U.S. Fish & Wildlife Service

Delmarva Peninsula Fox Squirrel
(Sciurus niger cinereus)

5-Year Review: Summary and Evaluation

Chesapeake Bay Field Office
Annapolis, Maryland

Summer 2007

5-YEAR REVIEW
Delmarva Peninsula Fox Squirrel (*Sciurus niger cinereus*)

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1.0 GENERAL INFORMATION

1.1 Reviewers:

U.S. Fish and Wildlife Service: Diane Lynch, Mary Parkin, Glenn Smith
Others: Carol Bocetti, Bill Giese, Bob Hilderbrand, Holly Neiderriter, Dan Rider, Scott Smith, Karen Terwilliger, Glenn Therres

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1.2 Methodology Used to Complete the Review

This 5-year review was developed by Chesapeake Bay Field Office (CBFO) staff. Dr. Cherry Keller, the lead biologist and primary author, was assisted and guided by Dr. Mary Ratnaswamy. Leslie Gerlich, CBFO GIS specialist, conducted most of the GIS analyses and obtained the GIS data layers used. Data for this review were solicited from interested parties through a Federal Register notice announcing initiation of this review on July 6, 2005, and through an August 18, 2005, email soliciting new information from interested parties. Data were provided by staff of the Maryland Department of Natural Resources, the Delaware Department of Natural Resources and Environmental Control, the Virginia Department of Game and Inland Fisheries, members of the Delmarva Fox Squirrel Recovery Team, and other experts. On January 12, 2006, a Federal-State Coordination meeting was held to discuss portions of the draft 5-year review, obtain comments on the approach, and seek additional information. On August 10, 2006, a draft review was sent to the Recovery Team and others for technical review; their input was incorporated into this document. A draft was sent from the Field Office to the Regional Office in September of 2006. Regional Office input was provided from a meeting held in November of 2006 and following discussions and input from these discussions was included in this final draft.

1.3 Background

This review constitutes an evaluation of information on the Delmarva Peninsula fox squirrel (*Sciurus niger cinereus*), generally called Delmarva fox squirrel, that has become available since 1993, when the Delmarva Fox Squirrel Recovery Plan (USFWS 1993) was last revised. During this time, there have been many sources of new information on this subspecies. A Status and Recovery Plan Update developed in 2002 (USFWS 2003) included a summary of newly derived information and a preliminary evaluation of threats. Additional sightings, new data, and a population viability analysis have become available since that update. The present review brings this additional information to the assessment of the subspecies' biological status and threats to its continuing survival. This review has been conducted in conformance with draft 5-year review guidance issued by the Service's Washington Office (USFWS 2006).

1.3.1 Federal Register notice announcing initiation of his review

70 FR 38976 (July 6, 2005): Initiation of a 5-Year Review of 5 Listed Species: The Virginia Northern Flying Squirrel (*Glaucomys sabrinus fuscus*), Delmarva Peninsula Fox Squirrel (*Sciurus niger cinereus*), Northeastern Bulrush (*Scirpus ancistrochaetus*), Chittenango Ovate Amber Snail (*Novisuccinea chittenangoensis*), and Virginia Round-Leaf Birch (*Betula uber*)

1.3.2 Listing history

FR notice:	32 FR 4001
Date listed:	March 11, 1967
Entity listed:	Subspecies
Classification:	Endangered

1.3.3 Associated rulemakings

Experimental non-essential population designated for Assawoman population (translocation) in Sussex County, Delaware. September 13, 1984 (49 FR 35951)

1.3.4 Review history

The DFS was included in cursory 5-year reviews conducted for all listed species between 1979 and 1991, as follows:

1. May 21, 1979 (44 FR 29566) – review of all listed prior to 1975

2. July 22, 1985 (50 FR 29901) – all species listed before 1976 and in 1979-80, resulting in a 1987 notice of completion (no change) on July 7, 1987 (52 FR 25522)

3. November 6, 1991 (56 FR 56882) – all species listed before 1991

No formal 5-year reviews have been conducted for the DFS since then; however, the following recovery plans and updates have included assessments of this subspecies' status:

1. DFS Recovery Plan. November 6, 1979
2. DFS Recovery Plan, First Revision. January 1983
3. DFS Recovery Plan, Second Revision. June 8, 1993
4. DFS Status and Recovery Plan Update. October 31, 2003

1.3.5 Species' Recovery Priority Number at start of 5-year review: 9C. Ranking for subspecies with moderate degree of threat, high recovery potential, and conflicts with economic development.

1.3.6 Recovery plan

Name of plan: Delmarva fox squirrel (*Sciurus niger cinereus*) Recovery Plan, Second Revision.
Date issued: June 8, 1993
Dates of previous revisions: Original recovery plan: November 6, 1979
First revision: January 1983

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) Policy

2.1.1 Is the species under review a vertebrate? Yes.

2.1.2 Is the species under review listed as a DPS? No.

2.1.3 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards? Not applicable.

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy? No.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes.

2.2.2 Adequacy of recovery criteria

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No. More recent information on the squirrel's distribution, subpopulation delineation, and population persistence is not reflected in the 1993 recovery criteria. Nonetheless, these criteria continue to act as generally appropriate measures of recovery.

2.2.2.2 Are all of the relevant listing factors addressed in the recovery criteria? No, none of the recovery criteria specifically addresses any of the five listing factors, although habitat-related threats are alluded to. The criteria evaluate the biological status of the species.

2.2.3 List the recovery criteria as they appear in the recovery plan, and describe how each criterion has or has not been met, citing information.

The 1993 revised recovery plan provides seven criteria for determining whether the DFS could be reclassified to threatened or delisted. While any reclassification action requires a five-factor analysis such as the one provided in this 5-year review, the recovery criteria act as milestones for assessing a species' conservation status. The DFS recovery plan states that upon meeting the first three criteria below, the squirrel could be reclassified to threatened, and upon meeting all criteria, the squirrel could be delisted. Recovery progress for the DFS vis-à-vis these criteria is discussed below.

Criterion 1: ***Ecological requirements and distribution within the remaining natural range are understood sufficiently to permit effective management.***
Criterion not fully met.

Considerable new information has been learned about the Delmarva fox squirrel's distribution and ecological requirements as summarized in this review and listed below.

- Current range and distribution based on USFWS GIS (Figure 1)
- Persistence of DFS populations from 1971 to 2001 (Therres and Willey 2005)
- Monitoring of benchmark sites (Dueser 1999)
- Recent monitoring of reintroductions (Therres and Willey 2002 and State data from DE and VA; see Table 1)
- Genetic variability of reintroductions compared to source populations (Lance *et al.* 2003)
- Revised Habitat Suitability model (Dueser, 2000)
- Population Viability Analysis (Hilderbrand *et al.* 2004)
- Effects of timber harvest (Paglione 1996; Bocetti and Patee presentation, 2003)
- Effects of fire for stand improvements at Chincoteague (Kulynycz 2004)
- Using LiDAR to assess habitat (Nelson *et al.* 2003, Nelson *et al.* 2005)
- Monitoring of the DFS at Home Port (trapping reports)

The most significant information needs that remain are: (1) an assessment of the amount of mature forest available within the DFS current range, and (2) a better understanding of the sustainability of the timber harvest across the squirrel's range.

Criterion 2: ***The following seven benchmark populations ... [a]re shown to be stable or expanding based on at least five years of data.***
Criterion has been met.

A benchmark site analysis conducted by Dueser (1999) focused on a slightly different list of populations than those specified in the 1993 recovery plan, but all seven sites were shown to be stable over five years based on the recovery plan's monitoring protocol. Although the original intent behind this criterion was to monitor natural populations as a means of determining the persistence or trends in the remnant population, the final list of sites included several translocations, probably because they were on public lands and monitoring might have been considered to be more feasible. Translocations, however, do not provide the best assessment of persistence or trends in the remnant population. Given this, whether Condition 2 has been met can be best determined by supplementing the benchmark results with additional data provided by Therres and Willey (2005), whose study determined presence/absence at 101 sites across the range and concluded that the DFS population was stable to slightly increasing.

Criterion 3: ***Ten new colonies are established within the species' historical range. Translocations that may contribute to this have already been conducted.***
Criterion has been met.

Eleven new colonies have been successfully established and have significantly expanded the range of DFS from the range known at the time of listing (see Table 1).

Criterion 4: ***Five post-1990 colonies are established, as defined by the criteria in condition 3, outside of the remaining natural range. These colonies will occupy various habitats and will represent an extension of the present range of the Delmarva fox squirrel.***
Criterion has been met.

Eight new populations have been identified: (1) northeastern Dorchester County, (2) southeastern Caroline County, (3) the Tuckahoe River Corridor in Talbot County, (4) northern Queen Anne's County (Chino Farms), (5) the Centreville area of Queen Anne's County, (6) the Kings Creek area of Talbot County, (7) northern Somerset County, and (8) Nanticoke Wildlife Management Area, Sussex County, Delaware (Figure 2). The latter population, discovered in southwestern Sussex County, represents the first population found in Delaware since the time of listing that was not a result of a translocation.

Criterion 5: ***Periodic monitoring shows that (a) 80% of translocated populations have persisted over the full period of recovery and (b) at least 75% of these populations are not declining.***
Criterion has been met.

All of the 11 translocated populations specified in Criterion 3 have persisted over the full period of recovery. While data on trends at these translocations are not precise, the catch-per-unit effort from post-release monitoring and observations of DFS at expanding distances from release site indicate that nearly all of these show either no decline or expanding areas of occupied habitat (Table 1).

Criterion 6: ***Mechanisms that ensure perpetuation of suitable habitat at a level sufficient to allow for desired distribution (according to results obtained in condition 1) are in place and implemented within all counties in which the species occurs.***

Criterion has been met in terms of development pressures.

There are several well-established programs that protect habitat from development (see Appendix C); these programs, in addition to State and Federal ownership, are currently protecting approximately 28% of the DFS-occupied habitat (Table 5). of the balance between public and privately protected lands is probably sufficient for recovery and is not expected change greatly, i.e., although acres of protected land may increase, the area of DFS-occupied habitat is also expected to increase on both protected and unprotected lands until some upper limit is reached for both protection and occupancy. This proportional limit is not a concern, however, if it can be shown that the total amount of mature forest acreage likely to remain on the landscape supports a viable and well-distributed DFS population.

Criterion 7: ***Mechanisms are in place to ensure protection and monitoring of new populations, to allow for expansion, and to provide inter-population corridors to permit gene flow among populations.***
Criterion has not been completely met.

Programs protecting land from development, as mentioned in Criterion 6, will also provide some protected areas for new populations. In addition, the analysis of current forest distribution included in the PVA (Hilderbrand *et al.* 2004) indicated, in general, that there is sufficient forest across the Delmarva Peninsula to allow for the presence and dispersal of DFS and that connectivity of habitat is not limiting for this subspecies. It should be noted, however, that this analysis could not distinguish mature forest habitat from all forest cover, limiting its utility in assessing habitat availability and sustainability across the range of the squirrel. With regard to monitoring, ongoing monitoring is being conducted at a limited number of sites, and a post-delisting monitoring program has not yet been developed.

2.3 Updated Information and Current Species Status

The information in this review focuses primarily on DFS populations in eight Maryland counties on the Eastern Shore (all except Cecil County) and in Sussex County, Delaware. Although the review also addresses the reintroduced population of DFS (releases occurred from 1968-1971) on Chincoteague National Wildlife Refuge (NWR) in Virginia, the potential for expanded distribution farther south through additional translocations is being evaluated as part of a Landowner Incentive Program grant to the State of Virginia and is not addressed in this review. The following sections summarize the biological status of the DFS and analyze threats to this subspecies based on information collected subsequent to the 1993 recovery plan.

2.3.1 Biology and habitat

DFS occurrence information is based on sightings reported by qualified observers, trapping data, and documentation from photo-monitors. Data are recorded and maintained in a GIS database at CBFO. Most information is recorded as point data (sightings, individual traps, etc.), which are then extrapolated into larger polygons that represent occupied habitat, sub-populations, and range (these terms are defined in Appendix A).

2.3.1.1 Population size and trends

Changes in species range: The current known range of DFS covers 27% of the Delmarva Peninsula; this represents the total acreage where DFS are likely to occur, delineated as the area within three miles of all occupied DFS habitat (Figure 1). In contrast, the range represented in the 1993 recovery plan included the distribution known at the time of listing (10% of the Delmarva Peninsula) plus the translocation sites (see Figure 1). The recovery plan map, an approximation of the map created by Gary Taylor (Taylor 1976), basically demarcated the periphery of documented sightings and presented the translocation sites as point data.

Comparison of the 1993 and current known ranges (see Figure 1) indicates that this subspecies has expanded eastward of the original distribution and toward the center of the Delmarva Peninsula. It is important to note, however, that although the current range appears to be larger and includes additional areas, the quantitative difference in total coverage between the 1993 and current known ranges is not very meaningful. Generally speaking, we can encompass all areas of occurrence into five general polygons that occupy approximately 26% of the Delmarva Peninsula. Below, we compare the known area of *occupied habitat* in1993 to known occupied habitat in 2005 to generate a more detailed description of where increases have occurred.

Changes in Occupied Habitat: The CBFO GIS allows comparison between a set of occupied-habitat polygons that represent the range as it was understood up to 1998 and a new set of polygons created from post-1998 sightings. Prior to 1998, we documented 102,867 acres of known occupied DFS habitat. Between 1998 and 2006, we added 25,567 acres of occupied habitat based on additional sightings, for a total of 128,434 acres. The additional acreage includes forested patches within the 1993 delineated range where DFS were not previously known to occur, as well as 11,608 acres of occupied habitat outside the 1993 range boundary, representing a range extension. Newly observed populations have been documented in eight localities (mapped in Figure 2):

1. Northeastern Dorchester County, Maryland
2. Southeastern Caroline County, Maryland
3. The Tuckahoe River Corridor in Talbot County, Maryland
4. Northern Queen Anne's County (Chino Farms), Maryland
5. The Centreville area of Queen Anne's County
6. The Kings Creek area of Talbot County
7. Northern Somerset County, Maryland
8. Nanticoke Wildlife Management Area in Sussex County, Delaware. This population represents the first population in Delaware that was not a result of a translocation.

We will never know with certainty which of these are newly established DFS populations and which represent historic but undetected populations; however, there is anecdotal information that some sightings are indeed new occurrences, as landowners who have lived in areas for 20 years report only recently seeing DFS. In any case, the known area of occupied habitat of DFS is now over 25,000 acres larger than it was in 1998, and some of the newly discovered populations significantly extend the periphery of the range known at the time of listing.

Although we can reasonably assume that some stands of occupied habitat blink out as a result of deterministic or random events, it is difficult to determine the extent to which previously identified occupied areas have been extirpated. In an attempt to do so, we compared post-1998 DFS sightings with the original distribution data set as a means of confirming continued presence of DFS. Assuming that recent sightings within 0.5 miles of an occupied-habitat polygon are evidence of continued DFS presence, continued presence can be confirmed in 92% of the 102,867 acres of occupied habitat identified as of 1998. This does not mean that the polygons without recent sightings have necessarily become extirpated; rather, they may simply lack confirming evidence, and follow-up on these sites is warranted. Nonetheless, DFS are considered to be absent in 212 acres (> 1%) of previously occupied habitat, based on trapping data or other evidence. These presumed extirpations generally occur in the vicinity of expanding urban/suburban areas.

Estimated total population size: Using a total area of occupied habitat of 128,434 acres (see above) and DFS density estimates, we can project a total population size of 20,000-38,000 DFS. The best density estimates come from mark-recapture data collected during studies at Blackwater and Chincoteague NWRs (Paglione 1996, Pednault-Willet 2002). Both studies had sites with densities that ranged from a low of 0.15 DFS/acre to a high of 0.5 DFS/ac (Paglione 1996, Pednault-Willet 2002). The average of these two values is 0.3 DFS/ac, suggesting a total population of about 38,000 DFS; a conservative projection, using a density estimate of 0.15 DFS/ac, indicates a total population size of at least 19,265 DFS or approximately 20,000 animals.

It should be noted that DFS density is variable across the landscape. Data are limited, but based on trapping catch-per-unit effort, frequency of observations, and general knowledge, densities of DFS in Dorchester, Talbot, and southern Queen Anne's County probably fall within the average-to-high range, while densities of DFS in northern Queen Anne's County and the periphery of the range (Caroline County) are probably average to low.

2.3.1.2 Population persistence

The following discussion evaluates specific sites where DFS have been monitored over time. These include translocation sites, benchmark sites, and a set of 101 locations where landowner surveys were conducted in 1971 and repeated in 2001.

2.3.1.2.1 Persistence of translocated or reintroduced populations

DFS recovery has focused on establishment of new populations within the historic range (Table 1); in all, 16 translocations have been attempted and monitoring data collected. Pursuant to the 1993 recovery plan, which called for additional monitoring and supplementation of populations that were started with less than 24 animals, considerable effort has gone into monitoring translocation areas, and additional DFS have been released at most sites. Results indicate that 11 of 16 translocations have been successful based on the criteria in the recovery plan (USFWS 1993, p. 42; also see Table 1). Data from the Maryland sites (Therres and Willey 2002) also indicate that the catch-per-unit-effort of DFS on reintroduction sites was comparable to live-trapping efforts conducted within the original DFS range. Additionally, recent sightings of DFS indicate that, for almost all the successful translocations, the squirrels have moved beyond the release site and occupied additional forest tracts. Thus, after approximately 25 years, almost 70% of the original release sites have persisting populations of Delmarva fox squirrels, with expansion indicated at the majority of these sites.

Of the unsuccessful translocation efforts (see Table 1), three were thought to have failed by 1993 (Nassawango, Fairhill, and Chester). A fourth (Brownsville, VA) began with a substantial number of DFS, but although a few DFS persisted at this site for an extended period, there was no evidence of reproduction (Terwilliger 2000). The most recent loss was the population at Assawoman, which was started with 13 animals and monitored as a benchmark site (see discussion on benchmark sites below). Despite comparatively low numbers, reproduction was occurring and the population persisted for about 15 years; however, Assawoman was not supplemented with additional animals, and this reintroduction is now considered unsuccessful according to the recovery plan criteria. It should also be noted that this population was designated as experimental in 1984 when it was established, in order to alleviate concerns about misidentification of DFS by gray squirrel hunters. Despite this concern, hunting of gray squirrels was never allowed at Assawoman, and the experimental status is not considered to have had any effect on the translocated population.

The population on Eastern Neck NWR was not counted as one of the 16 translocations; however, it started from an historic translocation conducted in the 1920s by the hunt club that owned the property at the time. The population thrived on this relatively small island for many years and was a source of DFS used to establish and supplement the translocated population at Chincoteague NWR (see Table 1). Recent trapping evidence and observations by refuge staff indicate that this population has diminished to a few individuals at most, and it remains to be seen whether this population will blink out or bounce back.

Genetics of translocated populations: Initial concerns regarding genetic diversity of translocated populations that derive from small founder populations has been evaluated to some extent. Moncrief and Dueser (2001) found that genetic variation of the translocated Chincoteague population, which was started with 30 animals, did not differ from a naturally occurring population. In addition, Lance *et al.* (2003) found that the current levels of genetic variation at nine translocated populations were representative of those found at 10 locations within the remnant natural population. Thus, at present, there are no data suggesting that genetic variation is a problem for translocated populations.

Summary: The majority of DFS translocations have shown success, and this technique has proved to be an important management tool for recovery of this subspecies. Supplementation appears to have helped several of the populations that were founded with low numbers and should be considered an important tool both for future translocations and for existing translocations that were started with fewer than 24 animals. DFS populations appear to be able to persist at low densities for relatively long periods of time before either blinking out or, possibly, rebounding under changed circumstances. Supplementing populations that are at very low densities, even naturally occurring populations, is a proven conservation measure.

2.3.1.2.2 Persistence of populations on seven benchmark sites

The 1993 recovery plan specified a series of benchmark sites where DFS were to be monitored for a minimum of seven years, using winter nest box checks and some trapping, in order to better understand the subspecies' population dynamics. The seven sites included Blackwater, Chincoteague, and Prime Hook NWRs; Hayes Farm; Lecompte and Wye Island WMAs, and Assawoman Wildlife Area. Only four of the sites, Blackwater, Hayes Farm, Lecompte, and Wye Island, are part of the remnant distribution of this species; the others are translocation sites. Monitoring results showed DFS to be present and breeding at all benchmark locations during the seven-year study period; however, since the conclusion of the benchmark evaluation (Dueser 1999), the Assawoman translocation has been deemed a failure.

Although the benchmark study provided some useful information, the seven sites chosen were probably not the optimal locations to assess persistence across the range. Further, although the relative numbers of DFS found among the benchmark sites were representative of high and low density sites, no population trend information could be gleaned from this monitoring effort. Annual variation in numbers was high, especially from nest box data; in general, the probability of finding DFS in nest boxes is highly dependent on winter temperatures (boxes are used if it is very cold) and availability of natural cavities (abundance of natural cavities limits use of boxes). Winter checks do, however, reveal females with young, as well as subadults, in the boxes, providing evidence of breeding and some information on litter size. In sum, the benchmark study described the persistence of DFS at these seven sites over a seven-year period and provided evidence of breeding and litter size at several sites. Trapping was also conducted at some of these sites and is still being conducted at Blackwater and Chincoteague NWRs. The resulting long-term trapping data can be useful in understanding local population dynamics but do not allow inference of rangewide trends.

2.3.1.2.3 Persistence of populations surveyed in 1971 and 2001

Persistence of naturally occurring DFS populations and colonization of new sites was also measured by following up on a 1971 survey. In 1971, Taylor and Flyger (1974) conducted a survey on the Eastern Shore of Maryland to determine the range of DFS. They interviewed knowledgeable individuals (e.g., biologists, game wardens, foresters, and landowners) regarding locations where DFS were known to occur and where they were known to be absent (based on none being seen despite frequent site visits). These interviews resulted in documentation of DFS presence at 65 locations and absence at 36 locations on the Eastern Shore.

In 2001, Therres and Willey (2005) revisited all 101 locations to assess current suitability and occupancy. Using the same methods, i.e., interviews with knowledgeable individuals, they determined DFS to be present at 71 sites (compared to 65 in 1971) (Figure 3). While these study sites did not extend into some areas where DFS are now known to be present, within the context of the original survey the follow-up study indicated persistence and a slight expansion of Maryland's DFS population.

2.3.1.3 Population viability

As described below, a population viability analysis was conducted for the DFS, using demographic parameters and environmental variables to identify the minimum size of a secure population and dispersal distance for interchange among populations (Hilderbrand *et al.* 2005).

Model parameters: Fecundity, the number of young produced per female, was estimated very conservatively as 1.2 for first-year females and 1.5 for ages two and up, based on litter sizes reported in the literature for this subspecies (1.7, Larson 1990; 2.2, Dueser 1999; 2.4, Lustig and Flyger 1975). Survivorship was estimated at 50% for juveniles (age class 0 to one year) and 66% for adults, based on Conner (2001). Conner (2001) found adult female survival in an unexploited population of southeastern fox squirrels (*Sciurus niger niger*) in Georgia to be 66% (range 55-80%). Paglione's (1996) estimate of female DFS annual survival (57%, range 51-63%) pooled juveniles and adults, consequently underestimating adult survival. Her results are, however, comparable to Conner's.

Fecundity and survivorship values were presumed to vary, and the PVA's model scenario thus incorporated variation of $\pm$20% in these parameters. The possibility of having two or more bad years in a row was also accounted for by allowing the correlation between annual survival rates to be as high as 0.4. Using these model features, 1000 simulations were run as a means of measuring the extinction rates of populations of different sizes.

Minimum size of a secure population: For modeling purposes, we defined a minimally secure population as having a 95% probability of surviving for 100 years. Using the modeling parameters described above, the PVA showed that a population with 65 females, or 130 total animals, has less than a 5% chance of extinction in 100 years. The habitat area required to support a population of 130 DFS, using an average density of 0.3 DFS/acre, amounts to 435 acres. Thus, a habitat base of 435 acres is presumed to support a minimally secure population (Appendix A).

Dispersal distance: The PVA also included a metapopulation analysis, for which it was necessary to estimate a reasonable dispersal distance, i.e., a distance within which populations could be considered interconnected. Based on several dispersal parameters (see Appendix A), we estimated that 75% of a given DFS population would have the ability to disperse to areas within 3.6 km (2.25 miles). We then buffered the occupied habitat polygons by half this distance (1.8 km, 1.125 mi) to identify areas within which DFS would be connected and beyond which populations would be considered isolated.

Subpopulations: Using the dispersal distance as a buffer around current occupied habitat, we can roughly identify interconnected subpopulations of DFS. However, because the Maryland portion of the squirrel's range includes a convoluted shoreline of peninsulas and rivers that can pose real barriers to dispersal, we further subdivided populations if they were separated by river barriers or constricted peninsulas where dispersal would be difficult even if distance isn't a limiting factor (Figure 4). Conversely, some of the populations on the periphery of the range were grouped if they were only slightly beyond the dispersal distance and there was relatively continuous habitat between them (e.g., Tuckahoe River Corridor). The result of this splitting and lumping was a series of 30 subpopulations of DFS occupying different-sized habitats.

The PVA then allowed us to characterize the likely persistence of these subpopulations based on their size and connectivity. If the subpopulation did not occupy at least 435 acres of habitat, it was considered small and its persistence tenuous. Subpopulations occupying more than 435 acres were classified based on size and proximity to (connectivity with) other subpopulations. At the present time, eight of the 30 subpopulations occupy less than 435 acres, and the model suggests that these small subpopulations are likely to be extirpated within 100 years. In terms of total extent, however, these small subpopulations cover only 2% of the total occupied habitat for DFS, and this level of lost distribution is not viewed as significant. More importantly, 96% of DFS-occupied habitat is occupied by 15 subpopulations, each of which covers over 1000 acres. As such, the present size and distribution of DFS populations appear to be relatively stable, although their continued viability must also be considered within the context of ongoing and foreseeable threats, particularly threats pertaining to habitat viability, as discussed in section 2.3.2 below.

2.3.1.4 Summary of biological assessment

Current DFS distribution is more extensive than that reported in the 1993 recovery plan. Although similar comparisons cannot be made with regard to rangewide population trends (because population size was not estimated in the past), total population size is currently estimated to be at least 20,000 animals, and new populations have been discovered to the north and east of the 1993 known range and near translocation sites. Eleven reintroduced populations are considered to be successful and contributory to the overall stability of the species. Because translocations are inherently more vulnerable to extirpation, we can infer that this rate of success is indicative of even higher rates of persistence in the natural populations. Indeed, population persistence within the natural range appears to be good, based on continued DFS presence at a majority of the 101 sites surveyed first in 1971 and later in 2001 (Therres and Willey 2005). Moreover, the persistence of DFS in 92% of the occupied habitat identified prior to 1998 has been confirmed on the basis of recent sightings within 0.5 miles of the delineated areas. Finally, a PVA model showed that 435 acres of habitat occupied at an average density would contain a population with a 95% probability of persistence over 100 years. Based on maps delineating general forest cover on the Delmarva Peninsula, only 2% of DFS populations occur on habitat patches smaller than 435 acres, whereas 96% of the population comprises 15 subpopulations, each of which occurs on over 1000 acres of habitat. Although our understanding of DFS occupancy may change when maps distinguishing mature from non-mature forest patches become available, based on the available evidence, the total population of DFS appears to be viable under current conditions.

2.3.2 Five-factor analysis

The 1993 recovery plan stated that, "timber harvest, short-rotation pine forestry, and forest conversion to agriculture and/or structural development (housing, roads, industry) constitute broad threats to the Delmarva fox squirrels and their habitat" (USFWS 1993, p. 12). For purposes of this review, these and other identified threats to the long-term survival of DFS have been categorized into the five factors used to list species under the Endangered Species Act (ESA), including habitat alteration, overutilization, disease or predation, inadequacy of regulatory mechanisms, and other factors. The five factors have then been assessed to determine whether the DFS meets the definitions of endangered – its current listing classification – or threatened under the ESA.

As a context for this assessment, it is important to first understand land use and land use trends within the range of this subspecies, as discussed below.

The Delmarva fox squirrel now occurs in eight Maryland counties on the Eastern Shore (all but Cecil County), as well as Sussex County, Delaware, and on

Chincoteague NWR in Virginia[1]. Land use within the range of DFS generally comprises a blend of forest and agricultural land uses. Agriculture is the predominant land use within the northern four counties of the squirrel's Maryland range, with forests covering only 24-31% of the land area (Table 2). Conversely, forests cover 36-53% of the land area in the southern four Maryland counties. Sussex County, Delaware, has approximately 35% forest cover. The percentage of each county that is developed ranges from 5-14% (Table 2).

Comparisons of land use between 1973 and 2002 (Table 3) show that development has increased in all eight Maryland counties through conversions of both forest and agricultural land, and it is likely that development will continue to increase commensurate to county population growth. The population of the four upper Eastern Shore counties was 123,344 people in the year 2000, with a projected population of 175,850 by 2030 (Maryland Department of Planning 2005). The human population on the lower Eastern Shore (including Ocean City and the town of Salisbury, albeit DFS do not occur in the vicinity of these two municipalities) was 186,608 in 2000, with a projected population of 249,950 by 2030. Sussex County in Delaware currently has 157,430 people, with projections of 252,388 by 2030 (http://censtats.census.gov/data/DE/0501005.pdf).

Most of this nine-county landscape consists of privately owned lands, with approximately 10% in State or Federal ownership (Table 4). In addition to the protections that generally accrue to public lands, a certain amount of private lands is considered protected from development because of easements on the land or because of ownership by conservation organizations. Combining the Federal, State, and protected private lands, the total percentage of land protected from development varies from 10% to 28% across the counties. The data in Table 4 describe the entire area of the nine counties, including protected forests, agricultural lands, and wetlands. These data provide a sense of the landscape and the potential for development across the landscape but do not specifically address the threat of habitat loss where DFS actually occur. Table 5 shows the proportion of DFS-occupied habitat that is currently protected from development in each county. In the three counties where DFS are most abundant, the proportion of occupied habitat that is protected from development ranges from 19% to 40%. The location of protected lands relative to DFS-occupied habitat were analyzed using the CBFO GIS, the results of which were then used in conjunction with DFS subpopulation information to assess the threat of habitat loss from development, as discussed below.

[1] The sole extant Virginia population occurs on highly protected land on an island of the Virginia coast. Because of this limited distribution, land use trends across Virginia are not considered a threat to the Chincoteague DFS population and will not be discussed here.

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of [the species'] habitat or range

2.3.2.1.1 Threat of habitat loss due to forest conversion for development

Effects of individual residential developments: Residential development can negatively affect DFS through: (1) direct loss of forest habitat, (2) degradation of habitat by homes or roads that are built within 150 feet of DFS habitat (i.e., various effects emanating from homes and roads may reduce survival of DFS), and (3) potential isolation of populations caused by siting developments in constricted areas needed for DFS dispersal. Once a dense residential development is built in a forested area, we do not consider DFS to likely inhabit the area, albeit they may use adjacent woodlands and nearby travel corridors. Conversely, if residential developments are built in farm fields, the effects may be minimal (primarily degradation of adjacent wooded areas), and although development of farm fields causes loss of an additional food source for DFS, DFS should be able to persist without the additional forage if their wooded habitat is adequate. In cases where homes and roads are built in agricultural fields but leave some undisturbed edge, we would expect DFS to continue to occupy nearby woods provided that the habitat is of sufficient size or is adequately connected to other woodlands. Thus, while developments can have a major impact on local DFS populations, the threat they pose to DFS across the landscape depends on how many acres of forest are lost and to what degree connectivity is impaired.

Observations indicate that although DFS do not inhabit suburban areas, they do occur in woods near low-density housing, (e.g., where a home may be surrounded by at least 40 acres of woods, or where a few homes are built along the edge of occupied woods). However, the precise density of housing that can be tolerated by DFS is unclear. We have conducted repeated trapping at one site from pre-development to build-out of 16 homes on a somewhat isolated peninsula, from which we can infer that on isolated sites where access to larger blocks of habitat is limited, small (e.g., 25-acre) woodlots near housing developments may not be able to support DFS over the long term. Periodic trapping of DFS before and after development projects in other settings is needed to better understand the landscape settings where housing and DFS can co-exist.

Threat posed by development across the landscape: As the human population increases on the Delmarva Peninsula, residential and commercial development (primarily buildings and associated roads) will result in the irretrievable loss of some agricultural fields and forested habitat. In addition, clusters of development and roads can isolate DFS populations, degrade adjacent habitat, and/or create obstacles for dispersal of DFS. Given that development will increase and habitat will be lost, the critical question is whether extant DFS populations can withstand this threat, which depends on *where* development is occurring relative to where the DFS populations are. To assess the level of threat to DFS due to habitat loss or degradation across the landscape, a GIS analysis was conducted. DFS subpopulations (as defined by the PVA) were overlaid with areas likely to be developed, including the "smart growth" areas of all counties (where there are State incentives for development such as assistance with infrastructure). Locations in Queen Anne's, Talbot, and Dorchester counties where county planning and zoning agencies have received proposals for development were also included, because DFS are most abundant in this part of the range, and development pressures thus have the greatest potential for impact in these three counties. Specific sources for the GIS layers are described in Appendix B.

The GIS analysis also included spatial delineation of areas where Federal, State, or private ownerships and easements preclude future development. As stated above, up to 28% of the occupied habitat across the range of DFS is on public or private land protected from development (Table 5). These protected areas ensure that some habitat that will remain despite continued development, and to some degree these areas will act as stepping-stones or corridors that will continue to facilitate DFS movement across the landscape. GIS overlays of development and protected areas were also used to predict where connectivity would be maintained among subpopulations (Figure 5) as a means of assessing the likely persistence of subpopulations in the face of projected development patterns.

Analysis results: Over 3,000 acres of habitat occupied by DFS subpopulations occur in areas likely to be developed, as evidenced by their overlap with smart-growth areas or proposed development sites (Table 6). Although it is likely that some woodland will remain on these sites after development, the GIS analysis assumed that all woodlands subject to development will either be lost or become unsuitable for DFS. Based on this analysis, the likelihood of persistence of each subpopulation subject to habitat loss or loss of connectivity was rated as 1 (very likely to persist), 2 (likely to persist), 3 (might persist), and 4 (expected extirpation) (Figure 6).

As one example, the Dorchester County subpopulation occupies over 85,000 acres of habitat and is very likely to persist regardless of expected losses due to development of nearly 1,000 acres (Table 6). Further, the three largest subpopulations (including the Dorchester County subpopulation) together contain almost 100,000 acres of occupied habitat – 80% of the known DFS-occupied habitat – and have the highest rating for likelihood of persistence despite likely losses of over 2,000 acres. Six small and isolated populations that are expected to become extirpated due to habitat loss occupy approximately 1,700 acres, while four other small- to medium-sized subpopulations could either persist (if they grow and merge together) or disappear (if they trend toward smaller, more isolated subpopulations). However, even if all the subpopulations classified as "expected extirpation" or "might persist" were actually lost, the remaining habitat would cover over 90% of the current occupied area supporting 20 subpopulations. In addition, if current DFS population trends continue and additional habitat becomes occupied, habitat loss accruing from development may be offset by gains in occupied habitat elsewhere. Thus, despite continued development, available data and GIS analysis indicate that loss of occupied habitat due to development will neither endanger nor threaten the DFS.

2.3.2.1.2 Threat of habitat loss due to timber harvest

In the 1993 recovery plan, timber harvest and short-rotation pine forestry were identified as continuing threats to the DFS (USFWS 1993, p. 12). Timber harvest can pose a threat if the rate of harvest exceeds the rate of forest growth, in which case timber harvest will reduce the acres of mature forest constituting suitable DFS habitat. Short-rotation pine forestry prevents forest acreage from ever becoming suitable for DFS, because trees are harvested before they become mature enough to provide essential habitat components. Available information on the effects of individual timber harvests indicates that a timber harvest within a larger forested landscape can be tolerated by DFS; however, the additive effects of timber harvests across the landscape as well as the effects of short-term pine forestry remain concerns. All of these factors and the risks they pose to DFS are discussed below.

New information on the effects of individual timber harvests: The impacts of individual timber harvests were not described in detail in the recovery plan. However, the Habitat Management Guidelines for timber harvesting (USFWS 1993, Appendix G) recommended that individual timber harvests retain at least 15-25% of the forested area on a tract and that the retained woods should be adjacent to riparian woods or other wooded areas. While not explicit, the underlying rationale implied that the effects of the timber harvest were reduced if some habitat remained on site for DFS to move into, and this basic concept is supported by more recent studies.

Since 1993, two major studies of the effects of timber harvest on DFS (Paglione 1996, Bocetti and Pattee 2003) have been conducted. In both cases the study areas were in Dorchester County, and most were surrounded by forest. The conclusions from these studies suggest that the effect of individual timber harvests on DFS depends on the size, location, and landscape position of the harvest. Smaller clearcuts (30-50 acres) that are surrounded by forests have relatively little impact on DFS, as individual squirrels shift their home ranges into adjacent habitat (Paglione 1996). In addition to adjacent forests, DFS will also use habitat islands that remain in clearcuts (Bocetti and Pattee 2003); in fact, in clearcuts surrounded by forest, the catch-per-unit-effort of DFS trapped in the overall area did not change dramatically after clear-cutting, whereas the number of gray squirrels was substantially lower after the timber harvest (Bocetti and Pattee 2003). When timber harvests occur in isolated woodlots or wooded peninsulas that are nearly surrounded by agricultural fields, however, DFS leave the site and have to travel much greater distances to move into suitable, and possibly already occupied, habitat (Paglione 1996). These findings lead to the conclusion that, generally speaking, DFS can accommodate timber harvests as long as there is sufficient adjacent habitat to move into.

Threat from short-rotation pine forestry: Short-rotation pine forestry involves harvesting at approximately 25 years for pulp and other fiber products. Since it takes approximately 40 years to produce suitable DFS habitat, acreage harvested at 25 years never becomes suitable for DFS. Chesapeake Forest Products Corporation (Chesapeake) and Glatfelter Pulp Wood Company have been the major industries on the Delmarva Peninsula managing for short-rotation pine. In 1999, the State of Maryland acquired 58,000 acres of Chesapeake land to be managed for sustainable timber production and wildlife values; these lands comprise scattered parcels throughout the southern four counties. In addition, 10,384 acres of forest land previously owned by Chesapeake and managed for short-rotation pine are now owned by the State of Delaware. Land previously owned by Glatfelter Pulp Wood Company has also been put into an easement held by the State of Maryland (Vision Forestry, LLC. 2004). All of these lands, which were previously managed on short-rotations, will now be protected from development and managed for sustainable sawtimber harvest and wildlife habitat objectives.

Most of the former Chesapeake land is currently in early stages of succession, with 70% of the Maryland stands being less than 25 years old (Maryland DNR 2005, Chapter 3, Table 8); nonetheless, some mature forest has been maintained, and DFS currently occupy about 5,844 acres of these lands (Table 5). DFS management has been integrated into the Sustainable Forest Management Plan for Chesapeake Forest Lands (Maryland DNR 2005, Chapter 8), and 33,899 acres are designated specifically for DFS management. These areas will be harvested on 60-80 year rotations, and management will emphasize mature mixed pine/hardwood stands (Maryland DNR 2005, Chapter 8 p. 100). Although the Chesapeake acquisition substantially removes the threat posed by short-term rotation pine management and provides a positive outlook for future habitat for the DFS on the lower shore, it is important to remember that most of these lands are currently unoccupied and will not be suitable habitat for at least 15 years.

Threat posed by timber harvest across the landscape: The response of Delmarva fox squirrels to individual timber harvests suggests a compatibility between this subspecies and sustainable timber harvest, i.e., harvesting at a rate that does not exceed the rate of regrowth. With sustainable timber harvest, a constant supply of mature forest is available, although stand location changes through time. Because DFS can move into adjacent forested areas in response to timber harvest (Paglione 1996, Bocetti and Pattee 2003), DFS can continue to occupy this shifting mosaic of stands; however, if mature timber is cut at a faster rate than the forest stands grow back, there will be a steady decline in mature timber and DFS habitat. The fundamental requirements for DFS are enough mature forest within the dispersal area of DFS to support viable DFS populations and a rate of harvest that will not cause a steady decline in habitat availability. Using the best available data on the acres of existing forest land and an estimate of annual harvest, we evaluated whether timber harvest was being conducted at a sustainable rate, as discussed below.

Estimate of total timberland: The U.S. Forest Service's Forest Inventory and Analysis (FIA) (Frieswyk 2001, Griffith and Widmann 2001) provides an estimate of the acreage of timberland (forest land producing or capable of producing crops of industrial wood) and sawtimber for each county in the range of DFS (Table 7). Based on 1999 data, Dorchester County, for example, has an estimated 132,800 acres of timberland, of which approximately 79,700 acres (60%) is considered sawtimber (i.e., mature forest stands producing sawlogs and likely to be suitable for DFS). This survey is repeated every 7-10 years, and although there is some sampling error associated with these estimates, these are currently the best data available.

Harvest Rate: Timber harvest rates have not been summarized by State or County foresters, but the Sediment and Erosion Control permits required for all timber harvests and issued by each county's Soil Conservation District provide a starting point for understanding rates of harvest across the squirrel's range. Permit records were available for different time periods in each county, as many counties do not keep older permits or keep a data base. Noting that the data come in different forms and require some interpretation, the available permit data nonetheless allow us to estimate the acres that are permitted for timber harvest annually (Table 7). In some counties, such as Sussex County, the acres permitted may be an accurate estimate of the actual harvest, but in other counties, such as Dorchester County, permitted acres are likely to result in an overestimate.

Timber harvest trends: To calculate rotation lengths on a county basis, we divided the total acres of timberland in each county by the estimated annual timber harvest (based on permits issued), recognizing that harvested areas are constantly regenerating (see Table 7). The resulting coarse estimates suggest that the northern counties have long rotation lengths, well beyond the estimated 40 years it takes for a stand to become suitable DFS habitat. However, several southern counties have much shorter rotation lengths. Dorchester County's total of 132,800 acres of timberland, with an average of 2,507 acres harvested annually, is indicative of a 53-year rotation length, and Somerset County 87,800 acres of timberland and an average 2,849-acre annual harvest suggests a 31-year rotation length. In lieu of better information, these figures suggest that suitable habitat is available for only 13 years in Dorchester County before being re-harvested, and no mature forest is available in Somerset County! It is clear that the available harvest rate data are insufficient in terms of understanding past and longer-term trends, and we recognize that not all forest acres will be cut. In addition, the averaging of county-wide harvest rates does not closely reflect the variability of harvest across the landscape. However, even if these estimates are not precise, they suggest that timber harvest is not occurring at sustainable levels in every county and that DFS-suitable habitat could be declining in some counties.

Regarding impacts on DFS habitat, timber harvest affects the largest number of acres each year and is currently the most poorly understood listing factor. If timber harvest is in fact reducing mature forest acreage in the southern part of the squirrel's range, as the available data indicate, then we would conclude that timber harvest is threatening this species. Further, the expansion of DFS distribution that has taken place since at least 1993 could be reversed if apparent habitat losses due to timber harvest, particularly alongside losses due to development in the northern counties, were to continue.

It is important to note, however, that currently available remote sensing data do not enable an accurate inventory of mature forest. A more complete inventory of mature forest and a more accurate and spatially explicit assessment of the actual harvests occurring across the squirrel's range are needed to determine the true extent to which timber harvest may be causing declines, if any, in this species' habitat.

Information needed to assess current acreage of potential DFS habitat: The DFS inhabits mature forest of mixed species with large trees, a relatively closed canopy, and a somewhat open understory (Dueser 2000). The species composition of stands can vary widely, but mature forest with sufficiently large trees is essential. A recent study found similar variables predictive of DFS occurrence within a forest stand, particularly canopy cover, canopy height, and patchiness of the understory shrubs (Morris and Stauffer 2005).

It is surprisingly difficult to assess current acreage of mature forest that constitutes potential DFS habitat. GIS data on general forest cover and detailed data on tree species composition are available, but there are no GIS data sets for forest stand maturity or tree size. The aerial imagery currently available for the CBFO GIS is mid-1990s infra-red imagery taken at leaf-off, which is insufficient for distinguishing forest age or height; this information is also becoming outdated.

Airborne laser data can provide remote sensing information on the location and amount of mature forest that may be suitable for DFS; this information is now being collected and will be analyzed shortly. Nelson *et al.* (2005) showed that 78% of the transects identified by LiDAR were considered to be suitable habitat for DFS based on ground measurements and Dueser's (1999) habitat model. A comprehensive map of canopy heights and mature forest will enable a complete assessment of the acres of mature forest habitat in a spatially explicit manner. This information will also enable us to determine acres of past timber harvests in different stages of regrowth. With this information, we can evaluate the extent to which past and current timber harvests may threaten this species by reducing their habitat.

Synthesis of threat of timber harvest: The transfer of the Chesapeake and Glatfelter timber lands to Maryland and Delaware with the provision that they are to be managed for sawtimber and wildlife goals significantly offsets the potential threat from short-rotation pine forestry. Further, these land transfers in conjunction with available data on harvest rates across the range of the squirrel make it appear doubtful that timber harvest poses an extinction risk to the squirrel. However, until we have a more complete understanding of the availability and spatial distribution of mature forests for DFS and a more thorough assessment of harvest rates across Dorchester and other counties, we cannot conclude that the timber harvest does not pose a threat to this species. An inventory of the current acres of mature timber and its connectivity (especially in Dorchester County) is needed, and a better analysis of harvest trends – especially in the southern part of the squirrel's range – is needed.

2.3.2.2 Factor B. Over-utilization for commercial, recreational, scientific, or educational purposes

Squirrel hunting may have been a factor in the original decline of this species. At the turn of the century, forest cover was less widespread than it now is, and the clearing of forest for agriculture resulted in fragmented forests in some areas of the squirrel's range (e.g., Queen Anne's County). Hunting within small and increasingly isolated DFS populations in forest fragments (e.g., narrow riparian corridors or small woodlots) likely resulted in local extinctions. This was a conjecture of Taylor (1976), who noted that DFS appeared to persist on large agricultural estates where hunting was not allowed; these areas may have provided a network of refugia for DFS as the subspecies was extirpated elsewhere. Squirrel hunting was fairly popular in the early and middle decades of the 1900s, and, given the Delmarva fox squirrel's larger size and tendency to be on the ground, DFS may have been hunted in preference to gray squirrels.

Delmarva fox squirrels have not been hunted since 1972. This, combined with other factors, is a possible contributing factor to an expanding DFS population, including re-colonizations and new occurrences in recent years, especially along riparian corridors that provide dispersal habitat across the landscape. Populations in riparian habitats (e.g., the Tuckahoe River populations) could become particularly vulnerable to local extinctions if hunting programs were to be reinstated; even so, the threat posed by hunting is probably low, because all hunting is now more carefully managed and the popularity of squirrel hunting has declined in favor of deer hunting. Although it is possible that misidentification may result in some accidental take of DFS by gray squirrel hunters, this is not viewed as a significant problem, especially considering the overall decline in the number of hunters pursuing gray squirrels. At any rate, hunting does not currently pose a threat to long-term survival of this subspecies.

2.3.2.3 Factor C. Disease or predation

Despite limited anecdotal information about predation by domestic and feral pets (e.g., cats and dogs) on DFS, there is no evidence of population-level effects. Avian and fox predation also occur, but this subspecies evolved with mammalian and avian predators and there is no evidence that natural predation poses a threat. For instance, local DFS populations may decline when red fox populations increase, but these types of events are sporadic and localized. There is some suggestion that avian predation (e.g., by great horned owls) may increase in areas where trees have been thinned just prior to harvest (Paglione 1996, p. 58), and there is some cause for suspecting that individual DFS using pine plantations are particularly susceptible to avian predation (W. Giese, Chesapeake Marshlands NWR Complex, *in litt.*). Regarding disease, DFS are known to carry and succumb to leptospirosis. Overall, however, there is no indication that either disease or predation constitutes an extinction factor for this subspecies.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms

Regulatory mechanisms must be considered with respect to how effectively they are safeguarding the species and its habitat as recovery is implemented, as well as how adequately they might protect DFS from endangerment or extinction after ESA protections are lifted. While past hunting and land use regulations were clearly inadequate in terms of preventing the original decline of DFS, several state laws and programs have been enacted since the species was listed. This assessment considers the conservation benefits of these programs to DFS and whether they would be adequate for protecting the squirrel after delisting.

The DFS is listed as endangered by all three states in which it occurs and is therefore directly protected, albeit to varying degrees, under state endangered species laws. In Maryland, all species listed as endangered or threatened under the federal ESA are State-listed, and conservation of these species closely follows federal programs. Delaware has a limited endangered species act that provides for State listing and restricts trafficking of listed species; penalties include fines and/or jail. Virginia has separate laws that cover endangered plants and animals; for animals, listings are based on scientific evidence only and take penalties include fines and/or jail. As with Maryland, federally listed species are included on Delaware and Virginia State lists, and when species are removed from the federal list, the states have discretion to remove them from their lists. This implies that a secure rangewide status must be achieved independently of protective state regulations in order to delist the DFS.

The Maryland Critical Areas Act, state-implemented wetland laws, and the Forest Conservation Act have proven to be significant long-term mechanisms for preserving forest land and DFS habitat in Maryland (Appendix C). The general requirements for conserving riparian forests in designated Critical Areas provide a means of maintaining important riparian forest as travel corridors for this species. In addition, the Forest Conservation Act will continue to provide protected forest areas within and along developments, which should support the movement of DFS through the landscape. The State-implemented Clean Water Act, however, provides the most significant protections, simply because the vast majority of forest lands that remain in Maryland, as well as in many areas of Delaware, contain forested wetlands; many forests today are present because they were too wet to farm and were thus not converted to agricultural many years ago. Even with programs that may promote long-term protection of both a significant amount of forest acreage and important aspects of habitat connectivity across the squirrel's range, some level of habitat loss must be anticipated both before and after delisting.

2.3.2.5 Factor E. Other natural or man-made factors

Forest pests: Gypsy moth and pine bark beetle outbreaks can decimate mature forest stands, albeit the affected stands will eventually regenerate. The last major gypsy moth outbreak in Dorchester County was in the early 1990s, and because gypsy moths have cyclic populations, another outbreak is anticipated there in the foreseeable future (M. Taylor, Maryland Department of Agriculture (MDA), *in litt.*). Pine bark beetle outbreaks are also a problem. Pine bark beetles necessitated salvage cuts of approximately 2,000 acres across Somerset, Dorchester, and Worcester counties in the early 1990s, and recent weather conditions (e.g., droughts and warm winters) suggest that another outbreak could occur soon (R. Rabaglia, MDA, pers. comm.). Reduced habitat availability caused by pest outbreaks could pose a considerable problem for DFS if concentrated in Dorchester County where DFS are most abundant. It should also be noted that there are few incentive or regulatory programs for pest control on private lands aside from the U.S. Forest Service's "State and Private Forestry Program," which provides funding for control efforts. This places habitat on private lands, particularly lands under regulatory protection, at greater risk of loss from forest pests. For example, if a landowner in Maryland owns timber stands within a designated Critical Area where harvest is restricted, it is less likely that an investment will be made to protect that timber from pests (W. Giese, Chesapeake Marshlands NWR Complex, *in litt.*).

Recognizing that forest pest outbreaks are likely to recur, safe control measures should be implemented and infestations should be monitored; nonetheless, this threat appears to be localized, sporadic, and not in and of itself an extinction risk factor.

Sea-level rise: Sea-level rise and land subsidence could result in the progressive but gradual inundation of DFS habitat within the Chesapeake Marshlands NWR Complex and other areas of southern Dorchester County. Historically, sea-level rise in the Chesapeake Bay region has amounted to between 3.21 and 3.52 millimeters per year (NOAA 2006), i.e., approximately a foot over 100 years. Using projections of a one-to-three foot rise in the next 50 years, one GIS analysis of new digital elevation data estimated that between 4 and 21% of Dorchester County forested areas will be affected in the next 50 years (Carlisle *et al.* 2006). Although the effects of sea-level rise appear to be real and a source of potentially significant forest losses in southern Dorchester County, the gradual nature of this problem should provide time for DFS to move out into unoccupied habitat in the central portions of the Delmarva Peninsula. Thus, if DFS populations continue to persist and expand, the subspecies could out-distance this threat. Assuming that habitat above the 100-year floodplain is not vulnerable to the effects of sea-level rise, Chesapeake Marshlands NWR is taking steps to ensure habitat protection and restoration of more upland areas through its acquisition program. Sea-level rise is not considered an extinction factor for DFS, because suitable upland habitat is widely available at the current time.

Vehicle strikes: Vehicle strikes are a relatively common source of DFS mortality, although we consider the probability of DFS being hit by vehicles to be dependent on the density of DFS in the area, the proximity of the road to habitat, and, possibly, the speed and number of cars. Vehicle strikes of DFS tend to be reported more frequently in areas where DFS are abundant even if traffic levels are relatively low, (e.g., Dorchester County). Although the conscientious reporting and collecting of DFS killed on roads at the Chesapeake Marshlands NWR, where DFS are very abundant, probably results in a more accurate count of vehicle strikes than we have from elsewhere, that DFS population does not appear to be in decline. It could be that vehicle strikes pose a greater albeit local threat to subpopulations that are at a very low density, e.g., populations at the periphery of the range or around translocations. Nonetheless, vehicle strikes alone do not appear to be a pervasive threat or an extinction factor for this species.

The five-factor analysis for this review is summarized in the table below.

SUMMARY OF FIVE-FACTOR ASSESSMENT: DELMARVA FOX SQUIRREL

Factor	**Magnitude**	**Management Feasibility**	**Does factor threaten or endanger the DFS?**
Factor 1.A Habitat loss from development	Effects are locally intense but restricted to a small proportion of DFS-occupied habitat across the range. Given the current distribution of DFS, does not pose a risk of extinction with the current distribution.	Other State and Federal laws help direct development to agricultural fields.	No.
Factor 1.B Habitat loss from timber harvest	Effects of single harvest are small if area is surrounded by habitat. Data appear to indicate that harvest rate across the species' range is sustainable.	Additional management at range-wide scale may not be necessary if harvest rate is sustainable.	No, if harvest rate is sustainable. Confirmation of sustainable harvest is needed.
Factor 1.B Habitat loss from short rotation pine forestry	Effects could be severe, as frequent cuts preclude growth of forest needed for DFS habitat. Threat was higher in the past but is now greatly diminished by state acquisition of 58,000 acres of potential habitat in Maryland and 10,000 acres in Delaware.	Maryland has management plans indicating these lands will generally managed for longer-term rotations, along with DFS-specific management goals.	No.
Factor 2. Over-utilization	Hunting may have been a factor in original decline but is presently not occurring and does not constitute a current or foreseeable threat.	Hunting seasons can be closed or limited and managed carefully.	No, as long as hunting season is closed or managed to prevent over-hunting.
Factor 3. Disease or Predation	Disease and predation are not significant threats for this species.	There are limited management options for these issues.	No.
Factor 4. Inadequate Regulatory Mechanisms	MD regulations are broad in scope, and several will continue to provide incentives not to develop in forested areas. DE has limited regulations for private lands, but State lands can be managed for DFS. The sole VA population is on fully protected lands.	Most laws would continue after delisting, but timber harvest plans in MD Critical Areas would not consider DFS specifically after delisting.	No. MD laws appear adequate to protect DFS on private lands, and DE and VA have sufficient habitat protected under state or federal authorities.
Factor 5. Other natural or man-made factors	Sea-level rise is broad but gradual; forest pests and vehicle strikes are limited in scope.	Habitat protection outside of areas most likely to be flooded will help. Programs of forest pest control help keep this factor in check.	Not in foreseeable future.

2.4 Synthesis

The best scientific and commercial information currently available to assess the biological status and the threats to the long-term survival of the Delmarva fox squirrel has led us to the following conclusions.

With regard to DFS population persistence, the empirical information presented in section 2.3.1.2 of this review (i.e., comparative interview-based surveys and trapping/next box check results indicating habitat occupancy) leads us to conclude that the DFS rangewide population has persisted at stable or increasing levels since 1971 and that its known distribution is expanding.

The PVA conducted for this subspecies also indicates that at least 15 DFS subpopulations are currently stable and will remain viable over the long term; however, the PVA is predicated on tentative conclusions about forest habitat availability and sustainability. Our understanding of long-term habitat availability is currently confounded by conflicting information about forest harvest rates within the range of the DFS, i.e., recently compiled erosion control permit data are inconsistent with long-term observational data. The permit data predict that rates of harvest across the squirrel's range would be variable, some sustainable and some not. The observational data, however, including current known DFS habitat occupancy and general forest cover mapping, infer a sustainable harvest rate in terms of mature stands that provide squirrel habitat. We consider the observational data set, which is more complete, to be the most reliable information currently available, but additional supporting information is needed to confirm the conclusion that forest harvest rates are sustainable. Further investigation of the erosion control permit data, in combination with the results of the LiDar assessment of Dorchester County's available habitat, should help us confirm whether forest harvest rates are sustainable.

Aside from the threat of possibly excessive forest harvest, there are no other substantial rangewide stresses on the DFS. The DFS does continue to face localized pressures such as urban development, but these pressures, either individually or in combination, are not likely to cause a rangewide population decline. The only other potential threat of a global nature is climate change, particularly as manifested through sea-level rise. We are witnessing the gradual inundation of some areas of shoreline forest, but this is unlikely to affect forests at higher elevations. Other environmental effects of climate change on the DFS and/or its habitat are not currently known.

Factor D, Inadequacy of Regulatory Mechanisms, is a key consideration in determining the appropriate legal status of the DFS, given the uncertainty associated with the data concerning habitat sustainability. Currently, continuing ESA protection allows for an appropriate response to the possibility that forest harvest could be shown to be a more significant extinction factor than previously understood. Pending confirmation that forest harvest rates are indeed sustainable, delisting the species would require that non-ESA regulatory mechanisms are adequate to ensure the long-term presence of squirrel habitat in the face of negative habitat trends. State and local regulations provide for some amount of forest conservation, particularly near or within riparian zones, but these protections would not necessarily extend to upland forests that do not harbor species listed as endangered or threatened. Because non-ESA regulatory mechanisms are not adequate to respond to a possible new understanding of forest harvest as a more significant extinction factor, removal of ESA protection by delisting cannot be justified.

Overall, our current understanding of population viability and forest harvest rates, combined with (a) areas of protected habitat (both extant and potential), (b) a high degree of success in establishing new colonies within the squirrel's historical range, and (c) the fact that five of the seven reclassification and delisting criteria in the 1993 recovery plan have been fully met and the remaining two are close to being met, enable us to conclude that this subspecies is no longer in danger of extinction. While the DFS has improved in status considerably since listing, without the assurances of non-ESA mechanisms to allow an adequate response if habitat trends prove to be negative, Factor D prevents immediate delisting of the subspecies. In summary, the available data indicate that the DFS should be reclassified from endangered to threatened. However, if new information confirms, as anticipated, that the threat posed by timber harvest is not significant, this subspecies could be delisted.

3.0 RESULTS

3.1 Recommended Classification: Downlist to Threatened

As explained in the Synthesis section above, the DFS appears to meet the definition of a threatened species. based upon the best information currently available. However, we are continuing to gather and analyze data regarding the availability and sustainability of suitable DFS habitat, which may change our understanding of the threats facing this subspecies. We recommend holding off on any rulemaking until this new information is fully analyzed. If this new information and analysis confirms, as anticipated, that the threat posed by timber harvest is not significant, we recommend initiating delisting at that time.

3.2 Recommended Recovery Priority Number: 15C

Brief Rationale: The DFS is considered to be faced with a low degree of threat, has a high recovery potential, is a subspecies, and experiences conflicts between conservation and economic activities.

3.3 Delisting and Reclassification Priority Number: 2

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Provide a reasonably accurate assessment of harvest rate. This could be accomplished either by additional ground-truthing to determine what proportion of Sediment and Erosion Control Permits result in actual harvest or through an alternative means of determining actual harvest.

- Provide an assessment of the quantity and distribution of mature forest that is potentially suitable for DFS in Dorchester County. As appropriate, either extrapolate these data to the rest of the range or conduct similar assessments for other counties. LiDAR mapping is available for this assessment, and other sources of imagery may also be helpful.

- Update data on DFS-occupied habitat based on new digital aerial imagery flown in fall of 2005. The assessment of DFS-occupied habitat is based on outdated 1995 imagery. Mature timber stands may also be discernable through new imagery.

- Work on agreements with the States regarding post-delisting management and monitoring of DFS populations.

- Contingent upon the outcome of the recommended research actions above and an improved understanding of long-term habitat sustainability, revise the DFW recovery plan.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Delmarva Peninsula fox squirrel

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

_X__ Downlist to Threatened
____ Uplist to Endangered
____ Delist
____ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Chesapeake Bay Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve [signature] Date 9/27/'06

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve [signature] Date 9/7/07
Regional Director

Appendix A. Glossary and Determination of Dispersal Distance

Dispersal Distance: A distance within which populations are considered connected. DFS populations are considered isolated from each other if they are more than 3.6 km apart.

Determination of Dispersal Distance: In order to conduct the population viability analysis (PVA) and metapopulation analysis for DFS (Hilderbrand *et. al* 2004), it was necessary to estimate a dispersal distance. This was done by applying the method outlined in Bowman *et al*. (2002) to determine maximum distance of dispersal based on home range size. The U.S. Fish and Wildlife Service recognizes 16.2 ha (40 acres) as the average home range of DFS (average of values provided by Flyger and Smith 1980, Larson 1990, Paglione 1996, Pednault-Willet 2002), resulting in a maximum dispersal distance of 18 km.

Animal dispersal can be approximated using an exponential decay function. This is typical of many mammals and supported by capture and recapture data of DFS (Larson 1990; Dueser 1999; C. Bocetti and H. Pattee, Patuxent Wildlife Research Center, *in litt*.). Assuming that only a very small percentage (0.1%) of squirrels would disperse the maximum distance of 18 km, we could then calculate the distance for a given connectance (or the reverse) by solving the equation $D = \ln C/-0.384$, where D = distance and C = connectance.

$C(0.75) = 0.75$ km $C(0.5) = 1.8$ km $C(0.25) = 3.6$ km $C(0.10) = 6$ km

Based on the negative exponential curve, only 25% of dispersers (connectance = 0.25) would move more than 3.6 km (2.25 miles) from their home patch. Thus 75% could disperse to areas within 3.6 km, and populations in polygons that were within 3.6 km of another polygon were considered to be connected and not isolated populations.

Endangered species: Any species which is in danger of extinction throughout all or a significant portion of its range (50 CFR 424.02).

Minimum size of a secure population: The PVA suggested that a population with 65 females, or 130 total animals, has a less than 5% chance of extinction in 100 years. Using an average density of DFS of 0.3 DFS/acre, it would take about 435 acres to support this number of DFS. We thus estimated that 435 acres of occupied habitat would support a minimally secure population.

Occupied Habitat: Forested areas considered to be occupied by DFS. Occupied habitat is delineated by the forested area that is contiguous, or adjacent to, one or several observations of DFS, and stops at any break in the forest caused by fields or roads. Based on these sightings, the forested area is considered to be occupied by DFS, and these areas are delineated as polygons in the CBFO GIS. Imagery used to identify woodlands has been infra-red Digital Ortho-photo Quarter Quads (DOQQ's) from the mid 1990s. The first set of polygons were originally drawn on paper maps by the Maryland DNR during the 1990s and subsequently digitized and provided to the USFWS in 1998 for use in the GIS. Additional observations of DFS, trapping reports, and other information have been recorded in the CBFO GIS since 1998, and polygons are drawn around the adjacent forested habitat using the parameters described above.

Range: The total area of land where DFS are likely to occur, delineated as the area within three miles of all occupied DFS habitat (see Figure 1). This represents a best estimate based on information about DFS dispersal and occurrence (USFWS memo dated October 8, 2004), but it does not necessarily imply that all DFS within the delineated area are interbreeding. Previous known range is that provided in a map in the 1993 recovery plan.

Recovery: The principal purpose of the Endangered Species Act is to return listed species to a point at which protection under the Act is no longer required. A species may be delisted on the basis of recovery only if the best scientific and commercial data available indicate that it no longer meets the definitions of endangered or threatened.

Subpopulations: A set of occupied habitat polygons that are located within 2.25 miles of each other and, based on the dispersal distance identified in the PVA, are considered to be close enough that individuals are likely to frequently disperse and interbreed. Subpopulations are delineated by buffering the polygons of occupied habitat by 1.125 miles; any areas that are interconnected are considered to be part of the same subpopulation (because an individual DFS would have to travel less than 2.25 miles to get from the edge of one occupied woodland to the next). Subpopulations are further delineated by rivers or peninsulas that pose geographic barriers to dispersal.

Threatened species: Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (50 CFR 424.02).

Appendix B. Data Sources for GIS Layers and Analysis

A. Data Sources for Protected Lands

Federal Lands - Download from http://www.fws.gov/northeast/gis/ (NWR boundaries) and http://dnrweb.dnr.state.md.us/gis/data/index.html (other federal lands); data from October 2002.

Maryland State Lands - Download from http://dnrweb.dnr.state.md.us/gis/data/index.html; data from October 2004.

County Lands -Download from http://dnrweb.dnr.state.md.us/gis/data/index.html; data from September 2002.

MET/ESLC Easements - (a) Wicomico, Somerset, Worcester counties - Download from http://dnrweb.dnr.state.md.us/gis/data/index.html; data from September 2002. (b) Kent, Queen Anne's, Caroline, Talbot, Dorchester counties - Obtained from MET/ESLC directly; data from October 2005.

TNC Lands - Obtained from TNC directly; data from March 2006.

Other Private Conservation - Download from http://dnrweb.dnr.state.md.us/gis/data/index.html; data from September 2002.

Agricultural Easements - Download from http://dnrweb.dnr.state.md.us/gis/data/index.html; data from August 2005.

Rural Legacy Lands - Obtained from Rural Legacy program directly; data from March 2006.

Land Area for each County - Maryland Office of Planning, September 2005 (www.mpd.state.md.us).

Delaware State, County, Private Conservation - Obtained from Delaware Department of Natural Resources and Environmental Control, January 2005.

B. Data Sources for DFS Occupied habitat and Threats Analysis

Photo-imagery for background - Infra-red DOQQ from Maryland DNR taken in mid-1990s (most around 1995).

Occupied Habitat - Polygons delineating contiguous forest around or adjacent to sightings of DFS, stopping at roads or breaks in the forest. Based on forest cover in photo-imagery described above.

Areas of anticipated development - Sources: " Smart Growth Areas"; this layer of likely development is defined in Maryland by the areas that counties have delineated for "smart growth" and that receive priority funding for infrastructure from the State (see www.mdp.state.md.us/fundingact.htm for information, and http://www.mdp.state.md.us/zip_downloads_accept.htm for data). In addition, we obtained the areas where development was already proposed from the Planning and Zoning Offices of Queen Anne's, Talbot, Dorchester, and Sussex counties and the City of Cambridge.

Appendix C. State Regulatory Programs and Land Protection Programs

The following statutes, regulations, policies, and programs comprise the most prevalent regulatory protections for DFS and/or their habitat.

Maryland Critical Areas Act -- This law designates all areas within 1,000 feet of high tide as Critical Areas and prohibits clearing within a 100-foot buffer around streams and the Chesapeake Bay. These areas serve as corridors and possibly habitat in some areas. In addition, timber harvests that occur within designated Critical Areas must be reviewed by the State if sensitive or endangered species are present. Where DFS occur, 15-25 percent of each forest stand must be retained, consistent with recommendations in the 1993 recovery plan. The area selected for retention is based on maintaining both the best DFS habitat and connectivity to other tracts of forest. Review of timber harvest plans and habitat retention will not necessarily occur after delisting. The proportion of each county that lies within the Critical Area varies but is highest in Dorchester County, where 50 percent of the land is designated; Talbot County is second highest, with 38 percent.

Maryland Forest Conservation Act -- This law requires that when a forested area is cleared, other portions of the forest must be placed in an easement that will preclude development in perpetuity. The total acreage in Forest Conservation easements has not yet been tabulated but generally includes forested areas near housing developments for which forested areas were initially cleared. This leads to protection of habitat for DFS to move into or move through in urbanizing areas.

Maryland Smart Growth/Rural Legacy -- This program attempts to offset sprawl by identifying Smart Growth areas in each county where the State of Maryland will fund infrastructure projects such as sewers and roads. The program also identifies Rural Legacy areas where land protection focuses on preserving rural and natural resources (see Land Protection Programs below).

Maryland Greenprint Program -- This program is aimed at preserving corridors and hubs (large patches) of undeveloped habitat across the State. Beginning as a study of forest land connectivity under the rubric of the Green Infrastructure Project, the Greenprint program is focused on coordinating Rural Legacy and county open space protection efforts with a view to preserving this Green Infrastructure.

Delaware Biodiversity Conservation Partnership -- This State program was developed with input from stakeholders, scientists, state and federal resource management agencies, and non-governmental groups (Environmental Law Institute 1999, Delaware Department of Natural Resources and Environmental Control 2001). The Biodiversity Conservation Partnership focuses on identifying priority actions in four areas: science, resource management, land use planning, and education and outreach. Recovery of DFS (e.g., habitat protection in the Nanticoke River watershed) could be advanced through this initiative.

Other conservation-oriented policies and regulations -- Maryland has a policy concerning the conservation of biodiversity that pertains to land use planning decisions on forested State lands. Other directives order the consideration of wildlife and natural resource issues when managing State lands, and a State wildlands preservation system seeks to preserve wildland areas in their natural condition. Maryland also has statutory provisions for cooperative management efforts. For instance, the State is part of the Interstate Environment Compact, which authorizes cooperative efforts to protect the environment, and the Chesapeake Bay Critical Area Protection Program is implemented on a cooperative basis between local and state government.

State Lands

Maryland manages several State properties that currently support DFS or provide habitat for possible expansion of the population. These include State Wildlife Management Areas, State Forests, and Chesapeake lands. DFS are currently supported on approximately 6,800 acres of state Wildlife Management areas, including Wye Island, LeCompt, Linkwood, Fishing Bay, Seth Demonstration Forest, and Taylor's Island in Maryland. In addition, the State of Maryland has acquired 58,000 acres of forest land previously owned by the Chesapeake Pulp Wood Company. Management plans for these Chesapeake lands already have specific goals for DFS and provides an example for other State Forest lands. Long-term management plans are not currently available for all State properties, but additional plans with a focus on DFS may result from current Habitat Conservation Plan work. General goals and missions of these lands support the conservation of Maryland wildlife, and one WMA was specifically set aside for the Delmarva fox squirrel. These properties will likely include management for DFS even after this subspecies is delisted.

Delaware manages both State Wildlife Management Areas and State Forests that either currently support DFS or could in the future. Delaware's Land Protection Act provides for acquisition of interests or rights in real property for State Open Space areas. In addition, several accounts exist to purchase land and conservation easements for open space, waterfowl habitat, state parks, and other state land. Legislation was approved in 1995 transferring approximately $6 million from other accounts to fund greenway projects and other land acquisitions, and approximately $7 million per year is available for acquisition of state land from state bond funds. With regard to conservation on private lands, conservation and preservation easements are provided for by statute, and a Natural Areas Preservation system encourages private landowners to set aside land for wildlife habitat.

Virginia has a policy to manage the State's wildlife resources "to maintain optimum populations of all species to serve the needs of the Commonwealth." In addition, Virginia has habitat acquisition programs such as the Conservation and Recreation Fund, which is used to purchase land for several purposes including wildlife habitat and natural areas, and bonds have been approved for acquisition of state park lands and state natural area preserves. Virginia also has some private land conservation programs. For example, under the Natural Area Preserve Act, private lands can be registered as a natural area. Conservation easements are authorized by statute, with land subject to the easement exempt from state and local taxation. The Forest Stewardship Program works with private landowners to address concerns, and by law, owners can convert agricultural land to wildlife management uses without losing their property tax exemption. Finally, the Coverts Project works with private landowners on biodiversity, ecosystem, and wildlife management theories and techniques.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Delmarva Peninsula fox squirrel

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

_X__ Downlist to Threatened
____ Uplist to Endangered
____ Delist
____ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Chesapeake Bay Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ______________________ Date 9/27/06

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve ______________________ Date 9/7/07
Regional Director

Land Protection Programs on Private Lands

Maryland -- Several state programs and private land trusts are working to secure easements that restrict development on private lands. The Maryland Environmental Trust (MET) holds conservation easements on almost 38,000 acres of land in the eight counties with DFS populations, and MET easements in the tri-county area were acquired at an estimated rate of 1,130 acres/year between 1990 and 2000. The Eastern Shore Land Conservancy (ESLC) has obtained easements on 21,359 acres (many co-held with MET) since 1990 in the eight Maryland counties where DFS occurs, and in the year 2000 a total of 4,149 acres of farmland and natural habitat were protected (ESLC, spring 2001 newsletter). In addition, the Maryland Agricultural Land Preservation Foundation (MALPF), a 24-year-old program created to preserve farmland and woodland for the continued production of food and fiber, has conserved over 75,000 acres in the eight-county area. In the tri-county area, MALPF easements have been established at a rate of 1,353 acres/year. Most of these easements are whole farm easements, which are primarily agricultural fields but also include wooded areas. Maryland Rural Legacy is a Maryland State program to purchase easements that protect property from future development. There are targeted areas that are the focus of this work; for example, Talbot County has identified the Tuckahoe riparian corridor for its Rural Legacy area, which will help preserve an important north/south corridor for DFS. Queen Anne's County has preserved lands in northern part of the county (Chino Farms), which includes the northernmost observation of DFS. Dorchester County has identified an area in the northeast portion of the county that is not currently occupied by DFS but represents an upland area not vulnerable to sea-level rise.

Delaware - The Farmland Preservation Program preserves working farms but can include working forests and typically includes a "Purchase of Development Rights". Several private land trusts are also active. The State also participates in the Forest Legacy Program, which prevents development and encourages wise stewardship of timber resources. Maps of State Resource Areas (SRAs) provide information that can be used by counties or other entities in planning conservation areas. Delaware's Landowner Incentive Program encourages (through financial and technical assistance) landowners to manage property for rare species, especially listed species.

List of Tables and Figures

Table 1. Summary of the success of sixteen translocations of Delmarva fox squirrel populations.

ID	State	County	NAME (Successful translocations in Bold)	Release Year(s) and number of DFS released	Successful?	Evidence of growth or expansion beyond release site	Documentation - Citation of most recent monitoring report or data.
1	MD	Kent	Remington Farms - Poplar Neck (DFS moved from here to DeBlasio)	1979,1980 (14 dfs)			
1	MD	Kent	**Remington Farms- (DeBlasio Tract)**	1980,1983 (5 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
1	MD	Kent	Remington Farms-DeBlasio Supplement	1994 (25 dfs)			
2	MD	Kent	**Quaker Neck**	1980,1981 (16 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
2	MD	Kent	Quaker Neck Supplement	2000, (18 dfs)			
3	MD	Somerset	**Dryden Farm**	1981 (9 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
3	MD	Somerset	Dryden Farm Supplement	1999 (19 dfs)			
4	MD	Somerset	**Eby Farm**	1981 (9 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
4	MD	Somerset	Eby Farm Supplement	1993 (17 dfs)			
5	MD	Cecil	Fairhill	1980,1982 (14 dfs)	NO		Therres and Willey 2002, and sightings during 2003-2006
6	MD	Somerset	**Riggin Farm**	1983,1984,1985 (26 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
6	MD	Somerset	Riggin Farm Supplement	2000, (9 dfs)			
7	MD	Worcester	**Jarvis Farm**	1982,1984 (8 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
7	MD	Worcester	Jarvis Farm Supplement (1mileNE)	1997, (21 dfs)			
8	MD	Worcester	Nassawango	1978, (5 dfs)	NO		Therres and Willey 2002, and sightings during 2003-2006
9	MD	Wicomico	**Hazel Farm**	1986,1987,1988 (20 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
9	MD	Wicomico	Hazel Farm Supplement	1999 (11 dfs)			
10	MD	Caroline	**Harmony**	1989 (30 dfs)	YES	YES	Therres and Willey 2002, and sightings during 2003-2006
11	MD	Kent	**Andelot Farm**	1991, (21 dfs)	YES	YES	Therres and Willey 2002
12	VA	Accomack	**Chincoteague**	1968,1970,1971 (34 dfs)	YES	YES	Pednault-Willett 2002; refuge data 2004
13	VA	Northampton	Brownsville Farm	1982,1983 (24 dfs)	NO		Report to State,Terwilliger
14	DE	Sussex	Assawoman	1984,1985 (13 dfs)	NO		2004 State Survey at Assawoman Wildlife Area,
15	DE	Sussex	**Prime Hook NWR**	1986,1987 (17 dfs)	YES	YES	2004 State Survey at Prime Hook National Wildlife Refuge
16	PA	Chester	Chester	1987,1988 (20 dfs)	NO		Report by M.Steele, 13 June 1996

Total of 16

11 Successful

5 Unsuccessful

Table 2. Land use in the nine Maryland and Delaware counties where Delmarva fox squirrels occur: 2002

County	Developed 2002	Agriculture 2002	Wetlands 2002	Forest 2002	Total Land Area (acres)
Maryland (a)					
Kent (acres)	10794	118451	4399	44735	178440
Kent (% of Co.)	6	66	2	25	
Queen Anne's (acres)	20532	150080	3840	63068	237549
Queen Anne's % of Co.	9	63	2	27	
Talbot (acres)	22106	103518	4500	41444	171622
Talbot % of Co.	13	60	3	24	
Caroline (acres)	16388	121347	3204	63710	204743
Caroline % of Co.	8	59	2	31	
Dorchester (acres)	17307	119824	91019	126760	355142
Dorchester % of Co.	5	34	26	36	
Somerset (acres)	12169	56077	56027	82518	206931
Somerset % of Co.	6	27	27	40	
Wicomico (acres)	34287	85403	14385	106236	240404
Wicomico % of Co.	14	36	6	44	
Worcester (acres)	21558	98822	18858	159988	301650
Worcester % of Co.	7	33	6	53	
Delaware (b)					
Sussex DE (acres)	30211	324434	20541	208560	601456
Sussex DE % of Co.	5	54	3	35	

Source : (a) Maryland Office of Planning, September, 2005.(www.mpd.state.md.us)
Development = total of all low, medium and high density residential, and commercial, industrial, institutional and other developed land. (b) RECON Jan 19, 2006

Table 3. Land use changes (in acres per year) in eight Maryland Counties: 1973-2002

	Change in Developed Land 1973-2002 (acres/yr)	Change in Agricul. Land 1973-2002 (acres/yr)	Change in Forest land 1973 - 2002 (acres/yr)
Kent	214	-56	-160
Queen Anne's	465	-170	-312
Talbot	490	-292	-180
Caroline	363	-101	-277
Dorchester	380	-46	-311
Somerset	291	-34	-241
Wicomico	743	-348	-389
Worcester	386	-3	-361

Source : Maryland Office of Planning, September, 2005 (www.mpd.state.md.us)
Development = total of all low, medium and high density residential, and commercial, industrial, institutional and other developed land.

Table 4. Acres of land protected from development in nine counties where Delmarva fox squirrels occur (See Appendix B for sources). Prot include forested, agricultural and wetland areas.

	Queen Anne's	Talbot	Dorchester	Kent	Caroline	Wicomico	Somerset	Worcester	Sussex
Federal	145	0	25,778	2,103	0	0	4,293	10,127	10,084
State	4,791	244	31,294	4,958	6,077	6,094	30,389	20,781	41,506
State (Chesapeake Lands)	0	0	11,527	0	1,231	15,866	17,088	12,843	N/A
County	1,388	421	148	511	312	735	751	1,275	117
MET/ESLC Easements	6,841	10,728	9,070	11,199	1,903	782	2,812	2,822	N/A
TNC	0	1,600	4,954	0	1,296	4,388	156	5,132	0
Other Private Conservation Groups	1,845	482	0	3,544	62	0	1,821	0	10,545
Agricultural Easements	10,488	2,243	4,574	5,236	18,340	1,726	787	611	N/A
Rural Legacy	5,264	1,261	4,389	1,233	3,057	739	0	5,656	N/A
Total protected	30,762	16,979	91,734	28,784	32,278	30,330	58,097	59,247	62,252
Total land area in County	237,549	171,622	355,142	178,440	204,743	240,404	206,931	301,650	601,456
% of County Land Area Protected from Development	13	10	26	16	16	13	28	20	10

ected lands
Totals
52,530
146,134
58,555
5,658
46,157
17,526
18,299
44,005
21,599
410,463
2,497,937
16

Table 5. Acres of forest habitat occupied by Delmarva fox squirrels that are protected from development.

	Queen Anne's	Talbot	Dorchester	Caroline	Kent	Wicomico	Somerset	Worcester	Sussex	Totals
Total acres of DFS occupied habitat	**5,007**	**17,445**	**90,252**	**937**	**4,079**	**2,080**	**4,066**	**1,569**	**2,999**	**128,434**
Federal	0	0	9,988	0	251	0	0	0	1,644	11,883
State	581	127	3,131	135	0	0	0	709	872	5,555
State (Chesapeake Lands)	0	0	5,034	0	0	105	705	0	N/A	5,844
County	20	0	89	0	0	0	0	0	0	109
MET/ESLC Easements	396	2,170	2,606	41	877	505	0	0	N/A	6,595
TNC	0	534	723	6	0	0	0	0	0	1,263
Other Private Conservation	323	372	0	0	1,279	0	0	0	0	1,974
Agricultural Easement	102	58	416	0	0	0	0	0	N/A	576
Rural Legacy	591	31	431	1	0	0	0	855	N/A	1,909
Total acres on protected land	2,013	3,292	22,418	183	2,407	610	705	1,564	2,516	35,708
Percentage of DFS Occupied habitat on protected land	**40%**	**19%**	**25%**	**20%**	**59%**	**29%**	**17%**	**100%**	**84%**	**28%**

Source: CBFO GIS analysis

Table 6. Acres of occupied habitat in each subpopulation and acres proposed for development or in smartgrowth areas.

Subpopulation	Acres of Occupied Habitat	Current size of Subpopulation (a)	Acres of Occupied Habitat proposed for development or in smartgrowth areas	Acres in subpopulation after losses	Projected persistence of subpopulation based on size, potential loss of habitat and isolation effects (b)	
Dorchester	86,218	very large	1069	85,149	1	very likely to persist
Tunis Mills	6,855	very large	207	6,649	1	very likely to persist
Southern Talbot	6,908	very large	834	6,074	1	very likely to persist
Dorchester Neck	4,230	large	9	4,220	1	very likely to persist
Carmichael Road	1,684	large	0	1,684	1	very likely to persist
Wye Mills	1,511	large	1	1,510	1	very likely to persist
Remington Farms	2,572	large	0	2,572	2	likely to persist
Hazel Farm	2,080	large	0	2,080	2	likely to persist
Prime Hook	1,886	large	17	1,869	2	likely to persist
Eby and Dryden	1,877	large	0	1,877	2	likely to persist
Northern Somerset	1,619	large	10	1,609	2	likely to persist
Jarvis Farm	1,569	large	0	1,569	2	likely to persist
Chincoteague	1,502	large	0	1,502	2	likely to persist
Nanticoke	1,149	large	0	1,149	2	likely to persist
Tuckahoe River Corridor	1,104	large	0	1,104	2	likely to persist
Andelot Farms	917	medium	0	917	2	likely to persist
Wye Island	492	medium	0	492	2	likely to persist
Riggin Farm	478	medium	0	478	2	likely to persist
Quaker Neck	340	small	0	340	2	likely to persist
Somerset new 2005	92	small	0	92	2	likely to persist
St Michaels Road	1,333	large	408	925	3	might persist
Chino Farms	645	medium	0	645	3	might persist
Centreville	508	medium	0	508	3	might persist
St Michaels South	103	small	0	103	3	might persist
Eastern Neck	251	small	0	251	4	expected extirpation
Grasonville	944	medium	227	716	4	expected extirpation
301 and 50 Split	403	small	54	349	4	expected extirpation
QUAN 301	135	small	0	135	4	expected extirpation
Hog Island	11	small	0	11	4	expected extirpation
Hampton Woods	361	small	359	2	4	expected extirpation
Total Sum of ACRES	129,776		3195	126,580		

(a) Size: small = <435 medium=436-1000; large = 1001-5000 acres, very large > 5000 acres

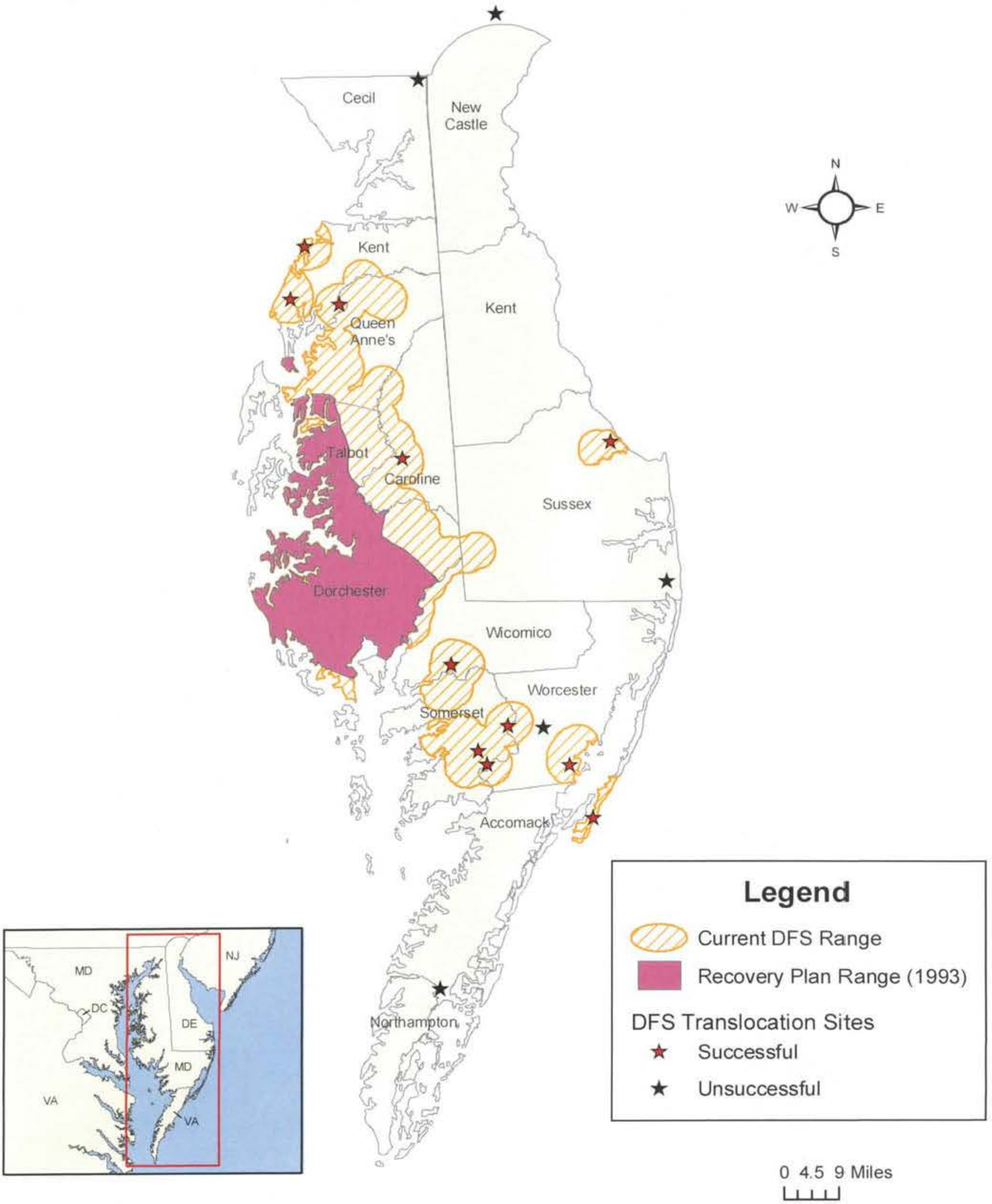
(b) Population persistence categories: 1- dark blue - large and connected, very likely to persist; 2 - light blue, medium to large, not well connected, but likely to persist; 3 - yellow - small to medium, isolation is a problem, might persist; 4 - red, small to medium populations, expected to be exitrpated because of habitat loss or isolation.

Table 7. Acres of timberland and sawtimber in each county in 1999, and average annual acreage permitted for timber harvest and estimated actual acres harvested.

County and years of permit records examined	Acres of timberland 1999	Acres of sawtimber 1999	Percentage of timberland that is sawtimber 1999	Average annual acres permitted for harvest (acres)
Kent (1992-1999)				521
(Kent and Queen Anne's combined	101,800	76,000	75%	969
Queen Anne's (2001-2005)				448
Talbot (2004-2005)				532
(Talbot and Caroline combined)	107,300	40,400	38%	1,377
Caroline (1994-1999)				845
Dorchester (1994-2005) Dorchester (2003-2005)	132,800	79,700	60%	2,507
Somerset (1994-1999)	87,800	36,400	41%	2,849
Wicomico (1992-1999)	115,400	79,600	69%	2,788
Worcester (1994-2004)	156,700	74,900	48%	2,232
Sussex County Delaware (1998-2005)	226,100	136,600	60%	3,376

Source: Frieswyk (2001) and Griffith and Widmann (2001) for sawtimber and timberland estimates. Sediment and erosion control permits required by counties for timber harvests. Averages based on years in parentheses following County name. Actual harvest is estimated to be about 50% of the acres permitted (see text).

Figure 1. Recent changes in the range of the Delmarva fox squirrel



These data represent the ongoing efforts of the U.S. Fish and Wildlife Service and Maryland Department of Natural Resources to consolidate, summarize, and regularly update and correct existing information regarding Delmarva fox squirrel occurrence. Comprehensive field surveys have not been conducted and changes in this map are expected to occur in the future. This map should be used as a tool to assist decision makers, but cannot provide a definitive statement on the presence, absence or condition of Delmarva fox squirrel populations.

Map updated in May 2006

Figure 2. Newly documented Delmarva fox squirrel populations (not tranlocations) outside the 1993 Recovery Plan Range

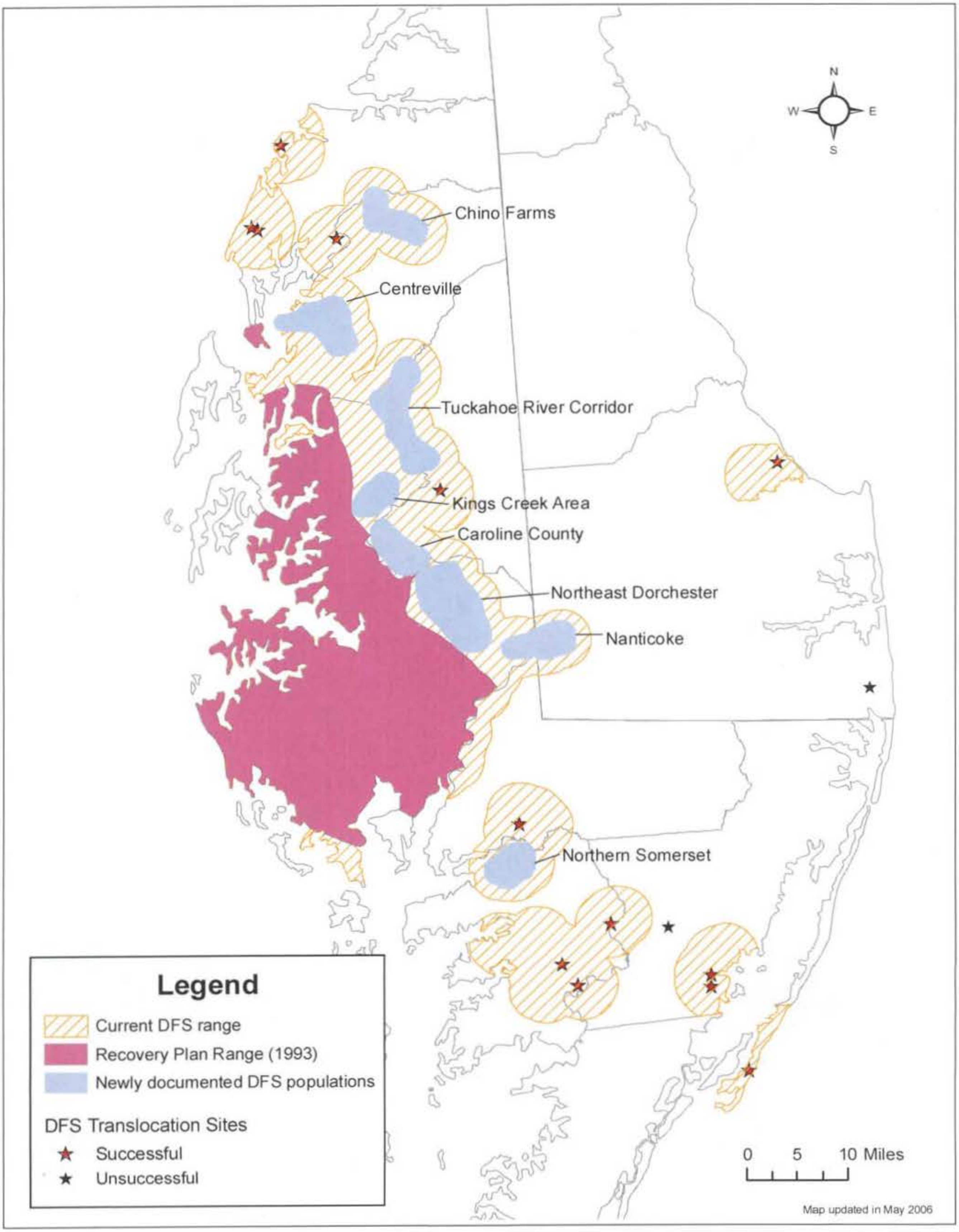


Figure 3. Locations of Delmarva fox squirrel present sites and sites absent of Delmarva fox squirrels in 2001 with changes in status from that determined by Taylor and Flyger (1974) in 1971. (Source: Figure 2 in Therres and Willey 2005).

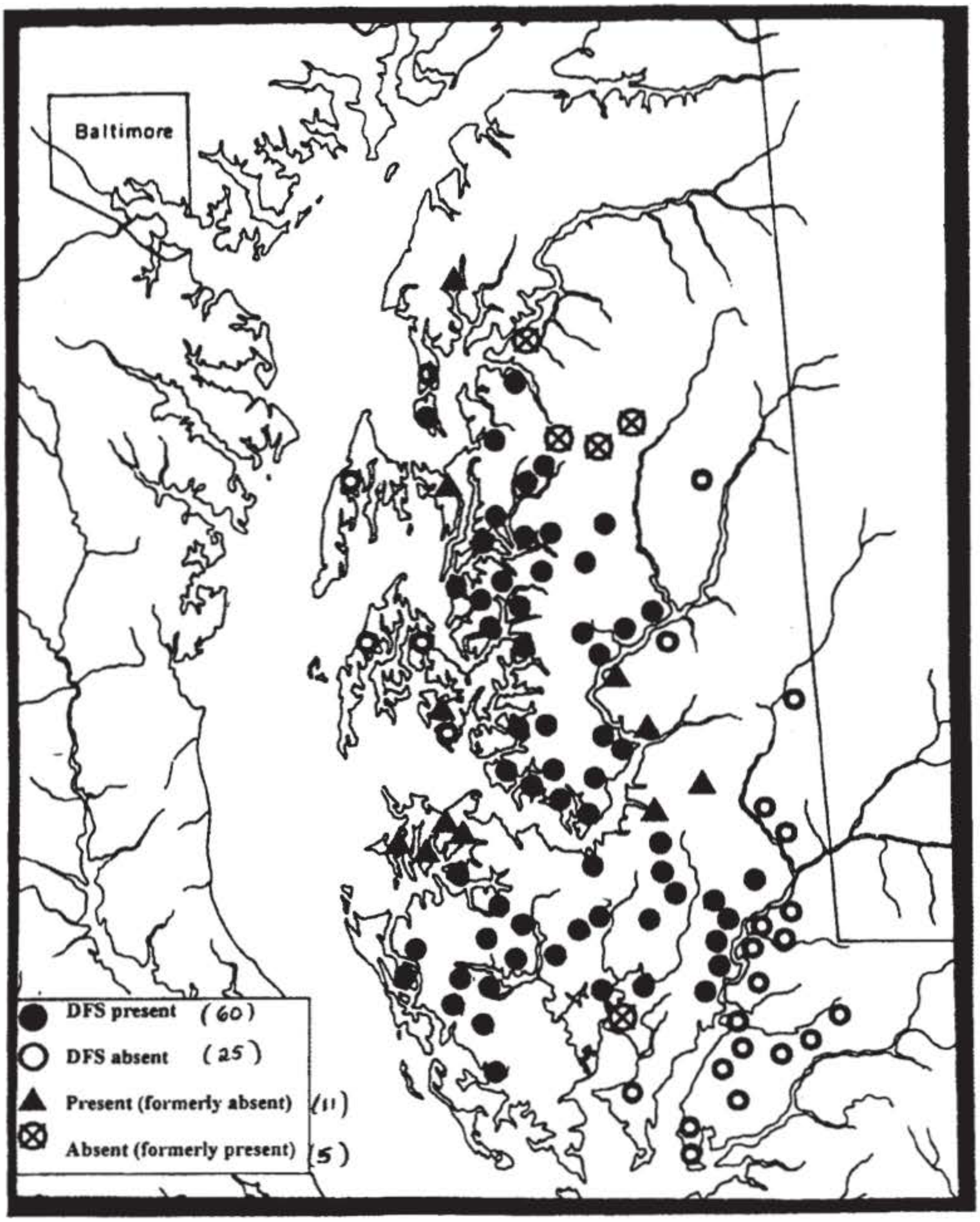


Figure 4. Thirty subpopulations of Delmarva fox squirrels

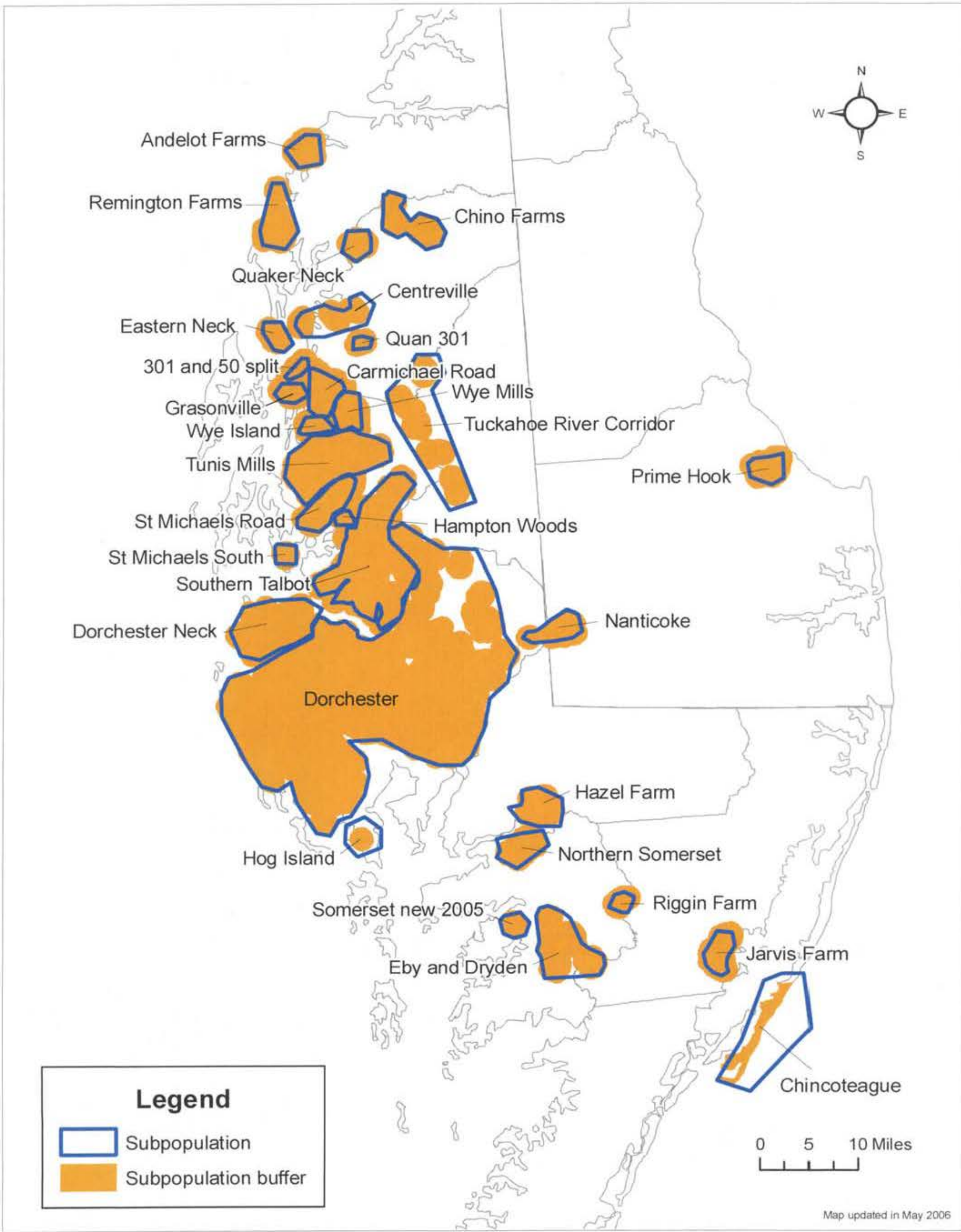


Figure 5. Example of evaluating persistence of Delmarva fox squirrel subpopulations in Talbot County based on proposed development, Smart Growth areas, and protected lands

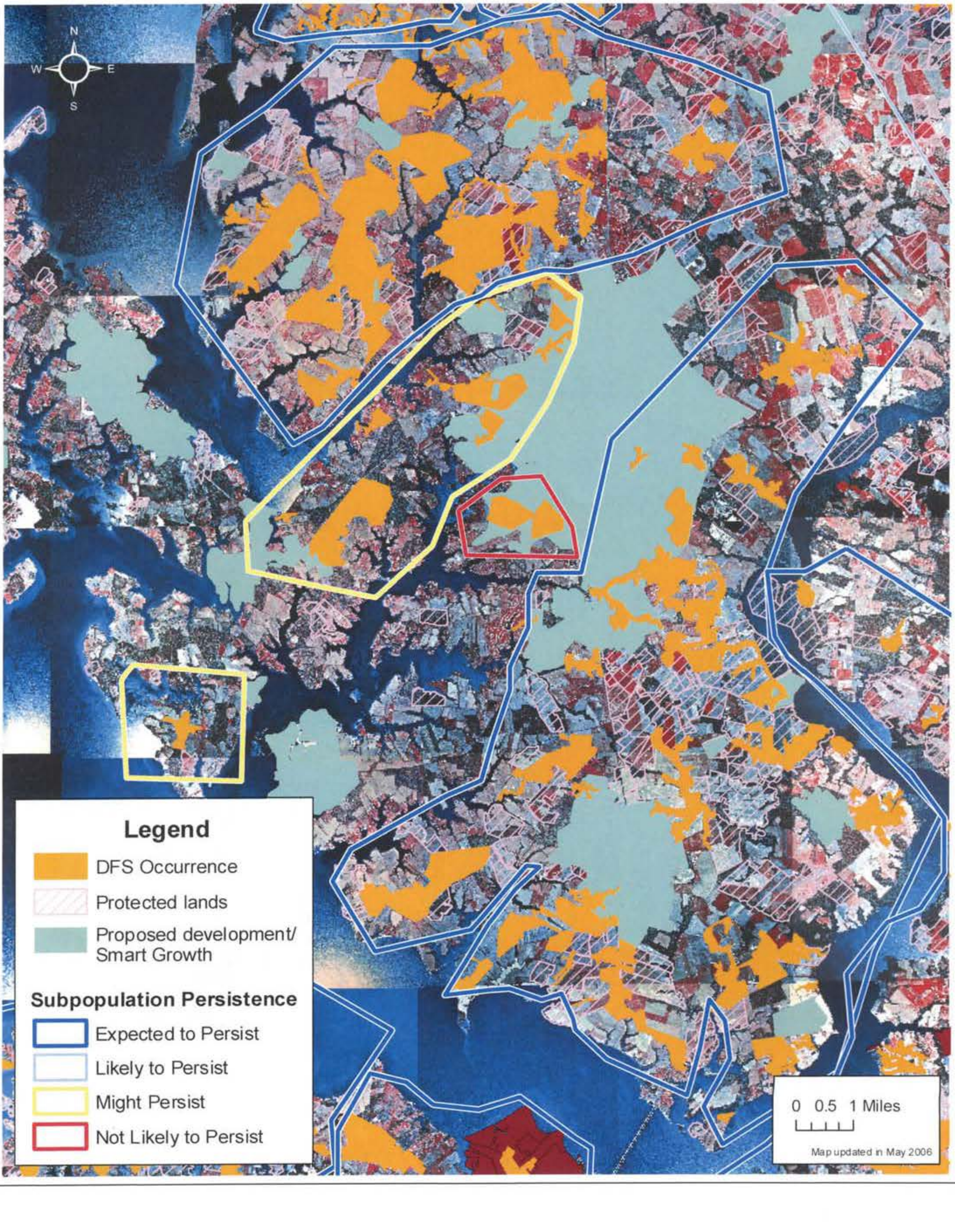


Figure 6. Delmarva fox squirrel subpopulations and expected persistence after proposed and likely development