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# WISCONSIN FOX POPULATIONS

Final Report

Pittman–Robertson Project 12-R

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TECHNICAL WILDLIFE BULLETIN NUMBER 6

Game Management Division

WISCONSIN CONSERVATION DEPARTMENT

Madison 2, Wisconsin

1953

# WISCONSIN FOX POPULATIONS

by

Stephen H. Richards and Ruth L. Hine

Final Report

Pittman–Robertson Research Project 12-R

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(Note: *This study was begun in 1946 as a Wisconsin Pittman-Robertson project by Stephen H. Richards. All of the field data were collected and the first drafts of the report prepared by Mr. Richards, who ceased working on the project in April 1950. The final analyses of the data, preparation of the section on fox bounties, and most of the conclusions were developed and are here presented as the work of Ruth L. Hine assisted by members of the Wildlife Management Department of the University of Wisconsin and the Game Management Division of the Wisconsin Conservation Department.—W. F. Grimmer, Superintendent of Game Management.*)

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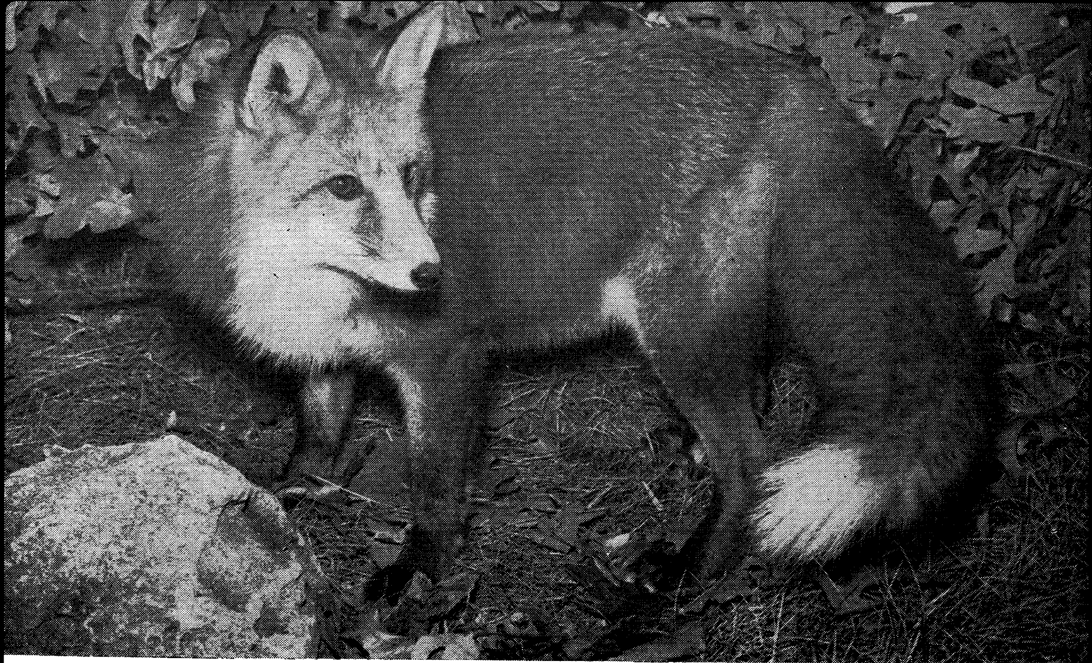
## ABSTRACT

Red and gray foxes are abundant in Wisconsin now and hold a position in the forefront of the wildlife community. In order to gain insight into fox management problems within the state, a study was carried on from 1946–1950 to investigate fox population status, productivity, food habits, and control methods.

Foxes are found throughout Wisconsin, but occur in greatest numbers in the southwestern part of the state. The red fox prefers hilly terrain that forms a patchwork of pastured and unpastured woodlots, cropland, permanent pasture, and stream bottoms, while gray foxes are found mostly in the brush-covered bluffs along the Wisconsin and Mississippi Rivers.

The fox population in Wisconsin over the past twenty-eight years has shown fluctuating levels of abundance. Peak densities have occurred in 1935–36, consisting mainly of grays, and in 1944–45, consisting mainly of red foxes. Since 1944–45, the red foxes have remained at a relatively high, stable level. The reported take of foxes based on hunting, trapping and bounty records is believed to provide a reliable index to statewide and county population changes. Fluctuations have occurred over the past years independent of fur prices and bounties. Also, changes in the reported take for the past decade parallel actual changes in abundance observed by conservation department field men.

A fairly high reproductive gain from spring to fall characterizes both red and gray fox populations. An average pair of red foxes produces 5.1 young per year. With this high reproductive potential of 255 per cent, a protected population of 5,000 red foxes in "ideal" environment would theoretically number over two million in five years. Assuming that the harvest may be one of the principal restraints on the growth of fox populations, over two-thirds of the population would have to be harvested just to prevent a population increase before the next breeding season. Although there are checks and balances on a population which tend to hold it within the limits of the environment, it appears that foxes have the capacity to increase rapidly—at a rate not a great deal lower than that of upland game birds.



**Red fox.**

Examination of den prey remains and stomach analyses showed that in southwestern Wisconsin rodents and rabbits topped the fox food list. Predation on game birds was slight except for gray fox predation on ruffed grouse. Sample analyses of the extent of fox predation suggested that foxes may eat a considerable number of animals during a year, even though the item occurs in stomachs or scats as a relatively low percentage of the total food eaten. The important question, however, is the effect of fox predation on prey populations. This was studied not only in terms of prey eaten, but also with respect to the population trends of the prey species. The effect of fox predation on game populations is apparently insignificant in Wisconsin. Although considerable predation occurred on certain prey species, there was no evidence that prey populations suffered. Rabbits, squirrels, and ruffed grouse have increased in spite of fox predation and continued high fox populations. Predation on pheasants was relatively slight. Although pheasant populations have been relatively low over the past few years, evidence from this state and other states has indicated that foxes were not responsible for the widespread decrease in pheasants.

There have been two "highs" in the incidence of rabies in the state since 1918, the first occurring in 1928 and the second in 1940, and the trend is again rising. The two periods of peak fox populations occurred during years in which there was a very low incidence of rabies.

Wisconsin has paid an average of about $100,000 a year for the past six years in state and county bounty payments. The major portion of the bounty money spent actually affects relatively few individuals. Seven per cent of the men who file bounty claims for foxes take ten or more foxes; this represents 62 per cent of the total number of foxes bountied. Sixty-seven per cent of the claimants take only one fox, but this accounts for only 17 per cent of the total foxes bountied.

An examination of the effect of the bounty on the kill of foxes indicated that in counties in which a $5.00 bounty payment is offered, the fox kill is 45 per cent greater than it is in those counties offering only $2.50, at least during periods of low fur prices. However, this stimulating effect of the bounty on the kill becomes less apparent on an individual county basis. There are local variations which reflect differences in harvest, bounty or no bounty. For example, under a $5.00 bounty the fox harvest in Jefferson county steadily increased, in Portage county it decreased, and in Marathon county remained the same.

The bounty has not been effective in controlling the fox population in Wisconsin to the extent of actual reduction. Since the bounty apparently boosts the harvest of the professional trappers during periods of low fur price, it possibly has restrained the increase of foxes. At present, the take of foxes in Wisconsin has levelled off—it is apparently only skimming the annual surplus.

Various possibilities in the use of bounties and their effects on both foxes and people are examined in the light of evidence from Wis-

**Gray fox.**

consin and other states. If the bounty system is judged on the basis of its "predator control" values, we must conclude that there is more evidence at the present time which indicates that the present bounty system is not controlling the fox population than there is evidence that fox bounties are accomplishing their purpose. If the bounty is continued as an attempt to control the fox population, refinements are needed in the present system which would increase its efficiency and effectiveness.

Removal of the bounty would undoubtedly result in a reduced take of foxes. However, the loss of such control as is now exercised by the present fox bounty might be compensated for by the crash of a peak population or by increased harvest through hunting. Information from various studies indicates that the present abundance of the fox population does not seem to create a serious menace to other wildlife. If damage to poultry and livestock is considered important enough to maintain some use of the bounty system, then the problem is primarily one of agricultural interests.

It is possible that the value of the fox bounty, if judged from the standpoint of its sociological or psychological merits, may be sufficient to justify public acceptance. This too is a matter for other agencies to consider.

# INTRODUCTION

The very presence of foxes in an area arouses controversy. Demands for an increased bounty to control the fox are met with suggestions for leaving him alone and letting nature handle him. The fox is important to many interests. He may in certain localities prey upon game and poultry. The red fox is potentially the worst offender, for he haunts the open areas also shared by farm game birds and livestock. It is especially important to know his effect upon other game populations, particularly during a fox "high". The fox is also a factor in the spread of disease.

On the other hand, the value of this species as a fur resource rates the fox a capital asset to the state. In 1942–43, when red fox pelts were worth about $10.00 apiece, trappers netted an income of about $150,000. Fox hunting is the sport of a great many enthusiastic hunters. Foxes also occupy an important place in the animal community by helping to maintain a natural check upon rodent populations.

It is clear that management is needed in order to conserve the fox as a game animal and control him as a predator. Specific management measures for this species in the state, however, depend upon a knowledge of population status, productivity, and food habits here in Wisconsin. We need to draw up a balance sheet for the fox and appraise his good and bad points in relation to the large amount of money spent in an attempt to control him.

The present study was carried on from July 1946 to April 1950 in order to collect information that would help in the evaluation of red (*Vulpes fulva*) and gray (*Urocyon cinereoargenteus*) fox management problems in Wisconsin. Numerous studies on fox behavior and ecology have been carried on in other states, but certain features of local populations made it necessary to study these animals under local conditions.

## STUDY AREA

The principal study area included seven southwestern counties of Wisconsin (Figure 1). Clifton township, in eastern Grant county, was selected for intensive surveys of fox populations. The study area was located in some of the best fox country in the state, as can be seen in Figures 2 and 3.

All of these counties, except southeastern Lafayette, are a part of the unglaciated portion of the state known as the Driftless Area,

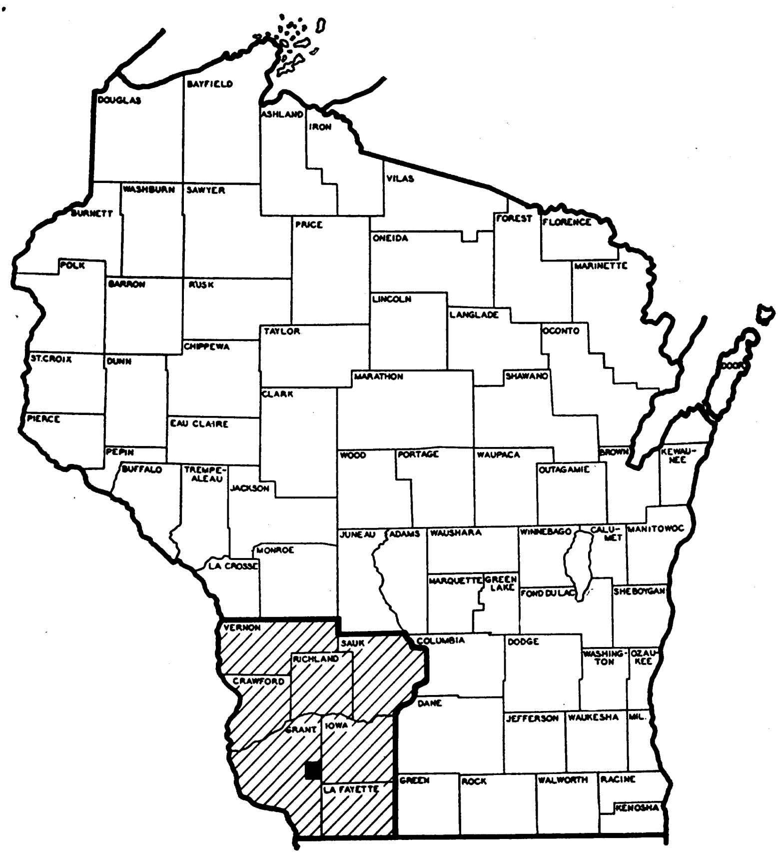



**Figure 1. Southwestern Wisconsin study area, showing principal study area, Clifton township, Grant county.**

which constitutes the roughest land in Wisconsin. In general the topography of this region is characterized by broad, rolling ridges, dissected by steep-sided, narrow valleys. The hillsides are wooded, and agriculture is generally restricted to the valleys and the gently rolling plateaus on top. The most rugged terrain, found in the western-most counties of Grant, Crawford, and Vernon, becomes gentler in slope as one progresses eastward. The woodlands generally supported gray fox populations, while red foxes inhabited the valleys and ridge tops in some areas.

Surveys and records of populations throughout the state and from other local areas were also analyzed and included in this report to provide a general statewide picture of foxes in Wisconsin.

## DISTRIBUTION

Red and gray foxes now occur throughout Wisconsin. The distribution of both species in the state, based on bounty reports for the period 1946–49, is shown in Figures 2 and 3. In order to correct for the differences in county size, an index based on bounty records per square mile of land area was devised. The use of bounty records for securing population data will be discussed later in connection with population trends. Although many counties pay a separate county bounty in addition to the state bounty of $2.50, resulting in some variation in the total amount paid for a fox by each county, there were no indications that the bounty returns inaccurately portrayed the general distribution of foxes by counties. There was little variation between counties in county bounty payments after 1945, for when the state bounty law was re-enacted, all counties were required to adjust their payments in accordance with the amount paid by the state.

In general the highest numbers of red and gray foxes are found in the western half of the state, with heaviest concentration occurring in the southwestern counties along the Mississippi and Wisconsin Rivers.

There are two subspecies of gray foxes listed for Wisconsin, the eastern gray fox (*Urocyon c. cinereoargenteus*) and the Wisconsin gray fox (*U. c. ocythous*). Although the exact determination of where the two forms separate geographically in the state has not been made, Dr. H. H. T. Jackson (letter, May 9, 1952) believes that in general

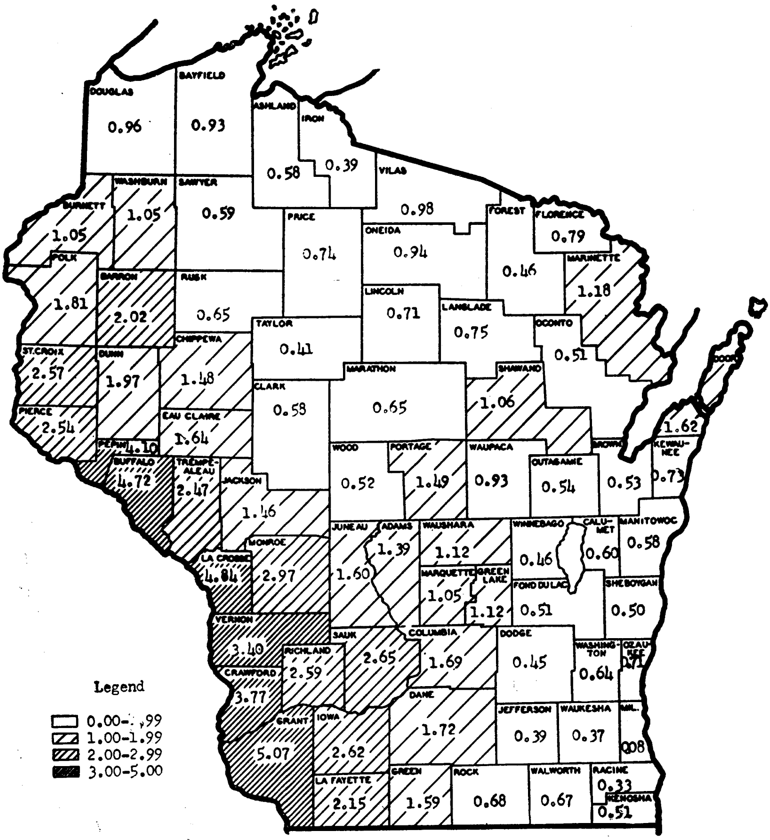



**Figure 2. Red fox distribution, 1946–49 (based on the number of animals bountied during this period per square mile of land area).**

the eastern gray fox is confined to the extreme southeastern corner of the state, possible only in Kenosha, Racine, and Milwaukee counties. The gray fox in the rest of the state is probably the Wisconsin gray fox. No attempt has been made in this study to distinguish between the two subspecies, and in this report they will be referred to only as the "gray fox".

The distribution of foxes for the period 1923–1931 is very similar to their present-day range in the state (Figure 4). These figures also represent the number of foxes bountied per square mile. Data on reds and grays are combined, for the two species were not separated during those years in bounty records.

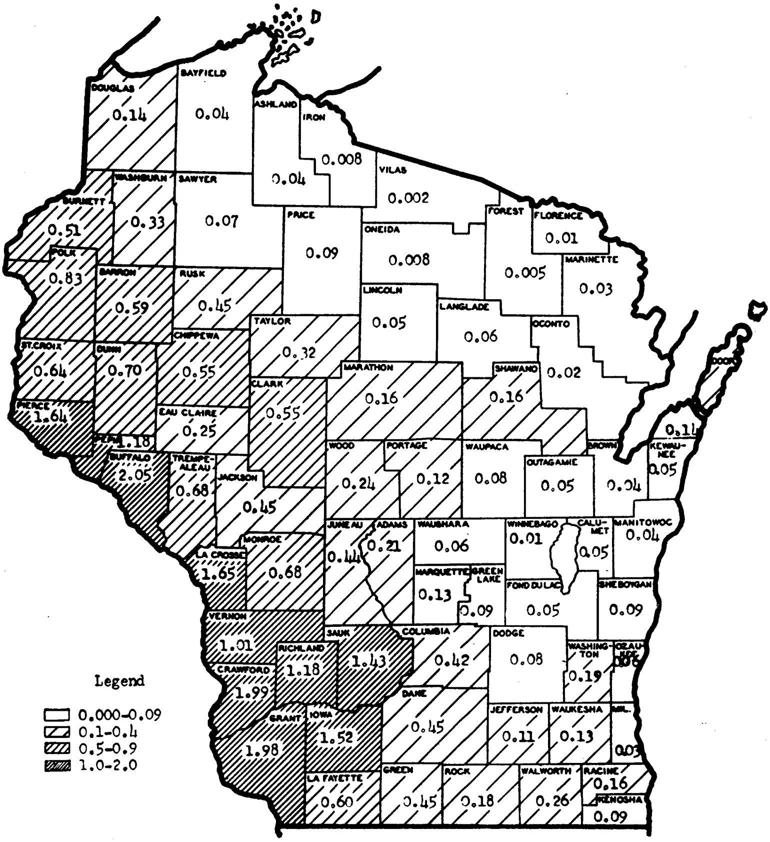



**Figure 3. Gray fox distribution, 1946–49 (based on the number of animals bountied during this period per square mile of land area).**

Information on the earlier history of foxes in Wisconsin is scanty. Cory (1912) wrote that the red fox was recorded as being distributed throughout the state, and was common in most parts of the interior. He also found the Wisconsin gray fox ranging throughout the greater portion of Wisconsin. The limits of the eastern gray fox were not definitely determined, but Cory listed it as far north as north-central Illinois. The eastern gray has only recently extended its range northward, according to Hamilton (1943) and Garlough (1945).

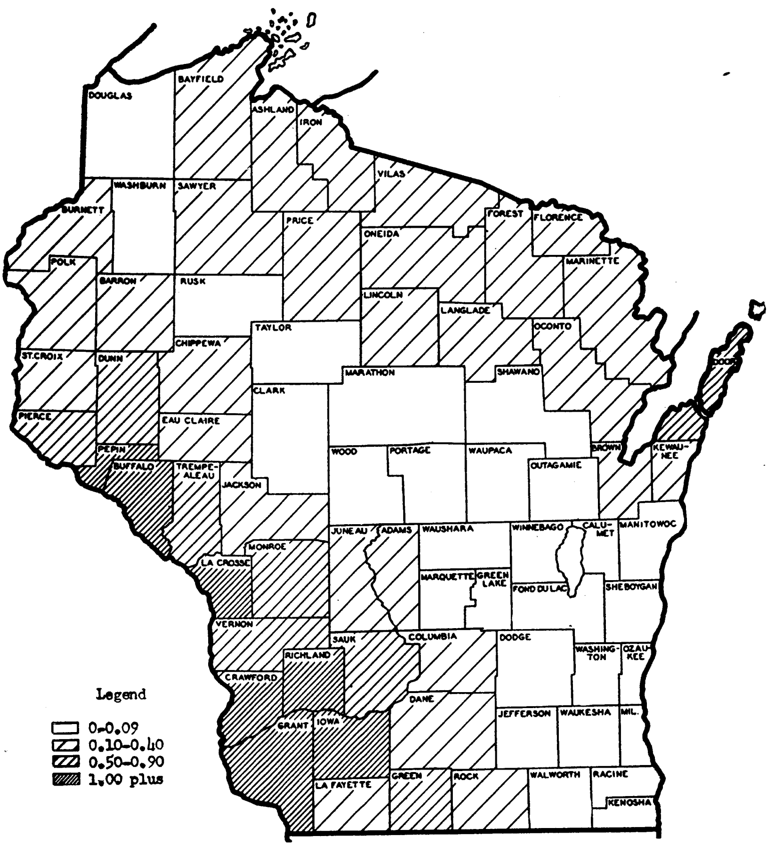



**Figure 4. Gray and red fox distribution, 1923–24 to 1931–32 (based on the number of animals bountied during this period per square mile of land area).**

## GENERAL BEHAVIOR

Certain characteristics of foxes observed during this study will be presented as a background for a better understanding of fox populations in Wisconsin. Since the habits of red and gray foxes have been described by many authors, they will not be discussed in detail here. Information concerning the gray fox gathered during this study is more limited than that for the red fox because of the less accessible habitat and more secretive habits of the gray fox.

## Habitat

In southwestern Wisconsin the red fox was found in greatest numbers in hilly terrain that formed a patchwork of woodlots, cropland, pasture, and stream bottoms. The red fox, unlike the gray, is readily able to adapt himself to his environment, and as a result, there were few places in the study area where some sign of this species could not be found.

The greatest number of gray foxes was found in the brush-covered bluffs of those counties bordering the Wisconsin and Mississippi Rivers.

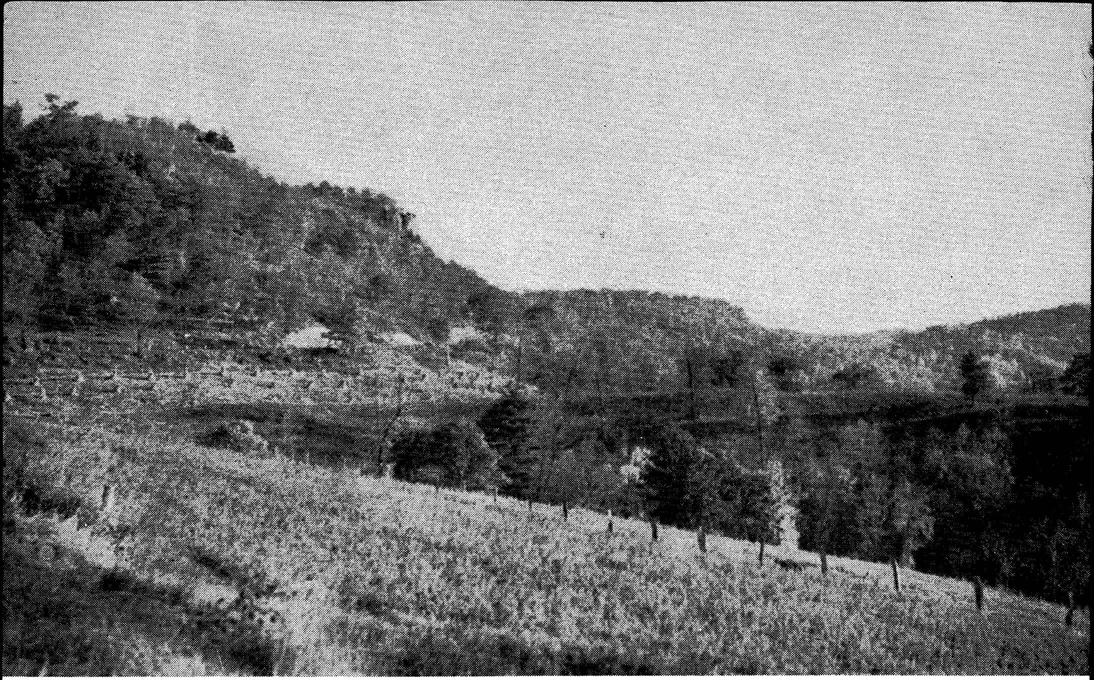
## Movement

Seton (1929) stated that foxes usually had a home range that was not more than five miles in diameter. Murie (1936) studied a red fox family in the 1,200-acre (approximately 2-square mile) George Reserve in Michigan and found that these foxes did most of their hunting within that area. In this case, they were undoubtedly influenced by the better foraging conditions on the preserve than on surrounding lands. In Iowa, Scott (1943) said the normal range of the red fox was about two miles in diameter. Observations on home range size in the southwestern Wisconsin study area agreed with those of Scott.

Changes in the extent of red fox movement occurred at different times of the year. During the breeding season (December-February), there was a great deal of activity over a wide area. After mating was over, there was much less movement on the part of both sexes. Denning activities and the presence of litters held the adults to one general area until mid-June or early July, according to trappers W. E. Hannan and Ernest Messeling. Dispersal and greatest movement then took place during the fall months and early winter.

Sheldon (1950), working with tagged animals in New York state, also reported that the red fox home range increased during the fall and winter. Both male pups and adults travelled widely in the fall in New York, and Sheldon believed that this probably accounted for the preponderance of males caught by trappers at this season. In the Catskills, according to this same author, the sex ratio of foxes caught in January and February was about even, suggesting that with the initiation of the oestrus cycle, females may also wander widely if unmated.

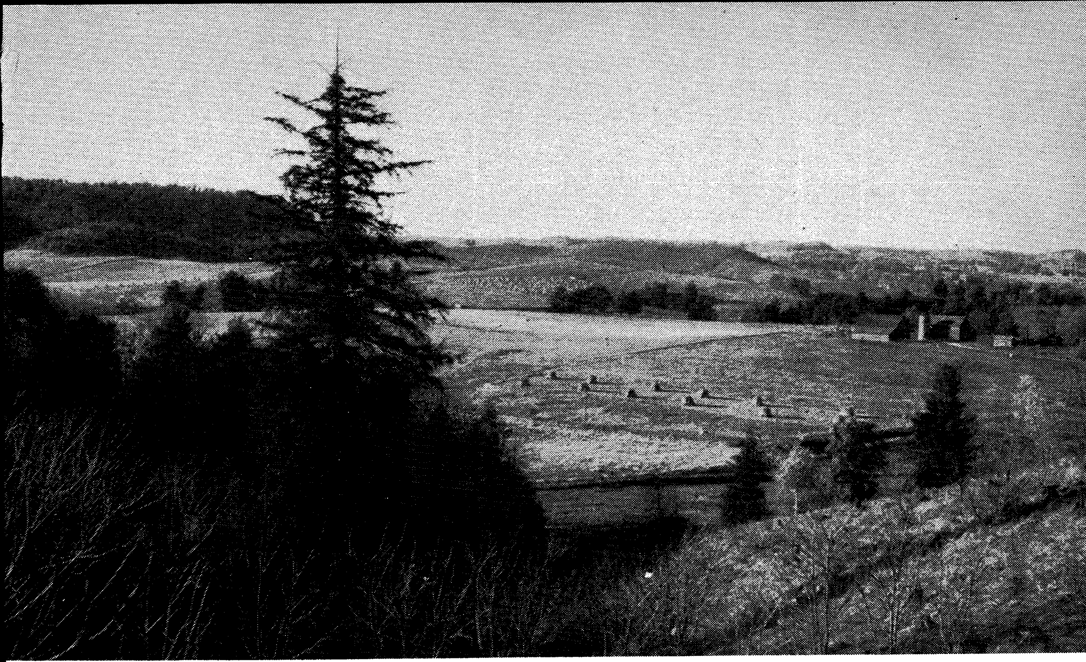
The observations on reduced late winter movement in the southwestern Wisconsin area are difficult to interpret for they may mean



**The red fox prefers hilly country . . .**

reduced activity or they may signify a reduction in the fox population at that season from natural mortality or from winter trapping. These observations were similar to those made by Cyril Kabat and Albert Gastrow (unpublished) at Prairie du Sac, Columbia county. Thirteen red foxes used the Prairie du Sac area (according to track sign) from December to February in 1942–43, whereas in late winter, there were signs of only two foxes. During mid-winter foxes roamed far and wide while feeding. When mating activities started, movement was restricted to small areas, within which much running around occurred. In these relatively small spots all sign indicated that copulation was taking place.

Red foxes appeared to follow certain routes of travel. Foxes and fox sign (tracks, scats, etc.) were found along fencerows, under the crests of ridges, on abandoned farm roads, along the edges of stream banks, on sand bars or in dry stream beds. Foxes seemed to delight in travelling across bare knolls and the top edges of quarries or sand pits. When going from one hilltop to another, the route taken was frequently a relatively smooth path such as a wagon or tractor track which passed through an old wooden gate on the edge of a field. Many times the foxes deviated from other routes just to use these gates. In passing from one valley to another, a fox often crossed at a point where the heads of two hollows joined. When skirting a woods,



. . . that forms a patchwork of woodlots, cropland and pasture (Vernon county).

the first or second furrow in a plowed field that ran parallel to the woods was often used. It was a common occurrence when travelling in snow for one fox to follow directly in the tracks of the one preceding it. Because of this trait, it was difficult to determine the number of foxes using the tracks. Scott (1943) stated that in census work such a trail must be followed to a steep slope where each fox made its own trail.

The home range of the gray fox appeared to be smaller than that of the red fox. The diameter of home ranges on the study area varied from about one-quarter mile to one and one-quarter miles. Often when the brush and woodlots were small in area, grays confined their activities to a territory not more than about a third of a mile in diameter. Gray foxes chased by dogs holed up readily, often without travelling more than a few hundred yards.

Unlike the red fox, the gray did not seem to travel widely except during the fall. Two local trappers, William and Ernest Messeling, reported that fall gray fox movements have consistently been along the river bottoms, up the hollows and valleys towards the high land, and into the interior of the counties bordering the Wisconsin and Mississippi Rivers.

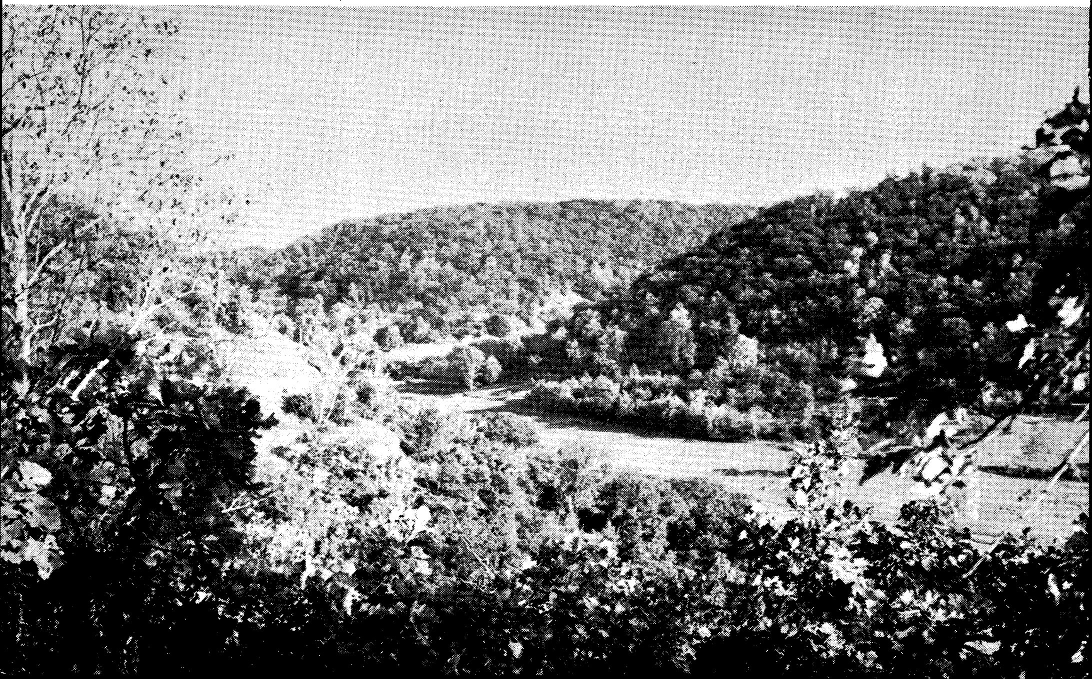
On hillsides that were wooded or covered with brush, the trail of the gray fox appeared as a series of staggered steps. Trails used by gray foxes were distinguished from raccoon trails by their narrower width. When travelling from one woods to another, the gray used much the same travelways as the red fox, i.e., crossings at gates, under ridge tops, etc. The gray was not seen, however, to go to such great lengths in order to use a smooth path.

## Social Habits

As is well known, the scent post is used by the fox as a means of communication. Urine or scats are left beside a small, usually solitary object as a "message" that a fox has visited that area. The scent post is located within the foxes' normal habitat but not necessarily along a travel route. Examples of good scent posts in the study area were rocks, fence posts, mullein stalks, ends of logs, trunks of small apple or thornapple trees, ant hills, and small stumps.

Uneaten food was often cached until some later visit by the fox. The food cache also acted as a scent station. According to W. E. Hannan (verbal communication), one reason for caching food was the foxes' liking for tainted meat. Scott (1943) also suggested this possibility. The foxes seemed to prefer tainted to fresh meat, but would not touch rotten meat. Fox sign observed on winter snows indicated that one fox will readily steal another's cache and bury it in a new location. According to Seton (1929), foxes made caches by burying bits of food with their nose and then urinating on some adjacent object.

**The favorite haunts of the gray fox are brush-covered bluffs (Vernon county).**



## Breeding

The breeding season of the red fox in southwestern Wisconsin began in December, when pairing, or the constant travelling together of a male and female fox, took place. Mating commenced during the middle of January and extended until late February. This agrees with observations made on red foxes by Sheldon (1949) in New York. Two exceptions, however, were brought to our attention in Wisconsin. A pair of reds were seen copulating southeast of Lancaster, on December 16, 1948, by T. Hannan of Livingston. On July 13, 1948, Ernest Messeling saw a litter of four red fox pups at a den in Crawford county. He estimated their ages at six to seven weeks, thereby placing the date of conception in the first week of April.

The breeding season of the gray fox began approximately one month later than that of the red fox, and mating took place between mid-February and late March. Sheldon (1950) found the peak of gray fox breeding in early March in New York.

**Den locations.** Red and gray fox dens were most often found on east-, southeast-, and south-facing hillsides. Twenty-nine dens were located two-thirds of the way up the slope, while 18 dens occurred at the one-third level, and five at the bottom of the hill. Most of the hollows or valleys examined averaged about five to ten miles in length. If these hollows opened into broad valleys, the red foxes were most apt to be in the upper third where the hills were close together. If the hollow did not broaden out and was covered with brush on the lower third of its total length, it was used by both red and gray foxes, the reds being in the upper two-thirds of the hollow or at the junction of a tributary and the main hollow.

The distribution of fox dens in different habitat types is presented in Table 1. The majority of red fox dens was in woods, both in rock outcrops and in the ground. A preference was shown for the more open aspects of a habitat type, e.g., pastured rather than brushy woods, and pastured rather than unpastured grassy areas. Sheldon (1950) found that some of the biggest and most often used dens in New York were in woods near open fields. This was true of several den sites in the Clifton township study area in Grant county in 1947. Pearson and Herbert (1940) in Alabama found that a hole in the ground was preferred, but that sawdust piles were frequently used.

All of the red fox dens examined were located below ground. Their size varied considerably depending upon their location and former

## Table 1

### Location of Fox Dens

| Location | Red Fox | Gray Fox |
|---|---|---|
| WOODS | | |
| Rock outcrop: pastured woods | 9 | 1 |
| brushy woods | -- | 6 |
| Gound: sand hole at edge of woods | 7 | -- |
| in woods | 4 | 2 |
| | 20 | 9 |
| BRUSH | 6* | 3 |
| GRASSLAND | | |
| Pastured | 6 | -- |
| Unpastured | 2 | 1 |
| | 8 | 1 |
| CROPLAND | 2 | -- |
| MISCELLANEOUS | | |
| Quarry | 3 | 2 |
| Rubbish | -- | 2 |
| Logs | -- | 1 |
| | 3 | 5 |
| TOTAL DENS | 39 | 18 |

*Dens on brushy hillsides, but not actually in brush. Three dens were in abandoned mine shafts.

owners. One excavated den measured approximately 53 feet long and 31 feet deep. Other dens in rock fissures extended for more than 80 feet.

Sheldon (1950) showed that only the larger dens were used for raising pups while the smaller dens found more in the open were used as temporary retreats. The data in this study substantiate those observations. Dens originally made by badgers were most often used for natal dens while woodchuck holes at the edges of fields were used only as secondary dens.

The majority of gray fox dens was located on brushy or timbered hillsides, mostly in rock outcrops (Table 1). The intersection of several gray fox trails on such a hillside often revealed a den nearby. The dens could usually be distinguished from those of raccoons by the presence of some debris, and from woodchuck dens by the absence of dry grass near the entrance. Well-beaten trails in the immediate vicinity of the den indicated the presence of pups.

While most of the dens were located below ground, under rock outcrops, in old quarries and elsewhere, three dens were found above ground. One was in a sawdust pile, another under a pile of decaying lumber, and the third in an old oak log.

The length and depth of most of the dens could not be measured since they were located in rock fissures. One den, dug out south of Verona, Wisconsin, in 1946, was six feet in depth and about 17 feet in length. The den in the hollow log was about six feet in length.

**Denning reactions to disturbance.** Any disturbance on the part of humans often caused adult foxes to move their litters to a new location. Pups were moved from one red fox den that was approached no closer than 50 feet. On the other hand, several young females remained in the same location even after scats and prey remains had been removed from the den entrance. The new den sites were often only a quarter of a mile away on a neighboring hill-side. During May of 1947, near Fennimore, Wisconsin, a litter of six pups was moved one-eighth mile to a new den following disturbance.

Loss of one of the parents sometimes caused the remaining parent to move its litter to the den of another pair. Three cases of this behavior among red foxes were observed during 1947 and 1948. Sheldon (1950) reported that the occurrence of two litters in one den was not uncommon, for a high degree of intraspecific tolerance existed during the denning season. He did not believe that polygamy was indicated from his evidence on multiple denning.

## Behavior in Captivity

Several red and gray foxes were trapped in the wild and penned at the State Experimental Game and Fur Farm, Poynette, Wisconsin. Observations showed that these animals exhibited fundamental differences in behavior. The gray fox is not only better camouflaged by his environment than the red fox, but he is also more secretive in his nature. The red fox is endowed with a curiosity that must be satisfied. When the cage was approached, the red foxes appeared less afraid while the grays became extremely nervous and vicious. In attempting to net them to obtain weekly weights, the grays immediately ran back and snarled and snapped viciously. The red foxes never made a sound or created a scene. Their actions for the most part seemed to signify contempt rather than fear. Under extreme conditions, such as malnutrition or starvation, however, the red foxes actively paced back and forth in their cages, while the grays remained lying down most of the time, thereby retaining their strength and weight longer than the reds.

# POPULATION TRENDS

Information on the abundance and population trends of a wildlife species may often be affected by the methods used for obtaining it. For this reason data on fox populations in Wisconsin have been gathered from several sources during the course of this study. Each method used in measuring statewide and local changes in abundance and the results obtained will be discussed and evaluated in order to determine not only the status of the fox population in Wisconsin, but also reliable means for detecting changes in abundance.

## SEASONAL POPULATION TRENDS

The use of scent stations was employed as a means of sampling fox populations. Stations were used to attract foxes to a certain point and induce them to leave scats, tracks, or urine. This census method was used one year during this study, and the results suggest only seasonal trends in the fox population. Artificial scent posts were established and studied during the fall of 1942 in New York by Cook (1949). His data suggested that records of fox sign at scent posts provided a practical index of relative abundance of foxes between areas and from year to year.

Certain prerequisites were necessary for an effective scent station. The object used must be solitary, not more than three feet in height or one foot in diameter, within the fox's normal habitat and away from buildings, devoid of human scent, located in the path of air currents, inaccessible to livestock as much as possible, and on a surface where a registry of sign was possible. The location of the scent station in the center of finely broken earth or sand, and the use of a scent attractive to foxes but not to other animals added to the effectiveness of the station. Rocks, fence posts, mullein stalks, ends of logs, small apple trees, and stumps made the best stations. Tufts of grass were used only if they were solitary.

If scent was placed on an "unnatural" object near one with the prerequisites for a good scent post, the fox was invariably attracted to the best post first and to the misplaced scent second.

Location of the scent station along the natural travelways of the fox—fencerows, cow paths, the edges of plowed fields, and barren knolls—proved most effective for red foxes. Grays could be best attracted along rock outcrops in heavy brush.

The effectiveness of various lures and baits was tested by a series of experiments in the field. A commercial lure, Dailey's No. 1 fox lure, was found to produce the best results, and was used in the scent-station census study.

Scent-station lines were set up in Iowa and Sauk counties. Route 1, in southern Sauk county, extended from Badger Village west and south to Leland and Spring Green. Route 2, in northern Iowa county, extended from Dodgeville northwest to Pine Knob, Union Mills, and Avoca. Stations were placed where natural fox crossings were found, and were located about 100 yards from the roads. Crossings that passed near farm buildings were omitted. The car routes were 30 miles long, and had 12 to 14 stations. The distance between stations varied, as the fox crossings determined their locations.

Stations were baited and left undisturbed for two days, so that foxes might have an opportunity to reach the station during one circle of their home range. Readings were made on the third day. This routine was repeated after a ten-day interval, the stations again being rebaited.

The results of the 1948 spring and fall censuses are given in Table 2. The figures represent the number of occurrences of foxes at the stations. Counts were simplified by the presence of scats that were deposited at the scent stations. As both spring and fall censuses were made on snow or mud, the registries were quite easily observed.

**Table 2**

**Scent Station Index, 1948**

| *Time of Year* | *Route I (Twelve Stations)* | *Route II (Fourteen Stations)* | *Total Count* |
|---|---|---|---|
| *Spring* (March) | | | |
| First readings | 16* | 23 | 39 |
| Second readings | 19 | 20 | 39 |
| *Fall* (December) | | | |
| First readings | 31 | 43 | 74 |
| Second readings | 41 | 48 | 89 |

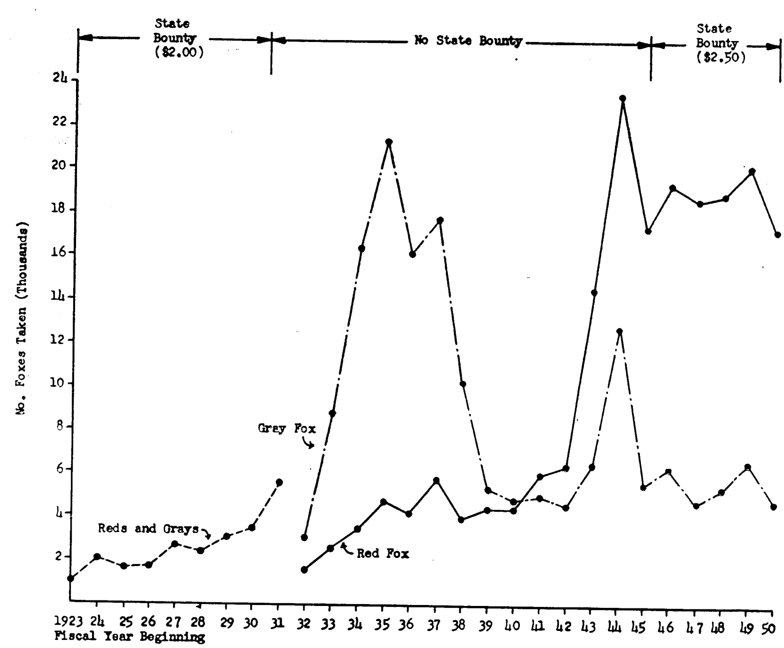
*Number of occurrences of foxes.

The spring count was believed to be a fairly close approximation of the breeding population. The rise in fox numbers in the fall is difficult to interpret at this time, for an actual population increase may have been clouded by greater fall movement. Nevertheless, continued use of this technique over a period of years should provide relative indices of both seasonal increase and annual population density which may be compared from year to year.

## Statewide Changes

The reported take of foxes offers the most available and extensive information on fox abundance and population trends. Data on the harvest of red and gray foxes for the state, based on hunting, trapping, and bounty reports are presented in Figure 5 for 1923–24 to 1950–51. The harvest for the southwestern Wisconsin study area from 1940–41 to 1950–51 is shown in Figure 6. This information was obtained from the Game Census Reports of the Wisconsin Conservation Department (Bersing *et.al.*), and represents actual fiscal year bounty records, and one hundred per cent corrections of hunting and trapping kill reports.

In using the reported take as an index to fox abundance it is important to consider whether the harvest reflects actual population levels or whether it merely reflects changes in hunting and trapping pres-




Note: 1923-24 to 1930-31: bounty records
1930-31 to 1945-46: 100% corrections of hunting and trapping records
1945-46 — : bounty records

**Figure 5. Wisconsin fox harvest, 1923–24 to 1950–51.**

sure, regardless of population density. The changes in hunting and trapping pressure and the factors that influence them, such as fur price and the bounty, must be analyzed in relation to the apparent population trends.

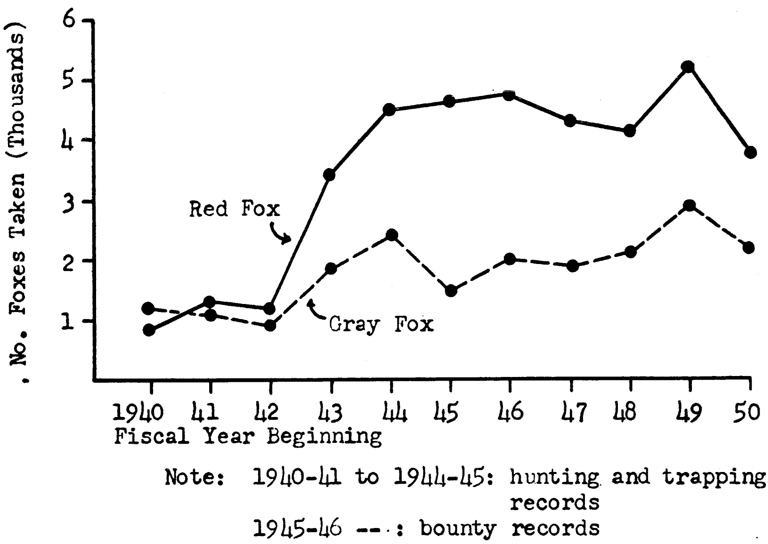



**Figure 6. Fox harvest in the southwestern Wisconsin study area from 1940–41 to 1950–51.**

The periods during which the state bounty was in effect are shown in Figure 5. The average values of fox pelts in Wisconsin based on Conservation Department records appear in Table 3. Unfortunately records for the early forties are not available, but that period is believed to have been one of high fur prices. Local Wisconsin fur buyers estimated the value of pelts in 1942–43 at about $13.00 apiece. The trend in the sale of hunting and trapping licenses is shown in Figure 7 for 1927–28 to 1950–51. In general, the number of trapping licenses sold has remained constant, while the number of hunting licenses has gradually increased over this period of 23 years.

From 1923–24 to 1931–32, when a $2.00 state bounty was in effect, the fox population was relatively low, but was gradually increasing. There was no differentiation at that time in the reports between reds and grays. Fur prices were high, but were gradually decreasing as the population increased.

## Table 3

### Average Fox Pelt Values

| | Red Fox | | Gray Fox |
|---|---|---|---|
| 1927–28 | | $ 9.93 | |
| 1928–29 | | 11.28 | |
| 1929–30 | | 8.38 | |
| 1930–31 | | 5.34 | |
| 1931–32 | | 2.76 | |
| 1932–33 | | 2.24 | |
| 1933–34 | | 3.40 | |
| 1934–35 | | 2.32 | |
| 1935–36 | | 2.67 | |
| 1936–37 | | 2.66 | |
| 1937–38 | | 2.09 | |
| 1938–39 | $ 3.60 | | $ 1.82 |
| 1939–40 | ------ | | ------ |
| 1940–41 | ------ | | ------ |
| 1941–42 | ------ | | ------ |
| 1942–43 | ------ | | ------ |
| 1943–44 | 10.78* | | 3.11* |
| 1944–45 | 3.86 (4.90)* | | 1.98 |
| 1945–46 | 6.00** | | 1.96 |
| 1946–47 | 1.84 | | 1.11 |
| 1947–48 | 1.25 | | 0.99 |
| 1948–49 | 0.79 | | 0.67 |
| 1949–50 | 0.53 | | 0.42 |
| 1950–51 | 0.98 | | 0.39 |

*Average obtained from sales slips from Master Furriers, Madison, Wisconsin.
**From Leopold (1945).

There was no state bounty from 1931–32 to 1945–46, although during this period one-third to one-half of the counties were paying bounties. The number of gray foxes taken rose abruptly and then declined. The value of the pelt had decreased before this gray fox high, and it is doubtful that the relatively small number of counties paying a bounty affected the take. The kill of red foxes remained low through 1942–43, although fur prices were at an all-time high. The take rapidly increased to a peak in 1944–45, however, and may in part have reflected the high pelt value. Fur prices declined in 1944–45, but trapping efforts for that year of high take were undoubtedly influenced by the high fur price of the previous year.

A $2.50 state bounty was placed on foxes during 1944–45. The law went into effect in March, however, and during the remaining months of the fiscal year, only 3,077 foxes were bountied out of a total of 36,487 for the fiscal year, indicating that the re-enactment of the bounty law could not have affected the high take of foxes during 1944–45.

The war years apparently exerted little influence on the fox harvest although their effect was evidenced in a slight decline in hunting pressure (Figure 7).

In 1945–46 the take decreased somewhat. Fur prices were lower, although the bounty was in effect. However, there has been no rapid decline comparable to that which occurred ten years ago in gray foxes.

The fox harvest from 1945–46 through 1950–51 has remained at a relatively high, stable level. When fur prices are very low, a bounty ranging from $2.50 to $5.00, depending upon the county in which the fox is taken, may offer sufficient stimulus to trappers to maintain this high take.

One of the most important variables affecting the use of harvest records as a population density index is generally believed to be the variation in trapping intensity caused by changes in the price of pelts from year to year. Seagears (1944) believed that pelt price strongly influenced the red fox take in New York, where he found a close correlation between the number of foxes taken and pelt price each year from 1918 to 1936. From 1936 to 1942, however, the take of red foxes rose disproportionately to the value of the pelt, due possibly to the fact that the fox population was building up towards a peak, and/or more good trappers were at work. However, Seagears concluded that the annual reported take of foxes had little or no relation to their actual abundance.

In Wisconsin there is little evidence supporting the apparent relation between take and pelt price found by Seagears in New York. During certain periods of high fur price, the take has been low. Conversely, during certain periods of low fur price, the take has been high. Although the increased harvest of red foxes during the mid-

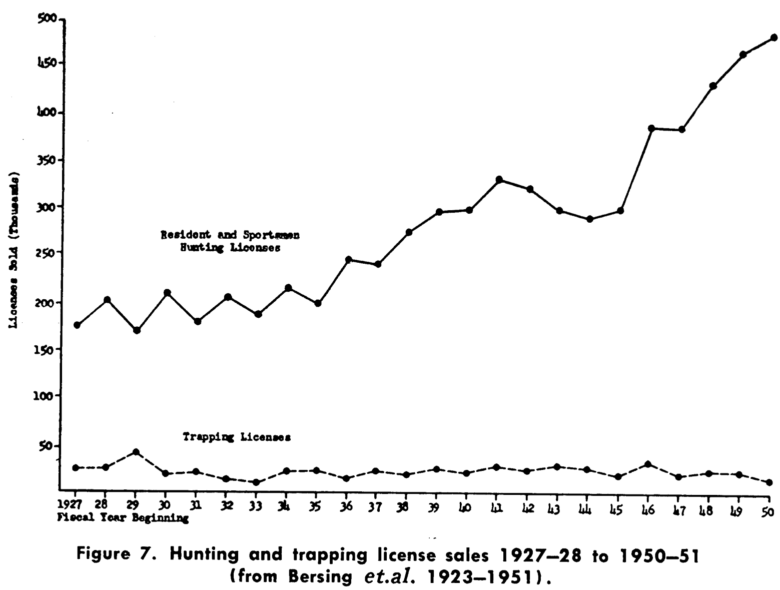



**Figure 7. Hunting and trapping license sales 1927–28 to 1950–51 (from Bersing *et.al.* 1923–1951).**

forties occurred while fur prices were still high, the fact that the take was low in the early forties while fur prices were at an all-time high tends to offset the controlling influence of pelt value on the fox harvest.

The influence of the bounty cannot be discounted after 1945, when fur prices were low. An analysis of bounties and their effect upon the fox kill will be discussed in a later section. It is apparent, however, that bounty payments have had little effect on the fox population itself in Wisconsin, and are not believed to have influenced the take of foxes out of proportion to the actual population.

Data from field observations offer additional information on red fox population levels from 1940–1952, and provide a good comparison with the population status determined by the reported take for this period. Questionnaires are sent annually to conservation wardens and game management division personnel of the Conservation Department requesting information on the status of game in each county—whether a particular species has increased, decreased or remained the same compared with the previous year. The material on foxes has been analyzed according to the method of Thompson (1951 and verbal) except that the values are expressed as a decimal index rather than a per cent (Table 4). In presenting this information as an index which is based on the previous year, 1.00 equals no over-all observed change. Above 1.00 indicates an increase and below 1.00, a decrease. By this method the highest index attainable is 2.00 (all reports indicating an increase) and the lowest is 0.00 (all reports indicating a decrease). The increase in the red fox from 1940–41 to 1944–45 is similar to that revealed by the hunting, trapping and bounty records for this period. A decline in the fox population after the peak was also observed by the field men.

## Local Changes

Direct observations in the field have been carried on for a number of years in two local areas, and are included here for comparison with the general statewide changes in population density. It is apparent from these observations that local changes may occur which are not reflected in population curves for a large area.

**Den counts.** Counts of fox dens were made over an eight-year period (1940–47) in Clifton township, Grant county by W. E. Hannan and S. Richards. Although this method was believed to be an accurate one for determining trends in the breeding popula-

## Table 4

## Summary of Data from Annual Questionnaires to Conservation Department Field Men—Status of Foxes Compared with Previous Year

| *Year* | Red Fox: *No. Reports* | Red Fox No. Reporting: *Increase* | Red Fox No. Reporting: *Decrease* | Red Fox No. Reporting: *Same* | Red Fox: *Index Based on Previous Year* | Gray Fox: *No. Reports* | Gray Fox No. Reporting: *Increase* | Gray Fox No. Reporting: *Decrease* | Gray Fox No. Reporting: *Same* | Gray Fox: *Index Based on Previous Year* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1939–40 | 71 | 16 | 11 | 44 | 1.07 | 61 | 10 | 21 | 30 | 0.82 |
| 1940–41 | 66 | 22 | 10 | 34 | 1.18 | 58 | 10 | 14 | 34 | 0.93 |
| 1941–42 | 70 | 41 | 3 | 26 | 1.54 | 57 | 24 | 12 | 21 | 1.21 |
| 1942–43 | 81 | 55 | 3 | 23 | 1.64 | 66 | 28 | 4 | 34 | 1.36 |
| 1943–44 | 63 | 53 | 3 | 7 | 1.79 | 54 | 30 | 5 | 19 | 1.46 |
| 1944–45 | 68 | 29 | 15 | 24 | 1.21 | 66 | 26 | 11 | 29 | 1.23 |
| 1945–46 | 70 | 21 | 34 | 15 | 0.81 | 68 | 15 | 23 | 30 | 0.88 |
| 1946–47 | -- | -- | -- | -- | ---- | -- | -- | -- | -- | ---- |
| 1947–48 | 72 | 7 | 44 | 21 | 0.49 | 61 | 5 | 23 | 33 | 0.70 |
| 1948–49 | 56 | 9 | 24 | 23 | 0.73 | 55 | 8 | 18 | 29 | 0.82 |
| 1949–50 | 98 | 23 | 32 | 43 | 0.91 | 86 | 12 | 25 | 49 | 0.85 |
| 1950–51 | 63 | 8 | 31 | 24 | 0.63 | 62 | 3 | 27 | 32 | 0.61 |
| 1951–52 | 63 | 42 | 3 | 18 | 1.62 | 65 | 13 | 4 | 48 | 1.14 |

tion present on an area, it had certain limitations. The time involved in finding all den sites, especially during years when the population was at a peak, was often considerable. Secondary dens must be distinguished from natal dens. An area of one or two townships (the most that could accurately be handled under the conditions mentioned above) might be all or part of a trapper's territory. His trapping pressure could render a population picture that was different from the surrounding untrapped area.

The den-count index of the population trend in Clifton township (36 square miles) is shown in Figure. 8. The number of dens increased to a peak in 1945, corresponding to the high numbers of foxes recorded in Grant county from bounty returns (Figure 8). The den count, however, dropped sharply to a low in 1947, while bounty records showed a high red fox population. Apparently the reduction was due to a local decline of foxes in Clifton township. The results of an investigation of this decline will be presented later.

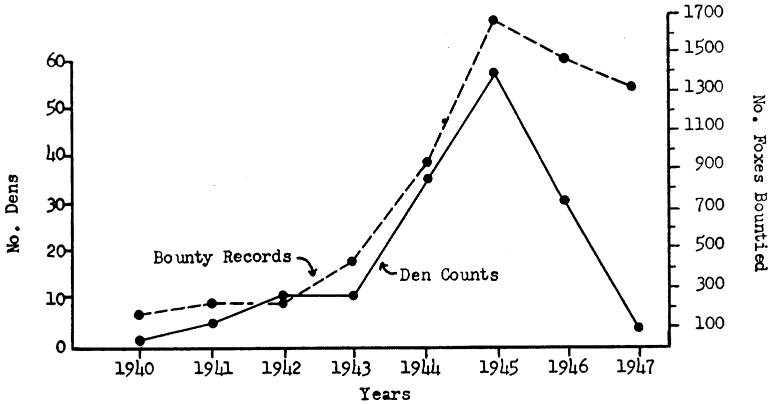



**Figure 8. Comparison of den counts in Clifton township, Grant county, and the Grant county harvest of red foxes.**

**Direct observations.** A census of all wildlife species on a 4500-acre tract of land in Prairie du Sac, Columbia county, has been carried on since 1931 by Albert Gastrow. The maximum number of foxes using the area has been determined by direct observations, track counts, kills, etc. The trend in the red fox population is shown in Figure 9. Peak numbers in this region were reached in 1943–44, one year preceding the state high in red foxes as revealed by hunting, trapping, and bounty records. Both the Prairie du Sac census and the Columbia county harvest records showed that the

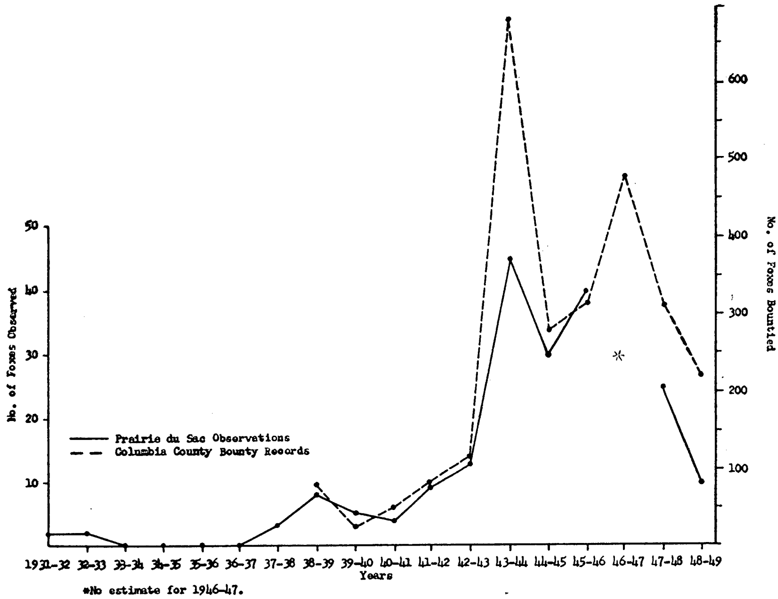



**Figure 9. Estimates of red fox population on the Prairie du Sac area based on direct observations. (The number of foxes bountied in Columbia county is shown for comparison.)**

red foxes decreased following the peak, where the statewide records indicated a continued high population (Figures 5 and 9). The reason for this local decline is not entirely clear, but heavy hunting and trapping in that locality, which was stimulated by high pelt prices, undoubtedly affected the population.

## Discussion and Summary

In general, fox populations in Wisconsin over the past twenty-eight years have shown fluctuating levels of abundance. Peak densities have occurred in 1935–36, consisting mainly of gray foxes, and in 1944–45, consisting mainly of red foxes. Since 1944–45 red foxes have remained at a relatively high, stable level. Records from the southwestern Wisconsin study area show fox population trends similar to the statewide trend from 1940–1951.

The recent abundance of foxes in Wisconsin is a part of a widespread fox increase. The 1944–45 high extended from Wisconsin east to New York and west to Iowa and Minnesota, according to Leopold (1945). Gier (1948) noted that the fox population was at an all-time high around 1947 throughout the Allegheny Plateau.

The reported take of foxes based on hunting, trapping, and bounty reports offers the most available and extensive information on fox abundance and population trends. We believe that this source of data provides a reliable index to statewide and county population changes. The fluctuations that have occurred over the past years have been independent of trends in pelt prices and bounty payments. In other words, an abundant fox population seems to be the primary incentive for the harvest of foxes, rather than a monetary stimulus. The reported take for the past decade parallels the changes in abundance reported by Conservation Department field men on annual questionnaires.

While observations of foxes and fox sign in the field provide more sensitive indices of local abundance than do the over-all harvest records, they do not necessarily reflect the statewide picture. Local decreases in the fox population were noted in Clifton township and Prairie du Sac which were not revealed by bounty records and observations on the statewide population.

## LOCAL DECLINE OF A RED FOX POPULATION

During the late winter of 1946 and early spring of 1947, red foxes declined in Clifton township, Grant county. During this time, numerous observations on emaciated and weakened foxes were made by farmers, hunters and trappers. Several specimens were examined and studies in the field were carried on in an effort to determine the cause of the decline.

### Condition of Carcasses

The external appearance of 28 unskinned red foxes from Clifton township examined during 1947 exhibited varying degrees of emaciation. In several of the more severe cases the pelts appeared stretched over the ribs, and the shoulder blades were prominent through the fur. The guard hairs had lost their lustre and the under-fur was woolly and matted. According to fur buyers and trappers, there was a gradual and progressive depreciation in the quality of the red fox pelt from this area during 1946 and 1947. The hide was thinner and the fur more woolly. The average fox pelt among 500 specimens did not become prime until mid-December 1946, 18–20 days later than during the preceding three years (Hannan, verbal communication).

At the State Experimental Game and Fur Farm, Poynette, normal fur growth pattern was halted by placing foxes on a starvation diet. During 1949, game-farm red foxes on short rations maintained their full winter coat into May, while the control animals had almost completely shed their winter coats.

A sample of 158 skinned carcasses examined during this time appeared abnormal. The subcutaneous and visceral fat was markedly reduced. This was especially evident in the pregnant females that normally have the largest visceral fat deposits. A blackened condition and inflammation was noted in some of the internal organs. The intestines in particular were blackened, possibly due to a partial disintegration of their walls. Some scats also showed this blackened condition, and there was some evidence of a waxy diarrhea. The kidneys and urinary tracts in many of the animals appeared to be inflammed. The pancreas and spleen were seldom affected, and there was no outward change in the liver or heart. No nematodes were found in the intestines showing the blackened condition, in those where a severe enteritis was present, nor in discolored stomachs or urinary bladders. Two severely emaciated foxes showing a blackness of the bowel and inflammation of the small intestine and urinary tract had greatly shrunken stomachs, not more than 3½ inches long.

The abnormal conditions found in these carcasses were apparently not caused by freezing and thawing, or by decomposition. Six fox carcasses from other counties were allowed to freeze, thaw, and decompose for varying lengths of time. None of the conditions found in the Clifton township foxes could be reproduced even by allowing decomposition to take its course. All tissues disintegrated at an expected rate. Freezing and thawing had little effect on the feces and caused neither a diarrhetic condition nor a discoloration of the intestinal walls.

In mild cases, the bone marrow of the femur was either granular or pasty, and was an opaque red-pink color. In carcasses with more pronounced symptoms, the bone marrow varied from a paste to a watery consistency of a deep red color.

## Field and Laboratory Observations

About 30 scent stations were set up during late February 1947 to determine whether or not there was a movement of the foxes off the area rather than a die-off. All scent stations, both within and beyond the periphery of the study area, showed a decline in the number of foxes visiting them. These results are clouded, however, by the fact that there may have been some seasonal diminution in fox movement during this time.

During the denning period of 1947, some dens which had been used for several consecutive years were cleared by pregnant females, but subsequently were not used. Dens with pups were later found in new locations not far from abandoned dens. In April and May, some of the dens which had been abandoned earlier by females were examined. Of 17 dens explored thoroughly, eight had dead foxes in them. While an adult fox ordinarily clears out all debris from a den, including other dead animals, it evidently will abandon the effort when another fox has died there. Two of these foxes were extremely emaciated and showed a blackened condition of the intestines. The other six were too badly decomposed to autopsy.

Numerous observations were made on weakened and dead foxes in the field. Some animals had apparently lost their fear of man. One emaciated fox trapped in early July 1947, was examined by Drs. Robert Rausch and S. H. McNutt of the Veterinary Science Department of the University of Wisconsin, and exhibited symptoms similar to those described above. Tests were negative for distemper and rabies. The animal had just molted its winter coat (which is more than a month late for pelage change according to Scott [1943]), and had not bred.

## Discussion

The first phase of the decline that took place during the fall and early winter of 1946 was unfortunately not studied. The evidence collected during the early spring of 1947 suggests that a local outbreak of disease occurred in Clifton township, Grant county, causing a marked reduction in the local fox population. The causative organism was not discovered. It is possible that starvation was the predisposing factor. With the advent of starvation and lowered resistance, many organisms which are normally nonpathogenic assume a pathogenic role and this possibly accounted for the inflammatory changes observed. Since there was no evidence of a statewide food shortage and no drastic decline in fox populations elsewhere in the state according to field men, it appears that this decline was a purely local phenomenon.

# CHARACTERISTICS OF THE POPULATION

While numerous studies on fox population trends and food habits have been conducted, information on the composition of the population and its relation to changes in density is generally lacking. Although management is highly dependent upon information such as the breeding potential of the fox population, there are few documented data available on this phase of fox ecology.

Data on age and sex ratios, productivity, and weights were therefore gathered over a period of four years (1946–1950) in Wisconsin in order to determine the composition of the fox population, and to correlate changes in composition with changes in population density.

## Carcass Collections

Cooperating hunters and trappers throughout the state contributed 1,230 carcasses (901 red and 329 gray foxes). Each carcass was first superficially examined for any abnormal conditions, and a search for ectoparasites was made if the carcass was fresh. Ovaries and uteri were removed and placed in a solution of F.A.A. (formalin acetic acid and alcohol). When the weather was warm, the carcasses had to be examined within a week of the time the foxes were killed. Beyond that time decomposition destroyed all obtainable information. A solution of neutroleum alpha, a replacer, was used to partially destroy disagreeable odors resulting from decomposition.

## Sex Ratios

Sex ratio data are presented in Tables 5 and 6 for 1946–1950. The red fox sex ratio averaged 52 per cent males to 48 per cent females, which does not differ significantly from a theoretical 50:50 ratio. The sex ratio differed significantly from year to year, but these differences may be related to the time of year at which the samples were taken. Since the over-all ratio is based upon samples taken from September through March, it is believed to be fairly representative of the annual picture.

In gray foxes, there were 53 per cent males to 47 per cent females, which also does not differ significantly from a 50:50 sex ratio. No significant differences existed between years in the sex ratios for this species.

## Table 5

### Monthly and Yearly Changes in the Sex Ratio of the Red Fox

| | *Sept.* | *Oct.* | *(Oct.-Nov.)* | *Nov.* | *Dec.* | *Jan.* | *Feb.* | *Mar.* | *Total* |
|---|---|---|---|---|---|---|---|---|---|
| 1946–47 | | | | | | | | | |
| Number | --- | -- | ----- | 7 | 10 | 59 | 37 | 19 | 132 |
| Per Cent Male | --- | -- | ----- | 43 | 60 | 63 | 43 | 54 | 57 |
| 1947–48 | | | | | | | | | |
| Number | --- | 19 | ----- | 17 | 10 | 64 | 22 | -- | 132 |
| Per Cent Male | --- | 63 | ----- | 53 | 30 | 37 | 9 | -- | 38 |
| 1948–49 | | | | | | | | | |
| Number | 83 | 54 | ----- | 39 | 23 | 25 | -- | -- | 224 |
| Per Cent Male | 72 | 59 | ----- | 46 | 61 | 44 | -- | -- | 60 |
| 1949–50 | | | | | | | | | |
| Number | 179 | -- | (234) | -- | -- | -- | -- | -- | 413 |
| Per Cent Male | 42 | -- | ( 57) | -- | -- | -- | -- | -- | 49 |
| TOTAL | | | | | | | | | |
| Number | 262 | 73 | (370) | 63 | 43 | 148 | 59 | 19 | 901 |
| Per Cent Male | 54 | 60 | ( 56) | 48 | 51 | 49 | 30 | 54 | 52.2±1.7 |

Sheldon (1949) believed that figures on number and sex of foxes taken in New York state and elsewhere by professional trappers do not reflect a true picture of what is in the population. In the fall when the majority of foxes are trapped, there is a preponderance of males caught, since they travel more widely than the females. Sheldon (1950) further noted that in the Catskills of New York, the sex ratio of foxes caught in January and February was about even. The data from Wisconsin tend to indicate a similar situation. From September to December, the red fox sex ratio showed a higher proportion of males (54 per cent) than did the sex ratio for the late winter period from January to March (45 per cent males). These two ratios were significantly different ($X^2 = 5.33$). The fall sex ratio was also significantly different from a 50:50 ratio.

The sex ratio of 10 red fox litters trapped or dug out of dens was 51 per cent males to 49 per cent females, which is closer to the ratio obtained from the carcass collections. Sheldon (1949) found a slight but insignificant preponderance of females in a sex ratio of 95 males to 100 females among 117 red fox foeti and juveniles.

## Table 6

### Yearly Changes in the Sex Ratio of the Gray Fox

| *Year* | *Number* | *Per Cent Male* |
|---|---|---|
| 1947–48 | 32 | 56 |
| 1948–49 | 97 | 54 |
| 1949–50 | 200 | 53 |
| Total | 329 | 53.4±2.8 |

## Age Ratios

Females were separated into age classes by the presence or absence of placental scars. When the presence of scars could not be definitely determined, the size and degree of transparency of the uterine tract aided in age determination. This technique was useful at all times of the year. The uterine horns of females of the year were less than 3 mm. in diameter. After the first litter, they increased in diameter to more than 3 mm. In old females, the uterine horn was 5–6 mm. in diameter. In juveniles, the horns were thin, pink, and translucent. The tract was darker in older animals and in barren females.

The lack of good age criteria for males prohibited their breakdown into age classes. Teeth, hair, and testes measurements were tried, but without success. A study of the baculum was started, but the effort was too late to be of value in this study.

Tables 7 and 8 give the age ratios for female red and gray foxes from 1946–1950. The red fox age ratio for all four years was 27 per cent adults to 73 per cent immatures. The percentage of immatures did not vary significantly during the first three years of the study, but was significantly higher (86 per cent) in 1949–1950. The percentage of young foxes taken during September to November was higher than that taken from December to February.

The age composition of the catch was influenced by the time of year in which trapping was undertaken. Most of the foxes in this sample were taken during the fall—a time when the young of the year were still easily trapped. The higher ratio of young during 1949–1950 may be partially explained by the fact that local conditions forced several fox trappers to frequently shift their areas. As a

### Table 7

### Seasonal and Yearly Age Ratios in the Red Fox (Females only)

| *Year* | *Sept.-Nov.* | *Dec.-Feb.* | *Total* |
|---|---|---|---|
| 1946–47 | | | |
| Number | 4 | 47 | 51 |
| Per Cent Imm. | 50 | 64 | 63 |
| 1947–48 | | | |
| Number | 15 | 67 | 82 |
| Per Cent Imm. | 87 | 54 | 60 |
| 1948–49 | | | |
| Number | 66 | 23 | 89 |
| Per Cent Imm. | 67 | 65 | 66 |
| 1949–50 | | | |
| Number | 203 | --- | 203 |
| Per Cent Imm. | 86 | --- | 86 |
| TOTAL | | | |
| Number | 288 | 137 | 425 |
| Per Cent Imm. | 81 | 59 | 73.3 ± 2.1 |

**Table 8**

**Yearly Change in Gray Fox Age Ratios (Females only)**

| *Year* | *Number* | *Per Cent Imm.* |
|---|---|---|
| 1947–48 | 14 | 72 |
| 1948–49 | 45 | 62 |
| 1949–50 | 97 | 72 |
| Total | 156 | 68.6±3.8 |

result, they were often unable to take more than one or two foxes at each set. Those foxes most apt to be caught first were the less trap-wise young of the year.

## Reproductive Aspects

**Litter studies.** Dens were located in several ways in order to make litter studies. Some were reported by hunters and trappers. Some were found with the aid of fox hounds, and others by noting locations most often used by the foxes, as described in the section on general behavior in this report. In those instances where the dens were not molested, several observations of the litters were made to insure a positive pup count.

A probe, later described in the food habits section, was modified to drive the young pups from the den. The fish hooks were covered with cotton and cloth soaked in a solution of ammonia and skunk scent. The skunk scent made the pups sick enough to leave, and the ammonia helped the scent to permeate to all corners of the den.

Red fox pups were successfully live-trapped by driving them from the dens into a trap tightly placed against the entrance. Some fox urine placed next to the trap attracted the young,

Methods of determining the age of pups seen at dens were based on general estimates of size and weight by hunters and trappers who have taken large numbers of denning foxes for bounty, and observations made on pups appearing at the den for the first time. The coat of a very small pup was browner than an older pup; its legs were chunkier and it walked with a waddle. The tail of an infant of four weeks or less was compact and tapered to a point. Teeth could be used as an age criterion up to the time that fox pups obtained their adult dentition during the fifth and sixth months of age.

The birth dates of 25 litters fell between March 13 and April 14. March 31 was computed as the average date of birth, based on the data in Table 9.

## Table 9

## Size of Red Fox Litters Observed During 1947 and 1948

| *Date Observed* | *Approximate Age of Litters in Weeks* — *Size of Litter Observed*: *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *No. of Litters* | *Ave. Litter Size* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Apr. 16–30 | 5 | 5 | 5,5,4 | ---- | --- | -- | ---- | ---- | --- | 5 | 4.9 |
| May 1–15 | - | - | ---- | 8,4,3<br>7,6,1 | 4,5<br>4,6 | -- | 5 | ---- | --- | 11 | 4.9 |
| May 16–31 | - | - | ---- | ---- | 6 | -- | 6,6,7 | ---- | 6 | 5 | 6.2 |
| June 1–15 | - | - | ---- | ---- | --- | -- | ---- | 5,5,4 | --- | 3 | 4.7 |
| June 16–30 | - | - | ---- | ---- | --- | -- | ---- | ---- | 5 | 1 | 5.0 |
| No. of Litters | 1 | 1 | 3 | 6 | 5 | -- | 4 | 3 | 2 | 25 | |
| Ave. Litter Size | 5 | 5 | 4.7 | 5 | 5 | -- | 6 | 4.7 | 5.5 | | 5.1 |

The average size of 25 red fox litters was 5.1 ± 0.3 (Table 9). No definite relation was apparent between size of litters and age when observed, nor did litter size change significantly throughout the spring.

There was a difference between the average size of 10 litters in 1947 (4.6 ± 0.4) and the size of 16 litters in 1948 (5.4 ± 0.3) but it is not statistically significant at the 95 per cent confidence level.

**Placental site counts.** Placental sites are scars left at the implantation points of embryos in the uterine tract. Each scar represents at least one embryo, and a placental site count will give approximately the number of young that the female had in her previous litter (Sheldon 1949). The average number of placental scars in red fox females was 5.1 (the same as the average litter size), and in gray foxes was 3.9 (Table 10). There was a highly significant difference between species in the number of scars present.

**Table 10**

**Placental Site Counts**

| | *Red Fox* | | *Gray Fox* | |
|---|---|---|---|---|
| *Year* | *No. Females* | *Ave. No. Sites* | *No. Females* | *Ave. No. Sites* |
| 1946–47 | 21 | 6.5±0.4 | 3 | 4.3 |
| 1947–48 | 21 | 4.4±0.4 | 3 | 4.3 |
| 1948–49 | 32 | 4.7±0.3 | 17 | 3.4±0.2 |
| 1949–50 | 29 | 5.3±0.2 | 21 | 3.9±0.4 |
| TOTAL | 103 | 5.1±0.2 | 44 | 3.9±0.2 |

Sheldon (1949) believed that litter counts were less accurate than counts of embryos and placental scars. Using the latter method, he found that the litter size of 95 red foxes averaged 5.37 (1–9), and that of 35 gray foxes averaged 3.66 (1–7).

Placental-site counts were made over the four-year period, and this information is presented in Table 10. A significant difference exists between the average number of scars observed in red foxes in 1946–47 (6.5) and the averages for the following three years (4.4, 4.7, 5.3). There was no significant difference between years in placental-scar counts in gray foxes.

## Weights

There was a highly significant difference between the average weights of red and gray foxes, the gray being the heavier of the two (Table 11).

The average weights of male, immature female, and adult female red foxes were significantly different, and a decrease in the weight of each sex and age class is apparent from fall to winter (Table 12). The decrease may have been due in part to the advent of the breeding season. It is particularly interesting to note that immature females, rather than continuing to grow, were also lighter in the winter than in the fall.

## Table 11

## Comparison of Red and Gray Fox Weights*

| | *No. Specimens* | *Ave. Weight (Gms.)* | *Stand. Error* |
|---|---|---|---|
| Males | | | |
| Red | 110 | 143.5 | 1.7 |
| Gray | 40 | 156.4 | 3.7 |
| Females | | | |
| Red | 44 | 124.4 | 1.7 |
| Gray | 21 | 137.0 | 3.2 |

*September–November 1948–49 data used.

## Table 12

## Sex–Age Weight Comparison and Seasonal Weight Differences in Red Fox (1947–49)

| | *Fall (September–November)* | | | *Winter (December–February)* | | |
|---|---|---|---|---|---|---|
| | *No.* | *Ave. Wt. (Gms.)* | *S.E.* | *No.* | *Ave. Wt. (Gms.)* | *S.E.* |
| Males | 134 | 141.7 | 1.5 | 113 | 130.3 | 1.7 |
| Imm. Females | 59 | 119.9 | 1.7 | 76 | 110.7 | 1.8 |
| Ad. Females | 27 | 130.6 | 1.7 | 61 | 124.8 | 1.9 |

A comparison of yearly weights of immature and adult female red foxes shows that there was a progressive weight increase from 1947 to 1949 (Table 13). The 1946–47 and 1948–49 weights for both age groups were significantly different.

## Table 13

## Yearly Difference in Red Fox Weights*

| | *Imm. Females* | | *Ad. Females* | |
|---|---|---|---|---|
| *Year* | *No.* | *Ave. Wt. (Gms.)* | *No.* | *Ave. Wt. (Gms.)* |
| 1946–47 | 15 | 101.3 | 11 | 115.3 |
| 1947–48 | 18 | 115.2 | 29 | 128.0 |
| 1948–49 | 15 | 116.7 | 8 | 130.5 |

*December and January data.

## Discussion

During the period from 1946–47 to 1949–50, the red and gray fox populations throughout the state decreased slightly in 1947–48 and showed a rise in numbers in 1949–1950. There is no marked correlation apparent between these density changes and the sex and age composition of the fox populations, except for the large, immature segment of the red fox population recorded during the relatively high fox year in 1949–1950. Changes in the average number of placental sites in red foxes roughly paralleled the population trend. Whether a change in litter size is a mechanism for regulating population size is not known.

The progressive increase in the weight of female red foxes during this period may be a key to the health and well-being of the population, but cannot be evaluated at this time.

Information on the characteristics of the fox population provides the raw data from which we can figure the reproductive capacity of the foxes in Wisconsin. During this study, an average pair of red foxes produced 5.1 young annually—a potential annual increase of 255 per cent. The fox is monogamous, breeds at the age of one year, and produces one litter a year with an approximately even sex ratio. With these breeding characteristics of foxes in mind we may estimate the potential increase of a protected fox population (Table 14). This method of analysis is designed after that used by Knudsen (1951) in computing the potential increase of beaver.

**Table 14**

**Potential Increase of a Protected Red Fox Population**

| *Year* | *Breeding Population* | *255% Potential Annual Increment* | *Total Population* |
|---|---|---|---|
| 1952 | 5,000 | 12,750 | 17,750 |
| 1953 | 17,750 | 45,262 | 63,012 |
| 1954 | 63,012 | 160,680 | 223,692 |
| 1955 | 223,692 | 570,414 | 794,106 |
| 1956 | 794,106 | 2,024,970 | 2,819,076 |

A population of 5,000 red foxes with no mortality would theoretically number over two million in five years. This rate of increase is not a great deal lower than that of gallinaceous birds.

The key to the actual rate of increase in one year lies in the fall age ratio. The age ratio based on fall and winter samples for female red foxes from 1946–1950 was 73 per cent immature and 27 per cent adult animals, or 2.7 young females per adult female. The males could not be aged in this study, but assuming that the same age ratio existed for the males, then each adult female produced 5.4 young. This is closely comparable to the average litter size (5.1). Although there is some discrepancy, probably due to differential trapability of young animals, this does suggest a fairly high reproductive gain from spring to fall. The high reproductive potential of foxes is of course not realized in nature; a number of factors operate constantly upon a population that by and large hold it down within the limits of the environment. What the checks and balances are on the red foxes in Wisconsin are not known. Mortality factors and the rate of turnover of fox populations have not been determined. Food and cover are probably not serious limiting factors in this state, for the intensified agriculture of the past decade is believed to have favored the increase and spread of red foxes. During times of very high populations, disease and parasites and probably intraspecific strife may be important limiting factors.

The harvest of foxes may now represent one of the principal restraints on the growth of fox populations. Table 15 shows the possible effect of harvest alone on the red fox population, discounting other mortality factors. A hypothetical harvest of half of the fox population would still allow a sizeable annual increase; at least 75 per cent of the population would have to be taken to effect a decrease in numbers.

## Table 15

## Effect of Harvest on a Sample Red Fox Population

| *Population* | *255% Potential Annual Increment* | *Total Population* | *Harvest* | *Remaining Population* |
|---|---|---|---|---|
| (1) 10,000 | 25,500 | 35,500 | 33% | 23,785 |
| (2) 10,000 | 25,500 | 35,500 | 50% | 17,750 |
| (3) 10,000 | 25,500 | 35,500 | 71% | 10,295 |
| (4) 10,000 | 25,500 | 35,500 | 75% | 8,875 |

Similar tabulations for the gray fox reveal a potential annual increment of 195 per cent, which would also allow a rapid population increase for this species, barring the effect of unknown natural mortality factors.

Although there are many unknowns clouding our knowledge of fox population mechanisms, it is at least clear that this species does have a high potential rate of increase. This fact must be taken into consideration in the management of both foxes and other game species. If the harvest is one of the important means now of controlling the fox population at its present high level of abundance, then over two-thirds of the population would have to be taken annually just to prevent an increase.

# FOOD HABITS

What a fox eats is of great importance. Of even greater importance is the effect of fox predation on prey populations. The reputation of the fox as a game-killer must be evaluated not only in terms of the foods eaten and their availability, but also with respect to the population trends of the prey species. Such information is needed in Wisconsin before the place of the fox in the wildlife community, particularly during times of high fox populations, can be properly appraised.

## Materials and Methods

A study of prey remains found at fox dens was carried on during the spring and early summer months of 1948 in Grant, Crawford, and Vernon counties. Fox dens were spotted by the presence of prey remains at or near the entrances. No other predator in this region leaves so much carrion in the vicinity of the den. Several kills were also found by walking at right angles to the prevailing wind on both sides of the den. The detection of kills by their odor was a method used successfully by Scott (1943) to locate prey that otherwise might have been overlooked. No attempt was made in our study to differentiate between kills and carrion.

Care was taken in examining dens which were to be revisited not to leave human odors which might cause the fox to remove the pups. Rubber boots about 16 inches high, rubbed in horse or cow manure, were standard footwear, and cotton gloves were used when picking up debris.

Prey remnants were removed from inside the dens by means of a den probe made from an electrician's quarter-inch tape or "fishwire". Three large fishhooks were brazed to one end of a 35-foot tape to form a claw. The opposite end was bent in the shape of a crank, so that the wire could be twisted down into a den. Another wire one-half inch in diameter and 80 feet long was used to explore some of the deeper rock fissures. Because this wire was heavier, it was more difficult to detect the presence of debris. The smaller wire was stiff enough to be pushed around corners or oblique surfaces. There was enough strength in it to pull out large pieces of debris such as dead foxes, and yet it was delicate enough to grasp and remove objects as small as dead mice or quail wings. An augur with a least a three-inch bit and a very long shank was used to bore horizontal holes on a level with the den floor. The fishwire probe was then used to remove carcass remains and prey remains from the den. Occasionally a hole was bored into the den chamber from above so that some light could enter for a more complete examination.

Several attempts to find the limitations of the probe were carried out on partially dug-out dens and indicated that those objects lying close to the back sides of rock fissures were sometimes missed.

Stomach analyses of foxes trapped in southwestern Wisconsin during the winters of 1947 and 1948 were performed by Bruce P. Stollberg at the Food Habits Laboratory, Poynette, Wisconsin (Pittman-Robertson Research Project 8–R). One hundred and thirteen stomachs were inspected for food remains. Fifty of these were found to be empty. Of those containing food, 59 were stomachs of red foxes and four were of gray foxes. Because of the well-known secrecy of trappers, it was impossible to get either the number of animals caught in baited traps or the type of bait used. The techniques used in predator stomach analyses have been previously described by Stollberg and Hine (1952.)

## Results

Data on prey remains collected from 33 red fox and 18 gray fox dens from April to July 1948 are summarized in Table 16. Chickens, cottontails, and woodchucks occurred most frequently at red fox dens; fox and gray squirrels and songbirds were next in importance. At gray fox dens, cottontails predominated; moles, songbirds, ruffed grouse, and woodchucks were also relatively important as prey species.

Information from stomach analyses of 59 red and 4 gray foxes trapped during the winters of 1947 and 1948 is combined and presented in Table 17. These data show that cottontails, rodents, and chickens were most important in the winter fox diet. Prey contained in five stomachs collected in the spring was similar to that of winter collections.

The results of the two types of food-habit analyses are generally similar, except for the occurrence of rodents. The most striking limitation of the den studies is the exclusion from den prey remains of almost all of the small rodents, which are usually swallowed whole.

The high priority of cottontails and mice on the fox food list is similar to the findings of Chaddock (1939) in Wisconsin, and parallels the results of stomach and scat analyses performed by investigators in

## Table 16

### Prey Remains Found at Fox Dens, April–July, 1948

| | Gray Fox (18 dens) | | Red Fox (33 dens) | |
|---|---|---|---|---|
| | Frequency of Occurrence (%) | Number Specimens | Frequency of Occurrence (%) | Number Specimens |
| UPLAND GAME BIRDS | | | | |
| Pheasant (*Phasianus colchicus*) | 6 | 1 | 3 | 2 |
| Quail (*Colinus virginianus*) | -- | -- | 6 | 2 |
| Ruffed Grouse (*Bonasa umbellus*) | 28 | 5 | 9 | 4 |
| UPLAND GAME MAMMALS | | | | |
| Cottontail (*Sylvilagus floridanus*) | 78 | 16 | 42 | 17 |
| Woodchuck (*Marmota monax*) | 22 | 4 | 39 | 15 |
| Fox Squirrel (*Sciurus niger*) | 11 | 3 | 27 | 10 |
| Gray Squirrel (*Sciurus carolinensis*) | 6 | 1 | 21 | 11 |
| PREDATORS AND FURBEARERS | | | | |
| Muskrat (*Ondatra zibethica*) | -- | -- | 12 | 4 |
| Skunk (*Mephitis* sp.) | 6 | 1 | 6 | 2 |
| Opossum (*Didelphis virginiana*) | -- | -- | 6 | 2 |
| Weasel (*Mustela* sp.) | -- | -- | 15 | 5 |
| RODENTS AND INSECTIVORES | | | | |
| Spermophile (*Citellus tridecemlineatus*) | -- | -- | 6 | 2 |
| Chipmunk (*Tamias striatus*) | 11 | 2 | 3 | 2 |
| Deer mouse (*Peromyscus* sp.) | 6 | 2 | 3 | 1 |
| Norway rat (*Rattus norvegicus*) | 6 | 1 | 3 | 1 |
| Mole (*Scalopus* sp.) | 40 | 9 | -- | -- |
| MISCELLANEOUS BIRDS | | | | |
| Redwing (*Agelaius phoeniceus*) | 6 | 1 | 24 | 9 |
| Cardinal (*Richmondena cardinalis*) | -- | ---- | 6 | 5 |
| Flicker (*Colaptes auratus*) | 11 | 2 | 15 | 5 |
| Meadowlark (*Sturnella* sp.) | -- | -- | 6 | 2 |
| Catbird (*Dumetella carolinensis*) | 33 | 14 | 3 | 1 |
| Crow (*Corvus brachyrhynchos*) | -- | -- | 9 | 3 |
| Unidentified songbirds | 33 | 8 | 3 | 1 |
| DOMESTIC ANIMALS | | | | |
| Pig (*Sus scrofa*) | -- | -- | 9 | 3 |
| Chicken (*Gallus gallus*) | 11 | 2 | 88 | 61 |

One specimen of the following was found at gray fox dens (none taken at red fox dens): mourning dove (*Zenaidura macroura*), shrew (unidentified), long-eared owl (*Asio otus*), and mallard (*Anas platyrhynchos*).

One specimen of the following was found at red fox dens (none taken at gray fox dens): mink (*Mustela vison*), starling (*Sturnus vulgaris*), sparrow (unidentified), domestic rabbit, and domestic cat (*Felis domestica*).

other states (Errington 1935, Bennett and English 1942, Eadie 1943, Scott 1947 and others.) Predation on upland game birds was relatively low, except for gray fox predation on ruffed grouse. This agrees in general with other studies.

Scat collections from several den sites suggested a preference for May beetle pupae (*Phyllophaga* sp.) during the early summer. Numerous scats observed about the entrance of several fox dens in the Spooner area (Washburn county) in the spring were composed almost entirely of the pupal cases of May beetle. Other workers have found insects, primarily Orthoptera and Coleoptera prominent in the fox diet during the summer (Scott 1943, Eadie 1943, Errington 1937).

## Predator–Prey Relationships

The relationship between the fox and certain of its prey species will be considered in the following discussion on the basis of: 1) the

## Table 17

## Stomach Analyses of 59 Red and 4 Gray Foxes Trapped During the Winters of 1947 and 1948 in Southwest Wisconsin

| | *Per Cent Occurrence* | *Per Cent of Total Food* |
|---|---|---|
| UPLAND GAME BIRDS | | |
| Pheasant (*Phasianus colchicus torquatus*) | 2 | 5 |
| GAME MAMMALS | | |
| Cottontail rabbit (*Sylvilagus floridanus*) | 45 | 39 |
| Muskrat (*Ondatra zibethica*) | 2 | 1 |
| Deer (*Odocoileus virginianus borealis*) | 2 | T* |
| RODENTS | | |
| Prairie field mouse (*Microtus ochregaster*) | 18 | 17 |
| Field mouse (*Microtus pennsylvanicus*) | 8 | 3 |
| Other Microtinae, excluding muskrat | 24 | 8 |
| Deer mouse (*Peromyscus maniculatus*) | 5 | 1 |
| Peromyscus (species unidentified) | 5 | 1 |
| Harvest mouse (*Reithrodontomys megalotis*) | 2 | T |
| Jumping mouse (*Zapus hudsonius*) | 2 | T |
| Rat (*Rattus* sp.) | 2 | 2 |
| Woodchuck (*Marmota monax*) | 3 | 3 |
| OTHER MAMMALS | | |
| Skunk (*Mephitis* sp.) | 3 | 3 |
| Domestic cat (*Felis domestica*) | 2 | 1 |
| OTHER BIRDS | | |
| Chicken (*Gallus gallus*)** | 27 | 8 |
| Flicker (*Colaptes auratus*) | 2 | T |
| Unidentified | 2 | T |
| PLANTS | | |
| Corn (*Zea mays*) | 7 | 5 |
| TRAP DEBRIS | 5 | 1 |

*Trace.
**Few chickens were running free during this period and most occurrences were probably carrion.

foods eaten and their availability (as measured by relative population density); and 2) a comparison of the population trends of predator and prey. The population trends of the red and gray fox and various prey species, based on kill records, are presented in Figure 10 for the southwestern Wisconsin study area from 1940–1950. A comparison of food availability and food eaten is presented in Table 18 for 1947 and 1948.

## Table 18

## Availability of Prey Species, Southwestern Wisconsin, 1947–48

| *Species* | *Estimated Population Status** | *Per Cent Occurrence* | |
|---|---|---|---|
| | | *51 Dens* | *63 Stomachs* |
| Pheasant | Low | 3.9 | 1.6 |
| Ruffed Grouse | Low (Rising) | 15.7 | ---- |
| Quail | Medium (Rising) | 3.9 | ---- |
| Squirrel | Low–Medium | 37.2 | ---- |
| Cottontail | Low | 55.0 | 44.4 |

*Estimated in relation to population trends observed from 1940–1950, Figure 10.

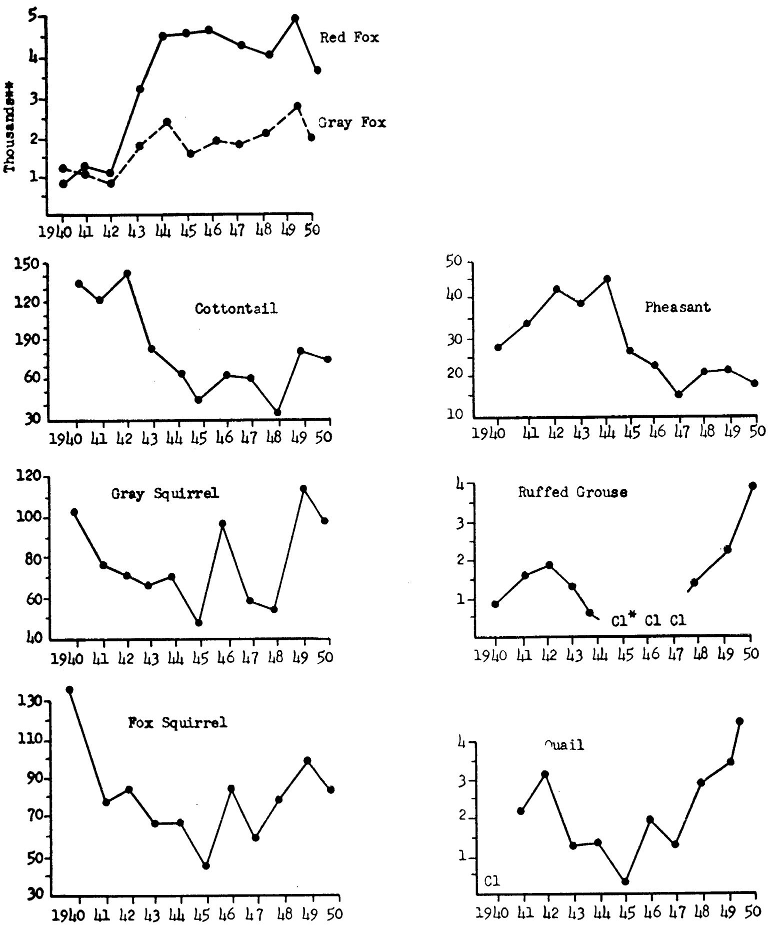
**Rodents.** Data on rodent populations were not available for this region. Evidence from the Madison area in Dane county, however, about 50 miles east, indicated high rodent populations in 1948, particularly of the field mouse, *Microtus pennsylvanicus,* which reached its highest density at that time during the period from 1947 to 1950 (Hine 1952). Rodents were a prominent food item in the fox diet, suggesting that animals tend to eat the food that is readily available.

**Rabbits and squirrels.** Cottontails and gray squirrels went into population troughs during the time of the study (1947–48), but were still of high priority in the fox diet (Table 18). This would seem to indicate that even though the population trend of a species denotes a "low", the animals still may not be below the threshhold of predation. It also suggests that such species are preferred by foxes, and are available to them despite low abundance. However, predation has not hampered the increase of the rabbit or squirrel population during the past two years of fox abundance (Figure 10).

**Pheasants.** There are three approaches to the problem of fox vs. pheasant in Wisconsin—the distribution of the two species within the state, the food habits of the fox, and the comparison of population trends of predator and prey.

The distribution of the pheasant as revealed by kill records is shown in Figure 11. When this is compared with red and gray fox distribution (Figures 2 and 3) it is clear that most of the pheasants are in the southeast and most of the foxes are in the southwest. The ranges of the two species do overlap, however, and the predation problem still exists, for a few members of a predator species are potentially capable of considerable damage.

Food-habit studies in southwestern Wisconsin showed that pheasants were rarely taken by foxes. Admittedly this is an area with a comparatively low pheasant population. Evidence from kill records suggests that there are far fewer pheasants per fox in southwestern Wisconsin than in the south and central parts of the state. But in spite of the potentially high predator pressure, the amount of predation on pheasants by foxes was light. This question cannot be completely answered in Wisconsin until fox food habits are analyzed in the southwestern part of the state, where there are high pheasant densities. Such a study will be made in the future.




*Cl = closed season.
**All figures on the ordinates represent estimated numbers of animals killed in thousands.

**Figure 10. Population trends of predator and prey species in seven southwestern counties, 1940–41 to 1950–51 (compiled from Bersing *et.al.* 1923–51).**

Scott (1947) in his study of the red fox in Iowa found that pheasants in both high and low densities were not preyed upon much. Errington (1935) found pheasants among 34 per cent of 910 den specimens during a midwest winter study, and among 8.2 per cent of 2,110 fox scats from pheasant range in Iowa (Errington 1937).

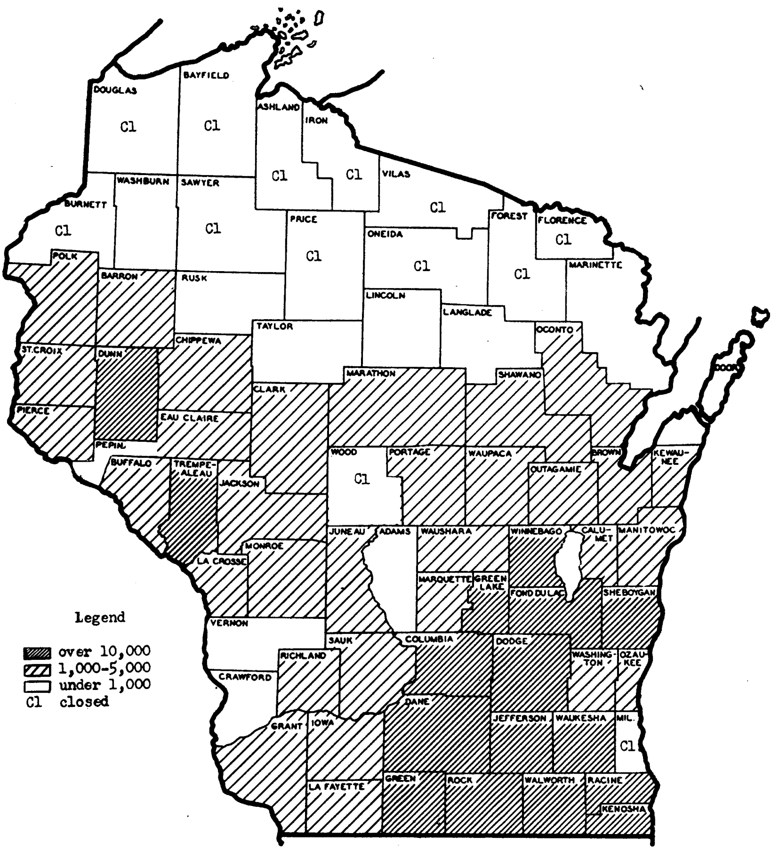



**Figure 11. Pheasant distribution based on kill records for 1947 (compiled from Bersing *et.al.* 1923–1951).**

In southwestern Wisconsin, pheasant populations were relatively high prior to the fox high, and remained so during the time when foxes were increasing toward a peak (Figure 10). The pheasant decline following the 1944 peak might be attributed to high fox densities. Kabat (1950), however, in an analysis of pheasant and fox kill records on a statewide basis, pointed out that the pheasant population throughout the state began to decrease *before* the red fox became abundant. He concluded that the red fox could not have been an important factor in the general decline of pheasants in Wisconsin which began about 1943. Furthermore, the decrease in pheasant populations in Wisconsin was apparently part of a widespread decline observed throughout most of the midwestern states in all areas regardless of whether foxes were high or low.

Other Wisconsin studies also indicated that the pheasant decline could not be blamed on foxes. Leopold (1945) pointed out that an excess of pheasants existed on the University of Wisconsin Arboretum where foxes were also abundant. Leopold further noted that pheasants were just as scarce in certain nearly foxless counties (Racine, Kenosha, and parts of Dodge) as they were in counties with many foxes present.

One of the real answers, however, lies in the decline of the pheasant population on Lake Erie's famous Pelee Island at approximately the same time as the decline on the mainland. Because Pelee Island has no foxes, we must rule out predators as a decimating factor of crucial importance in this period (Stokes 1952).

**Ruffed Grouse.** During the 1940's there was a superficial relationship between ruffed grouse and fox populations in southwestern Wisconsin (Figure 10). Ruffed grouse were high in this part of the state in 1942. A decline in populations occurred during the following two years—a period in which the foxes were increasing in numbers. The grouse, however, increased spectacularly in 1949 during the continued fox high. The food habit studies in 1947 and 1948 showed that gray fox predation occurred during relatively low grouse densities, suggesting, as in the case of cottontails, a preference for this food item. The occurrence of ruffed grouse at 28 per cent of the gray fox dens possibly represents a fairly high predation on ruffed grouse, particularly when these birds were at a population low, but it is nevertheless apparent that the population increased rapidly in the face of this predator pressure (Figure 10).

On the other hand, Eadie (1943) in New Hampshire found that although ruffed grouse were abundant, only a few remains of these birds occurred in the scats of red foxes. Murie (1936) stated that grouse predation by red foxes fell off considerably on the George Reserve in Michigan during the nesting season, a period of special significance to the welfare of the bird. In New York the incidence of grouse was consistently low in fox stomachs and droppings collected from good grouse range during years when this bird was plentiful, according to Robert W. Darrow (in Seagears 1944). Thus it appears that ruffed grouse are sometimes taken in fairly high numbers, as in Wisconsin, and that sometimes predation is less noticeable, as in certain other areas. This difference may be affected by regional variation in the habits of foxes or in the ratio of foxes to ruffed grouse.

**Quail.** Fox predation on quail during the study period was slight, despite the relative abundance of quail. A comparison of the population trends of fox and quail from 1940–49 shows an apparent relationship between fox and quail which is similar to that observed between fox and ruffed grouse. The quail population decreased in the early part of the decade, coincident with the increase of foxes. Quail were on the upswing from 1947 on, however, despite the continued fox abundance.

Haller (1951) found slight predation on quail by red foxes in Indiana. Quail occurred in only two per cent of the red fox stomachs collected from the best Indiana quail range, and in seven per cent of the stomachs collected elsewhere in the state.

In his studies at Prairie du Sac, Kabat (unpublished) found that under certain circumstances foxes can develop habits of preying on certain species. On this 4500-acre study area, which was checked almost daily during the winter period from 1929 to 1948, few quail kills were found which were attributable to foxes. This does not imply that the fox was not an important predator. Remains of quail kills are difficult to find, however. Very heavy quail mortality did occur each winter (1941–1950). Loss of cover was considered as an important factor in the high winter-loss rates.

In the winter of 1943–44, however, a total of 12 quail kills was found during February and March which were caused by foxes. The finding of this many kill remains was interpreted as evidence of very heavy predation. Trapping studies showed that the quail population was very low. The quail were well fed, and the weather was exceptionally mild. Foxes were frequently flushing night-roosting quail coveys. The same amount of flushing occurred in the previous winter when there was much snow on the ground and conditions were seemingly ideal for high fox predation, but fewer kills were found. There was evidence of fox predation on quail in all winters after 1941–42, but this amounted to the finding of only a few birds (less than six) in any one winter, even though both fox and quail populations in some winters were higher than in 1943–44.

**Poultry.** Other workers have found varying degrees of chicken predation, and believed it to have been largely on carrion except during summer and fall, when more chickens were usually running free. In the present study, before about May 1, most of the chickens taken were believed to represent carrion. After that time, most of them were fresh kills, which represented more than half of the chickens examined.

## Extent of Fox Predation

Food habit studies have been concerned mainly with *what* the fox eats—the percentage occurrence of various prey items in stomachs and scats and around dens. *How much* the fox eats is a question as yet unanswered. The effect of the fox on prey populations is perhaps the best measure of the extent of fox predation. Another approach to this question, however, lies in the determination of the numbers of a particular species that are eaten by a fox. Whereas the occurrence of pheasants in 100 stomachs may be only two or three per cent, this relatively minor representation may mean a considerable number of birds taken, in terms of the total pheasant population, by all of the foxes in the area studied.

On the basis of present-day knowledge of food habits, this type of analysis becomes almost buried beneath unknowns. Nevertheless an attempt is made here to present not conclusions but merely a quantitative approach to a subject which has so far been largely untouched. Perhaps it will help to point the way toward further refinements of food habit analyses and toward new problems for research.

The number of prey species taken by a fox over a period of time can only be very crudely estimated from stomach analyses. In the first place, foxes are known to kill more animals than they eat; they also eat carrion as well as fresh kills (Murie 1936). Representation in the stomach therefore is positive evidence that a prey animal has been eaten, but not necessarily that the prey was killed by the fox. Food is often cached, and a single food item may be "chewed upon" more than once (Murie 1936.) Furthermore, the chances of finding a prey item present in a stomach are relatively slight. Different foods have different rates of digestion, and may remain in the stomach for varying periods of time.

The stomach analyses performed on 113 foxes collected during the winter in southwestern Wisconsin provide us with the following known information: 28 stomachs contained rabbit remains, 50 were empty, and 35 stomachs contained other prey items. The 113 stomachs could be interpreted to represent one fox collected each day for 113 days. It could also be construed to mean that the prey remains found in these 113 stomachs represent the food eaten by one fox in 113 days. Since we do not know the actual feeding habits of foxes, we shall assume, for the purpose of this sample analysis, that one fox makes four meals on one rabbit.

Then, taking into consideration such variables as the relation between prey remains and prey actually taken and the chances of finding remains in the stomach, the number of rabbits eaten during 113 days by one fox may be solved by the following equation:

$$\text{No. rabbits eaten} = \frac{\overset{(A)}{\text{No. rabbit remains found}} + \overset{(B)}{\text{No. rabbit remains that would have been in 50 empty stomachs if digestion had not resulted in prey disappearance}}}{\underset{(C)}{4}}$$

(A) Number of rabbit remains found = 28.

(B) There were 50 stomachs which once contained prey, but due to digestion, were empty by the time the fox was collected. This entire sample of fox stomachs was randomly collected. Thus it is logical to assume that the 50 foxes whose stomachs were empty once contained rabbits and other prey in the same proportions as did the 63 containing food. The number of these stomachs which had rabbit remains present may be determined by the following proportion:

$$\frac{\text{rabbit remains formerly in stomachs}}{\text{total prey remains formerly in stomachs}} = \frac{\text{no. rabbit remains found}}{\text{total prey remains found}}$$

$$\frac{X}{50} = \frac{28}{63}$$

$$X = 22.2$$

(C) Since we are assuming that a fox feeds on a rabbit four times, each meal then represents only a quarter of a rabbit.

The equation then reads:

$$\frac{28 + 22.2}{4} = 12.6$$

The number of rabbits eaten by one fox in 113 days was 12.6, or 0.11 rabbits per red fox per day. If this were projected for the winter period during which these fox stomachs were examined (November through February, 120 days), 13.2 rabbits were eaten by one fox.

Assuming the same rate of predation throughout the year, one mature fox might eat 40 rabbits in one year. The amount of predation on rabbits by foxes in the spring as revealed by the den-prey-remains study, however, is a great deal less than that found in the winter. The work of other investigators has further indicated that larger mammals and birds play a minor role in the summer and early fall diet. We may therefore assume that the greatest predation on rabbits occurs during the winter and accept the winter rate of predation as derived in the above sample analysis as being near maximum for the year (13.2 rabbits per red fox).

A further projection of the extent of fox predation on rabbits is presented in Table 19. Taking the number of red foxes bountied during 1947–48 in southwestern Wisconsin as a sample population (4,387), then these foxes ate around 58,000 rabbits in that area during one year. The rabbit harvest for southwestern Wisconsin in 1947–48 was 63,576. Predation by the sample red fox population might equal up to 90 per cent of the number that were shot that year in that part of the state.

### Table 19

### Exploratory Analyses of the Extent of Fox Predation in Southwestern Wisconsin, 1947–48

**(For explanation, see text)**

| | *Rabbits* | *Pheasants* |
|---|---|---|
| No. stomachs | 113 | 113 |
| No. occurrences | 28 | 1 |
| No. per red fox per day | 0.11 | 0.004 |
| No. per red fox in 113 days | 12.6 | 0.5 |
| No. per red fox in winter period | 13.2 | 0.5 |
| Total eaten by sample red fox population (4,387) in southwestern Wisconsin, 1947–48 | 57,908* | 2,194* |
| Total harvest of each species in southwestern Wisconsin, 1947–48 | 63,576 | 15,848 |
| No. eaten expressed as a per cent of the harvest | 91% | 14% |

*These figures are crude estimates of the possible number of animals *eaten*, not *killed*, by foxes. Many prey items eaten by foxes represent diseased, surplus, winter-killed, etc. animals

In order to estimate the extent of red fox predation on pheasants, the same type of analysis was carried on. These results are presented in Table 19. The number of pheasants eaten by the sample red fox population on the basis of these figures might represent about 14 per cent of the number of pheasants that were harvested by hunters in southwestern Wisconsin in 1947–48.

It is important to emphasize again that these figures do not represent the number of rabbits or pheasants *killed,* but are only crude estimates of the possible number of animals that are *eaten* by a sample red fox population in one year. Even if exact determinations of the number of prey items found in stomachs were available, it still would not be possible to interpret the information accurately, for we do not know the exact feeding habits of foxes.

The above analysis of the extent of fox predation is presented merely as another "feeler" into the whole complex question of predator-prey relationships. The figures tend to suggest that the number of prey items taken may be considerable. In spite of this, however, foxes have not made inroads into breeding stocks of the prey species, or the population curves (as revealed by kill records) would not have increased during the recent years of fox abundance. Actually, the taking of diseased and surplus animals is natural and probably good for the population. Animals exceeding the carrying capacity of the range would be damaging their own habitat and would die anyway from one cause or another. Predation on these surplus animals results in little real loss.

Furthermore, many of the animals eaten probably represent carrion. For example, Errington (1941) and Kirsch (1950) cite examples of heavy winter-killing of quail and pheasants respectively. Foxes undoubtedly "capitalize" on these situations.

## Summary and Conclusions

The following points emerge from the consideration of fox food habits and predator-prey population trends:

1. In southwestern Wisconsin, the fox relies primarily upon rodents and rabbits for its food. Predation upon game birds is slight except for gray fox predation on ruffed grouse. The Wisconsin studies are in line with the findings of investigators in other states.

2. This study illustrates high incidence in both red and gray fox diets of those species occupying similar ecological niches. Cottontails and grouse, for example, were taken more frequently by gray than by red foxes, while chickens, squirrels, and woodchucks occurred more often at red fox dens than at gray fox dens.

3. Various authors have pointed out that food habits depend on the availability of prey (Errington 1935, Murie 1936, and others). Information gathered during the present study, however, suggests that high availability (as we are able to measure it) may not always be the ruling factor in predator food habits.

4. The effect of fox predation on game populations is apparently insignificant in Wisconsin. Even though considerable predation by red and gray foxes occurred on certain prey species, there was no evidence that the prey populations suffered. Certain species such as ruffed grouse and cottontails were observed to increase in spite of fox predation.

It has not yet been demonstrated in other states that high fox populations have been a major factor in the shortage of game, nor have attempts at predator control permanently increased game populations. In a New York study, for example, Robeson (1950) found that pheasant and cottontail populations on one study area were not measurably greater after foxes had been controlled when compared to the populations of these species on an area which was untrapped.

Predator control on Valcour Island, New York, coincided with a rising population of ruffed grouse and snowshoe hares; both populations subsequently decreased, however, while control was continued (Crissey and Darrow 1949). These authors considered that the degree of fox control was good, but wrote that their results did not indicate an improvement in hunting opportunity equal to the cost of the predator control operation.

## RABIES

There have been periodic outbreaks of rabies in Wisconsin over the past few decades. Records from the State Laboratory of Hygiene in Madison show that there have been two "highs" in the incidence of this disease in domestic and wild animals in the state from 1918 to the present, the first occurring in 1928 and the second in 1940 (Figure 12). The trend is again climbing. In 1952, 34 cases had been reported through September, as compared with 16 cases found up to this date in 1951.

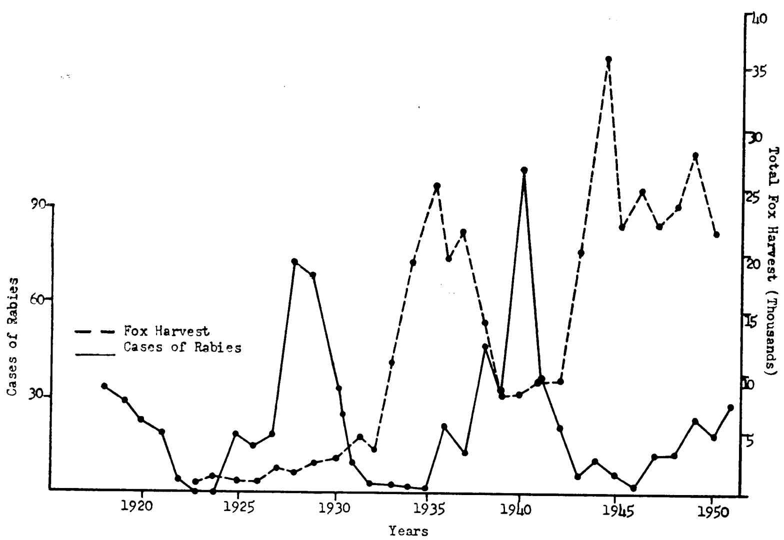



**Figure 12. Incidence of rabies in domestic and wild animals examined in the State Laboratory of Hygiene, Madison, Wisconsin, 1918–1951. (The trend in the total fox harvest is shown for comparison.)**

The disease has been found most frequently in dogs, cats, cows, and skunks. Records of the number of cases found in foxes were available only from 1942 to the present, but during this period only four rabid foxes were examined by the State Laboratory.

It is interesting to note that the two periods of peak fox populations, 1935–36 and 1944–45, occurred during years in which there was a very low incidence of rabies. This suggests that foxes were not a prominent target of the disease during their periods of high populations. It also seems to indicate that rabies was an unimportant factor in reducing fox populations following peak numbers.

Gier (1948), in a review of rabies in the wild, wrote that the disease occurs sporadically in wild animals, but has been reported in epizootic proportions in Massachusetts, Alabama, Kansas, California, Utah, New Mexico, and Arizona, principally in foxes, wolves, skunks, and coyotes. Dr. James H. Steele of the Public Health Service stated in a letter dated April 10, 1947 (in Gier 1948): "The fox rabies problem has become increasingly serious during the last four years in the Appalachian area of eastern United States. Fox rabies at present extends from North Central New York, the length of the Appalachian range to northwestern Georgia, westward across Alabama, Mississippi, Louisiana, into East Texas." The cases reported indicated that a very high incidence of rabies is possible in foxes. It is much more difficult to determine the extent of the transmission of rabies from foxes to other animals, but much of the loss of livestock in epizootic areas was charged to foxes. Gier further noted that during this time throughout the Alleghany Plateau the fox population was at an all-time high.

In the Northwest Territories, Cowan (1949) reported a decline of red foxes that was apparently brought about by an epidemic of a disease strongly resembling rabies. Red foxes were at a fairly high level over the western Arctic for several years preceding 1945; during the winter of 1944–45, a marked decline occurred.

Thus it is apparent from the situation in many areas that rabies may become a serious problem, involving foxes as well as other wild and domestic animals. There is no evidence as yet in Wisconsin that foxes have been seriously involved in rabies outbreaks. The present high population of red foxes and the current increase in the number of reported cases of rabies may or may not later prove to be related.

Regarding the control of this disease, Gier (1948) said: "Control of rabies in wild animals must begin with positive control of rabies in dogs, by compulsory vaccination or quarantine, or both, in order to eliminate reinfection of wild animals. Beyond that, control measures must be a matter of prevention or elimination of overpopulation which leads to conditions favoring rabies and other diseases." A program of quarantine and vaccination of dogs is being carried on at the present time in Wisconsin, and may help to curb the rising rabies trend in the state.

Where rabies is prevalent in a wild population, the alternatives are to let the disease run its course, which will eventually result in a reduction of the infected animals, or to reduce the population artificially and somewhat lessen the unhampered spread of the disease.

## FOX BOUNTY SYSTEM

### History

Foxes have had bounties on their heads off and on for about 70 years in Wisconsin. In 1880–81 a $2.00 state bounty was paid on foxes. From 1883–84 to 1917 there was no fox bounty. A $2.00 state bounty law was passed June 30, 1917 but was discontinued on June 30, 1931. This bounty-less period was ended March 11, 1945, when a bounty was again placed by the state on both species of foxes. This bounty of $2.50 on adult grays and reds and $1.00 on kits has continued to the present time.

Individual counties have also paid separate county bounties over a period of years. In 1938–39, there were 21 counties paying bounties; in 1942–43, 38; and in 1950–51, 51. Most counties paid one to three dollars, but a few offered five and seven dollars. After the state bounty law went into effect in March 1945, all counties paying more than $2.50 per fox were required to lower their payments in accordance with the state bounty. This was accomplished by early 1948. Most counties now pay $2.50, but a few pay less than that amount. Thus the total amount received for a fox in more than half the counties is $5.00, and in the remaining counties, $2.50.

### Cost

The money spent on bounty payments annually since 1923–24 is shown in Table 20. Since the bounty law was re-enacted in 1945, the state has paid $351,111 in bounty claims. Considering the bounties paid by individual counties in addition to the state bounty, this amount becomes almost $600,000 paid out for foxes in a little over six years—almost $100,000 a year. What has been the effect of this tremendous expenditure of money on the fox population? Are we getting our money's worth? The purpose of the following discussions is to examine the fox bounty system in Wisconsin in the light of evidence from this state and that offered by other states which have tangled with the same problems.

**Table 20**

**Bounty Payments Made by the State on Red and Gray Foxes from 1923–24 to 1950–51**

| *Year* | *Amount Paid* |
|---|---|
| 1923–24 | $ 2,134.00 |
| 1924–25 | 3,814.00 |
| 1925–26 | 3,418.00 |
| 1926–27 | 3,442.00 |
| 1927–28 | 5,416.00 |
| 1928–29 | 5,248.00 |
| 1929–30 | 6,086.00 |
| 1930–31 | 6,976.00 |
| 1931–32 to 1943–44 | none |
| 1944–45 (as of March 11, '45) | 4,958.00 |
| 1945–46 | 54,722.50 |
| 1946–47 | 60,410.00 |
| 1947–48 | 55,147.50 |
| 1948–49 | 57,497.00 |
| 1949–50 | 66,905.00 |
| 1950–51 | 51,471.00 |

## Inefficiency of Bounty System

One of the biggest problems regarding fox bounties concerns the payment of bounties for animals which would have been killed anyway. Foxes are killed for a variety of reasons, and it is important to know how many are taken primarily for bounty. Analyses of the number of foxes bountied per individual claimant were carried on by Latham (1951a) in Pennsylvania, and by Switzenberg (1951) in Michigan. A sample analysis was undertaken in three counties in Wisconsin for a six-month period to see if the results from this state were in line with the other more exhaustive studies. The information from the three states is quite similar (Table 21). Well over half of the claimants bountied one fox, but accounted for only 16–17 per cent of the total kill. Only a small proportion of the total number of claimants, on the other hand, bountied more than 11 foxes, but accounted for a large per cent of the kill.

Latham (1951a) conducted personal interviews and questionnaire polls in Pennsylvania and found that only 27 per cent of the single claims were taken for bounty. In other words, 73 per cent of these foxes were taken for other reasons and would have been taken even if no bounty were paid. Of the persons taking six or more foxes, 93 per cent killed them primarily for bounty. Switzenberg (1951)

## Table 21

### Foxes Presented Per Bounty Claimant

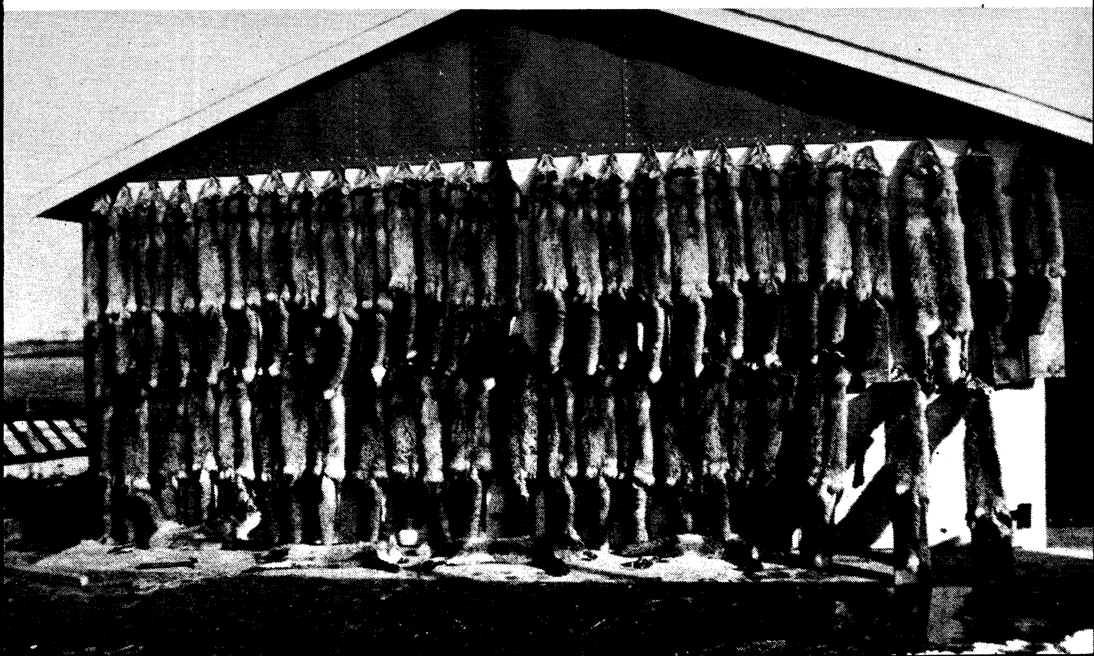
| | *Pennsylvania (1948–49)* | *Michigan (1947–48)* | *Wisconsin (1950)** |
|---|---|---|---|
| Total No. Claimants | 10,174 | 8,194 | 424 |
| Total No. Foxes | 34,826 | 29,943 | 1,752 |
| Per Cent of Claimants Taking One Fox | 57% | 61% | 67% |
| Per Cent Kill (Single Claims) | 16% | 16% | 17% |
| Per Cent of Claimants Taking 11 or More Foxes | 7% | 6% | 7%** |
| Per Cent Kill (Multiple Claims) | 42% | 47% | 62% |

*Adams, Ashland, and Grant counties, July–December, 1950.
**10 or more foxes.

suggested that about three-fourths of all the foxes bountied during 1947–1948 in Michigan were taken by persons who were not primarily interested in the bounty.

As a result of Latham's study, it seems reasonable to assume that single claims represent foxes that are killed accidentally, incidentally while hunting other game, or to protect personal property, and not primarily for bounty. On the basis of the sample analysis of bounty claims in Wisconsin, then, 17 per cent of the kill (Table 21) is presented for bounty by individuals who would have taken the foxes regardless of the bounty. These single claims have represented a useless expenditure of over $120,000 since 1945.

**Hunters and trappers who bounty more than 10 foxes apiece represent only a small proportion of all the people who file bounty claims; yet these men account for almost two-thirds of the state's fox harvest.**



## Effect of Bounty on Kill

There are two sources of bounty payments in Wisconsin: the state and the county. An analysis of the state bounty is complicated by the fact that some counties are paying an additional sum of money. In order to investigate the effect of the bounty on the kill of foxes, an analysis was therefore undertaken of bounty payments made by individual counties. The county clerks of forty-one counties were contacted for information on the bounty paid by each county from 1940 to 1950. The 39 replies received were studied and some of this information, correlated with the fox kill for each county, will be presented as examples of the general situation in the state.

A comparison was made between the kill of foxes in counties which have not paid a county bounty from 1940–1950, and those counties which have paid the same bounty during that period (Figure 13). All of these latter counties have paid $2.50 except two which paid $2.00. Before 1945–46, when there was no state bounty in effect, a direct comparison of the effect of the presence and absence of a bounty on the kill can be made; after that time, however, the comparison becomes one of the difference between a "high" and "low" bounty. As a result of the state bounty law, most of those counties paying a separate county bounty (Group A, Figure 13) offered $5.00 per fox, while those counties not paying a separate county bounty (Group B) offered only the state bounty, $2.50. Since different numbers of counties are involved and different numbers of foxes killed, the height of the curves cannot be compared, but only the slope.

From 1940–41 to 1944–45 the fox harvest in both groups of counties increased, indicating that the population increased in counties paying a bounty as well as in those not paying a bounty. The rate of increase in both groups of counties was the same (Table 22). However, the effect of the bounty is minimized here, since fur prices were high and trappers in both groups of counties would be interested in fur rather than bounty.

### Table 22

### Comparison of Fox Take in Counties With and Without Bounties

| | *No. of Times Take Increased* | |
|---|---|---|
| | *Group A (county bounty)* | *Group B (no bounty)* |
| 1942–43 to 1944–45 | 3.5 | 3.5 |
| 1944–45 to 1945–46 | 0.6 | 0.6 |

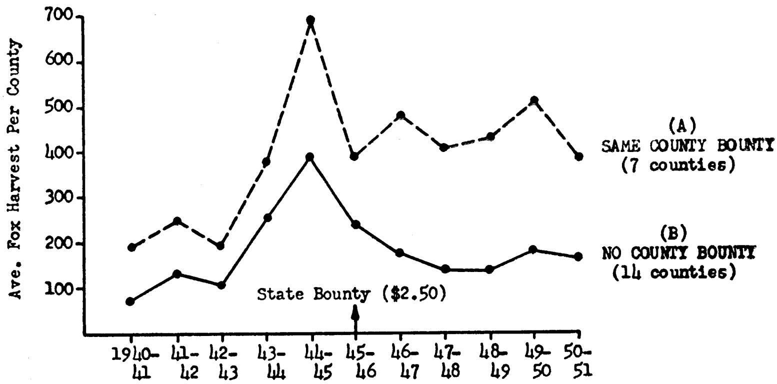



**Figure 13. Comparison of fox harvest in counties paying no county bounty and in those paying the same bounty, 1940–41 to 1950–51 (reds and grays combined).**

After the peak in 1944–45, the kill in Group B dwindled to a point only slightly higher than the take was before the peak, under a $2.50 state bounty (Figure 13). The kill in Group A, with a combined state and county bounty of $5.00 remained relatively high. Since pelt values were low at this time, the higher bounty may have had some effect on the difference in relative take between the two groups. Assuming that the bounty effect was apparently negligible previous to this period (when fur prices were high), the take for each group of counties for this period (1940–45) was made equal to 1.00. The takes for each group after 1945–46 were then compared as a ratio of this. This proportion was 1.28 for Group A, and 0.88 for Group B. The first ratio is 45.5 per cent higher than the second, indicating that in counties in which a $5.00 bounty payment is offered, the fox kill was 45 per cent greater than it was in those counties offering only $2.50, at least during periods of low fur prices. Since the take of foxes decreased in those counties offering only the state bounty of $2.50, it can be further concluded that a $2.50 bounty is not sufficient to maintain a high level of trapping pressure.

One factor that may confuse the issue here is that foxes taken in counties with a lower bounty might be bountied in higher-paying counties and thus increase the take of the latter group. However, a comparison of the fox harvest in Outagamie and Brown counties, lying adjacent to each other, and differing in their bounty payments, offers no conclusive evidence for this. The average number of foxes bountied per square mile is practically the same for both counties (Figure 2), although Brown county has not paid a county bounty from 1943–44 to 1949–50, and Outagamie county payments have ranged from $2.50 to $7.50. A comparison of the annual fox harvest and bounty changes during this period in the two counties is presented in Table 23. The trends in the take of foxes are not similar, but there is little evidence that foxes taken in Brown county have been bountied in Outagamie in any detectable numbers. For example, in 1945–46, when Outagamie county had a $7.50 bounty, the take in that county decreased, while the take in Brown county increased. The increase in foxes bountied by Outagamie county the following two years, and the decrease in Brown county are not inconsistent with trends observed in other counties, and are not necessarily related.

**County "case histories".** Individual case histories of changes in bounty payments and harvest for ten counties are presented in Table 23. The records from these counties clearly show that no hard and fast rule concerning the effect of bounties can be made in any one particular instance. There are local variations in the number of hunters and trappers, the "expertness" of trappers, weather effects, the attitudes of local people toward predator control, and also differences in the actual population level which undoubtedly reflect differences in take, bounty or no bounty. For example, under a $5.00 bounty the fox harvest in Jefferson county steadily increased, in Portage county it decreased, and in Marathon county, remained the same. In general, an increase in the amount of the bounty payment resulted in an increased kill. Similar increases in take, however, sometimes occurred in counties in which the bounty payment did not change. For example, the kill in Jefferson county doubled in the year in which the bounty increased from $2.50 to $5.00. In that same year, however, the kill in Ozaukee county showed a six-fold increase and the bounty stayed at $2.50. The raising of the bounty in Portage county from $2.50 to $10.00 didn't quite double the take of foxes. When the bounty was raised to $10.00 in Outagamie county, there was an increase in kill over the counties not changing their bounty. On the other hand, a decrease in kill occurred in 1944–45 to 1945–46 in Outagamie county when the bounty increased to $7.50 that was greater than the decrease in take observed in counties where the bounty did not change.

Thus it is apparent that there is some over-all effect of a high bounty in increasing the kill of foxes when fur prices are low, but that this effect becomes less clear on an individal county basis.

# Table 23

## Comparison of County Fox Harvests and Bounty Payments

### Jefferson County

| Year | County Bounty | State Bounty | Total | Harvest |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | 6 |
| 1941–42 | ---- | ---- | | 13 |
| 1942–43 | ---- | ---- | | 35 |
| 1943–44 | ---- | ---- | | 40 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50)* | 111 |
| 1945–46 | ---- | " | 2.50 | 36 |
| 1946–47 | Jan. '47 2.50 | " | 5.00 | 73 |
| 1947–48 | " | " | " | 79 |
| 1948–49 | " | " | " | 93 |
| 1949–50 | " | " | " | 94 |
| 1950–51 | " | " | " | 85 |

*Parentheses indicate that bounty payment probably came too late in year to influence harvest for that fiscal year. This applies to all figures enclosed in parentheses in each of the following counties.

### Portage County

| Year | County Bounty | State Bounty | Total | Harvest |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | ---- |
| 1943–44 | Nov. '43 5.00 | ---- | 5.00 | 152 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50) | 424 |
| 1945–46 | ---- | " | 2.50 | 251 |
| 1946–47 | Nov. '46 7.50 | " | 10.00 | 463 |
| 1947–48 | Feb. '48 2.50 | " | 5.00 | 354 |
| 1948–49 | " | " | " | 229 |
| 1949–50 | " | " | " | 213 |
| 1950–51 | " | " | " | 144 |

### Marathon County

| Year | County Bounty | State Bounty | Total | Harvest |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | 40 |
| 1941–42 | ---- | ---- | | 60 |
| 1942–43 | ---- | ---- | | 71 |
| 1943–44 | ---- | ---- | | 340 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50) | 339 |
| 1945–46 | Feb. '46 2.50 | " | 5.00 | 331 |
| 1946–47 | " | " | " | 343 |
| 1947–48 | " | " | " | 303 |
| 1948–49 | " | " | " | 320 |
| 1949–50 | " | " | " | 349 |
| 1950–51 | " | " | " | 288 |

### Outagamie County

| Year | County Bounty | State Bounty | Total | Harvest |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | ---- |
| 1943–44 | ---- | ---- | | ---- |
| 1944–45 | 5.00 | Mar. '45 2.50 | (7.50) | 119 |
| 1945–46 | " | " | 7.50 | 49 |
| 1946–47 | Apr. '47 7.50 | " | 7.50–10.00 | 111 |
| 1947–48 | Feb. '48 2.50 | " | 10.00– 5.00 | 124 |
| 1948–49 | " | " | 5.00 | 91 |
| 1949–50 | " | " | " | 80 |
| 1950–51 | " | " | " | 110 |

## Table 23 (Continued)

### Brown County

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | ---- |
| 1943–44 | ---- | ---- | | 9 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50) | 78 |
| 1945–46 | ---- | " | 2.50 | 84 |
| 1946–47 | ---- | " | " | 81 |
| 1947–48 | ---- | " | " | 59 |
| 1948–49 | ---- | " | " | 75 |
| 1949–50 | ---- | " | " | 90 |
| 1950–51 | ---- | " | " | 69 |

### Walworth County

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | 14 |
| 1941–42 | ---- | ---- | | 16 |
| 1942–43 | ---- | ---- | | 107 |
| 1943–44 | May '44 5.00 | ---- | 5.00 | 88 |
| 1944–45 | " | Mar. '45 2.50 | (7.50) | 177 |
| 1945–46 | " | " | 7.50 | 132 |
| 1946–47 | " | " | 7.50 | 182 |
| 1947–48 | Nov. '47 2.50 | " | 5.00 | 118 |
| 1948–49 | " | " | " | 91 |
| 1949–50 | " | " | " | 119 |
| 1950–51 | " | " | " | 91 |

### Oconto County

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | 94 |
| 1943–44 | 3.00 | ---- | 3.00 | 236 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50) | 253 |
| 1945–46 | ---- | " | " | 204 |
| 1946–47 | ---- | " | " | 120 |
| 1947–48 | ---- | " | " | 112 |
| 1948–49 | ---- | " | " | 152 |
| 1949–50 | ---- | " | " | 180 |
| 1950–51 | ---- | " | " | 130 |

### Washburn County

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | ---- |
| 1943–44 | Nov. '43 2.50 to | ---- | 2.50 | 575 |
| 1944–45 | Nov. '44 2.50 | Mar. '45 2.50 | 2.50 | 862 |
| 1945–46 | ---- | " | " | 407 |
| 1946–47 | ---- | " | " | 303 |
| 1947–48 | ---- | " | " | 224 |
| 1948–49 | ---- | " | " | 186 |
| 1949–50 | ---- | " | " | 201 |
| 1950–51 | ---- | " | " | 220 |

### Ozaukee County

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | 4 |
| 1941–42 | ---- | ---- | | 3 |
| 1942–43 | ---- | ---- | | 0 |
| 1943–44 | ---- | ---- | | 21 |
| 1944–45 | ---- | Mar. '45 2.50 | (2.50) | 12 |
| 1945–46 | ---- | " | 2.50 | 5 |
| 1946–47 | ---- | " | 2.50 | 31 |
| 1947–48 | Feb. '47 2.50 | " | 5.00 | 81 |
| 1948–49 | " | " | " | 65 |
| 1949–50 | " | " | " | 43 |
| 1950–51 | " | " | " | 45 |

## Table 23 (Continued)

**Sauk County**

| *Year* | *County Bounty* | *State Bounty* | *Total* | *Harvest* |
|---|---|---|---|---|
| 1940–41 | ---- | ---- | | ---- |
| 1941–42 | ---- | ---- | | ---- |
| 1942–43 | ---- | ---- | | ---- |
| 1943–44 | 2.00 | ---- | 2.00 | 1179** |
| 1944–45 | Sept. '44 3.50 | Mar. '45 2.50 | (6.00) | 763 |
| 1945–46 | " | " | 6.00 | 785 |
| 1946–47 | Jan. '47 2.50 | " | 6.00–5.00 | 1116 |
| 1947–48 | " | " | " | 850 |
| 1948–49 | " | " | " | 679 |
| 1949–50 | " | " | " | 846 |
| 1950–51 | " | " | " | 713 |

**Open season, all other counties October 16 to March 1.

The experience of other states paying bounties on foxes has been similar to that described in Wisconsin. In a Michigan study, Switzenberg (1951) reported that the bounty ($5.00) increased the trapping take of foxes, with the result that the combined statewide take was computed to be 25–30 per cent higher with a bounty than it would have been if the bounty had not been put into effect.

Gerstell (1937) compared the take of gray foxes in Pennsylvania during periods in which the bounty was $2.00 and $4.00. He concluded that a rise in the bounty rate increased the number of gray foxes presented for bounty payment each year. Latham (1951b) pointed out that removing the bounty tended to decrease the kill. He reported that when the $4.00 red fox bounty was removed in Pennsylvania, several professional trappers, many of whom trapped from 50 to 100 or more foxes apiece each season, stopped trapping foxes altogether.

It is important to point out that although a higher bounty resulted in a higher kill in Wisconsin, the bounty was not essential to insure a harvest of foxes. In Wisconsin foxes have been taken in considerable numbers without a bounty, even when fur prices were low. Seagears (1944) noted that an average of 19,000 foxes has been taken in New York without a bounty each year for the past quarter century.

## Effect of Bounty on Fox Population

The fox population in Wisconsin increased gradually from 1923–24 to 1931–32 under a $2.00 state bounty. Counties with their own bounties also showed an increase in past years. For example, the amount of money spent by St. Croix county on fox bounties shows an upward trend from 1936 on (Table 24).

## Table 24

### Levy for Fox Bounties, St. Croix County

| | | | |
|---|---|---|---|
| 1930 | $1,200 | 1940 | $ 200 |
| 1931 | 500 | 1941 | 200 |
| 1932 | 500 | 1942 | 200 |
| 1933 | none | 1943 | 200 |
| 1934 | none | 1944 | 400 |
| 1935 | none | 1945 | 1,000 |
| 1936 | 300 | 1946 | 1,200 |
| 1937 | 250 | 1947 | 1,000 |
| 1938 | 250 | 1948 | 1,500 |
| 1939 | 250 | 1949 | 1,600 |

The take of foxes in Wisconsin since 1945–46 has almost become a constant. In six years there has been no substantial decrease in the population. Even though a $5.00 bounty has increased the fox harvest in certain counties during this recent period of low fur prices, it has not resulted in a reduction of the fox population. Latham (1951b) wrote that in Pennsylvania the $4.00 bounty payment was effective in reducing the annual take finally from about 50,000 to about 30–35,000 foxes, but that there was then a levelling-off because at that density many trappers no longer found it profitable to trap. According to this author, the situation became a matter of "fox management" or "fox farming" by the professional trappers. They are careful that they do not overtrap a particular region, thus holding the fox population at a "high production" level. It appears that this levelling-off process has taken place in Wisconsin.

Gerstell (1937) also reported that although a raise in the bounty rate increased the number of gray foxes taken, there was still no evidence that the species was being controlled by the bounty. The bounty has not exerted control over the fox population in Indiana, according to Haller (1931). Fox highs were recorded in Indiana in 1926, 1934, and 1946. These increases and decreases occurred both in counties where a bounty was paid, and in those where none had been in effect. In Rhode Island, Wright (1949) also found that foxes were not controlled by a bounty. The yearly average of foxes bountied increased from 1901 to 1948, although a bounty was paid all during this time except for a period of six years. This bounty payment was $3.00 and at one time was increased to $5.00. Workers in numerous states have studied the effect of bounties on various species and in general have reached the same conclusion—bounties have shown little control over the predator population as a whole.

Latham (1951b) pointed out that a predatory animal could probably be controlled by bounty payments if these payments were high enough. But here we must first evaluate the status of the predator in the animal community, and decide how much "control" he needs.

## WHY AND HOW CONTROL

Inherent in the management of any game species is the harvest of the annual surplus. Since small game is heavily hunted in Wisconsin, predatory species must also be harvested. Associated with the harvest of a predator, however, is the idea of control—a word that has almost become synonomous with the word predator. Control means to "keep within limits". But what are the limits? What is the degree of control necessary to attain a "desired level" of a predatory population? We don't know. There is no formula yet that will give us the proper ratio of predator and prey species within an area. There is no formula chiefly because of the constant change in environmental conditions. Actually it may be the environment rather than the species that requires control. We therefore have to surmise the need for control of a predator, or the need for a change from current conditions, from an evaluation of the predator in a particular area.

The high potential increase of foxes each year complicates the control problem. In order to reduce the fox population, the harvest must remove more than the annual surplus to get at the breeding stock. Suppose the 17,000 red foxes had not been bountied in 1950–51 and remained as the spring breeding population for the following year. With a 255 per cent potential increment through reproduction in the spring, this population might increase to 43,350 animals by fall. Over 26,000 foxes would have to be taken just to prevent an increase in population before the next breeding season. In Wisconsin now, we are apparently only removing the annual surplus and are not touching the breeding population.

### Fox Pros and Cons

The fox as a predator tangles with the interests of sportsmen and farmers. Although rodents and rabbits top the fox food list, foxes will eat some game birds. The final "test" of the outcome of predation, however, is its effect on game population trends over a period of time. Although quite a high incidence of ruffed grouse was found at fox dens during a period of low grouse density, the species increased rapidly in the years following. Marked increases in rabbits, squirrels and quail also occurred despite a certain amount of predation and a continued high fox population during this time. Although there was potentially high fox pressure on the pheasant in the study area, actual predation on this species was light. Information from other sources also indicates that the fox had little to do with the decline of pheasants in the state.

A predator within environmental and inherent limits, lives on the annual surplus produced by the prey species, and seldom causes serious reduction in succeeding breeding populations. The effect of predation in the control of prey species was formerly believed to be great. Biologists now realize that predation in itself cannot "control", but is one of many factors limiting populations.

On the other hand, crude estimates of the number of prey species eaten by foxes tend to suggest that a considerable number of animals may be eaten. Whereas a predator may not "hold down" the prey population, it might take some of the surplus which would otherwise be available to the hunter. The question still remains, however, would the small game hunter increase his harvest if these "extra surplus" animals were available to him? If sufficient controls over animal populations were not present, then the populations of certain species, such as rabbits, might rise to excessive numbers and in themselves cause considerable damage. New York studies by Crissey and Darrow (1949) and Robeson (1950) have shown that the control of foxes, through very expensive trapping operations, has not resulted in greatly increased hunting opportunities for the small game hunter.

During periods of high populations any species becomes a factor in the spread of disease. Evidence from other states shows that a high incidence of rabies is sometimes possible in foxes. In Wisconsin, the rabies problem is again becoming serious, but at present there have been very few cases of rabies in the foxes examined by the State Laboratory of Hygiene. As Gier (1948) pointed out, the most efficient control of this disease involves vaccination or quarantine, or both, of dogs. He further stated that beyond this, control measures consist of the prevention of overpopulation leading to conditions favoring disease.

The foxes' "good points" are well-known but not often emphasized. Rodents form a large part of their diet (30 per cent of the total volume of food eaten.) Although rodent populations are not controlled by a predator, it is generally believed that enough are taken in certain local situations to somewhat diminish their destructive tendencies. Fox fur brings a fair income to trappers during years when fashion dictates. Fox hunting is an important sport in Wisconsin, and over half of the foxes harvested are shot by hunters.

## Methods of Control

The fox population is subject to fluctuating periods of high and low densities. The high of gray foxes in the mid-thirties in Wisconsin subsided fairly rapidly of its own accord. However, at the present time, the red fox population has remained at a high level following peak densities in 1944–45. The annual harvest of foxes in Wisconsin is apparently removing only the annual surplus. Theoretically, to effect further control, hunting and trapping pressure must be increased. The take would then increase up to a point, after which it would drop off, indicating a reduction in the population.

The hunting and trapping of foxes is governed by three incentives: sport, predator control, and money. The first two are self-regulating and will operate in proportion to the level of the fox population. Various methods of control, i.e., increasing the harvest of foxes, are discussed in detail by Latham (1951b) and will be outlined only briefly here. The encouragement of the sport of fox hunting is generally considered the best and the cheapest means of controlling foxes, other than letting nature run its course. The adoption of other more immediate measures may often be necessary, however, particularly at times when fox populations are high and fur prices low.

"Vermin" control campaigns are probably among the least desirable methods for controlling predators, for such campaigns are often short-lived and frequently result in the indiscriminate destruction of predators. Poisoning has been used with success under certain conditions in the control of wolves and coyotes. Although in the hands of experts the use of poison may be an acceptable method of fox control, it probably could not be recommended as a widespread control measure in this state.

A system of paid professional hunters and trappers has certain advantages in a consideration of fox control in that it would allow concentration against individual livestock and game killers, control work at all seasons and not just when pelts are prime, a means of meeting such emergencies as rabies outbreaks, and continued control efforts. However, Latham pointed out that the disadvantages of this type of control lie in its excessive cost, the reduced total take of predators, and the resentment on the part of local trappers toward the professional competition.

The Valcour Island experiment in New York provides us with an estimate of the staggering cost of a widespread, intensive predator control operation (Crissey and Darrow 1949). In that study, all mammalian and avian predators were controlled by trapping, hunting, and poisoning. The authors estimated that similar predator control throughout the state of New York would cost around $10,000,000 annually.

Pelt values provide the main monetary stimulus to trapping. When fur prices are low, the bounty acts as a substitute—actually as a subsidy to fur trappers. Many states, including Wisconsin, have for many years used the bounty system as a tool in predator management, and much has been written on the pros and cons of this method of control. In brief, the advantages of bounties as discussed by Latham (1951b) are: 1) an increased kill of predators; 2) added income for rural populations; and 3) stimulation of interest in hunting and trapping. On the other hand, bounties as commonly used are: 1) usually ineffective in controlling predator populations; 2) indiscriminate, promoting destruction of both beneficial and harmless species; and 3) inefficient, resulting in high costs and often fraudulent practices.

The major questions concerning the value of fox bounties are: Do bounties effectively control fox populations? What effect would changes in the present bounty system have both on foxes and people? In the following paragraphs we will examine various practices in the use of bounties in the light of evidence from Wisconsin and other states.

(1) Status quo (present system). The harvest of foxes now in the state is at a relatively stable level. So far it has apparently kept the population from increasing, although it has not resulted in any substantial reduction in the population. As long as the fox is not causing serious damage to game populations, the amount of control exerted in those areas paying a $5.00 bounty might be considered adequate. Local damage to a flock of chickens will be promptly taken care of, bounty or no bounty.

However, studies in Wisconsin and other states have shown that the bounty system as a predator control device in its present form is both inefficient and ineffective. For example, northern Wisconsin counties suffer little fox damage to livestock or game animals. Also the number of foxes taken on an area basis is so low that such a reduction could not possibly have any controlling effect on the general county populations. Yet the bounty payments in these areas represent an important part of the over-all bounty system costs. Thus the benefits to wildlife populations from the present bounty system are negligible.

(2) Raise the bounty. An analysis of the bounty system in Wisconsin has shown that a high bounty increases the fox kill, but as it

exists today, it is not controlling the fox population to the extent of actual reduction. It is logical to assume that still higher bounties undoubtedly would further increase the take. But is a degree of control warranted that would involve the expenditure of far more than the approximate $100,000 a year currently being spent? Not from the existing evidence in Wisconsin.

From a strictly economic point of view, for example, the cost even now of "controlling" the fox with bounties far outweighs the cost of the pheasants lost by predation. If the estimated number of pheasants taken by the sample population of red foxes in southwestern Wisconsin during 1947–48 represented artificially propagated birds, which cost about $.70 apiece at ten weeks of age (Kabat, Kozlik, and Thompson, 1952), we might be out about $1,500. The bounty payments on these 4,387 foxes amounted to about $20,000. Furthermore, in the case of pheasants, if most of the foxes are bountied in the southwest, and most of the pheasants are shot in the southeast, bounty money is wasted as far as "producing" more pheasants is concerned.

In some areas, a few trappers are taking most of the foxes, and are probably taking all they can in the time they are able to spend. An increase in the bounty would not in this case increase the take. As a matter of fact, the trappers could get as much money as they are getting now for fewer animals.

(3) Lower or remove the bounty. It has been apparent over the past few decades that foxes have been harvested without a bounty, even when fur prices have been low. It is also apparent from an analysis of bounty records over the past six years that a higher bounty increases the take. Removing the bounty would undoubtedly reduce the take. If the bounty provides the incentive for trapping needed to prevent a collapse of trapping effort while fur prices are low, then the removal of the bounty might be questioned. Professional trappers who take upwards of 62 per cent of the total foxes bountied would probably find it unprofitable to trap during the present period of low pelt prices. On the other hand, the fox harvest in areas in which the majority of foxes are taken by hunters for sport rather than for bounty probably would not suffer from a relaxation of the bounty payment.

Merely lowering the bounty seems grossly inadvisable, for one or two dollars has not in the past been sufficient incentive for maintaining trapping pressure, and the bounty money would become merely a "gift" to persons accidentally taking a fox.

(4) Sliding scale on bounties. In his detailed study of the bounty system in Pennsylvania, Latham (1951a) strongly recommended a sliding scale of bounty payments. This would involve raising the bounty at intervals when the harvest had levelled-off or stagnated. If, however, fur prices should rise markedly, the bounty could be lowered proportionately. According to Latham, "These payments will practically eliminate the undesirable 'fox farming' by the professional trapper, and, most important, they should effect a degree of control most consistent with the game management requirements of the state." (p. 30).

This seems to be a logical and sensible approach to the bounty problem. There is, however, another point to be considered in this connection. If the bounty were so controlled on a statewide basis, would the legislative process in Wisconsin be able to swing into action quickly enough at the time when the increase in bounty was most needed? Also, how difficult would it be later to lower a high bounty quickly according to the dictates of good fox management, which might possibly be against the dictates of an overly bounty conscious public?

(5) Elimination of single claims. One improvement that could be made in the administration of bounties is the elimination of bounty payments on animals which have been killed anyway. On the basis of evidence from Wisconsin and other states, single claims by and large represent animals which were killed accidentally, incidentally, or in protection of personal property, and not primarily for bounty. Latham (1951a) recommends that payment on mammalian predators be restricted to claims of three or more of each species. The elimination of at least single claims should not result in an appreciable reduction in the total fox harvest. Actually the cost involved in dragging one fox through the fields and transporting it to a county clerk's office may be more expensive than the bounty money received.

Latham (1951a,b) suggests as a possible alternative to this a system of registration for persons who anticipate hunting or trapping for bounty. The registration period could be restricted so that persons killing a predator incidentally or for reasons of predator control could not register after the killing had been made.

## Summary and Conclusions

These are some of the problems facing both the adherents to and the opponents of the bounty system. Unfortunately there is no clear-cut course of action. At the present time, if we judge the value of the bounty system on its "predator control" feature, we must conclude that there is more evidence which indicates that the present bounty system is *not* controlling the fox populations than there is evidence that fox bounties are accomplishing their purpose. If the use of bounties is continued in an attempt to control the fox population, refinements are required in the present system which would give greater weight to the important variables of the times and places of highest fox populations and greatest damage to man's interests. A more flexible system, perhaps modeled after Pennsylvania's "sliding scale" recommendation, administered at a local level rather than on a statewide basis, should increase the efficiency and effectiveness of bounty payments. Such a system of local administration of bounty payments should lead to a much-needed experimental approach to the analysis of the effect of bounties on fox populations, in which one block of counties would offer no bounty, and another block with similar range and numbers of this predator would continue bounty payments.

Another alternative lies in the removal of the state bounty. In the light of the evidence, the present abundance of the fox population does not seem to create a serious menace to other wildlife. In view of its diet, the fox renders a service to farmers in its "rodent-control" activities. One state greatly reduced its predatory population only to become overrun with rodents—their petition is now to protect the predator. One of the most important things we need to know in order to properly evaluate the bounty system is the effect of bounty removal upon the fox population. It is possible that the fox harvest now has "stalemated"; bounties may only stimulate the taking of enough animals to keep the present population stable and healthy. The removal of bounties as a stimulant to the harvest would undoubtedly result in a decrease of the harvest during the current trough in pelt prices, and the fox population might conceivably increase. However, it is axiomatic that when a population reaches a certain level, nature steps in and prevents further increase. Furthermore, the greater encouragement of the sport of fox hunting presumably will maintain a certain proportion of the present harvest. The loss of such control as is now exercised by the present fox bounty might be compensated for by the crash of a peak population or by an increased harvest through hunting. Such "natural control measures" might actually maintain a better control over the fox population in the long run than an artificial system of bounty payments.

In the final analysis, it should be re-emphasized that the *degree of control* of foxes should be determined by the *need for control.* There are two main justifications for controlling the fox: damage by the fox to wildlife populations and damage to farm animals. There is not sufficient evidence indicating that fox predation is enough of a disturbing factor to other wildlife species to warrant an expensive statewide control system. Attention must also be placed not only on the control of the predator, but also on the "protection" of the prey. It is well known that animals in good cover are much less susceptible to predation than those in poor cover. Habitat improvement measures, therefore, may be more important insurance for game abundance than direct reduction of predators.

The place of fox control in relation to agricultural damage is difficult to evaluate and no attempt is made here to do so. However, if damage to poultry and livestock is considered important enough to maintain some use of the bounty system, then the problem is primarily one of agricultural interests.

Furthermore, the authors do not have either the prerogative or knowledge to judge the value of the fox bounty system from the standpoint of its sociological or psychological merits. Income derived from bounties, even though limited to a small number of people, may be quite desirable to the general public. It is possible that the value of the fox bounty, if weighed on these scales, may be sufficient to justify public acceptance. Consideration along these lines, if warranted, should be the responsibility of those agencies charged with such public interests.

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