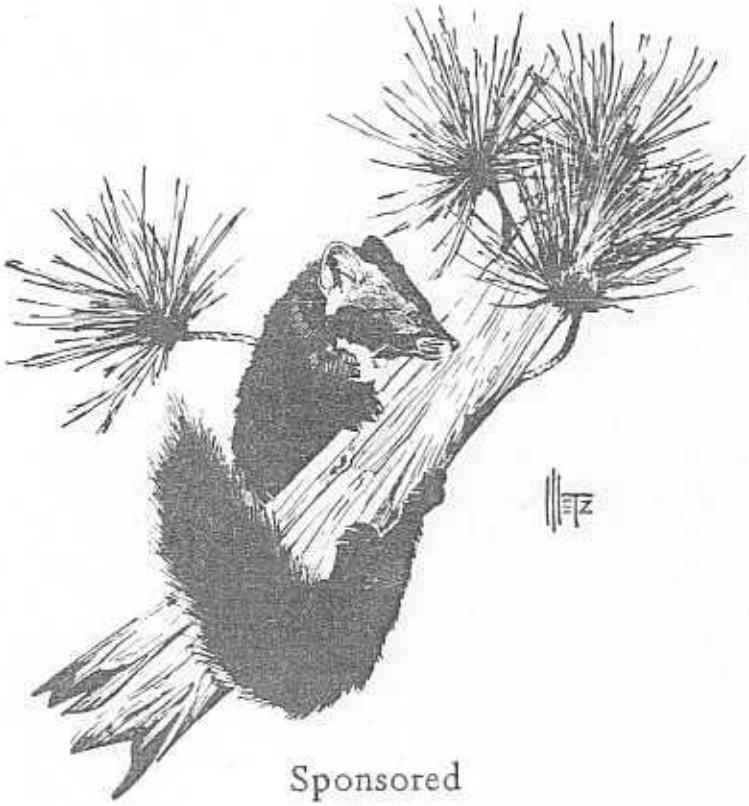
Mammalian Ecology and Habitat Management In Minnesota

A Symposium on
March 7-9, 1980

at

Bald Eagle Outdoor Learning Center
Cass Lake, Minnesota
(Proceedings)



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EDITORS' FOREWORD

Compiling the proceedings of the Mammalian Ecology and Habitat Management Symposium has taken longer than we hoped. Everyone who participated in this effort, however, did so on a voluntary basis, making time in already busy schedules to contribute valuable information and broaden the knowledge of mammalian species in Minnesota. We are grateful for the interest, help, and cooperation which made the symposium worthwhile.

The Editors

Adela S. Elwell
Katharine N. Cram

PRINCIPLES OF MAMMALIAN ECOLOGY

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The term ecology is derived from the Greek word "oikos" meaning house and was first used in 1869 to describe the relationships of organisms to the inorganic and organic environment. A modern definition of ecology is the scientific study of the interactions of intrinsic and extrinsic factors that determine spatial dis ributions and abundance patterns of organisms, populations, or communities in time and space. In recent years, the field of ecology has become increasingly quantitative, theoretical, and interrelated with other biological disciplines, such as physiology, genetics, ethology, and evolution.

The basic problem in ecology is to determine the set of factors that attribute to temporal and spatial differences (e. g., seasonal, among habitats) in distribution and abundance. Three major ecological concepts which are used to solve this problem in mammalian ecology include mechanisms of population regulation, the theory of island biogeography, and the ecological niche. Mammalian populations often exhibit stable, irruptive, or cyclic growth curves due to species-specific reproduction potentials. However, population density and dispersion pattern for a particular species or population may also be a product of one or more extrinsic and/or intrinsic factors. These factors include physical and vegetative features of the environment, food type and availability, predators, competitors, parasites, diseases, and social behavior.

The presence of a mammalian species in a habitat may be to a large extent the result of dispersal capabilities and characteristics of that potentially-colonizable habitat. The theory of island biogeography essentially states two things: (1) the number of species in a habitat is correlated to the size of a habitat and (2) immigration rates and extinction rates of species from "island" habitats are a function of both the size of a habitat and the distance of that habitat from similar habitats. The importance of this theory to mammalian ecology cannot be overemphasized. The availability of habitat to many species of mammals is declining due to urban sprawl, argicultural intensification, and other land-use practices. Hence, suitable habitats often remain only as fragments of "islands" in the form of mountaintops, isolated woodlots, roadsides, and so on. Moreover, barriers, such as interstate highways, may virtually eliminate dispersal and subsequent colonization of potential habitats for some mammalian species. In species requiring large home ranges, fragmentation of habitats into "islands" may result in local extinction of populations over time. The theory of island biogeography also gives valuable information regarding the proper design (shape, size, degree of isolation) of habitats for mammalian species.

The combination of various extrinsic and intrinsic factors which determine the dispersion and the abundance of a mammalian species in a given locality is the ecological niche. Obviously, the ecological niche for a species can never be measured completely; to accomplish this, all factors in the environment and the responses by each individual animal to the factors need to be measured. However, based on a knowledge of the natural history of a mammalian species, factors that are both biologically relevant and interpretable can be quantified to give important insight into ecological requirements of a species and its interactions with those of member species in a community.

Population regulation, island biogeography, and the ecological niche are three of many concepts in modern ecology which can be used to develop and test specific hypotheses to better understand the relationship of mammals to their environment. A thorough knowledge of mammalian ecology is a necessary prerequisite to proper and effective management of mammalian species as a natural resource.

SMALL MAMMAL COMMUNITIES AND HABITATS IN MINNESOTA

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A brief introduction to the concept of community ecology as the study of interacting populations is presented. Understanding of the characteristics, potential, and limitations of individuals, populations, and communities is essential to field biologists studying small mammal communities. The dynamic nature of our environment, including daily, seasonal, and long-term changes, results in dynamics within small mammal communities as each individual endeavors to survive and eventually to reproduce.

Small mammal assemblages and structural characteristics of their habits were studied in Minnesota by Kalin (Unpubl. Ph. D. dissert., Univ. Minnesota, 160 pp., 1976). Data on small mammal communities described herein are largely from that source, modified as appropriate to accommodate findings of our own studies (Birney and Nordquist, Peat Program Progress Report, Minnesota Department of Natural Resources, 5:14-66, 1979).

Kalin defined 14 community types in the state, but because three (road ditch, fence row, cultivated field) result exclusively from man's activities, only 11 are considered here. Even these are affected by man's activities, but to one extent or another they occurred naturally before European man began to modify North America. The 11 communities considered may be divided into three subgroups: upland forests, lowland forests, and nonforested habitats.

Upland forests include deciduous forest (12 species of small mammals, with the white-footed mouse, Peromyscus leucopus, being the most common), woodlot-riparian forest (8 species, with the white-footed mouse being most common), coniferous forest (6 species, with white-footed mouse being most common), and mixed forest (13 species, with the woodland form of the deer mouse, P. maniculatus gracilis, being most common). Lowland forests include deciduous forest (13 species, with deer mouse and red-backed vole, Clethrionomys gapperi, being about equally abundant and most common), coniferous forest (4 species, with red squirrel, Tamiasciurus hudsonicus, being most common). Nonforested habitats include lowland shrub meadow (13 species, with the meadow vole, Microtus pennsylvanicus, being most common), lowland shrubless meadow (10 species, with meadow vole being most common), bog (4 species, with the masked shrew, Sorex cinereus, being most common), and upland meadow (14 species, with meadow vole being most common). Upland meadows support the greatest number of small mammal species, and lowland coniferous forests and bogs support the fewest.

Kalin captured 23 species of mammals. These are listed sequentially by number of communities in which they occurred (in parentheses): red-backed vole (11), short-tailed shrew, Blarina brevicauda (10), deer mouse, including both P. maniculatus gracilis and P. m.

bairdii (10), white-footed mouse (9), masked shrew (9), meadow jumping mouse, Zapus hudsonius (8), star-nosed mole, Condylura cristata (6), eastern chipmunk, Tamias striatus (6), red squirrel (6), meadow vole (5), arctic shrew, Sorex arcticus (4), least chipmunk, Eutamias minimus (4), woodland jumping mouse, Napaeozapus insignis (3), house mouse, Mus musculus (3), southern bog lemming, Synaptomys cooperi (3), water shrew Sorex palustris (3), northern flying squirrel, Glaucomys sabrinus (2), pygmy shrew, Sorex hoyi (2), grasshopper mouse, Onychomys leucogaster (upland meadow only), thirteen-lined squirrel, Spermophilus tridecemlineatus (upland meadow only), prairie vole, Microtus ochrogaster (upland meadow only), southern flying squirrel, Glaucomys volans (upland deciduous forest only), and harvest mouse (upland meadow only). The plains pocket mouse, Perognathus flavescens, also an upland meadow species, was not captured either by Kalin or by Birney and Nordquist.

In summary, Minnesota small mammal communities vary in number of species from as few as four in lowland coniferous forest and bog habitats to as many as 14 in upland meadows. The 23 species of small mammals trapped vary greatly in the breadth of their ecological requirements, with red-backed voles, short-tailed shrews, and deer mice occurring in most or all habitats, whereas grasshopper mice, thirteen-lined ground squirrels, prairie voles, southern flying squirrels, and harvest mice were limited to a single habitat type. Four of these five species (southern flying squirrel being the exception) were found only in upland meadow.

HISTORICAL PERSPECTIVES

Milt Stenlund
Regional Administrator, Minnesota DNR

Changes in mammal numbers in the northern forested areas of Minnesota have been brought about by massive habitat changes which occurred from 1880 to 1920 due to logging and fires. Much of the area was changed from "needles" to "leaves" as pine and spruce were replaced by aspen and birch.

White tailed deer responded positively and peak populations were reached in the 1930's and 1940's.

With maturing of second growth forest, the "needle" trees, especially balsam fir and spruce, are taking over as the climax forest, with correspondingly decreasing deer numbers. Increased logging will be beneficial, but an important factor of fire will be lacking.

Original native moose populations were decimated by habitat changes, hunting, and disease. Static population in the 1930's and 1940's gradually increased so that hunting was allowed in 1972. Present habitat changes are negatively affecting deer more than moose, which should hold their own in the immediate future.

Native fisher and marten populations also decreased due to habitat changes and overtrapping. Both mammals were rare in the 1940's. Gradually, they increased so that by 1960 fisher were observed fairly commonly and marten sign was recorded in Cook County. Fisher trapping season opened in 1977 and 2,150 were taken. Present habitat is favorable for both animals.

Timber wolves were exploited until the mid 1950's, when protective regulations were first established. Bounties were removed in 1965. Wolf populations vary directly with big game numbers, primarily deer. Some areas in the BWCA now support no deer or wolves in winter. The no fire-no logging edict in the BWCA will keep wolf and deer numbers at a minimum.

The caribou, along with the moose, was the important big game mammal in the early forests. Habitat changes and exploitation eliminated all native caribou by 1940. Major habitat changes in the conifer forest have improved chances for re-introduction. Two proposals are under way for stocking--one in Superior National Forest and the other in Voyageur National Park.

The beaver was the main attraction for early white explorers. Exploitation reduced numbers drastically by 1900. Second growth hardwoods provided excellent habitat and a trapping season opened again in 1939. Minnesota now harvests 20,000 to 30,000 per year, second to Alaska in the United States.

THE DISTRIBUTION OF MAMMALS IN MINNESOTA

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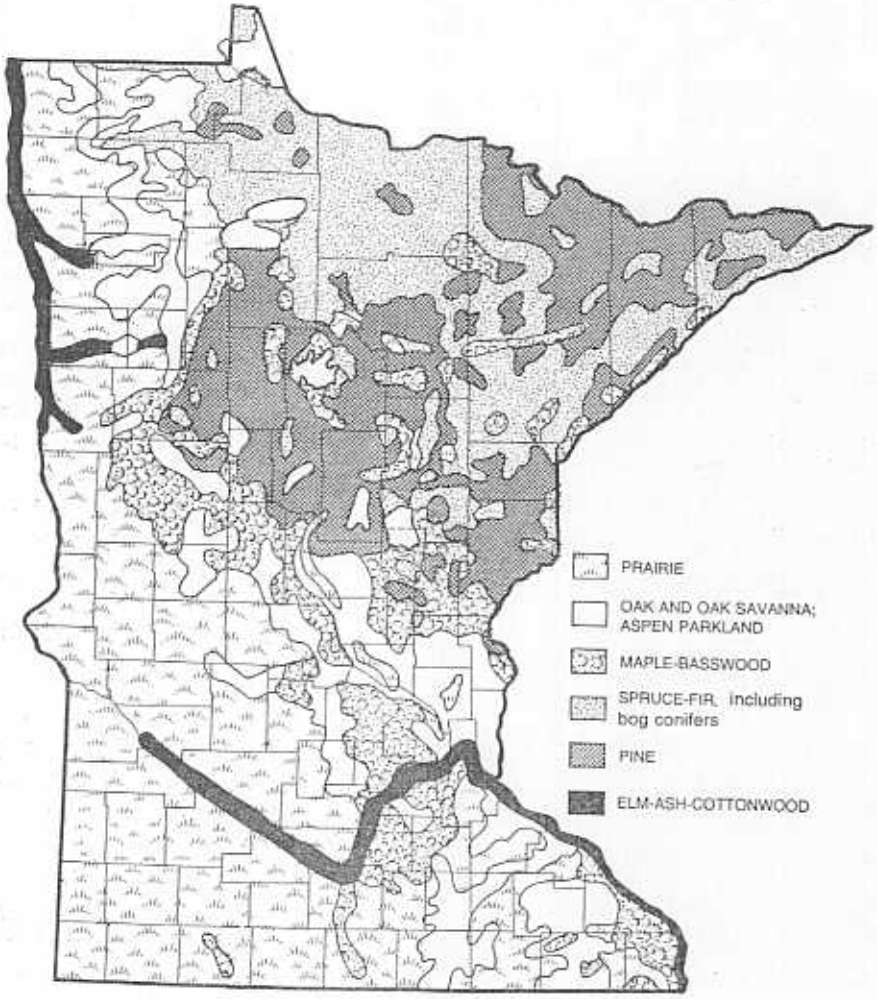
This paper will discuss some aspects of geographic distribution in Recent mammals, outline the standard methods for recording and reporting geographic distribution, consider the problem of what constitutes a valid record of distribution in mammalogy, and report briefly on the current status of knowledge of the geography of Recent mammals in the state.

SOME ASPECTS OF DISTRIBUTION. Any species is restricted to a habitat or range of habitats. The natural or pre-settlement upland habitats of Minnesota were tall grass prairie, broad-leaved deciduous forest, needle-leaved evergreen forest (=taiga), and various transition zones between these. Minnesota also had an abundance of aquatic habitats: bogs, marshes, swamps, and river bottom forests. People have variously modified these habitats in the last two centuries, both in total area occupied and in species composition and structure. These modifications have been detrimental to some native mammals and beneficial to others. Other speakers in this symposium will consider several examples of such effects. Figure 1 shows the distribution of pre-settlement vegetation.

Except for dispersing individuals, a species is likely to be found only in or near particular habitats--e. g., muskrats (Ondatra zibethicus) near still or slowly moving water. Special features of the habitat will affect the distribution of many mammals. For example, common moles (Scalopus aquaticus) are unlikely to inhabit heavy clay soils. For some species (e. g., the pygmy shrew, Microsorex hoyi) the range of acceptable habitats is not well known.

There are two chronological aspects of distribution. The first is seasonal or annual, and is of greater importance to ornithologists than to mammalogists. Among our mammals, various bats are the major migrators, occupying the state, or at least the northern parts of it, only in the warmer months. The great majority of mammals in Minnesota remain in a given area throughout the year, although some (e.g., the woodchuck, Marmota monax) take a seasonally inactive role by hibernating.

A second chronological aspect of distribution is long-term, perhaps cyclical, irruptions. Most species fluctuate in population density. When density is high, individuals often disperse into atypical habitats, but remain in much the same geographic area. For instance, southern bog lemmings (Synaptomys cooperi) typically inhabit wetlands, but, during population surges, they commonly occur also in nearby uplands. However, widely ranging larger mammals may move well outside their usual geographic ranges, especially when high density is followed by a food shortage. The Canada lynx (Lynx canadensis) resides today only in the wilder parts of north-central and northeastern Minnesota. In 1963 and 1973, however, they showed up as far south as the Twin Cities, probably in response to a



III. Presettlement vegetation types in Minnesota. (Adapted by Patricia Burwell from an unpublished map drawn by F. J. Marschner in 1930 for the United States Department of Agriculture, Washington, D.C.)

Fig. 1. Published with the permission of the University of Minnesota Press.

decline in abundance of their staple food, the snowshoe hare (Lepus americanus).

A basic aspect of distribution is geographic location itself. This can be expressed as latitude and longitude, but is commonly stated in terms of political units and subunits. This aspect of distribution is the one most commonly illustrated in publications on the mammals of states, provinces, or regions. The basis for such reports is primarily the collections and written records held and maintained by museums and other institutions.

RECORDING AND REPORTING DISTRIBUTION. Most of the contiguous United States, in addition to being divided into states and counties, has been divided by the U. S. Geologic Survey into townships, ideally six miles on a side, which are in turn divided into one-mile sections. Figure 2 shows the townships in Minnesota. Bemidji State University's Bald Eagle Center, the site of this symposium, has this location: Minnesota, Cass Co., Township 145 North, Range 30 West, Section 1. (It also spills over into T. 145 N., R. 29W., Sec. 6.) The "T." and "R." coordinates are measured from baselines designated by the U. S. G. S. County courthouses sell maps with these coordinates clearly marked, and compilations of all 87 Minnesota county maps are available commercially (Miles and Yeager, 1979). It is useful, in addition to recording the locality by this system, to indicate the distance by compass directions or along numbered roads from the nearest community in the same county. (If you have a location in Canada to report, consult a knowledgeable Canadian mammalogist about the best system to use.)

If a collector has deposited a specimen in a professionally-curated collection (which is where most specimens belong), there should be at least four records for that specimen at that museum or university. The collector will prepare a label for the specimen and will also record the data in her field notes, a copy of which will accompany her specimens when the museum acquires them. The museum will record the specimen in its accession book and in its card file. Each of these records will include the locality where the specimen was taken, along with other information. The field notes. in addition, will include a description of the habitat. For example, Miss Diane Dehart collected a red-backed vole (Clethrionomys gapperi) on 20 Oct. 1973. She subsequently submitted her collection in partial fulfillment of the requirements for Biology 452 Mammalogy. We assigned the specimen (her number 60) our number BSCVC 4509. (Actually, this specimen was turned in several years after she collected it.) Figure 3 illustrates facsimiles of her label, her field notes, and our specimen card, using current versions of the forms, not those in use in 1973. A system of this sort facilitates use of speciments for distributional or other studies.

The detail in which distributional data are published depends on the level and scope of the publication. In "Mammals of the Eastern United States" (2d ed., Hamilton and Whitaker, 1979), it would have been impractical to map the exact locality of each specimen. It has, however, been customary, in many state mammal surveys (e. g., Gunderson and Beer, 1953), to map distributional records to county only. For Minnesota's larger counties, such records are imprecise; Becker

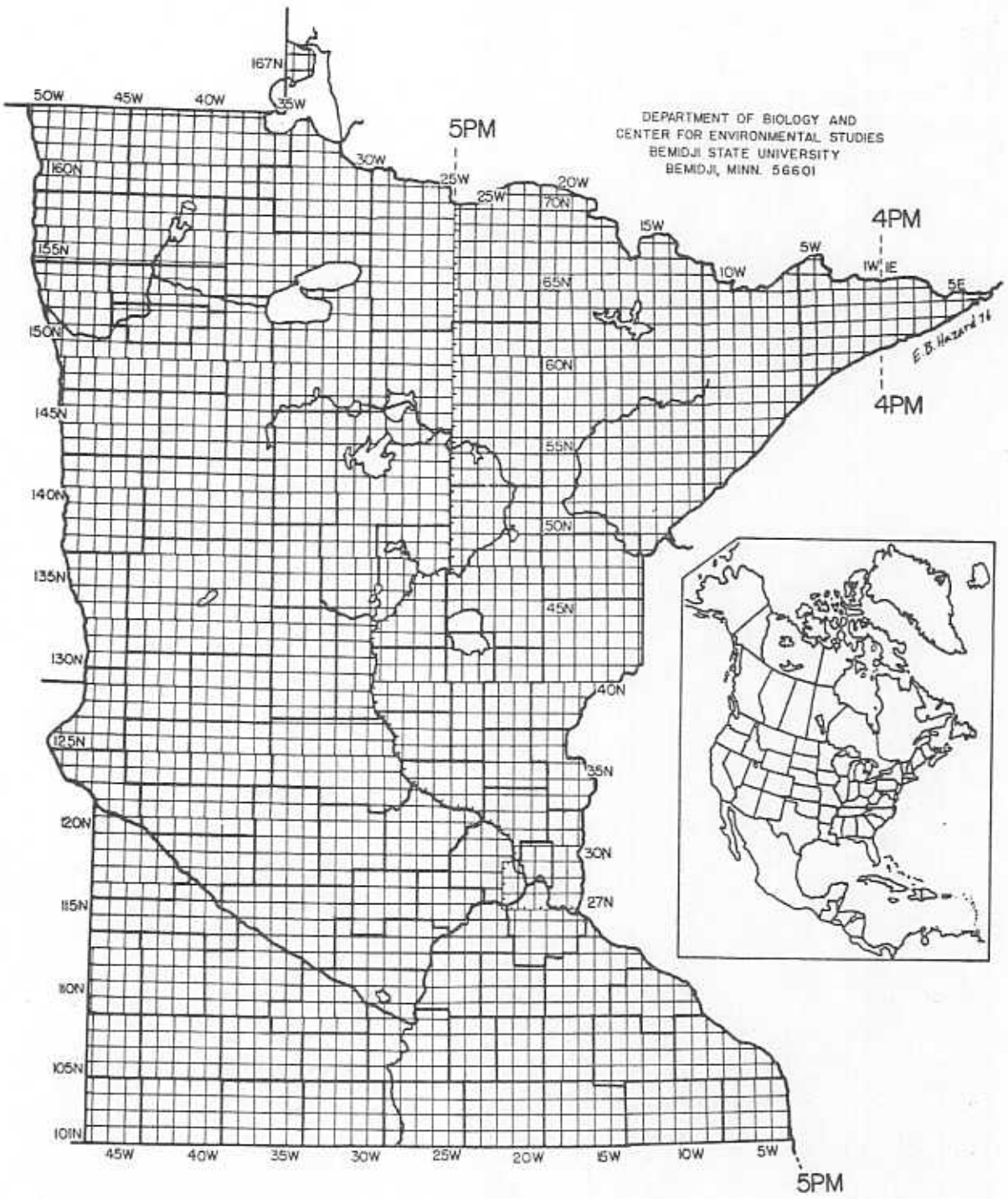


Fig. 2. Minnesota townships.

Bemidji State University Biol 452 Fall, 1973 Name Diane M. Dehart

No 56 Sp Blarina brevicauda Sex ♀ Age adult Date 13 November 1973

TL 119 T 25 HF [illegible] Other

St MN Co Hu [illegible] near cut

alfalfa in t [illegible]

BSCVC 4509 .Species Clethrionomys gapperi

Sex ♂ .Age Ad .Mount Skin ✓ Sku ✓ Skel Bac/oc Other

Acq mo/yr Oct 79 .Source Diane M. Dehart .S# 60

Date coll 20 Oct. 1973 .Donation/loan

St/Pr Mn. Co Beltrami T 146N, R 35W, S 36,

Other loc(km/mi)

No 57 Sp S [illegible] October 1973

TL 257 T 94 HF [illegible] Other ✓ corn and seed from cheek pouches

TL 109 BL T 31 HF 17 EFN 13 FA TR WT

Assoc # .Other

St MN C [illegible]

Disp mo/yr .Disposition

cheek [illegible]

BEMIDJI STATE UNIVERSITY VERTEBRATE COLLECTION ebh 78.

No 58 [illegible] mber. 1973

Minnesota, Beltrami Co. T146N R33W Sec36
20 October 1973
skin and skull Diane M. Dehart ♂ 5. adult 60
length x tail x foot x ear
109 x 31 x 17 x 13
BSCVC 4509

TL 144 T 7 [illegible]

St MN C [illegible]

Bemidji State College Vertebrate Collections
Bemidji, Minnesota 56601

Clethrionomys gapperi

was st [illegible]

Fig. 3. Field notes, label, and BSU file card for BSCVC 4509 (Diane Dehart 60), *Clethrionomys gapperi* (red-backed vole).

No 59 [illegible] uber 1973

TL 150 T [illegible]

St MN Co Hubbard Twp 144N Range 33W Sec 16 Habitat caught by dog, perhaps in yard area.

Collector Ed Dehart Disposition

No 60 Sp Clethrionomys gapperi Sex ♂ Age s. adult Date 20 October 1973

TL 109 T 31 HF 17 EFN 13 FA TR W Skin ✓ Skull ✓ Skel Bac/oc Other

St MN Co Beltrami Twp 146N Range 35W Sec 36 Habitat Open area with tag alder, small spruce, aspen type brush EH 1975

Collector DMD Disposition BSCVC 4509

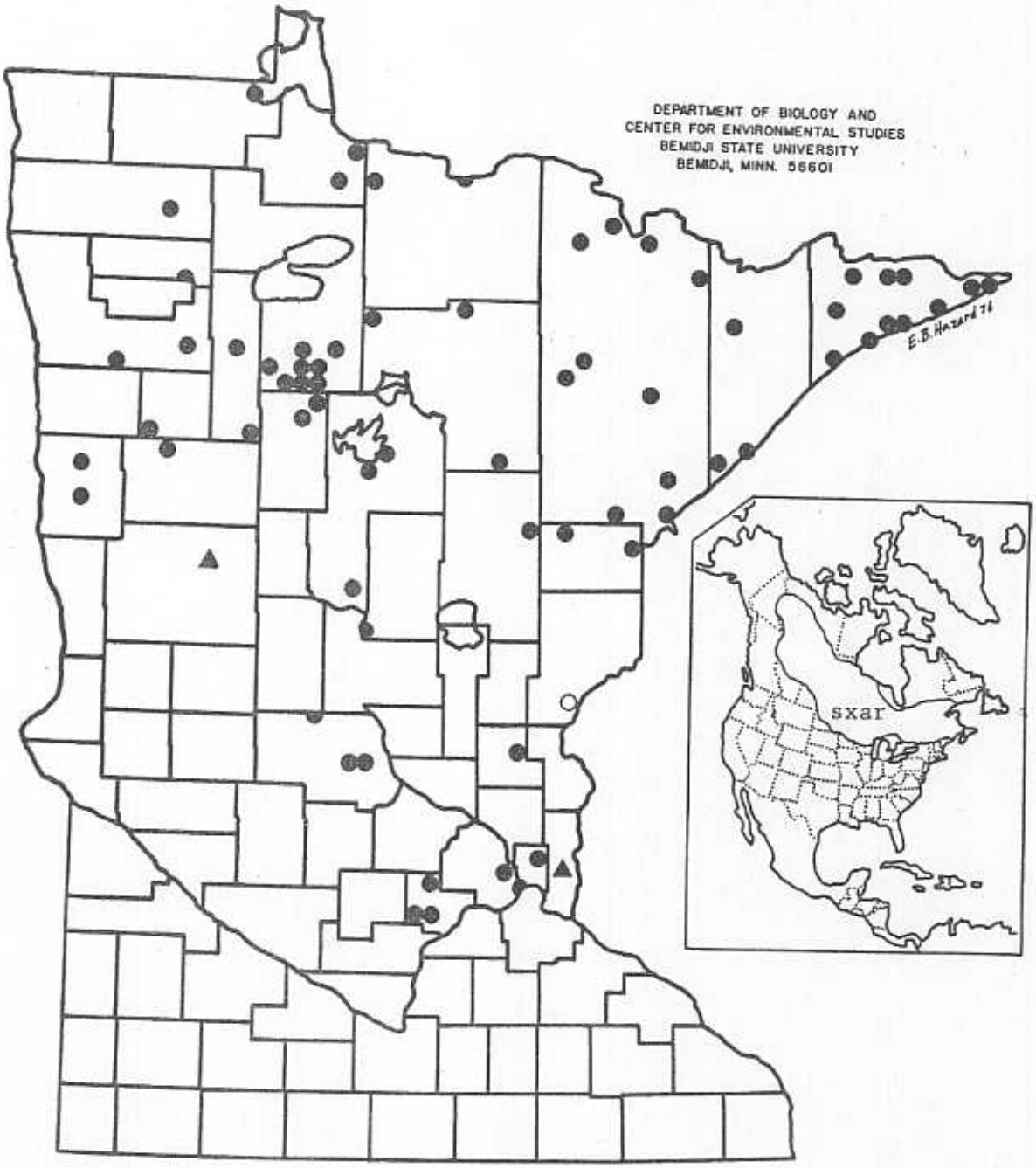


Figure 4. Distribution of *Sorex arcticus* in Minnesota. Solid circles = specimens known to township; open circles = other valid township records; solid triangles = specimens known only to county.

Co. is larger than Rhode Island, Beltrami Co. is larger than Delaware, and St. Louis Co. is larger than Connecticut. For a general work on a state or small group of states, centering map symbols on townships seems reasonable. Figure 4 shows the known distribution, as of the late 1970's, of the arctic shrew (Sorex arcticus), using this system. Unfortunately, many older Minnesota specimens are labelled simply "Ottertail Co." or "Washington Co."

Additional mapping techniques or appropriate written comments are needed to interpret such data. The arctic shrew is a sedentary mammal, occupying the area illustrated as well as many other townships where it has not been collected. The Canada lynx is capable of long-range movements; Twin Cities metro area localities indicate transients, not residents. Richardson's ground squirrel (Spermophilus richardsonii) is not a wide-ranging species. Its occurrence further east into our prairie counties over the last decade or so indicates a range extension, one that may bode ill for some Minnesota farmers.

WHAT CONSTITUTES A RECORD? My comments so far indicate that a distributional record is a properly labelled specimen in a collection. Will anything else do? Sometimes, but not often. We are generally less willing to accept a sighting of a mammal as a valid record than competent bird watchers are to accept the sighting of a bird. Most mammals are not strikingly marked, most are nocturnal and secretive, and few people are skilled in identification of mammals by sight. Many small mammals are hard for even experienced mammalogists to distinguish as specimens, let alone in the field. It is best to accept only specimens as valid records for most species.

However, some records not backed up by specimens are useful. Carrol Henderson, DNR Non-game Supervisor, has reactivated a system of field reports by DNR personnel that has provided many records, mostly of readily-identified, medium-sized mammals. This nicely complements our collections, which comprise mostly small species. He has also made available fur buyers' records, which are now being kept to township rather than only to county. Occasionally, a photograph exists to back up a sight record, for example one of the pronghorns in Lac Qui Parle Co. (Henderson, 1978).

CURRENT STATUS OF OUR KNOWLEDGE OF MAMMAL DISTRIBUTION. A few years ago, I made a rough map, based on the data I had then accumulated, of the number of species known per Minnesota township. Many townships, perhaps half, were blank. Except for Cook Co. (Timm, 1975), most of the marks on the map were clustered near institutions with significant collections: the University of Minnesota (Mpls.-St. Paul, Duluth, and Morris); Bemidji, Mankato, Moorhead, Southwest, and Winona State Universities; St. John's University and Gustavus Adolphus and Concordia Colleges; and Itasca State Park. Although the distribution of mammals is better known today than it was a few decades ago, there are still large areas, in many parts of the state, that need a closer look. There are also species that merit more intensive distributional study: most of the bats (Birney, 1980), a number of the microtine rodents (Timm, 1980), the woodland jumping mouse (Napaeozapus insignis), and others.

LAWS, REGULATIONS, AND PERMITS. Anyone who contemplates collecting for scientific purposes should find what is legal and what is not before starting out. It would be well to check with local MDNR personnel, or the equivalent provincial agency in Canada, in order to learn what species can be taken, at what seasons, in what areas, and by what methods.

ACKNOWLEDGEMENTS. The University of Minnesota Press has kindly permitted us to publish Figure 1. It first appeared in "Minnesota Birds: Where, When, and How Many" (Green and Janssen, 1975), and will appear in a forthcoming publication by the Press on mammals of Minnesota. The records on which any consideration of distribution is based are gathered by professional mammalogists and wildlife biologists, amateur naturalists, and many students, generations of them. I am grateful to all of these. I am particularly grateful to Mrs. Diane Morris, Curator-Naturalist at BSU, who cooperated in the preparation of Figure 3, who prepared the display of skulls and study skins and the blown-up label for this symposium, and who, in her earlier incarnation as an undergraduate, made a substantial contribution to the BSU collection and therefore to mammalogy in Minnesota.

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NONGAME WILDLIFE PROGRAM

1979 SUMMARY

Carrol Henderson, Nongame Supervisor
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The Department of Natural Resources' nongame wildlife program for 1979 was characterized by a wide variety of both new and ongoing activities that hopefully benefitted many nongame species.

Funding for this program, now three years old, is derived from hunting, trapping, and fishing license revenues through the state game and fish fund. During the past three years, sportsmen have contributed at least $70,000 for nongame work directly. Another $10,580 was provided by the United States Fish and Wildlife Service for a bald eagle study and $1,250 has been donated by sportsmen's clubs and bird clubs. The Evansville Sportsmen's Club donated $50 for the trumpeter swan project, the Willmar Sportsmen's Club donated $600 for the otter restoration project in southwest Minnesota, and the St. Paul Audubon Society donated $600 for the otter project.

Staff assistance has been provided by Diane Vosick, Betty Kennedy and Julie Reitter through the Young Adult Conservation Corps Program. Steve Hennes, a graduate student at the University of Minnesota, is employed on contract to carry out the bald eagle study. Lisa Hall from Colorado Mountain College in Colorado worked on the eagle project as an intern, and Mary Miller is now working in the nongame program as an intern from Metropolitan State University. Anita Manders, an intern with the Minnesota Heritage Program, has also assisted with data analysis.

Nongame species include 490 vertebrates which are not traditionally hunted or harvested in Minnesota. The nongame program is designed to carry out data collection and analysis on these species, to assign priorities to species which require intensified data collection and research, to plan and implement conservation programs for priority species, and to provide nongame data and literature to individuals and agencies which need such information.

Priority Species

The state has been divided into ten nongame regions, and a list of priority species has been compiled for each region. These lists were developed in consultation with authorities throughout Minnesota. These regional lists are available from the nongame supervisor.

DATA COLLECTION

Sandhill Crane Survey

Thirty-seven volunteers submitted 97 sandhill crane cards and reported seeing a total of 4908 cranes in 1979. Sightings documented the presence of at least 60 pairs with 30 young. Land clearing in northwest Minnesota continues to pose the greatest threat to the habitat required for this species. A separate report on this survey will be prepared in early 1980.

Colonial Waterbird Nesting Site Inventory

Nesting locations for 16 species of colonial waterbirds were checked by volunteers throughout the state. All volunteers were provided with standard forms for reporting heronry data. Over 220 nesting sites are now included in this inventory. New heronries located in 1979 included the Howard Lake heronry in Anoka. This colony includes about 400 nests of great blue herons, great egrets, and black-crowned night herons. A new double-crested cormorant colony was found on south Heron Lake in Jackson County, and new colonies of Forster's terns and black-crowned night herons were found on the Coon Creek Wildlife Management Area in Lyon County. Copies of this inventory will be available in early 1980.

Uncommon Wildlife Reports

There were 170 volunteers who contributed 569 reports on uncommon wildlife in 1979. Many of these reports represent new county records for species whose ranges need better documentation. Other records give the details for occurrences of rare species such as the great gray owl, merlin, bobwhite, burrowing owl, blue racer, and mule deer. This data is compiled by county and species to facilitate data retrieval. The information accumulated by this volunteer program has made a substantial contribution to our knowledge of nongame wildlife in Minnesota. It is also an indication of the broad public support being provided to the nongame program.

Common Loon Survey

A new effort began in 1979 with a volunteer survey of common loons. By the end of the year, 255 observations had reported 857 loons. This is undoubtedly just a small portion of the total number of loons breeding in the state. Of the total number of loons observed, at least 240 pairs were seen with 215 young, and the remainder were apparently non-breeders. This effort will be intensified in 1980. A summary of the loon records will be available in 1980.

Breeding Bird Survey

The United States Department of Interior annually sponsors a nationwide June breeding bird survey that includes 52 random 25-mile routes in Minnesota. In 1978 and 1979, Robert Janssen of the Minnesota Ornithologists Union coordinated the survey and 47 routes were run each year. The nongame supervisor helped find volunteers for the routes and has compiled the resulting data for about 170 nongame bird species. The results will be published in 1980 in a report entitled "Minnesota Birds: A Quantitative Assessment of Distribution, Relative Abundance, and Diversity, 1975-1979."

SPECIAL PROJECTS

Bald Eagle Research on Lead Poisoning

Bald eagle research on the potential for lead poisoning at the Lac qui Parle Wildlife Refuge continued in 1979. In 1978, four bald eagles were captured. X-rays and blood samples were taken. In 1979, nine more eagles were captured. About 450 dead Canada geese and 100 mallards have also been picked up for lead analysis. Some of the waterfowl being eaten by eagles at Lac qui Parls contain toxic lead shot and this in turn can create lead poisoning in the eagles. Steve Hennes, a University of Minnesota graduate student, is doing the research under the

supervision of Dr. Dan Frenzel. The project is also being coordinated with Drs. Gary Duke and Pat Redig of the School of Veterinary Medicine of the University of Minnesota.

As a result of this study, the MDNR has announced that steel shot will be required for waterfowl hunting in the Lac qui Parle goose zone in 1980.

Bald Eagle Restoration in New York

Through coordination with the U. S. Fish and Wildlife Service and the New York Department of Environmental Conservation, four 8- to 9-week-old eaglets were provided to New York for rearing and subsequent release. That state is down to one nesting pair, and this project is part of a restoration effort for bald eagles in the northeastern United States.

Hearding Island WMA

Hearding Island has now been designated as a Wildlife Management Area. It is the first to be designated primarily for nongame purposes. Last summer the island was post[illegible] and vegetation was cleared on the area selected as a potential colony site for common terns and piping plovers. The project is being carried out by the Area Wildlife Manager (AWM) LeRoy Angell.

Prairie Chicken Restoration at Lac qui Parle WMA

On September 27, 1979, 29 prairie chickens were released to augment the release of 34 chickens in 1977. On January 6, 1979, two prairie chickens were seen on the Chippewa Prairie near the 1977 release area. Repeated sightings of up to four birds, including booming cocks, were seen on the Chippewa Prairie during the spring of 1979. Prescribed burning on the Chippewa Prairie last year resulted in one of the most impressive responses by prairie wildflowers and grasses that has been seen in recent years.

Trumpeter Swan Restoration

On August 30, 1979, a meeting and field trip were held at Fergus Falls to disciss the restoration plan for trumpeter swans in western Minnesota. Officials from the MDNR, U. S. Fish and Wildlife Service, Trumpeter Swan Society, Fergus Falls Izaak Walton League, West Central Bird Club, and Hennepin County Park System were present. The Evansville Sportsmen's Club had donated $50 for this project and this money was used to help cover meeting expenses.

Several wetland areas were visited and evaluated as potential swan-rearing sites. Strategy was discussed for proceeding with the plan. Nongame funding will be necessary for implementation.

River Otter Restoration on the Minnesota River

The river otter once occurred on the Minnesota River in southwest Minnesota, but it disappeared from there about 100 years ago. A proposal has been implemented to transplant up to 12 river otters from northern Minnesota to the upper Minnesota River Valley from Odessa to Watson. The Willmar Sportsmen's Club donated $600 which was used to purchase 6 Hancock live traps and the St. Paul Audubon Society donated $600 to pay a trapper to capture otter. Trapping attempts in the fall of 1979 were unsuccessful, so another attempt will be made in the spring of 1980.

Marshall Lagoons

Current opportunities for acquisition of the Marshall lagoons are not good. The City of Marshall did finally decided it would be all right to sell one lagoon for a Wildlife Management Area, but now there are insufficient funds for acquisition. It appears that other means will be necessary to preserve and manage this area.

Pig's Eye Heronry

The Pig's Eye heronry in St. Paul is the largest heronry in the metropolitan area and also one of the most threatened in the state. Current plans by the St. Paul Port Authority call for construction of a barge fleeting area near the heronry. Reports and testimony from the nongame program have been provided during the past year to the Pig's Eye Coalition and the Metropolitan Council to help preserve this heronry. Although the barge fleeting proposal exists, Pig's Eye Lake and the heronry itself are now proposed for preservation as a park, and the heronry is proposed as a state Scientific and Natural Area.

Cliff Swallow Nest Structure Experiment

When two old buildings were recently removed from MDNR land near Grand Rapids, a special pole shelter was constructed to provide an alternative nesting structure for a large colony of cliff swallows which had nested on the sides of the buildings. The structure will be evaluated for use in 1980. Jay Janacek, Regional Wildlife Manager, planned and carried out the project with Bob Chesness, Area Wildlife Manager.

FIELD INVESTIGATIONS

Field investigations on nongame wildlife resources were carried out to collect data on several important areas. Sites visited were the Long Lake heronry in Hubbard County, Howard Lake heronry in Anoka County, Coon Creek Wildlife Management Area in Lyon County, Skaokatan Wildlife Management Area in Lincoln County, Talcot Lake Wildlife Refuge in Cottonwood County, and Heron Lake in Jackson County. Bob Janssen accompanied the nongame supervisor on the visits to Talcot Lake and Heron Lake.

Assistants in the nongame program also checked Pelican Lake in Wright County, Lake Jefferson in LeSueur County, Shields Lake in Rice County, and Swan Lake in Nicollet County with the respective area wildlife managers.

PUBLICATIONS AND AUDIO-VISUAL MATERIALS

Four papers were written and presented in 1979. "Nongame Bird Conservation Programs in Minnesota" was presented at the workshop on Management of North Central and Northeastern Forests for Nongame Birds in St. Paul. "Bobcat (Lynx rufus) Distribution, Management, and Harvest Analysis in Minnesota, 1977-79" was presented at the Bobcat Research Conference at Front Royal, Virginia. A paper on "Colonial Nesting Birds of Minnesota" was given at the 1979 spring meeting of the Minnesota Academy of Sciences. A presentation on wetland birds was also given at the Avian Ecology and Habitat Management Symposium at Cass Lake, Minnesota.

Minnesota Volunteer articles included "Last Call for Cranes" (June-July), and "Old Baldy" (Sept.-Oct.). New DNR Reports on nongame were "Look at Shorebirds," "Minnesota's Prairie Wildlife," "The Lynx Link," "Prairie Plants of Lac qui Parle and Vicinity," and

"Birdhouses in Minnesota."

Twenty-six other pamphlets were issued by the nongame program last year, including "The Occurrence, Distribution, Legal Status, and Utilization of Reptiles and Amphibians in Minnesota - 1979," and "The Taxonomy, Distribution, Legal Status, and Utilization of Nongame Mammals in Minnesota - 1979." A complete list of these publications and an order form are available from the nongame supervisor.

A new edition of "The Uncommon Ones" was written in 1979 and will be available early in 1980. It covers the status of threatened and endangered wildlife in the state and discusses the status of other priority species.

A new 80-slide presentation has been prepared which explains the nongame program. This one-hour program will be presented to groups on request.

A television program on building houses for birds was filmed for the North Star Report on KSTP-TV.

SALVAGE OF SCIENTIFIC SPECIMENS

Dozens of specimens of protected wildlife species were turned in to the nongame wildlife office in 1979. Crippled birds, including hawks, owls, eagles, pelicans, and swans, were given to the bird rehabilitation clinic at the University of Minnesota. Salvageable dead specimens were donated to the Science Museum of St. Paul, the Bell Museum of Natural History, Mankato State University, Bemidji State University, and other institutions. Among the most important donations were Minnesota's first specimen of a Ross' goose, a boreal owl, a burrowing owl, and several pine martens.

ENDANGERED SPECIES

In December, 1979, a cooperative agreement was signed with the USFWS which will provide for funding of recovery activities for the threatened bald eagle and gray wolf and the endangered peregrine falcon.

WILD GINSENG

Wild ginseng is a wild herb of Minnesota's hardwood forest region. The roots are reputed to have medicinal values and are mainly exported to the Orient. Recent prices are up to $150 per pound of dried root. The federal government informed the State of Minnesota in 1978 that a regulated harvest season would need to be established by 1979 if future exports of wild ginseng from Minnesota could be approved by the Endangered Species Scientific Authority. The State also needed to show that the season would not be detrimental to the species' survival. Prior to 1978, from 2,000 to 2,200 pounds of roots were dug annually in Minnesota.

The nongame office provided coordination for drafting the necessary legislation, and gave testimony in the legislature. The bill passed, and a public hearing was held in Rochester on July 17. Commissioner's Order 2030 was then drafted, and Minnesota's first ginseng season began August 15. The wild ginseng management program will be coordinated by the nongame office.

NONGAME LEGISLATION

As of January, 1980, the federal nongame bill has passed in the House of Representatives (H. R. 3292) and is pending in the Senate (S. 2181). The Senate bill is preferred and would provide $24 million for three years of nongame planning. It would allow some projects to be implemented immediately. The bill would be funded by an 11 per cent manufacturers' excise tax on bird seed, bird feeders, bird houses, and bird baths. The Carter Administration is reported to favor passage of the nongame bill.

Strong public support will be necessary to help achieve passage in the Senate before this Congressional Session adjourns.

Without passage of this legislation, Minnesota's nongame program cannot achieve its full potential.

SUMMARY

The nongame program represents the cumulative interest and efforts of hundreds of volunteers across the state. Grateful appreciation is extended to those volunteers who have contributed sightings, to the organizations which have donated money, and to Minnesota's sportsmen who have financed this program through the game and fish fund.

A PRELIMINARY REVIEW OF THE TAXONOMY, DISTRIBUTION, LEGAL STATUS, AND UTILIZATION OF NONGAME MAMMALS IN MINNESOTA

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Among Minnesota's eighty species of wild mammals are 58 nongame species. Nongame species are those which are not generally hunted or harvested. This review also includes those traditional furbearers which are either fully protected, like the gray wolf, wolverine, and marten, or those which are not protected by law, like the striped skunk, coyote, and long-tailed weasel.

Pending legislation which would provide for planning for nongame wildlife conservation is now in Congress. This could focus much-needed attention on nongame species.

This preliminary guide has been prepared to help assess the needs and priorities for conservation of nongame mammals. It includes a review of the taxonomy, distribution, legal status, and utilization of nongame mammals in Minnesota. Ten regional guides with species lists and county occurrence records have been prepared to be used in conjunction with this publication.

This review will be periodically updated. A new book on Mammals of Minnesota will soon be published by Dr. E. B. Hazard of Bemidji State University and will provide a comprehensive analysis of both game and nongame species.

REGIONAL ANALYSIS

For purposes of analysis, the State of Minnesota has been subdivided into ten areas. They conform generally to Department of Natural Resources regions and/or economic development regions. These are portrayed in Figure 1.

TAXONOMY AND IDENTIFICATION

The taxonomy accepted here is that published by J. K. Jones, Jr., D. C. Carter, and H. H. Genoways (1975).

Identification marks for nongame mammals are explained in the Peterson field guide "A Field Guide to the Mammals" by Burt and Grossenheider (1964).

A list of Minnesota's 58 nongame mammals, including families and scientific names, is given in Appendix A.

Subspecies designations are not dealt with in this review.

SPECIES DIVERSITY

Current information suggests that there are 58 nongame mammals in Minnesota, including 1 marsupial, 6 shrews, 2 moles, 7 bats, 9 squirrels, 2 pocket gophers, 1 pocket mouse, 12 New World mice, 2 Old World rats and mice, 2 jumping mice, 1 porcupine,

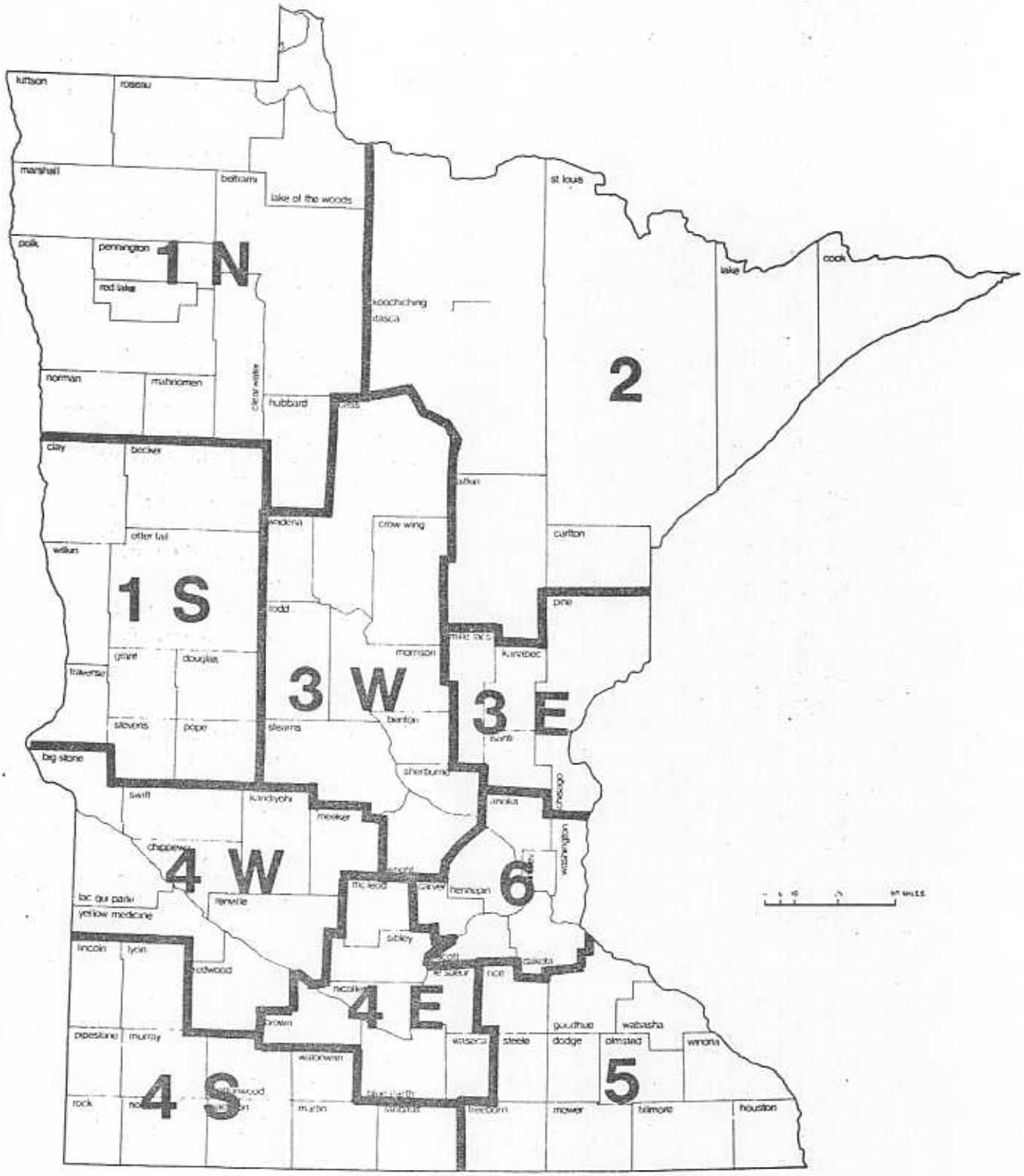

Figure 1. Regional breakdown used for nongame wildlife analysis.

2 dogs, 7 weasels and relatives, 1 cat, 2 deer, and the pronghorn.

The species diversity varies somewhat from one region to another. The maximum number of nongame mammal species known for one region, 42, is in Region 1N in northwest Minnesota. The lowest number, 27, is recorded for Region 4E in south central Minnesota.

There is a general increase in species diversity from south to north as peripheral northern species are encountered. These species are named in Table 1.

Fewer southern peripheral species like the least shrew, eastern pipistrelle, western harvest mouse, prairie vole, pine vole, and oppossum are picked up as distribution is reviewed from north to south. Other southern species are mentioned in Table 1.

This is opposite from the situation with reptiles and amphibians, which are most abundant in southeast Minnesota.

Figure 2 is a summary of the nongame mammal species diversity in the ten nongame regions. Two numbers are presented for each region. The top number is the actual number of nongame species that are verified in that region. The bottom number is the total number of species that have been verified plus the tally of hypothetical species which possibly or probably occur there. Some regions such as 1N, 2 and 6 have been well-researched by mammalogists, so few species remain to be verified.

Other regions such as 1S, 3E and 4E have ten or more hypothetical species and still require more survey work to verify their presence.

GAME MAMMALS

Twenty species of Minnesota mammals have been excluded from this summary because they are game species regulated by game laws. They include the white-tailed jackrabbit, snowshoe hare, eastern cottontail rabbit, eastern gray squirrel, fox squirrel, beaver, muskrat, black bear, raccoon, fisher, badger, mink, river otter, red fox, gray fox, Canada lynx, bobcat, white-tailed deer, mule deer, and moose. Two other species, the bison and grizzly bear, are extirpated, but by tradition they are also included here as game species.

EXOTIC SPECIES

An exotic species is one which has been introduced from another country and which is not native to Minnesota. The Norway rat and house mouse are the only exotic species of wild mammals which have become established. There are occasional records of nutria being found in the state but they are not known to have bred or established feral populations. Exotic species are identified in Appendix A.

EXTINCT SPECIES

None of the state's nongame mammals, or game mammals, have become extinct in recent times. As extinct species is one that has completely disappeared from the earth.

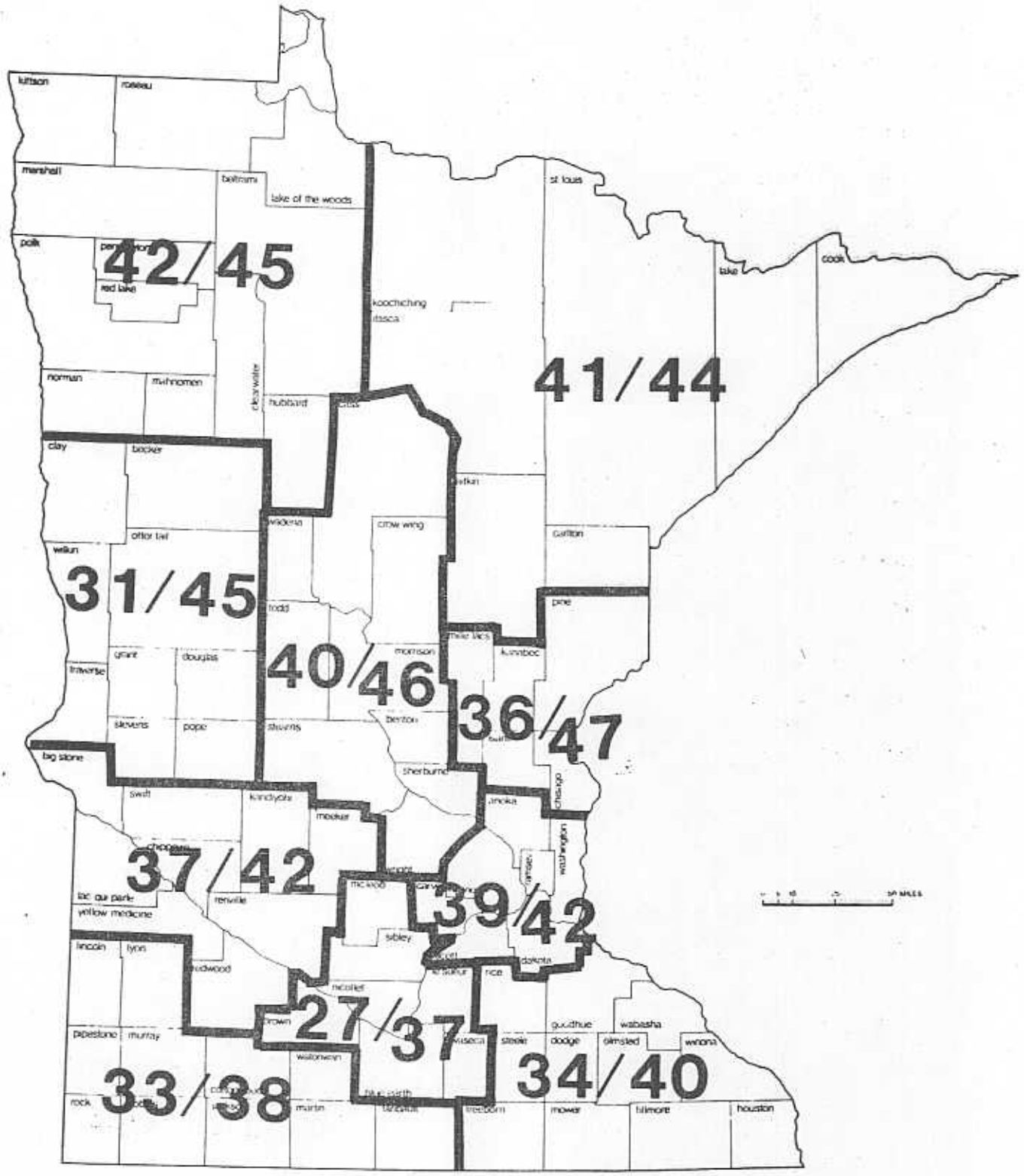

Figure 2. Species diversity of nongame mammals by region. Numbers on left are the number of species for which documentation exists. Numbers on right are totals for documented species plus hypothetical species.

EXTIRPATED SPECIES

An extirpated species is one which has disappeared from a portion of its original range that is usually defined by political boundaries. The grizzly bear, bison, woodland caribou, and wolverine have been extirpated from Minnesota. Studies are currently under way to assess the feasibility of reintroducing woodland caribou in northern Minnesota. Wolverines may accidentally range into Minnesota from Canada. Occasional reports of wolverines are received by the Department of Natural Resources, but none have been verified in this century by specimens or valid documentation.

Extirpated species are identified by region in Appendix A.

ENDEMIC SPECIES

An endemic species is one which is only found in one location or area. There are no endemic mammals which are found only in Minnesota.

ACCIDENTAL SPECIES

An "accidental" species is one which is found outside of its regular range. This includes species like the cougar and pronghorn which can easily move into Minnesota from adjacent areas. It can also include other species like the opossum. One unexpectedly showed up in St. Louis County in 1978. Sometimes these accidental occurrences result from the escape of pets or the capture and release of wild specimens by humans. Accidental species will not generally reproduce where they accidentally occur. Accidental species are identified by region in Appendix A.

HYPOTHETICAL SPECIES

Hypothetical species are those which are predicted to occur in a region or in the state but for which verification is lacking. Hypothetical species are identified by region in the regional summaries.

THREATENED AND ENDANGERED SPECIES (Federal)

The gray wolf is officially listed as a threatened species under the terms of the Endangered Species Act of 1973. There are no endangered mammal species in Minnesota.

THREATENED AND ENDANGERED SPECIES (State)

The gray wolf is officially listed as a threatened species by the State of Minnesota in accordance with the provisions of M. S. 1976, Section 97.488.

The pine marten was unofficially listed as a threatened species in the Department of Natural Resources publication "The Uncommon Ones" in 1975. This designation had no legal status. The pine marten is fully protected, and its numbers have increased considerably since 1975.

HABITAT AFFILIATIONS

Review of nongame mammals by habitat preference facilitates understanding their distribution and conservation needs (Batten 1979, Birney and Nordquist 1978, Burt and Grossenheider 1964,

Gunderson and Beer 1953, Kalen 1976, Martin, Zim and Nelson 1951, and Shelford 1963).

Nongame mammals have been divided into four broad habitat categories: cosmopolitan, forest, prairie and grassland, and wetland. Cosmopolitan species are those species which are so adaptable to varying habitats that they are found in all ten nongame regions of Minnesota. These include the species which incidentally are most often adapted to urban environments. It is recognized that some of these species will exhibit certain habitat affiliations throughout the state and for that reason could probably be designated in other categories. However, the cosmopolitan category is extremely useful to describe those species which are typically our most common and adaptable species.

Several mammals are apparent cosmopolitan species because their presence has been verified in eight or nine of the ten regions. These include the Keen's little brown bat, big brown bat, silver-haired bat, and red-backed vole.

Forest, prairie and grassland, and wetland habitat preferences have also been identified. There are 19 nongame mammals in the "cosmopolitan" category, 21 species in the "forest" category, 12 species in the "prairie and grassland" category, and 6 in the "wetland" category. These categories are identified in the species list in Appendix A.

DISTRIBUTION

The 19 cosmopolitan species identified in Appendix A occur in all ten nongame regions. Distribution of the other mammals is more restricted.

Many nongame mammals are "peripheral" in Minnesota. That is, they reach the edge of a portion of their North American range in the state. Ten southern species are at the northern limit of their range, four western species are at the eastern edge of their range, and twelve northern mammals are at the southern limit of their range. These species are identified in Table 1.

TABLE 1. PERIPHERAL NONGAME MAMMALS IN MINNESOTA

Southern Species	Western Species	Northern Species
Least shrew	Northern pocket gopher	Arctic shrew
Eastern mole	Northern grasshopper mouse	Northern water shrew
Eastern pipistrelle	Prairie vole	Pygmy shrew
Spotted skunk	Pronghorn	Star-nosed mole
Opossum		Pine marten
Southern flying squirrel		Gray wolf
Plains pocket gopher		Least chipmunk
Plains pocket mouse		Northern flying squirrel
Western harvest mouse		Heather vole
Pine vole		Woodland jumping mouse
		Porcupine
		Wolverine

The mammals known only from one region are the northern pocket gopher, heather vole, rock vole, and pine vole.

PRIORITY SPECIES

Some nongame mammals are peripheral and occupy a very small range in the state. They may have unique habitat requirements, they may be rare or uncommon throughout their range, or their range or numbers within their range may have declined significantly in recent years. Other mammals may be federally listed as threatened or endangered even though their status is secure within Minnesota, or they may be extirpated in Minnesota.

All of the above reasons provide justification for assigning "priority" status to some species so that appropriate actions can be taken in the nongame program to collect data on these species, monitor their status, and take appropriate management actions when necessary.

TABLE 2. PRIORITY NONGAME MAMMAL SPECIES IN MINNESOTA, WITH ANNOTATED REASONS FOR PRIORITY STATUS

Least shrew - 1
Keen's little brown bat - 3
Big brown bat - 2
Eastern pipistrelle - 3
Northern pocket gopher - 1
Western harvest mouse - 3
Northern grasshopper mouse - 2
Northern bog lemming - 1
Pine vole - 1
Heather vole - 1
Rock vole - 1
Pine marten - 1
Least weasel - 3
Wolverine - 6
Spotted skunk - 4
Cougar - 1
American elk - 1
Woodland caribou - 6
Pronghorn - 1, 6
Gray wolf - 5

Key

1 - Peripheral and/or occupies a very small range in the state

2 - Unique habitat requirements

3 - Rare or uncommon throughout its range in Minnesota

4 - Range, or number within the range, has declined significantly

5 - Federally threatened or endangered, although Minnesota status is secure

6 - Extirpated from Minnesota

LEGAL STATUS

There is a wide variety of legal status among nongame mammal species.

The gray wolf is totally protected by state and federal laws in accordance with provisions of the Endangered Species Act of 1973 and Minnesota Statute 1976, Section 97.488.

The American elk, woodland caribou, pronghorn, pine marten, and wolverine are totally protected by state law, M. S. 1976, Section 100:27. The Department of Natural Resources has no authority to set seasons on these animals unless legislation is passed by the Minnesota legislature.

All other nongame mammals listed in Appendix A are unprotected species. Their unprotected status is designated in M. S. 1976, Section 100:26, Subdivisions 1 and 3. Unprotected mammals may be

taken either in the daytime or at night, and in any manner, except with the aid of artificial lights. They may be possessed, bought, sold, or transported in any quantity. Poisons may not be used to take unprotected animals except in the manner authorized by Section 18.022. It is illegal to intentionally drive, chase, run over or kill with any motor-propelled vehicle any unprotected animals.

Striped skunks and spotted skunks are accorded a similar degree of protection, except that if control by poisoning is necessary, the poisoning is regulated by Minnesota Statutes 18.021 and 18.035, and amendments to that act.

Some "nongame animals" are traditional furbearers which are unprotected. These include the coyote, short-tailed weasel, long-tailed weasel, spotted skunk, striped skunk, and Virginia opossum. These species, however, have not been over-exploited for their fur and the unprotected status has not been detrimental to their status in the state. Prejudice against predators, livestock depredations by coyotes, and rabies problems caused by skunks have contributed to maintaining them as unprotected animals. This allows greater flexibility in carrying out control of problem animals without being detrimental to the species.

The cougar should probably be designated as a protected species. Recent substantial increases in pine marten numbers in Lake and Cook Counties should also be reviewed. Pine martens are traditional furbearers which may deserve game status if the harvest could be maintained without detriment to the species.

UTILIZATION

Utilization of nongame mammals is primarily restricted to those furbearers which technically fall into the nongame category because of unprotected status.

A mail survey of resident trappers yielded data on the 1977 furbearer harvest which is shown in Table 3.

TABLE 3. HARVEST OF SELECTED FURBEARERS BY RESIDENT HUNTERS AND TRAPPERS IN 1977

Species	Hunter Harvest	Trapper Harvest	Total Harvest	Mean Pelt Price	Est. Total Pelt Value
Long-tailed weasel	N. S.*	1,000	1,000	.85	$ 850.00
Short-tailed weasel	N. S.	1,000	1,000	.44	$ 440.00
Striped skunk	N. S.	29,000	29,000	2.78	$ 80,620.00
Spotted skunk	N. S.	1,000	1,000	5.42	$ 5,420.00
Opossum	N. S.	3,000	3,000	2.11	$ 6,330.00
Coyote	4,000	3,000	7,000	34.03	$ 238,210.00
TOTAL			42,000		$ 331,870.00

* N. S. = Not Significant

There is also a demand for red squirrel pelts on Canadian fur markets.

Hunted species are the woodchuck, Richardson's ground squirrel, thirteen-lined ground squirrel, and Franklin's ground squirrel. Hunting poses no threat to the status of these prolific rodents. It is a popular spring and summer activity in western Minnesota.

Virtually no nongame mammals are utilized for meat. Opossums can be eaten, but because of their scavenging habits, most people do not eat them. Porcupines are also reputed to be edible.

There is some demand for skunks as pets, but they are a major rabies carrier.

Flying squirrels and opossums are occasionally kept as pets. In general, nongame mammals do not make good pets. Prices at one pet retail business in Minnesota in 1979 were $32 for skunk kittens, $85 for coyote pups, $325 for gray wolf pups, and $800 for cougar cubs. Adult skunk prices at a pet dealer in Blaine were $55 apiece.

NUISANCE ANIMALS

Some nongame mammals create nuisance problems. For this reason, the control of some nongame species is a significant management consideration.

Species which most often create nuisance problems are the eastern mole, little brown bat, woodchuck, Richardson's ground squirrel, thirteen-lined ground squirrel, red squirrel, plains pocket gopher, Norway rat, house mouse, porcupine, coyote, gray wolf, and striped skunk.

Spotted skunks, Franklin's ground squirrels, long-tailed weasels, and opossums occasionally create crop damage or poultry depredation problems.

RECOMMENDATIONS FOR DATA COLLECTION

Reports of sightings of priority species or new county records of other species, excluding the house mouse and Norway rat, are important to help document mammal occurrences. When an important sighting occurs, the following data should be recorded: County, township, range, section number, date, year, type of habitat, and name and address of observer. List the identifying characteristics of the specimen which will distinguish it from similar species. Take photos or plaster casts of tracks for unique species like cougars. If the specimen is collected and preserved, tell where the specimen will be kept.

Send these reports to the Nongame Supervisor, Department of Natural Resources Section of Wildlife, Box 7, Centennial Building, 658 Cedar Street, St. Paul, Minnesota 55155.

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APPENDIX A

A CHECKLIST OF
MINNESOTA'S NONGAME MAMMALS

		HABITAT
ORDER MARSUPIALIA		
Family Didelphidae -- New World Opossums		
Virginia opossum	*Didelphis virginiana*	F
ORDER INSECTIVORA -- Insectivores		
Family Soricidae -- shrews		
masked shrew	*Sorex cinereus*	C
water shrew	*Sorex palustris*	W
arctic shrew	*Sorex arcticus*	W
pygmy shrew	*Microsorex hoyi*	W
short-tailed shrew	*Blarina brevicauda*	C
least shrew	*Cryptotis parva*	F
Family Talpidae -- moles		
eastern mole	*Scalopus aquaticus*	P
star-nosed mole	*Condylura cristata*	W
ORDER CHIROPTERA -- Bats		
Family Vespertilionidae -- vespertilionid bats		
little brown bat (little brown myotis)	*Myotis lucifugus*	C
Keen's little brown bat (Keen's myotis)	*Myotis keenii*	F
silver-haired bat	*Lasionycteris noctivagans*	F
eastern pipistrelle	*Pipistrellus subflavus*	F
big brown bat	*Eptesicus fuscus*	F
red bat	*Lasiurus borealis*	C
hoary bat	*Lasiurus cinereus*	F
ORDER RODENTIA -- Rodents		
Family Sciuridae -- squirrels		
eastern chipmunk	*Tamias striatus*	C
least chipmunk	*Eutamias minimus*	F
woodchuck	*Marmota monax*	C
Richardson's ground squirrel	*Spermophilus richardsonii*	P
thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	C
Franklin's ground squirrel	*Spermophilus franklinii*	C
red squirrel	*Tamiasciurus hudsonicus*	C
southern flying squirrel	*Glaucomys volans*	F
northern flying squirrel	*Glaucomys sabrinus*	F
Family Geomyidae -- pocket gophers		
northern pocket gopher	*Thomomys talpoides*	P
plains pocket gopher	*Geomys bursarius*	P

Family Heteromyidae -- pocket mice		
plains pocket mouse	*Perognathus flavescens*	P
Family Cricetidae -- New World mice		
western harvest mouse	*Reithrodontomys megalotis*	P
deer mouse	*Peromyscus maniculatus*	C
white-footed mouse	*Peromyscus leucopus*	C
northern grasshopper mouse	*Onychomys leucogaster*	P
Gapper's red-backed vole	*Clethrionomys gapperi*	F
heather vole	*Phenacomys intermedius*	F
meadow vole	*Microtus pennsylvanicus*	C
rock vole	*Microtus chrotorrhinus*	F
prairie vole	*Microtus ochrogaster*	P
pine vole (woodland vole)	*Microtus pinetorum*	F
southern bog lemming	*Synaptomys cooperi*	W
northern bog lemming	*Synaptomys borealis*	W
Family Muridae -- Old World rats and mice		
Norway rat	*Rattus norvegicus*	C
house mouse	*Mus musculus*	C
Family Zapodidae -- jumping mice		
meadow jumping mouse	*Zapus hudsonius*	C
woodland jumping mouse	*Napaeozapus insignis*	F
Family Erethizontidae -- New World porcupines		
porcupine	*Erethizon dorsatum*	F
ORDER CARNIVORA -- Carnivores		
Family Canidae -- dogs		
coyote	*Canis latrans*	C
gray wolf	*Canis lupus*	F
Family Mustelidae -- weasels and relatives		
pine marten	*Martes americana*	F
short-tailed weasel	*Mustela erminea*	C
least weasel	*Mustela nivalis*	P
long-tailed weasel	*Mustela frenata*	C
wolverine	*Gulo gulo*	F
eastern spotted skunk	*Spilogale putorius*	P
striped skunk	*Mephitis mephitis*	C
Family Felidae -- cats		
cougar	*Felis concolor*	F
ORDER ARTIODACTYLA		
Family Cervidae -- deer		
American elk	*Cervus elaphus*	P
woodland caribou	*Rangifer tarandus*	F
Family Antilocapridae - pronghorn		
pronghorn	*Antilocapra americana*	P

HABITAT KEY

C = cosmopolitan
F = forest
P = prairie and grassland
W = wetland

Habitat Requirements of Microtine Rodents in Minnesota

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Minnesota was blessed in having a diverse fauna of microtine rodents. At least nine species were found within the borders of the state before settlement by European man. What I would like to discuss with you this morning is:

1) What is a microtine rodent

2) What microtine rodents we have in Minnesota

3) Where they are found in the state and what their habitat requirements are

4) What is their status today

Microtines are mammals; they belong to the order Rodentia and family Cricetidae. The cricetid rodents include all the native North American rats and mice--the packrats, deer mice, white-footed mice, grasshopper mice, and numerous others. The microtine rodents are a subfamily of their own within the Cricetidae. The Norway rat and house mouse, our most common household mammalian pests, belong to an Old World family, the Muridae.

Microtines are robustly built mice; they have a short tail, small ears, small eyes, and a short, broad nose and short, stocky legs. In general, small rodents are referred to as mice and larger ones as rats, but these names have no taxonomic significance. The proper name for the smaller microtines is either vole or lemming. The voles and lemmings are seldom encountered by man although they may be very abundant locally. As with most rodents, they have a high reproductive potential. Gestation periods range from 17 to 28 days, and litter sizes range from 2 to as many as 12. The average litter size is around five or six. Additionally, most species come into estrus again soon after parturition, thus several litters can be born in succession. In Minnesota we see a few voles that have produced three litters. However, in the laboratory where abundant food is available, 10 to 15 litters in succession may be produced by a single female. Young born early in the spring can breed their first summer.

Muskrat (Ondatra zibethicus)--Muskrats are found throughout the state and are exceedingly common. They are atypical of microtines in general in that they have numerous adaptations for the aquatic environment, including a long laterally flattened tail and large body size. Some 200,000 to 500,000 muskrats are trapped each year in Minnesota and this harvest appears to have little effect upon the breeding populations. Their preferred habitat is emergent vegetation of marshes, lakes, and streams.

Red-backed vole (Clethrionomys gapperi)--These are the brightest colored of the microtines here; their back is rusty-red and the belly silver to grey. They prefer damp forest floors, and are found in both deciduous and coniferous forests. Along with least chipmunks, they are the first small mammals to colonize recently logged areas. Red-backed voles are very abundant mice and found throughout the northern two-thirds of the state.

Meadow vole (Microtus pennsylvanicus)--Meadow voles are one of the most abundant mammals of the state. They are a dark brown above and silver-grey below. Their preferred habitat is grass covered fields; average litter size in northern Minnesota is 5.25. Populations vary greatly from year to year. At a low density there may be only one or two voles per acre and at high density 200 + voles per acre. They are found throughout the state.

Pine vole (Microtus pinetorum)--Pine voles are dull-auburn colored. They reach the northern-and western-most limits of their range in extreme southeastern Minnesota. Presently, only two specimens are known from the state, both are from the unglaciated deciduous hardwoods area of Houston County.

Prairie vole (Microtus ochrogaster)--Prairie voles were once found throughout the prairie region of the western and southwestern third of the state. Today, I know of only three extant populations in Minnesota; all are in the extreme western tier of counties--Clay, Norman, and Polk. Their preferred habitat is dry grassland. The name ochrogaster refers to the orange coloration of the belly.

Rock vole (Microtus chrotorrhinus)--Rock voles are known from only three localities in northeastern Minnesota. Rock voles have been obtained in recent years from two localities in Cook County; however, none have been obtained from the Burntside Lake locality for 60 years. Their coat is similar in color to meadow voles, except they have a bright yellow-orange nose. The preferred habitat is apparently younger communities, including a relatively open overstory, a high density of shrubs, and thick moist litter layer. This habitat type is often associated with boulder fields or talus slopes. Because this vole has a very spotty distribution and populations tend to be small and localized, I suggest that the two localities in Cook County be set aside as natural areas with state protection.

Southern bog lemming (Synaptomys cooperi)--These are silver-grey mice with extremely short tails. They are most common in the coniferous forest zone and prefer low damp bogs and meadows, particularly if sphagnum is present. Sometimes they are found in moist upland woods. Southern bog lemmings and northern bog lemmings are difficult to distinguish.

Northern bog lemming (Synaptomys borealis)--These lemmings are known from only three localities in extreme northern Minnesota. It is a boreal species that reaches the southern limit of its range in Minnesota. Little is known about its habitat requirements.

Heather vole (Phenacomys intermedius)--A single specimen of a heather vole was obtained near Ely in 1940. Numerous individuals have searched throughout northern Minnesota for them since with no success. Although they may yet be present in Minnesota, it appears likely that they have been extirpated from the state due to habitat destruction.

Of the nine species of microtines native to Minnesota we need to consider five species (pine voles, prairie voles, rock voles, northern bog lemmings, and heather voles) rare. Microtines that are generalists in their habitat requirements are holding their own in Minnesota, whereas, the specialists on particular habitat types have greatly reduced ranges. In order to insure that more species are not extirpated from Minnesota, we need to preserve their habitat.

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REPRODUCTIVELY SPEAKING, A RAT BY ANY OTHER NAME IS STILL A RAT

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The muskrat (Ondatra zibethicus) is a semi-aquatic rodent, about the size of a hunched-up, dark brown cottontail, with a long, laterally-compressed tail. Stiff hairs fringe its hind feet, which are mounted on side-twisted ankle joints. The small forefeet are suited for skillful manipulation of foodstuffs and for house building. Its nostrils, lips and tongue are adapted for underwater activities.

Muskrats, found throughout most of the United States and Canada, reside in salt, brackish and/or fresh water areas, where there is sufficient food and water is not too swift. Along streams, ditches and steep-banked lakes, muskrats dig burrows into the banks or under tree roots and other structures (e. g., docks, houses, woodpiles, etc.). In fresh and salty marshes and shallow lakes, muskrats construct lodges from available emergent vegetation. Cattail, round-stemmed bulrush and wild rice are preferred materials. Submergent vegetation is seldom used except for interior lining.

Lodge construction begins in late September and continues until freeze-up. Houses, built in water from 0 to 36 inches in depth (optimum 18-36"), vary in size from 1.5 to 5 feet in height (above water) and 2 to 12 feet in diameter at water level. Despite these preparations, between 30 and 75 percent of the houses will freeze by March 30.

In addition to houses, muskrats construct feed piles of preferred foods such as cattail, round-stemmed bulrush and wild rice. Where corn is adjacent to ditches and marshes, muskrats will not hesitate to help themselves. Summer grazing of alfalfa fields by neighboring muskrats is also common.

With sufficient preferred emergent vegetation for shelter and/or food, the muskrat is a very prolific breeder. Females have an average of 2.6 litters per year (0 to 5) with 7.35 young per litter. Under excellent conditions, populations have increased over 1000 percent (10 times) from one year to the next. In fact, within 2-4 breeding years, a muskrat population normally expands to the point of destroying its own habitat.

The major threats to muskrat habitat are marsh drainage and filling and pollution. Since 1940, the muskrat population in Minnesota has been reduced by over half, primarily due to extensive drainage for agricultural purposes. Predation by man and other natural predators has no negative effects on a healthy muskrat population. In fact, heavy cropping of muskrat populations can reduce eat-outs and the probability of disease.

Because of their economic value, muskrats have been protected by law as a furbearer since 1875. Five to 6 month seasons (November through April) were the rule through 1922. From 1923 until 1941, one-month spring seasons with frequent closures were in style. Be-

cause of research conducted in 1939 and 1940, the season was changed to November and/or December, with 5 to 31 days allowed. These fall seasons, which promoted underharvest, continued until 1962, at which time a 2-month season (November and December) became the standard.

Since 1930, Minnesota trappers have taken an estimated 22,320,000 muskrats with no ill-effects on the population (Table 1). The value of these furs has ranged from $ .40 to $7.00 a pelt and has provided a gross income of between $42,000 and 3.6 million dollars, depending on the year. Over the last five decades, the muskrat has provided Minnesota trappers with an average annual income of $752,000.

Table 1. Summary of Minnesota muskrat seasons and take by decade from 1930 through 1979

Decade	Season Time	Season Length	Range	Number of Closures	Number Harvested	Average Annual Harvest
1930-39	Spring	20	(11-24)	8	1,395,000	348,750
1940-49	Fall	20	(5-31)	1	8,751,000	972,333
1950-59	Fall	17	(5-30)	0	2,897,000	321,889
1960-69	Fall	46	(30-60)	0	4,140,000	414,000
1970-79	Fall	55	(30-60)	0	5,137,000	513,700
		37.5	(5-50)		4,264,000	507,619

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MINNESOTA BATS

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Seven species of bats (Order Chiroptera) occur in Minnesota. All are insectivorous members of the family Vespertilionidae. Distribution records of six species, big brown bat (Eptesicus fuscus), little brown bat (Myotis lucifugus), Keen's myotis (Myotis keenii), silver-haired bat (Lasionycteris noctivagans), red bat (Lasiurus borealis), and hoary bat (Lasiurus cinereus), indicate that they may be found anywhere in the state. The eastern pipistrelle (Pipistrellus subflavus) occurs in Minnesota only in the southeastern third. The little brown bat and big brown bat are the two most common species in Minnesota.

Both species of Lasiurus are migratory, and do not winter in Minnesota. Winter habits of the silver-haired bat are poorly known; although individuals have been found hibernating as far north as southern Minnesota, it is believed that some individuals and perhaps some or all populations shift their ranges southward during winter. The other four bats in Minnesota hibernate here and elsewhere, but some spring and autumn movements of individuals and populations are known.

The reproductive potential of bats is low compared to other mammals of similar size. Red bats may have up to four young per litter, but the other species in Minnesota have only one or two young per reproductive effort. All seven species are limited to a single litter per year. On the other hand, longevity of bats far exceeds that of other small mammals. For example, little brown bats banded as adults are known to have survived for 30 years in Ontario.

Approximately 850 species of bats are known, but most of these occur in frost-free tropical regions where seasonality is often less defined than in Minnesota, or if well defined, seasonality is wet versus dry rather than warm versus cold. In such tropical areas, food in the form of fruits, flowers, insects and blood may be available year-round.

OVERVIEW PARAGRAPH: WILDLIFE DISEASE

This section is entitled "Wildlife Disease." Examples of viral, spirochetal, fungal, internal parasitic, and traumatic diseases will be given. Some emphasis will be placed on the zoonotic consideration of these diseases. A zoonotic disease is a disease that may be transferred from animal to man or vice versa.

ABSTRACT

LEPTOSPIRAL INFECTION IN MOOSE AND

POTENTIAL CONTAMINATION OF SURFACE WATERS*

Leptospirosis is a zoonotic disease affecting many species of animals and man. It results in an influenza-like illness in people.

In the United States approximately 100 humans cases are reported each year. The sources of infection are primarily natural surface waters and aniaml contact. Infected animals may shed leptospires in their urine for weeks in some species, to nearly lifetime in the rat.

During the fall of 1971, a Minnesota moose harvest occurred. From this hunt, 328 blood samples and 173 kidneys were collected from 374 moose killed by hunters. This study was conducted in cooperation with the Department of Natural Resources personnel. The hunt areas were located in three zones in northwestern Minnesota and three zones in notheastern Minnesota.

The plasma samples were tested for leptospiral antibodies against (serovars pomona, canicola, icterhaemorrhagiae, grippotyphosa and hardjo) by the microscopic agglutination test. Serologic titers (primarily against grippotyphosa) were found in 6.7 percent (1:100 dilution or higher) of the 328 plasma samples tested. A higher prevalence of leptospiral antibodies (9.7% at 1:100 plasma dilution) was found in nothwestern Minnesota than in the northeast (0.9% at 1:100 dilution.) Greater cattle and swine populations exist in northwestern than the northeastern zones. No leptospires were isolated from the kidney tissues of moose. Cattle tested from the northwestern zone showed evidence of leptospiral infection.

To help prevent contracting the disease, protective clothing and rubber gloves should be worn during the field dressing of moose. Kidneys should be discarded and care be taken that the urinary bladder is not punctured. Meat should be cooked to a minimum of 140° F. before eating. Swimming in natural waters frequented by domestic and possibly wild animals should be approached with caution.

Vaccines and treatment exist for some species of domestic animals. However, the disease is not amenable to eradication because of the broad host reservoir of the leptospires that exist in the U.S.

To document their role in the transmission of this zoonotic disease, further studies are needed on the ecology of leptospirosis in wild animals such as the moose.

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LEPTOSPIRAL INFECTION IN MOOSE AND POTENTIAL CONTAMINATION OF SURFACE WATERS*

Wild mammals can potentially transmit infectious diseases, such as leptospirosis, to animals, to persons engaging in water recreation, and to hunters and persons dressing, preparing and eating meat from killed animals. Leptospirosis is caused by organisms called leptospires, which are a type of bacteria. In early stages, the organisms are found in the blood of the infected animal. In later stages they concentrate in kidneys, and sometimes transmitted by natural waters, are contaminated with urine of shedding animals.

In the U.S.A. approximately 100 cases of human leptospirosis are reported each year. It is my opinion that underdiagnosing and underreporting are occurring.

In 1978, 108 human cases were reported in the U.S. Where source or likely source could be identified, 7 cases were associated with wild animals, 24 with water, and 32 with multiple animal species and water. Five of the 108 died and 82% of cases were in males. Oregon reported 5 cases in loggers exposed to surface water. One human case was reported in Minnesota.

A number of outbreaks have occurred where people seeking recreation have utilized surface waters. As an example, in 1964 an Iowa outbreak of leptospirosis occurred in 15 persons who had been swimming in a farm creek. Leptospira pomona was isolated from the stream. Surveys indicated extensive evidence of the disease in nearby cattle and swine. In addition, 7 of 75 wild animals trapped adjacent to the stream were found to be infected.

The following fall 4 human cases were identified in Iowa squirrel hunters. Squirrels were collected and leptospires were isolated from one of these.

Leptospirosis in human is a flu-like illness; jaundice appears in approximately 20% of the cases. Patients often report being sick twice -- first with high fever, muscle aches and pains, etc., and a couple of weeks later with severe headaches (meningitis).

Little is known about the extent of zoonotic diseases in Minnesota wildlife. In 1971 and 1973 we were able to participate in moose studies with the Department of Natural Resources.

Moose Study

In the fall of 1971 a moose hunt was held in Minnesota for the first time in 49 years. A limited season, authorized by the 1971 legislature, provided a maximum harvest of 400 moose, Alces alces andersoni, by 1,600 hunters in parties of four. One moose, either sex or any age, could be taken by each four-man group. Hunting zones designated were in the highest density moose areas in northeastern and northwestern Minnesota. Two seasons were designated, October 2-17 and December 4-19, 1971.

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In pre-planning the moose hunt, personnel from the Department of Natural Resources gave us an opportunity to participate in studies of disease in moose collected. The objectives of this study were to identify serologic evidence of leptospirosis, and attempt to isolate leptospires from kidney tissue.

Prior to the season, hunters were mailed centrifuge tubes containing heparin, together with instructions on collecting blood samples. Samples were carried by the hunters to one of seven registration stations at which time the kill site was reported. The whole blood was centrifuged to obtain the plasma for the study. Kidneys were removed by personnel from the Department of Natural Resources who examined each kill site. Collections were usually made within three to forty-eight hours post-kill.

Results

In the combined areas of the 1971 hunt, 374 moose were harvested from which 328 (88% sampling) blood samples and 173 (46% sampling) intact kidneys were collected (460 moose were harvested in 1973).

The kill was 65.8% males and 63.6% classified as adult bulls, and 43.2% females. Initial age classification identified was adult, yearling, and calf. Later, the incisor teeth collected was used to identify age by each year.

The greatest kill, 286 (76%)were made in the first half of the season (October 2-17). During the second half of the season, December 4-19, 88 (24%) were killed.

The highest prevalence of serologic antibodies was found against serovar gripportyphosa. Only minimal serologic evidence of serovar pomona was found.

The greatest prevalence of antibody titers (1:100 or >) was found in moose harvested in Zones 1, 2, and 3. No antibody titers at 1:100 or > were found in moose in the age of 1/2, or 11-1/2 to 14-1/2 years of age.

No leptospires were observed by darkfield microscopic examination or were isolated from the 173 kidneys cultured by artificial or animal inoculation techniques.

Discussion

Although moose are found in nearly all the northern states of the United States, to the best of my knowledge, this was the first extensive sampling of leptospiral infection in a moose population in the United States.

Canadian workers have investigated leptospirosis in moose. In 1963, McGowan, Karstad and Fish first reported serologic evidence of serovar pomona in 4 of 90 moose in the Kenora District of Ontario, Canada.

In experimental work a moose was infected with pomona through exposure to contaminated water. Antibody response and urinary shedding of leptospires were reported as occurring much as they do in the white-tailed deer. This area is located directly north of Minnesota.

The serologic evidence of leptospiral infection in Minnesota moose indicated that the major problem was associated with serovar grippotyphosa. Higher sero-positivity was noted in moose plasma collected form Zones 1, 2, and 3 (Northwest). On January 1, 1971, 108,100 cattle and 18,600 swine were reported on farms in Beltrami, Lake of the Woods, Roseau, Kittson, and Marshall counties. These counties include hunting Zones 1, 2, and 3. From March, 1970 to December, 1971, 454 serum samples were tested by our laboratories from 20 herds of cattle from the above counties; 7 cattle had titers of 1:100 or higher against serovar pomona, 4 against hardjo and 2 against grippotyphosa (1:10,000 or higher).

Serologic evidence indicates that the highest infection was found in Zones 1, 2, and 3. Zone 2 is Agassiz National Wildlife Refuge where there were approximately 1,900 animal use months of cattle grazing reported in 1971. In serologic testing grippotyphosa titers of 1:10,000 were found in 4 moose collected from Zone 3. In late September of 1971, just prior to the moose hunt, two cattle sera from Zone 3 tested by our laboratories had antibody titers of 1:10,000 against grippotyphosa.

A very low prevalence of antibodies was found in moose samples collected from Zones 4, 5, and 6. In Lake and Cook counties which encompass these zones, a population of 500 cattle and 0 swine were reported on January 1, 1971. No cattle sera were tested for leptospirosis.

No antibody titers of 1:100 or > were found in moose 1/2 year of age or the 11-1/2 to 14-1/2 year age group. This measurement of exposure experience by age groups may indicate that the young and the old have reduced exposure experience which may suggest reduced movement and less association with either infected cattle, moose, or other animals, either directly by contact or indirectly through water.

Some of the moose killed were reported to be heavily parasitized. In the northeastern hunting zones an 86.7% prevalence of liver fluke infestation was reported in moose examined, as compared to 17.0% prevalence in livers examined in the northeastern zones.

In the northwest, Zone 1 is described as heavily forested with scattered farming areas. Zones 2 and 3 contain agricultural grazing areas with land composed of lakebed soils from old glacial lake Agassiz. Greater surface waters composed of shallow lakes, marshes and drainage ditches are found in Zones 2 and 3 than in Zone 1. The northeast zones are heavily forested. There is essentially no agriculture, and the surface water is composed of lakes and rivers.

Leptospirosis remains a problem in cattle and swine in Minnesota. From July 1, 1970 - June 30, 1971, 13.7% cattle serum samples which were tested had a titer of 1:100 or higher. During this same time, swine samples were tested, with 6.3% serologically positive at 1:100 or higher.

From July 1, 1971 - June 30, 1972, 13.8% cattle serum samples which were tested had a titer of 1:100 or higher. During this same time, swine samples were tested, with 7.4% serologically positive titer at 1:100 or higher.

In 1979 18.6% of the cattle and 29.0% of the swine samples serologically tested were positive at 1:100 or higher.

Certain measures will help protect hunters and their families from exposure. Avoid puncturing the urinary bladder in field dressing, and don't use the kidneys for food. Avoid splattering of body fluids upon yourself. If you have cuts or lesions on your hands, wear rubber gloves in dressing game. Outer clothing helps protect against possible infection. This would be a good routine to use at all times against a number of diseases.

In the home, properly cook the meat to at least medium done. Temperatures of 140°F will kill leptospires in laboratory culture medium in 10 seconds. Do not depend upon freezing of meat to kill the leptospiral organisms. Studies indicate that they can survive in meat for an indefinite period of time at freezing temperatures.

Leptospires have been isolated from many species of animals. In the U.S., grippotyphosa has been isolated from nine species of animals: cattle, swine, racoon, opossum, skunk, fox, western harvest mouse, vole, and the fox squirrel. Indentification of this disease in wild animals and its widespread distribution will make prevention, control, and eradication programs difficult. The aquatic contact of moose would likely expose them to leptospires in areas where urinary shedders of their own species or other species contaminate the natural waters.

The role of water as a vehicle of transmission between livestock, moose and other animals is yet to be determined. There are vaccines available for cattle, swine and dogs. The possible health

implications to hunters and others using the common environment for recreation and farming must be identified.

Further ecologic studies of disease are essential to identify the interaction of the host-agent-environment complex associated with leptospirosis in the Minnesota moose population. Hopefully, future moose hunting seasons and the continued cooperation of the Department of Natural Resources personnel and others will allow attainment of this objective.

PARELAPHOSTRONGYLUS TENUIS IN MINNESOTA

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Since the early part of the 1900's, moose (Alces alces) in northern Minnesota had been dying from some myserious cause. Sick moose generally lost most fear of humans, tended to walk in circles, drooped ears and head to one side, and developed symptoms of ataxia. Major die-offs of moose were reported in the 1920's and 1930's, after which the moose populations made a very slow comeback. Similar situations existed in the southern fringe of the moose range from Nova Scotia west to Minnesota.

From the 1920's into the 1960's, investigators had many theories as to the causes of "moose sickness." Among them were ticks, bacterial or viral infections, and/or nutrient deficiencies. It wasn't until the early 1960's that the etiological agent of moose sickness was described. In Ontario, Dr. Roy Anderson's group, working with deer parasites, introduced the infective stage larvae of a roundworm, Parelaphostrongylus tenuis, into moose calves and observed the clinical syndrome described as "moose sickness" (Anderson 1963, 1965).

In 1963, a research team of Department of Natural Resources and University of Minnesota personnel in Minnesota found the parasite in wild "sick" moose. This confirmed the findings of Dr. Anderson that this parasite was indeed responsible for the moose malady (Karns 1967, Kurtz et al. 1966, Loken et al. 1965).

Now, with this information, it was possible to put together the pieces of the moose sickness puzzle, and the demise of moose populations along the southern fringe of their range. The normal host of P. tenuis is the white-tailed deer (Odocoileus virginianus). The paraside thrives in the central nervous system of deer, doing little apparent damage. The central nervous system is "home" for this parasite, and any knowledgeable parasite is not going to destroy home. The adult worm can generally be found on the surface of the brain in deer. The adult parasite is very slender and only 2.5-3.5 centimeters long, and looks much like a fine hair. Essentially, all deer 4½ years old and older are infested, and younger deer to a lesser extent (Karns 1967). The parasite is found in deer throughout the state.

The life cycle as described by Anderson (1963) involves land snails or slugs as intermediate hosts. The parasite lays eggs which hatch into first stage larvae in the cranium of a deer. The larvae enter the bloodstream where they are transported to the lungs, coughed up and swallowed, and discharged in the feces. The larvae then enter one of several suitable intermediate hosts, develop into the infective third stage, and wait to be ingested by an unsuspecting deer, moose, caribou, or elk. Once inside the new host, the larvae make their way into the spinal column where they develop into adults and then migrate to the cranium. If all this takes place in a white-tailed deer, the parasite

is well-behaved and no problems ensue for host or guest. However, should this scenario take place in one of the other aforementioned cervids, the parasite is unruly and causes great problems by penetrating the nervous tissue rather than remaining on the surface; this results in the death of the host in about 60-120 days, and, of course, the parasite. So it pays the worm to treat its host with respect.

Knowing P. tenuis as a normal parasite of deer, and knowing the history of deer distribution and its changes with settlement (Karns 1980), one could fit the next piece of the puzzle neatly into place. Deer, due to grossly improved habitat in northern areas, expanded their range to overlap with moose and caribou, bringing the worm with them. The result was a large-scale decline in moose, and the disappearance of caribou, and increases in deer populations.

This trend has been reversed in many areas with maturing habitat and declining deer populations. Moose populations have responded by increasing in these areas where deer populations have declined, as the parasite is dependent upon deer to complete its life cycle. Few or no deer is good for moose. Deer populations should essentially be non-existent in managing for woodland caribou, because caribou and white-tailed deer habitat use is very similar, increasing the opportunity for infestation.

With new emphasis on forest management, the land manager can now choose whether to increase or perpetuate deer populations, or to favor moose. This choice is made by the size and design of timber cuts and subsequent management.

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IMMOBILIZATION OF UNGULATES

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Equipment used in the immobilizing of ungulates varies with the specific animal situation and environmental situation. In a captive environment such as a zoological garden, CO_2-powered pistols and rifles predominate, as well as blow guns with home-made plastic darts. Blow guns have the advantage of being silent, possessing a lightweight dart, and are very inexpensive. In a wild environment, gunpowder-powered rifles prevail because of their accuracy at longer distances.

A standard capture dart possesses an aluminum syringe barrel of variable size which is determined by the amount of medicine to be administered, a rubber stopper apparatus, a small gunpowder charge, a yarn feather, and a needle. Upon impact into the animal, the dart's charge will fire, forcing the rubber stopper forward and consequently forcing the medication into the animal.

There are two uses of capture equipment. The first use is tranqilization of an animal for various purposes such as diagnosing disease, and research projects to improve our knowledge of ungulates. Data obtained directly from such procedures as blood analysis or antler measurement may be evaluated, as well as information obtained from telemetry devices used in such studies as the range of the animal, its activity, and its body temperature.

Common tranquilizing drugs are M99 and its antagonist M50-50, Rompun, Sernylan, and succinylcholine. In a captive environment such as the zoo, Rompun is used as a preanesthetic, followed in about ten minutes by M99, the anesthetic. The advantages are good muscle relaxation and minimal excitement to the animal. In a wild environment, there is usually only time for one shot and environmental problems such as water holes, cliffs, etc., must be evaluated as a hazard. For the ten minutes prior to the animal becoming immobilized, tracking the animal may be a problem. A radio telemetry dart, helicopter, and other methods have been used to track the animals during this time.

Slide presentations give examples of immobilization of moose and musk oxen with a mention of the importance of monitoring the body temperature of the animal, heart rate, and respiration rate.

TREATMENT OF INJURED WILD ANIMALS

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The basic difference between treatment of wild animals and domestic animals is how you handle the animal to: 1) evaluate the injury, 2) correct the condition, and 3) apply follow-up treatment.

The handling or restraint of the animal can be accomplished in two ways: 1) manual restraint and 2) chemical restraint. In order to choose which is best for the person involved, and secondly for the animal involved, one must have some knowledge of the behavior of the animal in regard to how it is going to react to the procedure; the size and species of animal, considering the human risk factor; and a "sense" of what the injury or disease condition might be. In my experience, by and large, most of the treatments of wild animals are done under chemical restraint. Basically, there is reduced human risk and less stress to the animal because under manual restraint, the wild animal will continually struggle in an attempt to escape.

The last consideration is the administration of antibiotics or other follow-up to insure proper healing. If the animal is eating, then oral use of medications is preferred. However, if the animal is not eating, then an injectable medication must be used. Blow guns, squeeze cages and nets may be methods of administering the medication. The disadvantage of the injectable antibiotic is additional stress on the animal and it will usually delay the return of the animal to normal eating habits. Trade-offs must be made, and the importance of continued follow-up medication must be stressed.

Slide presentations include heartworm treatment of a fox, abscess in a North American river otter, porcupine quills in a ferret, and a vaginal secretion of a North American otter.

ECHINOCOCCOSIS (HYDATID DISEASE) IN MINNESOTA

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This disease is produced by the presence of cysts of varying size which are the larval stages of Echinococcus. Two forms occur in the intermediate hosts: (a) Unilocular (Echinococcus granulosus) and (b) Multilocular (E. multilocularis) hydatid disease. A wide range of species, but especially ungulates/herbivores, may act as intermediate hosts while the primary hosts are usually members of the Canidae--most often dogs, wolves, foxes--and on occasions Felidae. Both domestic animal cycles (e. g., dog/sheep) and wildlife cycles (e. g., wolf/moose) occur with the potential for crossover to occur. Humans can be infected as intermediate hosts as a result of close contact with dogs and possibly cats.

Primary hosts become infected by eating infected viscera of wild or domestic ungulates, either intentionally or as a result of predation. The cestode worms develop to maturity in the intestines of the dog or wolf, for example, and numerous eggs are passed in the feces. These have the capability to survive for long periods on pasture, soil, and probably water. Intermediate hosts ingest the eggs and the larvae hatch in the intestine and migrate to various parts of the body. The liver, spleen, and lungs are common sites. In humans, cysts may occur in the brain with a high fatality rate.

In Minnesota, E. granulosus occurs as a wolf/moose cycle. For reasons not clear, the strain does not appear to involve domestic ungulates. However, in western states, particularly where sheep are grazed on range country, the disease is being increasingly recognized. Human cases are occurring in persons having close contact with dogs used for herding sheep or allowed to eat infected viscera. In 1977, a 56-year-old rural resident in southwestern Minnesota became the first case of alveolar hydatid disease diagnosed in the 48 contiguous states. E. multilocularis is enzootic in northern tundra zones, involving arctic foxes and their rodent prey. In Minnesota, surveys of foxes and rodents did not show this cestode to be present through the 1940's. However, Dr. Vande Vusse, Gustavus Adolphus College, St. Peter, Minnesota, has since shown this parasite to occur in 30-50% of red foxes examined and the range of counties involved increased from 4 in 1965 to 20 in 1978. The deer mouse and the meadow vole are the primary intermediate hosts in the upper midwest. It has been postulated that house cats may extend the sylvatic cycle to a domestic cycle involving house mice and thus increase the risk of human infections occurring.

Diagnosis of infection in primary hosts requires purging and examination of feces for the cestode worm or necropsy. This has to be carefully carried out as the worms are relatively small--approximately 2-5 mm.

Prevention of human infection requires that handling of potentially infected dogs or cats should be followed by strict personal hygiene. Also, hunters handling wolves, foxes, or their skins should take similar precautions.

BLASTOMYCOSIS

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Although the fungus Blastomyces dermatitidis is capable of causing disease in a variety of hosts, humans and dogs are the species most commonly affected in Minnesota.

Canine blastomycosis is a severe illness and is seen as loss of appetite, weight loss, lesions in the eyes and skin, and finally respiratory signs. The great majority of affected dogs cannot be saved. In humans, cough, weight loss, skin lesions and loss of appetite are the presenting symptoms.

Data collected from the Veterans Administration Hospital, Minneapolis, indicates that there is a very close association of human and canine illness and that the dog is a sensitive indicator of potential human disease in many instances.

The majority of dogs affected are hunting dogs, particularly those used to hunt ducks, grouse, raccoons, and other species.

It is believed that humans and dogs are exposed to this fungus in the same, albeit ill-defined, areas. From a review of diagnostic records in the University of Minnesota Veterinary Laboratory, a high proportion of the affected dogs come from northern counties and also southeastern Minnesota. Infected dogs from the cities often have a history of visiting northern areas of the state during the summer and fall.

Attempts to culture this fungus from soil have been unsuccessful, although it has been grown once out of pigeon manure.

The role of wildlife in this disease is virtually unknown, but we would encourage wildlife investigators to be aware of this disease, particularly in Canidae. Wildfowl and other hunters should also be alert to this infection, both in their dogs and themselves. There is, however, no evidence to suggest that blastomycosis is transmissible from dogs to humans.

Surveys are currently in progress within the College of Veterinary Medicine and School of Public Health, University of Minnesota, to measure exposure potential rates in young dogs on their first hunting season.

RABIES AND PET SKUNK PRODUCTION IN MINNESOTA

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Skunk rabies has been and continues to be a problem in the upper midwestern states and Minnesota in particular. A high percentage (1978 - 62% of 226 skunks examined) were positive for rabies. Of all wildlife examined in Minnesota for 1978, skunks contributed 96% of 145 positives.

Three categories of skunks were examined--the true wild animal found wandering in the open, the trapped or motherless kitten, and the pen-raised animal. Most positive rabies cases are found in the first group. Rabid skunks are found in most areas of the state except for the northeast. Skunks are no doubt responsible for most of the bovine rabies cases reported. Several surveys have shown that peaks of cases can be expected in December through February, with a second peak in May and June, both in Minnesota and nationwide.

The predominant signs shown by rabid skunks include daytime movements, aggressiveness, lack of fear, and incoordination. It does not appear that clinically-ill skunks travel very far afield.

The last Minnesota case of human rabies due to a skunk bite occurred in a 10-year-old child in Rochester in 1964. Other human cases in the U. S. A. have occurred either when patients were bitten trying to capture wild skunks, or while sleeping on the ground in unprotected sleeping bags. In Minnesota in 1978, a total of 47 persons were exposed to possible rabid skunks. Fortunately, only 2 of 34 animals were rabid and neither of these was classified as a "pet" skunk. However, in 1979 there were 2 disturbing incidents involving pet skunks reared in Minnesota. In the first instance, 2 of 161 animals shipped to Oregon and distributed through pet shops developed rabies within 2 months of arrival. In the second instance, 5 persons in southwestern Minnesota underwent rabies prophylaxis because of exposure to rabid skunks originally purchased as pets.

Skunks are unprotected under Minnesota State Law. There are approximately 12 breeders licensed under the Federal Animal Welfare Act as Class A farms in Minnesota. Some of these are also licensed by the State Department of Natural Resources as a game farm. Officials from Veterinary Services, U. S. Department of Agriculture inspect these farms regularly to see that they meet minimum standards of sanitation, housing, feeding, record-keeping, and veterinary care.

While the actual numbers of skunks sold as pets within the state is not known, in 1978 on the basis of health certificates issued, at least 2300 were exported to 30 states and Canada. Demand is highest in large cities, particularly on the east coast.

Nevertheless, as of mid-1978, 9 states had clear restrictions, and a further 15 had some type of restriction. A typical state law makes it illegal to sell, trap, give away, hold, import, own, barter, and even in some instances to descent or vaccinate a skunk. There is no state law in Minnesota restricting ownership of a pet skunk, but several of the larger cities (e. g., Minneapolis and St. Paul) prohibit this.

The breeding of skunks in captivity is a highly specialized activity and animals, particularly color mutants, are in keen demand. Although no breeders interviewed in Minnesota stated that they captured animals from the wild for resale, 2 admitted that they did obtain wild skunks for breeding purposes. These are usually taken as kittens in May or June and quarantined for about 4-6 weeks.

Theoretically, a pen-raised skunk should be a safe pet, but there are gaps in our knowledge of the transmission and maintenance of rabies in this species. The incubation periods, based on experimental studies, can be at least 177 days, thus spanning the winter denning period. The possibility of vertical transmission also exists with the development of latent carriers. While bite transmission is the major method of spreading rabies virus, experimental studies have demonstrated that skunks can be readily infected by the intranasal route. Also, skunks excrete very large amounts of virus in their saliva, increasing the risk of transmission.

Live vaccine induced rabies has occurred and as there is no rabies vaccine licensed for use in skunks, the great majority of veterinarians now refuse to vaccinate these animals on grounds of personal liability.

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

VETERINARY SCIENCE
FACT SHEET NO. 15-1978
MICHAEL M. PULLEN AND JAMES O. HANSON

Rabies in Minnesota

INTRODUCTION

Ever since the domestication of animals in early times, rabies has been one of the most dreaded diseases transmissible from animals to humans. Although all warm-blooded animals are susceptible to the rabies virus, the disease is maintained in nature by meat-eating mammals and bats.

The rabies virus usually gains entrance into the body via saliva following an animal bite. Bite transmission has accounted for virtually every human and animal case throughout the world; however, airborne transmission also can occur on rare occasions. Once the rabies virus is introduced into the body through the bite wound, it is carried to the central nervous system via the nerve trunks. Once the clinical symptoms of rabies appear, death is almost certain.

RABIES IN ANIMALS IN MINNESOTA

Animal rabies data accumulated by both the Minnesota Livestock Sanitary Board and the Minnesota Department of Health for a 27-year period (1950-1976) revealed 6,075 laboratory-confirmed rabies cases in Minnesota. The average annual number of cases was 225 (ranging from 16 to 443). Minnesota consistently ranked in the top five states in the U.S. for number of animal rabies cases identified. The skunk accounted for 62 percent of the diagnosed cases and is the most important animal species for maintaining rabies in Minnesota. Cattle, dogs, cats, and other species accounted for 18, 6, 5.5, and 8.5 percent, respectively, of the remaining reported animal rabies cases.

RABIES IN HUMANS IN MINNESOTA

Rabies in humans is characterized by a variable incubation period (i.e., length of time from exposure to onset of clinical symptoms), usually between 3 and 8 weeks but varying from 10 days to 1 year. The Minnesota Department of Health reports that from 1907 to 1977, 18 human deaths were attributed to rabies in Minnesota. Sixteen of those deaths occurred prior to 1917, with only one rabies death reported in 1964, and one in 1975. *It should be noted* that the most recent human rabies death was contracted from a *cat* bite. The rabid cat attacked two individuals on two separate occasions. One of the exposed individuals subsequently died.

CLINICAL SIGNS — ANIMALS

The incubation period in animals is quite variable—usually 15 to 50 days, but in rare cases several months. Rabid animals of all species exhibit certain clinical signs which are typical of rabies, with minor variations. Excess salivation, which often becomes frothy in appearance, frequently appears and is the result of the animal's inability to swallow due to paralysis of the muscles used in the swallowing process. This inability to swallow has resulted in the term "hydrophobia" (fear of water) being used to describe the behavior of animals and humans afflicted with rabies.

Animals usually cease eating and drinking and may seek solitude. Eventually, signs of paralysis appear or the animal becomes vicious. Dogs, cats, swine, and occasionally horses and mules attack and bite other animals or people at the slightest provocation. The disease progresses rapidly after the onset of paralysis, with terminal signs of convulsions and coma.

Skunk

In Minnesota, among wild animals, skunks provide the largest single source of rabies exposure to both humans and other animals. Given the absence of a licensed or proven effective rabies vaccine for skunks, coupled with the high endemicity of skunk rabies in Minnesota, they should *not* be considered for pets. Health officials in several states preclude or have placed restrictions on maintaining or selling skunks as pets.

Dogs and Cats

The low number of rabies cases in cats and dogs is a reflection of the generally accepted practice of immunizing pets and controlling stray animals. However, until an effective method of controlling rabies in the wildlife reservoir (skunk, foxes, etc.) is developed, the problem of rabies will continue to remain at its present level.

Considering the almost equal distribution of diagnosed rabies cases in dogs and cats, and the most recent human rabies death, it would appear that both of these companion animals pose a potential risk to the residents of Minnesota. Consequently, a rabies vaccination program should be directed toward both dogs and cats to maximize public health protection against rabies exposure.

Cattle, Swine, and Horses

Although cattle account for the second highest number of diagnosed cases of rabies in Minnesota, swine and horses occasionally may be infected. This primarily is due to their close proximity to skunks and the increased exposure factor. It is neither considered economically feasible, nor is it justified from a public health standpoint to vaccinate all livestock against rabies. However, owners who have valuable animals located in areas where wildlife rabies is endemic are encouraged to have their animals vaccinated annually.

Rodents

The Center for Disease Control, Atlanta, Georgia, reports that rabies is not endemic in rodents and rabbits anywhere in the U.S. Although 25,000 rodents are examined for rabies annually by various laboratories nationwide, only four or five are found to have rabies. There is no evidence that these few confirmed-rabid rodents play any role in the spread of rabies in its major wildlife hosts. Human rabies never has been traced to a rodent or rabbit, despite the fact that at least 24,000 persons are bitten by rodents each year.

The Minnesota Department of Health (MDH) has reported no rabies positives in small rodents or rabbits since 1960. The rare positives reported prior to 1961 actually may have been laboratory false positives. Consequently, MDH discourages sending small rodents (hamsters, gerbils, guinea pigs, chipmunks, squirrels, rats, mice, gophers, voles, moles) or rabbits for rabies testing. In the absence of a human rabies case attributable to exposure to these animals, a bite inflicted by rodents or rabbits rarely, if ever, indicates the need for post-exposure rabies treatment.

CONTROL AND PREVENTION OF RABIES

Control and prevention of rabies in animals and humans focus on five areas:

1. Rabies Vaccination of Dogs and Cats

   Some municipalities in Minnesota have an ordinance requiring compulsory rabies vaccination of both cats and dogs.

   All dogs between the ages of 3 and 6 months should be vaccinated, then revaccinated 1 year later. Adult dogs (1 year or older) vaccinated with modified live virus (MLV)-type vaccines are normally protected against rabies up to 3 years. All cats should be vaccinated annually with a rabies vaccine licensed for use in cats. Cats should be vaccinated initially when they are 3 to 4 months old, and annually thereafter.

   Because of species limitations, techniques, and tolerances, vaccines should be administered under the supervision of a licensed veterinarian. Peak rabies antibody titers are reached within 1 month after vaccination, at which time the animal may be considered protected. An animal should, therefore, be kept on a leash or confined prior to vaccination and for 1 month after vaccination.

2. Control of Stray Animals

   All dogs and cats should be licensed. Stray, unowned, or unlicensed animals should be removed from the community. Special emphasis should be placed on stray animal control in epidemic areas. Local health department or dog control officials can enforce the pickup of strays more efficiently if owned animals are confined in an enclosed area or kept on a leash. Strays should be impounded for at least 3 days to give owners sufficient time to reclaim them.

3. Avoidance of Wild Animals

   Because of the high incidence of rabies in Minnesota wildlife, particularly in skunks, contact with these animals should be avoided whenever possible to reduce rabies exposure potential.

4. Local Wound Treatment

   Immediate and thorough local treatment of all bite wounds and scratches is perhaps the most effective rabies preventive. The wound should be thoroughly cleansed immediately with soap and water. Your physician should be contacted for additional medical care.

5. Pre- and Post-Rabies Exposure Immunization

   The relatively low frequency of severe reactions to rabies duck embryo vaccine (DEV) has made it practical to offer pre-exposure immunization to persons in high risk groups: veterinarians, animal handlers, certain laboratory workers, and persons living in places where rabies is a constant threat.

   Post-exposure prophylaxis for definite, probable, or possible rabies exposure consists of injection of human rabies immune globulin followed by a 23-dose course of DEV.

MANAGEMENT OF THE BITING ANIMAL

Healthy domestic animals (cats or dogs) that *bite* a human should be captured, confined, and observed by a veterinarian for 10 days. If the animal develops signs suggestive of rabies or dies while under observation, the animal should be destroyed by a veterinarian and a properly prepared head specimen shipped in a refrigerated condition (not frozen) to:

Division of Medical Laboratories
Minnesota Department of Health
717 Delaware St., S.E.
Minneapolis, MN 55440

If no human exposure (bite wound) has occurred, the specimen should be forwarded with similar precautions to:

Veterinary Diagnostic Laboratory
College of Veterinary Medicine
University of Minnesota
St. Paul, MN 55108

It should be emphasized that observation of a domestic animal by a veterinarian is the most rapid method of excluding rabies as a diagnosis.

With wild or stray animals, observation is not practical. Such animals should be destroyed immediately with no damage to the head, and the brain examined in the designated laboratory for evidence of rabies.

HEALTH CERTIFICATES

Many states require that domestic pets moving interstate must have a current and valid rabies immunization. Consequently, your veterinarian must ascertain the rabies immunization status of your pet before issuing a health certificate.

Canada requires a certificate from a veterinarian clearly identifying the dog or cat and documenting vaccination against rabies within the preceding 3 years before entrance will be allowed. Seeing-eye dogs and puppies or kittens under 3 months of age are exempt.

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TULAREMIA

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Introduction

Tularemia was first recognized in 1911 by McCoy and Chapin who observed lesions of the disease in ground squirrels from Tulare County, California. The causative bacteria, now called Francisella tularensis, was isolated the following year. Tularemia is currently enzootic throughout the continental United States and in most areas of the world north of the equator except the British Isles. Rodents and rabbits are the major reservoirs. The disease can be transmitted to man by direct contact with infected animals, by the bites of arthropod vectors or by contact with contaminated water.

Etiology

Francisella tularensis is a small gram-negative rod which requires the addition of cystine or cysteine to culture media for its isolation and propagation. Strains of the organism with high virulence for man are most often associated with tularemia of rabbits transmitted by ticks. These strains which ferment glycerol and exhibit citrulline ureidase activity are referred to as Francisella tularensis var. tularensis. They are the predominant strains isolated in the United States. Strains of lesser virulence for man associated with waterborne disease of rodents seldom ferment glycerol and do not exhibit citrulline ureidase activity. These strains which have been designated Francisella tularensis var. palaearctica are also found in the United States and are the predominant type in Europe, Russia and the Far East. Factors conferring virulence to the organism are poorly understood.

Epidemiology

The Center for Disease Control, U. S. Public Health Service, reported 193 human cases of tularemia in the United States during 1979. Only one case was reported from Minnesota. Cases were reported most frequently from Arkansas (49), Missouri (23), Oklahoma (14), Montana (14), Tennessee (13) and Utah (12).

Francisella tularensis has been isolated from at least 75 different mammals and 22 different birds. However, the infrequent occurrence of infection in many of these species makes them relatively unimportant as sources of infection for man.

Wild rabbits and hares are associated with most cases of tularemia in the United States. Francis (1937) reported that 70% of the cases in man were directly attributed to contact with cottontail rabbits (Sylvilagus spp.). Jackrabbits (Lepus spp.) of several species are of lesser importance as a source of infection for man. Although a few cases of infection in man have been reported from contact with snowshoe hares (Lepus americanus), they are relatively unimportant as a source of infection for man. Domestic rabbits are susceptible to infection with Francisella tularensis, but such infections are rare.

Tularemia is commonly transmitted between wild rabbits by arthropod vectors. Numerous arthropod vectors have been reported with ticks, deer flies and fleas being mentioned most frequently. Haemaphysalis leporispalustris, the rabbit tick, is recognized as an important vector of tularemia. Fortunately, it rarely bites man, but usually feeds on rabbits and birds. Additional ticks which have been implicated as vectors of tularemia include Dermacentor variabilis (wood tick or dog tick), Dermacentor andersoni (western wood tick), Amblyomma americanum (lone star tick) and others. These ticks may serve as vectors of infection for man. Deer flies, particularly Chrysops discalis, have served as important vectors of tularemia. Some investigators believe that the percentage of human cases of tularemia transmitted by arthropod vectors has been increasing in recent years.

Among the mammals in the Order Rodentia which may be involved in the epidemiology of tularemia are beaver (Castor canadensis), muskrats (Ondatra zibethicus), ground squirrels (Spermophilus spp.), voles or field mice (Microtus spp.) and others. The transmission of tularemia between aquatic rodents is most commonly associated with contaminated water. Persistent contamination of certain watersheds is incompletely understood. Bell and Stewart (1975) have suggested that some infected voles are chronic urinary shedders of Francisella tularensis. Contamination of watersheds by chronically infected voles along with the capability of the organism to survive in the enviroment for long periods of time would explain instances where particular streams have been known to be contaminated for several years. Transmission of tularemia between rodents in non-aquatic environments may be due to arthropod vectors or cannibalism.

Tularemia is uncommon in domestic animals; however, severe outbreaks have occurred in sheep. The disease appears to be transmitted to sheep by ticks. Sheep are quite resistant to experimental infection with Francisella tularensis. Evidence indicates that a complex of stresses including inclement weather, lambing and heavy parasitism render sheep more susceptible to tularemia. Man has been infected by contact with infected sheep.

Natural infection with tularemia has been reported in a number of species of carnivores. Cases have been reported in coyotes (Canis lestes or C. latrans), bobcats (Lynx rufus), red fox (Vulpes fulvus), gray fox (Urocyon cinereoargenteus) and mink (Mustela vison). Severe epizootics have occurred in ranch mink which have presumably been infected by contaminated rabbit meat. Tularemia in man has occasionally resulted from scratches or bites by cats or other pets. Cats or pets which feed on infected rabbits or rodents may become infected or become transient oral or claw carriers of Francisella tularensis.

Tularemia has been reported in a variety of birds. Most reports of tularemia in birds have involved game birds because of man's abundant contact with them in hunting and in preparation for food (Jellison, 1974). Ring-necked pheasants, ruffed grouse, sharp-tailed grouse, ravens, bobwhite quail and other birds have been reported to be infected. Game birds are often hosts of the rabbit tick, H. leporispalustris, which is an important vector of tularemia.

A recent report documents a case of tularemia acquired from an apparently healthy black bear in Washington state. A serological study

of black bears in Idaho revealed elevated antibody titers to Francisella tularensis in some specimens.

Laboratory infection with tularemia was common prior to the use of a vaccine which was developed in Russia and introduced into the United States in 1962.

Characteristics of the Disease

Clinical signs of tularemia are seldom observed in wild animals. Experimentally infected rabbits exhibit loss of appetite, depression and death. The most characteristic lesions at necropsy of rabbits or rodents are small, white focal necrotic spots on the liver and spleen. These lesions are not observed in every animal.

The incubation period in man is usually 3-4 days but ranges from 2-10 days. Most cases are characterized by the formation of a slightly tender, erythematous papule at the site of entry of the organism. It has been said that Francisella tularensis penetrates the unbroken skin, but it is more probable that it penetrates through small breaks in the skin. The papule progresses to a pustule followed by the formation of an ulcer with surrounding erythema. The regional lymph nodes draining the affected area become enlarged, tender and may suppurate. These local manifestations may accompany or precede the onset of fever, chills, severe headache, loss of appetite and malaise. The preceding description is referred to as ulceroglandular tularemia which is typical of over 80% of the cases. More severe cases may develop a secondary pneumonia. Oculoglandular tularemia occurs when the organism is inoculated into the conjunctival sac or splashed into the eye. Oculoglandular disease accounts for less than 5% of the cases. Tularemia which is characterized by general and severe systemic signs is often referred to as typhoidal. The typhoidal form was formerly thought to result from the ingestion of F. tularensis. This view has not been supported by studies with volunteers. These studies have shown that man is difficult to infect by enteric exposure. However, organisms may penetrate the pharynx or be inhaled during mastication.

The severity of an individual case of tularemia may vary with the virulence of the infecting strain of F. tularensis and the resistance of the individual.

Diagnosis, Treatment

The presence of the characteristic lesions on the surface of the liver and spleen of dead animals is suggestive of tularemia. Confirmation is accomplished by isolation of Francisella tularensis.

In man, a history of contact with rabbits, ticks or other vectors is useful. The organism can be isolated from the primary lesion or affected lymph nodes. An agglutination test is available. Agglutinins are first detectable from the tenth to the fourteenth day of the disease.

Streptomycin is the antibiotic of choice for the treatment of tularemia.

Prevention, Control

Sick or dead wild animals, particularly rodents or rabbits, should be regarded with suspicion, and contact with these animals should

be avoided. Individuals who have inadvertently been exposed to infection should seek prompt medical advice.

Francisella tularensis is highly infectious and should be handled with care in the laboratory. Technicians should utilize proper safety equipment, including a vented hood and surgical gloves. A highly effective live vaccine is available for the immunization of individuals at risk, including laboratory personnel. The vaccine is not directly available commercially but can be obtained by consultation with the Center for Disease Control, United States Public Health Service.

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PREDATION

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It is impossible to understand the meaning of predation to mammal populations without understanding the concepts of genetics and evolution. Charles Darwin (1859) defined his theory of evolution as "descent with modification," and the tenets of evolution hold that animals best adapted for survival are those most apt to pass survival traits on to their offspring. Obviously, survival may depend upon random chance: being in the right place at the right time, as it were. There are, however, genetic differences which may affect survival between members of the same species. As an example, certain hormonal imbalances may lead to hyperactivity, which in turn tends to make an animal more vulnerable to predation. Digestive physiology in some animals may be perfectly adequate for digestion under normal circumstances but may be inadequate during periods of stress. Nerve or muscle function may be insufficient for optimal function in reacting to potentially dangerous situations. This is not to say that evolution always favors the fastest or the strongest: it is to say that evolution favors those animals which are best adapted to the stresses that they face during their lifetimes. Behavioral strategies favoring survival may be as critical as physiological strageties.

Biologists recognize that challenges are essential for the evolutionary refinement of all species. As we look around us, the species we see have one thing in common: they are all survivors. No one individual has survived all the challenges that nature has put forth, but each species has endured, through the countless millennia of its existence, all the hardships typical of the environments in which it has survived. All of those hardships, collectively, have had the effect of culling those members least capable of surviving, in addition to removing those very fit members which happened to be in the wrong place at the wrong time.

Predation cannot be viewed as a heartless and cruel fact of nature. Predation is a fact of animal life: some species seem "born to be prey," and have high biotic potentials with little intrinsic ability to curb reproduction, thus tending to allow seemingly endless predation. Other species can exist only as predators and tend to have low biotic potentials with "built in" methods of population control. Most species lie somewhere between these two extremes.

Paul Errington's (1962) excellent treatment of predation should be read by anyone interested in the subject, but there are two points he raises which should be mentioned here. One is that the presence of prey does <u>not</u> imply that the prey is available to predators. As long as conditions in an ecosystem remain favorable for the prey species, which has been "racially tested" since its beginnings, the prey may live in almost absolute security. However, anything that disrupts the ecosystem may cause the prey species

to become vulnerable to predation to some extent. In many cases, potential predator and prey may share habitat portions or live within close proximity to each other, apparently in peace and good health. It is only when the prey becomes vulnerable and the predator becomes acquisitive that such relationships may end.

A second point made by Errington is that predation by modern man must be considered in a different way from that of non-human animals, unless one is thinking of predation by a bare-handed, unarmed person. Man's special talent for devising traps, weapons, and sensing apparatus for exploiting wildlife populations gives him advantages that other animal predators do not have, and it is possible for him to affect prey populations in different ways. Man's predatory activities may not only extirpate a species in all or part of its range, but in some cases may even select for inferior genetic qualities. Human hunters tend to desire trophy specimens: given the opportunity, the human hunter chooses the wise, strong, defensive buck over the sickly buck that may live long enough to pass on his inferior genetic heritage, even though he may not live through the next winter. The non-human predator would take the most accessible prey.

Predation, then, is one of the great forces of nature, acting throughout the entire course of evolution to select for those traits which, during periods of stress, favor survival. In a very real sense, predation is as essential to the endurance of most well-adapted species as are food and water. Predators other than man are not interested in trophy specimens; they are interested only in meeting their dietary requirements, or those of their young. In most cases, it is difficult for a predator to catch and kill a healthy prey animal in its prime; a predator tends to remove the less wary, the weak, the sick, the old, and the young. In its turn, the predator who is unwary, weak, sick, too old, or very young not only cannot meet the hardships of its own dietary demands, but is apt to be taken as prey by another predator.

Thus moves the inexorable cycle of nature.

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ASPECTS OF THE ECOLOGY AND POPULATION DYNAMICS OF THE RED FOX

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The red fox (Vulpes vulpes) occurs throughout the upper midwest, including all of Minnesota. It is native to the region but population densities have changed much during the past century. Red foxes were probably never abundant in pristine times and populations declined to very low levels by the turn of the century. In many areas they were rare or absent. Densities remained very low until the 1930's, but then they increased rapidly. Since the 1940's, densities have remained relatively high, although below maximum levels. Fox population changes during the past century are likely the direct result of human-influenced mortality coupled with changes in the density and distribution of other canids, especially the coyote (Canis latrans).

Attitudes towards the red fox have also changed much over time because of the varied relationships of foxes to man (i. e. disease-carrier, farm pest, sport animal, furbearer, ecological asset). Prior to the mid-1930's, red foxes were considered valuable furbearers and prized sport animals, and efforts were undertaken to increase their numbers. During the 1940's and 1950's, they were regarded by many people as destructive farm and wildlife pests and bounties were paid to reduce their numbers. During the 1960's, red foxes began to regain their early stature as valuable components of the ecological system and now they are again considered valuable furbearers. To a large extent, man's attitude towards the red fox reflects the value of fox pelts.

Red foxes fare well in a wide variety of habitats, but populations seem to do best in agricultural communities. Populations are made up of family groups that occupy well-defined, largely non-overlapping, territories. Territories generally average about 9 km^2 but are very plastic to accommodate changes in population density; territories are large in low-density populations and small in high-density populations. Fox families generally consist of an adult pair and their pups from time of whelping in March or April to dispersal of young. Some families, however, include additional adults, usually females, and sometimes more than one vixen will have pups in the same territory. Dispersal of young starts in early fall and by spring nearly all young are gone from parent territories. Males tend to disperse farther than females; many males travel straight-line distances of 80 kilometers or more (up to 390 kilometers documented) before they are killed or establish residency. Adult pairs tend to remain together, although vacancies caused by death of mates are quickly filled by dispersing individuals.

Red foxes are skilled hunters and have highly developed sensory capabilities. The senses of smell and hearing appear to be especially important in their food-gathering activities. Although

adult pair bonds are tight, red foxes are solitary hunters. They nearly always kill prey smaller than themselves and they are efficient scavengers. Their foods include a wide variety of animals (primarily mammals, birds and some insects) and some plants (primarily fruits, berries and certain agricultural crops). Certain foods appear to be preferred, especially the meadow vole (Microtus pennsylvanicus) and cottontail rabbit (Sylvilagus floridanus). Cached foods, lightly covered with soil, vegetation or snow and scattered through the territory, play an important role in the survival strategy of the red fox. Through caching, foxes store surplus foods for use at later dates.

ECOLOGY OF COYOTES IN NORTHERN MINNESOTA[1]

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ABSTRACT: From 1968 to 1976 (continuing) coyote (Canis latrans) food habits, population dynamics, and movements were studied in the forests of north-central Minnesota. Seasonal food-habits data obtained from 1558 stomachs, 670 scats, and 509 km (318 mi) of coyote trails indicated that white-tailed deer (Odocoileus virginianus) was the major food item, occurring in 48.6 percent of the total stomachs, and 40.9 percent of the scats. Adult deer was consumed mostly as carrion. Fawn hair was found in 66.9 percent of the April-July scats. Other major food items consisted of domestic sheep and cattle, snowshoe hare (Lepus americanus), mice (mostly Microtus pennsylvanicus), and porcupine (Erethizon dorsatum). Plant and fruit material was common in scats, but not stomachs, throughout the year. Ages of 960 coyotes indicated that 47.2 percent of the coyotes over a 6-year period were less than 1 year old, with 74 percent of the total sample being less than 3 years old. The sex ratio for the 1558 trapped coyotes was 109 males to 100 females. Weights of 104 ovary pairs were not correlated ($r=0.218$, $p \geq 0.05$) with carcass weight, but were correlated ($r=0.775$, $p \leq 0.05$) with age. Adult male coyotes averaged 12-13 kg (28-30 lb) in weight, compared to 11-12 kg (26-27 lb) for adult females, with juveniles weighing 10-11 kg (24-25 lb) and 10 kg (23 lb), respectively, for males and females. A total of 2434 relocations obtained from 100 radio-tagged coyotes indicated home ranges averaging 60 km^2 (26.3 mi^2) for adult males, and 16 km^2 (6.3 mi^2) for adult females. Adult females were highly territorial, whereas adult male home ranges overlapped considerably. Juvenile males and females both occupied comparatively small home ranges of 5-8 km^2 (2-3 mi^2). Approximately two-thirds of the juveniles dispersed in late autumn, usually in a southerly direction, over distances averaging 48 km (30 mi). Sixty percent of 408 observations of coyotes from aircraft were of single individuals. Trapping and telemetry data indicated that coyotes generally avoided or were excluded from an adjacent area containing a pack of timber wolves (Canis lupus), and two coyotes, one radioed, were killed by wolves during the study period.

[1] Reprinted from: Berg, W. E. and R. A. Chesness 1978. Ecology of coyotes in northern Minnesota. pp 229-247 In : Coyotes-Biology, Behavior, and Management (M. Bekoff, ed.) Academic Press, New York. 384 pp.

ECOLOGY OF BOBCATS IN NORTHERN MINNESOTA[1]

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ABSTRACT: The bobcat (Lynx rufus) inhabits the forest areas of approximately 78,000 km^2 (30,000 mi^2) in northern Minnesota. Continuing studies by the Minnesota Department of Natural Resources since 1972 include telemetric monitoring of movements, home range, and social behavior. Information on food habits, age structure, and reproduction was determined from carcass examinations. More than 650 relocations from 22 radio collared adult bobcats indicate average home ranges of 62 km^2 (25 mi^2) (range 13-201 km^2) for males, and 38 km^2 (15 mi^2) (range 5-92 km^2) for females. Home ranges of radioed coyotes (Canis latrans) and timber wolves (C. lupus) consistently overlapped with those of bobcats. No juveniles were radio-collared, but two bobcats older than 1 year moved distances of 32 km (20 mi) and 136 km (82 mi) before establishing new home ranges. Preferred habitat types consisted of coniferous areas of black spruce (Picea mariana), white cedar (Thuja occidentalis), and balsam fir (Abies balsamea) interspersed with quaking aspen (Populus tremuloides) and lowland shrubs. The main food items during winter were snowshoe hare (Lepus americanus), white-tailed deer (Odocoileus virginianus), porcupine (Erethizon dorsatum), mice, birds and tree squirrels (Tamiasciurus hudsonicus, Sciurus carolinensis, and Glaucomys sabrinus). Juveniles comprised 47.5 percent of 215 bobcat carcasses examined since 1975, with 56 percent of the juveniles being males. Adults aged up to 9 years old, with 54 percent being males. Winter weights of adult bobcats averaged 13.0±1.8 kg (28.6 lb) and 9.2±2.3 kg (20.2 lb) for males and females, respectively, and 6.8±1.2 kg (15.0 lb) and 5.7 ±1.6 kg (12.5 lb) for juvenile males and females respectively. Preliminary analysis of female reproductive tracts indicates no reproductive activity in bobcats less than 1 year old, and an average of 3.2 placental scars per adult female. Adult females may give birth from mid-April to mid-July. Assuming 52,000 km^2 of suitable habitat the current population in Minnesota is estimated at 2,000-2,900 bobcats.

[1] Reprinted from: Berg. W. E. 1979. Ecology of bobcats in northern Minnesota. In: Proceedings of the Bobcat Research Conference, Oct. 16-19, 1979. Front Royal, Virginia. National Wildlife Federation. Washington, D. C. In press.

Food habits and predatory behavior of *Taxidea taxus* in east-central Minnesota.

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Badger food habits were analyzed at two study areas in east-central Minnesota during 1972-76. Examination of 172 scats and 15 stomachs demonstrated presence of 15 mammalian prey species as well as three reptiles, one bird, and seven families of insects. Estimation of biomass consumed indicated the importance of *Geomys bursarius*. During spring, summer, and fall, estimated consumption increased as did the proportion of the diet represented by *G. bursarius*.

Thirty areas where free-ranging badgers had hunted for *G. bursarius* were examined. Thirty-six percent of badger excavations at a hunting site penetrated a pocket gopher burrow. The average site of attempted predation had 16.4 holes and a total volume of displaced soil of 182 liters. Badgers were successful in capturing pocket gophers in an estimated 73.0% of their attempts. Sites of capture had a greater density of holes than areas where capture did not occur.

Four captive badgers were observed as they hunted for pocket gophers in enclosures. Components of predatory behavior were described and used to construct time budgets of predatory activity. Behavior was grouped according to detection, pursuit, capture, and consumption activities. Postures and movements varied with the depth of the hole. Badgers penetrated the pocket gopher burrow system in many areas and appeared to have utilized sensory information from such holes to identify the vicinity of the prey.

BLACK BEARS OF NORTHEAST MINNESOTA:
ECOLOGY AND MANAGEMENT

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For more than a decade, a comprehensive ecological study of the black bear (Ursus americanus) in the Superior National Forest of Northeast Minnesota has generated and answered questions with direct implications for management. Supported by the Wildlife Research Institute and directed by Dr. Lynn L. Rogers, this study has yielded classical information on a wildlife population ranging from the usual population dynamics to a scenario of familial relationships spanning, in some instances, four generations. When possible, this data base had been integrated with comparative habitat analysis relative to timber management practices and wilderness area (Boundary Waters Canoe Area) policies (Arimond, 1979). In recent years, a joint examination of habitat, berry failure, reproductive rates, mortality and hunting pressure has led to suggested guidelines for management to assure the future of the black bear in this area and throughout the state. Consequently, data and interpretations pertinent to timber and game management will be emphasized here.

The fact that fruit is a critical habitat requirement for black bears is evidenced by the coincidence of weight gains with the ripening of fruits in July and August (Rogers, 1977). Evidence of twenty-six fruiting species has been found in bear feces during midsummer. Five fruiting plants make up approximately 86% of the estimated fruit and nut diet of the bear (Rogers et al., in prep). These fruits are blueberry (Vaccinium myrtilloides, V. angustifolium), cherry (Prunus pennsylvanica, P. virginiana), hazelnut (Corylus cornuta), raspberry (Rubus strigosus), and wild sarsaparilla (Aralia nudicaulis).

Quantification of the relationship between tree density and berry production in these fruiting shrubs illustrates that which has been qualitatively assumed in the past. Low density stands (0-800 trees/hectare) showed significantly ($P < .005$) more fruit production than high density stands (1000-2100 trees/hectare). There is a critical exception to this generalization. One of the important fruiting species, sarsaparilla, which has the highest estimated volume percent (40%) in scats for July/August (1974-1977), is significantly ($P < .01$) more productive in high density stands (1000-2100 trees/hectare). It occurs and fruits predominantly in stands which have been essentially unmanaged for twenty years or more. The most productive stand was 96 years old.

The current timber management methods of clear-cut, strip-cut and select-cut result in an open canopy and low tree density, thus enhancing the conditions for optimum fruit production in blueberries, cherries and raspberries. But due to the dietary importance of the shade-tolerant wild sarsaparilla, a mosaic of age classes in forest management should be the goal of the coordinated efforts of timber and wildlife managers. Designated stands should be left to long-term rotation and estimates of optimum harvest age

in some cases should be adjusted upward (Arimond, 1979).

As previously noted, the mid-summer maturation of fruit coincides with major weight increases in the bear. In turn, reproductive success has been shown to be dependent upon this weight gain (Rogers, 1976, 1978). During three years of poor fruit production (1974, 1975, 1976), the black bear population in the study area declined approximately 35%. The decline was due primarily to a syndrome of low reproductive rates and high incidence of cub starvation in years following berry failure. Rogers (1979) subsequently reported that a compounding management problem has developed: overkill.

During 1977 and 1978, an average of 30% of the mature females in this sample bear population were killed each year. This kill rate is several times higher than the average 13% allowable mortality that can be sustained by recruitment. The trend of high harvest rates began in 1977, with 701 bear kills registered, and then climbed to 1,028 in 1978. The Minnesota Department of Natural Resources cancelled bear hunting during the deer season in 1979 and the bear kill was subsequently reduced to 743 (Rutske, 1979). The escalated 1980 figures, 1,245 registered bear kills, reflect two changes in Minnesota bear management. The season opened approximately two weeks earlier than in previous years and extended to late October (September 2 through October 28). Prior bans on age and size were removed, permitting the taking of cubs. Further reflection of a potentially dangerous trend is the increase in bear licenses issued: from 2,069 in 1972 to 7,581 in 1979.

Further black bear management should be designed to compensate for, rather than compound, the effects on the population of the variability in the fruit crop (Arimond, 1979). This can be done through monitoring the bear population and concurrent fruit availability. Several management options can then be employed, including delayed season openings, limits on licenses issued, and regional seasons.

It should be strongly emphasized that the data and recommendations herein are based on a sample black bear population from a primary study area of 300 km^2 in Lake County of northeastern Minnesota. Information on state-wide populations is sketchy at best. For example, the total number of bear taken as nuisances each year is unknown. Reproductive rates and mortality in habitats perhaps more favorable to the bear (e. g., Oak/Basswood) than the boreal conditions of the study area are not available. This information must be obtained in order to apply existing population modeling techniques (Conley, 1978), that can result in ecologically sound management guidelines. These guidelines, including the avoidance of overharvest, are necessary for the continued success of the black bear in Minnesota.

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THE TIMBER WOLF IN MINNESOTA

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This information is based on my own work in northwestern Minnesota and on the published literature based on the work from other parts of the state.

Abstract: The last significant range of the gray wolf (Canis lupus) in the lower 48 states is in northern Minnesota where an estimated 1000-1200 wolves occupy about 30,000 square miles. The basic social unit is the pack (usually 2-8 individuals), consisting of a mated pair and their pups from at least 1 litter. Social order is maintained by a dominance hierarchy. Pups (about 6) are born in April and by September or October are capable of following the pack. Packs maintain exclusive territories by scent-marking and howling. Some of the offspring disperse and become lone wolves which may become the progenitors of new packs if a mate and a territory can be found. The major foods are white-tailed deer, moose, and beaver. Livestock occasionally are killed, but a very small percentage of farms in wolf range are affected annually, and a minute fraction of the livestock available to wolves in the state are killed. The population has declined in the Superior National Forest in recent years because of a decline in white-tailed deer. Population increases have been documented in the Beltrami Island State Forest of northwestern Minnesota and in parts of north-central Minnesota since 1974. The Minnesota wolf population likely will continue to attract national attention which will influence management efforts.

PREDATOR MANAGEMENT

AN ENVIRONMENTALIST'S VIEW

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Predator management has been directed primarily toward the goals of maintaining man-hunted prey or giving livestock protection. The term "manage" in this respect is a generous description of what has in actuality been the elimination or dramatic reduction of a "competitor." Rarely has such management aspired to protect or preserve the predator as an essential part of the ecosystem. Many predators valued as furbearers or game commodities also carry the stigma of being considered varmints, or are labeled a threat to other species that man wants for himself.

The Predator Control Report (Cain, 1971) pointed out that the "programs of general reduction of predator populations were carried out with little attention to the effects of the program on the native wildlife fauna." The programs ignored predation's natural and necessary roles and implied that predation was some abnormal cycle which man had to control. Wallace Grange (1949) stated:

> ...the natural adjustments between species under wilderness conditions are adequate to ensure survival, and occasional abundance, of every species in the wild but may not suffice for the purposes of man, which include the creation of abundance of preferred forms with greater regularity.

Durward Allen (1954) noted the purposes of man and his interest in game "often led to abuse of the natural predator." For many decades, ecologists, wildlife researchers, and other scientists have conducted valuable studies on predators and their interaction with prey. Repeatedly, reports from such studies as well as those from scientific advisory commissions have offered guidelines for control programs. In spite of these, the ideals and research data presented by such renowned scientists as Murie, Leopold, Grange, Errington, Allen, and Cain have not been assimilated into the major part of the control activities. Policies of non-selectivity and overkill continue.

President Carter (1977) emphasized that control should focus on individual predators causing problems, not on the species as a whole. The Animal Damage Control (ADC) Program's Final Impact Statement cites President Carter's concerns and pays tribute to research results, but then outlines the same archaic, non-selective, biased predator control concepts that have dominated our nation's history. Secretary of the Interior Andrus (1979) countered, outlining stricter guidelines and a policy that stressed environmental acceptability, selectivity, and other corrective controls that would utilize non-lethal, non-capture methods and encourage extension services to employ better husbandry. Such stringent policy guidelines, set by the Secretary, principally affect the coyote. However,

should not equal, if not more stringent, guidelines be enacted to protect a threatened species such as the wolf? Notably, such scrupulous guidelines are lacking in the Minnesota plan offered in 1980 for the management of the threatened timber wolf.

Unfortunately, politics still plays a major role in predator management. According to Stanley Cain (1978):

> ...predator management decisions have been based on data that cannot stand critical evaluation because they consist to a large extent of uncontrolled observations by affected persons... It is almost incomprehensible that extensive federal studies do not discriminate between hard data in the technical sense and opinion surveys.

The time must come when predator management will be founded on research, free of bureaucratic manipulation and the influences of political factions that have thus far favored prophylactic, non-selective control. Decisions favoring only one segment of the population, the consumptive user, cannot be continued. For example, harvest of the wolf to allow the increase of the deer population in northeastern Minnesota cannot be regarded as a method to preserve the natural fauna. It is disturbing that wolf populations should be reduced in that area in a last-ditch attempt to maintain a deer population that increased only after man altered the original forest; the area now provides less suitable habitat for deer. Caribou in this area, also victims of man's intervention, were extirpated as a result of logging, over-hunting, and pressures from expanding deer herds. Now there is a possibility of caribou reintroduction. It is suggested by hunters and managers that wolf control should be continued in deference to this species as well. Grange's (1949) concept of "preferred" species is highlighted in both of these management plans.

It is astounding that the predator control activities of the past and present are not validated by much of the available data and scientific information. The myopic directors of predator control programs have ignored the critical concepts of social structure and other aspects of ethology, environmental diversity, aesthetics, and the basic tenets of ecology.

Some managers believe that exploitation, or "harvesting," is not harmful to the "whole" population. It is explained that, in some cases, annual removal of even 50% or more of a species would not drive it to extinction, but that survivors can swiftly reproduce and repopulate. This idea should not lead us to believe that such a "harvest" would have no effect on those species. I do not think that we can separate the "harvest" concept from the fact that such exploitation may have important effects on the social structure of some species. Even if the effect is temporary, it may be harmful or have irreversible negative impacts on the species, other species associated with it, or the habitat. The histories of many species on the Endangered Species List give more than an indication that this may indeed be an important concern. Because of the many environmental refinements needed to ensure species security, it is not enough for wildlife management to be directed toward a single interest: to maintain arbitrary numbers of bodies simply to be consumed by man as

fur or meat. This management policy disregards the fact that animals have non-consumptive importance and are participating members of ecosystems.

There is a vast philosophical gap between just "maintaining optimum numbers" to comply with some convenient textbook management formula aimed at producing wildlife crops, and stewardship, which affirms the integrity of natural fauna within ecosystems. For example, having large numbers of incessantly reproducing wolves, with continually unstable hierarchies roaming Minnesota, would not be a management achievement. A high number of rapidly reproducing animals would not necessarily be advantageous to the preservation of a stable animal community. However, to ensure the survival of a smaller number adapted to the habitat and prey would be an accomplishment even if man's "harvest" were affected.

Heavy control has not been considered threatening to predators. In 1967, Errington said:

> ...in some species extraordinary losses may be compensated by accelerated reproduction, more young being produced in consequence of more being destroyed.

L. B. Keith elaborated further on this compensatory trend in wolf population dynamics, noting

> ...the immediacy and magnitude of compensatory changes in reproduction and survival in response to human exploitation and to changes in their own population density.

In concurrence, the U. S. Fish and Wildlife Service paraphrases Dr. David Mech's data (1970), stating "wolves, like coyotes, seem able to withstand high rates of killing by humans."

I do not believe that management on what "seems able" is a just or adequate foundation for heavy control. Errington (1967) stated:

> Long term data are especially valuable in helping to provide the perspective needed to distinguish between what counts more and what counts less in complex situations. Conclusions based upon less comprehensive data may be shaky to the point of being misleading.

Alex Hall (1976) described a predator control program that sheds more light on this problem:

> Although the wolf population present when the program was initiated had high potential rate of increase, the increase was not realized and most pups died at an early age. During the first years of the campaign, young wolves comprised only 13 per cent of the population, but by 1961, after the population had been substantially reduced, pup survival had increased to the point where young made up 73 per cent of the population. In 1961 control measures were relaxed and wolves probably increased to their former numbers within several years.

In this case, control measures were fortunately relaxed and wolves

"probably" did return to former numbers despite the fact that what was known about social mechanisms was not actively considered. Hall concedes:

> Through social mechanisms not clearly understood, wolves regulate their own populations in relation to the available food and space with the result that fairly stable numbers are maintained. These social mechanisms manifest themselves by affecting litter sizes and the survival of pups.

Much more can be discussed about the impact of large numbers of pups, the instability within packs, and related dispersal consequences that may be possible after heavy harvest activities. The work of Erik Zimen (1975, 1976) offers much pertinent material on pack hierarchy and the effect of instability. Considering Zimen's work and other behavior studies, I find it hard to believe that there will be no detrimental effects caused by radical compensatory changes that are "immediate and of great magnitude" and that such changes can always be "withstood." When we study the past and present ranges of the wolf, it appears they did not "withstand" and ultimately did not survive in viable numbers in 47 of the 48 states. The red wolf situation gives a dramatic example: 250,000 red wolves were killed between 1937-1964 and the species is nearly extinct today. As in the red wolf predicament, many factors exert pressures against species and some of these factors have not been investigated or even remain unidentified. Thus, I think it is frivolous to claim that extensive or purposeless harvest can be considered inoffensive. Restraint can be a procedure for management especially when data are lacking.

Peter Klopfer (1973) remarked that there has been a "striking neglect of psychological factors that control or regulate the behavior of animals." Many other relationships have also been neglected and must be considered. Disruption of predators subject to "harvest" may not affect only their social hierarchy, reproduction, dispersal and territories, but may also affect their prey. A theory posed by David Mech (1979)

> ...implies that locations of wolf pack territories must be stable for long periods. If they were not, some buffer zones would end up in pack territory centers and the deer in them might eventually be decimated when conditions become severe enough. No one has yet studied individual territory locations long enough to determine how long they are stable. Nevertheless, certain inferences can be made.
>
> Several pieces of indirect evidence suggest that wolf pack territories generally are stably located for long periods. First, wolves may live for fifteen years or more, which would allow an individual and its mate to maintain their land tenure for a long period just within their own lifetimes. Then, since each territory is occupied by a pack, which consists of a family group, the potential is excellent for occupation of a territory by offspring for generations.

Stability of territories probably is related to the degree of exploitation and population (numerical) stability, along with the age of wolves and those factors just indicated. I am also reminded of

Leopold's (1933) observation:

> Racial sanitation by culling the unfit, and controlling other predators of more destructive habit than their own, are not necessarily the only benefits which the game manager derives from predators, and which help offset the toll they take of game. There are probably other effects which as yet defy definition, much less explanation. It is said that a normally distributed herd of deer on Vancouver Island, after the lions and wolves had been killed off for their benefit, suddenly "huddled up" on a small part of their original range and overgrazed it. Apparently normal depredation had some as yet obscure influence in keeping the deer normally distributed over their range... suggestive of many possible predator influences as yet beyond our vision.

Klopfer (1973) pointed out that among other changes after the removal of predators was a "striking decrease in species diversity," loss of heterogeneity and changes in "gene frequency based on selective pressure changing due to population changes of predator and prey." He further suggested that traits that are advantageous under one set of densities could be disadvantageous under another. Examples cited pertained to behavioral adaptations including escape behavior.

Does control also limit the geographic range of a population, pack territories and dispersals of individuals? How does a population made up of 73% pups use its territory and disperse? The Animal Damage Control Program report (1979) states that coyote dispersal tended to keep both exploited and unexploited populations near the carrying capacities of their habitats. Since control usually does not appear to be of value as a limiting agent, using it for that purpose would be unjustified, especially if it were harmful in the other respects discussed above. In northwestern Minnesota, the optimum breeding strategy of wolves involved increases primarily in numbers of units (packs), not in the sizes of territories. There was a compression of territories. Perhaps this infers some natural limits to growth and expansion of wolf packs. The 1980 Minnesota wolf plan does not adequately consider natural controls of this sort.

Another reason predator control is executed is to subdue rabies outbreaks. According to the Leopold report, after outbreaks the "government control machine" harvests on the "assumption that control of the reservoir population will hasten the termination" of rabies or reduce the danger to humans and domestic stock. The report states, "Scientific proof of this assertion is lacking." Grange (1949) suggested that exerting partial control may actually perpetuate both carriers and disease for a longer period of time. He questioned if in fact partial control tends to stabilize the predator population and change the occurrence of diseases such as rabies from the status of irregularly cyclic to chronic. I cannot further expound on the disease of rabies in wildlife populations, but propose that this debate is interesting and important in predator control considerations. Perhaps other ecological, genetic, and behavioral relationships may be affected by the "prolonging" condition. Perhaps this impact would

be negative, not corrective, and such damage may be inherent in prophylactic control.

Klopfer (1973) cites a very similar chain reaction among examples of negative wildlife oscillations produced by human intervention. The wild jackal was subject to an elimination program in Israel which led to the demise of the mongoose as well. With the steady decline of these two species, it was also noted that there was a steady rise in snake bites by snakes no longer controlled by the mongoose. There are also many examples of increases in rodent populations after the removal of predators. Examples of questionable, if not downright ludicrous, predator control are numerous.

Most livestock protection policies have been based on the false premise that all wolves or coyotes are livestock killers. It is more likely that the opposite is true. A study in northwestern Minnesota indicated that even when an increase of wolf population densities occurred, there did not seem to be an increase in the consumption of livestock. Where there was a reduction of 50% in coyote numbers in Western states, this dramatic coyote reduction did not produce any significant change in livestock losses. It appears that the number in the population is not absolutely related to the losses. Obviously most important is the understanding that unless the individual predators that are preying on livestock are eliminated, nothing is accomplished in control. Arbitrary killing of predators is meaningless. A theory proposed by F. Wagner (1973) suggests that the massive use of 1080 affected the coyote population by killing coyotes with a predilection for eating carrion, creating a natural selection for coyotes that seek live food. Indeed, this might also mean a selection against a valuable coyote feeding habit: the removal of wild carrion.

It is unfortunate that there have been limited activities regarding the improvement of habitat for predator and prey, and no improvement of husbandry practices that discourage predation by wild predators. Instead, perpetual control that often just begets more control and other forms of control is executed.

Karl Butzer (1971) writes:

> Environmental stress can create severe stress without actually eliminating a particular habitat. Deterioration would initiate interspecific competition between animals of similar, yet not identical, ecological roles, resulting in possible elimination of the less adaptive species of this fauna, ...fragmentation of ranges, and a complicated process of ecological shifts and readjustments for both plants and animals.... Environmental changes can create stresses of many kinds that affect different forms in different times....The more complex pattern of extinctions in the Americas may simply reflect on more subtle stresses in a more diversified environment.

Most environmentalists are not opposed to the professional trapping of predators in response to livestock depredations where that trapping is directed towards the capture and elimination of individual predators confirmed, to the best possible degree, as being involved in depredations. However, the following restrictions would, I believe, be imperative.

Predator control protection should be refused to those ranchers who do not use protective husbandry in caring for their animals. Wise practices such as proper disposal of livestock carcasses must be implemented to discourage predators rather than encourage them to enter the farm. Livestock should not be allowed to calve in the woods and wander uncounted until fall. Many missing animals have been claimed as predator losses when the reasons for disappearance are really unknown.

Research should be undertaken to determine why some farms have high losses while other farms have none.

Claims of losses must be thoroughly investigated and must include post-mortem examinations, where possible, to assure verification. When verifications are made, the control measures should be in proportion to the losses. In a case involving badgers discussed in Animal Damage Control (1977), the absurdity of excessive control measures is very evident. After 79 poultry were lost to badger depredation, 481 badgers were killed, 640 destroyed accidentally, and 331 captured and released. The number of predators taken is clearly out of proportion to losses.

Discrepancies in many control statistics pertaining to numbers of losses, claims, and predators taken should be reviewed and eliminated with a more precise reporting system.

Education is another aspect that cannot be ignored. Instruction in better husbandry practices must be made available to farmers. In order to gain their cooperation, farmers should be introduced to and given a better understanding of ecological principles, predator research, non-lethal control techniques and their relation to practical alternative control measures.

There is an absolute need for research into the non-lethal alternatives to predator control. Funds have been limited for research and experimentation of non-lethal programs. Of 15 predator control supporting studies outlined in the ADC impact paper, 11 were for lethal control, only 1 was for non-lethal control, and the other 3 dealt with tracking and the analysis of the lethal studies.

Finally, there must be better cooperation between the many disciplines of science related to animal studies. Some biologists. for example, have derided or disregarded the work of the psychologists. Disputes between the sciences have stopped the utilization of some valuable research. Ethology, psychology, even anthropology, have material that must be absorbed into management policies and into the philosophy concerning wildlife management.

The ADC Final Impact Statement indicates there has been little progress from the control work of years ago. There has generally been inadequate assimilation of available research into policy formulation and field work. The 1979 Minnesota wolf control program headed by Mech and Fritts, on the other hand, has been selective, rational, restrained and effective. This indicates that sound management based on and coordinated with research is possible.

Research to create an appropriate program with integrity is already available. More knowledge must be sought. With knowledge, however, comes responsibility. Apparently we have procured the

role of managers for ourselves, so I would suggest that we begin to differentiate between abuse and fulfilling that responsibility with concerned and prudent management. The ADC report is a testament to the fact that this had not yet been done.

The predator should no longer be considered competitor, villain, and plunderer just because he reaps what man wants to seize only for himself.

Management should not confine its vision, perspectives and policies to a few convenient statistics and control techniques. flaunted in "professional" terms. Restraint and conscience are needed in wildlife management, so that, while we quest for understanding of our environment, we do not destroy the irreplaceable.

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