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Long-Distance Dispersal By Eastern Gray Squirrels In Suburban Habitats

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Abstract - Natal dispersal by *Sciurus carolinensis* (Eastern Gray Squirrel) is poorly understood, given so rarely reported, yet dispersal patterns in small mammals can affect seed dispersal and predation, as well as population dynamics of predators. Herein, I document long-distance dispersal by 3 Eastern Gray Squirrels from the suburban coastal campus of the University of New England in Biddeford, ME. Mean dispersal distance was 10.1 km (min–max = 6.3–14.5 km), occurring in random directions (SW, S, NW). These results, combined with the previous studies, better describe the distribution of natal dispersal by Eastern Gray Squirrel—critical information in understanding population processes and potentially developing effective landscape-management strategies.

Introduction

Although *Sciurus carolinensis* Gmelin (Eastern Gray Squirrel; hereafter also "Gray Squirrel") is one of the most commonly encountered free-ranging mammals in eastern North America, key aspects of its demography, particularly the extent of juvenile dispersal and resulting implications regarding recruitment, remain poorly understood. Gray Squirrel population models have previously either used simulated data (rather than field-parameterized data; e.g., Rushton et al. 1997) or assumed a maximum dispersal distance of 5 km, where greater dispersal distances resulted in mortality (Lurz et al. 2001). This 5-km dispersal threshold was based on Koprowski (1996), who found Gray Squirrel natal philopatry distances of 0.38 to 3.23 km (mean = 1.1 km; n = 7) for males and 0.32 km for a single female. Similarly, but for unknown-aged individuals, Mosby (1969) reported average male (n = 30) and female (n = 15) dispersal distances of 0.88 and 0.61 km, respectively. In notable contrast, following a crash in food availability, Sharp (1959) documented 3 extreme long-distance movements varying from approximately 64 to 100 km during a period commonly associated with natal dispersal. To my knowledge, these are the only other documented long-distance dispersals by Gray Squirrels.

Although we know little about the distribution of dispersal distance, some factors that influence dispersal are better understood. For example, spring-born Gray Squirrels are known to emigrate between their 4^{th} and 6^{th} month of age (Thompson 1978). Additionally, Gray Squirrels show female-biased natal philopatry; females form kin-based communal nests, whereas males seek nests with unrelated males (Gurnell et al. 2001, Koprowski 1996). Further, aggressive juveniles and heterozygous color morphs have shown shorter dispersal distances (Pasitschniak-Arts

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and Bendell 1990). Such individual behavior within a species social structure, likely in combination with other environmental factors, however, continues to confound any estimation of dispersal distances, necessitating detailed observations of long-distance movements.

I established a long-term ecological study of Gray Squirrels on a suburban, coastal university campus in southern Maine. To my knowledge, there are no previous studies of this species' movement ecology in the northeastern portion of its range in North America, which spans from southern Florida to eastern Texas in the US to southern Manitoba to southern New Brunswick in Canada (Patterson et al. 2003). Herein, I aim to improve our knowledge of dispersal by Gray Squirrels, describing 3 long-distance dispersal events. Along with Koprowski (1996), Mosby (1969), and Sharp (1959), these events provide a greater understanding of this species movement ecology.

Materials and Methods

Over the course of the study, I used various appropriately sized Sherman live traps (64 cm x 19 cm x 19 cm, 50 cm x 19 cm x 19 cm, 43 cm x 13 cm x 13 cm; H.B. Sherman Traps, Inc., Tallahassee, FL) baited with peanut butter to capture a total of 132 Gray Squirrels on the University of New England's campus in Biddeford, ME (43.4587°N, 70.3890°W). This work was approved by the University of New England Institutional Animal Care and Use Committee (IACUC permit #040618) and the State of Maine Department of Inland Fisheries and Wildlife (permit #557). The 220-ha campus includes densely concentrated low-rise buildings, including paved pathways lined by mature *Quercus rubra* L. (Red Oak), and ornamental annual and perennial gardens. Eighty percent of the campus is undeveloped and contains mature forest fragments defined by native vegetation, including Red Oak, *Carya ovata* (Mill.) K. Koch (Shagbark Hickory), *Acer rubrum* L. (Red Maple) and *Pinus strobus* L. (White Pine). I set traps (n = 4–8) randomly across campus from early September to late November and from late January to late April, 2010–2018. I trapped 1–2 days per week when I had <4 currently active radio collars. I checked traps every 2 hours to allow for immediate processing and to reduce retention and handling stress. Once captured, I removed the squirrel from the trap using a handling cone (per Koprowski 2002), took morphological measurements, including body mass, applied a numbered ear-tag with a color washer, and affixed a radio collar (Wildlife Materials; model #2380, 8–10 g). I both ear-tagged and radio-collared all squirrels that weighed ≥450 g (n = 100) and only ear-tagged squirrels that weighed <450 g (n = 32). Undergraduate research assistants monitored collared squirrels 1–10 times weekly (September through April) and 1–2 times monthly (May through August) until either the collar failed, the individual died, or we determined the collar was no longer on the animal. I also collected data on squirrel locations through the community by raising awareness through articles in the local newspapers, leaving pamphlets that described the project at neighborhood houses, through a website where community members could submit their observations (www.une.edu/squirrel), and through observations by students and research assistants who lived off-campus. In 2017, Biddeford had ~10,000 dwellings across 77.92 km^2 units with a human population of 21,488 (City of Biddeford 2019).

Results

I identified 3 long-distance dispersal events over the course of the study, varying in length and direction from the University of New England's Biddeford campus. On 20 February 2017, an ear-tagged and radio-collared individual was seen at 358 Old Post Road, Arundel, ME (43°25'03.63"N, 70°30'13.15"W), about 14.5 km southwest from its original tagging location (Fig. 1). I was unable to re-sight or relocate (with telemetry) this individual and therefore could not identify its age or sex. This individual was observed at a bird feeder in a yard with gardens and mature

Figure 1. Long-distance dispersal by 3 Eastern Gray Squirrels during 2017–2018 in Biddeford, ME. The star indicates the initial capture location (43.4587°N, 70.3890°W).

Red Maples. The straight-line dispersal corridor was primarily forested, although it crossed multiple roads varying in speed limit from 40 to 88 kph. On 1 November 2018, a second radio-collared squirrel was seen and photographed at 3 Wildwood Avenue, Kennebunkport, ME (43°23'57.95"N, 70°24'53.29"W), 9.6 km south of its original tagging location. Again, I was unable to re-sight or relocate (with telemetry) this individual and therefore could not identify its age or sex. This individual was also seen near a bird feeder about 100 m from the Atlantic Ocean and adjoining tidal marshes, where there were small gardens and mature *Pinus rigida* Mill. (Pitch Pine). The straight-line dispersal habitat was primarily forested, but included roads ranging in speed limit from 40 to 88 kph, as well as small tidal wetlands. Also, on 1 November 2018, a third ear-tagged individual was seen at a bird feeder at 283 Pool Street, Biddeford, ME (43°29'00.29"N, 70°25'59.54"W), 6.3 km northwest from its original tagging location. This yard was composed of small gardens and mature Red Oaks, Red Maples, and White Pines. This individual could have dispersed without crossing any roads, possibly following a back-yard corridor composed of gardens and mature Red Oak and White Pine wood lots. I recaptured and identified this individual—a juvenile male, originally ear-tagged and radio-collared on 15 October 2018. His original collar was chewed off between 30 October 2018 and 5 November 2018 and recovered on 23 March 2019; he was first sighted at a bird feeder at 283 Pool Street on 6 November 2018 and was seen at that bird feeder or found nearby with telemetry 128 times by 15 April 2019 (total area used was 1.01 ha). This unusually large individual weighed 817 g on the initial capture as a juvenile and 794 g on the second capture, 22 days later.

Discussion

I documented long-distance dispersals by 3 Eastern Gray Squirrels of 6.3 to 14.5 km (mean = 10.1 km). This is notably greater dispersal than that identified in either suburban parkland habitat by Koprowski (1996) in Lawrence, KS, where the mean juvenile dispersal was 1 km (n = 8; max = 3.2 km), or the dispersal distances of 0.6–0.8 km observed in hunted woodlot habitat by Mosby (1969) for unknown-aged individuals in Blacksburg, VA. As a caveat, however, the results presented in this study were gathered opportunistically, rather than part of a controlled study of dispersal distances with robust samples sizes collected over multiple years. Moreover, I only radio collared individuals that weighed ≥450 g; thus, collecting little movement data on known juveniles, the majority of which may have been dispersing much shorter distances. As such, the values presented in this study may represent relatively extreme dispersal distances, rather than mean dispersal distances, as presented by Koprowski (1996). Notably, 2 additional studies attempted to experimentally assess movement by live-trapping, moving, and following Gray Squirrels to see how far they may have dispersed (Goheen et al. 2003, Rosenblatt 1999). Rosenblatt (1999) found average movements of 0.54 km and 3.64 km for translocated sub-adult females that were moved during spring and summer, respectively, and all post-translocation movements observed by Goheen et al. (2003) were <1000 m.

Regardless of the methods used to observe dispersal distances in previous studies (varying from ≤1 km to possibly 100 km), the distance data provided here (averaging 10 km) may help better define the distribution of dispersal distances—critical to understanding Gray Squirrel population processes. While these data do not provide much of the ecological context necessary to more fully understand the effect of population density, food availability, or habitat quality on dispersal, it is important to note that during the summer and fall of 2018, when 2 of the observed dispersal events occurred, a population irruption of Gray Squirrels occurred in southern and central Maine, with numerous reports of significant agricultural damage and unusually high numbers found dead on roads (Casto 2003, Flyger 1969, Forbes 1910, Seton 1920).

Understanding movement ecology of this species—and other small mammals that play similar roles within their ecosystems—is critically important in understanding ecosystem function (Davidson et al. 2012). Moreover, Gray Squirrels are known to affect predator–prey dynamics and therefore predator populations (Sheehy et al. 2018), influence disease ecosystems where they have been introduced (Tompkins et al. 2003), and indicate environmental contaminants (McKinnon et al. 1976). Therefore, they play diverse and critical roles in both their native and introduced ecosystems. I encourage future researchers of population dynamics to design their studies to detect dispersal distances that are more variable. Multiple ecological (e.g., Sharp 1959) and anthropogenic factors (e.g., roads; see McGregor et al. 2008), often in combination, may influence dispersal distances. Understanding population processes in the future will depend on our ability to assess both constraints and enabling factors for dispersal, and we should aim to understand these factors both individually and in conjunction with each other.

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