AN ECOLOGICAL STUDY OF THE RED FOX IN THE EAST-CENTRAL UPPER PENINSULA OF MICHIGAN

Thesis for the Degree of M. S.

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ABSTRACT

AN ECOLOGICAL STUDY OF THE RED FOX IN THE EAST-CENTRAL UPPER PENINSULA OF MICHIGAN

by Robert Samuel Huff

Ecological data on the red fox were collected in the east-central portion of the Upper Peninsula of Michigan to determine its actual predation and effects on game species, its habitat preferences, its behavior, and its winter food habits.

Behavior and activities of foxes were studied by following fox trails 98.4 miles in the snow and interpreting animal signs along the trails. Fifty-eight fecal groups and forty-two stomachs were collected and analyzed for food items. Foxes were separated into age classes by using cranial characteristics. Reproductive tracts were analyzed for litter size and breeding seasons. The peak of the breeding season is February to mid March. Average litter size is 4.6 with average ovulation rate of 5.6.

Foxes tend to be nocturnal in habit, although some diurnal travel was noted. Most foxes traveled alone; groups of more than two foxes traveling together are uncommon in winter. They tended to meander about, visiting a variety of cover types in their nightly travels. Areas with several interspersed cover types are preferred. Extensive areas of hardwoods and conifers were generally avoided. Foxes used the vegetation types in approximately the same proportion as the types

occurred. Some preference was shown for small coniferous swamps, semi-open and mixed hardwood-conifer types.

Mice and voles occurred in the foxes diet with the highest frequency of occurrence in the winter months. They also ranked second in total volume. White-tailed deer shot and wasted by hunters constituted the greatest volume of winter foods. Snowshoe hares were also prominent in the winter diets. Insectivores were commonly discarded by foxes, however, they occurred with a surprisingly high frequency in the stomach analysis. Ruffed grouse occurred in minor amounts in both stomachs and scats. A variety of small mammals rounded out the winter diet. Effects on small game species appeared negligible.

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By

Robert Samuel Huff

A THESIS

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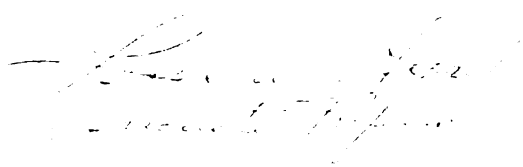

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INTRODUCTION

The red fox (Vulpes fulva) as a predator has long been a controversial subject in Michigan. Its status as a predator and its role as a bountied animal has considerable economic significance to the field of conservation. The Department of Conservation, many sportsmen's groups, and individual conservationists feel that the bounty system has not accomplished the objectives for which it was meant and would like to repeal the present bounty. The money thus saved could then be used for other much needed conservation programs. Bounty figures indicate that foxes are at least as abundant today as they were in 1947, the year the present bounty was initiated. The many proponents of the fox bounty maintain that the red fox takes excessive numbers of small game animals in Michigan. Ecological and food habits studies in the pheasant range and in the ruffed grouse range in southern Michigan by Arnold (1956) and Schofield (1959) have somewhat clarified the foxes position in the animal community.

Ecological data and food habit information pertaining specifically to the red fox in the Upper Peninsula of Michigan are sparse or lacking. Plant and animal communities there differ somewhat from those found in the southern Michigan studies. Thus I feel that the southern Michigan data may not be applicable to the Upper Peninsula.

In this study, I collected ecological data on red foxes in the east-central portion of the Upper Peninsula of Michigan during the winter of 1954-55. The objectives were: (1) to determine the actual

predation of the red fox on species of prey, and attempt to determine the effects on game species numbers; (2) to determine the winter food habits of the red fox; (3) to determine home range, cruising radius, daily movements, and habitat preferences; and (4) to gather as much information as possible concerning predator habits, hunting success, mating dates, reproductive rates, age structure, and other data of interest. It is the object of this thesis to report these data so that a clearer picture may be obtained as to the true relationship of the red fox to its environment.

STUDY AREA

This study was carried on in the east-central portion of the Upper Peninsula of Michigan. Field work was carried on in portions of Marquette, Alger, Schoolcraft, and Chippewa counties. Areas investigated were determined by the presence of red fox activities. Many miles were traversed by automobile in search of fox signs. The areas in which the most fox tracks were found thus comprised the most typical description of the study area. These areas were generally loamy sands, sands, and sandy loam soils, varying from level to rolling terrain. The original forest was mainly hardwoods with scattered areas of white pine. A considerable amount of the land had been cleared for agricultural use and then abandoned, thus creating many openings. Small coniferous swamps are scattered throughout the area; almost no hardwood swamps are present. Most of the vegetation consists of second growth hardwoods. Extensive areas of dense coniferous swamp were checked throughout the winter, but these areas generally had few fox signs.

The second growth hardwoods are composed mainly of sugar maple (Acer saccharum) beech (Fagus grandifolia), and white elm (Ulmus americana). White birch (Betula papyrifera) and small-toothed aspen (Populus tremuloides) are found frequently in these areas also. Hemlock (Tsuga canadensis) and balsam fir (Abies balsamifera) frequently occur as associated species in the hardwood types. Densities vary from medium stocking to heavy stocking with diameters averaging up to ten inches.

Low areas of organic soils with white cedar (Thuja occidentalis), spruce (Picea spp.), tamarack (Larix laricina), balsam fir, and black ash (Fraxinus niger), are scattered throughout the study area. Stocking of these plants is heavy, with a dense overstory in most instances.

Semi-open areas support scattered clumps mainly of red maple (Acer rubrum), trembling aspen and pin cherry (Prunus pennsylvanica). Associated species in this type were juneberry (Amelanchier canadenses), hawthorn, (Craeteagus spp.), and hazel (Corylus americana). Density was a very light stocking with diameters of trees seldom exceeding 8-10 inches. The terrain is mostly flat to slightly rolling, interspersed with low ridges.

Open areas consist of idle fields and pastures under a heavy canopy of snow. Very little vegetation or cover remained above the snow except for occasional single trees, stumps, and tufts of grass. Some grassy areas on wind-swept knolls provide cover for mice.

METHODS AND SCOPE

Between December 28, 1954, and March 25, 1955, 54 foxes were tracked by the author in the central and eastern portion of the Upper Peninsula of Michigan. During this period 98.4 miles of tracking data were compiled. The mileage was determined by use of a pedometer, and a count was kept of paces, using a Veedor counter. Frequent checks were made under varying conditions of snow depth and consistency, to eliminate as many errors as possible and to obtain the greatest possible accuracy.

Taken from the files of the Michigan Department of Conservation are 25.5 miles of additional tracking data. These are records of 29 foxes tracked by game biologists during the years 1952 through 1955.

The tracking technique has been used by several investigators in past studies of the larger predatory animals. Murie (1936), Erickson (1955), Arnold (1956), Schofield (1960), and Ozoga (1963) used this method in ecological studies of the red fox, bobcat, and coyote. Stebler (1939) says, "stated simply, the method consists of following the trails left by these mammals and interpreting from the clues they may leave, their activity and behavior." Murie (1936) notes: "It is practically equivalent to observing an animal for a long period of time under natural conditions." Our Upper Peninsula weather provides suitable tracking-snow conditions from late November to mid-April.

Arnold (1956) trailed foxes for 1,000 miles in the agricultural areas of southern Michigan to determine their winter food habits. Schofield (1960) trailed foxes for 1,000 miles in the northern half of the Lower Peninsula, primarily to determine the effects of red foxes on ruffed grouse (Bonasa umbellus).

In the present study, areas of fox concentrations were found by driving along side roads until a track was found crossing the road. Fox tracks were determined by the size of the track and the characteristic manner of travel (described later under fox sign). Scent posts with an odor peculiar to foxes served to corroborate track evidence. These tracks often lead to dens. Areas of known fox concentrations were visited regularly. Information from local hunters and trappers aided in finding tracks. Several dens were being used through the winter, and these were watched closely.

When tracking foxes, the different habitats used were recorded on a tracking record form. The distance traveled in each habitat was recorded to determine preferred habitats. I noted each time a fox passed into a different habitat to determine possible habitat preferences. When the meeting of two or more trails confused the identity of the track being followed, the record of the first trail was ended. A new trail record began when a single trail could again be distinguished. A later discussion will cover habitat descriptions.

The distance from the point where a fox trail was first encountered to the point where a fox was "jumped" from its daytime bed was recorded to determine the average nighttime or daily travel. A straight line measurement from the place a fox was jumped to the point where its trail began was used as a radius to determine daily range.

The 47 specimens used in this study, were bountied animals taken by hunters and trappers in the general study area, and collected by Michigan Department of Conservation biologists and by me. From these animals 42 stomachs were saved for food analysis. Reproductive organs, skulls and long bones were saved as possible means of determining age, and reproductive data.

The winter food habits have been determined mostly from the analyses of materials collected in the winter of 1954-55. In addition, 25.5 miles of fox tracking in the Upper Peninsula by Michigan Department of Conservation personnel between the years 1952-54 are also used to substantiate my findings. I personally followed 98-1/2 miles of tracks. Fifty-eight scat groups and 42 fox stomachs were analyzed.

The food found in the stomachs was often in recognizable chunks. The smaller animals, such as squirrels, mice, and shrews, were usually bitten into small chunks. The larger animals, such as deer, rabbits, woodchucks, and porcupines were usually in larger chunks. The stomach contents were washed in sieves of two different sizes. The contents were then separated. It was almost always necessary to make microscopic examination of the hair.

"Scat" groups were collected in the field. Only "scats" found on fox trails were saved, due to the similarity to bobcat and coyote scats. A total of 58 fox scats were collected while tracking foxes during the period January through April, 1955. The scats were placed in paper bags, labeled as to date, location and any other pertinent information, and dried and stored.

I analyzed the fox scats at the Michigan Department of Conservation Game division laboratory at Michigan State University. Identification of the food items was accomplished by use of a binocular

dissecting microscope. The hair was identified by use of a compound microscope, with reference to a collection of hair slides and photographs available at the laboratory. The analytical procedure followed closely that of Erickson (1954) and Mosby (1960). All scat materials were examined in the dry state after careful separation of materials. Percentage calculations were then made for frequency of occurrence.

Each stomach content, each food item eaten while being tracked, and each scat group, is considered to represent a meal. The food items eaten while being tracked are listed as number of items, number of attempts, and number of actual kills. The scat groups are tabulated by their frequency of occurrence, by months, and as a total. The stomach contents were tabulated volumetrically and by frequency of occurrence.

The volume of the individual foods are important in determining the relation they play as a prey species or as a source of food. Therefore, the contents of the stomachs were tabulated by the percentage of total volume.

In addition, 21 bacula and 22 female reproductive tracts were collected for examination. The bacula were used as one means of aging the male segment of the population using Petrides (1950) method of relative roughness and muscle attachments. The skulls and long bones were saved as a means of determining age from cranial variation as set up by Churcher (1960) and by the closure of the epiphyseal lines of the long bones (Sullivan and Haugen 1956).

Twenty-two female reproductive tracts were saved as a means of determining reproduction rates, mating periods, and as a possible means of separating adults from juveniles. Litter size was determined by a count of mature Graafian follicles, corpora lutea, and number of embryos.

Breeding dates were determined by noting when females were in oestros. The development and size of the Graafian follicles was also used as an indication of the peak of the breeding season.

All food items eaten by foxes in the field were recorded on tracking record forms. Any item eaten was considered food. Only in cases where there was positive evidence of mortality was the item considered as a fox kill. Except in cases of actually finding blood, fur, or other signs in the snow indicating a positive kill, all attempts to capture mice were considered as merely attempts. This probably results in a considerable error, as the small size of mice enables a fox to "bolt" the animal entire, thus leaving no signs of a kill. Carrion was considered as any animal not killed at the time of eating.

RESULTS

DESCRIPTION AND DISTRIBUTION OF THE RED FOX

According to Burt (1948), Vulpes fulva is the only species of fox commonly found in the Upper Peninsula of Michigan. There are records of the grey fox (Urocyon cinereoargenteus) in the Upper Peninsula but they are exceedingly rare. (Seton 1925, Burt 1948). Burt (1948) lists records of red foxes in every county in the Upper Peninsula with the exception of Keweenaw County.

The color variations of the red fox are many and varied. Usually the color of the fur is reddish-yellow with a somewhat darker back, black ears, and black legs and feet. The tail is long and full in winter pelage, reddish yellow with some black, and tipped with white. The throat and cheeks are whitish and the belly greyish white. The fur is full and lustrous in winter. The total length is 955-85 mm. (37-38 inches) and the average weight is 10-15 pounds (Burt 1948).

The most common variations of the red fox are (1) dark crosses on the withers (cross fox); (2) black, frosted with white hairs (silver fox); and (3) entirely black. Lesser variations of the usual color can consist of many different color shades. All these variations can and have appeared in the same litter (Seton, 1925). The two outstanding color phases collected by the writer were a cross fox and a fox tending toward albinism (eyes were not pink).

The red fox skull may be distinguished from the skulls of the

other carnivores by the following characteristics. The teeth number 42, eleven on each side below and ten on each side above. The last upper molar is smaller than the tooth in front of it. The bony palate ends just in front of the last molar. The parietal ridges usually form a sagittal crest. If present, these ridges are separated at the suture between the frontals and the parietals by a space of less than 10 mm. (more than 10 mm. in Urocyon). The dorsal surfaces of the postorbital processes are slightly concave, forming shallow pits (no pits in Canis).

FOX SIGNS

When tracks were encountered in the snow the first problem was that of proper identification. The red fox foot print is slightly longer than it is wide, and usually shows nail marks. It is usually about two inches long and not quite as wide. In fresh snow, the track often appears larger, due to the enlargement as the foot goes into and comes out of the track. Good tracking snow on a crust shows four toe pads, the toe nails, and the ball of the foot. The coyote (Canis latrans), domestic dog (Canis domestica), bobcat (Lynx rufus), and the common housecat (Felis domestica) all make tracks similar to that of the red fox; however, there are differences that enable one to distinguish them from fox tracks. The bobcat makes an almost round track, and the nails rarely show. The housecat makes a round track, shows no nail marks, and has a much shorter pace. The coyote and dog tracks are difficult to distinguish from fox tracks except by larger size of the track and the behavior of the animals.

The length of the pace of the red fox is usually 12 to 15 inches, and the fox places the hind foot in the track made by the front foot. This leaves a trail that is a comparatively straight line of tracks under normal traveling conditions. When jumped or running hard, the fox makes fairly long leaps, and the pattern changes completely (Fig. 1). Rarely does the fox run at a hard pace for more than one-quarter mile unless hard pressed.

Foxes often follow other fox trails or previous trails of their own. As they often step exactly in the previous track, it is difficult to determine the number of animals that have passed. However, if a multiple trail is followed for any distance, one will find short excursions branching off from the original trail to investigate various interesting scents and objects. In the snow it is extremely difficult to distinguish differences in tracks of individual foxes. The fairly heavy furred paw and the soft sifting snow tends to prevent distinguishing individuals by the characteristics of their tracks. In areas of fox concentrations it seems that foxes travel on loosely established routes. Foxes I trailed followed old fox signs for distances up to a mile.

Foxes freely use old roads or trails without evidence of recent human usage. There does not seem to be any specific purpose to use them other than for travel lanes. In several cases foxes wandered down unused trails and roads for considerable distances. Plowed roads were usually crossed in a straight line.

When obstacles were encountered, the fox usually jumped over them if they were small. However it is common for foxes to jump on top of fallen logs and walk the length of them before jumping off. When

Fig. 1.--Tracks of bounding fox.

encountering a fence a fox almost invariable jumps over or through the fence rather than crawling under it.

The urine of the red fox is characteristic. The odor of fox urine very closely resembles the odor of skunk musk, but not as intense. The odor is much stronger than that of the coyote scent and serves as another means of distinguishing between tracks of the two animals. The fox, as well as other Canidae, characteristically urinate frequently. Urinations for the most part were made on tufts of grass, mounds of snow, stumps or other objects protruding above the snow. In most cases it seemed to be a manner of leaving a scent post as a possible means of identification. I could find no evidence of differences between male and female in manner of urinating. Thus this cannot be used as a means to determine the sex of the animal being tracked.

Scent posts were frequently encountered, and rarely did a fox fail to leave its scent. Scent posts seem to have stimulated urination, to leave scent, as many scent posts have been visited by an individual in a very short distance. Fecal deposits were generally found at random spots along the trail. However, it was common to find fecal groups on elevated spots. This may indicate a degree of wariness. In no cases were fecal groups found buried.

REPRODUCTION

Twenty-two pairs of ovaries and reproductive tracts were collected in this study. These were collected between January and March, 1955, except for one collected in April of that year. Data from these were analyzed to determine litter size, breeding season, ovulation rates, and also used to determine age.

Seton (1925) places the breeding season of the red fox in late February or early March. Hamilton (1943) places the breeding period as the month of February in Eastern United States. Asdell (1946) places most breeding dates as late January and February for red fox in general. Richards and Hines (1953) places the mating dates as mid-January until late February in Wisconsin. The breeding season of the northern red fox in this study was determined by the maturation of the Graafian follicles, the condition of the uteri, corpora lutea scars, and approximate age of embryos.

The first indication of the breeding season was noted in a fox killed February 5, 1955. The ovaries showed developing Graafian follicles upon dissection. The horns of the uterus were turgid and vascular. This animal had Graafian follicles 5 mm. in diameter. Since the follicles measure 4 mm. diameter 2-3 days before acceptance (Asdell 1946), this places the breeding date of this animal at, or near February 5. All five females in oestrus had turgid uteri. Thus, I believe that this can also be used as a means of determining the breeding season.

My data to determine the peak of the breeding season are very limited. Five animals were found to be in oestrus, three between February 5 and February 17, and two on March 5. Ripe follicles were found in all of these specimens. Four embryos were found in a female killed February 9, (Fig. 2) while six embryos were found in an animal killed March 13. A female that had very recently dropped her young was trapped April 18. Two females were just starting to develop follicles on February 28 and March 9. In these two instances, the uterus was not turgid.

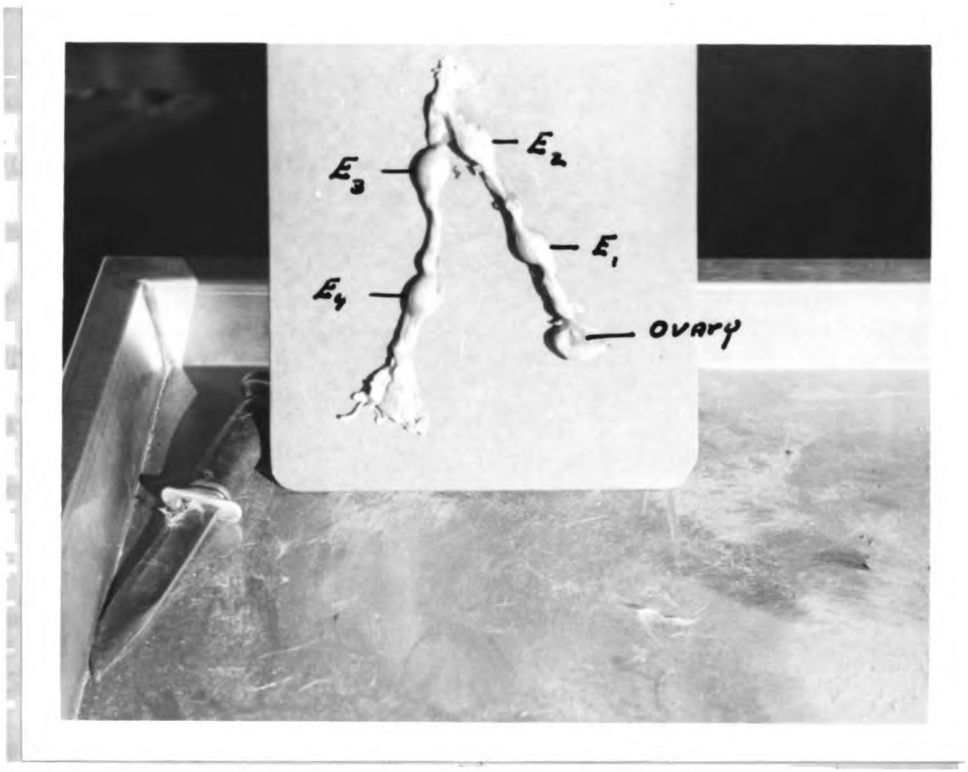


Fig. 2.--Reproductive tract showing four developing embryos; female killed February 9, 1955. E_1 through E_4 are four embryos.

From these limited data, it seems that the peak of the breeding season is in February and early March. The specimen with well-developed embryos on February 9, indicates that breeding activity does take place in late January, while the specimens just developing follicles on March 9 indicates that the breeding season probably extends well into March.

The ovulation rate is based on only eight animals, as these were the only animals showing either corpora lutea or mature Graafian follicles. I have based the ovulation rate on one year only. The average number of mature Graafian follicles was 5.6 with extremes of 4 and 8. The corpora lutea also averaged 5.6 with extremes of 5 and 6. The only two specimens containing embryos averaged 5 embryos each. Accordingly, I have put the ovulation rate at an average of 5.6 with extremes of 4 to 8.

Average litter size of 4.5 has been reported by Asdell (1946). Richards and Hines (1953) lists litter size as 5.1 in Wisconsin. Seton (1925) reports general litter size as 4.9. Burt (1948) lists litter sizes as 4.9 in Michigan. Placental scars on one fox showed a litter of 4, whereas two records of embryos show litters of 6 and 4 each. Sheldon (1950) believes that 9 is the average high number but cites many reports of more than 9 in a litter. On the basis of the number of corpora lutea and follicle counts, my information does not vary greatly from previous studies.

AGE DETERMINATION

Criteria for the aging of red foxes are limited. Petrides (1950)

classified male foxes as young and adult by using characteristics of the baculum. Churcher (1960) used variations of the cranial characteristics to age and sex red foxes. As the corpora lutea apparently completely regress, there are no scars to indicate previous breeding or the number of times females have bred. Churcher's method (1960) of aging has several advantages in that animals can be aged up to 82+ months and that it can be applied to both sexes. Petrides method is restricted to separating young from adults only and applies to only the male segment of the population.

In the present study, age was determined by using the variations in the sutures of the skull. All specimens were collected in the winter period, January through April, so all of the animals were at least approaching the one-year-old age class. The skull sutures used as age criteria were the presphenoid-basisphenoid and the lateral palatal portion of the premaxillar-maxillary suture lying between the anterior palatine foramen and the lingual margin of the alveolus of the upper canine. The presphenoid-basisphenoid suture closes at approximately 10 to 22 months of age (Churcher 1960). The premaxillar-maxillary suture begins to close at 58 months and is completely fused at 82+ months (Churcher 1960). The shape of the postorbital processes was used to designate the 22-33 and the 34-57 month age classes and was used as an additional factor useful for checking diagnoses based on the evidence of the cranial sutures. The basioccipital-basisphenoid suture was fused on all specimens. This suture which fuses at approximately 9 months of age (Churcher 1960) thus was of little value in aging specimens collected in the winter months.

The males were also aged by using the baculum as an aging criterion.

All males classed as juveniles fell within the 10 to 22 month age class with one exception. In that particular specimen the age as determined by the cranial sutures was used. Aging by use of the baculum is more subject to error, being dependent on the ager's opinion as to the degree of roughness and the extent of muscular attachments.

As there is a complete overlapping of lengths and weights of juveniles and adult bacula, aging by the baculum had to be based on other characteristics of that bone. The basal area of the bacula is used the most. Bacula with enlarged basal areas and with roughened large muscle attachments were classed as adults, while bacula with less developed basal areas and small smooth muscle attachments were classified as juveniles. When the skull of a male specimen was either destroyed or missing, the baculum was used as the basis for aging.

Skulls from 21 males and 21 females were used to determine age ratios. Both sexes were divided into 16 younger foxes (first two age classes) and 5 older foxes on the basis of cranial characteristics. It was impossible to separate the first year age class from the second year age class by using this method. The first two age classes comprised 76 per cent of the population with older foxes totalling 24 per cent.

Of the five older females three were in the 34-57 month age-class, one was in the 22-33 month age-class, and one was in the 58-81 month age-class. Of the five older males two were in the 34-57 month age-class, one was in the 58-81 month age-class, one was in the 82+ month age class, and one was aged by the bacula only as an adult.

The average weight of 17 males was 10 lbs. 2 ounces. Younger males averaged 9 lbs. 15 ounces; older males, 10 lbs. 8 ounces.

Females, based on 20 animals averaged 9 lbs. 3 ounces. Younger females averaged 9 lbs. 3 ounces; adult females, 9 lbs. 4 ounces.

MOVEMENT OF RED FOX

In this study the daily cruising range was determined by tracking 16 foxes from where their tracks were first encountered until the animals were jumped. An attempt was made to determine the daily cruising range by back-tracking a jumped fox to the previous bed. This was found to be practically impossible due to the confusion of tracks.

Only one complete day's travel was recorded during this study period. One fox was tracked from the den, back into the den, a total of 1.54 miles. I believe that weather conditions were responsible for the short distance of this trail as it was recorded the morning after a heavy snow. The animal had moved out of a den, fed on carrion, and returned immediately to the den. If one assumes that on the average all tracks were encountered mid-way along the daily travel, doubling this average figure would represent the average daily cruising range. If a fox was jumped, the straight line distance from the point the track was first picked up, to the place where the fox was jumped, was recorded. This distance was used as a radius of a circle to determine daily hunting area.

Arnold (1955), Schofield (1959), and Erickson (1955) used this method and based it on the assumption that the observer on the average intercepts a fox or bobcat trail at the mid-point, and that the average straight line distance from the point of interception to where the animal was jumped should approximate the radius of a circle equal in size to the area over which the animal hunts in one hunting period.

The validity of the above assumption is unknown; however, this method does offer a method for comparing daily movements of foxes in the Upper Peninsula with the daily movements in the two areas in southern Michigan.

In the present study the average straight line distance from the point of interception of the fox trail to the fox bed was 0.79 mile. Consequently the nightly hunting area was 1.94 square miles. This is somewhat less than in the north part of the southern peninsula (2.8 square miles) as reported by Schofield (1959) but larger than that of the southern Michigan foxes (1.4 sq. miles) as reported by Arnold (1956). Seton (1925) found foxes to have a daily cruising range of 2 to 5 miles. The average length of trail, based on 16 foxes jumped, was 1.96 miles. Doubling this figure, on the assumption that the trail was encountered at the mid point, would place the daily cruising range at 3.92 miles. The extremes of daily travel as determined from the above figures were .52 miles and 11.9 miles. This figure is probably considerably smaller than the actual cruising range due to the difficulty in distinguishing longer trails. My figures show a relatively large number of short trails. The daily cruising range is probably somewhat longer.

The home range of northern foxes can only be estimated in this study. The farthest straight line distance any one fox traveled from a denning area was 2.00 miles. Due to the difficulties encountered in tracking these animals, an average home range cannot be defined. Foxes, however, in two different areas could be found consistently in 12.5 sq. miles to 19.5 sq. miles. This may indicate the home range as being 12-20 square miles. It is believed that the abundance of food determines largely the home range, and thus home ranges may vary

tremendously.

There is some indication that foxes use regular crossings in some areas. Tracks could be found quite consistently in particular areas. When a source of food is present for a period of time, such as large carrion, definite trails lead to the source of food. In one case, foxes regularly crossed a highway to get to a dead cow. The crossing area did not exceed more than 150 feet in width, and no tracks were observed crossing in adjacent areas. In another area, I found four trails of foxes crossing a highway in an area not more than 100 yards wide.

Regular trails were used as travel lanes in many diverse areas. Many trails were observed where three or more different foxes have used the trail. On these trails, old signs were observed thus indicating that these trails were used regularly. Well established trails seemed to be more common in open country, such as across fields and through plains areas. Approaches to the dens seem to be along established trails.

Travel Reactions to Weather

Foxes seemed to travel the most when there is a minimum of fresh snow, over a firm layer of snow. One to two inches of snow overlying a crust seemed to be ideal for traveling purposes. When several inches of fresh soft snow is on the ground, movement seems to be restricted. During periods of heavy snowfall, tracks were not found for a period of three days in an area of heavy fox population. On one occasion, after a heavy snow, a fox moved out of the den, traveled directly to a known source of food, ate, and returned directly to the

den. This is very unlike usual fox behavior and may be a direct effect of the weather.

Extremes of temperature did not seem to affect the movement of foxes. On February 28, 1955, foxes moved about in -20° weather. Other occurrences of travel were observed in sub-zero weather. Foxes also traveled readily in thawing weather, when the tracks melted away very quickly.

Reaction to Man's Activities

Even though foxes are generally found around marginal farming areas, and areas broken up by civilization, they are extremely shy of man. In this study, foxes reacted strongly to my tracks and presence in areas of fox concentrations.

During the night, foxes hunted and traveled to within one-eighth mile of farm yards. Also, dens were found within a half mile of farms. Foxes however tended to avoid the actual farm yards and man's activities around the yards.

Foxes seemed to have a deep fear of snowshoe tracks. On many occasions, foxes encountered my snowshoe trail of previous days. In all cases, the animal apparently displayed a complete distrust and fear of the track, and whenever possible avoided crossing the trail. If it was absolutely necessary to cross the trail, the animal usually jumped over the trail on the run, and continued running for considerable distance. On one occasion, my trail accidently formed almost a complete square while I was tracking a fox. Two days later in the same area, a fox was followed into the narrow opening on one side of the square. The animal soon encountered one of the trails, and after looking at it,

turned aside. But, since it was blocked in, almost any direction the fox went it encountered a snowshoe trail. The animal apparently got panicky after the fifth occurrence and started to run. When it came to the snowshoe trail the sixth time, it made a big leap and landed on the other side of the trail and continued running. In no case were foxes observed traveling along a snowshoe trail. This behavior is similar to that of the coyote, but wolves and bobcats, seem to accept and travel on snowshoe trails.

Foxes are very sensitive to the intrusion of man in the vicinity of the dens. If snowshoe trails went too close to the den, the animals in that vicinity would refuse to use the dens for many days, and sometimes weeks. On one occasion, an attempt was made to drive foxes with dogs. In the course of the hunt, two dens that had been active for the entire winter were visited. The dog and one of the hunters investigated the dens closely, leaving tracks and scent. A close check of the den area was kept, and it was observed that the foxes moved out of the dens. There was no activity at these dens for more than two weeks, although foxes moved in the vicinity of the dens.

A porcupine was shot in the vicinity of an active den, to see if the foxes would utilize it as food. The porcupine was shot February 8, 1955, and allowed to lay where it fell. By the next day the carcass had frozen solid. Periodic checks were made of the carcass to see if the foxes would utilize it as food. After three weeks during which there was no utilization, the porcupine was thrown to within ten feet of the den opening. There it remained for another two weeks. A period of warmer temperatures prevailed at this time, and on March 15, 1955, the porcupine was consumed. It appears that it took a long time for

the human scent to disappear and for the foxes to get over their mistrust.

Dens, Beds, and Resting Places

Seton (1925) believes that, as a rule dens are seldom used in winter. However, he also reports that others have noted foxes using dens in the winter. In this study active dens were found in January, and on through the end of March. Tracks indicated that these dens were used quite frequently. On one occasion I found a den with the fox in it. Of 15 dens I found, only four or possibly five were used regularly. Of these five, three were used frequently.

The dens were found in a variety of situations: four just inside the woods, three under stumps, two in small brush and shrubbery, four dug in the sides of hills, one under a brush pile, and one under a windfall. Two of these dens had three openings, one den had two openings, and all the others had only one opening.

The openings were kept clear, with very little signs of additional work being done on the three most permanent dens. Ten of the fifteen dens are believed to be temporary dens, or dens being investigated for future use. These were all deep enough and large enough to conceal a fox. Some of these may have been more permanent, but a close observation was not kept of these dens. From approximately the middle of February, several places were found where a fox would dig down through the snow to the earth, dig a shallow hole and then abandon it.

The openings into the dens averaged approximately 12-15 inches high and 10 inches wide, they had deep entrances through the snow (Fig. 3). In some dens the entrance path was deeply indented (Fig. 4). Other dens

Fig. 3.--Foxes made deep openings in snow to keep dens open.

Fig. 4.--Deeply indented entrance path to den indicating constant winter use.

were only visited at intervals and these were not dug out each time that they were visited.

Foxes do not seem to lie down or sit down to rest very often in the course of a night's hunt. Beds that were found seemed for the most part to be used throughout the day. Sheltered spots, and elevated points of vantage were almost invariably used for beds. There seemed to be no specific effort to make a bed in areas frequented by prey animals. Prey animal tracks were noted near beds but it is believed that this is a matter of chance. On a few occasions beds were found in fairly open hardwoods with practically no cover. These spots were probably temporary resting beds of short duration.

The beds used during the day, the semi-permanent beds, were all located at some vantage point, probably to insure comparative safety. Several beds were found in the vicinity of dens, or immediately above a den. In all cases, when the fox was jumped, it ran off, away from the den. In no case did any of these foxes go into the den. Ridges, overlooking considerable area, were popular spots for beds. Other beds were found in very thick brush, such as speckled alder (Alnus incana). In these instances the beds were on elevated logs, or mounds of snow.

The beds are small and round, formed as the fox curls up and pulls its feet in under the body. Most of the beds were melted down into the snow a few inches (Fig. 5). In many beds were bits of fox fur, frozen to the bed and pulled out. In no case were remnants of food eaten by the foxes found near beds.

It was noted on several occasions that a fox moved its bed as many as three times to remain in sunlight. Also, in adverse weather, foxes tended to bed down on the lee side of knolls. Three foxes were

Fig. 5.--Fox bed located on knoll.

jumped under these circumstances. On all three occasions, it was snowing heavily, thus muffling almost all of my sound. Tracks were almost obliterated and filling in with snow. Each time the fresh bed was found with fresh tracks leading away from the bed. None of these animals were observed on the beds or leaving them. Thus it seems that the foxes depend on olfactory senses at such times, as the fresh snow made my movement almost noiseless.

Foxes tend to bed down near each other when traveling together. On only one occasion did I observe more than two animals bedded down together. On that occasion five beds were found located close together. However, two animals bedding down close together was not unusual. Due to early family break-up, groups of more than two foxes together are very unusual during the winter.

Movement in Relation to Vegetation Types

Foxes tend to meander in their travels and investigate several cover types in the course of their daily (or nightly) travel. During the period of January through March, 1955, I followed 54 fox trails for a total of 173,163 yards or 98.4 miles. The foxes changed cover types 359 times during that distance, or an average of a new cover type every 482 yards. They exibited a tendency to use cover type edges, meandering in and out of adjacent cover types. Foxes seldom traveled for more than 1,000 yards in any one cover type. (Fig. 6). As the study area was well interspersed with several cover types, the vegetational cover types were grouped into nine main categories (Table 1). Foxes tended to pass from one cover type to another in a random manner.

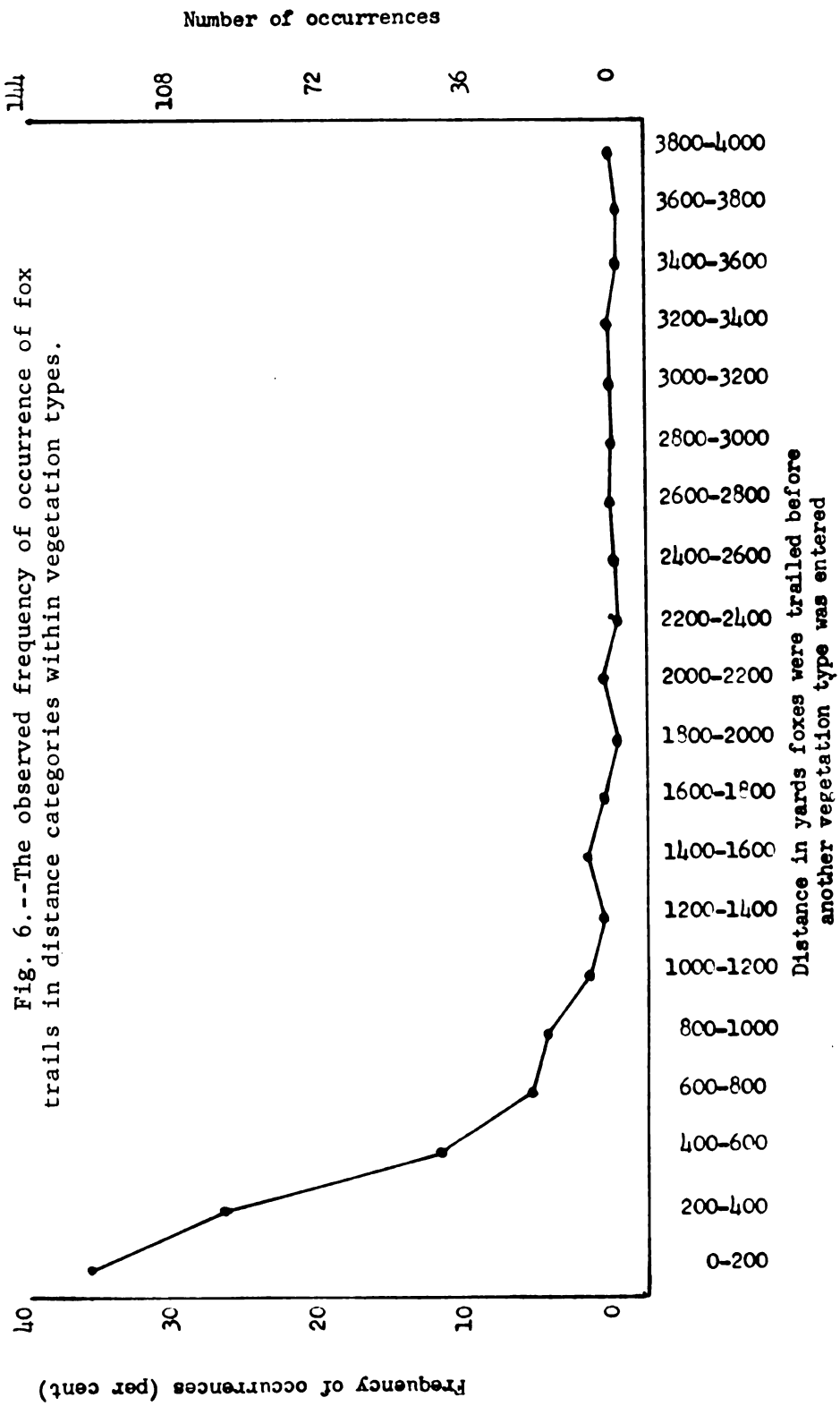


Fig. 6.--The observed frequency of occurrence of fox trails in distance categories within vegetation types.

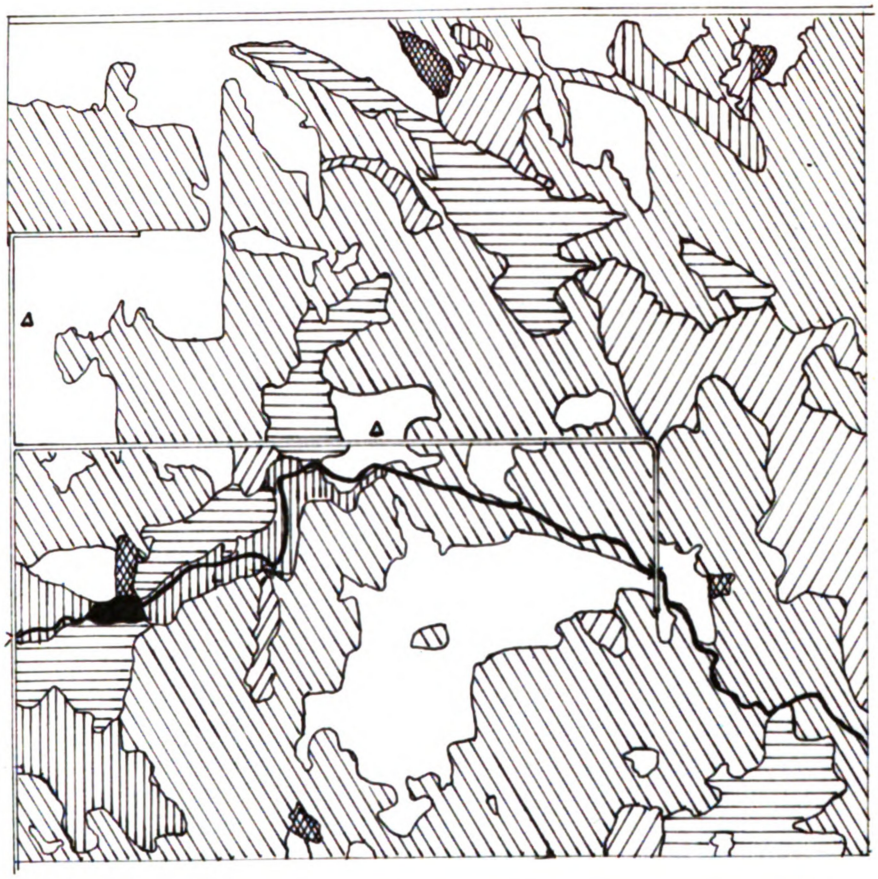
TABLE 1.--Winter habitat use by red foxes during 98.4 miles of tracking in central Upper Peninsula of Michigan - 1955

Vegetational Types	Linear Distance in Yards	Per Cent of Use
Upland hardwoods	75,964	43.9
Open areas	35,947	20.7
Mixed hardwood conifers	17,426	10.1
Semi-open	16,788	9.7
Marsh, lowland brush, streams	9,470	5.5
Coniferous swamps	15,431	8.9
Pine plantations	999	0.6
Upland brush	761	0.4
Roads	377	0.2
Total	173,163	100.0

Four sections (2,560 acres) in Alger County were chosen as typical of the study area. Foxes were trailed through this area on several occasions. The diversity of habitat and percentage of individual vegetational types are representative of this study area. A cover map was made of this area to determine the approximate amount of each cover type available for use by foxes (Fig. 7).

In this study the foxes trailed hunted fairly uniformly through the available cover types (Table 2). There seemed to be some preference for coniferous swamps, semi-open areas, and the mixed hardwood-conifer timber types. The upland hardwood type, although the most prominent cover present, was not used in proportion to its availability. Movement in relation to cover types are discussed as follows:

Sections 2, 3, 10, 11
Town 45 N, Range 21 West



Scale 2-1/4" = 1 mile

= Open

= Upland Hardwood

= Semi-Open

= Hardwood-Conifer

= Swamp Conifer

= Upland Brush

= Stream-Lowland Brush

△ = Farm Sites

Fig. 7.--Cover map of 2,560 acres considered most typical of the study area.

TABLE 2.--Habitat availability as determined from 2,560 acres considered most representative of the study area, and fox use during 98.4 miles of tracking

Cover Type	Per Cent of Area in Type	Per Cent Use
Open areas	22.5	20.7
Semi-open	8.8	9.7
Upland hardwood	52.1	43.9
Mixed hardwood conifers	9.2	10.1
Coniferous swamp	5.3	8.9
Marsh, lowland brush streams	0.5	5.5
Upland brush	0.6	0.4
Roads	0.1	0.2

Open

The open areas consisted of pastures, hay fields, and abandoned idle fields. These fields are generally interspersed throughout the other vegetational types and are generally not more than 40 to 60 acres in size. Foxes used such areas 21 per cent of the tracking distance in this study. Foxes used this type habitat 98 times during the winter with the average trail being 367 yards long. As in the other vegetational types, the foxes tended to meander across the fields in an attempt to find food. Foxes tended to stay fairly close to the edges of the openings while searching for food. Seldom were small openings passed up in the course of the travel.

One attempt to capture prey each 1,239 yards was the average, with one kill per 7,189 yards recorded (Table 3). As the only available

TABLE 3.--Winter hunting and feeding activities of red fox as determined by 98.4 miles of tracking in central and eastern Upper Peninsula - 1955

Vegetational Types	Miles of Tracks	Unsuccessful Attempts to Capture	Successful Attempts to Capture	Carrion Found Along the Trails
Open areas	20.42	Mice. 29	Mice. 5	Deer. . . . . 2 Snowshoe hare . . 1 Porcupine . . . . 1 Shrew . . . . . 1 Poultry 1
Semi-open	9.54	Mice. . . . . .10 Snowshoe hare . . . 1 Red squirrel. . . . 2	Mice. 1	Deer. . . . . 2 Snowshoe hare . . 2 Ruffed grouse . . 1 Shrew 2
Upland hardwoods	43.16	Mice. . . . . .22 Ruffed grouse . . . 3 Snowshoe hare . . . 5 Red squirrel. . . . 2 Cottontail rabbit . 2	Snowshoe hare . . 2 Pine grosbeak . . 1	Deer. . . . . 9 Ruffed grouse . . 2 Porcupine . . . . 3 Cow . . . . . 1 (Visited on 4 occasions) Unknown . . . . . 1 Songbird. 1
Mixed hardwood conifers	9.90	Mice. . . . . .11 Snowshoe hare . . . 4		Deer. . . . . 5 Snowshoe hare . . 1 Porcupine . . . . 2 Ruffed grouse . . 1
Coniferous swamp	8.77	Mice. . . . . 1 Snowshoe hare . . . 7 Ruffed grouse . . . 1 Red squirrel. . . . 1	Mice. 1	Deer. . . . . 2 Snowshoe hare . . 2 Shrews. . . . . 3 Frog. 1

Marsh, lowland brush, streams	5.38	Mice. 4		
Upland brush	.43	Mice. . . . . 1 Cottontail rabbit . 2		
Pine plantations	.57	0	0	0
Roads	.21	0	0	0

prey appeared to be mice, voles, or insectivores, I believe that the number of kills recorded is lower than the actual number of kills. The small size of such prey enables the fox to consume the animal without leaving blood or fur on the snow. Carrion along the trails was relatively scarce, occurring only once every 5,991 yards. White-tailed deer (Odocoileus virginianus) carrion was conspicuously lacking, occurring only once every 17,973 yards.

Thus it appears that mice, voles, and insectivores are the main attraction in the open areas. As the snow depth increases it becomes increasingly more difficult for the fox to find small rodents in the open fields. Close investigations of stumps, clumps of grass sticking out of the snow, and wind blown bare areas were characteristic. As mouse sign was most numerous around such places, it is possible that foxes check these places due to past experiences. The largest number of attempts (29) to capture mice were in this type habitat. Foxes were also most successful at capturing mice in the open areas where they had 15 percent success.

Semi-open

The semi-open areas consisted of poor stocking of red maple, aspen and pin cherry. Rolling terrain characterized this vegetational type. Foxes used this type of habitat 30 times and averaged 560 yards per visit. Trails in this type constituted 10 per cent of the total distance. This type of habitat offers more variety of prey. Thirteen attempts were made: mice 10, snowshoe hare (Lepus americanus) 1, and squirrels 2, for 1 attempt for each 1,339 yards. Evidence of success was not as high as in the open area; only one kill per 16,788 yards was recorded. However, since most of the attempts were made for mice, it

is believed that the success is somewhat higher than indicated.

Carrion was found along the trails in moderate amounts. Carrion of all types occurred once every 2,398 yards, and deer carrion every 8,394 yards. This increase in carrion undoubtedly offsets the apparent drop in availability of mice and the success in capturing them. Snowshoe hares, red squirrels (Tamiasciurus hudsonicus), and mice were relatively abundant in this cover type and provided a potential food source.

Upland Hardwoods

The upland hardwoods were composed mainly of hard maple, elm, and beech of varying densities. Small stands of trembling aspen and white birch are included in this type. The terrain is mostly rolling to hilly. Slopes are generally gentle, but some steep slopes do occur. Upland hardwoods constitute the highest percentage of the habitat in the study area. In this study 44 per cent of the total trails occurred in this type. Trails were found in this type 158 times, with the average trail being 481 yards long. The variety of prey was again more complete than in the open areas. Attempts were made on mice, ruffed grouse, snowshoe hares, cottontail rabbits (Sylvilagus floridanus), squirrels, and small birds. A total of 34 attempts were made, or one attempt per 2,234 yards. Only 3 actual kills were noted, one in each 25,321 yards. Carrion of all types occurred only once each 5,064 yards, with deer carrion occurring at about the same rate as in the semi-open areas, or once each 8,440 yards.

Few fox tracks were found in areas of extensive hardwood cover. Foxes showed a tendency to avoid the interior of large areas of hardwoods and confined their travels to the edges. This is probably due to the

greater availability of potential food found along the edges.

Mixed Hardwood-Conifer

This vegetational type consists of rolling terrain covered with aspen, hard maple, elm, and beech, and interspersed with balsam, spruce, and hemlock. Stocking varied, but generally was no heavier than medium. Exceptions were some ridges, rather well stocked with hemlock. Fox trails found in this type habitat totaled 10 per cent of the tracking distance. Trails occurred 15 times in the hardwood conifer habitat and averaged 1,162 yards long. Trails were noticeably longer in this area, the result of more determined hunting. Attempts to capture prey occurred once per 1,162 yards, with no successful kills observed. Prey were fairly abundant: snowshoe hare, mice, ruffed grouse and porcupine (Erthizon dorsatum).

Carrion was quite abundant and utilized heavily by foxes. Carrion occurred once each 1,936 yards. Deer carrion, an important winter food, occurred in this type habitat with the highest frequency or once each 3,485 yards.

An abundance of prey in combination with a relatively high occurrence of carrion make this type habitat very desirable. The frequent occurrence of deer carrion undoubtedly provides much incentive for using this type of habitat.

Coniferous Swamp

Vegetation consists of white cedar, spruce, balsam, tamarack, and ash. Stocking was generally heavy with a dense over-story. Swamps were usually located in fairly level depressions. Animal signs indicated an abundance of snowshoe hares, ruffed grouse, and deer. Mice

activity was relatively light. Fox trails were found in this type habitat 21 times and averaged 735 yards long. Trails in coniferous swamps constituted 9 per cent of all winter trails. Attempts to capture prey species was difficult to determine due to foxes habit of traveling on well packed snowshoe hare runways. The recorded attempts occurred once each 1,543 yards, with one hare killed per 15,431 yards.

Carrion was frequent along the trails. Carrion occurred once each 1,929 yards, with dead deer occurring once each 7,715 yards.

An abundant supply of prey species constituting a potential food supply and an abundance and variety of carrion is believed to make the smaller coniferous swamps a desirable habitat. Foxes did not appear to have much success at capturing animals in this type, despite an abundance of animals. Snowshoe hares found as carrion however indicates some evidence of past success.

Other Vegetation Types

Pine plantations, upland brush, frozen streams, marshy areas, roads, and lowland brush totalled only 7 per cent of the total trails. The upland brush areas were used 5 times with the average length of the trail being 152 yards. Attempts to capture prey occurred once every 254 yards. The small size of these areas undoubtedly influenced the limited amount of time spent in these areas. No carrion was found in upland brush areas.

Marsh, speckled alder, and frozen streams were used 27 times, with average trails of 351 yards. Attempts to capture prey occurred once every 2,368 yards. No kills were observed in this cover type. Carrion was mostly absent.

Pine plantations are not numerous in this area and were used only once by foxes. Little available food was present in the one plantation visited. The fox passed through the area in a relatively straight line.

Roads were used twice apparently as travel lanes only. No attempts at food were noted.

It would appear that the lack of potential food discouraged the use of these areas in winter months, even though frozen streams provide good travel lanes for winter travel. Signs of prey were not as numerous as in the other types.

SOCIAL BEHAVIOR

The social behavior of foxes seems to be of a very limited nature. Seton (1925) has records of foxes chasing each other on moonlight nights, a phenomenon that could only signify good will and fun. On one occasion I found two foxes hunting together in what seemed to be a mutual social agreement. On several occasions I found tracks of two foxes traveling together for a short distance. Many foxes when encountering another fox trail, would follow it for a while, then continue in another direction. Beds were found in pairs several times, indicating that two animals had bedded near each other.

Carrion showed signs of many animals using the same food source, and of several different foxes using the same food. I believe that most of the time the foxes fed at different times; however, this may not be correct. I noted no signs of animosity between foxes in the vicinity of food supplies.

On February 17, 1955, I started on the trail of two foxes

traveling together. Shortly afterward another fox joined the trail. After trailing the three foxes for a period of time I found an area thoroughly cut up with tracks, and several splotchs of blood. A short distance away, I found another area where the foxes had apparently been fighting. Again there was blood and fur scattered about on the snow. One set of tracks that led away from the area this time had blood in them. About one-half mile further, I found a third area where a fight had occurred. There was very little blood on the snow, and shortly afterward the blood trail was no longer visible. The tracks were very fresh, and the fights had taken place shortly before I saw the tracks. The tracks went by an area where a previous fight had occurred, apparently involving more than three foxes. The main area of the fight covered an area approximately 35 yards in diameter. There was much fur on the snow and some large splotches of blood. I found five beds within 100 yards of the fight area. Shortly afterwards I surprised the three foxes I had been trailing, and they came within 20 feet of me. I shot one of the foxes and found it to be a 7-3/4 pound female in oestrus. The other two foxes separated, and I heard both foxes bark several times, obviously calling the female. Under these circumstances I believe the two males were fighting over the female.

On investigating the largest fight area I found a blood trail leading away from the area. On following this trail in hopes of finding a badly wounded animal, I finally came upon the bed. The bed was caked with blood and had considerable fur stuck in it. Apparently, these wounds were not too severe, as there was no blood trail leading away from the bed. I believe that the wounds were superficial and that no great harm had been done.

I believe foxes tend to hunt alone during the winter months. In areas of high fox concentrations the trails may coincide with another one for a short way, but usually the tracks separate and each fox goes its own way. Foxes do not appear to hunt in groups as wolves and coyotes do.

FOOD HABITS

In any phase of an ecological study of a predator species, the food habits are very important. There has been much controversy as to the relation of the red fox to other game animals. I hope that this study will help clarify the winter food habits of the northern red fox.

Hamilton (1935) found that the winter food habits of 206 New York and New England foxes were mice, 83 times for a 29.3 per cent frequency of occurrence, rabbits 56 times for a 22.1 per cent frequency, grasses 51 times for a 13.9 per cent frequency, and carrion 17 times for a 8.1 per cent frequency. These stomachs were collected over a period of eight years. Errington (1935) found that in winter, mice occurred 31 times and cottontail rabbit 25 times in Wisconsin, and mice 48 times and rabbits 27 times in Iowa. The frequency of occurrence was not cited.

Hatfield (1939) found that the winter diet of Minnesota foxes consisted mainly of mice (38.4 per cent of the total volume, 21 per cent frequency of occurrence) and rabbits (24 per cent of the total bulk, and 12 per cent frequency of occurrence). Schueler (1951) indicates that deer carrion was the most important food in the winter and spring, in his New York studies.

Arnold's (1956) work in southern Michigan indicates that the bulk

of red foxes food in winter months in farm country consists of mice and rabbits. Carrion (mostly domesticated stock) is used a great deal. He states: "Except under unusual circumstances pheasants and other birds are ignored by foxes during the winter."

Schofield (1959) found that deer carrion, made up the bulk of the winter food of foxes in the northern half of southern Michigan. Also, mice, shrews, porcupines, and cottontail rabbits were prominent. On the average, foxes visited deer carcasses for each 5.5 miles of trail. Evidence of predation on game species was negligible.

In summary, these studies indicate mice and rabbits to be perhaps the most important source of food in winter. Carrion when available, seems to be an important food item. A check of the lesser food items indicates that foxes probably eat what is most abundant and most readily accessible. Since they are largely omnivorous, this covers a tremendous range.

Food Availability

Some knowledge of the availability of the food is necessary to give a complete picture in any food habits study. In 1955 both ruffed grouse and snowshoe hare were near or at the bottom of their 10-year cycle. Efforts were made while in the field to determine the relative abundance of prey species, in particular the game animals.

Animal signs were recorded as being present, and game animals such as ruffed grouse, snowshoe hare and cottontail rabbit were recorded when actually sighted. In tracking foxes, fresh ruffed grouse sign was observed along 74 per cent of fox trails followed in this study. Fifteen grouse were flushed, or one grouse per 7.2 miles of trail.

Snowshoe hare signs occurred on 90 per cent of the trails but only 6 live hares were actually observed along the trails, or one hare per 18 miles of trail. Cottontail rabbit tracks occurred along 35 per cent of the trails, but only one live animal was seen.

Deer carrion was visited frequently along the trails. Foxes visited deer carrion 20 times, an average of once every 5.4 miles. It is believed that the majority of the deer visited were the result of illegal kills or crippling losses sustained during the hunting season. Viscera from field dressed deer are also important.

Manner of Hunting

Night seems to be the most common time for foxes to hunt. Most signs indicate that the hunt begins at or near dusk and terminates in the early morning. Snowfalls that stopped after five o'clock in the morning were usually unproductive of tracks. This indicates that most travel is done at night. Diurnal travel is not uncommon however. Seton (1925) states that diurnal travel increases later in the winter. On several occasions I jumped foxes while on the trail during the day. On these occasions, there was no indication of beds. In breeding season there is probably more daylight movement than at other times. On one occasion three foxes ran out in front of me, being totally unaware of my presence. One of the foxes, a female, was killed and found to be in oestrus, which may account for their movement. At other times I have jumped single individuals in daylight hours. These records indicate that diurnal movement is not uncommon.

Foxes seem to meander about the woods, investigating anything interesting. In the course of an evening hunt, foxes usually zig-zag

and circle through a variety of habitats, apparently depending on chance to obtain food. There seemed to be very little effort to hunt a specific prey animal with any degree of persistence. The general pattern seemed to be a disconcerted search, where everything is investigated. The extremely varied diet of the fox may account for this trait.

During the hunt, foxes investigate carefully most windfalls, brush piles, rock piles, stumps, upturned roots, hollow logs, and other places of possible food. When going across cut-over areas with many stumps, the line of travel visits all the stumps, resulting in an intricate trail. As these are excellent places to find mice, it is believed that this is in search of food. Other areas closely examined are tufts of grass protruding from the snow. Several attempts at mice were found in these situations (Fig. 8). It is believed that most of these areas are investigated for food.

Carrion is an important source of food for foxes in winter. As most of the study area is in good deer country, there is quite a bit of deer carrion present. On occasion foxes went directly to carrion quite a distance away. This was probably due to memory of these locations, as I believe that the scent would not carry that far. On other occasions however, while a fox was apparently wandering through the woods, it would abruptly change its direction of travel and proceed in a straight line to a supply of carrion. I believe that they scent food in such cases, and proceed to the source. Portions of carrion were dug up and worried long after any edible flesh remained. Examples of this are the lower portions of deer legs and bones devoid of meat.

With few exceptions, snowshoe hares were the only rabbits present.

Fig. 8.--Tracks of red fox hunting small rodents. Note investigation of stumps and other places of possible food.

Most of the travel of snowshoe hares is done along well established runways. As a result, these runways are quite large and very well packed. Foxes follow these runways quite often, but seldom for a very long distance. Usually the runways are well enough packed to hold up a fox. Thus it is very difficult to see if attempts are made for rabbits while on these runways. As these runways also provide a good travel route, it is possible that some of the time they are used as travel lanes. Only two rabbits were killed along runways. These rabbits were apparently sighted and captured after a short, fast run. Foxes also seem to prefer to walk along a porcupine trail. No instances were noted where foxes attacked porcupines, but carcasses were eaten as carrion.

Foxes, in their wanderings, apparently depend mostly on their sense of sight or sound to obtain prey. The most common method of capturing mice was to make a short pounce or two when the animal was sighted. It appeared that the front feet were used to hold the mice until grasped in the mouth. Seven animals were killed in this manner. No actual observation of a kill was recorded, but the signs left in the snow were interpreted to the best of my ability.

The effectiveness of the fox's hunting methods and its degree of success is questionable. Many attempts are seen while tracking, with surprisingly few captures. The majority of attempts were made on small mammals of the mouse size, and as animals this size can be "bolted" without replacing them on the ground or tearing the flesh into smaller pieces, it is difficult to determine the number of kills. However, many attempts were made on larger animals such as rabbits, and birds with a small degree of success. It seems that swift moving alert game is quite effective at evading the fox.

No particular prey seemed to be the object of any one hunt. Hunting took place in areas of concentrations of prey animals, but it seemed to be chance more than predetermination that decided the food. Microtus seemed to be the easiest prey caught.

Storage Habits

Foxes have a habit of storing up food when they have more than they need. On several occasions I have found where they have fed on a food item, carried a portion away and buried it in the snow. An article in Seton (1925) states that foxes usually bury surplus food, and that foxes infallibly return to these sites. He also believes that a fox will not touch another's cache unless really hard pressed. Some people believe that these caches are marked by urination, but this habit was never observed on this study.

Winter Foods by Species

Mice and Voles

Mice and voles are the most frequent winter food of the northern red fox. These include the meadow vole (Microtus pennsylvanicus), white footed mouse (Peromyscus spp.), red-backed vole (Clethrionomys gapperi), common house mouse (Mus musculus), and the bog lemming (Synaptomys cooperi).

In scat analyses, stomach analyses, and field records, mice have the highest frequency of occurrence of all food items. Scat analyses showed a decrease in the frequency of mice as the winter progressed. The highest frequency of occurrence, 82 per cent came in January, with a considerable decline in February and March (see Table 4). Almost no

TABLE 4.--Winter foods of red fox in central Upper Peninsula determined from analyzing 58 scats collected in winter 1955

Food Items	Frequency of Occurrence (Per Cent)									
	January		February		March		Unknown*		Total	
Mammals										
Peromyscus spp.	**(5)		(9)		(5)		(0)			
Microtus spp.	(8)		(5)		(3)		(2)			
Clethrionomys spp.	(2)		(0)		(0)		(0)			
Synaptomys spp.	(1)		(0)		(0)		(0)			
Cricetidae (total)	82	(9)	48	(12)	47	(7)	29	(2)	51	(30)
Tamiasciurus hudsonicus	0		0		13	(2)	0		3	(2)
Erethizon dorsatum	0		24	(6)	6	(1)	0		12	(7)
Lepus americanus		(4)		(8)		(7)		(4)		
Sylvilagus floridanus		(0)		(0)		(1)		(0)		
Leporidae (total)	36	(4)	32	(8)	53	(8)	57	(4)	41	(24)
Blarina brevicauda		(4)		(2)		(0)		(0)		
Sorex spp.		(0)		(3)		(2)		(0)		
Soricidae (total)	36	(4)	20	(5)	13	(2)	0	(0)	19	(11)
Odocoilius virginianus	45	(5)	92	(23)	73	(11)	28	(2)	70	(41)
Vulpes fulva	0		16	(4)	0		28	(2)	9	(6)
Domestic stock	0		4	(1)	0		14	(1)	3	(2)
Birds	0		24	(6)	6	(1)	0		12	(7)
Vegetable matter	36	(4)	24	(6)	6	(1)	0		19	(11)
Unknown	0		4	(1)	6	(1)	28	(2)	6	(4)

*Winter-date unknown.
**Species occurrence.

change in frequency of occurrence was noted for February and March. This may indicate that mice and voles get progressively harder to capture as the snow gets deeper. As mice decreased in the diet, carrion, which was fairly abundant, increased in frequency.

Due to the small size of mice and voles, it takes much more effort to secure a full meal. Tracking records suggest that most of the hunting of foxes was for mice and voles. In analyzing the winter stomachs, mice and voles were the most frequent item, but due to their small size, they did not compose the greatest volume.

Field records show that foxes apparently make many attempts at mice without success (Tables 5 and 6). Field observations show that in 1954-55, foxes were only 8 per cent successful in capturing mice, while the tracking data from 1952-1954 shows that foxes were only 5 per cent successful. However, the records of kills are believed to be an under-estimate, and therefore the success estimates are probably too low. The small size of the animals make it possible for a fox to catch a mouse and eat it without leaving fur or blood on the snow, or without placing the animal back on the snow before eating.

Apparently all the mice captured by animals tracked during this study were consumed at, or soon after capture. At no time did I find any indication of foxes caching mice or voles.

Small mammals undoubtedly are important prey for foxes, as they occur in high frequency in both the scats and stomachs. Considering their size, they occur in a surprisingly high volume in the stomach. The meadow vole was most frequent. This is apparently due to the abundance and widespread distribution of this animal (Burt 1946). White footed mice were the second most frequent, probably due to the

TABLE 5.--Winter food habits of red fox as determined by field observations along 98.4 miles of trails in east central Upper Peninsula - 1955

Food Items	January			February			March		
	Killed	Attempts	Carrion Eaten	Killed	Attempts	Carrion Eaten	Killed	Attempts	Carrion Eaten
Mice & Voles	4	26	0	2	29	0	1	19	0
Red Squirrel	0	1	0	0	3	0	0	1	0
Porcupine	0	0	1	0	0	3	0	0	2
Snowshoe Rabbit	0	11	1	2	6	5	0	0	0
Cottontail Rabbit	0	1	0	0	2	0	0	0	1
Deer	0	0	7	0	0	9	0	0	4
Cow	0	0	1	0	0	0	0	0	4
Ruffed Grouse	0	4	2	0	0	1	0	0	1
Song Birds	0	0	0	1	0	1	0	0	0
Poultry	0	0	1	0	0	0	0	0	0
Moles & Shrews	0	0	5	0	0	0	0	0	1
Frogs	0	0	1	0	0	0	0	0	0
Non-edible	0	0	0	0	0	0	0	0	1

TABLE 6.--Winter food habits of red fox as determined by field observations of Department of Conservation personnel while tracking foxes 25.5 miles in central Upper Peninsula 1952-54

Food Items	Winter Months		
	Killed	Attempts	Carrion Eaten
Mice and Voles	1	20	0
Red Squirrel	0	0	0
Porcupine	0	0	0
Snowshoe Hare	0	5	0
Cottontail Rabbit	0	3	0
Deer	0	0	0
Cow	0	0	1
Ruffed Grouse	1	5	0
Shrews and Moles	4	0	0
House Rat	0	0	1
Rodent, unknown	0	0	1

abundance of the animals in the travelled habitat. (See Table 7.) It is unknown whether the difference in occurrence in the diet is due to a preference on the part of the fox or to differential difficulty in capturing these animals. The house mouse, red backed vole, and bog lemming occur less frequently, and are probably the result of random hunting.

From the evidence gathered, it is evident that mice and voles are one of the most important food items of the red fox in northern Michigan. Despite heavy snows, the frequency of occurrence and the total bulk indicated that this class of animals is an important food item.

TABLE 7.--Winter foods of red fox determined from analyses of 42 fox stomachs collected in east central Upper Peninsula in winter of 1955

Food Items	Frequency of Occurrence (Per Cent)										Occurrence by Volume (Total Winter)	
	January		February		March		April		Total		Ml.	Per Cent
Mice and Voles	60	(6)*	60	(12)	40	(4)	0		60	(22)	940	17
Deer	30	(3)	35	(7)	30	(3)	100	(2)	36	(15)	1,774	31
Snowshoe Hare		(3)		(6)		(3)		(0)	29	(12)	750	13
Cottontail Rabbit		(0)		(1)		(0)		(0)	2	(1)	105	2
Hares and Rabbits (Total)	30	(3)	30	(6)	30	(3)	0	(0)	29	(12)	855	15
Porcupine	0		10	(2)	0		0		5	(2)	155	3
Woodchuck	10	(1)	20	(4)	0		0		12	(5)	602	11
Red Squirrel	10	(1)	5	(1)	0		0		5	(2)	60	1
Shrews and Moles	10	(1)	25	(5)	10	(1)	0		17	(7)	176	3
Ruffed Grouse		(2)		(1)		(1)		(0)		(4)	313	6
Birds (Total)	20	(2)	15	(3)	40	(4)	0	(0)	21	(9)	398	7
Poultry	20	(2)	10	(2)	10	(1)	0		12	(5)	419	7
Vegetable Matter	0		15	(3)	10	(1)	50	(1)	12	(5)	115	2
Non Food	10	(1)	15	(3)	0		0		9	(4)	15	trace
Unknown	0		5	(1)	0		0		2	(1)	18	trace

*Figure in parenthesis is the number of times occurred.

Snowshoe Hares and Cottontail Rabbits

Snowshoe hares and cottontail rabbits constitute the third most important winter food item. As the snowshoe hare is far more abundant than the cottontail rabbit in the Upper Peninsula, it occurs much more frequently in the red fox diet. Cottontail rabbits were observed during this study, but they were quite scarce.

Leporids ranked third highest in number of occurrences and also ranked third in total volume. It was found that they constituted 15 per cent of the total volume of food consumed for the winter of 1954-55.

Snowshoe hares commonly travel along heavily packed, well established runways, it is difficult to determine the degree of hunting done by foxes on these runways. The packed snow enables foxes to walk on the top of the runway, and it is very difficult to determine the number of attempts made to capture hares. In this study foxes were successful in capturing snowshoe hares 12 per cent of the times attempted. When unsuccessful attempts were made, the foxes did not pursue the hares more than 40 to 50 feet. A snowshoe hare can probably evade a fox if it gets sufficient warning, and escape cover is near. I did not find any occurrences where foxes pursued snowshoe hares once the hare had left the well packed runway.

Places where two hares were killed by red fox were observed during the winter of 1954-1955. In both occurrences the foxes probably signted the hares and broke into a rapid run, catching the hares within 20 feet. A careful interpretation of the tracks indicated that the foxes probably had no previous knowledge of the presence of these animals either by scent or previous visual detection. Six other hares were observed to have been fed upon, as carrion. The cause of

death was not determined, however one of the hares appeared to have been killed by an owl.

Even though snowshoe hares were near the low of their cycle in the Upper Peninsula during this study, fresh signs were observed along 90 per cent of the trails followed. Schofield (1959) reports only one snowshoe hare and five cottontail rabbits killed by foxes in 1,000 miles of tracking in southern Michigan. In my study two snowshoe hares were killed by foxes whose tracks I was following. In addition parts of six snowshoe hares were found along the trails as carrion.

I believe that the snowshoe hare is an important winter food for red foxes in the Upper Peninsula. Because of the abundance of snowshoe hares, and the relatively low success foxes have in capturing them, fox predation does not seem to seriously affect the breeding population of the hares. In the Upper Peninsula hares are probably underharvested by human hunting and animal predation combined. Cyclic population fluctuations seem to be the dominant controlling factor.

Deer

Deer meat is an important food for foxes in the winter time. As it is virtually impossible for foxes to kill adult deer, all the deer consumed at this time of the year was probably carrion from hunting season losses, predation, and illegal kills. Also, portions discarded by hunters, such as intestines and stomachs and lower portion of legs, were utilized by foxes. No known case of deer starvation was found by the writer, but there seemed to be an abundance of dead deer left after the hunting season. Deer occurred in 36 per cent of the stomachs analyzed, comprising the greatest bulk of any single food

species, namely 31 per cent by volume. Deer occurred in 70 per cent of all scats analyzed. In the field, fox tracks led to deer carcasses on 20 different occasions. Seton (1925) lists a report of Yellowstone Park foxes feeding largely on elk and deer carrion in the winter. Schueler (1951) seems to feel that deer carrion is among the most important food item in late winter and spring. Schofield (1959) reports deer carrion made up the bulk of the winter food of foxes in the northern part of southern Michigan.

Deer carrion seems to be a preferred food of foxes, as they revisited deer carcasses until nothing was left. Inedible portions of the deer were constantly dug up and dragged around. Foxes apparently have a good memory for carrion, as they were observed to have travelled in a straight course for considerable distances, and then dug down into the snow to uncover the food. The scent would probably not carry under those circumstances, therefore a good memory is the only answer.

It has been well established that the diet of the red fox is somewhat omnivorous (Burt 1948, Arnold 1956). Due to the deep snow in the winter months, vegetable matter is scarce. As foxes seemed to highly prefer deer stomachs (either discarded by hunters or from other carrion), it may be that this partially satisfies a desire for vegetable matter. When no other part of the carcass was consumed, the stomach was invariably utilized.

Porcupine

Porcupines were found in only two stomachs, but composed three per cent of the winter foods found in the stomachs. They were utilized six times as indicated by field observations, and occurred seven times in fecal collections.

It is believed that foxes are physically capable of killing porcupines, but that this is not common. Foxes, on several occasions walked along trails made by porcupines, and in one instance investigated a porcupine den with the animal in it. Without showing undo curiosity the fox moved on. On another occasion, a fox dug down into the snow and uncovered a dead porcupine, but did not eat any of it.

Porcupines found as carrion is usually the result of hunters having a grudge against the "porky", believing that they kill trees. Animals killed in this manner provide a considerable supply of carrion.

I killed a porcupine and left it intact in the vicinity of a fox den. Three weeks went by and foxes had not bothered the carcass, or even investigated closely. The animal was then thrown to within ten feet of the entrance of the den. It remained near the den for two more weeks with no apparent effect. On March 15, 1955, it was discovered that foxes had finally utilized the porcupine, and had consumed all the edible flesh. The skin and the remainder of the carcass had been dragged about 200 feet by one of the foxes. Tracks in the vicinity gave the impression that some of the quills had stuck in the face or head of one of the foxes since there were marks in the snow that looked as if a fox were rubbing itself along the snow. The carcass was opened from the belly side, and the skin seemed to have been peeled back from the flesh. The fleshy tail was also left (Fig. 9).

Foxes ingested quills with no apparent ill effects. Quills still firm enough to penetrate the skin were found in scat specimens. One stomach contained a considerable number of quills some of which had penetrated the stomach wall. A hardening of tissue at the point

Fig. 9.--Porcupine carcass "skinned" by red foxes.

of penetration seemed to be the only affect on the animal. Seton (1925) lists one instance where quills had apparently been harmful to foxes -- a fox killed in an emaciated condition which had quills embedded in its mouth and throat.

Moles and Shrews

These animals were the only items the foxes commonly discarded. Six shrews, 4 short-tailed shrews (Blarina brevicauda) and 2 masked shrews (Sorex cinereus), were found discarded along the trail. Latham (1951) states that foxes kill, but seldom eat shrews and moles, and suggests that these animals may be distasteful.

However, shrews and moles do occur in the fox diet more often and in greater volume than is generally believed. In fecal analyses in this study these animals occurred 11 times, a 19 per cent frequency of occurrence, but consisted of only 3 per cent of the total food volume.

Dearborn (1923) reports that the short-tailed shrew and both the prairie mole (Scalopus aquaticus) and star-nose mole (Condylura cristata) were eaten by foxes. In this study the short-tailed shrew, star-nosed mole, and masked shrew were found in both stomachs and scats.

In view of the evidence, I believe that this class of food is certainly not preferred, but is occasionally utilized. It is probable that these foods are utilized more in the winter than in the summer due to the greater food shortage. Schueler (1951) found a high incidence of Insectivores in scat analyses in a wilderness area in New York. As this study was also conducted in a semi-wilderness area,

this similarity may be significant.

Squirrels

Squirrels occurred only twice in the stomach analyses. Both occurrences were of the northern red squirrel (Tamiasciurus hudsonicus). The total volume consisted of only 1 per cent of the total winter food volume. These two occurrences are attributed to carrion or unusual luck in capturing the animal. It is unlikely that this animal constitutes much of the winter diet as the speed and agility of red squirrels is sufficient to enable them to escape the fox.

Domestic Animals

The only occurrences of fox feeding on domestic stock involved cattle. Fecal analysis showed domestic stock two times or in 3 per cent of the scats, while field observations showed four occurrences of foxes feeding on cattle. The only source of domestic stock in the winter is carrion as most of the stock is penned or closed in.

One cow that I observed to be carrion and food for foxes, was heavily utilized by other animals also. Foxes ate down into the body cavity and continued from the inside out. This class of food is not considered an important source of food due to relative unavailability. However, when domestic stock is available as carrion it seems to be fully utilized.

Woodchuck

Woodchuck (Marmota monax) was found only in stomach analysis but occurred in 12 per cent of the stomachs. How foxes capture woodchucks in winter can only be guessed at. I believe that foxes, while

seeking and enlarging dens in preparation to the denning season, occasionally choose woodchuck dens with a hibernating animal inside. Also, woodchucks have been known to come out of hibernation during warm spells in the winter (Burt 1948), when foxes may capture them. Woodchucks are a common food of foxes (Hamilton 1943, Dearborn 1923), but usually in summer.

The animals that contained woodchuck remains had a large volume of this food in the stomach. The apparent gorging on these animals account for the large bulk of this prey species. Due to their hibernating habits and their rare appearances during the winter months, this food item is not considered as important. I believe that the above occurrences do not give a true picture of their importance.

Birds

Birds constituted 7 per cent of the winter diet as determined from stomach analyses. Fecal analyses showed birds occurring in 12 per cent of the scats. This total does not include poultry, which will be discussed later. Of the 9 birds found in the stomachs, four were ruffed grouse (Bonasa umbellus), 4 were unidentified songbirds, and the other bird was larger, but not a game bird.

In the tracking data of 1954-55, I noted four attempts to capture grouse, all unsuccessful. Four times I found where foxes had fed upon grouse carrion. Very little of the birds remained at the time of observation; thus cause of death was unknown. The tracking data of 1952-55 lists five attempts, with one kill on ruffed grouse. Ruffed grouse were common throughout the study area, yet very few attempts were made to capture them.

Schofield (1959) found no ruffed grouse kills during 1,000 miles of tracking in southern Michigan. Nineteen dead grouse were found as carrion along the 1,000 miles. At least 4 of these birds were killed by hawks or owls. Cause of death could not be determined for the remaining 15 birds.

The small number of times that ruffed grouse occurred indicated that red foxes are not serious predators of this game bird during the winter months. Only one kill was noted in 124 miles of tracking. Grouse occurred as carrion along the trails only 4 times during this study.

Songbirds were present four times in the stomach analyses, but in no case was enough left for identification. I found one instance of a fox catching a pine grosbeak. The bird apparently had roosted on a limb close to the ground. The fox evidently leaped and caught the bird, for feathers and blood on the branch indicated this. The fox then proceeded to rip out feathers which were scattered over a large area. Only feathers and some blood was left in the snow.

Due to roosting in trees and shrubs, most songbirds are not accessible to foxes. I believe that songbirds found in the fox's winter diets are carrion or the result of very exceptional circumstances.

Larger, non-game birds present were owls, hawks, crows, and raven. Of this type of bird, the only occurrence would probably be as carrion.

Poultry in this study consisted of barnyard chickens. On only one occasion was a chicken noted to have been fed upon in the field. On that occasion the chicken had been thrown out by a farmer, and then

a fox fed on it as carrion. In stomach analyses poultry occurred in 12 per cent of the stomachs and consisted of 7 per cent of the total food volume. As the farmers keep their chickens locked up in the coops all winter long, these occurrences must have been from carrion discarded by the farmers. Thus, while chicken probably is a preferred food, it probably cannot constitute an important winter food.

Vegetable Matter

Vegetable matter found in stomachs or droppings consisted of leaves, twigs, etc. Fecal analyses showed vegetable matter in 11 specimens, a 19 per cent frequency of occurrence. All of this, however, may not be considered as food, but material taken incidental to hunting for mice and other animals. However, in the stomach analyses five stomachs did hold enough vegetable material to be considered as food. I was unable to identify most of the vegetable matter as it was partly digested. This consisted of only 2 per cent of the total volume.

Previous studies (Dearborn 1923), Seton (1925), and Hamilton (1943) have shown that the fox is omnivorous. Deer entrails are perhaps the most available part of the deer, as hunters clean the animals and leave the stomach and intestines where the deer is killed. This source of food appears to be highly utilized by foxes. Much of the vegetable matter in the stomach is eaten along with the viscera.

I believe that other types of vegetation found in winter fox stomachs are accidental rather than preferred foods. One stomach, however, showed the seeds of apples in considerable quantity. These could be all that is left from digested apples or they could have come from garbage. Dearborn (1923) and Seton (1925) both indicate that

fruit is a preferred food. Fruits, however, cannot play a very important part most of the winter.

Although vegetable matter consisted of only 2 per cent of the total volume in the stomachs, I believe it to be an important addition to dietary requirements.

Inedible Material

Non-food items were the materials found in stomach or scat groups that were absolutely inedible. These are surely ingested accidentally. Only 0.3 per cent of the food was in this category: bits of rubber twice and cellophane once. These probably came from garbage.

Fox

Fox hair was found to be present in many of the stomachs in trace amounts. These occurrences are probably the result of foxes licking themselves. The fur seemed to pull out easily as patches of fur were common in the beds.

SUMMARY

The predatory habits of the red fox and its status as a bountied animal have created a state-wide controversial issue. Research has revealed the fox's relationship to the wildlife communities of southern Michigan. This study was undertaken to better understand the relationship of foxes in wildlife communities in the Upper Peninsula of Michigan.

Field data were gathered during the winter of 1954-55, in the east-central Upper Peninsula of Michigan. Foxes were trailed 98.4 miles to study behavior and food habits during the winter. In addition, game biologists recorded data along 25.5 miles of fox trails in the Upper Peninsula from 1952 to 1955. A total of 58 fox scats were collected during the winter. Stomachs were saved from 42 animals during the winter for food analysis. Reproductive tracts from 22 females were examined to determine breeding dates and litter size. Twenty-one bacula and 42 skulls were saved and used to indicate age.

The red fox is the only fox species commonly found in the Upper Peninsula of Michigan. There are authentic records of red fox in every county in the Upper Peninsula with the exception of Keweenaw County.

The first indication of the breeding season was noted on February 5, 1955, but a pregnant female, taken February 9, 1955, establishes breeding as early as late January. Five females were collected in

oestrous between February 5 and March 5, 1955. Thus the peak of the breeding season has been placed as February and early March. The ovulation rate is based on the presence of Graafian follicles and corpora lutea in eight females. Mature Graafian follicles averaged 5.6 with extremes of 4 and 8. The corpora lutea averaged 5.6 with extremes of 5 and 6. Two specimens with embryos averaged 5 embryos per animal.

The age was determined by cranial characteristics. The first two age classes (0-22 months) made up 76 per cent of the population. Males were also aged as adults and juveniles by using the characteristics of the baculum. This method agreed closely with the age as determined by cranial suture.

The average weight of 17 males was 10 pounds 2 ounces. Females averaged 9 pounds 3 ounces.

The average tracking distance from where tracking first began to where the fox was jumped was 2.17 miles (minimum .64 miles, maximum 5.9 miles). The average straight line distance from the point where trailing first began to the beds was 0.79 miles. The home range was estimated as 12-20 square miles.

Permanent dens were used regularly during the entire winter. Interest in other dens increased as the breeding season approached.

Foxes traveling in pairs was more common in late winter as breeding season approached. Males apparently will fight for the females favors, but serious injury appears rare. No other evidence of social behavior was noted. Fox signs indicate that the hunt begins at or near dusk and terminates in the early morning. Hunting methods employed in the winter was stalking and pouncing, and chasing. Foxes tend to hunt alone in the winter. They do not appear to hunt in groups as wolves

and coyotes do.

Foxes tend to meander about the woods in their search for food. They visit a variety of habitats and depend mainly on chance to capture prey. Excess food is commonly stored for future use. Mice and voles were the most frequent food item detected in the winter diet of red foxes. In scat and stomach analyses and field records, mice had the highest frequency of occurrence. Mice and voles ranked second in total volume.

Snowshoe hares ranked third in both frequency of occurrence and total volume. Two hares were killed by foxes along trails I followed. Five other hares were fed upon as carrion.

White tailed deer shot and wasted by hunters is a very important source of winter food. Deer carrion had a high frequency of occurrence and ranked first in total volume. Field observations indicated a high utilization of deer carrion. Vegetative matter in deer stomachs was also eaten.

Porcupine occurred in 12 per cent of the scats and 5 per cent of the stomachs. Most porcupine is eaten as carrion.

Moles and shrews were commonly killed and discarded. However, insectivores occurred more often and in greater volume than is generally believed.

Red squirrels were found occasionally in the winter diets. Field observations indicate it is difficult for foxes to capture squirrels, and their presence in the diet is attributed to carrion eaten.

Domestic animals are utilized when available. However, this source of food is not considered important due to the relative unavailability.

Woodchuck occurred in 12 per cent of the stomachs analyzed. Source of these animals are believed to be from hibernating animals.

Birds constituted 7 to 12 per cent of the winter diet. Ruffed grouse occurred in stomachs 4 times for 6 per cent of the total volume. No evidence of actual grouse kills were observed in this study. Songbirds occurred occasionally in winter diet.

Poultry was present in 12 per cent of the stomachs. Due to poultry being confined in winter months, this source of food must be from carrion.

Vegetable matter consisted of only 2 per cent of the total volume. This may be an important dietary requirement.

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