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Extreme Movements of an Individual Male Fox Squirrel

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Abstract - We observed a series of long-distance movements by an adult male *Sciurus niger* (Eastern Fox Squirrel). The squirrel traveled 1040 m between 25 May and 27 May, and ≥503 m on 5 separate occasions between 29 April and 25 May 2017. The individual traveled between experimental foraging sites and was photographed by remote cameras placed at each site. The time it took to travel between sites varied from 1 h and 5 min to 5 h and 7 min. The distance this squirrel regularly traveled is approximately the diameter of an average Eastern Fox Squirrel home range in the southeastern United States.

Introduction. *Sciurus niger* L. (Eastern Fox Squirrel) is North America's largest arboreal squirrel (Koprowski 1994) and is commonly associated with *Pinus palustris* Mill. (Longleaf Pine) forests in the southeastern US (Perkins and Conner 2004). Eastern Fox Squirrels are highly mobile on the ground and in trees, but preferentially travel on the ground (Weigl et al. 1989). The squirrel's large body size reduces its risk of predation while moving and foraging on the ground (Smith and Follmer 1972), particularly in the open understory and incomplete canopy found in Longleaf Pine forests (Landers et al. 1995). In the southeastern US, patchy availability of resources within Eastern Fox Squirrel habitat results in large home-ranges (Prince et al. 2014) and may require long movements between foraging patches (Conner 2000, Weigl et al. 1989).

Estimates of Eastern Fox Squirrel home ranges in the southeastern US vary (Table 1), with males typically having a larger home-range than females (Conner 2000, Hilliard 1979, Weigl et al. 1989). Less research has been devoted to fine-scale temporal and spatial movement. Hilliard (1979) found a mean distance between extreme diel locations for 8 *S. niger niger* L. (Southeastern Fox Squirrels) varied from 203 m to 395 m, with a maximum of 817 m. Weigl et al. (1989) reported median distance moved per hour for Eastern Fox Squirrels in North Carolina varying from 60.0 m/h to 112.8 m/h. When chased by a human, Eastern Fox Squirrels have been observed running up to 375 m in a single burst (Moore 1957).

Recurring long movements in Eastern Fox Squirrels are not well documented, and most large-magnitude travel distances are associated with one-time events such as dispersal (Wooding 1997) or human interference (Hilliard 1979). Herein, we present our observation of a repetitive pattern of long-distance movements that have not previously been observed in Eastern Fox Squirrels.

Field-site Description. The study took place at the Joseph W. Jones Ecological Research Center (Jones Center) in Newton, GA. The Jones Center is a 12,000-ha privately owned research facility that primarily consists of fire-managed Longleaf Pine forest. The Jones Center manages for *Colinus virginianus* (L.) (Northern Bobwhite) by interspersing small agricultural plots within the forest (Conner 2000).

Methods. As part of a study on Eastern Fox Squirrel antipredator behavior, we created experimental foraging patches to examine foraging behavior. To identify suitable patch locations and to habituate squirrels to the experimental sites, we placed 3.8-L rubber buckets

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Table 1. A summary of home-range estimates for Eastern Fox Squirrels in the southeastern US. M = male home-range and F = female home-range. Except for Greene and McCleery (2017), we calculated the mean home-range radius as the radius of a circle with an area equal to the reported Eastern Fox Squirrel home range. Habitat codes are L = Longleaf Pine, P = other pine, H = hardwood forest, X = mixed forest. Methods used for calculating home range are indicated by superscript.

Study area	Reference	Subspecies	Habitat code	Mean home-range (ha)	Mean home-range radius (m)
Fort Stewart, GA	Hilliard 1979[A]	*S. niger niger*	P, H	M = 19, F = 9	M = 245.9, F = 169.3
Sandhills Game Area and Brunswick County, NC	Weigl et al. 1989[A]	*S. niger niger*	L	M = 43.7, F = 17.2	M = 373.0, F = 234.0
Spring Island, SC	Lee et al. 2008[B]	*S. niger niger*	H, X	M = 9.57, F = 3.43	M = 174.5, F = 104.5
Fort Bragg, NC	Prince et al. 2014[C]	*S. niger niger*	L	M = 81.26, F = 19.83	M = 508.6, F = 251.2
Easton, MD	Flyger and Smith 1980[A]	*S. niger cinereus*	H	29.9*	308.5
Ordway-Swisher Biological Research Station, FL	Kantola and Humphrey 1990[A]	*S. niger shermani*	L	M = 42.8, F = 16.7	M = 369.1, F = 230.6
Fort White, FL	Wooding 1997[A]	*S. niger shermani*	H	M = 79.5, F = 33.0	M – 503.0, F = 324.1
Goldhead, FL	Wooding 1997[A]	*S. niger shermani*	L	M = 83.0, F = 35.6	M = 514.0, F = 336.6
Joseph W. Jones Ecological Research Station, GA	Conner et al. 2000[B]	*S. niger shermani*	L	M = 37.0, F = 21.0	M = 343.2, F = 258.5
Camp Blanding WMA and Ordway-Swisher Biological Research Station, FL	Greene and McCleery 2017[D]	*S. niger shermani*	L	-	262*

[A]100% MCP.
[B]95% kernel.
[C]99% kernel.
[D]Mean maximum distance moved.
*Sex not reported.

(Fortex CR-40, Fortiflex Inc., Dorado, PR) in the environment and placed 4–5 whole pecans on top of each overturned bucket. At each bucket, we mounted a remote camera (UWAY Model VH400 or Model SR1; UWAY Outdoors Canada, Lethbridge, AB, Canada; or Bushnell Trophy Cam Model 119436c; Bushnell Outdoor Products, Overland Park, KS) to rebar stakes ~1 m away from the bucket and 40 cm high. We set the cameras to take a 3-photo burst and then become inactive for 30 seconds. We varied sensitivity settings between cameras based on vegetation characteristics. We visited each site daily to restock the bait and check cameras. We identified individual Eastern Fox Squirrels by their unique pelage characteristics, ear scars, and tail abnormalities (Tye et al. 2015). All methods were approved by the University of Florida's Institutional Animal Care and Use Committee (IACUC # 201709906).

Observations. Between 29 April and 27 May 2017, we observed a repetitive pattern of long-distance movement by an individual adult male Eastern Fox Squirrel between 4 of our experimental foraging patches. The patches were arranged nearly linearly and the distance between the farthest points was 1040 m. The squirrel was uniquely identifiable by a scar on the right ear. On 5 occasions, the squirrel traveled between the 2 middle experimental foraging sites (site 1 and site 2) on the same day. The linear distance between sites 1 and 2 was 503 m. Travel time between sites 1 and 2 varied from 1 h 5 min to 5 h 7 min (Table 2). On 3 days, the squirrel traveled from site 1 to site 2 and on 2 days from site 2 to site 1. Between 25 May and 27 May 2017, the squirrel traveled between the farthest sites (site 3 and site 4). We observed the squirrel leaving site 4 on 25 May 2017 at 13:31 and observed him at site 3 on 27 May 2017 at 17:00.

Discussion. Our observation of an Eastern Fox Squirrel repeatedly traveling ≥503 m between experimental foraging sites is unique in several ways. The regularity with which the squirrel moved such a far distance has not been reported before in this species. Estimates of Eastern Fox Squirrel home ranges in the southeastern US suggest the squirrel was crossing most of an average home-range each time it traveled between sites 1 and 2 (Table 1). The speed with which the squirrel traveled between sites was also unusual, once covering the entire distance in 1 h and 5 min. The maximum average distance moved per hour recorded by Weigl et al. (1989) was 210 m, indicating that the squirrel we observed was traveling faster than previously observed between experimental sites. Our observation of an Eastern Fox Squirrel moving ≥1040 m in 2 d is undocumented outside of dispersal events, which typically occur over 2–3 weeks (Wooding 1997). However, we first observed the squirrel at sites 1 and 2 on 29 April 2017 and we continued to observe the individual at sites 1 and 2 until 5 July 2017, indicating that the individual we observed was not engaged in dispersal behavior.

The squirrel's long-distance and repeated movements were likely motivated by a preferred food item during a seasonal period of declining food resources (Weigl et al. 1989). The abundance of natural foods declines in late May into a season when food is less available

Table 2: Dates, times, and total travel time between experimental foraging sites on 5 occasions when an individual male Eastern Fox Squirrel traveled 503 m in a single day at the Joseph W. Jones Ecological Research Center in Newton, GA.

Date	Departure time (site #)	Arrival time (site #)	Travel time (h:min)
29 April 2017	10:23 (2)	14:03 (1)	3:40
1 May 2017	15:55 (1)	17:20 (2)	1:25
7 May 2017	11:53 (1)	15:08 (2)	3:15
10 May 2017	11: 45 (1)	16:52 (2)	5:07
25 May 2017	9:54 (2)	10:59 (1)	1:05

(Weigl et al. 1989), which causes male Eastern Fox Squirrels to increase their home-range size (Conner 2000). Weigl et al. (1989) suggested that males increase their movements during periods of limited food because females deplete patchy resources by concentrating foraging around their nests.

Limited knowledge of fine-scale Eastern Fox Squirrel movement makes it unclear whether our observation of a single squirrel is an anomaly or representative of normal behavior. If this is a common behavior, then our observations could have implications for designing future Eastern Fox Squirrel studies, particularly for ensuring spatial independence between study sites. Recent technological advances have made it possible to deploy GPS collars on squirrels (Stevenson et al. 2013), giving researchers fine-scale temporal and spatial movement data. Additional studies using these new technologies will help establish the frequency of the extreme movements we observed.

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