UNIVERSITY OF MICHIGAN
MUSEUM OF ZOOLOGY
MISCELLANEOUS PUBLICATIONS NO. 32

FOLLOWING FOX TRAILS

BY
ADOLPH MURIE

CONTRIBUTION FROM THE EDWIN S. GEORGE RESERVE,
UNIVERSITY OF MICHIGAN

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
August 7, 1936

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FREDERICK M. GAIGE
Director of the Museum of Zoology

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INTRODUCTION

Miscellaneous information on the food habits of the red fox, not only in America but also in Europe, has been available for so long a time and has been characterized so often in literature, that in the public mind the red fox diet has become more or less legendary.

In recent years, when many of our carnivores are forced into closer contact with human affairs, and we feel the necessity of taking precautions to preserve wild animal life from extinction, the need for more exact knowledge of the food habits of many species, including the fox, has become apparent. Investigators have been responding to this need with various studies of stomach contents or droppings, and progress is being made.

It was felt that a close study of a single locality, or of an individual animal, or a small group of animals over a period of time would be of especial value. An opportunity for such a study was presented at the Edwin S. George Reserve, an outdoor study area administered by the Museum of Zoology, University of Michigan, located in a farming section five miles from Pinckney, Michigan.

A study of a pair of foxes (*Vulpes fulva*) was begun in January, 1934 and continued until the following August. The field work consisted mainly in gathering fox droppings for food determination and in observing as depicted in the snow the habits of the fox. Snow in which tracks may be easily followed is not too plentiful in the rather mild climate of southern Michigan so that opportunity or this method of study was somewhat limited.

Concurrently with this study investigations were being made of the food habits of the white-tailed deer inhabiting the same area, and all possible information was secured on other members of the fauna of the Reserve, as well as on the vegetation. It was the purpose to consider the data on the red fox in its ecological background.

Since the completion of these investigations other field work has so constantly kept me away from laboratory facilities that I have not had the opportunity to analyze personally the contents of the droppings. I have examined briefly, however, most of the material after the determinations were made. I am greatly indebted to Harold Leraas, then of the Cranbrook Institute of Science, for the painstaking labor of identifying the vertebrate contents of the droppings. I am also indebted to Lawrence M. Saylor, University of California, for making the insect determinations, to Joseph S. Dixon, Wildlife Division, National Park Service, and Seth Benson, Museum of Vertebrate Zoology, University of California, for the identification of some sheep remains, and to Josselyn Van Tyne, Museum of Zoology, University of Mich-

igan, for examining down feathers picked up at food caches. I wish to express my appreciation to Paul F. Hickie, of the Michigan Department of Conservation, for supplying valuable data, and to L. R. Dice and F. M. Gaige of the Museum of Zoology, University of Michigan, for generous aid at all times and many kindnesses.

DESCRIPTION OF THE GEORGE RESERVE

The Edwin S. George Reserve of the University of Michigan consists of twelve hundred acres of typical rolling glaciated terrain inclosing a small pond a hundred yards long, a small stand of cat-tail, a large cassandra bog about five hundred yards long by two hundred yards wide, two extensive tamarack swamps, one about twelve hundred yards long and half or less as wide, the other six hundred yards long and one to two hundred yards wide, groves of oak and hickory fairly well distributed, extensive areas of grass ranging from wet meadow to dry grassland in type, and deserted, cultivated fields now grown up in grass, asters, everlasting, herbaceous cinquefoil, goldenrod, and blackberry and smooth sumac in patches. There are also about fifteen acres of alfalfa. The tamarack swamp is characterized by poison sumac, Michigan holly, mountain holly, low swamp birch, shrubby cinquefoil, spiraea, buttonbush, viburnum, dogwood, ferns, sedge, and tamarack. Around the edges of the tamarack swamp there are various combinations of the other listed species. There is an extensive area in which spiraea, swamp birch, and shrubby cinquefoil are dominant, and there are small patches of almost pure sedge. Dogwoods form brushy stands on many of the margins. In the woodlands there is an understory of hazel, witch hazel, black huckleberry, sassafras, young oaks, and black cherry. Between some of the fields stands a single line of trees which formerly probably separated farms. A high game fence more or less dog-proof incloses the Reserve. Adjacent to it are many small farms.

HUNTING HABITS

I was usually able to follow only a part of the extensive tracery of prints left by the foxes after each snowfall. Not only was the day too short to follow all of them, but part of the time I followed deer tracks to observe the food habits of deer (*Odocoileus virginianus borealis*). Tracking is a valuable method of learning animal habits for it is practically equivalent to observing an animal for a long period of time under natural conditions; the trail is a sign language which only needs a certain amount of interpretation to be understood. Some of the observations made along the fox trails are here related. The food items noted along the trails are listed in Table I.

January 8

A little less than an inch of snow had fallen during the night, forming a fairly smooth tracking surface in the fields where the long grass lay flat, but poor tracking in the woods where the leaves lay loose so that the snow flakes slid into crevices between them. Near the south gate where I entered the Reserve there were tracks of two foxes, a house cat, and an opossum (*Didelphis v. virginianus*). One of the foxes, traveling along a level bench grown up in weeds, had made a right angle turn, and five yards to one side had uncovered a prairie deer-mouse (*Peromyscus m. bairdii*) which, on a previous occasion, had been cached in a dirt depression of just the size to accommodate it. The head was chewed and partly missing, and the fur was moist with saliva. The mouse was not re-cached but was lying where it had been uncovered. The fox continued along the bench, turning aside to inspect all burrows along the way, entering one or two of them. After passing through a piece of woods the fox had stopped at the carcass of a buck deer lying in the marsh beside a water hole where it had died the previous September. After investigating the premises and the carcass rather thoroughly, but not eating any of the decayed, dried shreds of meat which still adhered to the backbone, the fox had gone into the woods again.

The deer carcass was a rallying-point for a number of animals; the cat tracks reappeared, and the opossum had also been there, fresh chewing and mouthing of the bleached shreds of deer tissue showed that he had tried to manage a meal. Cat tracks were never again seen which suggests that the fox may have eliminated the cat. (A cat claw was found in a June dropping.) A medium sized bird, possibly a jay, had perched about the carcass. Although any group of bones, on its own merits, is something for a fox to investigate, the presence of other creatures at a carcass must make his visit doubly important and perhaps fruitful.

Tracking was so poor in the woods that I did not try following the fox beyond the deer carcass but instead turned back to a meadow where I found another track which led through a marsh and up the hill three hundred yards to an apple orchard where fox tracks were very numerous. In one corner of the orchard lay the front leg of a muskrat, and there were spots of blood in the snow where the fox had been feeding. The muskrat had probably been taken in the marsh below the orchard. A short distance away the fox had been feeding on a rabbit. Blood marks and the tail were all that remained. In one place part of a decayed stump had been torn away, perhaps in a vain effort to get at a deer-mouse.

At the edge and near the center of the swamp I found the beds of two foxes about one hundred and fifty yards apart. I had evidently jumped one of the foxes, for the tracks leading away from the form showed that the fox had been galloping.

January 14

Some snow had fallen during the night but not enough for good tracking. In crossing a field, which supported a sparse stand of dead weeds, I found where a fox had dug out a nest made of fine grasses. The bottom of the nest cavity was about seven inches deep. The nest probably belonged to a prairie deer-mouse, rather than to a field mouse for it was in a habitat more typical of the former. From here the fox had trotted down an old road only a short way before catching something four yards to one side. A few flecks of blood on the snow marked the spot.

February 19

A farmer, taking advantage of five or six inches of new snow, was out early this morning looking for signs of game. He came to my door shortly after daybreak to say that he had noticed the track of a big dog fox cross the road about three hundred yards from the house; he wondered if we would mind if he set a trap or two for the fox just outside the Reserve fence. I explained that I was making a study of the fox, and suggested that it might be to his advantage to let the foxes in the neighborhood breed for a year or two. To this suggestion he graciously agreed, and said he did not care particularly about getting the fox but would "just like to take a shot at him." There was something genuine about this farmer; he was out enjoying a snowy morning, happy to be in the woods, and, paradoxically as it may sound, he liked the foxes he wished to shoot, liked "to have them around." Although his remark concerning "a shot at the fox" seemed thoughtless it was perhaps the only way he knew of grasping something from the woods to which he felt akin. The farmer left assuring me that he would do nothing to harm the animal.

The fox had caught a mouse in a narrow strip of grass behind the wood shed but had found there little else of interest, not even any chicken feet or heads, such as no doubt adorn the garbage piles of the various farms in the community with which he was acquainted. He had left a dropping on the road between the house and the Reserve entrance and then had trotted parallel to the fence to a ravine where he could enter the Reserve by crawling under the bottom wire. In the long grass on the brow of a hill the fox had cut back along his trail at a forty-five degree angle for seven feet. Here tracks showed he had been standing, probably listening or smelling to establish the exact location of a mouse before springing four feet and coming down on a clump of grass. There was no sign of a capture, no blood spots on the snow, and nothing had been cached, but a capture may have been made for often there is no indication of the success attending a pounce. The mouse may have escaped or it may have been bolted by the fox.

A little way beyond this point, at the bottom of a ravine with steep sloping sides of loose dirt, the fox had approached a rabbit protected by the wire mesh of a live-trap. (On a study of home range, Mr. Paul Hickie was marking and live-trapping rabbits.) The snow within six feet of the rabbit was covered with tracks, but the trap had not been molested. The fox had

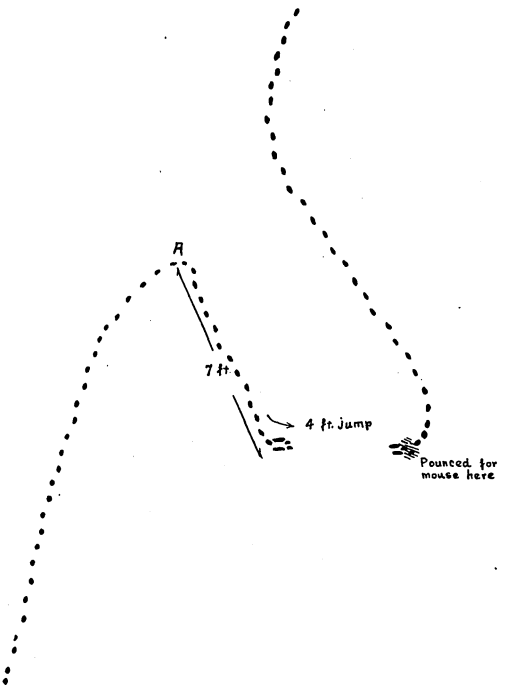

FIG. 1. At *A* the fox turned sharply to one side for a distance of seven feet and pounced on a clump of grass where a mouse was probably captured.

climbed the steep sides of the ravine several times, and along the rim, marks in the snow showed where he had sat on his haunches in five different places to contemplate the strange prospect below him. After tarrying for some time, apparently thoroughly frustrated, the fox followed the fire lane to the orchard leaving another dropping en route.

After a meandering ramble through the orchard and a detour in the swamp below it the fox had trotted over some grassy rolling hills and through a sedge marsh, at the edge of which he had made a dash after a rabbit which had escaped in a hole. In the marsh he had left another dropping. For the next half mile the tracks led from one burrow to another; about ten burrows were visited and at the entrance of each he had left his calling card, a bit of yellow scent.

At this point I left the fox trail to follow deer tracks in order to learn what the deer had been feeding on during the night; but after about three

hours I returned to the fox trail and followed its winding course over a meadow. In four places the fox had gone off to one side six or seven feet to pounce on something in the grass. He must have been feeling frolicsome for he had zigzagged over the snow, in one place picking up a barren corn cob which some fox squirrel had probably lugged in from a farmer's field over the hill. Marks in the snow showed where his tail had been jerked to one side on the sharp turns.

The fox had traveled through a woods on a slope for some distance, passing within thirty yards of the deer carcass at the water hole without turning aside. Scent was left on a stake, three times in the trail, and at two more holes. In the grass at the upper margin of the woods the fox had captured a long-tailed shrew (*Sorex cinereus cinereus*) and tossed it to one side where it lay on the snow unmutilated. Farther on he had nosed an old dropping. From here his trail passed along a marsh, down an old railroad bed, through an isolated group of tamaracks, and into a grass meadow. In the meadow he had caught a least shrew (*Cryptotis parva*) and tossed it to one side. He entered a tamarack swamp where there were many rabbit tracks. There was such a maze of tracks that I was unable to learn what had taken place; the fox had galloped in several places, probably in chase of rabbits.

February 24

I was out early to make use of a light snow which fell during the night. The fox had passed some muskrat houses in a marsh but apparently had not happened to find any of the muskrats abroad although they had been out foraging during the night. In the orchard the fox had been feeding on a muskrat (*Ondatra z. zibethica*). A piece of the back with a little meat and hide attached had been left on the snow; part of a leg had been carried a hundred yards and covered with snow. In a grassy ditch lay the hind quarters of a long-tailed shrew freshly killed; the head and shoulders had probably been eaten. In a weedy field the fox had investigated an old prairie mole (*Scalopus aquaticus machrinus*) carcass which had been previously captured and left in the open. The head had been chewed. In the long grass along a row of trees separating two fields, the fox had torn open two mouse nests and in three places had pounced on mice.

At times the two foxes traveled together, even stepping in the same tracks so that the trail seemed to be that of only one of them. At other times they took parallel courses one or two hundred yards apart or else traveled alone. For a time one fox had traveled on a ridge along the edge of a forest while the other ranged parallel with it in the woods farther down the hill. In two or three places where there was a good view the fox on the ridge had sat on his haunches facing down hill, perhaps gazing toward his mate.

March 14

On this day about 9 A. M. I saw one of the foxes for the first time. He slowly climbed an open hillside to a group of holes near the summit, dug a few sticks and leaves away from the entrance of one of them, and disappeared within. For five minutes he remained at the holes, entering them several times and continuing to scrape away a few leaves. He left at a slow trot, occasionally breaking into a lope. When trotting his tracks were spaced from nine to eleven inches apart (often trotting tracks are spaced fourteen to fifteen inches apart). He left his scent at a tuft of grass.

March 18

As usual after each snowfall fox tracks were to be found over most of the Reserve. I came upon them inside the gate in the meadow along the margin of a depression grown up in a dense stand of ragweed. I often flushed pheasants from this ragweed patch but never found that the fox had entered it. The tracks led into a luxuriant thicket of dogwood and button-bush where rabbit tracks were very numerous and fox tracks were almost equally numerous. There were too many tracks in this thicket to learn what had taken place except that the fox had been chasing rabbits.

On the otherwise immaculate snow, in the center of a small opening surrounded by brush, lay a piece of fresh rabbit hide with some crow tracks beside it. Later, in the meadow near the edge of the thicket, I came upon a spot where the fox had recently been feeding on a rabbit and where the crow had probably salvaged the piece of skin. A front foot still remained, but that was all except for a few tufts of fur.

The fox had struck off across the meadow, crossed a marsh, and followed an old railroad bed to a cat-tail marsh. Along the way he had left scent on a mullein, a bunch of grass, a juniper bush, a snow-covered object which proved to be the remains of an old fawn carcass, and on an old bone, which smelled as though it had been so treated hundreds of times. In the meadow a meadow mouse (*Microtus p. pennsylvanicus*) had been cached beside the trail. The spot was marked by a disturbed patch of snow nine inches across. In the marsh, supporting a growth of swamp birch, spiraea, and sedge, he had followed deer trails lying between the hummocks except where the trails were wet, then he kept to these hummocks making his way by jumping from one to another. In one place he dropped an owl pellet he had been carrying. After passing through the marsh he stopped on the railroad bed to chew two ice balls from his feet; a few hairs stuck to one of the balls.

On a knoll at the east end of the sand flat he had left a dropping. At the edge of a cat-tail marsh an old, dried up, partly eaten fox squirrel (*Sciurus niger rufiventer*) carcass had been pawed out of the leaves. There were many fox tracks in the cat-tail marsh and the brush along its margin.

A least shrew had been captured in a open stand principally of goldenrod and everlasting and left lying on the snow.

In an open oak woods the fox had captured three short-tailed shrews (*Blarina brevicauda talpoides*), the second and third, respectively, three hundred and eight hundred yards from the first. The first one had been cached in the snow, the second had been carried a few yards and dropped where the fox had stopped to leave his scent on a tree, the third had been pushed into a cavity among the leaves eight paces from the place where it had been captured.

March 19

The snow of the preceding day was still on the ground, and the foxes had left a fresh supply of tracks during the night. Since tracking was none too good, and the foxes had in places circled about considerably, it was difficult to get a continuous story of activities. The tracks covered much the same ground as on March 18. In several places along the trail a neat pointed mark in the snow showed where the fox had poked his nose to investigate something, perhaps a faint whiff of a mouse or some other smell of similar interest. As usual scent was frequently left along the way. At times there did not seem to be clumps of grass at which to place it, consequently it was left in the trail where there was no apparent incentive, although there no doubt was or had been one. Possibly a turtle shell or some other object then removed had been the original stimulus, and thereafter it was the fox scent which had accumulated at the spot.

In a meadow where the fox had been trotting along at an easy gait he had suddenly made two jumps of about five feet each and on the second jump had come down on a clump of grass. The mouse which the fox had caught had probably squeaked or made some noise, and the fox had seemingly been able to locate the sound definitely at a distance of ten feet. The meadow mouse had been carried eight paces and hidden at a clump of grass under three inches of snow. Fifty yards farther along the fox had captured a lemming-vole (*Synaptomys c. cooperi*) and hidden it ten paces to one side at a clump of grass. Where each of these was hidden the snow was disturbed over a space ten inches across.

On an open sandy area the fox had dug out a grass nest an inch or two below the ground surface. A prairie deer-mouse had been captured in the nest and was buried in the snow nine paces to one side. After hiding the mouse the fox had returned to sniff at the nest before continuing on his way. On a hillside in the open the fox had dropped a least shrew he had been carrying; there was no indication as to where it had been taken.

In one place a hickory nut had been uncovered and left uneaten. A turkey leg, protruding out of the snow had been sniffed but left undis-

turbed; on a former trip out of the Reserve this leg had probably been picked up in some farmer's back yard. In several places the fox had pounced on clumps of grass in the meadow. A fox had stopped at two badger holes and excavated some dirt near the entrance of each.

March 20

Tracking was unsatisfactory as the snow was entirely gone from the south exposures and was scanty elsewhere. Along a row of trees a fox had captured a lemming-vole and cached it thirty paces to one side in a clump of grass. As usual there were no extra tracks at the cache; the fox had apparently stopped in his stride, poked the mouse into the cavity, and trotted away. The nose is probably used in most instances to cover a cache.

On an open hillside the fox uncovered a short-tailed shrew and left it lying in the open. Its condition proved that it had been dead for several days.

March 28

A heavy snowfall on March 26 and 27 resulted in about twenty inches of snow and good tracking conditions. The crust on the snow was such that the fox remained on top when walking or trotting but broke through when galloping. I broke through at every step, consequently my progress during the day was slow.

On a hillside, grown up in juniper and oak, the fox had dug into the snow at the base of a tree and uncovered a garter snake (*Thamnophis*) about thirty-five inches long. He had tasted the meat around the posterior vertebrae and, at some previous time, he had eaten part of the ribs. The snake was left stretched out on the snow. The following day I found some crow tracks at the spot, and it was gone.

After leaving the snake the fox had frolicked about in an open glade. In his exuberance he had bitten the seed head off a Lespedeza and dropped it a few jumps away.

From the glade the fox had gone to a sandy flat bordering a marsh. Here he had uncovered an old survey stake, the top of which had been five inches below the surface of the snow, and watered it. Evidently this stake was one of the favorite scent stations. His trail followed along the border of the marsh to a large fallen tree, where he had started up a little rise to the sandy flat.

While the fox was thus occupied a weasel (*Mustela n. noveboracensis*) had been traveling in the marsh parallel to its margin. Shortly after the weasel came to a tamarack swamp about a quarter of a mile from the fox, it had started a rabbit. After making a small arc in the swamp, the rabbit had come out on the sandy flat. Apparently it had not been very concerned

nor frightened, for its pace was very moderate for a rabbit, the jumps averaging only about three feet. The weasel also had been progressing with three-foot jumps, which, in its case, meant that it was hurrying along at its best pace. In the swamp the weasel tracks followed closely those of the rabbit, but out in the open they were always a little to one side, usually nearer than four yards, but in places, where the tracks circled more sharply, as much as six yards away. The weasel tracks were on the inside of the arc, giving to the weasel a slight advantage.

After a short run on the sandy flat the rabbit had turned toward the marsh and unexpectedly met the fox coming over the rise. It literally ran into the open jaws of the fox. The fox had not pounced on it but simply picked it off the snow without enough disturbance to break the crust. The only marks on the snow were those made by the sprawling side sweeps of the victim's hind legs, the widespread claw marks showing clearly. The rabbit's jumps continued up to the last at the same even gait.

Evidently the fox had no more than snuffed out the rabbit's life before the weasel caught up with events. Its tracks came within six feet of the rabbit's last marks on the snow, and here they suddenly turned down the short slope. The fox had dropped its prey and dashed after the weasel. The snow had supported the weasel, but the fox had broken through the crust at each jump, which may have been a factor in the weasel's escape under the branches of the fallen tree. On the other side of the tree an irregular line of tracks showed that the weasel had returned to the marsh, probably seeking another rabbit or some other venture less ambitious.

The fox had gone back to his kill, and, after leaving some scent, had carried the rabbit away in his jaws; in a few places the limp body had dragged in the snow. Following an uncertain course for fifty yards the fox had stopped at a juniper bush beside which he cached the rabbit four inches beneath the snow surface. A disturbed area on the snow about fifteen inches across showed the location of the cache. From here the fox had wandered into a cat-tail marsh where he had sniffed at some muskrat tunnels in the snow.

March 29

In a gully I surprised a marsh hawk feeding on a rabbit which was over two-thirds devoured. The rabbit had been removed from a hollow in the snow bank where it had been cached by the fox. Signs on the snow showed that a skunk had followed up the gully, smelled the rabbit under the snow, dug it out, and after a feed continued on his way across a field. Crow tracks showed that these birds had later learned about the rabbit in the gully, then the marsh hawk had come, possibly elbowing the crows away from their meal. The following day two crows flew away from the spot as I approached. A little fur, two cleaned mandibles, and some ribs were all that remained.

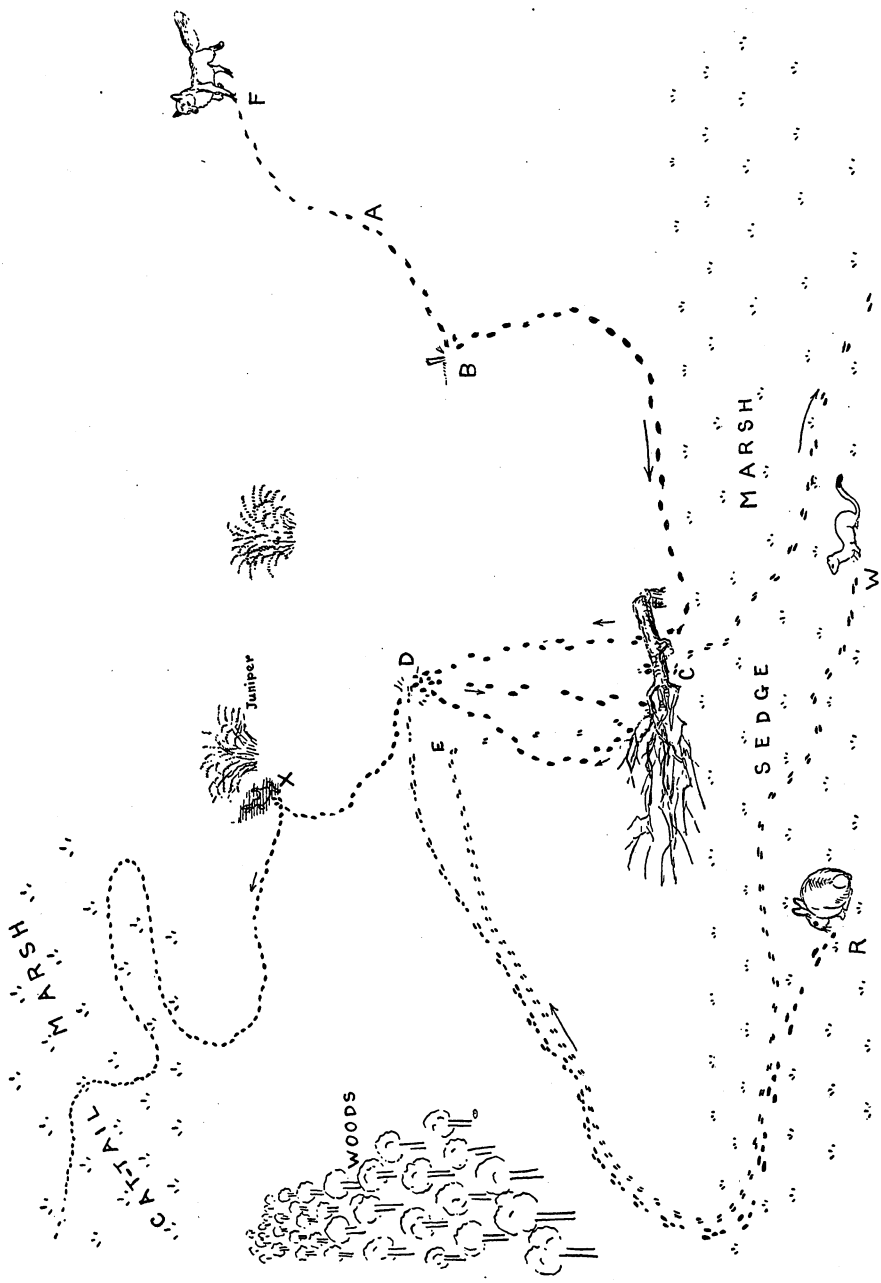

FIG. 2. Semi-conventional and non-proportional sketch of a fox hunting incident, the total space greatly constricted for details. This is the incident described on pages 15–16. The fox, coming over a sandy area, left a dropping at *A*. At *B* he uncovered the surveying stake. A weasel had chased a rabbit to *D* into the jaws of the fox. The weasel arrived at *E* and dashed to *C* to escape. The fox cached the rabbit under the snow at *X*.

March 30

There was still much snow on the ground. In the fields where the sun had shone on the snow yesterday, a firm crust had formed so that fox tracks were very hard to see, especially in the gray light which prevailed all day. During the night the foxes had been unusually active in a tamarack swamp and on some islands of higher wooded ground in this swamp. Both foxes had been hunting, but most of the kills found had been made by the fox with the large track which presumably was the male. It was impossible because of the many tracks to determine the sequence of events along the trail, but the story of several episodes was clearly defined on the snow.

The first fox tracks I found were slightly dirty, and they became increasingly dirty back over the trail as they neared a fresh badger digging on a steep wooded slope which the fox had investigated. Below the badger hole, near the base of the hill, the fox had chased and captured a rabbit in the open woods and had cached it under three inches of snow. The tail was missing, otherwise it was not externally mutilated.

In a tamarack swamp the fox had chased a rabbit across a sedge swale and captured it at a group of holes at the edge of the oak forest. Both animals had bounded six and seven feet at a time. The rabbit had been carried sixty yards into the swamp and left lying on the snow behind a tangle of brush. This was the only rabbit kill definitely known not to have been cached.

An oak-covered island in the swamp was all trampled with tracks; the foxes had apparently been romping over it. Two sets of tracks indicated that the foxes had spent some time galloping after each other. Two or three holes had been visited, and a little dirt had been pawed out of the entrances. Lying on the snow were the remains of a freshly killed fox squirrel, eaten, except for the tail and skull.

About three hundred yards from the cat-tail marsh a fox had frisked around with a rabbit in his jaws, had dropped it on the ground in several places, and had carried it about one hundred yards where he had cached it at the edge of a ditch a few feet from a large willow.

In a thick growth of tamarack, dogwood, and poison sumac, the foxes had beaten around a great deal, their tracks crisscrossed and circled in all directions. Evidently they had been hunting rabbits for each fox came from the swamp carrying one. The male fox had cached the rabbit in the woods near the edge of a cat-tail marsh; the female had left her prey in the middle of the marsh where the crows had found it and eaten a considerable portion of it. There was no indication that it had been cached.

The male fox had returned to the swamp and chased another rabbit which had bounded rapidly through a thick growth of tamarack, dogwood,

and poison sumac, but the fox had done quite as well for he had overtaken it at a group of holes at the base of a tamarack. The captured rabbit had been carried fifteen paces and buried under three inches of snow. Once before a rabbit had been captured at a group of holes, and it occurred to me that the rabbit may be specially vulnerable at the moment it is about to escape into a hole. Possibly, in entering, the rabbit is delayed a fraction of a second, sufficient to permit a fox in close pursuit to close the gap between the two. In entering some holes, such as one leading into a brush pile where the opening is parallel to the ground surface, there would be very little delay, but other holes would be less advantageous for escape and might detain a hard-pressed rabbit at the entrance a little too long. Since rabbits are generally trying to escape in a hole, by the law of chance a certain percentage of captures should be expected quite near them so that my two observations on this point are not necessarily significant. Then, too, a fox fully acquainted with all the holes in his range may put in an extra effort at the right time to overtake a rabbit about to escape into one of them.

After making this cache the fox had resumed a meandering course through the swamp. In one place he had turned aside to a flat-topped hummock on which lay an uneaten star-nosed mole (*Condylura cristata*) which had probably been dead for a week or ten days. In the oak woods the fox had returned to a cached rabbit, had galloped with it twenty-five or thirty yards to a

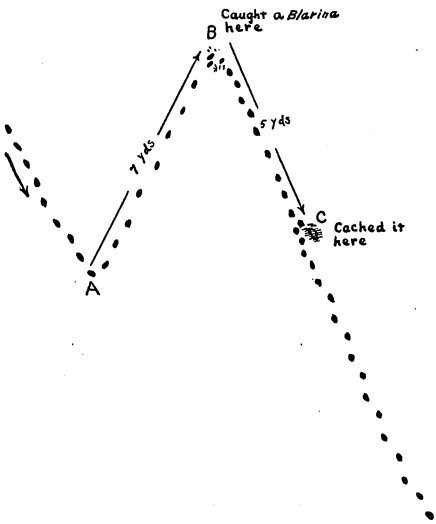

FIG. 3. While trotting through an open woods, the fox became aware of a sound or smell, for he turned suddenly at *A* and at *B* captured a short-tailed shrew which was cached in the snow at *C*. Everything was done practically in stride, and the original course was resumed after the shrew was cached.

large hole where a few tufts of hair lay scattered about, had carried it about ten paces to one side, and had cached it in the snow beside a log. Its back had been broken but not any of it had been eaten. From here the fox had climbed the hill to a badger hole, then angled down the hill to a hollow where an old dried up woodchuck (*Marmoto monax rufescens*) skin with head and tail attached had been scraped out of the leaves. Six rabbits had been killed during the night; a seventh rabbit and the fox squirrel may also have been taken during this time.

March 31

Today snow still remained in the woods but much of it in the fields had melted, and south exposures were bare. The foxes again had been very active over the same area they had tracked up yesterday. There were now so many tracks that it was difficult to follow a trail. In one place I found that one of the foxes had been lying on a hummock. On a side hill a fox had uncovered a rabbit cached yesterday, and carried it at a gallop for a short time before re-caching it. Of other incidents than these little was learned.

I finally found a track which struck off by itself to the north side of the Reserve. The fox had traveled along an old railroad bed and over some open rolling hills and then through a stretch of oak forest. Around a pothole, grown up with buttonbush and a few willows, and surrounded by grassy slopes, the fox had been chasing rabbits but, so far as I could tell, with no success. One of them had covered ten feet at a jump and at least had made the pothole in safety. After investigating a few holes the fox had uncovered a cached rabbit, one I had not previously found, he had galloped about with it in play and re-cached it twenty yards from where he had uncovered it. In the woods the fox had turned seven yards to one side and captured a short-tailed shrew which he had cached five yards beyond.

On the top of a grassy hillside at the edge of a woods the fox had been lying down. I undoubtedly had jumped him for beyond his bed the tracks were fresher, and showed that he had galloped for about a half mile. At the head of a ravine he had stopped long enough to pick up a least shrew which had been lying on some dry oak leaves. It was not fresh. While in full gallop the fox had swerved, left his scent ten yards to one side, and resumed his gallop.

On a steep sidehill I noticed that a badger had made a round trip in the snow between two holes about a quarter of a mile apart. Examining the tracks I found that the fox had stepped carefully in each badger track. The fox had made the round trip, and in only one place had he stepped out of the badger's tracks, and this was only for five or six steps. The spacing of the tracks varied between five and eleven inches; the spacing of the fox tracks is

generally between eleven and sixteen inches, so that the fox had to shorten his stride somewhat to accommodate his steps to those of the badger.

April 1 During the night the foxes had shifted their hunting activities to some swamps and woodlands a half mile from where their main hunting had

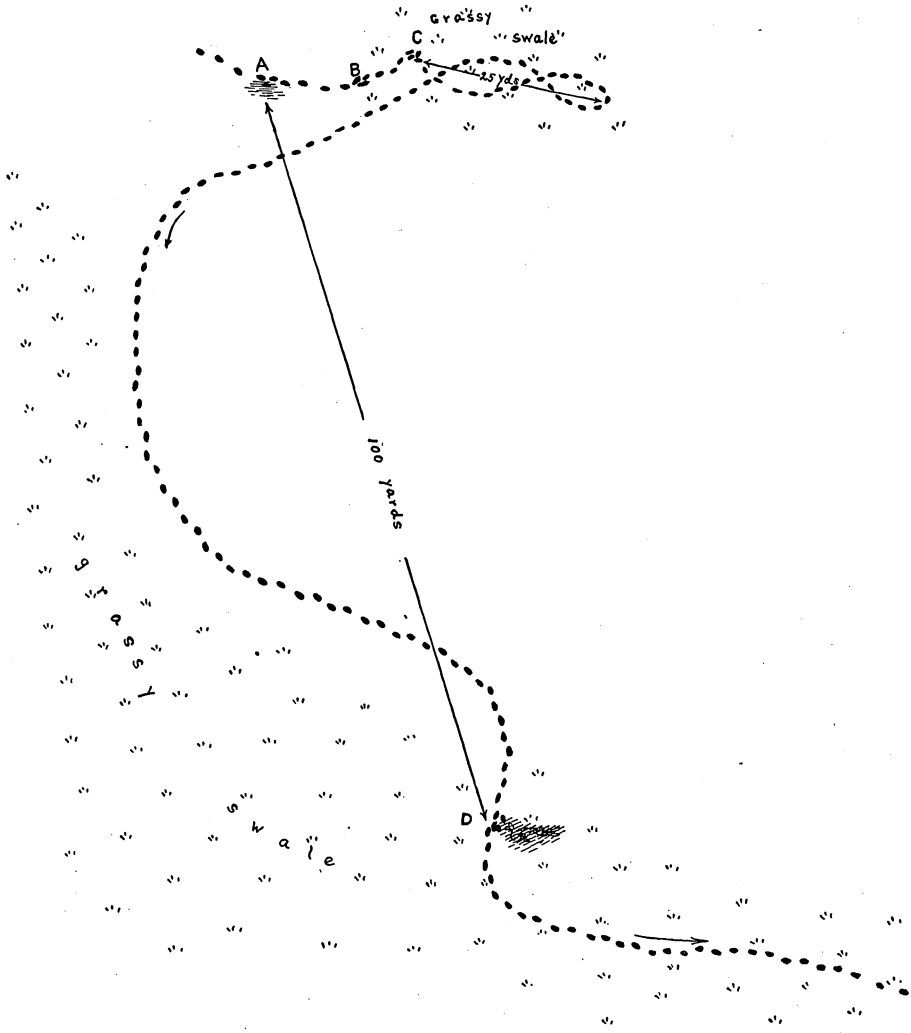

FIG. 4. The fox returned to a rabbit cached at *A* and fed on it at *B* and *C*, then he carried it to *D* where it was again cached in the snow.

been carried on the two preceding nights. I found the fox track at the orchard and followed it down a fire lane for about three-fourths of a mile to where most of the hunting was done. Traveling along the fire lane the fox apparently remembered something, for he turned at right angles to his

course to chew on a yellow cob of corn twenty yards down the steep hillside. Some kernels lay loose on the snow, some still adhered to the cob, and possibly a few had been eaten by the fox.

On the margin of a sedge marsh the fox had entered a hole at the base of a leaning willow. Rabbit hair lay scattered about the entrance.

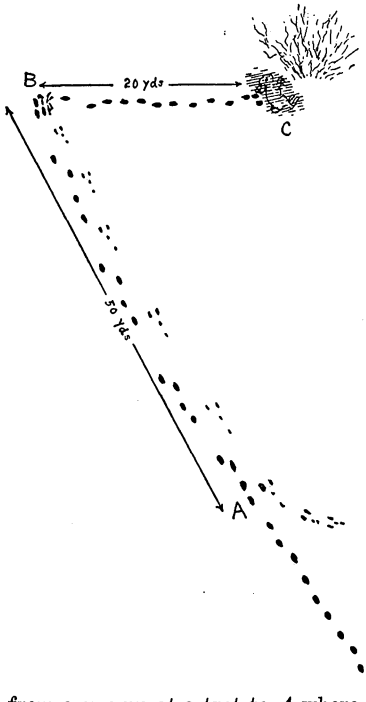

FIG. 5. The fox emerged from a swamp at a trot to *A* where he started chasing a rabbit which was overtaken at *B* and cached in the snow beside a cinquefoil bush in an open field at *C*.

At the edge of a small pothole, grown up in grass and sedges, a rabbit had been dug out of the snow. Out in the sedges in two places marked by fur and chunks of stomach contents, the fox had fed on the carcass. The head, neck, and shoulders had been eaten and the remainder buried in the snow at the edge of a grassy swale about a hundred yards away.

I followed successively several trails here which led off in different directions. One trail led past a fairly fresh fox squirrel which was lying on the snow uneaten. In a tamarack swamp a rabbit had been cached. At the edge of a swale a ring-necked pheasant had met tragedy; only a scattered bunch of feathers remained. The fox and either a hawk or owl, as shown by white splashings, had visited the spot. There was nothing to indicate what had killed the pheasant.

The fox had come out of the swamp at the site of an old haystack and captured a rabbit after chasing it in the open for fifty yards. Twenty yards

from the end of the run the fox had cached it in the snow beside a cinquefoil bush.

Another rabbit had been started at the border of a cassandra bog. Both fox and rabbit had traveled at full speed through a rather dense growth of hazel for about a hundred yards. A capture had evidently been made among the branches of a fallen tree for the tracks showed both animals galloping all the way to the tree branches and only the fox emerging. The rabbit was left beside a log in a sedge pothole and as usual covered with snow.

At one end of a row of trees between two fields a rabbit had escaped a fox, which had made a dash for it, by scrambling into a brush pile.

While trotting along parallel to this line of trees and about fifteen yards to one side the fox seemed to have heard something, for he changed his course directly toward the trees. Absence of snow on the leaves prevented me from seeing what had interested the fox until I had walked twenty yards beyond, and here I picked up a freshly killed short-tailed shrew which had been dropped on the dry leaves.

Shortly before leaving the fox tracks for the day I found a spot where the fox had chased a rabbit down a hillside for sixty yards to a hole into which it had escaped.

April 3

Something had eaten a rabbit cached March 28; nothing remained of it except two mandibles and some scattered bits of fur. Liberal white bird splashings at the spot showed that a large bird, either hawk, owl, or crow, had eated the carcass.

Another rabbit re-cached by the fox March 31 on an open slope had been eaten by a hawk, owl, or crow, judging by the bird splashes.

April 6

A rabbit cached April 1 in a deep swamp had been moved to a hummock four or five feet away. Here it had been plucked, for an evenly distributed ring of fur surrounded the hummock. The carcass had been carried to a perch formed by the upturned roots of a fallen tamarack and here hung the skeleton, picked clean. Although it had rained late the preceding afternoon the plucked fur encircling the hummock had not been rained upon. There was but little time for a diurnal bird to have eaten the rabbit after the rain so that it seems almost certain that this cache had been eaten by a night prowling owl.

A rabbit killed March 30 and cached in a brushy part of a swamp had been eaten by a hawk or owl for at the spot were white splashings and two white down feathers. The carcass had been moved to a mound three feet away. The bones were picked clean. While examining the remains I heard the hooting of a great horned owl near-by.

A rabbit left in the swamp March 30 had been eaten, probably by a hawk or owl judging from the way the bones were picked and from the presence of a white down feather. A great horned owl was seen in a tree twenty or thirty paces from this kill while I was examining it; the owl was probably returning to the rabbit to feed again.

A rabbit cached in the oak woods fifty yards from the one just mentioned also had its bones picked clean, probably by hawk or owl, for two white down feathers were on the ground at the site. The cache may have been eaten by the great horned owl for it was located near the place when this bird was seen.

April 13

A light snowfall again made tracking possible. On some grassy rolling country, the fox, apparently the female, had caught three mice as indicated by the spots of blood on the snow where the captures were made. The fox had turned sharply from its course, in two instances five yards, in one instance ten yards, to make the captures. Apparently the mice had been eaten at once.

The male fox tracks were picked up at the fence where they came into the Reserve from the outside. In the grass meadow a lemming-vole had been captured and poked into a cavity in a bunch of grass eight paces away. Although quite well hidden it was not covered. In an isolated stand of tamarack another lemming-vole had been hidden in a clump of grass some of which covered it. Farther along the fox had pounced and had either missed or eaten the prey. In crossing three or four feet of water the fox had broken through the ice. Water dripped from him on the farther bank; the tracks showed he had galloped fifty yards to counteract the ducking.

In the large swamp I followed tracks for some distance and came upon the hind quarters of a rabbit lying on the snow. The fox had probably carried this rabbit at least three hundred yards before feeding on it.

April 27

At daybreak I met the fox as he came trotting along a hillside. I heard him some time before he made his appearance for he created an unusual amount of noise in the dry leaves. Both in trotting and in loping he held his nose close to the ground. Several times he turned aside two or three yards to investigate, then continued on his way. He seemed to be in a hurry. He passed twenty-five yards to one side without seeing me.

Food Caches

The habit of storing, of putting something away for a rainy day, is strongly developed in many animals. In northern climates many rodents which remain active all winter store away a food supply sufficient to last

until spring returns, when a variety of food again becomes available. This storage habit is specially developed in seed-eating forms but is also present in grass and bark eaters such as the muskrat and beaver. The fox, as well as other carnivores like the coyote, makes many caches, but they are of a more temporary nature: serving more as an icebox than as a root cellar. Things are stored away to be returned to in a few days.

The foxes on the George Reserve continued to hunt and cache food for future use long after the point of satiety in respect to their belly capacities had been reached. Hunting is probably a matter of some sport to a fox just as it sometimes is to the well-fed house cat, so that he at times must hunt for that reason; and of course, a fox is always alert to catch something, whether he has that express purpose or is simply trotting off to some sunny hillside to rest after a busy night.

CACHING OF FOOD ITEMS

Sixty food items were found along the fox trails. Twenty sites were noted where the fox had turned aside to pounce on something in the grass; although mice were probably taken at most of these places, actual evidence, such as blood spots, was usually absent.

Of the sixty food items twenty-six had been cached, three of these, a dilapidated prairie deer-mouse, a short-tailed shrew, and a partially eaten garter snake, had been uncovered and left exposed, and thirty-four had not been cached. The cached items were: twelve rabbits, one muskrat, four lemming-voles, two meadow mice, four short-tailed shrews, one garter snake, two prairie deer-mice. Of the thirty-four items which were not cached twelve consisted of only a few remnants such as fur and feet, too fragmentary and worthless for food to stimulate the caching instinct, seventeen were insectivores which do not appear to be highly relished and perhaps therefore were left uncached, one item was a cob of corn, and only four items were remains of animals usually valued for food. Of these a blue racer was partly eaten and spoiled so perhaps not very highly valued; one of the rabbits listed as not cached may possibly have been cached and later uncovered.

It appears that most food items not needed immediately are cached. At times when food is scarce no doubt the caches which the fox makes while hunting successfully are highly valued and utilized completely on later occasions when the hunting yields but skimpy returns. On the Reserve there was not much need for providing for the future, yet the caching instinct continued to function.

RETURN TO FOOD CACHES

The food caches and also items not definitely cached but killed and left lying, apparently become landmarks or points of interest often visited, even

when not fed upon, by the foxes in their wanderings. Perchance each visit to a cache recalls to the fox pleasant memories of the circumstances attending past events at the spot. Each cache seems to be definitely located on the fox's mental map.

My observations on the number of food items revisited by the fox are very incomplete but to my knowledge the fox returned to sixteen of them. He returned to four rabbits and to a spot where he had been feeding on a rabbit on the day following the capture. The fox ate half of one of the rabbits before re-caching it; with three of them he galloped about in a circle before he re-cached them. He returned to parts of two dried up fox squirrels and a woodchuck skin with head and tail attached, to a partly devoured garter snake which he fed upon and left on the snow, to a prairie deer-mouse and a short-tailed shrew which he uncovered and left lying near-by, to a prairie mole carcass lying exposed which he had no doubt often visited for there were four droppings beside it, to another prairie mole in a field, to a star-nosed mole lying on a hummock in the middle of a tamarack swamp, to a least shrew lying among some dried leaves, and to a lemming-vole ten days after it had been cached.

USE OF FOX CACHES BY OTHER ANIMALS

It seems certain that the foxes killed more animals than they were able to eat. For example, on March 30 at least six rabbits had been killed and cached. On April 1 there were to my knowledge, and certainly there were others of which I did not know, ten cached rabbits yet untouched by anything. It might seem that here was a great waste, but apparently this was not the case because other birds and mammals used the surplus.

Items of food were generally removed a few days after being cached. Some of them were definitely known to be removed by animals other than the fox. The fact that much of the prey was buried in snow which soon melted away and thus left the food exposed may have contributed to this rapid disappearance of caches. It should be noted, however, that some of the rabbits which were left in the brush were quite inconspicuous after the snow had melted, and that some of the mice which disappeared early, had been partially hidden by grass, and at least one rabbit was removed by a skunk while still covered with snow. The exposure of the caches would perhaps make little difference to their safety from raids by skunks and other mammals, which are dependent mainly on their noses for information about such things, but it may have rendered food items more accessible to birds.

Of sixteen caches which I was watching nine disappeared a few days later without leaving any marks to indicate what animal had removed them. Of three rabbits cached March 30, two were gone on April 3 and one on April 4; of three cached April 1, two were gone on April 3 and one on

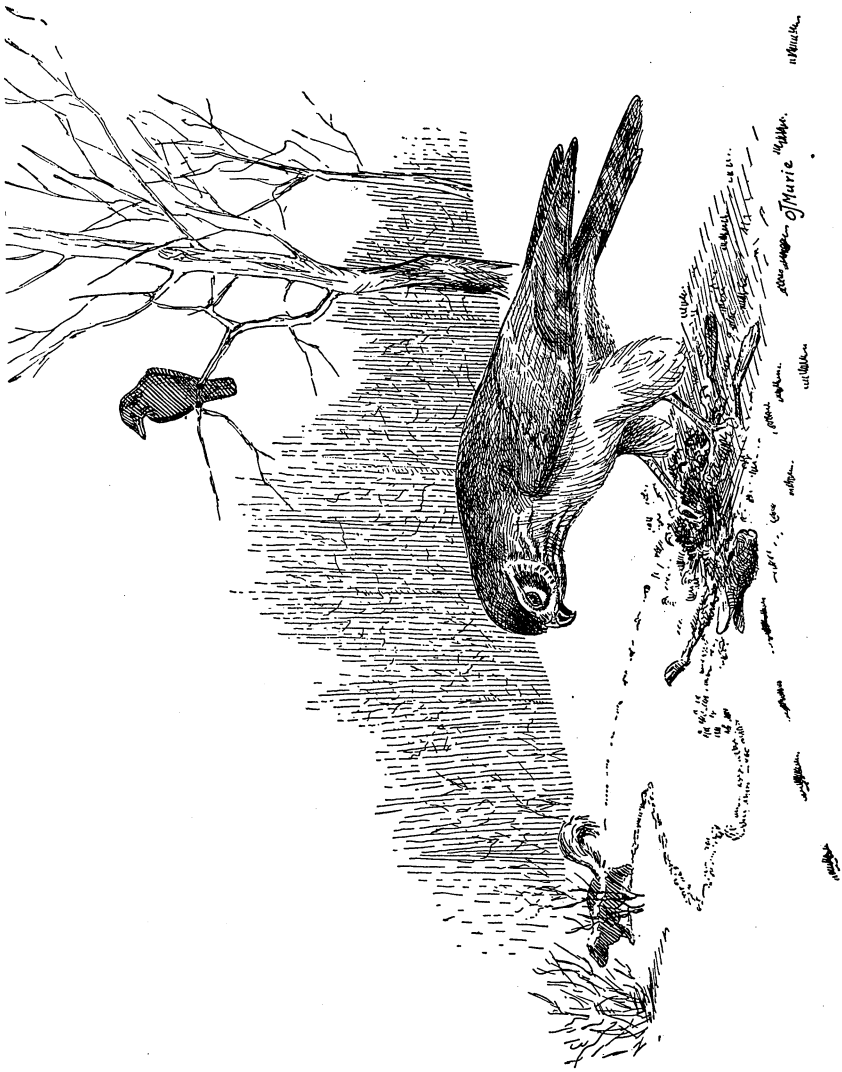

FIG. 6. Food items cached by the foxes are often eaten by other animals. This rabbit was first uncovered and fed upon by a skunk, later it was visited by crows and a marsh hawk.

April 5; two lemming-voles cached on April 13 were gone April 15; a fox squirrel left lying in the open on April 1 was missing on April 3.

Seven of the caches, almost half of those I had under observation, and four other food items which did not happen to be cached but were left in the open, were not utilized by the fox but furnished food for other animals. Some of these food items were utilized by more than one species. Crows had visited four caches, a marsh hawk one, a skunk one, a hawk or an owl four; a hawk, an owl, or a crow three. (White down feathers, and other bird signs were taken to indicate hawk or owl; bird whitewash splashes with no other sign to indicate either hawk, owl, or crow.)

Two other rabbits possibly captured by the fox had been eaten by birds. On one occasion a marsh hawk was seen to drop a half-eaten rabbit which it was trying to carry. Another rabbit was found which had been eaten around the neck by a bird.

Obviously the observations here recorded represent only a part of the story, but they are sufficient to indicate the trend of affairs in the fox's hunting economy. Although the fox kills more than it actually uses, the prey evidently serves its purpose as food for some creature and appears to fit into a scheme of natural balances.

FOOD HABITS

Food habits were studied in two ways: (1) by noting kills along fresh fox trails and (2) by collecting and examining fox droppings. Neither method is complete in itself but each supplements the other rather well. Certain facts were brought out by following the trails which could not have been ascertained by the examination of droppings alone. The results from the two methods are in general agreement, in fact one of the interesting features of the study was this agreement between field observations and the analyses of droppings. This may be illustrated by a few examples. (1) A turtle nest was found robbed; near-by a dropping was picked up containing two tiny turtles which had probably been taken at the nest. This might seem to be rapid digestion; however, the dropping was probably left near the nest at the time of a second visit or else the turtles in the dropping came from some other nest. (2) The large number of shrews and moles found uncached and uneaten indicated they were not relished; this was substantiated by the slight evidence of these animals in the droppings. (3) Only blue jay feathers were found at the den, and den droppings contained few bird remains. (4) Sheep remains were found at the den, and sheep remnants also occurred in droppings found there. (5) Field observations on the importance of rabbits, field mice, and other animals in diet agreed closely with the results of examination of the droppings. (6) Vulnerability of muskrat as shown by their habits was also confirmed in the analyses. (7) In the field

blue racer and garter snakes, hickory nut, and corn were noted eaten, or, in the instance of the hickory nut, uncovered; all these items appeared in the droppings. (8) A turkey leg was left in a meadow indicating a visit to a farm yard, perhaps to the garbage pile; chicken feet and corn in a dropping also suggest a visit to a garbage pile.

Analyses of Droppings

Analyses of droppings are a very useful method for the study of food habits if used with caution. In rambling through the woods I often surmise from the contents of the dropping what animal has left it, but of course for obvious reasons this cue to the identity of a dropping must be thrown out entirely in a food habits study. There is great variation in the appearance of droppings from the same animal depending upon the food eaten. A dozen fox droppings which were measured varied in average diameter from eleven to seventeen millimeters, in length from sixty to one hundred and thirty-six millimeters. Occasionally droppings may be only six or seven millimeters in diameter over most of the length. Usually they are drawn out at the ends. Generally they contain much fur. Droppings of different genera overlap broadly. I have seen badger, opossum, coyote, and even skunk droppings which could not be distinguished with certainty from those of the fox. In some areas where several species having similar droppings are present in considerable numbers these studies perhaps would not be feasible because of the impossibility of definitely identifying the droppings. Attendant circumstances, however, often help to make proper identification. For example, in Teton Park, Wyoming, along the side of the trail and on rocks bordering the trail my brother and I came upon some small droppings the contents of which included berries and fur. Because of the size and location of the droppings we conjectured marten, but we looked for evidence before collecting any of them. Soon we found a number of marten tracks in the trail, then to the side of the trail we saw a marten in a bush feeding on huckleberries. Here the evidence was sufficient for identification of the droppings.

On the George Reserve there were at least two opossums and one badger. It is possible that some of the droppings gathered belonged to these animals, but the probability seems slight that a significant number were other than fox droppings. Most of them were picked up on trails and fire lanes regularly traveled by the fox where I never saw opossum or badger tracks. During the winter months the badger and opossum traveled very little, and I knew their general whereabouts. Of course the droppings at the fox den were definitely identified.

Many of the droppings are only approximately dated, but they can be considered fairly accurate to the month. Ninety-five of them were fresh when found, that is they were not over three or four days old. Others were

collected over previously worked trails and hence were dated within a few weeks. There tends to be a lag between deposition of a dropping and its harvesting so that the ones picked up at the beginning of a month might have been deposited during the latter part of the preceding month. The den droppings are quite accurately dated. On the whole the droppings of January, February, and March are not so accurately dated as are those for April, May, and June. Since by the end of March I had gathered almost all the droppings on the more fruitful trails, later droppings on these trails could be assigned to the period between my successive trips.

Droppings are left in all kinds of situations, both on and off the trails, but since trails are often followed, there are a number of droppings deposited along them. Certain stretches of trail, perhaps because more frequently traveled by foxes, were especially productive. One dropping seems to suggest another, so that sometimes five or six droppings are found to occur together. In the West I have seen as many as thirty or forty coyote droppings in a favorable location. Several fox droppings were found on the mounds at the entrances to burrows which the foxes had visited.

The results of the analyses of droppings are shown in Table I. It will be noted, in examining the table that the rabbit was the most important food item, followed by the lemming-vole and meadow mouse. During May and June beetles became a staple food item. Refuse in the form of leaves, grass, sand, and sticks was present in many of the droppings.

The following mammals, known to occur on the Reserve, were not found eaten or killed by the foxes: opossum (*Didelphis v. virginianus*), raccoon (*Procyon l. lotor*), weasel (*Mustela n. noveboracensis*), mink (*Mustela vison mink*), badger (*Taxidea t. taxus*), chipmunk (*Tamias striatus lysteri*), red squirrel (*Sciurus hudsonicus loquax*), flying squirrel (*Glaucomys v. volans*), and pine vole (*Microtus pinetorum scalopsoides*). The pine vole was extremely rare, and the chipmunk was relatively scarce. The food items are discussed separately below.

Direct comparisons with food habits discussed in other fox studies are usually not made because the differences in habitat and food available would, of course, have to be considered, and this data is not always obtainable. In general my study of the food habits of the foxes on the George Reserve agrees with similar studies made by Dearborn (1932) in Michigan, Nelson (1933) in Virginia, Hamilton (1935) in New York and New England, and Errington (1935) in Iowa and Wisconsin.

So far as the general picture of the foxes' food habits is concerned, the information gathered on the trails agrees very well with that derived from analyses of the droppings. Before the various food items are separately discussed the food at the den as determined from these analyses will be considered.

TABLE I

FOOD ITEMS FOUND IN 768 FOX DROPPINGS. In last column, the food items noted on fox trails. The number of droppings are listed in which the various food items were found. No dropping contained remains of more than one individual of any species except with regard to insects, and nine droppings which each contained remains of two lemming-voles, and six droppings which each contained remains of two meadow mice.

	Jan. 33	Feb. 5	Mar. 187	April 156	May 103	June 47	July 4	Trail 535	Den 233	Total 768	Percentages on trail	Percentages in den	Percentage total number	Food items found on trail
Prairie mole (*Scalopus aquaticus machrinus*)			1					1		1	.18		.13	2
Star-nosed mole (*Condylura cristata*)														1
Long-tailed shrew (*Sorex cinereus cinereus*)			1	1				2		2	.3		.2	4
Least shrew (*Cryptotis parva*)			1					1		1	.1		.1	4
Short-tailed shrew (*Blarina brevicauda talpoides*)														10
Skunk (*Mephitis nigra*)			3		1			4		4	.7		.5	
Woodchuck (*Marmota monax rufescens*)					1			1		1	.1		.1	1
Striped ground squirrel (*Citellus t. tridecemlineatus*				2		1		3	7	10	.5	3.0	1.3	
Fox squirrel (*Sciurus niger rufiventer*)				2				2	1	3	.3	.4	.3	4
Prairie deer-mouse (*Peromyscus maniculatus bairdii*)			1		2			3		3	.5		.3	2
Forest deer-mouse (*Peromyscus leucopus noveboracensis*)			5		3			8	1	9	1.4	.4	1.1	
Prairie or forest deer-mouse		1	8	6	1	1		17	1	18	3.1	.4	2.3	
Lemming-vole (*Synaptomys cooperi cooperi*)	8	2	47	44	23	3		127	5	132	23.7	2.1	17.1	4
Meadow mouse (*Microtus pennsylvanicus pennsylvanicus*)	3	1	43	37	16	8	1	109	10	119	20.3	4.2	15.4	2
Lemming-vole or meadow mouse			5	3	1	1		10		10	1.8		1.3	
Muskrat (*Ondatra zibethica zibethica*)	1		8	20	7	1		37	8	45	6.9	3.4	5.8	3
House mouse (*Mus musculus musculus*)			1	1				2		2	.3		.2	
Jumping mouse (*Zapus hudsonius hudsonius*)					1	1		2	1	3	.3	.4	.3	
Cottontail (*Sylvilagus floridanus mearnsii*)	30	3	132	104	77	31	2	379	200	579	70.8	85.8	75.3	20
White-tailed deer (*Odocoileus virginianus borealis*)				1	1			2	1	3	.3	.4	.3	
Domestic sheep	1		1	1			1	4	5	9	.7	2.1	1.1	
House cat									1	1		.4	.1	
Birds	1		34	16	9	4	2	66	10	76	12.3	4.2	9.8	
Chicken					1			1		1	.1		.1	
Bird egg					3	4	1	8		8	1.4		1.0	
Painted turtle (*Chrysemys bellii marginata*)					1			1		1	.1		.1	
Blue racer (*Coluber*)			1		1			2	6	8	.3	2.5	1.0	1
Garter snake (*Thamnophis*)					2			2		2	.3		.2	1
Insects			3	6	24	20	2	55	151	206	10.2	64.8	26.8	
Acorn			1	1				2		2	.3		.2	
Hickory nut			1	9	2		1	13		13	2.4		1.6	
Corn			1	1	3			5		5	.9		.6	1
Miscellaneous seeds			5	3				8	1	9	1.4	.4	1.1	
Leather					1			1		1	.1		.1	

FIG. 7. First lessons in foraging. The prevalence of insect remains in the den droppings suggests that youthful hunting begins with beetles.

Food at the Den

The den at which droppings were gathered was occupied approximately during the last two weeks of May and the first week of June. The majority of the droppings were found at the lower part of the mound of the main entrance and among the leaves beyond the mound, others were found at some of the adjacent holes and in various places on the premises. Pieces of bone and fur were scattered about the area used, particularly among the sedges in the pothole immediately in front of the den. Here, where the young had evidently often retreated to chew on food brought to them, there were many rabbit bones and pieces of fur, the skull and a piece of the hide of a muskrat, the rear half of a fox squirrel, the posterior part of a skull, scapula, and femur of a lamb, part of an adult deer sternum, and some blue jay feathers, the only feathers noted at the den.

Rabbit remains were present in two hundred, or 85.8 per cent, of the the two hundred and thirty-three den droppings, a higher frequency than in those in the trail for any month; the meadow mouse and lemming-vole together were present in only fifteen droppings, or 6.4 per cent of them, a much lower frequency than in those in the trail. It seems that the foxes, to feed their young, had concentrated on a food item having sizable proportions, which, whether they knew it or not, probably increased their parental efficiency considerably. The rabbit seems to be the optimum food for den purposes.

Bird remains were found in only ten droppings picked up at the den.

Insect remains were found in one hundred and fifty-one, or 64.8 per cent of the den droppings, a much higher frequency than in those in the trail during May or June. It seems likely that the fox pups supply the insect portion of the diet by their own efforts. The beetles probably furnish both play and food to the pups as well as good hunting experience. Catching beetles no doubt develops in the young foxes judgment of distance, pouncing precision, sound localization, and other hunting qualities of value to a fox.

Annotated List of Food Items

SHREWS AND MOLES

In a total of seven hundred and sixty-eight droppings only two long-tailed shrews (*Sorex c. cinereus*), one least shrew, (*Cryptotis parva*), and one prairie mole (*Scalopus aquaticus machrinus*) were represented. The remains found in the droppings all belonged to the anterior part of the body, which suggests that the posterior portion of the body bearing the glands was not eaten. In one instance the posterior half of a fresh long-tailed shrew found on a fox trail had been left on the snow. Apparently

the head and shoulders had been eaten, and the remainder, perhaps less palatable because of the glands, had been left. Sometimes an entire shrew is bolted by the fox so that it is entirely possibly that in the above instances it was only accidentally that no remnants of the posterior parts of the shrews and moles were found in the droppings.

Studies by Dearborn (1932), Nelson (1933), Hamilton (1935), and Errington (1935) agree with my observations in that few remains of insectivores were found in the stomachs and droppings examined. Nelson reports none in twelve stomachs; Hamilton three shrews in two hundred and seventy-two stomachs, and five moles and shrews in one hundred and ten food items gathered at thirty-one dens; Errington seven moles in nine hundred and ten specimens found at dens, and moles in five of eleven hundred and seventy-five droppings; Dearborn, in three hundred droppings, a frequency of 0.8 per cent for shrews and 0.8 per cent for moles, considering only the mammal remains, and in another collection of two hundred and eighty droppings the volumetric index for moles was 0.34 per cent and for shrews 0.08 per cent, only mammal remains considered.

Of fifty-nine food items which I found along fox trails twenty-one were insectivores of the following kinds: two prairie moles, one star-nosed mole, four long-tailed shrews, ten short-tailed shrews, and four least shrews. It is interesting to note that in 1929 only nine specimens of the least shrew had been taken in Michigan (Blossom, 1931). The fact that only four of the ten short-tailed shrews were cached and that none of the other shrews or moles were cached suggests that these forms are not highly valued by the fox.

It would appear that the numbers of shrews and moles represented in the fox droppings gives little indication of the part the fox plays in the ecology of these animals. Although the fox seldom eats shrews or moles he seems to prey on them to about the same extent as he would if he relished them. The fox probably pounces on any available source of a smell or a sound and examines what he has captured later; it is likely that every pounce has an element of sport in it. If the shrews and moles lived in a habitat in which there was no other fox food available they perhaps would be relatively free from attack by foxes for there would be little attraction to their habitat. Thus their vulnerability to foxes, in part, may be dependent upon the company they keep.

SKUNK

Skunk (*Mephitis nigra*) remains were noted in three March droppings and one May dropping. There is a strong possibility that the skunk was carrion thrown out by a trapper, since the remains consisted of claws. There were several skunks present on the Reserve.

WOODCHUCK

Woodchuck (*Marmota monax rufescens*) was found in only a single dropping. A dried-up skin of a woodchuck which was probably killed the preceding summer or fall was visited by a fox on March 30. The relative scarcity of woodchucks on the Reserve may account for the almost total absence of them in the diet for the months when woodchucks were active. Since it is a matter of daily routine for the foxes to call at all dens in their path, one would expect woodchucks to be often exposed to fox attack. Where woodchucks are plentiful they no doubt are an important item in the fox diet during the warm months.

STRIPED GROUND SQUIRREL

The remains of the striped ground squirrel (*Citellus t. tridecemlineatus*) were found in seven den droppings and one trail dropping. The striped ground squirrels were common in certain places, but over much of the foxes' hunting territory on the Reserve they were scarce or absent.

TREE SQUIRREL

Fox squirrel (*Sciurus niger rufiventer*) remains were present in only three droppings; four fox squirrels, two of which were old, were found on the trails; part of a carcass was found at the den. Fox squirrels were very numerous over most of the Reserve; one day in March I saw six of them chasing about over a hillside. Apparently fox squirrels are not very accessible to the fox. Red squirrels (*Sciurus hudsonicus loquax*) were not so plentiful as the fox squirrels were. They were largely restricted to the swamps and borders of the marshes. The fact that red squirrels are more agile than fox squirrels and also probably frequent the ground less, may account in part for their high immunity to fox attack.

The fox squirrels at times make long trips away from the protection afforded them by trees. In one instance tracks showed that one had traveled about four hundred yards across a treeless flat to visit a cornfield and numerous cobs in the woods proved that this hazardous trip in the open was frequently undertaken. Several other long excursions by fox squirrels were also noted. Should a fox chance to find a squirrel on one of these expeditions opportunity for escape would be slight. Although the time of activity of the squirrels and foxes overlaps broadly still the diurnal habits of the squirrel are highly advantageous to it in escaping the fox.

FOREST DEER-MOUSE AND PRAIRIE DEER-MOUSE

Remains of deer-mice were found in twenty-eight, or 5.2 per cent, of the five hundred and thirty-five trail droppings and in two, or 0.8 per cent, of the den droppings. In the trail droppings there were remains of eight

forest deer-mice (*Peromyscus l. noveboracensis*) and of two prairie deer-mice (*Peromyscus m. bairdii*). Eighteen of the remains were identified only to the genus. Two remains in the den droppings represented both species.

The deer-mouse seems to be present in normal numbers on the Reserve, but it does not often appear in the fox's food record. This may be due to living in an environment offering fairly good protection, at least much better protection than that available to the meadow mouse. I strongly suspect that the habitat of the deer-mouse, in crevices, under logs, and other recesses, its alertness and speed, and its general habits afford the explanation for its greater freedom from attack. When it is abroad it has some opportunity to see a fox and seek shelter, and usually it scurries from cover to cover. In my own experience I often have opportunity to capture meadow mice with my hands, but there is seldom an occasion to take deer-mice. Similarly the coyote, who hunts much like the fox, infrequently captures deer-mice. O. J. Murie (1935) found only eight deer-mice in a total of fifteen hundred and fifty-six food items, while meadow mice led the list with five hundred and four occurrences, and the easily caught jumping mouse was near the top; it may be added that in this region deer-mice were very abundant. There may be a taste preference, but I strongly suspect that ease of capture is the key to frequency of capture. The deer-mouse no doubt breeds more slowly than do the meadow mouse and lemming-vole, consequently it requires a higher survival rate and better protection from enemies.

LEMMING-VOLE AND MEADOW MOUSE

Since these two species represent the same type of food and occur in the same habitat they will be discussed together. Lemming-vole (*Synaptomys c. cooperi*) remains were found in a hundred and twenty-seven droppings or in 23.7 per cent of the five hundred and thirty-five droppings gathered away from the den and in five instances or 2.1 per cent of the two hundred and thirty-three droppings found at the den. Meadow mouse (*Microtus p. pennsylvanicus*) remains were found in one hundred and nine droppings or 20.3 per cent of the droppings gathered away from the den and in ten instances or 4.2 per cent of those gathered at the den. Ten droppings contained remains which were either those of the lemming-vole or the meadow mouse. Five droppings each contained remains of two meadow mice, nine each contained remains of two lemming-voles.

In May, and especially during June, the frequency of these microtines in the diet drops considerably. A possible explanation may be that at this time the foxes were feeding the young and seemed to be concentrating on rabbits for den food; also at this time insects became an important food item.

These species of microtines are exceptionally vulnerable to attack. No doubt they have a false sense of security while traversing their canopied

runways for, although hidden from the fox's view, they are not hidden from his nose and ears. Sounds from chewing activities, chattering of teeth, and squeaks resulting possible at times from slight altercations when two animals meet in a runway, together with their odor, all serve to communicate the knowledge of their presence and exact location to the fox. Although easy prey their numbers are maintained by a high rate of breeding. Their rate of increase seems to be adjusted to the presence of predators and a high vulnerability to them. The meadow mouse is known to breed at all seasons, and the lemming-vole seems to have a prolonged breeding season. Leroy C. Stegeman (1930) found young of the lemming-vole early in April about twenty miles from the George Reserve, and A. B. Howell (1927) states that females containing four to six embryos have been taken from March 11 to October 7.

Stegeman (1930) states that the lemming-vole and meadow mouse occurred together in about equal numbers in an intensively trapped area. The occurrence of the lemming-vole in a hundred and twenty-seven of the fox droppings and of the meadow mouse in a hundred and nine of them suggests that a similar numerical relationship existed at the George Reserve.

MUSKRAT

Muskrat (*Ondatra z. zibethica*) remains were found in forty-five droppings, or in 5.8 per cent of the total number. They were present in droppings found in each month covered by the study except February and July, which months, however, are represented by only a total of nine fox droppings. Hamilton (1935) found muskrat remains only twice in two hundred and seventy-two stomachs and at four of thirty-one dens, and found none in a hundred and six droppings; Errington (1935) does not record muskrat in any of the nine hundred and ten specimens picked up at dens nor in eleven hundred and seventy-five droppings. Dearborn found none in five hundred and eighty fox feces. The high percentage of muskrat found in the droppings examined in this study as compared with the percentage frequency of its occurrence mentioned in the above papers may be due to a difference in vulnerability and abundance of the muskrats in the localities studied. The swamps and marshes in the George Reserve have little or no water in them during the winter, so that at this time the muskrats probably travel abroad more than those having recourse to considerable water. Even in June one of the marshes inhabited by several muskrats showed no water on the surface; well defined trails, averaging four inches in width, connected the various holes showing that the muskrats spent much time above ground.

The following records of muskrat travels show that the muskrats are quite often in a dangerous situation in respect to predators. On February 24, in a marsh in which there were three or four houses, a muskrat had wandered

a hundred and fifty yards from one of them. Along the way it had been feeding on roots and green sedges and had cut down and into short lengths several dried weeds. A fox passing that way during the same night, had sniffed at one of the muskrat houses. The muskrat was fortunate that its foraging was not coincident with the time of the fox's appearance.

On February 26 at 2 P. M. in this same region, a muskrat was feeding on sedges about thirty yards from his hole. He scrambled to get to his hole when he found me apparently blocking his way to escape. Since several pieces of sedge lay strewn along his trail he was probably carrying some food to his den.

On March 2 in the vicinity of a ditch containing water a muskrat had traveled over the ice and snow-covered sedges for a distance of sixty-five yards in one direction and a hundred and forty yards in the opposite direction. The tracks showed that the muskrat had alternately galloped and trotted.

On March 18 a foraging muskrat had crossed an open area forty yards in width. Another had traveled overland from one marsh to another for a distance of a hundred and eighty yards; on the way it had stopped to feed on sedges. On March 19 a muskrat had walked forty yards out on a grassy slope. At this point the tracks had drifted in with snow. On March 31 a muskrat had traveled across sedges and grass areas covered with snow for a distance of nearly a half mile.

The muskrat under conditions more favorable to its mode of life than those existing on the George Reserve would probably be less vulnerable to fox attack.

HOUSE MOUSE

The house mouse (*Mus m. musculus*) was found in two droppings. This species is rare on the Reserve.

JUMPING MOUSE

Only three droppings contained jumping mouse (*Zapus h. hudsonius*) remains. The jumping mouse like the ground squirrel and the woodchuck was in hibernation and consequently unavailable to the foxes during the winter and early spring months. It was very scarce on the Reserve.

COTTONTAIL RABBIT

The most important item in the fox diet was cottontail rabbit (*Sylvilagus floridanus mearnsii*); it was present in three hundred and seventy-nine or in 70.8 per cent of the five hundred and thirty-five droppings collected on the trails and in two hundred or in 85.8 per cent of the two hundred and thirty-three den droppings. The foxes seemed to delight in rabbit hunting.

Rabbits were very abundant on the Reserve and continued to flourish in spite of the fox depredations. During May seven nests were found within an area one hundred yards across; young were found in three of the nests and a litter had apparently been raised in each of the other four nests.

Rabbits seem to be relatively easy prey for the foxes; in most of the chases which I followed on the snow the fox had succeeded in overtaking the rabbits. Their vulnerability to capture is probably dependent rather directly on their position in relation to the fox and to protective cover at the moment they first discover the fox. This in turn is probably correlated with the number and the distribution of escape retreats, and the distribution of food supplies in relation to these retreats. Where rabbits are available foxes probably prefer them to most forms of food. It seems that the fox can hunt deliberately for meadow mice, lemming-voles, and rabbits with a certainty of success; many of the other food items in the diet are picked up more or less accidentally.

On one occasion I saw a rabbit with a wry neck which I just missed being able to catch. The fox probably quickly picks up animals in this condition thus benefiting the rabbit population by removing the sick and the unfit.

WHITE-TAILED DEER

Remains from adult deer (*Odocoileus virginianus borealis*) were found in three droppings, and a section of sternum was found at the den. This all represented carrion. Although there were more than a hundred and fifty deer on the area and a large number of fawns were dropped during late May and June there was no evidence that the foxes had harmed any of them.

DOMESTIC SHEEP

Remains of domestic sheep were found in nine droppings, and part of a very young lamb skull and other bones were found at the den. Besides wool, the remains in the droppings consisted of hoofs and some incisor teeth. It seems very likely that the sheep remains represented carrion.

DOMESTIC CAT

A cat claw was found in a dropping taken at the den. Cat tracks were noted on the Reserve but once; possibly their scarcity was due to fox depredations. Hamilton (1935) lists two cats found at dens, and two of his observers report cat as a fox food.

BIRDS

Bird remains were found in sixty-six or in 12.3 per cent of the trail droppings and in ten or in 4.2 per cent of the den droppings. In the field remains of three ring-necked pheasants and a ruffed grouse were found, but there was

no indication as to what had killed these birds. Identification to species of the bird remains in the droppings was very difficult because usually little remained of the feathers but the shaft. In twenty-four droppings the feathers were large, from a bird the size of a chicken or grouse; of course the small feathers in some of the droppings may also have come from a large bird. Ruffed grouse remains were definitely identified in one dropping and bobwhite in another. Some of the remains were definitely identified as those of small birds. What appeared to be the remains of chicken feet, together with corn, probably from the chicken crop, were found in one dropping; this indicated that some farmer's Sunday morning refuse heap had been visited by the fox. Bird eggs were found in only eight droppings.

The effect of the foxes on bird life did not seem to be severe. A population of perhaps thirty or forty ruffed grouse on the area seemed to maintain its numbers from year to year. Bobwhite apparently have been on the increase on the Reserve and its vicinity during the last few years. There were a few pheasants on the Reserve. Other winter birds were present in good numbers. Of interest is the fact that a grouse had taken a dust bath on the mound of the first den used by the fox about a week after the foxes left this den.

It seemed strange that bird remains were less frequent in the droppings during May and June, the nesting season, when we should expect many brooding ground nesting birds to be especially vulnerable, than during March and April. At the fox den occupied during the nesting season the only bird refuse found consisted of some blue jay feathers. This suggests that nesting birds are not so vulnerable to fox attack as one might be apt to expect. The bird predations may not have been so much greater in winter as the figures indicate for possibly many of the bird remains for the winter months represent carrion. In this regard it would have been interesting to have followed the fox outside of the Reserve to observe its farmyard habits. Poultry apparently was not being bothered by the foxes for no complaints were voiced by any of the farmers.

DOMESTIC CHICKEN

Although there were many farms within the home range of the fox there was no evidence that chickens were often eaten by the fox. The only positive identification was made in a dropping which contained scales from chicken feet together with a quantity of corn. It seems likely that this represented carrion. A turkey leg had also been brought in to the Reserve.

PAINTED TURTLE

Painted turtle (*Chrysemys*) remains were found in only one dropping; in it there were two painted turtles, one inch in diameter. On March 25

five or six empty shells of the painted turtle, pungent with fox scent, lay on the shore of a small pond. In the mud near them were several fox tracks. On the road I picked up the shell of a painted turtle which probably had been dropped by a fox for in the dust were fresh fox tracks. Direct evidence that the fox fed on these turtles is lacking, but it seems likely that he did. There were but few marks on these shells, and they were practically entire.

BLUE RACER AND GARTER SNAKES

Blue racer (*Coluber*) remains were found in eight droppings, garter snake (*Thamnophis*) remains in two droppings. Six of the former were at the den. On April 4 a partly eaten blue racer was found at the edge of the swamp. Beside it lay a fox dropping. Possibly it had been killed by a fox. On March 28, as recorded on page 15, a fox had dug a garter snake out of the snow and eaten a part of it. Both species of snakes were rather common.

INSECTS

Insects are utilized extensively as food during May and June, and no doubt during the remainder of the summer months. Of the droppings collected in May, twenty-three per cent contained insects, of those collected in June, forty-two per cent contained insects, of those collected at the den approximately between May 20 and June 6, 64.8 per cent contained insects. As would be expected, the utilization of insect food is closely correlated with its abundance. Although the quantity of insect remains in the droppings varied considerably, in a great many of them these remains made up a large part of the total.

Beetles, mainly June beetles, made up almost one hundred per cent of the insects eaten. L. W. Saylor, University of California, examined the material and summarized his findings as follows:

Order Coleoptera

Family Scarabaeidae. June beetles

1. *Phyllophaga fusca.* The majority of the insect remains were made up of this species.
2. *Phyllophaga marginalis.* Frequent occurrence.
3. *Phyllophaga ulkei.* A few noted.
4. *Phyllophaga (priunina?).* A few noted.
5. *Serica* sp. Several noted.

Traces of a few other forms noted whose identification was uncertain.

Family Carabidae. Predaceous Beetles

1. *Carabus.* Remains of this genus were rather common. Three or four species were represented.

2. Carabid larvae. Several noted.

Family Lucanidae. Stag-beetles

1. *Pseudolucanus capreolus.* Several noted.

Family Ostomidae

1. *Tenebrioides.* One example.

Family Curculionidae

Three or four specimens identified.

Family Silphidae. Carrion beetles

One specimen identified.

Family Tenebrionidae. Stink beetles

One present.

Order Hymenoptera (bees, ants, etc.)

Three or four specimens identified.

Order Orthoptera (grasshoppers and crickets)

Two or three noted. These insects are not plentiful during May and June.

MAST

Fragments of hickory nuts were found in thirteen droppings, and an acorn was noted in two. On March 19 I noticed that a hickory nut had been uncovered by the fox. The fact that these nuts were eaten when other food was abundant indicates that nuts might become quite an important food where game is scarce. It is interesting to note that in the West the coyote frequently feeds on pine nuts.

CORN

There were a number of cornfields outside of the Reserve where ripe corn was available to the foxes, but apparently very little was eaten. Only five droppings contained corn, one of these contained about a handful and another a slightly smaller quantity. In one instance the corn seemed to represent the crop contents of a chicken. On April 1 a fox had chewed on a cob of corn inside of the Reserve and apparently had eaten some of the kernels. The cob may have been brought inside the fence by the fox, but it is more probable that it was carried in by a fox squirrel.

FRUITS AND MISCELLANEOUS SEEDS

Seeds in the droppings indicated the quantity of fruit in the diet. Only nine droppings contained seeds; these represented cherry, grape, and sun-

flower. Some of the seeds listed were so small that it seems they may have been taken accidentally or secondarily with a deer-mouse or a bird. Probably owing to its scarcity only a small amount of fruit was eaten. Occasionally frozen apples dropped to the ground in the orchard, but usually these were quickly consumed by the deer.

DENNING

Two foxes, presumably a pair, were first found traveling together on January 8, soon after I started making observations on them. Tracks seen on later occasions showed that the foxes often were together, at other times their tracks were parallel, one or two hundred yards apart, and frequently they traveled alone.

On May 4 I found, on a slight rise of land covered by a growth of oak and hickory, and surrounded by tamarack swamp, what proved to be the fox den. The principal entrance was near the base of a slope only a few paces from the edge of the swamp. The only débris about the entrance was a short length of intestine. There were five or six other holes within thirty or forty yards which also seemed to be in use.

On May 9 at 5:30 A. M., while I watched the den from a point seventy-five yards away one of the adults approached it from behind me. On seeing me hunched beside a tree at a distance of about twenty-five yards from him, he galloped into the swamp. On May 14 I heard growls coming from within the den and noticed the hind leg bones of a rabbit on the dirt mound.

On May 25 the den had been deserted. The following day I found the new den to which the foxes had moved at the edge of a sedge pothole about twenty-five yards in diameter and about four hundred yards from the original den. There were several holes near-by, all of them were much used, and there were dim trails between them. When first I approached the den I saw the face of a half-grown fox almost filling its entrance; I backed slowly away and waited from a distance of about seventy yards. One of the young ones soon came out and inspected my tracks, another disappeared over the rise back of the den, and a little later two appeared from over the rise. Four were seen at one time. The young foxes amused themselves in various ways; at times they maneuvered in elaborate stalks to pounce on an imaginary mouse or possibly on a real insect; occasionally they stretched out in the sunshine, scratched an ear, walked a log, or engaged in a free-for-all.

After an hour one of the adults trotted out of the swamp behind me, carrying a rabbit (*Sylvilagus floridanus mearnsii*) in its jaws. Although I remained perfectly quiet the fox noticed me when about thirty yards to one side of me. It dropped the rabbit, uttered a sharp "ye-ye-yow," and galloped into the swamp. At the cry the young scurried into the burrow. Four days later the rabbit had been eaten at the spot the fox dropped it. Several bird splashes indicated that a bird of prey had found it.

On June 1 the foxes were still at the den, but on June 13 the den had been deserted for perhaps a week. The original set of holes were being used by something on June 16, but the family was not definitely located again during the summer.

HOME RANGE

Probably most of the foxes' hunting was performed within the twelve hundred acres of the Reserve, but the foxes regularly visited the surrounding region, for tracks were seen at various points along the fence where the foxes had passed in and out of the Reserve. A farmer who hunted in the region stated that he once followed a track from the fence to the vicinity of a village four miles away. If it were not for the fact that hunting was better on the Reserve than on the neighboring farms, the area used for intensive hunting would probably have been considerably larger than that contained in the Reserve. The foxes no doubt cover a wide area each night.

DISCUSSION

The food habits of the fox are largely dependent upon the availability of favorite foods. If rabbits were scarce and meadow mice plentiful rabbit hunting would decrease because of the small returns, and mouse hunting would increase. The small rabbit population would have an opportunity to build up to a point where the rabbit hunting would again become profitable for the fox. There is probably a tendency for some such automatic levelling of the various populations of animals preyed upon by the fox.

It is difficult to evaluate the economic status of the fox. We do not know the economic value of the species preyed upon, nor what effect the fox actually has upon their populations. Furthermore the economic status will vary from one locality to another depending upon man's main interest in each locality, and as a corollary the importance of each species eaten varies from place to place. Although the rabbit hunter may hold a grudge against the fox, the farmer, forester, and orchardist no doubt feel that the destruction of rabbits by the fox is entirely beneficial to their crops and nurseries. The hunter who seeks primarily rabbits might be justified in feeling that the fox is inimical to his sport. In spite of heavy depredations, however, the rabbits on the Reserve continued to flourish and were present in large numbers at the end of the winter, showing that it is possible for the fox and the rabbit to coexist in the same locality. The squirrel hunter might object to the fox taking some of the fox squirrels yet this predation would be mildly beneficial to the farmer whose corn shocks this squirrel sometimes raids.

The destruction of lemming-voles and meadow mice could be either beneficial or neutral, and this is also true of several other rodents. Where

crops are cultivated the fox acts as a natural check on the rodents, tending to prevent their overabundance. On waste lands or on hunting lands destruction of mice would probably be of more or less neutral economic value for the mice would not be harmful, in fact they might be considered beneficial in that they act as buffer species for quail or other game. The use of mice by the fox and other flesh eaters in these areas is legitimate and proper.

Predations on shrews and moles are perhaps on the debit side, for these species eat many insects. The muskrat item in the food also is on the debit side. It is doubtful, however, that many muskrats living under favorable environmental conditions are taken.

The robbing of turtle nests and the preying on turtles may be neutral or beneficial, probably the latter in the case of snapping turtles known occasionally to eat young ducks. The snake predation is probably of more or less neutral character.

Some birds were eaten, including grouse, highly valued by the sportsman. How extensively these predations affected any bird species was not determined. It is important to note they fell off considerably during the nesting season, a period of special significance to the welfare of the bird species.

The heavy predation on beetles is of course entirely beneficial. Some biologists might call this fox activity neutral and of slight significance to the beetle population. It seems likely that the steady pressure exerted on beetle and other populations by the fox and other forms, does have an important effect under average conditions in maintaining normal populations.

The fur value of the fox and the sport it renders to trappers and hunters would seem to compensate for any harmful effect it might have on the rabbit hunter's sport and on the game bird populations.

In summing up, the economic status of the fox is found to be both harmful and beneficial to our interests, just as is most every other species. It is difficult to evaluate it in detail because of the complexity of the ramifications of its activities. From the purely economic point of view it would seem best to permit it to exist in fair numbers controlled primarily by hunting and trapping. These, especially when carried on by boys, give a close acquaintance with Nature, very valuable for any one's development.

Besides the economic there are also aesthetic values which are often too intangible to receive the attention they deserve. The feeling of a woods is much improved by the presence of a fox. It is good to know that the fox is present in a region for it adds a touch of wildness to it, gives tone to a tame country.

If our out-of-doors is to be managed on broad lines so that the various interests both economic and aesthetic are considered, and not for the special benefit of small minority groups, then the fox should be permitted to occupy its rightful niche in the woods and fields.

In following the trail of the fox and noting the many tragedies on it, one is apt, either to label the fox a killer and dislike him for his acts of violence, or, to condone his behavior, knowing he is acting true to his instincts, and to have a sympathetic attitude towards his way of life. The latter point of view is perhaps a happier one. It indicates a deeper understanding of Nature and an acceptance of Nature's laws.

SUMMARY

1. The main food items in the red fox diet were cottontail rabbit, lemming-vole, meadow mouse, and beetles.

2. Depredations on birds were highest in March, lowest during May and June, the nesting season.

3. More food is captured than can be eaten, the surplus is cached for future use.

4. The skunk, crow, marsh hawk, and owl (probably great horned owl) were found to utilize caches of food made by the fox.

5. Shrews and moles are not relished by the fox. Many of them are captured but few are eaten. They are so lightly valued that they usually are not cached.

6. The food assortment at the fox den, as determined from droppings, differs somewhat from that away from the den. More rabbit and insect remains and fewer mice remains were found at the den.

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PLATE I

FIG. 1. A view on the Edwin S. George Reserve showing some of the more open country and an isolated clump of tamarack. March, 1934.

FIG. 2. The second den site showing the sedge pothole in front of it. The main entrance to the den is just out of view between the trees in the foreground. June 15, 1934.

FIG. 1

FIG. 2

PLATE II

FIG. 1. Typical lemming-vole and meadow mouse habitat. A fox had cached a lemming-vole in the foreground. March 19, 1934.

FIG. 2. A hollow in which the fox had cached a lemming-vole. March 30, 1934.

FIG. 1

FIG. 2

PLATE III

FIG. 1. A cottontail cached by a fox and partially exposed as a result of the thawing of the snow. This cottontail disappeared but no clue remained as to what animal had removed it. April 3, 1934.

FIG. 2. This cottontail, cached by a fox, apparently was later eaten by a great horned owl. March 31, 1934.

FIG. 1

FIG. 2

PLATE IV

FIG. 1. This cached cottontail was originally covered by three inches of snow. Later it was eaten by a hawk or an owl. April 3, 1934.

FIG. 2. A deer carcass often visited by the foxes and other animals. April 3, 1934.

Fig. 1

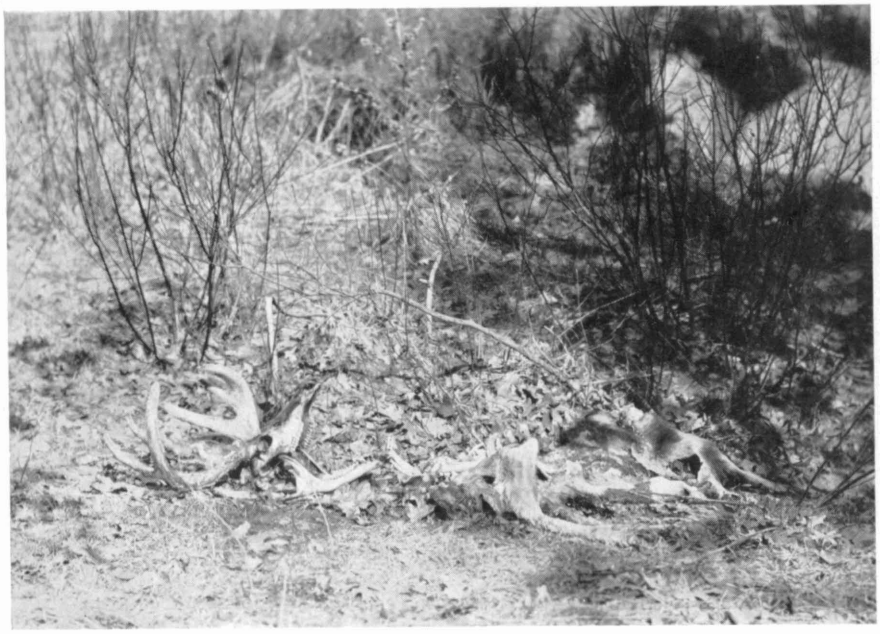

Fig. 2

PLATE V

FIG. 1. A typical cottontail nest in an open field with a platform of dirt in front of it. A large number of these nests were found only one of which had been disturbed by any predator. May 8, 1934.

FIG. 2. This cottontail nest had apparently been raided by some mammal. It was the only nest so disturbed. May 15, 1934.

Fig. 1

Fig. 2

PLATE VI

FIG. 1. Fox tracks and deer-mouse tracks in the fresh snow. March 14, 1934.

FIG. 2. Mouse tunnels in the snow just below the surface. Mice in these tunnels are scarcely protected from a fox. March 18, 1934.

Fig. 1

Fig. 2