A Telemetric Study of the Red Fox in Agricultural Areas of Southeast Louisiana

George Washington Taylor
Louisiana State University and Agricultural and Mechanical College

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A TELEMETRIC STUDY OF THE RED FOX IN AGRICULTURAL AREAS
OF SOUTHEAST LOUISIANA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science in Game Management

in

The School of Forestry and Wildlife Management

by

George W. Taylor
B.S., Mississippi Southern College, 1960
August, 1972
MANUSCRIPT THESSES

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ACKNOWLEDGEMENTS

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The primary study objective was to determine the daily activities of red foxes on agricultural habitat. It was also hoped to learn something of the fox's food preferences and predation on quail, rabbits, deer, and poultry. Information was also desired on optimum methods of capture, the incidence of rabies, and the use of Tranimul and Sernyl as immobilizing drugs.

Fifteen red foxes (*Vulpes fulva*) were trapped during late winter on Louisiana State University property near Baton Rouge, Louisiana. Six foxes were equipped with radio transmitters and their movements were monitored by means of portable VHF radio receivers and hand-held antennas. One adult female ranged over an area of 1,000 acres, while a male pup confined his movements to only 40 acres. All animals under study retired to the shade of heavy cover within two hours after sunrise and were inactive until late afternoon. Little opportunity was had to study the effects of inclement weather on the activity patterns of these animals. Radio performance was considered to be poor throughout the study, with maximum distance of dependable signal reception limited to only about 0.3 mile.

Field observations indicate that the local red fox eats cottontail rabbits, small rodents, beetles, birds, and blackberries. No evidence of predation upon quail
was found. Very few deer and no poultry were available to the foxes.

Steel traps proved to be by far the most effective method of capturing foxes, though the animal may severely injure himself in his struggles.

The area has no recent history of rabies, and none of the animals studied displayed any symptoms of this disease. One adult female died during handling of what was later diagnosed as distemper and pneumonia.

Close proximity to men engaged in cattle ranching appears to have no adverse effects on the red fox.
INTRODUCTION

The American red fox (Vulpes fulva) has historically been maligned as a ranking predator of the smaller game animals and birds of North America. His wide distribution from sea level to elevations of up to 10,000 feet have brought him into close association with men of widely varying occupations. Whereas the Western cattleman hates the coyote, his sheep-ranching neighbor also must fear the fox as a killer of young lambs. The domestic poultry farmer of the Midwest sees the red fox as a threat to his birds. The small farmers and country folk over all the land envision the fox as a pest who would steal their last chicken. Growing numbers of upland game hunters firmly believe that if the red fox could somehow be eliminated from his favorite hunting grounds, all manner of birds and small game would appear there in legendary numbers.

A search of the literature would indicate that these attitudes can be largely attributed to folklore and superstition rather than facts. Much has been learned about the habits and food preferences of the red fox through studies made in several midwestern states, The Great Lakes region, and Southeastern United States.

Little has been published about the red fox in the general location of the study areas. It was believed that a sizeable fox population existed on an area just
south of the campus of Louisiana State University and this site was chosen as the primary study area. As the work progressed, two other areas were also enlisted as areas of study.

The basic purpose of the study was to learn the daily movements and behavior of the local red foxes. Additional information on food preference and availability, predation upon game species, optimum methods of capture, and incidence of disease relative to the local fox population was also desirable. The study was planned to obtain data from late winter through mid-summer. This was expected to span the period of time when the females would be in the earth preparatory to giving birth, the whelping period, and subsequent months which would normally be spent in the rearing and training of the pups.

The planned procedure was to capture and fit with radio-transmitter collars a number of red foxes, in order that their movements could be monitored by the use of a portable VHF radio receiver and hand-held antenna. Field observations of stomach contents and casual analysis of scats found was planned as a means of determining food preferences and availability.

Though possibly over-ambitious, considering the short duration of the study, other objectives of the study were to determine the optimum method of capture
experimentally by means of box traps, steel traps, and both electronic and mouth-blown predator calls. Two drugs were also to be tested for their effectiveness as immobilizing agents. These were Sernyl and Tranimul. Sernyl was to be injected intramuscularly as an aid in handling the animals while being fitted with the transmitters. Tranimul was to be employed as an oral tranquilizer contained in gauze rolls affixed to the jaws of steel traps. It was hoped the animals would chew these gauze rolls, ingest the Tranimul, and thereby reduce the extent of their injuries from struggling in the trap.

Significant results were obtained relative to the daily movements of red fox on two study areas. Only very generalized observations as to food preference and availability were made. No data of consequence relative to the incidence of diseases among the local red foxes resulted from this study. It was determined that the local foxes average slightly smaller in body size, and are generally lighter in color, than the red foxes of more northerly regions. Living in close proximity to man in essentially a cattle-ranching environment does not appear to pose any serious problems to the animals under study.
PREVIOUS WORK

The literature abounds with many interesting publications based upon studies of the red fox. In their excellent paper, Errington and Berry (1937) gave an account of "several hundred" young red fox pups which were removed from dens in Iowa during a fox eradication project. Some surprising facts were brought out as a result of the subsequent tagging and release of 236 of these fox pups. A low tag return of only 7 percent indicated very high mortality among these pups that were taken from their mothers before they were able to fend for themselves. Many were killed on roads in traffic near the release sites. The most distant tag return was from a point 96 miles from the release site. The average was a surprising 51 miles for all "younger" pup tag returns. Two young pups released near the den of the parents were able to rejoin the parents and apparently fared well. Three other young pups released two miles from the den never were able to rejoin their parents. In addition to the younger fox pups, some 55 "older" pups were later released. A much higher percentage of tags returned (18 percent) indicated that these youngsters were far more able to take care of themselves than were the very young pups previously released. The tags returned ranged from road kills in
the vicinity of releases, to one tag returned from an astounding 160 miles away. Errington gave the opinion that starvation was not a cause of high mortality in either age group.

Storm (1965) studied daily movements and minimum home ranges of the red fox in Carrol County, Illinois. His foxes generally laid-up in cover during the day and came out foraging for food during evenings and nights. The size of minimum home ranges was determined to be about 1.5 miles long by 1.0 mile wide. The foxes used many dens within this established home range, apparently using whatever den was handy for laying-up days, or for taking cover. On two occasions a pack of hounds was used to chase the fox in order to observe his actions while being pursued. On both occasions the fox easily eluded the hounds while staying well within the boundaries of his established range.

Hamilton (1935) examined 131 scats during midsummer in New York and found the following:

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<th>Foods</th>
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<tr>
<td>Cherries (Prunus serotina)</td>
<td>54</td>
</tr>
<tr>
<td>Insects</td>
<td>52</td>
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<tr>
<td>Blackberries (Rubus sp.)</td>
<td>34</td>
</tr>
<tr>
<td>Blueberries</td>
<td>14</td>
</tr>
<tr>
<td>Cottontail rabbit</td>
<td>11</td>
</tr>
<tr>
<td>Mice</td>
<td>9</td>
</tr>
<tr>
<td>Birds (total of all kinds)</td>
<td>4</td>
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During November Hamilton also found (36 scats examined):

<table>
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<tr>
<th>Foods</th>
<th>Percent scats</th>
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<tr>
<td>Fruits</td>
<td>55</td>
</tr>
<tr>
<td>Mammals</td>
<td>50</td>
</tr>
<tr>
<td>Insects</td>
<td>25</td>
</tr>
<tr>
<td>Birds</td>
<td>5</td>
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It is interesting to note that Hamilton also found the remains of many stray house cats in the fox stomachs. He found no grouse, and no bobwhite quail, but did find a number of woodchucks. He also stated that the foxes dug up and ate snapping turtle eggs. One 2/3-grown red fox killed on a road had his stomach filled with blueberries.

Errington (1935) suggested that the fox eats anything that he can catch or find dead. He also suggested that the fox is not a particularly swift animal, and that most of the fox's food animals are relatively slow animals. Errington placed the occurrence of quail in the fox diet at a low 3 percent. He examined den refuse from 113 dens and found young lambs and pigs were common and thought to be carrion. He counted 269 cottontail rabbits at the dens, plus every conceivable animal and bird occurring in the area.

Sargeant (1972) found the number of adult waterfowl remains at red fox dens in North Dakota to range from a low of 1.4 ducks to a high of 12.5 ducks per den. He also made the interesting observation that even during
periods of high fox population densities, individual waterfowl engaged in egg-laying and incubation may be exposed to predation by only a single family of foxes. It is no doubt true that the fox destroys a number of nesting pheasants and ducks during periods of low prey-animal populations. Darrow (1945) examined this relationship between fox predation and abundance of buffer species in his study of fox predation upon nesting grouse. Glover (1949) found little cause for concern when considering the fox as a factor on turkey range in West Virginia. The majority of studies show that the cottontail rabbit, rats, and mice are by far the most important staple items in the diet of the red fox. During the course of one study (Schofield, 1960), game management biologists followed the trails of foxes in snow for a distance of 1,109 miles in Michigan. The data gathered suggested that the principal food of the foxes at that time of the year was hunter-killed deer left to die in the woods. They further stated that they did not consider many, if any, of the 19 grouse found eaten by foxes to have been actually killed by the foxes. In his evaluation of the red fox, Scott (1955) concluded that foxes are scarcely a menace to bobwhite quail. He blamed the poultry farmer for much of the fox's alleged destruction of domestic poultry, claiming that many a farmer's practice
of leaving dead birds in the vicinity of the pens serves to entice foxes to the area.

Korschgen (1957) and Scott (1955) credit the fox as a major factor in limiting population levels of rabbits. Both workers indicate that small rodents, especially the meadow mouse, are important items in the fox's diet. Scott (1955) also suggested that when seasonally available, fleshy fruits such as berries and mulberries are preferred by foxes over prey such as rabbits and birds.
THE STUDY AREA

The study was carried out on three areas. The first area, known as Ben Hur Farms (Fig. 1), is located about three miles south of Baton Rouge, and lies between Highway 30 and the levee of the Mississippi River. This area is approximately 2.5 miles long by 1.0 mile wide. The land is owned by Louisiana State University and used for agricultural experiment purposes. About one-half of the area is utilized for sheep farming and cattle raising. People responsible for the sheep feel that they have lost at least a few young lambs annually to red fox predation.

This is low land with poor drainage. The soil is a dark gray, highly calcareous, heavy clay. The vegetation is mostly permanent pasture grasses, with the remainder in cultivated experimental crops. A few isolated shade trees stand in the pastures. These are live oak (Quercus virginiana), water oak (Quercus nigra), and pecan (Carya illinoensis). Several canals and drainage ditches run through the area. These are often grown up in black willow (Salix nigra), cottonwood (Populus deltoides), and blackberry (Rubus sp.).

The Louisiana Cooperative Wildlife Research Unit has a section of this area devoted to raising white-tailed deer experimentally. One reason this area was
selected for study was several reported sightings of foxes in close proximity to the deer holding pens.

As it happened, no foxes were ever under radio surveillance on Ben Hur Farms. Trapping was begun on the area in mid-January 1972. After a week of intensive scouting for fox sign, baiting with live chickens, and searching for fox dens, it became apparent that either the fox were not moving about or there were few fox on the area. A fox was captured on Ben Hur Farms much later, but due to circumstances that prevented checking traplines early on that particular day, the young red fox was found dead in the trap during the afternoon.

When it became obvious that it would not be possible to capture a number of foxes on Ben Hur Farms, a second area was chosen as a study area. This second area is located 10 miles south of Baton Rouge on the land of the old prison farm at St. Gabriel, Iberville Parish, Louisiana. The area comprises some 1,400 acres and is owned by the Agricultural Experiment Station of Louisiana State University for use as a cattle experiment station. Part of the area is leased from the Louisiana State Department of Institutions by the Animal Science Department of Louisiana State University. This is also a flat, low lying area with few terrain features (Fig. 1). The soil is the same dark gray,
Figure 1. Study Areas

Above: Study Area 1
Below: Study Area 2
heavy, highly calcareous clay described above. The area is poorly drained, and a moderate rain tends to temporarily flood the area to the extent that may make travel by vehicle difficult.

The area is utilized as a cattle experiment station, and has the usual lay-out of barns, corrals, roads, fences, and pastures. Several areas have been allowed to grow up in heavy weed cover. One 20-acre block of hardwood forest is on the area. Many of the older fencerows offer good escape cover for fox, as do many of the drainage ditches in the area. Several drainage canals traverse the area, with heavy weed cover on the levees. Extensive stands of dewberries and blackberries are found on levees, fencerows, at edges of woods, and as isolated clumps in the pastures. Several of the pastures have isolated shade trees standing alone, or in groups of two or three. These are live oak and water oak. Along the edges of woods, canals, sloughs, and older levees can be found black willow and sweet gum (*Liquidambar styraciflua*). This area lies adjacent to the Gulf States Power Station and is criss-crossed with power transmission lines mounted on high steel towers. The towers proved to be a serious problem in radio-tracking the transmitter-equipped foxes. The radio signal very often was received from the overhead wires or steel towers when
the fox was far away. Another facet of the study area might well be mentioned here. The radio frequency selected for use in the study happened to be a frequency used by the Baton Rouge Department of Public Works. On weekdays, radio-tracking of the foxes under study was very difficult due to heavy voice traffic on the same frequency as the monitored foxes. The usual result of radio communication between personnel carrying out daily activities was to completely block any possible radio signal from at least two of the foxes under surveillance. This problem did not exist during nights and weekends, however. The close proximity to the Mississippi River also contributed to difficulty in using the telemetry equipment due to voice traffic from the many tugs and barges plying the river. Access to this area was controlled by many locked gates, however, the cattle station personnel were very cooperative in every way.

A third area was also used during this study. This was an area of approximately 1,000 acres lying between the Gulf South Research Institute and the levee of the Mississippi River. This land is bounded on the south by Highway 327 and extends north to the south boundary of Ben Hur Farms. Highway 30 and the tracks of the Illinois Central Railroad run generally north and south through the middle of the area. All comments as to
soil types, vegetation, and drainage expressed above would apply to this third study area. The presence of the railroad proved to be a factor here due to its adverse effect on radio signal reception. The trains using this track apparently take a toll of small game and other small animals. One of the foxes under surveillance was killed on this railroad. This incident will be explained elsewhere in the text.

The wildlife found on the study areas include cottontail rabbits (*Sylvilagus floridanus*), fox squirrels (*Sciurus niger subauratus*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), cotton rats (*Sigmodon hispidus*), woods rats (*Neotoma floridana*), shrews (*Blarina brevicauda*), and several species of field mice. Some of the birds present were hawks, owls, crows, cowbirds, meadow larks, mockingbirds, flickers, woodpeckers, and bobwhite quail. Two white-tailed deer responded to a predator call at night on the cattle station, and were later jumped from their beds at the edge of a woods. They were bedded in extremely heavy growth of blackberries. This was the only area known to be used by deer.

All areas used in this study were accessible by 4-wheel drive vehicles. The general absence of heavily timbered areas proved to be a factor in the study.
With the extremely limited signal reception distance possible from the equipment used, any further range reduction by foliage would have made it impossible to monitor the study animals.
EQUIPMENT AND PROCEDURES

Fox Traps

Wire mesh box-type live traps were used experimentally in the study, but without success. These were baited with a variety of baits including rats, birds, muskrats, opossum, beef, sardines, liver, and cottontail rabbits. One fox trapper of great experience (Dailey, personal communication, 1972) stated that, in his opinion, the chances of capturing red foxes in box traps were very poor indeed. It might be worth mentioning here that these traps took several opossums, rabbits, rats, and armadillos during the limited time they were in use.

Oneida Victor coil spring jump steel traps in size number 2 (Fig. 2) were used and found to be about ideal. The square jaw design of this trap provides a higher leg-hold on the animal without great weight and bulk. The steel traps were equipped with steel stakes fabricated from .375-inch diameter concrete reinforcing steel rods. These stakes varied from about 18 inches to a length of 30 inches. In the extremely hard soil found on the study areas, these stakes proved to be longer than was actually needed. The nature of the soil and the terrain was such that the use of trap drags was not feasible. During most of the time the
Figure 2. Steel Traps With Tranquilizer Tabs Affixed

Above: Drug-dosage coded by colors

Below: This tab is smaller, more weather-proof
ground was so hard that a drag could have been moved away from the immediate area without leaving a trail of drag marks. The Victor brand steel traps are manufactured by the Woodstream Corporation, Lititz, Pennsylvania. This particular model is light, compact, has adequate jaw size, and is easily concealed.

**Radio Transmitters**

Several transmitters of varying designs were tested and discarded during preliminary field testing of equipment (Fig. 3). Much valuable time was lost due to this, as not one of these proved to be acceptable for the use intended. Three transmitters were later received from the AVM Instrument Company, Champaign, Illinois. These were single stage pulsating-signal transmitters rated at 2.7 volts. The antenna was a loop fabricated as a part of the collar, and was 1/2-inch wide brass stock backed with 1/8-inch thick Formica. This collar was fastened with a single brass bolt 1/8-inch in diameter. The circuitry components and batteries were covered with dental acrylic. To activate the transmitters it was necessary to solder two leads together and cover them with epoxy. The units appeared to be well protected from moisture except for the exposed loop antenna. In use, the exposed loop appeared to fail to transmit in a normal manner when the animal was
moving through grass wet with dew, or during a rain. The AVM transmitters weighed about six ounces, and cost $75.00 each in lots of six. The single unit cost of this transmitter was $100.00. The performance of the first three AVM transmitters received was disappointing during preliminary testing. However, a number of foxes were being held in cages pending delivery of transmitters and it was decided to use the transmitters. When tested, these transmitters gave a maximum signal reception distance of 0.5 mile if placed on top of a fence post. This was across short-grass pasture lands. If placed on the ground, the signal could be picked up at no more than possibly one-half that distance. The transmitters proved only barely adequate in use. The average distance at which a fox could be contacted was 1/8-mile. The maximum distances where contact was made measured about 0.3 mile. It was not unusual to receive only a very weak signal from a fox known to be in a small isolated thicket or clump of heavy cover from a distance of only 100 yards. This was especially true during early morning hours when the grass was wet from a heavy dew. These transmitters were designed to emit signals on a frequency range of 150.800 MHz/151.070 MHz. The signal pulse rate varied from about 45 to 60 emissions per minute.

The second set of three AVM transmitters was re-
ceived after several weeks of delay, apparently due to some misunderstanding of the terms of the purchase order. The maker had been advised of the unsatisfactory range of the first three transmitters and constructed the remaining three with whip antennas and powered by three 1.35-volt mercury batteries (Fig. 3). The collar was identical to that described above. In preliminary testing, the transmitters gave slightly greater range than the original three had. The pulse rates for the three transmitters were between 76 and 98 pulses per minute. The increased voltage and whip antenna was incorporated into the design in order to get more distance on signal reception, but the author had misgivings about using the stiff 10-inch long whip antenna on foxes that would be going through wire fences, briars, vines, heavy weed cover, and into burrows. One female fox was equipped with one of the modified transmitters and apparently broke off the antenna, or hung it on some object and destroyed the collar in her struggles, during the first night following her release. This was the only one of the last described transmitters that was actually fitted on a fox.

Some transmitters of unknown origin originally intended for use on bear were modified by the author and powered by 9-volt batteries. These had 10-inch long flexible whip antennas, collars of nylon seat
Figure 3. Radio Transmitters

Above: AVM transmitter, whip antenna
Below: Homemade transmitter
belting, and weighed 10 ounces. In tests the transmitters gave a reception distance of one measured mile when placed on the ground. When placed atop a fence post the signal was received a distance of 1.4 miles. The pulse rates varied from 120 to 180 emissions per minute. These transmitters were only available toward the end of the study period, and there was no opportunity to equip a fox with them.

Radio Receivers and Antennas

Two VHF receivers were used in this study. The AVM Model LA-12 was purchased from the AVM Instrument Company, Champaign, Illinois at a cost of $600.00. This unit is compact, light in weight, transistorized, and powered by eight 1.5-volt penlight batteries. This unit was originally paired with a two-element hand-held antenna supplied with the unit (Fig. 4). Someone spliced the antenna lead cable in order to lengthen it and this proved to be a source of problems. The receiver and antenna were returned to the maker during the study and the antenna was found to be inoperative. The receiver was returned along with a new five-element Cush-Craft antenna. Though somewhat unwieldy in use, this antenna gave satisfactory performance during the remainder of the study. The AVM receiver had a frequency range of 150.800/151.075 MHz.
The other VHF receiver used in the study was an older unit manufactured by Sidney L. Markusen, Cloquet, Minnesota (Fig. 4). This receiver was described by Lewis (1968), and had been used by J. Taylor (1969) and D. Taylor (1971). The unit is a 12-channel, crystal-controlled unit and is powered by 10 size "D" flashlight batteries. The weight of this unit was 7 pounds. Two antennas were used at various times with the Markusen receiver, both giving good performance. The antennas were two-element, hand-held types, similar to one described by Taylor (1971).

In side-by-side tests, repeated a great number of times, the Markusen receiver was able to pick up signals from test transmitters significantly farther than did the AVM receiver. However, the Markusen receiver failed quite suddenly, for yet undetermined reasons, and the AVM receiver continued to perform adequately for the remainder of the study.

Even considering their many limitations, both the receivers described above performed better than the transmitters used in this study.

In addition to the antennas described above, a 14-foot long Hy-Gain antenna manufactured by Hy-Gain Electronics, Lincoln, Nebraska, was field tested. This unit breaks down into two pieces and has eight elements. The big antenna gave very good directional
Figure 4. Radio Receiver and Antenna

Above: Two-element antenna in use
Below: Markusen VHF radio receiver
performance and received signals somewhat farther than the small antennas described above. The Hy-Gain unit was much too large and unwieldy to be carried in a vehicle, but could be mounted on the mast provided as a semi-permanent installation at a strategic location within a given study area. Used in this manner, one could connect a portable receiver to the antenna lead cable, and rotate the antenna until the desired signal was received. This type installation might be useful if three or more were located in an area where a sufficient number of transmitter-equipped animals could be tracked to warrant the expense of such installations.

**Vehicles**

Two vehicles were used in this study. A 4-wheel drive International Scout was used most of the time. A 3/4-ton Ford pickup truck was used on occasion. Both vehicles gave satisfactory performance, though a 4-wheel drive vehicle was a necessity during the early part of the study period, and after any rains.

**Miscellaneous Equipment**

A Cap-Chur gun was purchased for the purpose of testing an immobilizing drug on foxes called into range with electronic and mouth-blown predator calls. Dart syringes of the proper dosage were not received in time
to investigate this phase of the study.

An electronic 8-track cartridge tape player was purchased from Burnham Brothers, Marble Falls, Texas, for the purpose of calling foxes into range of the Cap-Chur gun (Fig. 5). As stated above, darts of proper dosage were not received in time to allow investigation of the effectiveness of this method of capturing foxes.

The compass used to obtain bearings on signals received was a Fast Accuracy Compass manufactured in Finland by the Suunto Company.

Sernyl was used as the immobilizing drug to enable safe handling of foxes during the fitting of transmitters. This drug worked satisfactorily and all animals recovered satisfactorily. The optimum dosage was found to be 0.75 mg per pound of body weight. This drug is rated at 25 mg per cc of liquid, and correct dosages required careful measurement. Only 0.25 cc of the drug was required for complete immobilization of adult foxes. Sernyl is a product of Parke, Davis, and Company, Detroit, Michigan.

A "choker" snare was used to handle trapped foxes. This device utilizes a loop on the end of an aluminum tube about five feet long which is manipulated by a rod running through the tube.

Foxes were transported from capture sites to a
Figure 5. Predator-calling Equipment

Above: Cap-Chur gun and tape player
Below: Red fox approaching caller
holding cage in small steel cages with wire mesh covers. Black vinyl electrical tape was used almost daily to make field repairs on antennas and other pieces of equipment. It is doubtful if the study could have been continued without it!

Several lights were used in the study. A 260,000-candle power lamp was used to illuminate fields to long distances while scouting the area early in the study. This powerful spotlight was also used to shine the eyes of animals responding to predator calls, though it was found to be too bright for that purpose. When a fox was caught directly in this light it usually was frightened away and was not seen again on that particular night. A homemade spotlight utilizing a 200,000-candle power aircraft landing lamp was also used for the same purpose (Fig. 6). Both these powerful lights were operated off of the vehicle battery. Six-volt lightweight headlights that can be worn on a hat were utilized in the predator calling. Animals would continue to approach the caller after being caught in the spot from these less powerful lights. A 9-volt flashlight was used sometimes when away from the vehicle. A 6-volt flashlight was used at night to enable the operator to see radio equipment controls, read the compass, and for all general use.
Figure 6. Lights Used During Study

Above: Lightweight headlight

Below: Homemade 200,000-candle power spotlight
Methods of Capture

The soils found on the study area were a poor medium for track impressions. Very few fox tracks were ever found, and these usually at edges of mud holes. The day following a rain offered some possibility for locating fox sign, but within hours after a rain the ground usually had dried out very hard and did not take track impressions. This type soil makes trap concealment very difficult, also.

Lacking means of determining areas of high fox usage, the initial traplines were placed along roads, canals, and wherever there appeared to be a natural fox crossing. Trapping success was very poor initially, though many types of trap sets were tried.

A live chicken placed at a break in a levee, that promised to be a crossing between two fields, produced the first fox caught. The steel traps were placed near the small cage containing the live chicken. The traps were reset, and captured another fox a few days later. A cow that died of what was thought to be Anaplasmosis was utilized as bait. Two foxes were captured in steel traps placed around the dead cow. Both these foxes were caught in the same trap, on successive nights.

The well-known "dirt hole" set was tried many times using muskrat flesh as the bait, without success.
After fresh urine was collected from the red foxes held in cages pending delivery of radio transmitters, capture success increased markedly. The urine post set proved to be by far the most successful type of set for capturing red fox in this area. There was very few natural urine posts to be found and stakes were driven into the ground for that purpose. The most effective sets proved to be those that were made using isolated clumps of grass or weeds as the "post".

The typical urine post set was made by selecting a small stump, post, bush, or isolated clump of grass, well away from vegetation that would not allow the fox to see all around as he approached the set. The trap was placed 8 or 10 inches to the side of the object selected and covered with whatever was available for the purpose. As the work progressed, it was learned that grass pulled at the trap site, or dead grass gathered nearby, was the best choice for trap cover. Various other materials were tried early in the trapping, such as sand, rotten wood, dried and crumbled droppings from cows, and straw from a hay barn. It was found that straw which was soaked in fox urine from having been used in the fox holding cages was a powerful attractor to other fox. Once the trap stake was driven, the trap was positioned and concealed. The urine was then sprinkled on the "post" a few inches
above the ground on the side nearest the trap. If no natural objects already existed that would tend to direct the fox to the trap, sticks, weeds, and small bushes were placed in such a manner as to force the fox to step over the trap in order to investigate the scent used. Once a fox is captured, it usually struggles as long as it is held in the trap. This results in the vegetation being destroyed in a circle of a few feet in size. This also leaves much fox odor at the site and the trap should be reset.

Woods (1959) found traps located along old roads and spaced 0.2 mile apart to be most effective. He did considerable experimentation and found that to be the optimum distance for spacing steel trap sets.

Once captured, the foxes were removed from the traps with the aid of a choker device described elsewhere. They were placed in holding cages and given antibiotic injections to combat infection from injuries received from struggling in the trap.

It was planned to experiment with an oral tranquilizer (Tranimul) contained in gauze rolls and affixed to the trap jaws (Fig. 2) as described by Payne, Jenkins, and Provost (1966). The purpose of this was to minimize injuries inflicted by the trap as a result of the animal struggling to free himself. A modified version of this tranquilizer tab was made up using varying amounts of
Tranimul and dyed with food coloring to distinguish the different dosages. This first trial of the tranquilizer tabs proved of little benefit as all tabs were ingested by skunks and opossums. Some of the trapped skunks that ingested the Tranimul were taken into deep ataxia, others were found dead in the traps.

A second lot of tabs was made according to the description in the cited study, and appeared to be a better assembly. The last effort produced a smaller, neater, more weather-proof tab (Fig. 2). It is regrettable that the limited amount of the drug on hand at the beginning of trapping operations was used up before successful fox trapping began. For some reason unknown to the writer, this drug was unavailable later in the study.

The abundance of skunks and opossums was a problem in the early trapping operation. Upwards of 50 of these animals were removed from the area before they ceased to be a major nuisance by springing traps and fouling trap sites. They were less a factor where only urine was used as an attractor, than where flesh baits were used. This writer suggests that where a number of fox are to be trapped, much time might be saved by mounting an intensive trapping program using flesh baits at sets designed to take skunks and opossums. Once their numbers have been significantly reduced
through trapping, the trapping for fox should be accomplished with greater success.

It might be worth noting here that the fox suffers greatly from thirst if held in a trap after the sun is high above the horizon. Much of the trapping necessary for this study was done in relatively warm weather and observations indicate that the fox cannot tolerate long periods of exposure to hot sunshine. Two foxes found dead in the traps were believed to have died from a combination of thirst and long exposure to direct sunlight.

Several attempts to capture foxes in box-type live traps were unsuccessful. Comments on this were noted elsewhere.

It was hoped to learn the feasibility of using an immobilizing drug (Sernyl) fired from a Cap-Chur gun as a means of capturing foxes called up with a predator call. The gun was purchased but no darts of the proper dosage were received in time to permit investigation of this method of capturing foxes. Both electronic tape players and mouth-blown predator calls were tried and successfully lured foxes into reasonably close range (Fig. 5). It is regrettable that no suitable dart syringes were available for testing.
Field Testing of Radio Equipment

As noted in the section devoted to the description of equipment, considerable effort was made to test radio equipment prior to release of the study animals. The transmitters were tested in many ways. One method of testing was conducted by placing a transmitter on top of a fence post and driving slowly along a road until the receiver was no longer able to receive a signal. The vehicle engine was shut down and careful calibration of receiver controls was made to insure that the receiver was tuned to the transmitter frequency. The distance was noted on the vehicle odometer, and verified by known distances taken from maps of the area. This procedure was usually repeated several times. The transmitter was next placed close to the ground and the test repeated. Some of the transmitters used in this study were tested 20 times and more. It is of utmost importance to count the pulses to determine the rate of signal emission early in the testing in order that a given transmitter may be identified. It is not uncommon for a single transmitter to emit signals on more than one frequency and identification may not be possible if the signal pulse rate for a given transmitter is not known. The rate at which the signal pulses changes as the voltage of the transmitter drops in use, and the signal pulse rate for all transmitters should be counted
periodically in the field. This is a simple procedure of simply counting the signals through a 60-second interval of time. To illustrate this point, a transmitter emitting 125 pulses per minute was placed in use. After a time the signal was counted and found to have dropped to 107 pulses per minute. At last count, this transmitter pulse rate was down to 98 pulses per minute. Toward the end of the study, the rate of pulse for two transmitters had changed as their respective power supply voltage was lowered until both were emitting signals at a rate of 46 pulses per minute. This can be a problem where both transmitters are operating on similar frequencies.

It should be pointed out here that much trouble with signal identity can result in attempting to test more than one transmitter at the same time. It is of utmost importance to test each transmitter individually, and preferably where no other transmitters are within receiving range of the receiver used. Once each transmitter has been positively identified in this manner, they are then ready for fitting on the animal to be studied.
Fitting Radio Transmitters

All foxes were assigned an arbitrary number based upon sex, area trapped, and frequency channel of transmitter carried.

To enable the foxes to be safely handled while being fitted with radio transmitter collars it was necessary to use an immobilizing drug. Sernyl was injected intramuscularly in varying dosages until an apparent optimum dosage was found. This proved to be 0.75 mg per pound of body weight. As only 0.25 cc of the solution was needed on an average adult fox, the remainder of a 1 cc syringe was filled with a saline solution as a vehicle for the drug. Injected at this dosage level, Sernyl proved to be very effective. The final three injections resulted in complete immobilization after only 3 minutes had elapsed. Recovery was complete within 5 hours on one adult female kept under surveillance. The other two mentioned were completely recovered the following morning. The exact time required for their recovery was not determined. The highest dosage level tried was 1.25 mg per pound of body weight, and resulted in the adult female fox injected going into convulsions after 9 minutes had elapsed. This fox made a complete recovery overnight.

Once immobilized, the foxes were laid out on a bench and the collars were fitted by securing a single
1/8-inch brass bolt (Fig. 7). The excess bolt was cut off and the end flared to prevent the nut from backing off.

After being fitted with transmitter collars these animals were held in individual cages overnight to insure complete recovery from the drug used. They were then transported to the release site in the same cages and released (Fig. 8).

Radio Tracking Procedures

The transmitter equipped foxes were tracked by driving the vehicle to locations expected to be within signal receiving distance of the fox under surveillance. If radio contact was made from this point, a compass bearing was taken and the vehicle driven to another point where it was expected that the signal could be received. If the desired signal was received, a second compass bearing was taken. When plotted on a map of the area, the intersection of the two bearings constituted a "fix". It would be nice to be able to state here that it always worked out that way in practice, but this was simply not the case. There were very few straight roads, and no road intersections, in the study area which would allow the "classic" radio-telemetry "fix" to be taken from. This area was also criss-crossed by high tension power lines mounted on high
Figure 7. Transmitter Being Fitted to Drugged Fox

Above: Fitting collar to fox

Below: Transmitter in position on fox
Figure 8. Transmitter-equipped Foxes Being Released

Above: Female Fox 621 leaves the cage

Below: Female Fox 439 at moment of release
steel towers. An extensive list of variables which affect the transmitted signal could be compiled from the observations made during this study. The overhead wires, and especially the supporting steel towers, were possibly the worst offenders. Other factors to consider on any given "fix" might be the nearness of a wire fence, a line of bushes along a levee, the levee itself, any nearby road, a pipeline right-of-way, the type and amount of vegetation, and especially the close proximity of railroad tracks. The early mornings were especially a problem because of heavy dew on the grasses. On occasion, it was possible to get as much as a 120-degree shift in apparent signal direction by walking a few paces away from isolated standing live oak trees! Signal reception was almost nil during rainstorms. This was thought to be a result of the exposed loop antenna of the transmitter coming into contact with wet vegetation. Time after time the writer, accompanied by other graduate students, would experience several major shifts in apparent signal direction before jumping the fox from isolated clumps of cover in open pastures, right where it was thought to be all the while! This was done several times to verify actual location of the animal.

Only experience gained with specific animals in a given area will allow the operator to make allowances
for the many variables encountered under these conditions, in order to obtain valid information.

Several 24-hour surveillances were conducted in order to better understand the sequence of daily movements. These were varied as to starting times. Some of the periods began at noon and ended at noon on the following day. Other periods began at 6:00 p.m. Both starting times tend to yield essentially the same information. A third starting time was tried which yields slightly different information. If the period began at midnight the information gathered indicated the time interval of greatest movement, a complete dawn-to-dark interval of least movement, and the usual evening and early night interval of moderate movement.

It is entirely possible that certain daily movements of the monitored foxes could be attributed to the maintenance of territory as suggested by Sargeant (1972).
RESULTS AND DISCUSSION

Minimum Home Ranges

Minimum home ranges for all foxes carrying functional radio transmitters are presented (Table 1). Range calculations were based on the method described by Mohr and Stumpf (1966). The ranges varied widely from approximately 1,000 acres for an adult female to only 40 acres for a male pup aged five months.

Fox 224. The greatest range shown (Fig. 9) was established in 9 days of rather frantic activity by an older female. Fox 224 (Table 2) had shown exceptional aggressiveness in the trap and later in a holding cage. It was speculated that the vixen had pups in a den somewhere, and that this was the cause of her anxiety. When released, however, she traveled a minimum of 1.25 miles and was found in a steel trap only 8 hours after release. She continued ranging widely in a long oval pattern of movement until contact was lost only 9 days later.

Fox 1310. An adult male, established a similar range (Fig. 10), but did it in a different manner. This fox moved south away from the release site into an area of freshly plowed fields surrounding stands of heavy cover on ditches, sloughs, and small stands
Table 1. Minimum home ranges (MHR) of red foxes studied

<table>
<thead>
<tr>
<th>Fox</th>
<th>Number of fixes</th>
<th>MHR acres</th>
<th>MRH ratio length:width</th>
<th>Days tracked</th>
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<td>224</td>
<td>28</td>
<td>960</td>
<td>3.20:1</td>
<td>9</td>
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<td>1310</td>
<td>49</td>
<td>920</td>
<td>2.45:1</td>
<td>44</td>
</tr>
<tr>
<td>439</td>
<td>221</td>
<td>497</td>
<td>1.10:1</td>
<td>77</td>
</tr>
<tr>
<td>3211</td>
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<td>---</td>
<td>---</td>
<td>--</td>
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</tr>
<tr>
<td>5210</td>
<td>101</td>
<td>42</td>
<td>1.15:1</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 2. Measurements (inches) and weights (pounds) for transmitter equipped red foxes recorded during this study

<table>
<thead>
<tr>
<th>Fox</th>
<th>Sex</th>
<th>Total length</th>
<th>Tail length</th>
<th>Hind foot</th>
<th>Ear</th>
<th>Weight</th>
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<tr>
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<td>F</td>
<td>37.5</td>
<td>13.5</td>
<td>5.50</td>
<td>3.375</td>
<td>7.0</td>
</tr>
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<td>12.5</td>
<td>6.0</td>
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<td>9.0</td>
</tr>
<tr>
<td>621</td>
<td>F</td>
<td>37.5</td>
<td>14.0</td>
<td>6.0</td>
<td>3.375</td>
<td>7.75</td>
</tr>
<tr>
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<td>M</td>
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<td>12.0</td>
<td>5.50</td>
<td>3.125</td>
<td>5.75</td>
</tr>
</tbody>
</table>
of timber. This phase of his activities lasted only a few days, and may have been influenced by the fact that he was known to have been in the company of a female which was released at the same time, and from the same site. Fox 1310 was never again to be contacted in the area south of Highway 327, but confined his activities to periods of daytime inactivity spent in heavy cover around an abandoned house, and hunting afield from late evening until well after sunrise. This fox apparently moved away from his favorite daytime haunts as a result of farm tractors working close to his weed cover while disking the surrounding fields preparatory to the planting of soybeans. For whatever reasons, the fox moved a full 3/8-mile north of his previous known territorial boundary, and was killed by a train on the second day in new surroundings (Fig. 10).

Fox 439. A female fox, designated Fox 439, was inadvertently released near the Gulf South Research Institute, 6.5 miles north of the site of her capture. She was contacted moving in a southerly direction during the first night following release, and was in company with Fox 1310. Contact was maintained for 3 days in the vicinity just south of Highway 327. No contact was made for 3 days following this, and it was believed the fox was enroute back to the site of her capture on Study Area 2. She was seen by spotlight.
as she entered the approximate northern boundary of the study area, and 1 hour later responded to the author's predator call near the site of her capture.

Fox 439 was under surveillance a total of 77 days, and after arriving back on familiar ground established a range of less than 1 square mile (Table 1). The shape of this fox's territory was roughly in the form of a square (Fig. 11).

**Fox 5210.** A male pup estimated to be 14 weeks of age was badly injured in two steel traps. He was nursed back to good health by the author during almost a month of confinement. During this time he was given worm medication, canine distemper and canine hepatitis immunization shots, and massive doses of broad spectrum antibiotics. It was decided to equip the pup with a radio transmitter in order to learn what influence, if any, the period of confinement might have had on him. He was released at the capture site, and within minutes had moved 400 feet to a small thicket in the corner of a pasture. This was very heavy cover and was located astride a levee. The pup continued to use this well-chosen cover during the daylight hours. He appeared to stay within the thicket all during the night on occasion. His movements during the first few days were short trips along a levee which offered good concealment,
Figure 9. Minimum Home Range of Fox 224
Figure 10. Minimum Home Range of Fox 1310

- Minimum Home Range
- Capture and Release Site
- Fox 1310 Killed by Train
Figure 11. Minimum Home Range of Fox 439
Figure 12. Minimum Home Range of Fox 5210
to three den complexes believed to have been his rearing dens. Data for this fox are not considered valid and are presented only as a matter of interest. Fox 5210 established a range of only 40 acres (Table 1, Fig. 12).

Behavior of Individual Animals

A detailed summary of each fox studied is presented here to enable the reader to better interpret individual home range and daily movements.

**Fox 224.** This adult female was captured March 30 in a steel trap at a urine post set located alongside a farm road on the cattle experiment station. She displayed unusual viciousness in the trap, and was very aggressive while confined in a holding cage awaiting delivery of radio transmitters. This particular fox was never injected with the immobilizing drug. She was restrained with a choker device while a transmitter collar was being fitted. At the time of her release on April 17, a movie film was being made for the purpose of television presentation. The activities associated with the filming may have influenced the fox's behavior, for she moved rather casually along a road for a distance of 200 yards, investigated a urine post trap site, then stopped in a clump of blackberries on a small ditch. The fox stayed in cover along this ditch for several hours, then moved east toward a woods.
She then moved south staying inside the woods edge and was found in a steel trap 8 hours after release. The minimum distance covered between release and capture in the trap was 1.25 miles. The fox was given an injection of antibiotics and released at the trap site. She remained in the area throughout the night and the following day. During the next few days, this fox ranged over an area 2.4 miles long by 0.75 mile wide (Fig. 9). She repeatedly penetrated a block of dense woods on the southeast side of the study area, only to re-cross the area, usually the following night. She was contacted off of the study area on two occasions, and appeared to be hunting in a grazed pasture. The fox was seen in the beam of a searchlight on two occasions while crossing pastures near the main cattle corrals. Fox 224 was last contacted at the extreme northwest limits of her range on the night of April 25. Many attempts to contact her from all adjacent roads failed, and she was first thought to have been a traffic victim. However, both the nearby highway and railroad were walked for a distance of 2 miles in an effort to locate any road kills, with no results. The search was moved to Highway 74 at the extreme southern limits of her range, but the fox was never found. It is possible that she moved out of the area in a normal dispersal pattern of movement such as was described by
Fox 1310. This adult male fox (Table 2) was captured at a site baited with a live chicken on March 19. No transmitters that had proved to be acceptable in preliminary testing were available until much later, and it was necessary to hold the fox in confinement until fitted with a transmitter and released April 18. A movie of the release was being filmed, and the fox emerged from the release cage (Fig. 8), whipped around, climbed a levee, and took cover in heavy weeds a few yards from the release site. He was monitored all day and did not move from this hiding place until after dark. During the evening the fox moved south in company with Fox 439, crossed Highway 327, and entered a large area of freshly plowed fields surrounding small clumps of heavy cover found along ditches and sloughs. He remained in the general area for the next few days. It is not known if he remained in the company of Fox 439 during this time, and it may be only coincidental that he returned to the release site at about the time that Fox 439 was moving southward on her return to the site of her capture some 6.5 miles away. Fox 1310 occasionally used the dense weeds atop the levee at the release site as daytime cover. The levee was separated from Highway 30 and the Illinois Central
Railroad by 40 acres of well-grazed pasture. During this time, his favorite daytime lay-up spot was a row of dense bushes along a fence paralleling the railroad. He was contacted so many times during the day from a spot just across the highway from this cover that an attempt was made to find his bedding sites. The fox apparently was disturbed by the writer and his assistant, and moved 1/4-mile south, staying within the cover offered by a row of bushes. He then took cover in a heavy stand of giant ragweed surrounding an abandoned house. The fox was sighted on several occasions by spotlight while he was engaged in hunting activities. In company with a graduate assistant, the writer attempted to learn the nature of his daytime bedding site. The fox came out of weed cover a few yards from one of the men, moved casually along the edge of this cover a short distance, then returned to his original position. Fox 1310 spent more and more days in this cover over the next few weeks, and finally used it almost exclusively. From here he frequently ranged across the plowed fields nearby as far west as the levee of the Mississippi River. Before he began using the site of the abandoned house almost exclusively, Fox 1310 was accidentally disturbed in his former favorite daytime cover when the author stumbled onto a fox den while
crawling under a tangle of vines and bushes alongside the railroad. A strong signal from the entrance to a fox den located under a wire fence indicated the presence of the fox. This incident apparently caused the fox to abandon this favorite cover, as he was never again contacted at this spot. This incident was one of several that indicated a surprisingly high level of sensitivity on the part of the foxes to the intrusions of man.

Fox 1310 was apparently disturbed by the presence of farm tractors working close to his daytime haunts near the old abandoned house, for he moved a full 3/8-mile farther north than his known territorial limits, and was killed by a train on the second day in these new surroundings (Fig. 13). The fox was found lying between the rails of the Illinois Central Railroad on May 31. The fox's head had been severed and was never found, however a diligent search located the still-operative transmitter lying in grass 37 feet from the carcass. Apparent differences in the stages of fly larvae development gave evidence that an opossum lying alongside the fox carcass had also been killed by a train while feeding on the fox carcass.
Favored Daytime Cover

Nighttime "Fixes"

Capture and Release Site

Fox 1310 Killed by Train

Figure 13. Pattern of Habitat Usage by Fox 1310
Fox 439. This small female (Table 2) was trapped at the carcass of a dead cow near the south boundary of the cattle station on March 24. She was inadvertently released April 18 near the Gulf South Research Institute. This was a distance of 6.5 miles north of where she was captured. The fox remained in heavy weed cover atop a levee near the release site until late evening. She moved south in company with Fox 1310 and crossed Highway 327 early in the night. Contact was made with this fox for the next 3 days in a large area of recently plowed fields surrounding small clumps of very heavy cover. This area was approximately 1/2-mile south of the release site. No contact was made with Fox 439 for the next 3 days, and it was supposed that she was making her way back to her former range. On the sixth night following her release, this fox was seen entering the north boundary of the study area where she had been captured. Approximately 1 hour later the fox was seen a mile away when she responded to a predator call near her capture site. Fox 439 was relatively inactive for several days after arriving back on familiar grounds. She used an area of extremely thick weed growth for shade and cover during the day, and hunted in a nearby pasture at night. As time passed, this fox slowly extended her range to include more adjacent pastures. She also began to utilize another weed
field as daytime cover. The writer walked up this fox, when the signal indicated her to be far from her usual daytime haunts, and found her to be lying-up in a very small clump of dewberries well out in a pasture. She was in the company of another fox at this time. Fox 439 continued to use the weed fields for day cover, but occasionally was found to be lying-up in isolated clumps of cover far out in a large pasture (Fig. 14). She was sighted by the writer on several occasions during this time. Dewberries were in season at the time, and the writer feels that the fox was eating them to the exclusion of almost all other foods. Observations made on several scats during the time would tend to support this belief. The writer searched one of this fox's favorite daytime bedding sites in an effort to learn the nature of its preferred cover. The fox was found to be lying in the shade of a heavy growth of bushes surrounded by tall weeds on top of a levee. The fox moved away at the approach of the writer, and was never known to use this particular cover again.

A total of four 24-hour surveillances were made on this fox (Figs. 15, 16, 17, and 18). During this time, the fox displayed a pronounced tendency to lie in the shade of heavy cover during most of the day, coming out into the adjacent pastures to hunt during the early evenings. The fox usually was active all
Figure 14. Pattern of Habitat Usage by Fox 439
Figure 15. Relative movements of Fox 439 during a 24-hour period, May 30-31. Arrows indicate sunrise and sunset. Weather clear.
Figure 16. Relative movements of Fox 439 during a 24-hour period, June 1-2. Arrows indicate sunrise and sunset. Weather clear.
Figure 17. Relative movements of Fox 439 during a 24-hour period, June 11-12. Arrows indicate sunrise and sunset. Weather rain showers.
Figure 18. Relative movements of Fox 439 during a 24-hour period, June 26-27. Arrows indicate sunrise and sunset. Weather foggy.
night, returning to heavy cover within 2 hours after sunrise. The period of greatest movement proved to be the first 2 hours of daylight (Fig. 19). This was chiefly due to the necessity of crossing extensive pastures in order to reach the preferred daytime cover. It appears that this fox very rarely used any form of den, preferring to bed down above ground, and in the shade of good cover. Impressions left by the fox where it had lain in high grass were observed on several occasions, but these were probably seldom in the exact spot where the animal had lain previously.

Fox 439 appeared to have well-defined territorial boundaries. She was never previously contacted on one side of a road running through her range, even though it was merely a track, and posed no barrier of any kind. During the last week of the study period, however, some 80 acres of pasture adjacent to this vehicle track was mowed. This apparently caused Fox 439 to move across this road and take up residence in very heavy cover at the edge of a tract of woods. The fox then seemed to alternate spending her days at this new location with days spent nearly a mile away in the weed field previously described.

A total of over 200 radio-location fixes were made on Fox 439 during the 77 days she was under surveillance.
Figure 19. Relative movements of Fox 439 during a 48-hour period, June 20-22. Arrows indicate sunrise and sunset. Weather clear.
Fox 3211. This male red fox (Table 2) was captured April 7 at a trap site located in open meadow adjacent to a weed field. A clump of bunchgrass was used as a urine post, and the trap covered with straw removed from a fox holding cage. The meadow was mowed during the afternoon after the set was made, yet the fox was found in the trap early the following morning. It is probable that the strong odor of fox on the straw used to cover the trap was the attractor.

Since this animal was a male in his prime, he was selected to carry a transmitter of a design somewhat different from the others in use (Figs. 3 and 7). This transmitter had been partially assembled by a graduate assistant and construction was completed by the writer. The writer made the mistake of testing this transmitter in the presence of three other operating transmitters, and learned too late that what he had thought to be the transmitted signal from this homemade transmitter was actually being produced by one of the other transmitters located nearby.

Fox 3211 was released at a time when voice traffic on his supposed frequency would have made signal reception impossible. It was learned later that his supposed signal was actually being transmitted by Fox 1310. Though many attempts were made to contact him, no signal
was ever received from the transmitter fitted to this fox.

**Fox 621.** This older female (Table 2) was trapped March 23 alongside a road on the cattle experiment station. She was taken in a urine post set that had captured a fox a few days earlier. The first fox died shortly after being freed from the trap. Exposure to a hot sun, combined with thirst, was thought to have been the cause of death.

Due to reasons not entirely clear to this writer, transmitters that had supposedly been ordered several weeks previously still had not been delivered. Consequently, Fox 621 was held in a cage 8 weeks as a result of this, and was finally released May 25. The long-awaited transmitters were delivered with 10-inch long stiff antennas (Fig. 3) of what appeared to be brass brazing rod material, but may have been gold-plated wire. The antenna appeared to be very likely to hang up in heavy cover or become entangled in one of the many fences in the area. The writer also had strong doubts that a fox could successfully negotiate underground dens while wearing a collar with this antenna attached.

Fox 621 was released near the capture site on May 25. She ran 300 yards, entered thick woods, and all contact was lost during the first night following
her release. It is supposed that the stiff antenna became entangled in a fence or heavy growth and was torn from the collar by the struggling fox.

**Fox 5210.** This male pup (Table 2) was judged to be 14 weeks old when captured in a steel trap May 16. The jaws of several traps had been padded by wrapping strips of burlap around them and securing with vinyl tape. These traps were set near what was thought to be a natal den where a red fox pup had been captured 6 weeks previously. Two traps were set where a well-used trail passed under a wire fence in the hope that if another pup was caught the second trap might help to prevent extensive injury. This proved not to be, as the pup somehow got through the fence and was able to pull directly against a trap caught in the strands. The foreleg appeared to be broken, and a hind foot was badly mangled. The pup was kept at the writer's home, and eventually made a complete recovery from his injuries.

He was equipped with the same transmitter that had been worn by Fox 1310 prior to his being killed by a train. This pup was released at the capture site June 11. He had responded well to treatment and had gained an average of 1 ounce per day during the 4 weeks he was in confinement. The pup raced 400 feet along a levee and hid in a dense thicket.
approximately 100 feet in diameter. This was probably the best escape cover on the study area, and the pup continued to stay in it during the days following his release. He made short trips along the levee to visit three denning complexes which were believed to have been his rearing dens. The pup was seen a week after release in company with what was described as an adult fox by the writer's companion. The two foxes were flushed from cover some 400 yards north of the release site.

The writer found this pup to be a likeable little animal, and merely released him equipped with a transmitter out of curiosity. He was seen on two occasions, and appeared to be doing well.

Even though he had on occasion eaten from the author's hand, this young male red fox may have been the wariest of the animals under surveillance after he was returned to the wild.

The author does not consider data gathered from the monitoring of Fox 5210 to be valid, and includes it here only as a matter of interest (Figs. 20, 21, 22, and 23).
Figure 20. Pattern of Habitat Usage by Fox 5210
Figure 21. Relative movements of Fox 5210 during a 24-hour period, June 11-12. Arrows indicate sunrise and sunset. Weather rain showers.
Figure 22. Relative movements of Fox 5210 during a 48-hour period, June 20-22. Arrows indicate sunrise and sunset. Weather clear.
Figure 23. Relative movements of Fox 5210 during a 24-hour period, June 26-27. Arrows indicate sunrise and sunset. Weather foggy.
Other Findings

Food habits. Field observations indicate that at least moderate populations of cottontail rabbits, cotton rats, woods rats, and white-footed mice are available as food for the red foxes on the study areas. In addition, cowbirds, mourning doves, blackbirds, grackles, meadow larks, flickers, woodpeckers, and bobwhite quail are to be found on the area. The only fruits observed on the area were dewberries and blackberries.

Casual analysis of scats found showed that the foxes were eating rabbits, small rodents, an occasional bird, and berries. During the time when berries were most plentiful, both fox and raccoon appeared to be eating them almost exclusively.

The contents of the stomachs of three juvenile female red foxes were examined and found to contain a few feathers, straw (probably incidentally ingested), and small amounts of partially digested flesh. Two large black beetles were found in each of two stomachs. A female pup, which lost a foot in the trap, was brought home and fed some warm milk. She immediately regurgitated about 50 grams of what appeared to be an immature flicker.

On successive days the remains of a small Hereford calf, a Black Angus calf, a King rail (Rallus elegans), and a short-tailed shrew (Blarina brevicauda) were
brought to the entrance of a natal den that the author was checking daily.

Young rabbits were to be seen in numbers during early summer, and as the berry crop disappeared the fox scats examined showed increasing amounts of what appeared to be hairs from rabbits and small rodents. Only one scat was seen by the writer which contained a few feathers that might have been from bobwhite quail or woodcock.

**Diseases.** No attempt was made to investigate disease factors associated with the local fox population. The writer made a point of noting any possible symptoms of rabies among the foxes he observed, but found no evidence that the disease was present in advanced stages at any rate.

One particularly vicious female that was thought to be a juvenile did bite the author while being placed in a cage. This young vixen subsequently died and the head was turned over to authorities for a test for rabies. The test results were negative.

One of the last foxes captured was a female in extremely poor condition. This fox died the day following capture, though she had not suffered injury in the trap. The vital organs were removed in the field, and later examined by a veterinarian. The result of the autopsy was a diagnosis that the fox had
died as a result of canine distemper followed by pneumonia.

Denning. During the early part of the study the writer was unable to locate active fox dens. The soil found on the study area appeared to be so hard as to make excavation of dens very difficult. Many smaller burrows were commonly found along small ditches and fencerows. It was not until a levee which was old enough to be overgrown with sizable young trees was examined that dens suitable for the rearing of young foxes were located (Fig. 24). This levee was the north boundary of Study Area 2. The two male red fox pups mentioned elsewhere were captured at a den site on this levee. At least three sites were found along this levee where there was more than one den entrance in close proximity to other dens. The levee was searched for 3/4-mile and several other single den entrances were seen.

It appears that for the most part the local red foxes utilize burrows dug by armadillos, which they deepen and enlarge into suitable dens.
Figure 24. Fox Dens

Above: Natal den of Fox 5210
Below: Fox den in a levee
Reproduction. A male red fox pup was captured outside the natal den on April 10. If his age at the time of capture was accurately estimated, this pup would necessarily have to have been born no later than the middle of February. If true, this indicates that the local foxes breed somewhat earlier than do the foxes from more northerly regions (North Dakota Fish and Game Department, 1949). The few red fox young-of-the-year that the writer was able to observe varied greatly in size. This may be an indication of a breeding season of long duration.

Young red foxes. A few comments regarding the red fox pups mentioned elsewhere in this paper may prove of interest to the reader. During the course of this study the author had occasion to observe two male pups and one female pup closely over a period of time. The two males were believed to be litter-mates. The female pup was captured in a trap more than 1 mile from the natal den of the male pups. She was thought to be approximately the same age as the males.

The first pup was captured outside the natal den April 10. A foreleg was severed by the trap and had to be amputated. This little guy proved to have the courage of a lion. His indomitable spirit endeared him to the author and his wife, who kept him in their
home for a period of three weeks. He only weighed 2.75 pounds when captured, but grew rapidly during the 3 weeks he was observed (Fig. 25). He was given worm medication and massive dosages of broad spectrum antibiotics. He was known to be anemic and to have pneumonia. He also demonstrated incredible cunning, totally unexpected in so young an animal. This fine young animal died on April 29 after a day of excitement, when he had ridden downtown in an automobile and ate vanilla ice cream from a spoon.

A second male pup (Fig. 26) was captured in a steel trap near the natal den and thought to be a brother of the first pup. This one was estimated to be 14 weeks of age when trapped on May 16. This fox was designated Fox 5210, and has been equipped with a radio transmitter and released. Though they looked alike in physical appearance, the two pups were very different in other respects. Where the first one was spirited, friendly, and unconquerable; the second pup was shy and overly sensitive.

The female pup was trapped June 21, and also lost the left foreleg from injuries suffered in the trap. She is being treated at the author's home and is responding well. She may be more vicious than the male pups were. This trait appeared to be common among the adult female foxes which were confined to the holding cage.
Figure 25. Very Young Red Fox Pup

Above: Author's favorite, aged 9 weeks

Below: Same pup, aged 6 weeks, shown on day of capture in steel trap
Figure 26. Fox 5210 Aged 4 Months

Above: Brother of fox pup shown in Fig. 25

Below: This pup fitted with radio transmitter and released
Epilepsy. Two of the three young foxes which the author treated for injuries suffered from what appeared to be epilepsy. The seizures could be described as typical of epileptic seizures in man. The second male captured suffered such a "fit" at the home of the author at a time when he had been acting strangely. This youngster had a badly sprained right foreleg, and a splint had been concocted from four long plastic-stem cotton swabs and tape. The pup had fever, and was generally unwell at the time. While chewing on the bandaged leg, the pup swallowed one of the long plastic cotton swabs. This was discovered the day following the seizure when this swab, bent in a "U" shape, was passed by the pup.

The female had four such seizures in the space of 10 days. Two of these were caused by excitement and over-heating when she jumped out a window of a parked vehicle and hung by her leash until discovered. The first time this happened, she was covered with a towel and kept in the shade. The pup appeared dead except for a heartbeat. It took 15 minutes for her to regain consciousness.

The last two such seizures were a result of stress. All fox appear to be very nervous and high-strung, but this young female was extremely so. She was allowed to sleep or roam throughout the house for 2 days and
this apparently "spoiled" her. At a time when it was necessary to confine her to her own quarters, she threw a tantrum much as a child might do. While restraining her in his hands, the author felt the neck muscles go rigid, the head was pulled back sharply, the mouth opened wide, and the pup lapsed into unconsciousness. She recovered enough to raise her head in 1 minute, but required 24 hours to fully recover. The fourth time this occurred, the pup was stubbornly attempting to push past the author to leave her room. She was angry and excited, and when the author brushed her back with a broom she gave the appearance of being extremely angry. The door was closed and the author observed the pup from hiding. She looked all around, just as she usually did when contemplating how to climb out of the room via some shelves, bit at herself, licked her feet, and then slowly assumed the pose of the wide-open mouth with the head thrown back. This was followed by tonic spasms. She was unconscious for only seconds, then began thrashing wildly on the floor. She was sick, listless, and would not eat for a day.
Parasites. Three young foxes were given proper dosages of two kinds of worm medication. These were N-Butyl Chloride and Piperazine. The first pup was about eight weeks old when given this medication. He passed a small handful of large flat "tapeworms", and thread-like roundworms. He was autopsied later and the liver was speckled with white necrotic foci. The other two pups given this medication did not pass any worms.

An adult female that died a day after being captured in a steel trap was also examined. This fox was down in her cage on the morning she died, and both eyes were pasted shut with a yellow scale. She was believed to have died of distemper and pneumonia. While examining her, the blade of the knife being used pulled a 4-inch long white nematode from a bronchial tube when an incision was made in the lungs. This fox was in the poorest condition of all the foxes captured during this study.

External parasites noted included two species of ticks, and a mange mite.
CONCLUSIONS

Red foxes on agricultural habitat of Southeast Louisiana are strongly territorialized. These territories may overlap those of other foxes. The means by which the territorial boundaries are established is not known, but there is no evidence to indicate that natural barriers are necessary to define them. There is also no evidence of agonistic behavior among neighbors. An adult female stayed within an area bordered by a vehicle track across pasture lands for about 70 days before crossing this simple track as a result of the pastures having been mowed. She then started using the heavy cover at the edge of some woods approximately 200 yards north of this vehicle track. An adult male was found to use heavy weed cover atop a levee during the day, but was never contacted east of this spot even though the grain field adjacent to the low levee might have provided a more productive hunting area than the closely grazed pasture on the opposite side. A simple track across a pasture proved to be the boundary along one side of a territory utilized by another female fox. This track bordered her known range for over 1/2-mile along one side, yet she was never known to cross it. She regularly crossed it, however, on the south side
of her range, while moving from the night hunting grounds to a favorite daytime cover at the edge of a weed field. This same fox was never known to visit the adjacent field to the west of her favorite hunting grounds. The most formidable barrier separating the two was a simple barbed wire fence! Over 200 radio "fixes" were recorded for this particular fox.

All foxes monitored were found to use heavy cover for shade and concealment during the day, and to leave this cover during the evenings to hunt in adjacent fields and pastures. The foxes usually returned to one of several favorite daytime haunts within two hours after sunrise. The animals proved to be only slightly crepuscular. The period of greatest movement was found to be early mornings. Much of this movement was a result of travelling considerable distances to reach areas of daytime usage. The average distance travelled from day cover to favorite hunting grounds was not great, and the fox sometimes did not return to its usual daytime haunts the following day. On these occasions, a fox would either lie-up in small clumps of cover well out in relatively open habitat, or move to another favorite daytime cover.

Steel traps proved to be by far the most effective method of capturing foxes. Attempting to pad the jaws of steel traps may be of little value. The use of an
oral tranquilizer tab affixed to the trap jaws should materially decrease the extent to which a trapped fox injures himself during his struggles. The author regrets that he was not able to determine the effectiveness of this technique due to being unable to secure a supply of Tranimul. Box-type live traps are a poor choice as a method of capturing foxes.

Foxes were called into reasonably short range with both mouth-blown predator calls and an electronic tape player. A Cap-Chur gun was purchased, but no dart syringes suitable for use on fox were ever received in time to allow them to be tried as a means of capturing foxes. However, the author feels that due to the rather lengthy latent period established for the drug in question, it would prove to be unsuitable for capturing foxes. Any fox darted with the drug could move out of recovery range before being immobilized.

The foxes were found to have been eating rabbits, small rodents, birds, and berries. During the time when both dewberries and blackberries were plentiful, the foxes were known to frequent the vicinity of good berry stands. One adult female was often found to be lying-up in small clumps of blackberries during this time. Scats examined during this time contained a high proportion of blackberries. Raccoons were also known to be feeding heavily on the berries at this
Bobwhite quail utilized the study areas, but no evidence of fox predation on quail was observed. One very old scat contained a few feathers that were thought to be from either quail or woodcock.

No symptoms of rabies was noted among 15 captured foxes. The local foxes were generally in poor condition when captured.

We regret that we were unable to borrow a pack of fox hounds in order to observe the escape tactics of a transmitter-equipped fox while being pursued.

The young fox pups observed during this study proved to be one of the most interesting aspects of the study. They proved to be highly intelligent animals, but were extremely nervous and prone to seizures similar in nature to epilepsy in man.

The long delay in obtaining radio transmitters was a major disappointment. The extremely limited range of the equipment used in this study often resulted in much time being lost in having to actually hunt down a fox known to be regularly using a given area. The many overhead wires and supporting steel towers found on the study area often made it difficult to get a true bearing on a transmitted signal.

The foxes proved to be surprisingly sensitive to man's intrusion into areas of daytime cover. On
at least five occasions, the foxes abandoned a favorite cover after it was visited by the author. A vixen moved her family from three favorite rearing dens as a result of the author's visits to these sites.

The extremely hard soil probably restricts the choice of den sites to levees, or other areas where the soil has been disturbed.

Significant differences in the sizes of several young foxes examined indicates the possibility of a breeding season of greater duration than has been reported for the foxes of more northerly states. The author hopes that the work will be continued through a calendar year, and that emphasis will be placed on establishing the period of breeding activity.

Radio telemetry is a useful tool where it is desired to study the movements of animals on their chosen habitat. A signal receiving distance of at least one mile should be specified by anyone purchasing radio equipment to be used to monitor the movements of red foxes on agricultural habitat.
LITERATURE CITED


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VITA

George Washington Taylor was born September 30, 1929, at Paragould, Arkansas. He was the ninth of thirteen children born to Ralph Hubert and Lela Jane Taylor. The family lived on a farm in the Oak Grove High School District, and the children attended that school. George also attended high school in Southern California, and was graduated from Paragould High School in 1947. He was active in baseball, basketball, and football.

He served as a Forward Observer and Mortar Unit Leader in Korea during 1951-52, as a member of the First Marine Division. He was a member of the base football team at Camp Pendleton Marine Base, California in 1952 and 1953, and was honorably discharged in January, 1954.

He attended Mississippi Southern College and was graduated in 1960 with Bachelor of Science Degrees in both Geology and Mathematics.

George has traveled extensively while working as a Petroleum Engineer in Alaska, South America, North Africa, Ireland, and Scotland. He was fortunate in being able to spend several months working with the Wildlife of Africa during 1965, 1966, and 1967.

He is married to the former June Elaine Becker of Devils Lake, North Dakota. George is now a candidate for the Master of Science Degree in Wildlife/Game Management at Louisiana State University.
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Major Field: Game Management

Title of Thesis: A telemetric study of the red fox in agricultural areas of southeast Louisiana

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