Home Range and Population Estimation of Red and Gray Foxes at Brookhaven National Laboratory

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ABSTRACT

Home Range and Population Estimation of Red and Gray Foxes at Brookhaven National Laboratory. RENEE FALLIER (Boston University, Boston, MA 02215) JENNIFER HIGBIE (Brookhaven National Laboratory, Upton, NY 11973).

Foxes play an important role in Long Island ecosystems as one of few remaining predatory animals in the area, yet little is known about their natural histories there. Non-invasive genetic studies in 2006 and 2007 identified the presence of red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) at Brookhaven National Laboratory (BNL). A study performed in the summer of 2008 built upon this initial research by investigating the individual home ranges of these foxes and again testing for the presence of red and gray foxes. Two red fox kits were trapped, one of which was successfully collared and tracked. Additionally, scat was collected for DNA analysis over an eight-week period with a focus on areas with historic gray fox activity. The collared fox maintained a home range of 0.05 mi^2 but was only tracked for one week before he could no longer be found. It is likely that competition forced him out of his parents' home range. Fecal DNA was extracted at a 17% success rate and analyzed using mitochondrial DNA markers. All tested samples were determined to be red foxes. Furthermore, no gray foxes were seen on an automated field camera, implying that there may no longer be a gray fox population at BNL. Trapping and radio collaring will resume next winter in order to track adult foxes with permanent home ranges at BNL, and continued fecal DNA analysis will verify the status of the gray fox population there.

INTRODUCTION

Non-invasive DNA studies in 2006 and 2007 confirmed the presence of permanent red and gray fox populations at Brookhaven National Laboratory (BNL) in Upton, NY [1,2]. Aside from these preliminary studies, very little research has been conducted over the past several decades to study fox populations despite their important role in Long Island ecosystems. No large carnivores such as bears, wolves, or coyotes inhabit Long Island, leaving only foxes and predatory birds as the top carnivores. Furthermore, Long Island provides a unique habitat for foxes due to its island geography and high level of fragmentation due to human habitation. As a result, population studies from undeveloped sites may not accurately represent populations and behaviors of foxes on Long Island. The island fox *(Urocyon littoralis),* a recent descendant of the gray fox and an inhabitant of six Channel Islands in southern California, clearly demonstrates the possible effect of Long Island's biogeography on fox populations [3]. Researchers determined that island foxes disperse over shorter distances than related mainland canids, have an average home range size that is significantly smaller than gray fox home range size, and experience severe lack of genetic variation [3]. Red and gray foxes on Long Island may exhibit similar behavioral deviations from mainland individuals. Additionally, most fox habitats on Long Island are highly fragmented by roads and commercial and residential areas, which may further inhibit dispersal, home range size, and other natural behaviors. Although significant human development in fox habitat does not prevent individuals from inhabiting the area, they are forced to alter their natural behaviors [4]. A study of gray foxes in a residential versus undeveloped landscape determined that home range was more complex and less uniform in the residential area

[5]. It is possible that a similar effect on Long Island could be responsible for the decline in gray fox population documented in the early 1900s [6]. Humans also have been shown to impact red fox populations. A compilation of several home range studies indicates that most of the smallest red fox home ranges recorded were in urban or suburban areas [7]. Typically, a red fox home range in an urban or suburban landscape is less than 0.386 mi^2 [7], and a demographics study of gray foxes determined their average home range to be 0.853 mi^2 [8].

Radio telemetry and home range studies provide information on many aspects of an animal's behavior. Home range size, movement and activity patterns, preferred habitat, and interaction among individuals can all be studied through long-term tracking, which makes this technique an invaluable tool in the initial stages of a population study [7, 9].

A study was conducted at Brookhaven National Laboratory over 10 weeks in the summer of 2008 to study the home ranges of foxes on site through radio tracking and to verify the presence of both red and gray foxes through fecal DNA analysis. I hypothesize that the home ranges of radio-tracked individuals will be smaller than previously studied home ranges of foxes living on undeveloped land and I also predict that both red and gray foxes have permanent populations at BNL.

MATERIALS AND METHODS

Radio Telemetry

The study took place at Brookhaven National Laboratory, located on 5265 acres of land in Upton, NY. Padded foothold traps were placed in areas with heavy fox

activity, largely in secluded roadside locations. Various trap sets, baits, and lures were used in 351 trap nights. Animal trapping and handling was performed in agreement with IACUC of Brookhaven National Laboratory. When a fox was caught, it was restrained and released from the trap. Weight, age, sex, body size, tail length, neck size, hind foot length, canine length, general health, and any other notable information were recorded and the animal was ear-tagged. A trapped animal was fitted with an 84g radio-transmitting collar (Advanced Telemetry Systems, Model 2210). The collars have a mortality mode that activates after 8 hours without movement and a guaranteed battery life of 1.5 years. A collared fox was tracked daily and its location was triangulated using a radio receiver, antennae, and three compass bearings taken within 20 minutes. Each receiver location was logged using a handheld GPS device (Thales MobileMapper). The animal was located several times each day. Each location was triangulated and plotted using ArcMAP and ArcGIS software.

Fecal DNA Analysis

Transects were walked several times a week in order to collect scat samples, focusing on areas with known fox activity. Each sample was individually labeled and its location recorded on a handheld GPS device. All samples were preserved and stored in resealable bags in a freezer at -20˚C. Fox species was determined from scat based on a previously determined method to differentiate canid species from DNA [10]. Mitochondrial DNA extraction was performed according to the Qiagen QIAamp DNA Stool Mini Kit protocol. The extracted DNA then underwent a Polymerase Chain Reaction according to a standard Taq PCR kit protocol. Next the PCR product was run

through a 2% agarose gel to determine if the PCR product contained the target DNA. Successful PCR products were then run through enzyme restriction using TaqI and HinfI enzymes. The product of enzyme restriction was then run through a 2% agarose gel to determine the species of the sample. Additionally, a digital automated field camera was set up in several locations to document the presence of red and gray foxes and determine areas of fox activity.

RESULTS

In 351 trap nights, two male red fox kits from this year's litter were trapped in one area, the second of which was large enough to safely radio-collar without risk of him outgrowing the collar. The home range of the collared red fox kit was 0.05 mi^2, but he was only tracked for one week until he could no longer be found (Figure 1). The fox's last recorded location was 0.76 mi north of his home range area (Figure 1). The fox was not found in the 45 mi^2 area on and around BNL that was checked for a collar signal (Figure 2).

Out of 56 scat samples, DNA was successfully extracted from 10 (17% success rate). Out of these 10 successful extractions, 4 samples underwent successful enzyme restriction. 2 samples were determined to be red fox, but species could not be accurately identified from the other 2 samples due to incomplete digestion. Additionally, three red foxes were seen on camera, but no grays were found.

DISCUSSION

The home range data from this study returned unexpected results. Firstly, the fox kit remained in a very small area compared to various other home range studies on red foxes [7, 11]. It is possible that the fox was unsettled from being trapped, which may have limited his movement. Since the fox's home range area was enclosed by two heavily trafficked road and two fire break dirt roads, it is also possible that human traffic contained him to one area. It should be noted that all locations were recorded between 6AM and 6PM, so the fox may have traveled out of this determined home range at night to hunt but returned to the area each day.

Another surprising event during the study was the fox's disappearance, which has several possible explanations. The fox left the BNL property and was not found in the surrounding wooded areas. Since another fox kit was caught less than two miles from the collared fox and several scat samples were found in the area, it can be assumed that other foxes resided in the area, including the fox's parents. His disappearance is peculiar since generally kits do not disperse until September or October in the year of birth [12], therefore this fox was quite young to have dispersed. However, the collared fox had a peculiar scar on his abdomen, possibly a result of aggression from other males in the litter. It is possible that the collared fox was the subordinate male of the litter and perhaps his brother forced him out of the territory.

If the fox did disperse, it is still curious that he was not found in any of the adjacent areas that provide appropriate habitat. The fox must have traveled a minimum of three miles from his last recorded location based on the areas checked for a collar signal. A prior study of red foxes determined that dispersal distance ranged from 0-187

mi, and therefore the fox could be a significant distance away from BNL [13]. One possible location within a reasonable distance of BNL is the NYS Department of Environmental Conservation property, northwest of BNL. Limited road access to the area made it difficult to thoroughly check the property, but since red foxes readily travel through residential areas and busy roads it is possible that he moved there to escape competition in his parents' home range.

Human interference could also explain the fox's disappearance. The fox's last recorded location was very close to both William Floyd Parkway and Middle Country Road, so there is always the possibility that the fox was hit by a car and removed from the area. The collar is labeled with contact information in case it is found, but the collar has not been returned. A collar malfunction is not likely because his last recorded location indicates that he was moving quickly north, and it is more likely that he dispersed.

The lack of gray fox DNA from fecal DNA analysis conflicts with studies from the past two years that found multiple scat samples from gray foxes, however the DNA extraction success rate and sample size were much lower compared to the studies from 2006 and 2007. The low success rate of DNA extraction was most likely due to poor quality scat samples resulting from unfavorable weather conditions and infrequent scat deposits. Heavy rain washes away cells on the scat, and the difficulty experienced finding scat samples means samples were exposed to the environment longer, increasing the likelihood of DNA degradation.

Although a decline in gray foxes cannot be proven from the fecal DNA results alone, the lack of photo documentation must still be considered. The 2007 study at BNL

frequently caught gray foxes on camera [2]. During the current study, the field camera was placed in areas of historic gray fox activity, but none were found, supporting the possibility of a decline in the gray fox population. Furthermore, trappers south of BNL caught two adult gray foxes in winter 2007, and it is possible that these were the two resident adults seen on camera in 2007 [2]. Assuming that all of last year's gray fox kits dispersed, the death of the only two known gray fox adults means loss of the population.

Various experimental problems occurred during the course of this study that interfered with the goals of the research. A three-year demographics study found success rates between 1 and 2.7 foxes per 100 trap nights [8], which is much better than our success rate of 0.6 foxes per 100 trap nights. Trapping in summer caused trapping difficulties in this study. A trapper's scent is more easily deposited when setting a trap in summer as the hot summer temperatures increases the likelihood of perspiration getting deposited at a trap set. Additionally, a survey of trappers in upstate New York stated that in the winter and fall, the foxes "come to them" and in the summer and spring, they have to "go to the foxes" [12]. This may be a consequence of food being more readily available in summer, causing the foxes to have no interest in baits and lures used at trap sets. Without successful trapping, no significant home range data can be recorded.

Although aspects of this study did not work as intended, the study provided valuable information for future fox research at BNL. This is only the initial stage of a multiple year fox population study, so these results will help improve future trapping success and partially redirect focus to determining the status of the gray fox population. Trapping will resume in the winter of 2008 with hopes of radio-collaring adult foxes rather than transient kits, and continued scat collection and use of the wildlife camera will

help confirm the presence or disappearance of gray foxes at BNL. This study has also demonstrated the fragility of the gray fox population and the need for widespread research on this species throughout Long Island in order to minimize the negative effects of humans on sensitive gray fox populations.

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REFERENCES

[1] Finn, W., Non-Invasive Species Confirmation of Fox Populations at Brookhaven National Laboratory, 2006.

[2] Mallin, P., Non-Invasive Indexing of Red and Gray Fox Populations at Brookhaven National Laboratory, 2007.

[3] Roemer, Gary, Smith, Deborah, Garcelon, David, Wayne, Robert, The behavioural ecology of the island fox (*Urocyon littoralis*), *The Journal of the Zoological Society of London*, 255: 1-14, 2001.

[4] Harrison, Robert L., A survey of anthropomorphic ecological factors potentially affecting gray foxes (*Urocyon cinereoargenteus*) in a rural residential area, *The Southwestern Naturalist*, 38 (4): 352-356, 1993.

[5] Harrison, Robert L., A comparison of gray fox ecology between residential and undeveloped rural landscape, *The Journal of Wildlife Management*, 61(1): 112-122, 1997.

[6] Connor, Paul F., The Mammals of Long Island, New York, 48-51, 1971.

[7] Adkins, C. A. and Stott, P., 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, 1997.

[8] Murray Weston, Julie Lynn, Demographics of a protected population of gray foxes (*Urocyon cinereoargenteus*) in South Carolina, (Doctoral dissertation, The University of Geogia, 2001.

[9] Baker, Philip J., Funk, Stephan M., Harris, Stephen, and White, Piran C. L., Flexible spatial organization of urban foxes, *Vulpes vulpes*, before and during an outbreak of sarcoptic mange, *Animal Behavior*, 59(1): 127-146, 2000.

[10] Paxinos, E., Mcintosh, C., Ralls, K., Fleischer, R., A Noninvasive Method for distinguishing among canid species: Amplification and enzyme restriction of DNA from dung, *Molecular Ecology*, 6: 483-486, 1997.

[11] Dekker, Jasja J. A., Stein, Alfred, and HeitkoÈnig, Ignas M. A., Spatial analysis of a population of red fox (*Vulpes vulpes*) in the Dutch coastal dune area, *Journal of the Zoological Society of London*, 255: 505-510, 2001.

[12] Sheldon, William, Denning habits and home range of red foxes in New York State, *The Jounal of Wildlife Management*, 14(1): 33-42, 1950.

[13] Allen, Stephen and Sargeant, Alan, Dispersal patterns of red foxes relative to population density, *The Journal of Wildlife Management*, 57(3):526-533, 1993.

FIGURES

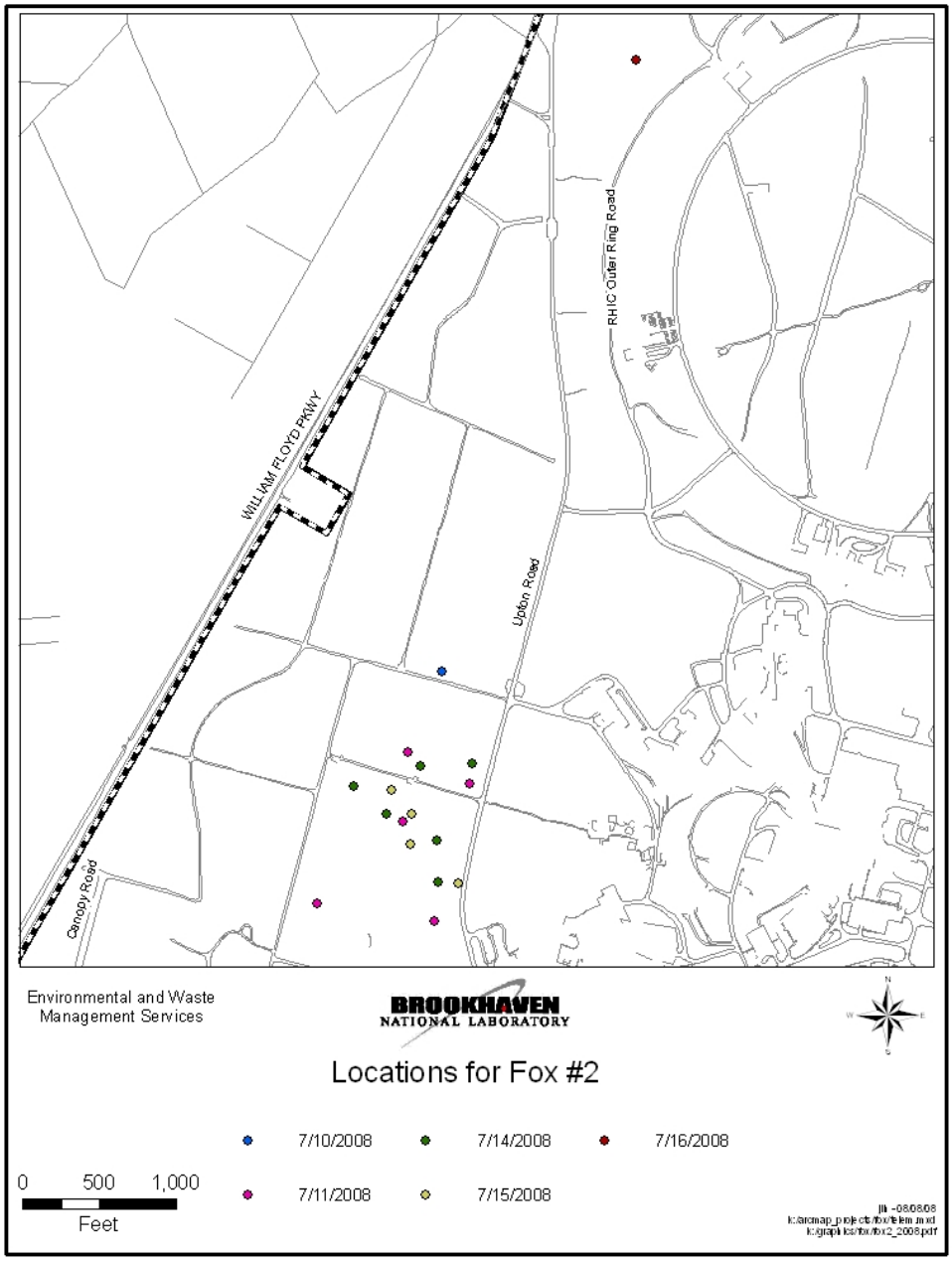

Figure 1. All fox locations recorded between July 10 and July 16, 2008.

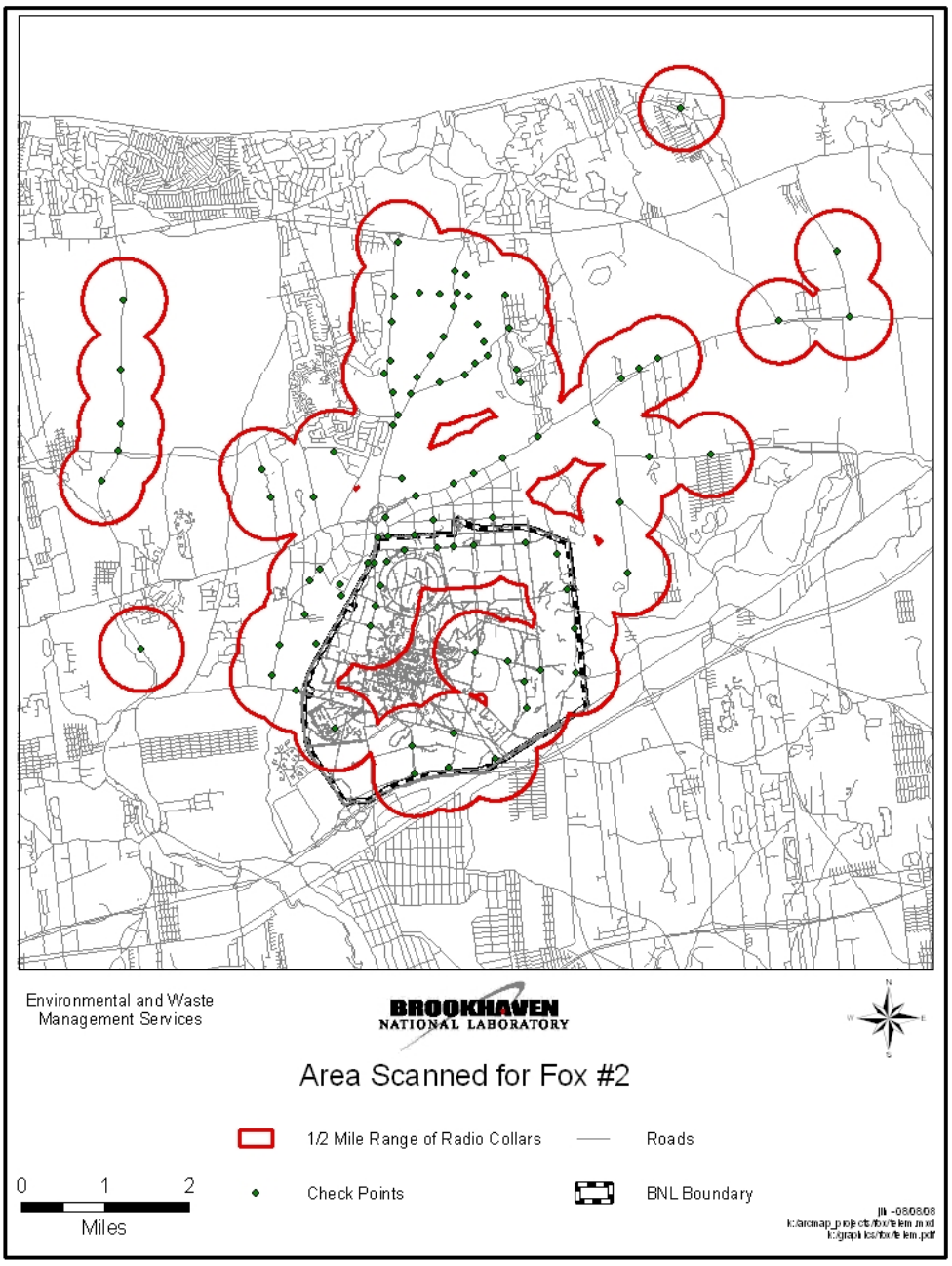

Figure 2. Areas checked for radio collar signal within and around BNL