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Movements, Site Fidelity and Survival of Delmarva Fox Squirrels Following Translocation

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ABSTRACT.—Twenty wild-trapped Delmarva fox squirrels (*Sciurus niger cinereus*) were translocated from core population areas to a release site within their former range in Maryland. Squirrels were equipped with radio-collars and released during midspring and midautumn and monitored at least 90 days postrelease. Nine known deaths occurred during the study, five within the 1st 35 days. All translocated squirrels remained on the release site. The mean distance moved from the point of release was 589 m (n = 15). The ranges for males (n = 5) and females (n = 10) were similar (P = 0.743). Midspring released squirrels (n = 8) ranged further from the point of release than those translocated in midautumn (n = 7) (P = 0.043). Seasonal differences in movement appeared to be influenced by habitat. Delmarva fox squirrels used certain forest types in greater proportion than available and habitat use differed between seasons.

INTRODUCTION

The Delmarva fox squirrel (*Sciurus niger cinereus*) once ranged throughout Delaware, the eastern shores of Maryland and Virginia, and into southeastern Pennsylvania and southern New Jersey (Taylor, 1973). By the time it was federally listed as an endangered subspecies in 1967 it occurred in only four counties in eastern Maryland, representing <10% of its historic range (Taylor, 1976). Habitat loss was considered the primary cause of decline (Taylor, 1973).

Current occupied habitat for this squirrel consists of mature forest, particularly hardwoods and mixed stands with loblolly pine (*Pinus taeda*) (Taylor, 1973, 1976). These areas generally have a higher percentage of large trees (>30 cm dbh), a lower percentage of shrub groundcover, and a slightly lower understory density than forests without Delmarva fox squirrels (Dueser *et al.*, 1988). Unoccupied, but apparently suitable, habitat now exists in portions of the Delmarva fox squirrel's former range (U.S. Fish and Wildlife Service, 1993).

Re-establishing populations of this endangered subspecies through translocation was proposed as a major recovery strategy (Flyger and Lustig, 1976; U.S. Fish and Wildlife Service, 1983) and translocation efforts began in 1978. Attempts to re-establish fox squirrels occurred at 14 locations between 1978 and 1989. Release sites were selected by visual inspection based on Taylor's (1976) general descriptions of occupied habitats. Post-release monitoring of these translocation efforts was limited, and did not include intensive evaluation of postrelease movements. Some release locations currently support small breeding populations (U.S. Fish and Wildlife Service, 1993), whereas the outcome of others is not known. The success of any translocation depends not only on habitat, but also, on the number of animals released, their site fidelity and survival (Griffith *et al.*, 1989; Wilson *et al.*, 1992). Sustaining a viable population of any endangered species is more difficult because the luxury of releasing many individuals is limited.

The purpose of this study was to intensively monitor a group of translocated Delmarva fox squirrels to determine if they remained in the vicinity of a release site considered suitable using Dueser *et al.*'s (1988) modified description of occupied habitat. Our objectives were to determine survival of translocated fox squirrels, evaluate movements imme-

diately following midspring and midautumn releases and evaluate the influence of forested habitat types on these movements and site fidelity.

STUDY AREA AND METHODS

The study site was a 1177-ha area near Worton, Kent County, Maryland (Fig. 1), within the former range of the Delmarva fox squirrel. Several habitat types were present on the study area, including 385 ha of forest. Gross habitat conditions were identified and mapped through the use of a timber inventory, aerial photographs and visual inspection of the release site. Forest types were classified, based on tree species dominance, such as upland hardwoods: oak (*Quercus* spp.), hickory (*Carya* spp.), beech (*Fagus grandifolia*) and some tulip poplar (*Liriodendron tulipifera*); mixed-pine hardwoods: loblolly pine, white pine (*Pinus strobus*) and Virginia pine (*P. virginiana*) with some hardwoods; tulip poplar: tulip poplar with some red maple (*Acer rubrum*); bottomland hardwoods: tulip poplar with other hardwoods along stream banks and swamps; or sweetgum: sweetgum (*Liquidamber styraciflua*) and black locust (*Robinia pseudoacacia*), with some sycamore (*Platanus occidentalis*) and black cherry (*Prunus serotina*). Corn, soybean, rye and barley were the major crops farmed on the site. Dairy cattle and pasture were also present. Ponds, creeks and wetlands were on the site. Gray squirrels (*Sciurus carolinensis*) and southern flying squirrels (*Glaucomys volans*) also occupied the forests on site.

Twenty adult Delmarva fox squirrels (nine males, 11 females) were live-trapped in Dorchester and Queen Anne's counties, Maryland, in May and October 1991. Squirrels were captured in Havahart live traps baited with ear corn. Traps were checked twice daily and closed at dusk. Captured squirrels were immediately transported to a holding cage (4 × 3 × 3 m) containing nestboxes and food (corn, apples and water) in the largest forest on the release site. Squirrels were held from 1–4 days and released in small groups.

Before release, each squirrel was anesthetized with Metofane (Methoxyflurane), weighed, aged, sexed, ear-tagged and fitted with a radio transmitter (Wildlife Materials, Carbondale, Illinois). Each collar weighed approximately 11.0 g (<1.4% of minimum body weight) and had a maximum transmitting range of 1.0 km at ground level. All squirrels were permitted to recover from the anesthetic for approximately 1 h, then released.

The schedule of release was: 6 May (three males, two females); 10 May (three males, four females); 18 October (two males, four females); 28 October (one male, one female). After each release, squirrels were tracked for a minimum of 90 days, until they were found dead or their signal was lost. Field evidence or necropsy were used to determine the cause of mortality. Deaths were classified as predation, starvation, collar-induced trauma or unknown. Squirrels were considered missing if radio signals were lost. Monitoring was conducted from a mobile unit and on foot during daylight hours using a receiver (Telonics, Inc.) and directional H-type antenna. Locations were acquired by triangulation and direct observation. Triangulation gave a rough estimate (within 50 m) of location. Then radio-tagged squirrels were located by moving towards the area of maximal signal strength which was within 10 m of their actual location. Once squirrels were located, no effort was made to follow them. Squirrels were located at random and efforts made to obtain one telemetry location per day for each collared animal. Monitoring was conducted from 6 May 1991 through 25 January 1992.

Each telemetry location was plotted daily on a map of the study area (scale: 1 cm = 50 m) by taking distance and bearing measurements from each location to known landmarks. All map measurements were estimated to be within 10 m of the observed radio location. The distance to each telemetry location was then determined from the point of release as a straight line measurement. The mean distances moved by individual squirrels from the

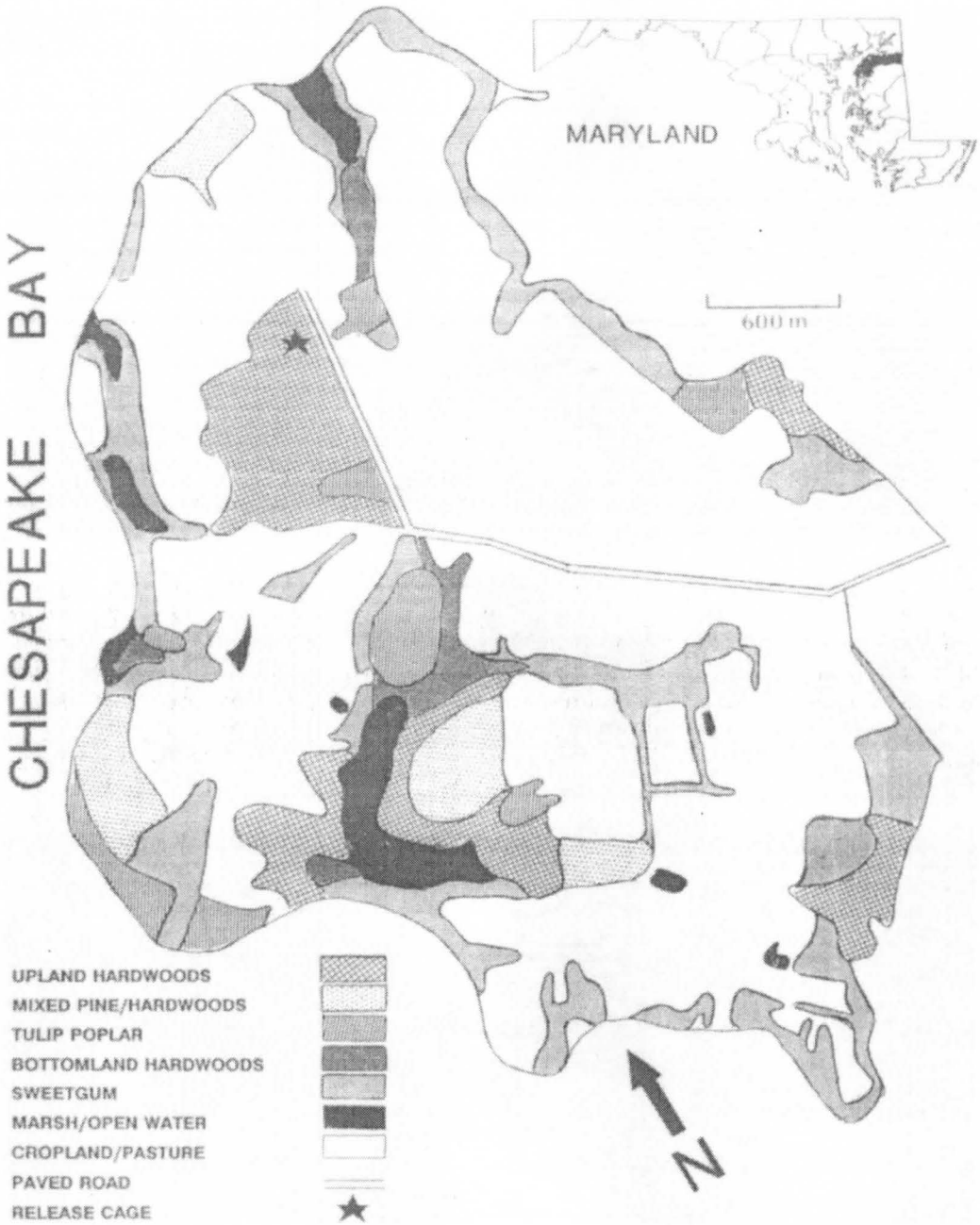

FIG. 1.—Release site located in Kent County, Maryland, showing different habitat types

point of release was used as a measure of site fidelity. Consecutive daily movements from locations of the previous day were also measured for each individual (no movement equalled a measurement of zero). These mean distances were used to assess activity. Comparisons were made between distinct 90-day postrelease periods to evaluate seasonal differences in movement. Movement data were analyzed with two-sample t-tests. Squirrels (n = 5) dying of trauma, starvation or unknown causes were not included in any comparative analysis because of low numbers of telemetry locations and possible aberrant behaviors associated with illness. However, individuals killed by predators (n = 4) or missing (n = 2) were included in the distance analyses. The sites of recovery of squirrels preyed on were not included in any analysis.

Squirrel occupancy of the study site was used to assess habitat use. Only forested habitats were considered available because all movements occurred within >90% of the forested area on the study site. The availability (proportion) of each forested habitat type was then determined by calculating its area with a planimeter. The number of telemetry locations observed in each type was determined for each of the squirrels. The resulting percentages were compared to the proportion of each forested habitat type using t-tests to assess seasonal habitat use and its influence on movements from the point of release.

RESULTS

Mortality.—Seven fox squirrels (five males, two females) were known to have died within the 1st 90 days postrelease, five during the 1st 35 days. Two (one male, one female) others died after this 90-day period. One male died from trauma induced by the collar. Two males and one female died from unknown causes. Two males and two females died from predation by great horned owls (*Bubo virginianus*). One male died of cachexia (starvation in the presence of food). Two females were missing and nine others (three males, six females) survived.

Movements and site fidelity.—All translocated squirrels with active radio collars remained on the release site. Two missing squirrels were considered lost due to transmitter failure or predation. Dispersal off the study site was unlikely because of the sudden loss of signals 103 and 194 days after release, and an intensive search within 7 km of the study site immediately following the loss of radio contact revealed no evidence of these animals.

A total of 1449 telemetry locations were obtained during the study. The 15 squirrels used in the analyses accounted for 1313 locations (595 midspring, 682 midautumn, 36 between release periods). The average distance moved from the point of release for these squirrels was 589 m (SE = 79, range = 239–1260 m). Males moved an average of 549 m (SE = 132, range = 282–964 m, n = 5) and females averaged 607 m (SE = 103, range = 239–1260 m, n = 10) from the point of release. These differences were not significant (t = 0.33, 13 df, P = 0.743). The maximum known distance traveled from the release cage was 3719 m during November by a male squirrel released in October that subsequently died of cachexia.

Squirrels released during the midspring moved an average of 825 m (SE = 153, range = 326–1351 m, n = 8) from the point of release during the 90-day postrelease period, whereas squirrels released in the midautumn averaged 438 m (SE = 56, range = 282–618 m, n = 7) during an identical postrelease period. These differences were significant (t = 2.37, 8.8 df, P = 0.043).

Consecutive daily movements of the 15 fox squirrels averaged 210 m (SE = 32, range = 77–514 m) from their locations of the previous day. The maximum straight line distance traveled in 24 h was 2280 m during May by an adult female immediately after release. Consecutive daily movements during the midspring release averaged 191 m (SE = 30, range = 103–328 m, n = 8), whereas midautumn-released squirrels averaged 252 m (SE = 58,

TABLE 1.—Forest habitat availability and use by 15 translocated Delmarva fox squirrels (excluding multiple observations at den sites) during the 6 May 1991 through 25 January 1992 postrelease study period. Sample sizes: Midspring n = 8; Midautumn n = 7

	Available habitat		Habitat use by midspring release[a]			Habitat use by midautumn release[a]		
Habitat	%	ha	%	SE	P ≤	%	SE	P ≤
Upland hardwoods	30.5	117.1	31.1	8.7	0.894	84.0	6.5	0.001
Mixed pine/hardwoods	12.5	48.2	1.1	0.6	0.001	0.9	0.6	0.001
Tulip poplar	10.7	41.3	35.6	7.9	0.021	7.1	4.3	0.119
Bottomland hardwoods	5.8	22.3	13.8	5.7	0.651	6.2	3.1	0.430
Sweetgum	40.5	155.9	18.4	8.6	0.027	1.8	1.1	0.001

[a] Data were analyzed by t-test after data were arcsin-transformed, original means and standard errors are presented. Use is expressed as a mean of the percentage of locations each squirrel was found in various habitats. These means were compared to the percent of that type's availability

range = 77–514 m, n = 7). This difference, however, was not significant (t = 0.971, 13 df, P = 0.350). Midspring-released squirrels, on average, remained in the same location as observed on the previous day 23.1% (SE = 3.3, range = 16.3–37.0, n = 8) of the time, whereas midautumn-released squirrels did not relocate 16.8% (SE = 4.9, range = 3.1–38.4, n = 7) of the time. These differences were not significant (t = 1.09, 13 df, P = 0.295). During these times of limited activity squirrels were at den sites.

Habitat use.—Delmarva fox squirrels used certain forest habitat types disproportionately to their availability (Table 1). Squirrels released in midspring occupied tulip poplar areas much more frequently than expected. During midautumn, squirrels were observed almost exclusively in upland hardwood areas near the release cage. Throughout the entire study sweetgum-dominated forests and mixed-pine hardwood areas were used much less than available. Squirrels were never observed in open fields.

DISCUSSION

Little information on the mortality rates of fox squirrels is available. Hansen *et al.* (1986) found mean annual disappearance rates of 34% for males and 37% for females in Illinois. Eveland (1974) observed 55% annual disappearance from an unexploited population of fox squirrels. Mortality rates for translocated Delmarva fox squirrels in this study appeared similar. Most deaths occurred within the 1st 35 days after release. After these initial postrelease deaths, mortality appeared to decline and resulted totally from predation. In Pennsylvania six of 16 translocated Delmarva fox squirrels died within 6 mo after release (J. Dunn, Pennsylvania Game Comm., Harrisburg, pers. comm.). Mortality was heaviest during the 1st mo. At a release site in Delaware, all known mortality (two of 29 animals) occurred during the 1st mo following translocation (K. Reynolds, Del. Div. Fish and Wildl., Dover, pers. comm.). Mortality during the weeks immediately following a translocation was typically much higher than normal for other species (Schultz, 1980; O'Bryan and McCullough, 1985; Miller, 1990).

Fox squirrels in this study exhibited a high degree of site fidelity. This is a desirable condition when trying to establish a population through translocation. In Pennsylvania, maximum dispersal distances ranged from 100–2480 m from the release cage, averaging 849 m (J. Dunn, Pennsylvania Game Comm., Harrisburg, pers. comm.). All but one individual remained within 1000 m of their release site during the first 6 mo postrelease. In

one previous release in Maryland, Delmarva fox squirrels moved up to 7.4 km from the release site (U.S. Fish and Wildlife Service, 1993). In our study, long-distance movements were often followed by a return to the vicinity of the release woodlot. These movements appeared to be exploratory in nature and not an attempt to wander or leave the site.

At Chincoteague National Wildlife Refuge, Virginia, dispersal of Delmarva fox squirrels was significantly restricted where contiguous or interconnected forests were lacking (B. J. Larson and R. D. Dueser, Univ. Virginia, Charlottesville, pers. comm.). Squirrels in our study had ample opportunity to leave the area because of the large woodlots and numerous wooded corridors that lead off the study area. However, all travel remained on the study area in the woodlands, with most squirrels remaining in the general vicinity of the release point. On occasion, squirrels were located in fields along forest edges but they never traversed a completely open area.

The seasonal difference observed in movement from the point of release may have been influenced by habitat conditions. Larson (1990) observed that Delmarva fox squirrels shifted food consumption from soft mast during spring to hard mast during winter. During our midspring release, over 49% of squirrel activity, outside den sites, was in clusters of tulip poplar and bottomland hardwood stands, even though these areas accounted for <17% of the available woodland habitat. These sites supplied early spring food and cover. The fact that they were scattered throughout the study area helps to explain the increased variability in movement from the point of release associated with midspring-released squirrels. During the midautumn release, activity shifted almost totally (averaging 84.0%) to the release woodlot which had a number of mature hard mast-producing trees (*e.g.*, oaks, hickory and beech). Sweetgum-dominated forests were primarily used for travel.

Activity was restricted to areas close to the den sites of most squirrels during the latter portion of the midspring release (June–July). Some squirrels were never located outside their dens for periods of 7–10 days. Weigl *et al.* (1989) referred to this period as the disappearance phase. Fox squirrels will limit activity to the vicinity of the den site in an effort to conserve energy during summer periods when foods, like spring buds and autumn mast, are scarce. During the midautumn release squirrels also had periods of limited activity at the den site. However, upon emerging from their dens, movements were generally greater.

The high degree of site fidelity observed in this study suggests that the release site was suitable. Using Dueser *et al.*'s (1988) description of occupied habitat to select release sites may aid in the recovery efforts for the Delmarva fox squirrel. However, long-term evaluation of this and future release sites is needed to determine if this description is adequate.

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