

Reintroductions of the Endangered Delmarva Fox Squirrel in Maryland

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Abstract: Reintroductions of Delmarva fox squirrels (*Sciurus niger cinereus*) to suitable habitat have been a recovery tool used for this endangered species. In Maryland, we attempted reintroductions at 11 sites beginning in 1978. The last reintroduction was completed in 1992. At each site, 8–42 individuals were released during spring or fall over a 1–3 year period. Attempts were made to release an equal number of males and females. Monitoring at reintroduction sites by live-trapping has documented recruitment and establishment of populations at 9 sites. Criteria used for determining population establishment follows that of the Delmarva Fox Squirrel Recovery Plan (U.S. Fish and Wildlife Service 1993). Because 7 of these populations were established with <24 individuals, supplemental releases of Delmarva fox squirrels were conducted to bolster genetic diversity. This paper summarizes the history of Delmarva fox squirrel reintroductions in Maryland, provides the results of recent live-trapping efforts at the sites, and discusses success of these efforts.

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The Delmarva fox squirrel (*Sciurus niger cinereus*) was listed as an endangered species by the U.S. Fish and Wildlife Service in 1967. At the time of listing, endemic populations occurred in only 4 counties in eastern Maryland, representing <10% of the species former range (Taylor 1976). Historically, this fox squirrel occurred patchily throughout the Delmarva Peninsula of Delaware, Maryland, and Virginia, and into southeastern Pennsylvania. The primary reason for the decline of this species was loss of suitable forest habitat (Taylor 1973, 1976) though other factors such as hunting may have contributed (U.S. Fish and Wildl. Serv. 1993). Habitat required by the Delmarva fox squirrel is characterized as forests predominated by large trees (>30 cm d.b.h.) with sparse understory and groundcover (Taylor and Flyger 1974, Taylor 1976, Dueser et al. 1988). Tree species composition is highly variable among occupied forests, with loblolly pine (*Pinus taeda*) predominating in the southern portion of the Delmarva fox squirrel's range and hardwoods, including oak (*Quercus* spp.), hickory (*Carya* spp.), beech (*Fagus grandifolia*), tulip poplar (*Liriodendron tulipifera*), and red maple (*Acer rubrum*), in the northern part of the range.

Suitable, but unoccupied, habitat existed on the Delmarva Peninsula subsequent to the species' listing. Much of this habitat occurred in counties with no remaining

populations of Delmarva fox squirrels and at considerable distances from extant populations, thus natural reoccupation was limited. An experimental reintroduction was attempted during 1968–1971 at Chincoteague National Wildlife Refuge in Virginia when 30 Delmarva fox squirrels were translocated into suitable habitat (Dueser and Terwilliger 1987). This reintroduction was completed by releasing squirrels on 3 separate occasions at 1 area on the refuge. Squirrels were live-trapped from 2 source populations in Maryland. Reproduction was documented in 1971, and by 1974 this population had expanded beyond the original release area (Dueser and Terwilliger 1987).

Flyger and Lustig (1976) evaluated the potential for re-establishing Delmarva fox squirrel populations and concluded “it seemed highly probable that with proper management fox squirrels could be re-established in portions of their former range, especially since some of this range appears to be good fox squirrel habitat.” The Delmarva Fox Squirrel Recovery Team agreed with Flyger and Lustig (1976) and established a reintroduction objective as one of the primary recovery actions for the species (U.S. Fish and Wildl. Serv. 1979). The recovery objective for downlisting called for 10 new colonies to become established within the historic range but outside of the occupied range for a minimum of 5 years with evidence that expansion occurred beyond the original number released. Removal from the list entirely could be attained if an additional 20 prospering colonies could be established.

Criteria for determining establishment was developed by a subsequent Delmarva Fox Squirrel Recovery Team (U.S. Fish and Wildl. Serv. 1993). A reintroduced population would be considered established when either of the following conditions were met: (1) 5 or more years after the last release, 1 or more lactating females or 2 or more juvenile fox squirrels are captured in addition to at least another adult fox squirrel; or (2) 8 or more years after the last release, at least 3 fox squirrels other than those originally released or at least 1 juvenile fox squirrel is captured. The revised recovery plan established a downlisting objective of 10 new colonies established and delisting with an additional 5 post-1990 reintroductions.

The first reintroduction attempt in Maryland was initiated in 1978, and since then reintroductions were attempted at 11 sites throughout the Maryland portion of the Delmarva Peninsula. This paper summarizes these reintroductions and their status as of 2001.

Special thanks are extended to the private landowners who allowed for the reintroduction of an endangered species on their properties and for allowing access to monitor the outcomes. Also, special thanks are extended to the landowners who allowed Delmarva fox squirrels to be live-trapped and transported from their properties to serve as founder individuals for reintroductions. Members of the Delmarva Fox Squirrel Recovery Teams provided valuable input and assistance to these efforts over the past 25 years. Various staff of the Maryland Department of Natural Resources provided assistance in reintroductions and monitoring effects. C. Keller (U.S. Fish and Wildl. Serv., Chesapeake Bay Field Off.) provided graphics support for this paper. Three anonymous reviewers provided helpful suggestions for improving the manuscript. Funding for these efforts were provided in part by the Federal Aid in

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History of Maryland Reintroductions

Site Selection

Since the intent of the reintroductions was to re-establish the Delmarva fox squirrels throughout their historic range, sites were selected in counties in which no naturally occurring populations were known to exist with 1 exception. An extant population of Delmarva fox squirrels occurred on Eastern Neck Island at the extreme southern end of Kent County. This population was isolated from the mainland portion of the county with no other fox squirrels known to occur in the county.

Requirements for release sites were that suitable forested habitat was present, there was opportunity for population expansion beyond the site of release, landowners were willing to accept an endangered species onto their property, the site was to remain in suitable forested habitat, and no squirrel hunting was conducted on the property. There was no property size limit, though most sites were greater than 100 ha. Sites were nominated by members of the Delmarva Fox Squirrel Recovery Team, staff of the Maryland Department of Natural Resources, or interested landowners. Habitat was visually assessed for suitability by members of the recovery team.

For sites on private property, a verbal agreement between the landowner and the Maryland Department of Natural Resources was secured. No written agreements were developed. Essentially, the landowners agreed to allow for the release of this endangered species onto their property and to allow for periodic monitoring of that effort. No releases in Maryland were declared experimental nor were any safe harbor agreements entered into (since that mechanism was not yet available).

Release Methodology

At each reintroduction site, a holding cage was placed in suitable forested habitat. The holding cage was constructed of a wooded frame enclosed with heavy poultry wire. Dimensions of the cage were $4 \times 2.5 \times 2.5$ m. The cage was elevated 1 m off the ground. Six wooden squirrel boxes were placed in the holding cage, suspended on the sides near the top of the cage. Whole-eared corn, apples, and water were provided on the cage floor for food. The purpose of the holding cage was to allow the fox squirrels to become acclimated to the site prior to release.

Delmarva fox squirrels were live-trapped with Havahart No. 1025 or Tomahawk No. 103 or No. 106 traps from wild populations within the remaining historic range, primarily Dorchester County, and transported to the holding cage. Donor squirrels came from more than 1 location. Six fox squirrels were held in the cage from a few days to 2 weeks prior to release. At some sites more than 1 release occurred within a season, and at most sites releases occurred in more than 1 season.

Live-trapping and releases were conducted in spring or fall. No live-trapping was conducted in summer or winter due to extreme weather conditions. Fall releases

occurred no later than mid-October, so that fox squirrels had adequate time to secure den sites prior to winter. At most sites, nest boxes were erected in the vicinity of the holding cage to provide supplemental den sites.

An attempt was made to reintroduce an equal number of males and females. No effort was made to release a certain ratio of adults to juveniles, since the availability of juvenile fox squirrels varied seasonally and annually.

Prior to release, every Delmarva fox squirrel was weighed and marked. During the period 1978–1988, the principal method of marking was toe-clipping. One digit was clipped off the front or hind foot of each fox squirrel in such a manner that a different digit was clipped from each squirrel for individual recognition. After 1988, the principal method of marking was changed to ear-tagging. Individually-numbered ear tags (size 1 monel, Natl. Standard Band and Tag Co., Newport, Ky.) were placed in both ears of every Delmarva fox squirrel released. Some individuals, including adult males and females, were also equipped with radio transmitters (Wildl. Materials, Inc., Carbondale, Ill.) to follow their movements post-release. Each non-expandable neck collar weighed <15 g (<2% of minimum body weight) and had a maximum transmitting range of 1 km at ground level. Prior to placement of collars on the squirrels, each animal was anesthetized with Metofane (methoxyflurane), then allowed to recover for at least 1 hour after the collar was fitted around its neck.

On the day of release, each fox squirrel was weighed and marked in the holding cage and placed in a squirrel box until all individuals were processed. The door of the holding cage was left open and squirrels were either allowed to leave on their own or the nest box in which they were placed was taken out of the cage and opened. Releases were usually conducted in the late morning hours.

Reintroductions Attempted

In Maryland, reintroductions were attempted at 11 locations. The first occurred in 1978 and the last in 1991–1992. Table 1 lists the sites, years, and number of Delmarva fox squirrels released. All but 1 reintroduction (Fairhill) occurred on private property. At Remington Farms, the site of release was moved after the initial reintroduction to a location 7 km away because several of the initially-released fox squirrels had chosen to settle into the latter site.

Reintroductions were attempted in every county within the Delmarva fox squirrel's historic range in which no extant population was known (Fig. 1). Attempts by county were 1 each in Caroline, Cecil, and Wicomico; 2 in Worcester; and 3 each in Kent and Somerset.

Post-release Monitoring

Monitoring of Delmarva fox squirrels following release varied by site. At some sites, such as Remington Farms, annual live-trapping was conducted for 3 years post-release. At other sites, such as Andelot Farms and Harmony, nest boxes were monitored once each winter for 3 years after release. The purposes of these efforts were to document survival of the original animals and recruitment into the population. Recruitment was documented by capturing unmarked individuals, lactating females, or

Table 1. Number of Delmarva squirrels initially released at reintroduction sites in Maryland.

Site	Year(s) reintroduced	N releases	N individuals released		Total
			Male	Female	
Nassawango	1978	1	3	2	5
Remington Farms	1979–1983	3	10	9	19
Quaker Neck	1980–1981	3	10	8	18
Fairhill	1980–1982	3	9	6	15
Dryden	1981	2	4	5	9
Eby	1981	2	4	5	9
Jarvis	1982–1984	2	4	4	8
Riggin	1983–1985	2	14	12	26
Hazel	1986–1988	3	10	10	20
Harmony	1989	2	17	13	30
Andelot Farms	1991–1992	3	22	20	42

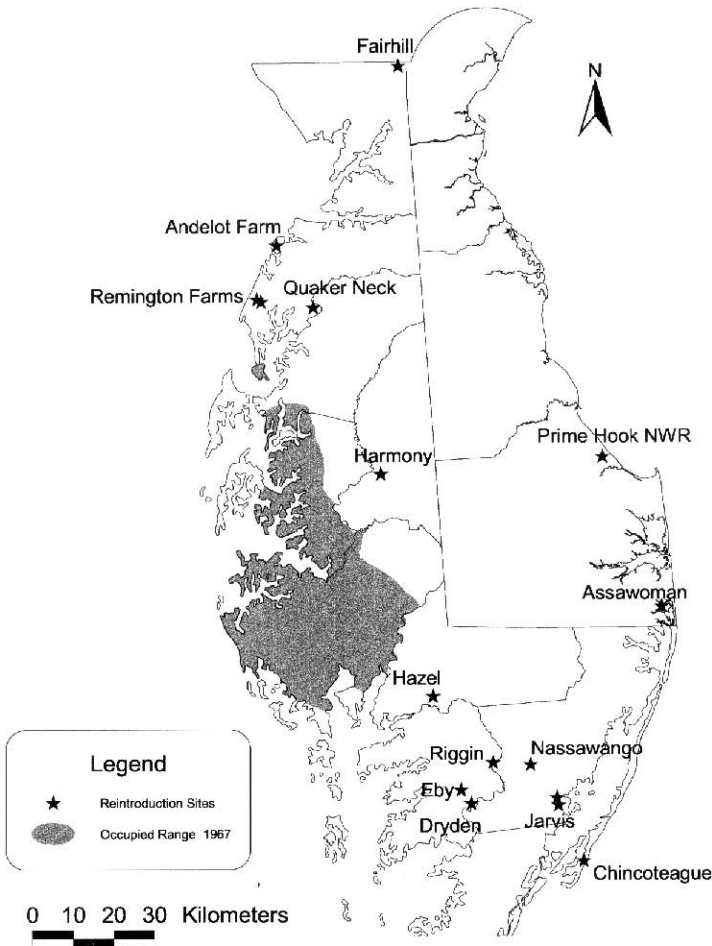


Figure 1. Locations of Delmarva fox squirrel reintroduction sites in reference to the remaining occupied range at the time of listing as an endangered species.

young in nest boxes. Recruitment was documented at the Eby, Harmony, Hazel, Remington Farms, and Riggins sites within the first 5 years post release.

Radio telemetry was used at several sites to monitor movements and survival of Delmarva fox squirrels immediately after release. Usually, 2–6 individuals were equipped with radio transmitters and followed weekly for the first 3 months after release. Monitoring was conducted on foot during daylight hours using a directional H-type antenna. Squirrels were located by triangulation and direct observation. Locations of each squirrel were mapped and dated. The most comprehensive effort of monitoring post-released squirrels was conducted at Andelot Farms. Bendel and Therres (1994) followed daily movements of the first 20 Delmarva fox squirrels released for at least 90 days post release. They found that translocated squirrels exhibited a high degree of site fidelity, though some individuals wandered >2,000 m in a single day. Similar results were found at other sites where radio telemetry was employed (Md. Dep. Nat. Resour., unpubl. data). Seasonal differences in movement were found, with spring released individuals moving more than fall released ones. Mortality at Andelot Farms was 25% during the first month after release, then decreased to normal levels (Bendel and Therres 1994).

Status of Reintroductions

Recent Monitoring

During 1990 to 2001, we revisited all but 1 reintroduction site to assess population status of Delmarva fox squirrels at the sites. The Fairhill reintroduction effort was believed to have failed, so no further monitoring was conducted there. At all other sites, live-trapping was conducted once or twice at each site to document presence of new Delmarva fox squirrels in the population and to assess relative abundance of the population.

A series of live traps were distributed within the forested areas at each reintroduction site during the spring or fall trapping period. During the period 1990–1994, number of live traps used per site varied between 15–35 and were set for 3–9 days. Number of traps per site was standardized in 1998 with 50 live traps used per site. Live traps were left open and corn placed in each for a period of 5 days. This pre-baiting period was used to acclimate squirrels to traps and bait. After 5 days of pre-baiting, traps were activated and squirrels were trapped for the next 3 consecutive days. On days of steady or heavy rain, traps were closed and checked the next suitable weather day. This protocol followed guidelines for monitoring given in the recovery plan (U.S. Fish and Wildl. Serv. 1993). All sites were trapped in spring (April through May), except that one trapping period at the Riggins reintroduction site was live-trapped in the fall (October 1998). All sites were trapped at least 6 years after the last release of the founder animals.

Delmarva fox squirrels were caught at 9 of 10 sites (Table 2). The only site where fox squirrels were not captured was the Nassawango site, where only 5 individuals were released in 1978. Numbers of individuals caught per site ranged from 1 to 10 prior to supplementation. All Delmarva fox squirrels captured were checked for

Table 2. Results of monitoring reintroduction sites in Maryland at least 5 years after the last release of Delmarva fox squirrels (DFS) by live-trapping during 1990–2001.

Site	Year monitored	Years post release	N DFS trapped	N lactating females	Catch per unit effort ^a
Nassawango	2001	23	0	0	0.0
Remington Farms	1990	7	3	1	1.1
Remington Farms ^b	2000	17	4	1	2.7
Quaker Neck	1990	9	3	0	2.9
Quaker Neck	2000	19	4	1	2.7
Quaker Neck neighbors	2000	19	3	1	2.0
Dryden	1999	18	4	1	2.7
Eby	1990	9	1	0	2.2
Eby ^b	1999	18	11	5	7.3
Eby neighbors ^b	1999	18	7	1	9.3
Jarvis	1990	6	5	1	3.6
Jarvis	1994	10	5	1	3.6
Riggin	1991	6	3	1	3.3
Riggin	1998	13	4	0	1.6
Hazel	1999	11	5	1	3.3
Harmony	2000	11	8	3	5.3
Harmony neighbors	1999	10	5	0	3.3
Andelot Farms	2000	8	10	2	6.7

a. Expressed as number of individuals caught per 100 trap days.

b. Monitored after supplemental release.

previous markings, sexed, weighed, and ear-tagged. No individuals originally released were captured during this monitoring period.

All 9 sites where Delmarva fox squirrels were caught met the U.S. Fish and Wildlife Service's (1993) criteria for an established population. At 8 of 9 sites, lactating females were trapped prior to supplementation and new individuals were trapped at all 9 sites.

Occurrences of Delmarva fox squirrels beyond the property on which the original releases occurred were reported by landowners, hunters, and others knowledgeable of Delmarva fox squirrel identification for at least 6 sites. We obtained permission to live-trap 3 neighboring properties as part of this effort. Delmarva fox squirrels were caught at all 3 sites (Table 2), documenting expansion beyond the release site. Visual observations by Maryland Department of Natural Resources staff confirmed expansion at a fourth site (Jarvis).

Supplemental Releases

All reintroduction efforts prior to 1985 were attempted with fewer than 20 individuals released at a given site (Table 1). The revised Delmarva Fox Squirrel Recovery Plan (U.S. Fish and Wildl. Serv. 1993) called for a minimum of 24 to 30 individuals to be released per site when attempting to establish a new population. Moncrief and Dueser (2001) found genetic variation of the re-established Chincoteague population, founded with 30 individuals, did not differ from a naturally occurring population. The recovery plan also called for supplementing previous translocations that

Table 3. Number of Delmarva fox squirrels supplemented at reintroduction sites in Maryland.

Site	Year	<i>N individuals released</i>		
		Male	Female	Total
Eby	1993	11	6	17
Remington Farms	1994	11	14	25
Jarvis ^a	1997	12	9	21
Dryden	1999	8	11	19
Hazel	1999	7	4	11
Quaker Neck ^b	2000	9	9	18
Riggin	2000	3	6	9

a. Supplemental animals released = 1.6 km north of original release site.

b. Eight supplemental animals released = 0.8 km west of original release site.

had small (<24 individuals) founder populations to bolster genetic diversity of the established populations. Seven reintroduction sites were supplemented with additional Delmarva fox squirrels (Table 3) after it was determined that populations had become established at these sites. All supplemental individuals released were live-trapped from stable populations within the historic range. They were sexed, weighed, and ear-tagged prior to release. All were released immediately upon arrival to the site; no acclimation period in a holding cage was employed during supplemental releases.

Discussion

Results of our monitoring efforts at 9 reintroduction sites suggest that Delmarva fox squirrel populations have been established as a result of the translocations. The criteria of the U.S. Fish and Wildlife Service (1993) for considering reintroduced Delmarva fox squirrel populations as established was met at 9 sites. At 8 sites lactating females were captured at least 5 years after the last original release. At 2 sites lactating females were documented 18 and 19 years after the original releases. At all sites, new unmarked individuals were captured.

Another measure of success is comparing re-established populations to naturally-occurring populations. Within the remaining range of the Delmarva fox squirrel, several monitoring and research efforts used live-trapping protocols similar to that used for monitoring the reintroduction sites. A comparison of population densities between reintroduced and natural populations would be an ideal way to assess success of reintroductions. Unfortunately, few such estimates of naturally-occurring populations exist and no attempt was made to do such at the reintroduction sites. Catch-per-unit-effort can be used as an indicator of population density. Captures per 100 trap days of effort has been obtained from several naturally-occurring Delmarva fox squirrel populations (Paglione 1996; Dueser 1999; Md. Dep. Nat. Resour., unpubl. data; U.S. Fish and Wildl. Serv., unpubl. data) and from our study.

Catch-per-unit-effort ranged from 1.1–9.3 Delmarva fox squirrels per 100 trap

days on sites where a population became established (Table 2). Paglione (1996) live-trapped Delmarva fox squirrels at 12 study areas on Blackwater National Wildlife Refuge in Dorchester County, Maryland, and had similar results (range = 1.6–10.8 individuals per 100 trap days). While monitoring benchmark populations at 3 sites within the fox squirrel's historic range during 1992–1998, catch-per-unit-effort averaged 4.9 individuals per 100 trap days at Hayes Farm, 7.5 at LeCompte Wildlife Management Area, and 5.4 on Wye Island (Therres and Willey, unpubl.data). At 2 other benchmark sites on Blackwater National Wildlife Refuge, catch-per-unit-effort averaged 12.1 individuals per 100 trap days on the Egypt Tract and 3.7 on the Jarrett Tract during 1991–1996 (Paglione 1996). Larson (1990) live-trapped 0.8 Delmarva fox squirrels per 100 trap days on Chincoteague Island, the location of the first reintroduced population.

Benchmark populations and others at Blackwater National Wildlife Refuge are considered secure, naturally-occurring populations. Given that populations at the reintroduction sites have similar catch-per-unit-effort results suggests that these populations have become established and increased in numbers to levels commensurate with naturally occurring populations.

Success of reintroductions of Delmarva fox squirrels in Maryland fits most of the predictor variables of successful translocations formulated by Griffith et al. (1989) and Wolf et al. (1996). Reintroductions were of wild-caught individuals released within the species historic range and into habitat of suitable quality. Reintroductions of game animals, of which the Delmarva fox squirrel was formerly classified, were found to have greater success than nongame species. Mammals were found to be better candidates for success (Wolf et al. 1996). Species with high potential for productivity (3 or more offspring and breeding by 2 years of age) which characterizes the Delmarva fox squirrel, were also found to have greater success during translocations. In most cases, our releases at each site occurred over more than 1 year. The 1 predictor variable that our reintroductions did not meet at most sites was number of individuals released. In Maryland, 3 Delmarva fox squirrel populations were established with <10 founder individuals each. Persistence and genetic variability of such populations is questionable; thus, all subsequently were supplemented with additional Delmarva fox squirrels. Genetic diversity of translocated Delmarva fox squirrels can be maintained with larger numbers of founder individuals (Moncrief and Dueser 2001).

Supplementation appeared to bolster re-established populations. Catch-per-unit-effort was increased at 2 sites monitored after supplementation (Table 2). At the Eby site, the greatest number of Delmarva fox squirrels per 100 trap days was recorded 6 years after supplementation. This number approaches that of Blackwater National Wildlife Refuge's Egypt Tract (Paglione 1996), which is considered the site with the highest density of Delmarva fox squirrel on the peninsula.

We consider reintroductions as a viable tool for recovery of the Delmarva fox squirrel and recommend that such efforts be expanded within the historic range of this endangered species. Periodic monitoring of all reintroduction sites should be continued.

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