

# Establishment of Home Range by Juvenile Barrier Island

## Red Fox after Dispersal

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### Proposal Summary

RETROACTIVE  
PERMIT

This study will analyze the home range of dispersed juvenile red fox, Vulpes vulpes, from a barrier island ecosystem. Eleven juvenile red fox will be captured and equipped with a radio-collar beginning in June, 1991. They will be tracked with radiotelemetry until the end of May, 1992, at which time they should have established their adult home range. Special attention will be given to dispersal and recovery distance, direction and timing, and establishment of an adult home range.

### Introduction

Most research on the red fox in North America has been conducted in the mid-west, in such areas as Wisconsin (Ables, 1969), Illinois, Iowa and Minnesota (Storm et al., 1976). Variations in habitat and climate within an animal's known range may cause variation in the ecology of that animal from one area to the next. Since local populations are geographically separated, they are likely to experience different environmental conditions. Natural selection will promote adaptation to local conditions (Elseth and Baumgardner, 1984) and each breeding group within the population may have a slightly different genetic make-up. In an animal as adaptive as the red fox, extensive study

throughout its entire range will provide a broad and increasingly accurate description of the species' general ecology. According to Voigt and Macdonald (1984) red fox are so variable in their behavior that any extrapolations leading to the management of foxes in one area based on studies from another should be viewed with caution.

Twelve races of the red fox have been described world-wide (Lloyd, 1980). According to Lloyd (1980) red fox were introduced to Maryland in the middle of the eighteenth century from Britain, and were later introduced to other eastern states to augment numbers and to provide better sport. Seton (1929) reported that the red fox was common in North America north of latitudes 40-45 N, but that it didn't become common in the south until agriculture began to increase in the east. At this time, the European red fox spread its range westward, until it encountered the range of the native red fox, somewhere south of the Great Lakes. This evidence suggests that the red fox on Assateague Island may have originated from European stock. These red fox may, therefore, demonstrate considerable variation from red fox in western parts of North America. The red fox has an enormous geographical range, and is able to live in a great variety of habitats, including barrier islands, barren tundra, deserts, mountains, agricultural areas and cities. It is a highly adaptive species, and would be expected to exhibit behavioral variations between the various geographical areas it inhabits (Lloyd, 1980).

In this study, the home range of juvenile red fox born on a barrier island system in Maryland will be examined and compared with results found in other parts of North America, including a study by Storm et al. (1976) in Illinois, Iowa and Wisconsin. The study area in this project will vary considerably in both habitat and climate to that of other red fox studies. Barrier islands are a unique and harsh environment. They are isolated from the mainland, but are often not far enough away to prevent immigration and emigration. There are no known studies which have examined the dispersal of red fox on or from a barrier island. The ability to study the fate of juvenile red fox under limited agricultural, trapping and highway pressures is unique since these factors are major causes of mortality of red fox in other areas (Storm, 1976).

It is unknown how many red fox disperse onto or off of Assateague Island. Population estimates were made on the Maryland section of Assateague Island in 1985 and 1987 by counting active and inactive den sites. These estimates showed a population of 8 breeding pairs of red fox in 1985 and 11 breeding pairs in 1987 (Krim et al., 1990). It is unknown what is happening to the pups of the resident breeding pairs. Each vixen may have up to 10 pups, with an average in other areas of the country anywhere from 4.2 pups/litter in Illinois and Iowa (Storm et al., 1976) to 5.5 pups/litter in Michigan (Schofield, 1958). Using these figures to estimate the red fox population in 1987 on ASIS, the population would be anywhere from 57 to 72 individuals



from April to October. A census has not been conducted since 1987, and it is unknown if the population has increased in certain sections of the park. Sitings of red fox by park personnel, however, have increased during this period.

It is the purpose of this study to determine the fate of juvenile red fox during dispersal and first mating season by studying dispersal patterns and newly established territories. 13 TO BE  
RADIO  
COLLARED  
(JUVENILES)  
Thirteen juvenile red fox will be radio-collared beginning in June and the red fox will be radio-tracked through the following May. Natal home range will be calculated for those animals captured between June - September. Dispersal and recovery timing, distance and direction will be recorded, and established home ranges will be calculated.

Home range has been defined, calculated and analyzed in many different ways in previous studies. Sargeant (1972) defined home range simply as a well-defined area in which resident families were restricted. Lloyd (1980) defines home range of a settled red fox as the area on which it depends for food, shelter and the other requirements of life. He states the range may partly or largely overlap those of other red foxes at some or at all times of the year, but a part of it may be defended from encroachment by other red foxes, in which case it is more suitably described as a territory. Burt (1943) defined home range as that area traversed by the individual in its normal activities of food gathering, mating and caring for young. Brown and Orians (1970) stated that to define a home range, only the presence of an

animal is required. No behavior, such as home range defense and/or advertisement is necessary to define a home range.

In this study, the definition of Burt (1943) will be used to define home range. Natal home range is defined as the area used by a red fox pup during its period of maturation. Home range will be calculated for three seasons of the juvenile red fox. These defined seasons are natal home range (June - September), dispersal and the mating season (October - February) and establishment of an adult home range (March - May). During these defined seasons, it is possible that changes in home range may occur. It is also possible that distinct home range changes may not occur between the defined observation seasons. This will be especially true if an animal does not disperse from its natal home range, or travel significantly from its point of capture.

Storm et al. (1976) calculated the home range of 2 red fox families by taking daytime locations of each member of the family and taking 12 night-time radio locations for each adult male during September and October of one year. Gese et al. (1988) calculated home range and habitat use of 72 coyotes, Canis latrans, in southeastern Colorado over 13 consecutive biological seasons spanning 4 years, and found that  $\geq 22$  locations were necessary for seasonal home range analysis. Konecny (1987) studied home range and activity patterns of 14 feral house cats, Felis catus, in the Galapagos Islands, with a mean of 97.4 days of observation per individual, a total of 20-600 radio locations per individual, and a total of 2613 locations in the study. He

tracked the study animals for 6-hr periods, eventually spanning 24 hrs, taking 1 location/hr. Cedurlund and Okarma (1988) studied home range and habitat use of 14 adult female moose, Alces alces, over 5-28 consecutive months from 8:00 a.m. - 6:00 p.m.  $\geq 1$  time/week, with a total of 1118 locations during the study period. Zoellick et al. (1989) studied habitat use and movements of 7 desert kit foxes in western Arizona for 14 months. Each kit fox was located for 6-hr sample periods from dusk - 1:00 a.m. and 1:00 a.m. - dawn, 2 times a month. During this time the kit fox was located at 15-20 minute intervals.

During this study, red fox will be located 6 days/week for 4-hr periods, covering a 24-hr cycle/week. During each shift every red fox will be located as many times as possible, with a minimum time of 30 minutes between each location reading. An average of 2 locations per animal will be obtained over a 4-hr period. A minimum of 22 location readings will be obtained before home range is calculated for a given season. This figure is based on the minimum number of location readings required to calculate home range determined by Gese et al. (1988) in a home range study of coyotes in southeastern Colorado cited earlier in this paper.

Storm et al. (1976) calculated that each red fox family stayed within an area of 2.5 x 1.5 miles (955 acres) [4.0 x 2.4 km (386.8 hectares)]. These results were consistent with those found by Sargeant (1972). Murie (1936) observed that the movements of a pair of red foxes in Michigan were confined to an

area of 1200 acres (486 hectares). Schofield (1960) calculated that the home range of red foxes in Michigan was 1.0 - 1.5 miles (1.6 - 2.4 km) in radius.

The shape of home range was calculated by Ables (1969). He found that the shapes of ranges tend to be linear with linearity partially associated with habitat features. Assateague Island rarely exceeds 1 mile (1.6 km) in width, and is 37 miles (59.5 km) long. It is known that the home range of red fox on Assateague Island is proportionately much longer than those calculated in other areas, and corresponds to the shape of the island (Bashore, pers. comm., 1991). It is hypothesized that red fox in proportionately wider sections of Assateague island will have proportionately wider home range size than red fox in proportionately more narrow sections of Assateague island. The total area is expected to be approximately equal in all home ranges.

McNab (1963) suggested that home range size is closely correlated to food supply. Scott (1943) and Storm (1965) found that food is important in influencing red fox movements. It was noted by Ables (1969) that home ranges were highly variable in size, shape and dispersion of fixes, and that they may vary spatially and temporally. In other words, the home range of a red fox at one location may be very different from that of a red fox at a similar location elsewhere. In addition, home ranges may vary considerably over a given calendar year, depending on food abundance, population density, day length and other factors.



For example, Bashore (pers. comm., 1991) has observed on Assateague Island that the home range of red fox encompasses more of the bay in the winter, when mosquitos are diminished and when ducks are present as a prey species. In the summer he has observed that the red fox appear to avoid the mosquito-infested bay, and appear to spend more time scavenging on the beach.

Gese et al. (1988) used analysis of variance (ANOVA) to test for differences in home range size between sexes, ages, seasons, years and habitats of coyotes in southeastern Colorado.

Cedurlund and Okarma (1988) used Kruskall-Wallis statistics to test for differences in average monthly and seasonal home ranges of adult female moose in Grimso, southcentral Sweden. Konecny (1987) tested for significant differences in home range size of feral house cats in the Galapagos Islands with the Mann-Whitney U-test. Storm et al. (1976) used the computer program Univar to yield standard statistics such as mean, range, standard deviation, standard error of mean, variance and coefficient of variation. A one-way ANOVA was performed when 2 or more groups were being compared. Buskirk and McDonald (1989) analyzed variability in home range size of the American marten, Martes americana, using estimates of marten home range size from the literature. They examined variability in home range size using ANOVA techniques, and followed this with pairwise comparisons of home range using Duncan's multiple-range tests. In this study standard statistics such as mean, range, standard deviation, standard error of mean, variance and coefficient of variation



will be calculated in relation to home range size using the computer program SYSTAT. ANOVA will be used to analyze variability in home range size between foxes.

Ables (1969) described areas of high utilization within a home range as biological centers of activity, a concept which has been used by other researchers as well. An individual may have more than one biological center of activity within a given home range (Ables, 1969; Cranford, 1977). Lair (1987) defined three activity centers. She defined the arithmetic mean center as the point from which the mean squared distance to all other points is minimal, the bivariate median center as the point that minimizes the mean distance to all other points in the activity field, and the harmonic mean center as the point that minimizes the inverse of the mean of inversed distances to other points. Her calculations were based on areas in which an animal was most active, not necessarily where most of the location readings occurred. Her radio locations were paired with direct behavioral observations. She found that the arithmetic mean center, the classical center of activity, was an unsatisfactory estimate of focal center location. This statistical center was proposed by Hayne in 1949, and has been criticized by biologists (Smith et al., 1973; McDonald et al., 1979) as lacking biological significance because it often lies in little-utilized areas, or may even lie outside of home ranges. Lair (1987) warns against the calculation of harmonic mean without the aid of visual observation, and states that this may result in aberrant



locations.

In this study, a modal home range center will be calculated. The calculations will depend only on the number of location readings, and will not be aided with activity data or behavioral observation. The modal home range center will be defined as an area within the home range in which a large percentage of location readings are recorded. This area will contain 10% or more of the location readings in a concentrated area with a maximum distance of 200 meters between location readings on the periphery of the modal home range center, and those within the modal home range center. Any reading not within 200 meters of the nearest location reading within a defined modal home range center will be excluded from the modal home range center. It is possible that there may not be a definable modal home range center for a given animal. It is also possible that more than one modal home range center may exist.

The geometrical home range center will be calculated for each animal in this study by the computer program SPADS (Juneja et al., 1991). This center will be compared with the modal home range center using the methods of Lair (1987). She used Bonferroni's bounds to compute a 99% confidence region around the arithmetic mean center. She then computed the distance  $D_{max}$  between the arithmetic mean center and the most distant corner of this rectangular calculated confidence region. By doing this, she defined a conservative circular confidence region around the arithmetic mean center that completely includes the 99%

Bonferroni region. She used  $D_{max}$  as a tentative index of the maximum error distance between the various estimates of the focal center, and determined that when two centers were separated by a distance less than or equal to the corresponding value of  $D_{max}$ , they coincided.

Dispersal is defined by Lidicker, Jr. and Caldwell (1982) as a one-way movement in which an individual leaves its living space to seek out other suitable home sites. Dispersal is distinguished from dispersion, which refers to the spatial arrangement of individuals within a population. Migration is distinguished from dispersal by Lidicker, Jr. and Caldwell (1982) as a movement which results in a net movement of zero. The individual returns to the original point of departure. Such movements tend to be seasonally organized. Lidicker, Jr. (1975) defined dispersal further as any movements of individual organisms or their propagules in which they leave their home area, sometimes establishing a new home area. He stated this does not include short-term exploratory movements, or changes in the boundaries of a home range such that the new range includes at least part of the former. Dispersal is usually defined as the process by which an animal moves from its birthplace to a new locality (Storm et al., 1976). Storm et al. (1976) defined dispersal more precisely as the spreading of individuals outside the limits of the range of the species, consequently expanding the area of the population. They defined dispersion as spacing of individuals within an existing distribution area. It is

unknown what initiates dispersal. Storm et al. (1976) stated that the onset of dispersal was related to the red fox's stage of development and maturation. They noted that males disperse earlier than females. This difference may be correlated with the time of puberty and sexual maturation, which occurs earlier in males. Storm et al. (1976) found that food abundance and aggression from socially dominant individuals do not seem to be causative factors in the onset of dispersal. Storm et al. (1976) stated that distances traveled by dispersing red foxes are most likely regulated by a combination of genetic, social, and physical environmental factors that may vary locally. They state that the availability of vacant red fox ranges also plays a role in dispersal distance.

Sheldon (1950), Phillips et al. (1972), Jensen (1973), Storm et al. (1976) and Tullar and Berchielli (1980) indicated that dispersal movements of red fox began during October and occurred gradually in the fall. Tullar and Berchielli (1980) defined 1.5 miles (2.4 km) as the threshold distance of dispersal because none of the 137 red fox pups recaptured before their first October had travelled farther. Jensen (1973) reported that among tagged red fox pups recovered from November through February of their first year, 81% of the males and 24% of the females had dispersed (3.1 miles [5.0 km] or more). Tullar and Berchielli (1980) observed that 87 and 44% of male and female pups, respectively, recovered from November through their second October, had dispersed (1.6 miles [2.6 km] or more). Storm et

al. (1976) observed that sub-adult red foxes did not start to disperse until late September or early October, when about 7 months old and nearly full grown. They found that of the ear-marked subadults recovered between October and March of their first year, 80% of the males but only 37% of the females had travelled more than 5 miles (8.0 km) from their natal home ranges. They found this difference to be significant. The recovery distances for juvenile and subadult males for all months ranged from 0.0 to 130.6 miles (208.9 km) with a mean of 19.4 miles (31.0 km) and a median of 13.3 miles (21.3 km). Recovery distances for juvenile and subadult females ranged from 0.0 to 67.0 miles (107.2 km) with a mean of 6.7 (10.7 km) and a median of 1.9 miles (3.0 km). Tullar and Berchielli (1980) found that the tendency of pups to disperse long distances may not be related to population density, per se, so much as to the ability of a certain area to support a given number of potential home ranges per unit area. For the purposes of this study, a threshold distance of 3 miles (4.8 km) will be used to define dispersal from the natal home range by juvenile red fox. Any distances traveled under 3 miles (4.8 km) will be considered a shift in home range or an expansion in home range. Storm et al. (1976) chose an arbitrary limit of 5 miles (8.0 km) as a dispersal distance because their data showed that home ranges of non-dispersing red foxes are less than 5 miles (8.0 km) in diameter. Data in this study for natal home range of 3 juvenile red fox show a maximum length in home range of 2 miles (3.2 km).

Trewhella et al. (1988) used the term recovery distance to describe the recoveries of red fox pups captured and tagged at the age of 6 months or more. This compensated for the fact that the red fox pups may not have been in their natal home range at the point of capture. Trewhella et al. (1988) calculated the mean recovery and dispersal distances separately for each sex. They analyzed the pattern of distribution of recovery distances with a generalized linear model fitting package, GLIM (Baker and Nelder, 1978), which uses a variety of transformations to produce approximate linearity of the relationship between two variates. They conducted linear regression analysis to compare dispersal and recovery distance and home range size with population density in the red fox. For those red fox captured after October 1, recovery distance will be calculated instead of dispersal distance. This is due to the fact that red fox captured after October 1 may be dispersing at the time of capture. Therefore the point of capture will be used as an originating point, from which total distance travelled, or recovery distance, will be calculated to the geometrical center of the newly established adult home range. In this study total recovery and dispersal distances will be calculated and compared using standard statistics such as mean, range, standard deviation, standard error of mean, variance and coefficient of variation.

Establishment of adult home range has not been studied as extensively as dispersal in red fox. In this study, a juvenile will be said to have established its adult home range once it has

settled at a new location for greater than 2 weeks time, and establishes normal patterns of home range use.

The objectives of this study are to:

1. Capture, radio-collar and record movements of 13 juvenile red fox on Assateague Island beginning in June, 1991 and ending in May, 1992.
2. Calculate home range size and compare with that of other animals within this study.
3. Observe the timing, direction and distance of dispersal and recovery.
4. Observe patterns of establishment of an adult home range.
5. Calculate modal and geometric home range centers and compare their positions.

### **Research methodology**

General approach: Radiotelemetry will be the principle method used to collect data. One year (June - May) will be required to determine the home range, dispersal patterns and establishment of an adult home range of juvenile red fox in the study area.

Study area: Juvenile red fox will be trapped on Assateague Island as far north as the Ocean City inlet and as far south as dune crossing 6 on the back trail of ASIS (Figure 1). The potential study area will include ASIS and Chincoteague NWR (National Wildlife Refuge) on Assateague Island. The study area will also include surrounding areas on the mainland if captured juvenile red fox disperse off of the island.

Equipment: Juvenile red fox will be captured using Victor Soft Catch padded leg-hold traps developed to capture foxes alive and cause limited injury to the animal. Kreeger et al. (1990) found that leg-hold traps equipped with padded jaws, center swivels, reduced spring tension, and shock absorbing coil springs in the chain, significantly reduced leg injuries in red foxes (Tullar, Jr., 1984; Olsen et al., 1988).

Radio transmitters, each with a unique frequency ranging from 159.204 MHz - 159.300 MHz, attached to neck collars constructed of 5-ply industrial belting, will be secured onto the red fox upon its capture. Transmitter components and batteries are encapsulated in electrical resin. Transmitters are supplied with lithium batteries for optimum life, minimum weight, and temperature performance. Each collar emits a single pulse per second. The average life span of one collar is 2+ years. The approximate range for each radio collar signal is 2 miles (3.2 km).

The tracking station is a 4WD vehicle fitted with a Null system yagi antenna (140 MHz - 220 MHz) used to receive signals from radio-collared animals. A Fieldmaster model 10 field receiver from Advanced Telemetry Systems (1987) will be used during tracking to obtain a reading of weakest signal as the antenna is rotated over 360 .

A standard boat compass will be used to take bearings of animal positions. A LORAN-C receiver will be used to obtain the position of the tracking station.

A model 2000B telemetry receiver from Advanced Telemetry Systems (1987) will be used to monitor the radio-tagged animals and to confirm their frequency identity. The receiver is equipped with a 2MHz range and a selectable scan rate (2 sec. - 16 min.).

Procedures: Trapping will start June 1, 1991 and will continue until 13 juvenile red fox have been captured and radio-collared. The area around active dens will be surveyed to determine those trails frequently used by red foxes, and traps will be set along intersections of these trails. Commercial bait, red fox urine and scent will be used as attractants. All traps will be checked at least every 12 hours.

All captured foxes will be immediately weighed, sexed, measured and fitted with a radio-collar. After red foxes are radio-collared, locations will be recorded 6 days/week for 4-hr observation periods, covering a 24-hr cycle/week. Prior to dispersal, readings will be taken for animals successively during one tracking period, with an average of 2-4 readings per animal over a 4-hr period. Once dispersal occurs it may be necessary to track animals which disperse off of the island on different days than those which remain on the island, due to the potential distance involved.

The null-system antenna will provide the location of the animal as a null point, defined as the point of weakest signal as the antenna system is rotated over 360 . A bearing will be taken



by adjusting the compass reading to the animal's direction using a compass rose. Three bearings will be taken using this method by moving the tracking station from successive locations a sufficient distance to alter the LORAN position between each reading. An approximate time of 1-3 minutes will elapse between each bearing. The approximate position of the animal will be determined from these bearings through triangulation.

System reliability: Because of the inherent problems associated with accuracy of radiotelemetry locations (Heezen and Tester, 1967; Springer, 1979; Cochran, 1980; Lee et al., 1986; Saltz and Alkon, 1986), the telemetry systems will be ground-truthed before data collection. The LORAN-C unit will be tested by placing it at United States Geological Survey (USGS) control markers on the island with known latitude and longitude. Ground truths will be determined by putting marker beacons at known locations on the island and recording bearings. Deviations between the recorded bearings and the true bearings will be calculated and used to obtain corrected bearings. At this time the precision and reliability of the bearings will be calculated by determining the standard deviation of the bearings. Earlier studies in other areas (Verts, 1963; Storm, 1965; Hutton et al., 1976) have found that most of the fixed locations can be assigned to within a hectare of their actual locations.

Data analysis: Home ranges will be calculated for radio-collared



red foxes using the computer program SPADS (simplified plotting analysis and data storage) developed by Juneja et al. (1991). This program provides the option of using three methods of home range calculation: the bivariate normal; circular normal; and convex polygon methods. This study will calculate home range using all three methods, and use the one which is the most representative of the true home range.

Standard statistics such as mean, range, standard deviation, standard error of mean, variance and coefficient of variation will be calculated in relation to home range size using the computer program SYSTAT. ANOVA will be used to analyze variability in home range size between foxes.

The geometrical home range center will be calculated for each animal in this study by the computer program SPADS (Juneja et al., 1991). The geometrical home range center will be compared with the modal home range center using the methods of Lair (1987).

Total recovery and dispersal distances will be calculated as a straight line between successive readings. Total dispersal distance will be calculated from the geometrical center of the natal home range to the geometrical center of the newly established adult home range. In the case of animals captured after October 1, when dispersal may have begun, recovery distance will be calculated from the point of capture. The point of capture will be used as a replacement for the geometrical center of the natal home range for those red fox for which home range

cannot be calculated prior to dispersal. Total recovery and dispersal distances will be compared using standard statistics such as mean, range, standard deviation, standard error of mean, variance and coefficient of variation.

Implementation: Information provided in this study will provide insight about the natal home range, dispersal, and establishment of adult home range by juvenile red fox born on Assateague Island. This information can be used by the National Park Service (NPS) and the United States Fish and Wildlife Service (USFWS) for population management purposes, and may be of special interest due to the role of the red fox as a predator of the piping plover, Charadrius melodius.

Task schedule:

1. Field work June, 1991 - May, 1992.
  - a) Radio-collaring red foxes June - October, 1991.
  - b) Monitoring red fox movements June, 1991 - May, 1992.
2. Data analysis May, 1992 - August, 1992.
3. Thesis writing August, 1992 - September, 1992.

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