Comparative study of the home range and habitat usage of red foxes and gray foxes in an urban setting: a preliminary report

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Abstract

The shift of human population from rural to urban areas has lead to the rapid loss of rural and undeveloped land to urban development. Little is known about the effect these changes have had on wildlife. Eight foxes, 4 red foxes, and 4 gray foxes were tracked in an urban setting by radio telemetry. Home ranges were evaluated and a significant difference was found between gray foxes and red foxes in Newport News Park, Virginia. Female gray fox home ranges averaged 3.28 km^2 and the male gray fox had a home range of 6.54 km^2. Female red fox home ranges averaged 2.12 km^2 and male red fox home ranges averaged 3.04 km^2. The male gray fox had the largest home range, 6.54 km^2 and a male red fox had the smallest, 1.47 km^2. Analysis of habitat usage indicated that gray foxes preferentially utilized open fields and mixed forest more than expected, and pine and hardwood forests less than expected. In contrast, red fox utilized fields and pine forests more than hardwood and mixed forests. Sound management of red foxes and gray foxes in urban settings must include an understanding of their home range and habitat needs in urban habitats.

INTRODUCTION

Since 1900, the population of the United States and Virginia has shifted from rural to urban settings (Serow and Spar 1972; Hall and Gaquin 1997) (Table 1). Large tracts of forest and farmland have been lost to urbanization and what remains in rural and urban areas are becoming fragmented.

Newport News, Virginia is located on the lower peninsula of eastern Virginia and encompasses an area of 177 km^2. The population increased from 24,523 in 1900 to 171,439 people in 1990, and the city predicts the population will exceed 200,000 by the year 2000. Since the 1960s, a continuous string of homes and businesses has sprung up on a 20-mile corridor from the old urban center of Newport News, leaving no concentration of open land.

The red fox (*Vulpes vulpes*) rivals the gray wolf (*Canis lupus*) for having the largest geographic distribution of any contemporary living terrestrial mammal (Bueler 1980, Nowak 1991). Red foxes in North America are found from the Arctic to the extreme southern United States (Bueler 1980). Habitats range from deep forest to arctic tundra, open prairie, and farmlands; the red fox likes areas of highly diverse vegetation and avoids large homogenous tracts (Ables 1975). The red fox has been studied in urban and suburban sites in England, Japan (1 study) and Canada (1 study), but not in the United States (Harris 1981; Adkins 1991; White et al. 1996; Doncaster and Macdonald 1997).

The gray fox (*Urocyon cinereoargenteus*) is found from southern Canada to northern Venezuela and Colombia, excluding the central and northern Great Plains and northern Rocky Mountains, Great Basin, Cascades and Coast range (Fritzell and Haroldson 1982; Trapp and Hallberg 1975). Gray fox habitat is highly varied, including mixed pine-oak woodlands bordering pastures and fields, bottomland hardwoods associations along streams and creeks, citrus groves, railroad rights-of-way, shrublands, brushy woodlands, and rough rocky or broken terrain (Follmann 1973; Trapp and Hallberg 1975; Nowak and Paradiso 1983; Sheldon 1992). A search of the literature found no reports addressing the effects of urbanization on the gray fox. Harrison (1995), studying gray foxes in a rural setting in New Mexico, found that home range was inversely affected by human population densities.

Reported home ranges of gray foxes in the United States vary from 0.3 – 8.14 km^2, with males having larger home ranges than females (Fuller 1978; Sawyer and Fendley 1990; Harrison, 1995). Home ranges of red foxes in the United States have been reported to be

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2.06 – 19.9 km^2, in Iran approximately 50 km^2, in Sweden from 4 – 12 km^2, and in England from 0.21 (urban) – 10.0 (rural) km^2, with males having larger home ranges than females (Macdonald 1987; Major and Sherburne 1987; Ingle 1990; Henry 1993, Reynolds and Tapper 1995; Doncaster and Macdonald 1997).

Sound management of red foxes and gray foxes in urban areas requires an understanding of their home ranges and habitat needs in these urban settings. With the increasing conversion of wilderness and rural habitats to urban development, the need to understand the effects of this loss of habitat on red and gray foxes increases. This study may help predict problems other carnivores will face as they attempt to adapt to suburban or urban landscapes.

The objectives of this study were to:

(1) estimate home range sizes of red foxes and gray foxes in an urban setting,

(2) determine which habitats within this study site are most frequently used by gray foxes and red foxes.

METHODS

The study site is located in Newport News Park, on the southeastern peninsula of Virginia (approximate longitude 76°25´ and latitude 37°10´) and covers approximately 32 km^2. The approximate boundaries of the core study area are Ft. Eustis Boulevard on the north side, U. S. Highway-17 on the east side, Oriana Road/ Old Denbigh Road on the south side and Jefferson Boulevard on the west side with an approximate area of 9.2 km^2. Woodlands in the park are dominated by loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), and sweet gum (*Liquidambar styraciflua*). Numerous small creeks bisect the park. Harwoods Mill Reservoir and the regional airport are on the southeast side of the study area. Single and multi-family homes, shopping centers, and small businesses surround the rest of the study site. Elevation across the park varies little, ranging from 20m to 40m above MSL. Soil found in this area is Slagle fine sandy loam. Daily temperature average is 14°C, with lows in January averaging -2°C and highs in July averaging 25°C. There is an average of 206 frost-free days and 119cm of precipitation yearly. Using recent aerial photographs and ground truthing, the author classified and determined the proportion of the core study areas in pine, hardwood or mixed forests or fields.

Capturing and Handling

Foxes were trapped using No. 1 ½ Victor coilspring padded leghold traps to minimize the chance of injury. Traps were baited with commercial fox lure and urine. Trap sets were along roadways, game trails, and scent posts. Traps were checked every morning. Foxes were removed from the trap, their fore and hind legs taped together, and their mouths taped shut. Ear tags and radio telemetry collars were applied, weights and measurements taken, and the foxes were then released. The process was completed in approximately 10 minutes. Staff of Todd's Lane Veterinary Hospital were available to treat any injuries to trapped animals.

Eight of the 17 foxes trapped were fitted with radio telemetry collars (2 red fox males and 2 red fox females, 1 gray fox male and 3 gray females). L.L. Electronics radio-telemetry collars, Urbana Electronics CE-12 receivers, and Wildlife Materials antennas were used to track the collared foxes.

Home Ranges

Home range in this study is defined as the area used on a daily basis. It may change with season and an animal's age (Burt 1943). Home range differs from territory in that it is not defended. Home range, using the minimum convex polygon method and excluding outliers (Burt 1943; Mohr 1947; Dixon and Chapman 1980; Samuel et al. 1985), was estimated using ArcView™ (Environmental Systems Research Institute, Inc. 1996 GIS software). SigmaStat IIä for Windowsä (Jandel Scientific Software 1996) was used to evaluate home range and habitat usage for significance using the chi-square goodness – of – fit and t-test statistical techniques.

Habitat Usage

Movements and locations of foxes were tracked and plotted with aid of radio telemetry, GPS, GIS, and a night vision scope. Every other day the foxes were located by telemetry and the habitat in which they were found was described as pine forest, hardwood forest, mixed forest or field. Fields were clear cut or open areas with or without cover vegetation. Foxes within 25m of human habitation, whether or not they were actually seen or radio tracked within the bounds of a yard, apartment, condominium complex, were considered to be near human habitation. A special note was made, if they were actually tracked or seen within human habitation.

RESULTS

Seventeen foxes were trapped and radiocollared; 8 foxes were included in this study. Four red foxes (2 males and 2 females) and 4 gray foxes (1 male and 3 females) were tracked for a minimum of 2 months, 1 female red fox was tracked for 12 months, the mean was 5.13 ± 3.85 months for this study. The day was divided into four 6hr blocks, and each fox's location was recorded least once every other day during 1 of four 6hr blocks.

Home Range

A significant difference existed between the mean home ranges of gray foxes (4.09 ± 1.64) and red foxes (2.58 ± 1.39)(Table 1.) ($t(6) = 6.04$, $p<.01$). Mean home range for red foxes and gray foxes combined was 3.34 ± 1.62 km^2 with a range of 1.47 – 6.54 km^2 (Table 2). For the red fox males, mean home range was larger (3.04 ± 2.21 km^2) than for females (F) (2.12 ± 0.11 km^2). Only 1 male gray fox home range (6.54 km^2) was included in this study, but it was larger than the mean for the 3 females (3.28 ± 0.23 km^2).

Home range size varied from 1.47 km^2 for 1 male red fox to 6.54 km^2 for the male gray fox (Table 2.). The smallest and largest red fox home range was for the 2 males, the smallest was 1.47 km^2 and the largest was 4.6 km^2. The smallest gray fox home range was 3.01 km^2 and the lone gray male had the largest home range, 6.54km^2 (Table 2).

Core is defined here as an area equal to or less than 0.5 km^2 that contained at least 25% of the telemetry fixes of a fox. Four of the foxes had definite core areas (Table 2.). Two of the 3 female gray foxes had core areas (0.41 km^2 for 46% of the total telemetry fixes and 0.44 km^2 for 83% of the telemetry fixes). One red fox female had 2 core areas (0.34 km^2 for 48% of the telemetry fixes and 0.20 km^2 for 30% of the telemetry fixes). The smallest core area (0.15 km^2) was for one of the male red foxes. These core areas did not appear to change during breeding and whelping seasons.

Habitat Usage

Foxes used some habitat types more than others (Figure 6) ($x^2=18.0$, $df=3$, $p<0.01$). Both gray foxes and red foxes were found more than expected in fields (observed = 50.0% and 36.6%, expected = 34% of telemetry fixes) (Figure 1). Gray foxes were also found more than expected in mixed forest (observed = 35.25%; expected = 28% of telemetry fixes), whereas red foxes were found more than expected in pine forest (observed = 29.3%; expected = 24% of telemetry fixes) (Figure 6). Female foxes showed a preference for fields and were found there more than expected (observed = 51.4%; expected = 34% of telemetry fixes). Male foxes appeared to use mixed forest more than expected (observed = 35%, expected = 28% of telemetry fixes). The lone male gray fox in this study was found more than expected in the hardwood forest (observed = 66.75%; expected = 28% of telemetry fixes), but was never found in the mixed forest. Red fox males and gray fox females preferred fields (observed = 43.9% and 58.7%; expected = 34% of telemetry fixes), whereas red fox females preferred pine forest (observed = 35.2%; expected = 24% of telemetry fixes). Only the gray foxes were found in close proximity to human habitation (range 3.7% telemetry fixes for one gray male to 80.0% telemetry fixes for a gray female). As a group, foxes were found more frequently than expected in fields (observed = 41.5%; expected = 34% of telemetry fixes) and less frequently than expected in hardwood forests (observed = 8%; expected = 14% of telemetry fixes) (Figure 1).

DISCUSSION

Home Range

The size of red fox home ranges in Newport News Park fell within published ranges for red foxes in the United States (Nowak and Paradiso, 1983; Major and Sherburne 1987; Ingle 1990). The home ranges of the red foxes in this study are larger than home ranges reported for urban red foxes in England (Macdonald 1987; White et al. 1996; Doncaster and Macdonald 1997).

Home range sizes obtained for the gray foxes in this study were also within the reported ranges for gray foxes in the United States (Fuller 1978; Sawyer and Fendley 1990; Harrison 1995). There are no studies of gray foxes in an urban setting, but Harrison (1995) gives a home range of 7.0 km^2 in his study of gray foxes in a developed rural setting. The home ranges of urban gray foxes in this study were smaller than the home range of the gray foxes in Harrison's study.

Habitat Usage

Linzey (1998) states, that the gray fox is more of a woodland species than the red fox. In contrast to expectation, this study found gray foxes on the edges, even outside, of the park boundaries and close to or among human habitation (Harrison 1995). One female was found twice in the middle of a condominium complex. A second female spent 80% of her time in the center of a block of homes and a small business, and was often found in a nearby trailer park.

In this study, red foxes were rarely found near human habitations. One red fox was found behind a housing complex on one occasion and the next day was back inside the park. This is in contrast to other published reports of red foxes. In England, red foxes were often found in or near human habitations (Harris 1981; Doncaster and Macdonald 1997). Linzey (1998) reports that, the red fox occasionally wanders into urban habitats.

Gray foxes and red foxes were found more than expected in fields. But red foxes used fields located in the center of the park, whereas the fields used by gray foxes were on the edge of the park. The core area of one gray female was behind a convenience store and another was inside an urban block of houses and a small business.

Red foxes are believed to be recent immigrants to the southern peninsula. As late as 1948, the red fox was still scarce or absent on the southern peninsula (Linzey 1998). By contrast, gray foxes are indigenous to this area (Linzey 1998). Red foxes moved onto the peninsula after urbanization was under way, but gray foxes were here while these changes were taking place. It is unclear how the immigration of the red fox onto the southern peninsula affected the distribution of gray foxes. But continued loss of habitat is certain to affect the ranges and habitat available to red foxes, gray foxes, and other carnivores.

The City of Newport News and adjacent York County, which surround Newport News Park, are growing rapidly and new land will be needed to build homes for this increasing human population. A new multi-family housing project is being built on the south side of the park on land with mixed growth and a moderate-to-thick understory and a large field. One gray fox female heavily used both of these areas (91.5% of locations). The gray fox male in this study and a red fox male not included in this analysis have also been found in this area. This land lies adjacent to the boundaries of the core study area. It is unknown what effect the loss of habitat that borders the park will have on the foxes and their prey in the park, but development will certainly decrease the area available for the current populations and their future offspring. Another problem of concern is how to keep these populations from becoming genetically isolated. A corridor will need to be maintained to allow foxes to move on and off the peninsula. This will be a growing problem as more and more habitats become urbanized.

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REFERENCES

Ables, E. D. 1975. Ecology of the red fox in North America. Pages 216-236 *in* M. W. Fox, ed. The wild canids: their systematics, behavioral ecology and evolution. Robert E. Krieger Publishing Co., Malabar, Florida.

Adkins, C. A., and P. Stott. 1998. Home ranges, movements and habitat associations of red foxes (*Vulpes vulpes*) in suburban Toronto, Ontario, Canada. Journal of the Zoological Society of London 244:335-346.

Alderton, D. 1994. Foxes, wolves and wild dogs of the world. NY. Facts on file. 194 pp.

Bueler, L. E. 1980. Wild dogs of the world. Stein and Day, New York. 274 pp.

Burt, W. H. 1943. Territoriality and home range as applied to mammals. Journal of Mammalogy 24:346-352.

Dixon, K. R., and J. A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology 61:1040-1044.

Doncaster, C. P., and D. W. Macdonald. 1997. Activity patterns and interactions of red foxes (*Vulpes vulpes*) in Oxford city. The Journal of the Zoological Society of London 241:73-87.

Environmental Systems Research Institute, Inc. 1996. ArcView GIS. Redlands, CA.

Follmann, E. H. 1973. Comparative ecology and behavior of red and gray foxes. Doctoral Thesis, Southern Illinois University, IL. 153 pp.

Fritzell, E. K., and K. J. Haroldson. 1982. *Urocyon cinereoargenteus.* Mammalian Species 189:1-8.

Fuller, T. 1978. Variable home-range sizes of female gray foxes. Journal of Mammalogy. 59:446-449.

Hall, G. E., and D. A. Gaquin. 1997. 1997 County and city extra annual metro, city, and county data book. Berana Press. MD. 1324pp.

Harris, S. 1981. An estimation of the number of foxes (*Vulpes vulpes)* in the city of Bristol, and some possible factors affecting their distribution. Journal of Applied Ecology 18:455-465.

Harrison, R. L. 1995. The effect of rural residential development on the ecology and behavior of gray foxes (*Urocyon cinereoargenteus*). M.S Thesis, Univ. of Albuquerque, NM. 133pp.

Henry, J. D. 1996. Red fox: The catlike canine. Smithsonian Institution Press, Washington, DC. 174 pp.

Hockman, J. G., and J. A. Chapman. 1983. Comparative feeding habits of red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) in Maryland. The American Midland Naturalist 110:276-285.

Jandel Scientific Software 1996. SigmaStat IIä for Windowsä. Jandel Scientific Software, San Rafael, CA.

Linzey, D. W. 1998. The Mammals of Virginia. The MacDonald & Woodward Publishing Company, Blacksburg, VA. 459pp.

Macdonald, D. W. 1987. Running with the fox. Unwin Hyman, London. 224pp.

Major, J. T., and J. A. Sherburne. 1987. Interspecific relationships of coyotes, bobcats, and red foxes in western Maine. Journal of Wildlife Management 51:606-616.

Mohr, C. O. 1947. Major fluctuations of some Illinois mammal populations. Proceedings of the Illinois Academy of Science 40:197-204.

Nowak, R. N., and J. L. Paradiso. 1983. Walker's mammals of the world, 4th edition. The Johns Hopkins University Press, Baltimore, MD. 1629pp.
Reynolds, J. C., and S. C. Trapper. 1995. The ecology of the red fox *Vulpes vulpes* in relation to small game in rural southern England. Wildlife Biology 1:105-119.
Samuel, M. D., D. J. Pierce, and E. O. Garton. 1985. Identifying areas of concentrated use within the home range. Journal of Animal Ecology 54:711-719.
Sawyer, D. T., and T. T. Fendley. 1990. Seasonal home range size and movements behavior of the gray fox on the Savannah River site, South Carolina. 1990 Proceedings annual conference of Southeastern Association of Fish and Wildlife Agencies 44:379-389.
Serow, W. J., and M. A. Spar. 1972. Virginia's population: a decade of change. Graduate School of Business Administration. University of Virginia, Richmond, VA.
Sheldon, J. W. 1992. Wild dogs: the natural history of nondomestic Canidae. Academic Press, Inc., New York. 239pp
Trapp, G. R., and D. L. Hallberg. 1975. Ecology of the gray fox (*Urocyon cinereoargenteus*): A review. Pages 164-178 *In* M.W. Fox. ed. The Wild Canids: Their systematics, behavioral ecology and evolution. Robert E Krieger Publishing Co., Malabar, FL.
White, P. C. L., G. Saunders, and S. Harris. 1996. Spatio-temporal patterns of home range use by foxes (*Vulpes vulpes*) in urban environments. Journal of Animal Ecology 65:121-125.

Table 1. Human Populations, Changes 1900 to 1990

	Population 1900	1950	1990
Virginia	1,854,184	2,319,000	6,187,358
Newport News	24,523	82,333	171,439
VA. Rural	1,514,117	1,560,115	1,893,915

Table 2. Home Ranges and Core Areas of Gray Foxes and Red Foxes in Newport News Park.

FOXES	Home Range (km^2)	s.d.	Core Area #1	Core Area #2
GRAYS				
Females				
Felicia	3.37			
Gizzelle	3.01		0.41	
Lady Gray	3.45		0.44	
Mean	3.27	0.23		
Male				
New Guy	6.54			
Total Mean	4.08	1.64		
REDS				
Female				
Waif	2.04		0.34	0.20
Bushy	2.19			
Mean	2.12	0.11		
Males				
Tough Guy	4.60			
Big Guy	1.47			
Mean	3.04	2.21		
Total Mean	2.58	1.39		
Total Mean	3.34	1.62		
All Foxes				

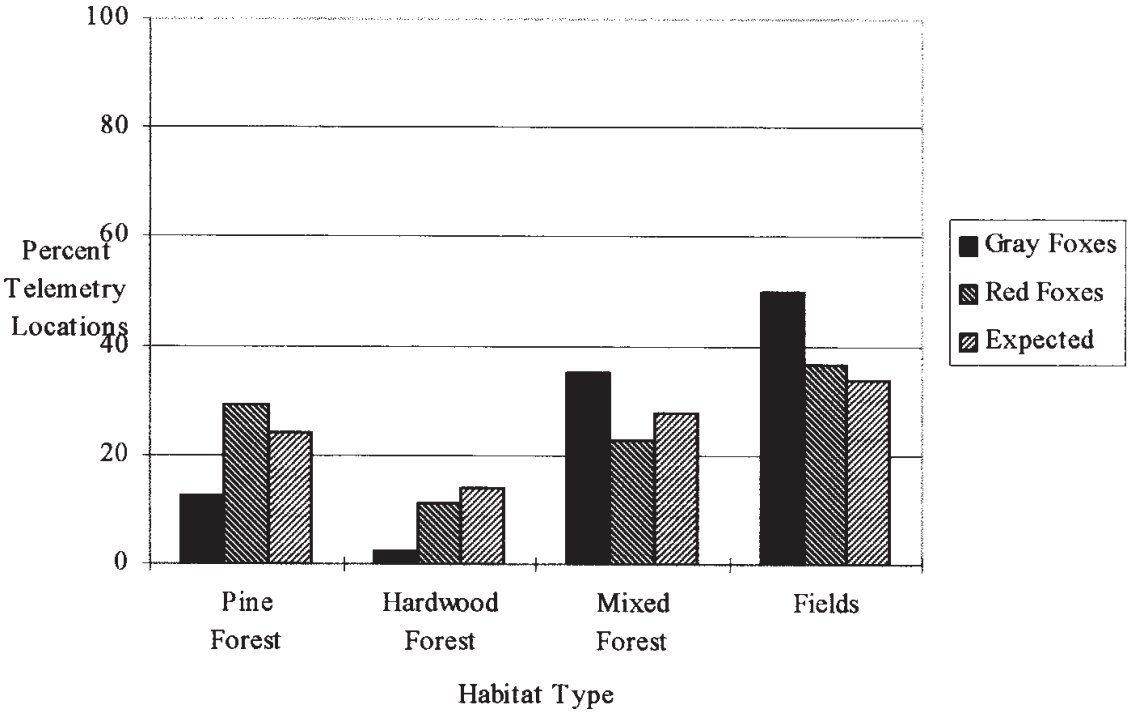

Figure 1. Gray Foxes and Red Foxes Habitat Preferences.