Post-delisting Monitoring Plan for the Delmarva Peninsula Fox Squirrel *(Sciurus niger cinereus)*

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Prepared by the U.S. Fish and Wildlife Service
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I. Introduction

A. History of Delmarva Fox Squirrel Recovery

The Delmarva Peninsula fox squirrel, (*Sciurus niger cinereus*), commonly called the Delmarva fox squirrel (DFS), is a subspecies of the eastern fox squirrel found only on the Delmarva Peninsula. It is a large, silver-gray tree squirrel with white underparts and a very wide tail. It can be distinguished from the gray squirrel (*Sciurus carolinensis*), the only other tree squirrel in the area, by its larger size, short ears, general shape, and color. The DFS inhabits mature forests of mixed hardwoods and pines in the agricultural landscapes of the area. The large trees in mature forests provide abundant crops of acorns, pine cones, and other food, as well as cavities for dens.

This subspecies was listed as endangered in 1967 because the population was considered to have declined to 10 percent of its historical range. The most likely causes for this decline were losses of mature forest from clearing land for agriculture, short-rotation timber harvest, and overhunting. Since the initial listing, the hunting season was closed, and Federal and state biologists translocated DFS to establish new populations and expand the distribution within its historical range. Many of these translocations have been successful and have resulted in 11 new populations that continue to survive and grow 25 years after the initial releases. This has substantially increased the range of the DFS (figure 1). In addition, eight new populations of DFS were discovered on the periphery of the 1993 range that did not result from translocations (USFWS 2007). The most recent 5-year status review (USFWS 2012) identified additional sightings between several of these new populations, and these new occurrences now connect subpopulations and result in lower vulnerability to extinction of the populations (USFWS 2012, figure 3). These translocations and discoveries have increased the range and reduced the risk of extinction. The status review (USFWS 2012) also evaluated the DFS population distribution, the abundance and connectivity of habitat, and all threats to DFS persistence, concluding that the DFS was not in danger of extinction throughout all or a significant portion of its range and not likely to become so in the foreseeable future. Thus, the recommendation was to delist due to recovery.

Section 4(g) of the Endangered Species Act (ESA) requires the U.S. Fish and Wildlife Service (Service), in cooperation with the states, to monitor the status of all species that have recovered and been delisted for not less than 5 years. The purpose of this post-delisting monitoring (PDM) is to insure that a species delisted due to recovery remains secure from extinction after the protections of the ESA have been removed. Section 4(g)(2) directs the Service to make prompt use of its emergency listing authorities to prevent a significant risk to the well-being of any recovered species. Thus, the purpose of a post-delisting monitoring plan is to track the species to ensure it remains secure and does not require relisting. This document constitutes the PDM plan for the DFS.

B. Monitoring History of the DFS

The two key variables that have been the focus of DFS monitoring since it was listed are (1) the distribution of DFS populations, including the size of the range, and (2) the persistence of populations within the range. This species was initially listed because its distribution had diminished to 10 percent of its historical range, and initial recovery efforts therefore focused on translocations to increase the size of the range. The recovery criteria in the revised DFS recovery plan (USFWS 1993) focused on the persistence of the translocations and persistence of other populations within the range, as well as the need for discovery of new populations. Thus, monitoring the distribution of this species and ensuring its long-term persistence on the landscape have been the primary goals of the monitoring program while it has been listed and will continue to be the primary goals of PDM.

Monitoring the distribution and demographics of this species can be challenging. The DFS is quiet and secretive, and cannot be readily observed in a casual walk through the woods or a line-transect (Paglione 1996). They do not vocalize frequently and can remain quiet and hidden, and skilled observers can walk through a wooded area where DFS are known to occur in high densities (from trapping surveys) and not detect a single squirrel. Yet DFS are often seen on the edges of fields and roadsides or in the woods by individuals who live, work, and hunt in these areas. Their visibility on the landscape depends on the season and the day and is not easily predicted. Thus, people who are most frequently in a DFS-occupied area have the best chance of seeing them. These valuable observers offer “eyes” for observing DFS on a wide range of public and private lands throughout the year. Many survey techniques have been evaluated for DFS (appendix A), and trapping and camera surveys can provide useful information for smaller areas, but ultimately, the range of this species has been understood primarily from reported sightings.

Sighting information was the source of our initial conclusions regarding the species’ decline and has continued as the basis of several past assessments of its rangewide distribution (Dozier and Hall 1944, Taylor 1976, Therres and Wiley 2005, USFWS 2007, USFWS 2012). Initially, sighting reports were relatively informal, but over time sighting reports have been improved by making them more precise in location and more standardized and automated. Since 1998, the Service has maintained a Geographic Information System (GIS) database of sighting reports of this animal from knowledgeable observers (i.e., observers who have seen DFSs and know how to distinguish them from gray squirrels). These observations, as well as the locations of trapping and camera surveys are recorded in the GIS. The data are now used to determine whether a specific forest tract or woodlot is occupied by DFS. By tracking changes in occupancy of woodlots over time, we can also measure the local persistence and extirpations of DFS; these population dynamics are the underlying mechanisms for understanding rangewide population trends.

The first assessment of DFS distribution was conducted by describing the squirrel’s presence or absence on 101 sites across the range (Taylor and Flyger 1974, Taylor 1976). This assessment concluded that DFSs were distributed across three Maryland counties with presence on one site in a fourth county. The DFS occupancy on these same sites was re-assessed about 30 years later, documenting continued DFS persistence on 92 percent of the sites, extirpation from five of the previously occupied sites, and new colonization at 11 sites (Therres and Willey 2005). More recently, the species’ distribution has expanded into new areas, so the original 101 sites no longer reflect its current range.

In the 1990s, the Maryland Department of Natural Resources (MDDNR) mapped DFS distribution in Maryland by delineating on topographic maps those woodlots where biologists had observed DFS. These areas of occupied forest were then digitized and recorded in the Chesapeake Bay Field Office's (CBFO) GIS in 1998. This provided a much more detailed mapping of the distribution at the scale of the woodlot. The CBFO continues to map new sightings and other evidence of DFS occurrence and designates adjacent woodlot as occupied (appendix A). The current distribution occurs across 10 counties and includes over 134,000 acres of occupied forest.

In addition to recording the sightings of DFS, several other techniques for monitoring DFS have been explored and implemented (appendix B). Trapping has been used to document persistence at translocation sites (Therres and Willey 2005, USFWS 2012) and at designated benchmark sites (Dueser 1999). At seven benchmark sites identified in the 1993 Recovery Plan (USFWS 1993), monitoring was conducted for 5 to 7 years to better understand local population dynamics in a variety of areas across the range. These data were summarized (Dueser 1999) at the end of this time period, but trapping has continued at several benchmark sites, providing up to 20 years of information on population dynamics, density, and survival (Larson 1990, Pednault-Willett 2002, USFWS 2010, Gould 2008, Gould 2009, Mullen and Lindberg 2014). These detailed and long-term data sets provide background information for our overall monitoring program (appendix C).

Additional techniques for monitoring DFS have been developed (appendix B). Remotely triggered cameras are now a primary tool for surveying the presence or absence of DFS. While sightings of DFS can determine where DFS occur, lack of sightings is not sufficient to determine DFS absence in a particular area since, as mentioned above, these squirrels can be difficult to detect, and some woodlots are infrequently visited by observers. Thus, camera surveys in a sample of woodlots have been implemented to better understand presence *or absence* of DFS in different areas.

Monitoring the occurrence of DFS in woodlots repeatedly over time allows an assessment of where DFS are persisting on the landscape, where they are disappearing from sites that were previously occupied, and where sites have been colonized (appendix C). It is essential to note that there is always some uncertainty associated with absence information, as the animal may be truly absent or merely undetected. Recently, there have been advances in how to explicitly incorporate this probability of detection into occupancy data and create models of habitat use and distribution (MacKenzie et al. 2006). However, because we are using several types of data to determine presence, we cannot incorporate this approach completely into the PDM plan. We are, rather, drawing conclusions about persistence, extirpation, and discovery or colonization by simply describing the evidence that leads to these conclusions on a site-by-site basis. We conclude that DFS are present if they are observed in the woodlot or detected using cameras or traps. We conclude that DFS are absent from a woodlot only if they are not detected using camera surveys (see appendices A and C for more details). This approach enables us to use several types of data to map the presumed distribution of the animal, and then followup on the presence or absence of DFS in a sample of woodlots to evaluate longer-term persistence and extirpation. This approach is discussed in further detail below.

C. Purpose and Goals

The purpose of PDM is to ensure that a species remains secure from extinction after the protections of the ESA have been removed. Because delisting is based upon evidence of long-term viability, our overriding aim in PDM is to detect signs, if any, of a decreased probability of future persistence based upon evidence, if any, of declining DFS abundance and/or distribution.

The 5-year status review (USFWS 2012) recommended delisting because the abundance and distribution of DFS and its habitat were sufficient to withstand current and foreseeable threats. Past status reviews have documented increases in the size of the DFS known range, increased connectivity of the occupied forest, and high persistence of DFS in occupied forest (USFWS 2007, USFWS 2012). These trends are expected to continue and will be monitored to confirm or refute this expectation.

Threats to DFS such as loss of habitat from sea level rise and development will also be monitored, using aerial imagery, GIS layers, and other expert analyses, such as those conducted by state and local planning and zoning departments for development trends. This PDM, in addition to making inferences from these analyses, is intended to assess changes in DFS persistence that may result from factors that we cannot see or predict easily like disease, predation, weather events, or unfortunate combinations of these factors.

The two main goals of this plan are to:

1. map the distribution of the DFS to determine the overall size and configuration of its range and quantify the total acres and number of occupied forest tracts; and

2. monitor persistence of DFS within the range by reassessing DFS occupancy in a sample of occupied forest tracts to estimate the relative proportion that demonstrate persistence.

II. Monitoring Methods

A. Mapping DFS Distribution and Range Changes

Sightings of DFS, or any other evidence of DFS occurrence, will be recorded in the CBFO GIS, and the adjacent woodlot will be delineated as occupied forest (appendix A; data supporting the assumptions of this effort can be found in appendix C). Evidence of DFS occurrence at a site may come from observations by knowledgeable observers, photographs sent in from trail cams, specific camera surveys conducted for DFS, or trapping data. This will result in a map of the woodlots where DFS have been observed within a specified time period.

Sightings of DFS discovered in areas where they have not previously been observed will continue to be the primary method for determining future range expansion. We recognize that this relies on opportunistic sightings made by a network of knowledgeable observers;

thus, our ability to detect changes is not ensured and might decrease simply because observers fail to report sightings or no longer are on the landscape as often. We accept this limitation for the following reasons:

- The purpose of the PDM plan is to detect declines that may require relisting of DFS. Although increases in distribution that counteract any decreases are desirable to know, the time and effort required to formally camera-survey the many unoccupied woodlots that exist on the landscape in anticipation of future colonization diminishes our ability to predict persistence and extirpations based on currently known occurrences. Considering that the primary goal of the PDM program is to detect declines, we consider opportunistic sightings to be a sufficient means of identifying newly occupied forest while we devote most of our survey efforts to assessing persistence.

- The increases in the range identified in the past have resulted from this same approach, and we expect this source of information to continue at some level post-delisting.

- Although it is possible that reported sightings may decrease based on decreased efforts by observers, as mentioned above, we consider it just as likely that more observers will be interested in reporting DFS sightings after delisting, when the ramifications of DFS presence are not perceived to be a detriment to the landowner.

B. Determining Changes in Occupancy

Sampling Unit: The unit to be sampled for occupancy is a patch of forest that is generally between 50 and 500 acres in size. Note that this is described as a site in MacKenzie et al. (2006, p.157). Few woodlots are completely isolated on all sides from other woods or corridors, and this is not a requirement. Rather, it is simply important to delineate the area to be assessed so that subsequent surveys are conducted in the same area. The forest patch must be big enough to include several animals if it is occupied, but if it is within a very large forest tract, we must define the portion of the forest we will be assessing. Patches within large tracts of forest are generally demarcated by property lines. Thus, the sampling unit will often be the portion of the forest owned by one landowner.

Sample Selection for Occupancy Change Analysis: In the most recent 5-year status review (USFWS 2012), we attempted to determine the current occupancy of 273 woodlots totaling 103,027 acres. However, the range of the DFS now includes over 134,000 acres in more than 500 occupied woodlots and consequently is too large for reassessment of all occupied woodlots. Thus, in the future we will monitor changes in occupancy of a subset of these woodlots.

The sample of woodlots should have the following characteristics:

1. Be as large a sample as possible (thus including sites already being monitored),

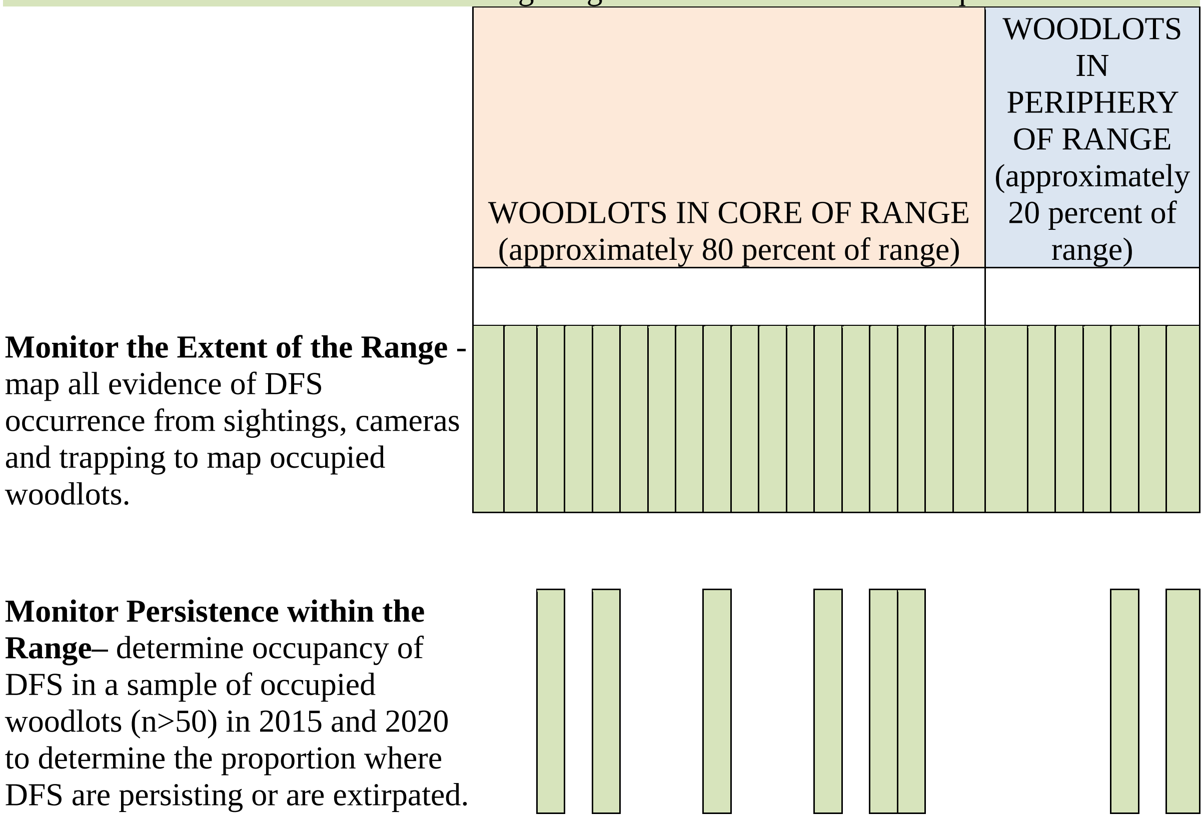
2. Include both core and peripheral areas of the range,
3. Represent the landscapes and areas that occur throughout the range (to be determined through GIS analysis of land use and habitat surrounding the samples and in the landscape as a whole),
4. Generally be accessible for years to come, and
5. Be between 50 and 500 acres in size.

Strata: There are two main strata for sampling based on portions of the range where probabilities for persistence are likely to be different: (1) the *core area* of the range, where DFS have always occurred and where there are many occupied forest tracts in close proximity; and (2) the *periphery* of the range, where DFS have been more recently discovered and where occupied tracts of forest are more often isolated from other population sources. We consider it most likely that DFS from the core are expanding into the periphery, and that populations in the periphery are growing and expanding as well. Note that we are including both translocations and recently discovered populations in the periphery stratum. While the persistence of translocations was an important recovery criterion in the DFS recovery plan (USFWS 1993), it is becoming increasingly difficult to determine whether a new sighting is a result of an expanding translocated population or is a wholly new discovery, and these may be blending as time goes on. Thus, all populations outside the core area will be considered periphery populations. Currently, there is approximately 80 percent of the occupied forest in the core and 20 percent in the periphery.

The DFS in woodlots within the core range are more likely to persist and less likely to be extirpated, because they often have high densities of animals, have already exhibited strong persistence, and are often surrounded by other occupied woodlots; thus, any brief extirpation could be quickly recolonized. However, a true extirpation in this area would be a serious concern and might indicate problems. DFS persistence in a given woodlot in the periphery is less likely and extirpation is more likely because animals are often at lower densities, have just recently occupied the site, and/or are more isolated from other occupied forest tracts with population sources. In addition, a perceived extirpation in these areas may simply result from animals moving into unoccupied habitat nearby but remaining undetected. To address these competing issues, we intend to develop a sample that is approximately 70 percent core woodlots and 30 percent periphery, but will then weight the extirpations of core and periphery somewhat differently.

Our initial sample is approximately 60 percent core and, 40 percent periphery, but as additional sites are added on private lands, we expect this to increase the number of sites monitored in the core portions of the range. Ideally, we would randomly select the woodlots from each stratum; however, since most of the landscape (80 percent) is private land, this involves approaching randomly selected landowners about monitoring a species of concern on their properties, and in our experience this approach is not practical. It is also important that we be able to revisit these sites, and landowners can change, making that less likely. We are thus starting with a sample of woodlots that are primarily on public lands or other lands where we are able to ensure future access. Additional private lands may be added in the future.

Chart 1. General Monitoring Program for the Delmarva fox squirrel.



After the entire sample is selected, and as it grows, we will use GIS analysis to compare the land use features in the areas surrounding the sample woodlots to those same features over the entire landscape as a means of identifying any potential biases in our sample.

Evidence for Presence or Absence in a Woodlot: The ***presence of DFS*** in a woodlot can be documented from the following, in order of increasing costs: (1) sighting reports, (2) camera surveys, and (3) trapping surveys. However, the ***absence of DFS*** in a woodlot can be concluded based only on camera surveys of adequate effort that do not record DFS. Thus, as discussed above, while sightings are evidence of presence, the lack of sightings cannot reliably indicate the absence of DFS in a woodlot. Further details on this and the supporting evidence for why we consider the following techniques appropriate for determining occupancy are provided in appendix B.

Sighting Reports: Observations of DFS from knowledgeable observers will be recorded in the CBFO GIS using the same approach used since 1998. Sightings are indicated with point data, and the woodlot adjacent to the sighting is considered occupied forest. We consider a previously occupied forest block to be currently occupied if there has been evidence of DFS occurring within .25 miles of the woodlot (diameter of an average home range). Sighting reports are an accumulation of positive data (evidence that DFS occur) and do not provide any negative data (evidence that DFS are absent).

Sighting reports are obtained from a variety of knowledgeable people, including Federal and state biologists, hunters, foresters, and citizens who are familiar with the DFS. Photographs of DFS sent in by hunters using trail cameras, or any other pictures that may be sent in, also provide evidence that DFS in a forest tract. These photographs provide additional documentation for the sighting but are not a requirement.

Sighting reports have been particularly good at identifying new areas of occurrence because observers are more apt to report sightings of DFS in areas that are somewhat surprising (i.e., areas where they were not known to occur before). These new sites may represent colonization of new sites by DFS or discovery of new areas where DFS were present but not detected. In either case, the result is a larger distribution for the DFS, which diminishes its risk of extinction. Sighting reports are often not reported in areas where DFS are very common, (because observers are too used to seeing them there) and in areas that are not frequently traveled (ends of peninsulas, the centers of large forest tracts, and areas far from most towns). As described above, lack of sightings of DFS is not evidence of absence of DFS in the woodlot. However, lack of sightings would suggest a need to do a follow-up survey using cameras. If there are no new sightings of DFS in a sample woodlot in a 5-year time frame, this would require additional camera surveys to determine DFS absence from the woodlot.

Camera Surveys: As in the past, remotely triggered cameras can be used to document DFS presence or absence where search effort is not strong or where DFS presence is uncertain. The camera is placed about 10 to 15 feet in front of a trap that is wired open and baited with corn. The trap is used only to prevent rapid removal of the corn by other animals (deer and raccoons). Not surprisingly, DFS will come to the bait and have their presence documented on camera earlier and more frequently than they can be caught in a trap. In some cases where cameras have been focused on active traps, cameras captured a picture of a DFS at the site when the animal was never captured by the trap.

The probability of detection using cameras was analyzed using the program PRESENCE (*http://www.mbr-pwrc.usgs.gov/software/presence.html*). Assessment of 35 camera traps active for 10 days from several sites that include high and low DFS densities, indicate that the probability of detecting a DFS in 1 day was 0.338. Over the first 4 days, the probability of detecting a DFS when it is present is approximately $1 – (1 – 0.338)^4 = 0.81$. This value for a 7-day period is 0.94. We use 10 days as the minimum time for camera placement to allow for days of bad weather and to ensure adequate detection even if DFS abundance is low.

Delmarva fox squirrels are not evenly spread throughout a forest, and most forest tracks include patches of young and old trees. Even in a 50-acre patch of generally mature forest, there are typically some areas where a few trees have fallen, light penetrates to the forest floor, and the understory vegetation is thick. These are not suitable places to put cameras because they tend not to be used by DFS and/or the vegetation is too thick to enable a view of a large enough area to sample. For these reasons, cameras cannot be placed randomly in the woods. They must be placed in a way that has the best chance of detecting DFS, which is generally at the base of a large tree in an area with a relatively open understory. Thus, within the defined forest area that is to be sampled, cameras are placed at a density of about one camera for every 10 to 20 acres with an average distance between cameras of about 150 meters (m), but cameras are placed to maximize detection of DFS.

Evidence that DFS do not occur in a woodlot is determined by a lack of recent sightings and camera surveys that do not record DFS. We will need at least one spring survey to conclude that DFS are absent from a site. Spring is when DFS are most attracted to bait; thus, one spring season is sufficient, but one fall survey is not sufficient.

There is some indication that the frequency of camera days that have pictures is a coarse indicator of DFS relative abundance (i.e., it can indicate when abundance is relatively high or low (see appendix B for more detail). However, we are using it to estimate only presence or absence, not relative abundance. There is always a chance that we could have negative results of a survey and miss a DFS that was actually present. Table 1 discusses this possibility. However, with a reasonable density of cameras, we believe this technique provides the strongest evidence for a conclusion that the DFS is absent from a woodlot.

Trapping: Trapping has been conducted on several national wildlife refuges and clearly provides evidence of presence, as well as other information. Trapping provides the most information about a population, (estimated number of animals, densities, sex ratios, age structure); however, it is also the most time-consuming and costly technique. Long-term trapping has been conducted at three sites at Chincoteague National Wildlife Refuge (NWR) and three sites at Blackwater NWR. Trapping has also been conducted on six additional sites at Blackwater NWR associated with a long-term study of timber harvest and additional sites for a fire study. We now have 12 sites on refuges that have at least 5 years of trapping data and 9 sites that are actively being trapped. All of these trapping data provide the empirical support for the assumption that DFS population dynamics are generally stable and not erratic, and provide many other types of information. Some of this trapping may continue into the future, but on most sites camera surveys are likely to replace trapping.

Trapping would not be used to determine if DFS were absent from a woodlot. Camera surveys can be used to accomplish this with better detectability and at lower cost and lower stress to the animals. If a long-term trapping site failed to trap DFS in a given year, we would followup with camera surveys to better assess the true presence/absence of DFS from the site.

In summary, all three techniques (reports of sightings, cameras, and traps) can provide evidence of DFS presence in a woodlot; however, to conclude that DFS are absent from a woodlot and are now extirpated, we would need to conduct camera surveys whose results supported that conclusion. Note that if there were complete and permanent destruction of all habitat we would also conclude that no DFS remain.

Frequency and Duration of Monitoring: The PDM of DFS will continue for 10 years post-delisting though we anticipate that DFS monitoring will also become incorporated into existing monitoring programs conducted by the States (e.g. bow-hunter surveys, atlas efforts, or other programs). State programs may compliment or even replace this program in the last 5 years of this effort if these programs are more effective than this current approach. Persistence over a long time period is a better indication of a population that is relatively stable than over a short time period. At a minimum, we anticipate surveying half of the listed woodlots in the first 5 years and half of the woodlots in the second 5 years. We have been summarizing the status of this species in approximately 5-year intervals in the past and will continue to compile a brief summary of monitoring results every 5 years until 10 years post-delisting. The past 5-year status review was based on data up to 2010 (USFWS 2012). In 2015, we will reexamine the sample of woodlots chosen and summarize the occupancy of these woodlots and overall distribution at that time based on sightings and data accumulated from 2010 to 2015. We will then continue to assess at least 25 woodlots by 2020 and at least another 25 by 2025. Sites will be classified as either persisting or extirpated and the triggers are built on the percent of the sites and acres in those two categories. Any newly discovered/colonized sites will also be described and the overall range with all new sightings will be mapped.

III. Results, Triggers, and Interpreting Occupancy Change

Results will be summarized in a way similar to that used in the 2012 status review. The proportion of the sampled woodlots will be tallied and placed in a chart like that below. These will also be mapped in the GIS to facilitate inspection of where extirpations may be occurring and possible causes.

Chart 2. Example of a table that could be used to summarize results of future monitoring.

Change in occupancy between 1990 and 2010				Change in occupancy between 2010 and 2015 in sample of woodlots		Change in occupancy between 2010 and 2020 in sample of woodlots	
Occupancy change	**Presence (+) or absence (0) in 1990 sample and as of 2010**	**Acres of forest (# of forest tracts)**	**Percent of the original 103,093 acres in each occupancy status as of 2010**	**Percent of forest tracts (and acres) persisting vs extirpated as of 2015**		**Percent of forest tracts (and acres) persisting vs extirpated as of 2020**	
				Core	**Periph**	**Core**	**Periph**
Persistence	(+, +)	94,221 acres (181 forest tracts)	**96 percent** of forest tracts with known outcomes				
Extirpations	(+, 0)	1,298 acres (8 forest tracts)	**4 percent** of forest tracts with known outcomes				
Uncertain	(+, ?)	7,574 acres (85 forest tracts)	--	--	--	--	--
Discoveries or Colonization	(0?, +)	32,227 acres (250 forest tracts)					

Persistence is indicated by new observations of DFS within 0.25 miles (diameter of a home range) from the occupied woodlot. When forest tracts are larger than 300 acres, we will attempt to obtain more than one observation of DFS to reconfirm persistence in the whole forest polygon. However, if only one new observation is present for a polygon larger than 300 acres, but there are sightings in adjacent or nearby polygons and other evidence such as high abundance of DFS in adjacent or nearby tracts, we will consider persistence in the polygon to be probable and label it persisting.

Extirpation is indicated if there are no new sightings of DFS in subsequent surveys and there is additional information indicating that observers have been in the area and would normally have seen DFS, and that cameras have been placed in the woods and did not detect a DFS. For example, if someone had been hunting and walking in a woods for many years, had previously seen DFS nearly every year, but did not see them in the last 5 years, we might consider that DFS have become extirpated. We would then use cameras to provide additional information. If DFS are actually present but elude detection, we will overestimate extirpation (underestimate persistence and colonization), which is acceptable for this monitoring program.

Colonization/Discovery is indicated if new sightings document DFS occurrence in woodlots where they were not previously recorded. In a few cases, we may have data to indicate that DFS did not previously occur in the stand and be able to conclude it is a true colonization.

Generally, we will describe all new sightings as discoveries, unless we have some negative data indicating absence in the previous survey.

Uncertain is indicated if a polygon has not had a new sighting of DFS, and we do not have observers who frequent this area. Additional effort should be spent trying to determine the true occupancy of these polygons.

Triggers and Responses
The interpretation of the results of this monitoring will take into account the acres and the locations of sites where DFS may have been extirpated and all other information available at the time before making a specific recommendation. The four examples in chart 3 describe situations where the extent of extirpations in the core and periphery would trigger concerns and potential relisting versus interpretations that the population is stable and no relisting is necessary.

Chart 3. The percent of the acres of extirpations in the core and the periphery that would trigger actions regarding relisting.

Response Action	Core	Periphery	Any new discoveries?
Worst case – If there are >20 percent extirpations in the acres of occupied forest in the Core and in the Periphery, we would recommend swift study of the cause of these extirpations to determine whether relisting is necessary.	>20 percent	>20 percent	No or < 100 acres
If we document that DFS have been extirpated from 10 to 20 percent of the acres in the core and more than 20 percent in the periphery with only a few acres added, we would recommend careful study of the causes of these extirpations and consideration of relisting.	10 to 20 percent	>20 percent	No or < 100 acres
If we document that DFS have been extirpated from <10 percent of the core and 10 to 20 percent of the periphery, and, with some additional acreage, we will consider the population to be generally stable and we will continue monitoring, but relisting would not be necessary.	< 10 percent	10 to 20 percent	>100 acres
Best case – If we document that DFS have been extirpated from 10 percent or less of the core or periphery forests and we have at least 100 acres of newly discovered occupied forest, we will consider the population to be stable, and relisting would not be necessary.	<10 percent	<10 percent	>100 acres

IV. Implementing the Survey Effort after Delisting

Monitoring of DFS in the past 10 years has been a combined effort of Federal and state biologists and citizens working together, and the CBFO expects that this will continue to be effective post-delisting. Sightings of Federal, state, and private citizens will continue to be reported, and the CBFO will have continued responsibilities for entering data into the GIS and overall coordination and reporting. The following summarizes specific responsibilities and plans for PDM and management.

CBFO will have continued responsibilities for entering data into the GIS twice a year (January and July) and overall coordination and reporting. The CBFO will also conduct camera surveys to further understand the occupancy of some of the sample woodlots. CBFO will also prepare the reports summarizing the post-delisting monitoring and provide them on their website.

Blackwater NWR will continue to manage its property to maintain and enhance populations of DFS as described in its Comprehensive Conservation Plan (CCP). The refuge will continue to monitor DFS populations using periodic trapping or camera surveys on at least three areas with the expectation of moving into more camera surveys of larger areas and less trapping – or no trapping (table 2).

Chincoteague NWR will continue to manage its property to maintain and enhance populations of DFS and will document that in its upcoming CCP. The refuge will continue to monitor DFS populations using periodic trapping or camera surveys on at least three areas with the expectation of moving into more camera surveys and less trapping (table 2).

Prime Hook NWR will continue to manage its property to maintain and enhance populations of DFS as described in its draft CCP. The refuge will use camera surveys to determine the occupancy of forest tracts on the refuge over time (table 2).

MDDNR will continue to list the DFS on the State list of Endangered Species but its status will likely be changed to (I) Species In Need of Conservation. The department will continue to manage its State land to maintain and enhance populations of DFS as described in its State plans and the Chesapeake Forest Lands Plan (see appendix E). State biologists will continue to report sightings of DFS on State lands and elsewhere.

Delaware Natural Resource and Environmental Control (DNREC) will continue to list the DFS on the State list of Endangered Species as a State Endangered species. The State will continue to manage its property to maintain and enhance populations of DFS as described in appendix F. The State will continue to conduct camera surveys to monitor DFS on the Nanticoke State Wildlife Management Area and potentially additional sites where DFS are suspected.

Virginia Department of Game and Inland Fisheries (VDGIF) will continue to list the Delmarva fox squirrel on the State list of Special Legal Status Faunal Species in Virginia. The status will likely remain endangered; however, such decisions are at the discretion of the Board of VDGIF. The department will report any new areas of occupancy that might occur in the future (see appendix G).

Private citizens will continue to play an important role in conducting monitoring, and private land will continue to provide substantial habitat for the DFS. Recovery of this species is occurring not on only Federal and state lands, but primarily on the many acres of private lands. We anticipate a partnership of Federal and state biologists, with the many interested citizens on the Delmarva Peninsula, to continue monitoring the recovery of this species into the future.

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VI. List of Tables and Figures

Table 1. Occupancy changes and their significance for DFS monitoring and the relative impact of incorrect absence data.

Occupancy Change	Presence (+) or Absence (0) in first and second survey	Importance of understanding this change for DFS	Significance of the uncertainty of DFS absence	Overall Strategy for Monitoring
Persistence	(+, +)	**Very Important –** critical to understanding potential declines	Not an issue, no absence data involved.	Follow-up on **all or most** previously occupied sites. Use sighting reports and any camera or trapping information to document presence.
Extirpation	(+, 0)	**Very Important –** critical to understanding potential declines.	Acceptable bias: we will overestimate extirpations if some of the absences are really presence of DFS.	Follow-up **all or most** previously occupied sites; use multiple surveys and cameras to gain more confidence in true absence.
Colonization or Discovery	(0, +)	**Important –** describes sites where population is potentially expanding.	Acceptable bias: false 0's will mean we will confuse colonization (0,+) with discovery (?,+) of DFS, but it doesn't matter which if total distribution is larger.	Sighting reports have been very good at identifying DFS in new areas and we will continue to rely on these to identify colonization or discoveries. But there is no real need to distinguish between them.
Continued Absence	(0,0)	**Less important**, however, may miss real colonization	Acceptable bias: false 0's means we have underestimated the total range for this species. Thus range is conservative and there are actually more DFS.	We will not be spending a great deal of time and effort in areas outside the periphery. Again, sighting reports have been providing newly discovered sites in the periphery every year since 1998 when the GIS recording started.

Table 2. List of woodlots to be monitored. *

State	County	Core vs Periphery	Ownership	Monitoring Sites
VA	ACCO	P	USFWS	CNWR _White Hills
VA	ACCO	P	USFWS	CNWR_Lighthouse Ridge
VA	ACCO	P	USFWS	CNWR_Sow Pond
VA	ACCO	P	USFWS	CNWR_Woodland Trail
MD	CARO	P	ESLC	ESLC property - from Harmony
MD	CARO	P	Private	J.G. Hunting Sites both
MD	CARO	P	Private	LZucker east side of Tuckahoe
MD	DORC	C	USFWS	BNWR_Jarrett_UnitM
MD	DORC	C	USFWS	BWNR _Buttons Neck MU
MD	DORC	C	USFWS	BWNR _Greenbriar east of fields
MD	DORC	C	USFWS	BWNR _Greenbriar west of fields
MD	DORC	C	USFWS	BWNR_Egypt Track
MD	DORC	C	USFWS	BWNR_entrance area
MD	DORC	C	USFWS	BWNR_Unit T_White Marsh
MD	DORC	C	USFWS	BWNR_Kentuck Swamp MU
MD	DORC	C	Private	Cambridge Commons
MD	DORC	C	Private	Blackwater Crossing
MD	DORC	C	MDChes	CF #4204 and 4219 Palmers
MD	DORC	C	MDChes	CF#4237.02 ChurchCreekMit
MD	DORC	C	County	COUNTY Pk-Egypt Road County Park
MD	DORC	C	MDDNR	DNR_owned Blackwater Resorts
MD	DORC	C	MDDNR	DNR_Chicone Creek_North
MD	DORC	C	MDDNR	DNR_Chicone Creek_South
MD	DORC	C	MDDNR	DNR_LeCompte
MD	DORC	C	MDDNR	DNR_Linkwood
MD	DORC	C	Private	Frequently seen from road here
MD	DORC	C	Private	GWDrivetoTudor
MD	DORC	C	Giese	Malkus Track
MD	DORC	C	NPS	NPS - TC1
MD	DORC	C	NPS	NPS - TC2
MD	DORC	C	NPS	NPS - TC3
MD	DORC	C	TNC	TNC_DorchesterPond
MD	DORC	C	TNC	TNC - Robinsons Neck-Roadside
MD	DORC	C	TNC	TNC Robinson Neck Marsh and Woods
MD	KENT	P	Private	Andelot NorthEastWoods
MD	KENT	P	Private	Andelot MainWoods

MD	KENT	P	Private	RemingtonNorth
MD	KENT	P	Private	RemingtonSouth
MD	QUAN	C	Private	Asp. Inst. East
MD	QUAN	C	Private	Asp. Inst. West
MD	QUAN	P	Private	C. Farm_East
MD	QUAN	P	Private	C. Farm_South
MD	QUAN	P	Private	C. Farm-central
MD	QUAN	C	MDDNR	DNR_Wye Island
MD	QUAN	C	Private	QUANGolfCourse50/301
MD	QUAN	C	Private	Sportsmens Neck
MD	SOME	P	Private	Eby House
MD	SOME	P	TRANS	Hazel
MD	SOME	P	Private	Eby
DE	SUSS	P	DNREC	DNREC - Pete Gum
DE	SUSS	P	DNREC	DNREC S. Nanticoke Wildlife Area
DE	SUSS	P	DNREC	DNRECNanticoke_Red_House
DE	SUSS	P	USFWS	Prime Hook NWR -2 Woodlots
DE	SUSS	P	USFWS	Prime Hook NWR MainEntrance
MD	TALB	C	AUD	AUD_Pickering Creek-SouthAUD
MD	TALB	C	AUD	AUD-Pickering Creek North - office
MD	TALB	C	MDChes	DNR Seth Forest
MD	TALB	C	Airport	Easton Airport A
MD	TALB	C	Airport	Easton Airport B
MD	TALB	C	Izaak	Izaak Walton - Parcel
MD	TALB	C	Develop	Lakeside Trappe - north
MD	TALB	C	Develop	Lakeside Trappe - south
MD	TALB	P	Private	M. and C. Stence Hunting Site
MD	TALB	C	SHA	MDSHA-Island Creek Woodlot
MD	TALB	C	MOU	MOU Miles River Neck
MD	TALB	C	MOU	MOU Mill Creek
MD	TALB	C	County	TALB_Waterside Landing
MD	TALB	C	TNC	TNC-Third Haven Woods
MD	WORC	P	MDDNR	EAVaughn - South
MD	WORC	P	MDDNR	EAVaughn - Central

*Note: a minimum of 50 woodlots will be monitored and some substitutions in this table may be made if landowner interest changes in the future.

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

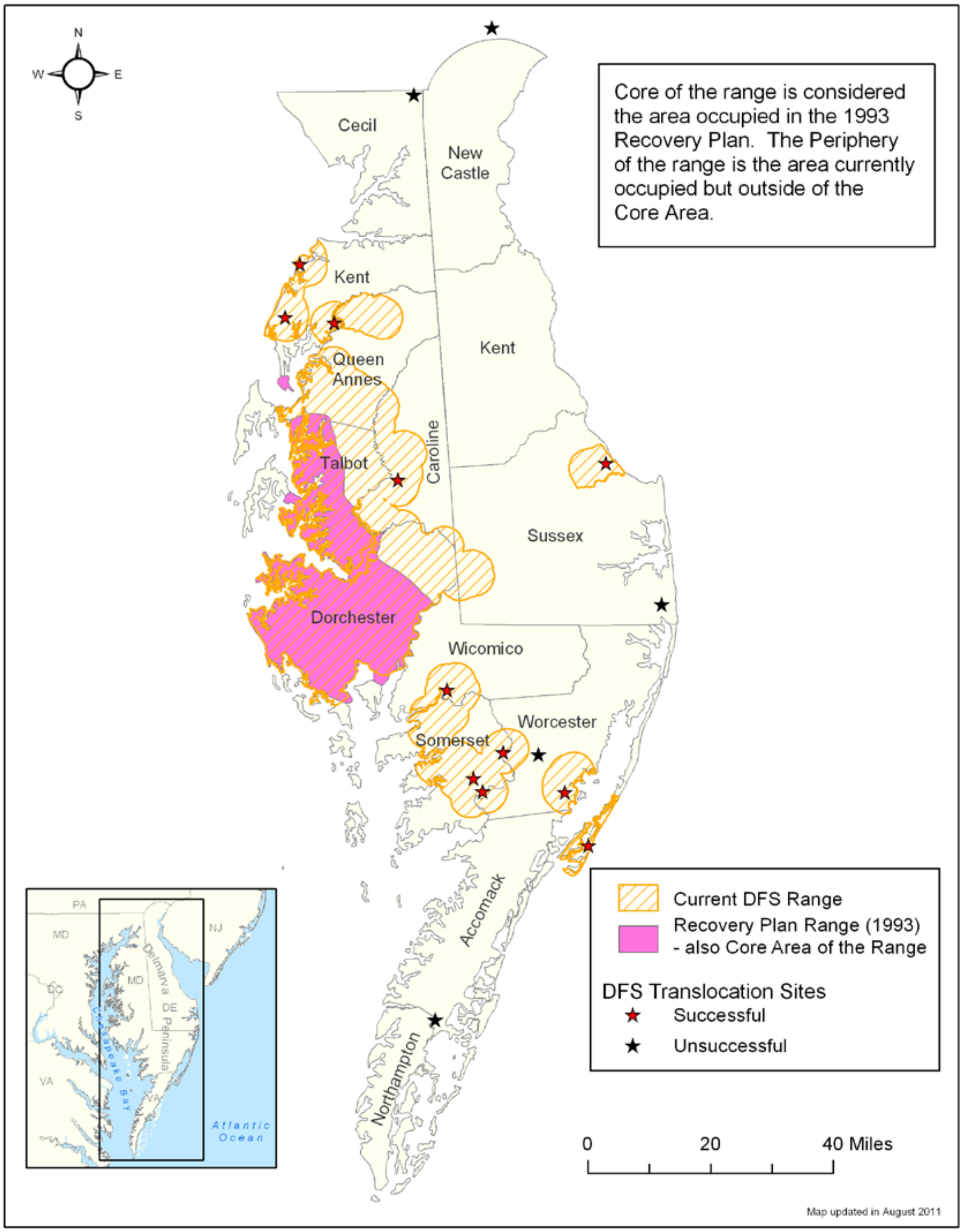
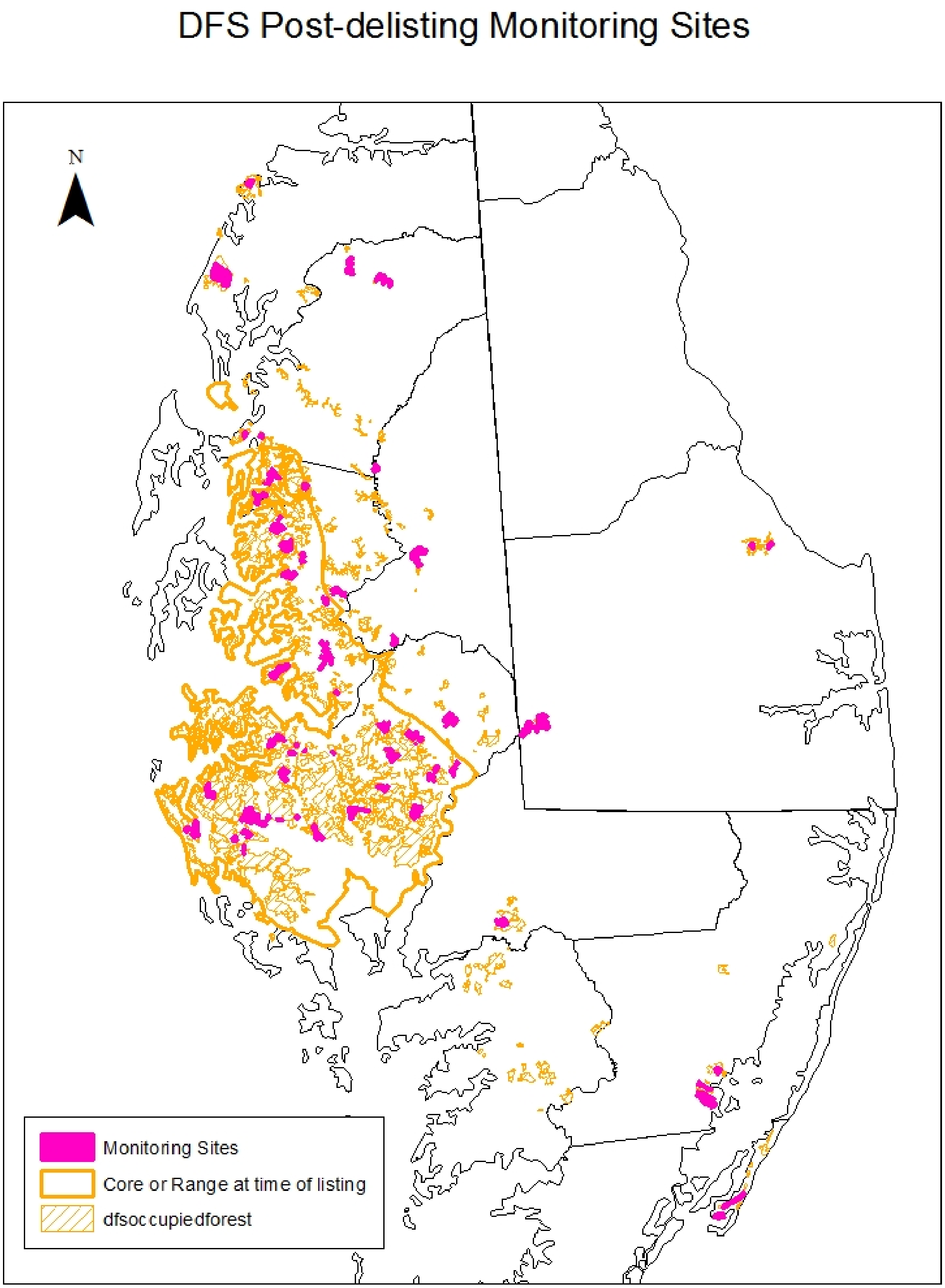


Figure 2. Distribution of woodlots for PDM. Additional sites on private lands are anticipated.



Appendix A. Glossary and Determination of Dispersal Distance

Dispersal Distance: A distance within which populations are considered connected. The DFS populations are considered isolated from each other if they are more than 3.6 kilometers (km) (2.25 miles) apart.

Estimation of Dispersal Distance: To conduct the population viability analysis (PVA) and metapopulation analysis for DFS (Hilderbrand et al. 2007), 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 Service recognizes 16.2 hectare (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/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 percent) 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 percent of dispersers (connectance = 0.25) would move more than 3.6 km (2.25 miles) from their home patch. Thus 75 percent 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.

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

Occupied Forest: Forested areas considered to be occupied by DFS. Occupied forest 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. Delmarva fox squirrels are not considered to occur uniformly throughout the forest, but are expected to occur in some parts of the forest. These areas are delineated as polygons in the CBFO GIS. Imagery used to identify forest tracts or woodlands was originally infra-red Digital Ortho-photo Quarter Quads (DOQQ's) from the mid-1990s. Subsequently, these polygons have been drawn using the most recent color imagery from the NAPP program, currently 2007 imagery.

The first set of occupied forest polygons were originally drawn on paper maps by the Maryland DNR during the 1990s and subsequently digitized and provided to the Service 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 area of land where DFS are likely to occur is delineated as the area within 3 miles of all DFS occupied forest (see figure 1). This represents a best estimate of where DFS are likely to occur based on information about DFS occurrence and dispersal (Service memo dated October 8, 2004), but it does not necessarily imply that all DFS within the delineated area are interbreeding.

Core Area of the Range: The area where DFS have always occurred and does not include translocations. This is also the range as described in the 1993 Recovery Plan and shown in pink in Figure 1 of this document. This area is also called the Natural Range in the 1993 recovery plan.

Periphery of the Range: The newly occupied portions of the historical range where DFS have either been reintroduced through translocations, or where new populations have been discovered, either because DFS have expanded back into these areas, or they have now been detected. Thus this area is currently occupied but outside of the Core Area of the range.

Rangewide population: The entire population of DFS across its entire range.

Recovery: The principal purpose of the ESA is to return listed species to a point at which protection under the ESA 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 and threatened.

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

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).

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 be interbreeding. Subpopulations are delineated by buffering the polygons of occupied habitat by 1.125 miles, and any areas that are interconnected are considered to be part of the same subpopulation (because an individual DFS would have to travel 2.25 miles or less 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. Thus a subpopulation is an area of occupied forests that contain DFS that are likely to be interbreeding and are separated from other subpopulations by more than 2.25 miles. The use of subpopulations in this document is generally a way to understand if there are smaller, more isolated groups of interbreeding animals where extinction risk could be higher because of the groups' smaller sizes and separation from other groups of animals.

Appendix B. Survey Techniques That Have Been Considered for DFS

Walking transects in the woods: These were shown to not be effective (Paglione 1996). No call counts have ever been considered because these animals are generally quiet. Even people who are very good at seeing DFS can walk through a stand that we know has a high density of squirrels and not detect a single animal.

Roadside surveys: In the early 2000s we tried to survey DFS by simply driving the roads, especially in the spring, when DFS are often observed on the edges of fields or roads. This effort produced some results in Dorchester County where the DFS are very abundant, but was not very successful in Talbot and Queen Anne's Counties where DFS are not as abundant. It also depends on the proximity of roads to woods, and observer differences are substantial. While we do not anticipate this technique providing a standardized unit of effort, these can provide observations of DFS for mapping the distribution. DFS are often along agricultural field/woodlot edges in the spring and driving some roads where field edges are in view can produce sightings. Thus observations of DFS are likely to happen from roadsides but we do not anticipate this technique providing reliable negative data.

Nest box surveys: Benchmark sites were established in the early 1990s (USFWS 1993, Dueser 1999), and these sites were surveyed through trapping and/or nest box surveys. Nest boxes are placed in trees and are often used by DFS. Surveys of the boxes are conducted on a winter night, and they count how many boxes are occupied. However, occupancy of nest boxes is highly dependent on temperature, with highest use on very cold nights. Occupancy also varies depending on the availability of other natural den sites. Nest box occupancy is higher in pine sites and lower in mature hardwood forests with many beech trees. Thus, it is not a reliable way of surveying population numbers. However, if these surveys are done in early spring, they can be a good way of simply documenting breeding and litter size, which can be useful.

Trapping: This is the oldest survey technique and provides the greatest amount of information about a DFS population on a particular site. The trapping protocol described in the 1993 recovery plan (USFWS 1993) requires 3 days of pre-baiting and 3 days of trapping, and this protocol was used to monitor the Benchmark sites and most research projects to assess population dynamics on sites already known to have DFS. In 2000, a trapping protocol was established for use in surveys of sites proposed for development. In these cases, the protocol was developed to enable a potential conclusion that DFSs were not present on a site and thus the trapping standards were raised. This trapping protocol required 5 days of pre-baiting and 5 days of trapping, and two seasons (one spring and one fall) of trapping to conclude that no DFS occurred on the site. Trapping is labor intensive, time consuming and can produce some stress in the animals, but provides a great deal of information for a small site.

Camera Surveys: Since about 2000, CBFO has been developing the use of cameras for DFS surveys of presence or absence. Remotely triggered cameras are set up focused on a bait station that attracts DFS and cameras are triggered by the movement and heat of the animal. While it is generally not possible to distinguish individual DFS from the resulting photographs, (though some individuals have distinct markings), it does provide the presence/absence of DFS at a site, and at particular camera stations within a site. The overall frequency of detections of DFS across the camera sites and days can also be determined. We are currently evaluating whether the relative frequency of camera detections reflects the relative abundance of DFS at a site by comparing paired trapping and camera data taken at the same site.

Cameras surveys cannot provide an assessment of actual numbers of DFS as trapping does; however, camera surveys have the following advantages: they do not inflict stress on the animals, they require less personnel time to conduct, and surveys can occur in many more times of year. Trapping is restricted to times of year when temperatures are not too hot or cold for captured animals. Camera surveys can be done any time that DFS are still interested in coming to bait. Camera surveys have been very useful in determining presence/absence of DFS at sites, and we now have an established protocol.

The probability of detecting a DFS at a camera station is actually better than the probability of capturing a DFS at a trap location. Cameras have been placed focused on trap sites, and the camera can detect DFS that visit the site but do not ever enter the trap. The probability of detection using cameras was analyzed using the program PRESENCE (*http://www.mbr-pwrc.usgs.gov/software/presence.html*). Initial assessment of 35 camera traps in place for 10 days indicated that the probability of detecting a DFS in 1 day was 0.338. Over the first 4 days, the probability of detecting a DFS when it is present is approximately $1 – (1 – 0.338)^4 = 0.81$. Thus, camera traps should be out at least 4 to 5 days, and our 10-day sampling frame should be adequate to detect DFS if they are present. This 10-day window allows for some days of lower activity as a result of weather. We may consider more than 10 days in the periphery of the range where DFS are not as abundant.

Hair Catchers: Several studies have been conducted in the development of a hair-catcher survey technique, and these are described below. Hair catchers can provide presence/absence data, but currently are not considered as cost effective as cameras.

- Charisa Morris determined the following in a study at Chincoteague NWR: The DFS would enter a hair catcher trap constructed of a PVC tube and leave hair on a sticky trap.
- Dueser and Moncrief developed a genetic assay to identify DFS hair in a sample of gray squirrel hair, and they concluded they could reliably identify the presence of one DFS hair in a sample of 18 hairs. They field tested the technique at Chincoteague and Blackwater NWRs and Patuxent Research Refuge and did the lab work.
- The CBFO conducted field tests of hair catchers in 2007 to determine the probability of capture. The original genetic lab that had conducted the tests up to this point was not available for this study so a new lab was contracted for the analysis. There were some problems with the new lab retrieving the genetic material from the glue trap, and there were a fair number of samples that could not be used (see table provided at 2008 Federal/state coordination meeting). Overall, cameras were accomplishing the same goal that we wanted to accomplish using hair catchers. Cameras were somewhat more reliable, and over time they were more cost effective. While the original cost of cameras is high ($500), they can be used at little cost over and over again. The only risk is potential theft in the field. Haircatchers (the PVC pipe and glue trap) were very inexpensive, but the genetic analysis of the hair is somewhat costly ($100/sample). But more importantly, not every sample provided results. Analysis of 20 samples (glue traps)

may have useable results for only about 60 percent of those samples. Hair catchers might be of use in the future if there were a genetic assay of hair that could identify individual DFS. If the genetic assay could provide that level of information, then hair catchers might be worth pursuing again for some applications.

Landowner /Land Manager Interviews: Interviews with landowners, land managers, and conservation officers were used by Taylor and Flyger (1974) to determine the original distribution of the DFS, and Therres and Willey repeated this approach in 2001 (Therres and Willey 2005). Individuals who actively work on a property throughout the year are very likely to observe DFS at some point in the year; especially as DFS tend to be seen along field edges in the spring and fall. Generally, it is not hard to determine if the individual knows what a DFS looks like, and individuals who are on a property throughout the year are the best source of information on DFS occurrence. The Taylor surveys were assessing presence or absence of DFS on a particular farm or even larger area, and the presence or absence was not specific to individual woodlots. So the areas surveyed were larger, and not as geographically precise as our current GIS assessment of DFS occurrence in individual woodlots. However, the Taylor surveys enabled the first assessment of the range, and subsequent assessment of the persistence of the population on these larger sites. Landowner interviews can still be useful ways of determining DFS presence/absence on a site, unless the regulatory program is affecting the perceived impact of a landowner reporting DFS as present. There are times when landowners do not want to identify that an endangered species occurs on their properties.

Sighting Reports of DFS in Specific Woodlots by Knowledgeable Observers: As previously stated, the distribution of DFS has been largely understood and monitored through the sightings of squirrels reported by knowledgeable observers. Since 1998, Federal and state biologists, foresters, conservation officers, and private citizens have reported their sightings of DFS to the MDDNR and the Service. These private citizens include landowners, farmers, bird watchers, and hunters. These sightings are mapped very specifically and used to determine which woodlots are occupied by DFS. Most of these observations occur while observers are in the woods conducting forest surveys, driving in the car, or hunting. These valuable observers offer “eyes” that can “capture” DFS in a wide range of public and private lands throughout the year. The sightings provided by these observers have provided the best assessment of the range of the DFS, including sightings that have documented their occurrence in many new areas. This source of information is our best evidence for documenting the range of the DFS and its persistence in the range as outlined in this monitoring plan.

Appendix C. Background to Monitoring Changes in Forest Occupancy by DFS and Support for Assumptions Made Using This Monitoring Approach

Background

The Delmarva Peninsula can be thought of as a landscape of forest patches that are either occupied by DFS or unoccupied. A forest patch is delineated as contiguous forest that stops at roads or fields. Forest blocks range in size, and for very large forest blocks we may delineate a smaller portion of the forest that is owned by one landowner as the area we are going to sample or make inferences about. If we compare the DFS occupancy of forest patches during one time period, and then resurvey these patches at a second time period, we can classify the changes in DFS occupancy of the forest patches into four possible outcomes as follows:

Persistence (+,+) (present in first survey, present in second survey)
Extirpation (+,0) (present in first survey, absent in second survey)
Colonization (0,+) (absent in first survey, present in second survey)
Continued absence (0,0) (absent in first survey, absent in second survey)

We can be confident of the occupancy of a forest patch when the animal or some minimum number of animals have been detected. However, the absence of an animal in a habitat patch has greater uncertainty. Absence may mean the animal is truly absent, or it may mean the animal was present but not detected. There has been considerable recent work on ways to statistically incorporate this uncertainty (detection probability) into surveys using presence/absence data (MacKenzie 2006). This is especially important to include when using occupancy modeling to determine habitat relationships of a species using a sample of locations. However, in this monitoring plan, the potential biases that may result from missing an animal that was actually there are acceptable as the potential biases of the negative data only make our estimates more conservative (Table 1). In addition, by leaving cameras in the field for a long enough time period, the probability of detecting a DFS at a woodlot site increases and we have greater confidence in the naïve estimate of presence or absence. Other analyses indicate that with longer time frames the naïve description of occupancy becomes very similar to the estimated occupancy using PRESENCE.

The statistical power of presence/absence data is greatly improved with larger samples (Strayer 1999, MacKenzie et al. 2006, p.219) and repeated monitoring over time provides the strongest evidence for persistence, extirpation, and colonization (MacKenzie et al. 2006, p.222). These range dynamics reflect the many underlying population changes that are occurring in specific sites and provide the most meaningful parameters for assessing extinction risk and overall trend. If DFSs are persisting in most of the range, and there are more sites being discovered or colonized than are being extirpated, then the DFS is at a lower risk of extinction.

Assumptions behind the use of sightings and cameras in determining presence or absence and supporting evidence for these

1. DFS populations do not change rapidly and are not erratic. We can generally assume that if DFS are present in year 1 and are again present in year 5, they were present in years 2, 3, and 4. This species has high site fidelity, and populations in high, medium, and low densities, persist on the landscape over long periods of time. Evidence for this is seen as follows:

> **Sites with long-term trapping data from refuges indicate occupancy in every year –** Twelve sites at Blackwater NWR and 3 sites at Chincoteague NWR have been trapped for many years. Sites have remained occupied every year – even those with low densities (e.g. Sow Ponds at Chincoteague and Greenbriar at Blackwater) (Gould 2008, Gould 2009, Larson 1990, Pednalut_Willet 2002, USFWS 2010, Mullen and Lindberg 2014).
>
> **Sites with long-term trapping data at Refuges often have the same rank abundance–** Three sites at Chincoteague NWR have been trapped over 20 years, and these sites generally keep the same rank in DFS abundance (e.g., the same sites have the high, medium, and low abundance in 1990, 2002, and 2010) (Larson 1990, Pednault-Willet 2002, USFWS 2010). Trapping sites at Blackwater NWR show a similar pattern, although there may be some change in abundance over time (Mullen and Lindberg 2014).
>
> **Translocations which began with 24 animals or even less have been persisting and growing in the last 25 years; 11 of the 12 sites that were established by 1993 continue to be occupied in 2010–**
> The high success of the translocation indicates that DFS can persist and grow even from a small population. Most of the translocation sites and other sites surveyed because of proposed projects have remained occupied in subsequent surveys (Dueser 1999, Therres and Willey 2002, CBFO trapping data). Of the 12 translocations identified as successful in the 1993 recovery plan, 11 continue to be successful nearly 20 years later. Extirpations do happen in translocations (Eastern Neck NWR, Assawaman Wildlife Management Area) and may also happen as a result of changing habitat from sea level rise or development (USFWS 2012). However, high persistence of DFS populations that have been started from only a small number of animals, indicates high potential for persistence. Overall, persistence of DFS has been demonstrated repeatedly; over 90 percent of the 65 occupied Taylor sites were occupied 20 years later (Therres and Willey 2005, Figure 3), and over 90 percent of the DNR occupied woodlots considered occupied in the 1990s were still occupied 10 to 15 years later (USFWS 2012).

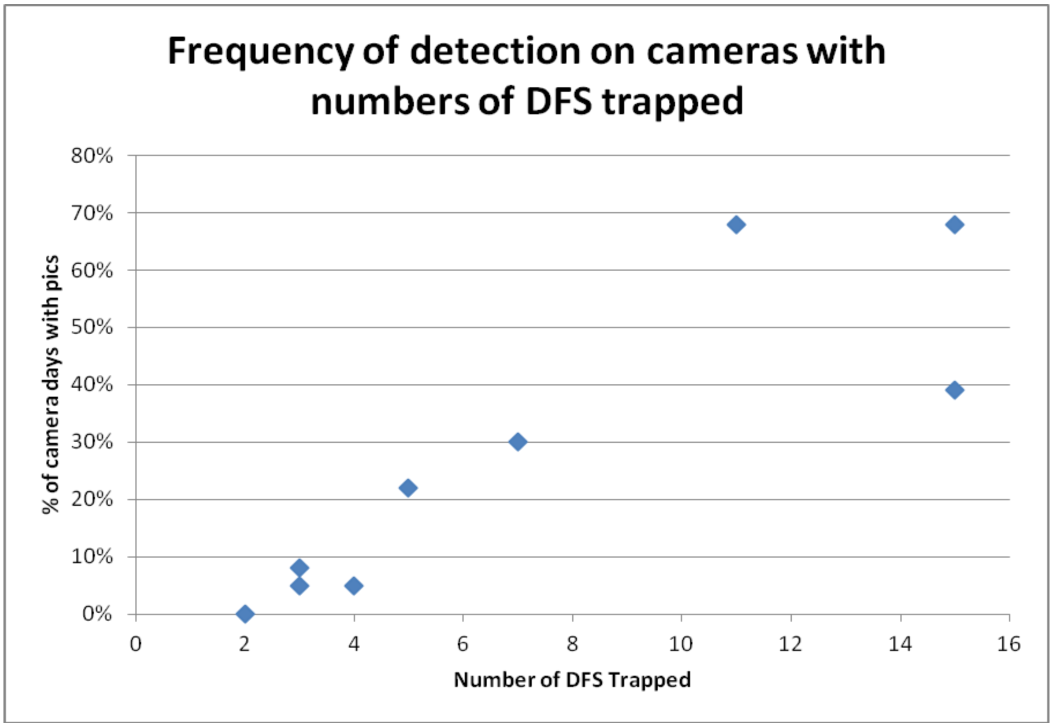
2. Delmarva fox squirrels have high site fidelity, and tend to make smaller shifts in home ranges in response to disturbance rather than abandon a site. This is indicated by their response to timber harvests in Dorchester County (Paglione 1996). Radio-collared DFSs were tracked before and after a 30-acre timber harvest was conducted in an area surrounded by forest. The response of animals with home ranges that overlapped the timber harvest was to simply shift their home ranges into adjacent habitat. They did not abandon the site or make large-scale movements to new areas (Paglione 1996). A similar lack of overall population change in response to clear cuts was observed by Bocetti and Pattee (2003) at three sites in Dorchester County. In this study, DFS abundance remained very similar before and after the timber harvest, whereas the abundance of gray squirrels dramatically decreased. The gray squirrel response to the clear cut was to leave the area, but DFS were staying in the area, at least for several years after the clear cut. Ten years after the clear cuts, when the openings had become filled with tall young saplings, the mean number of DFS in each site was about half of the original numbers; however, they were still present in the study areas (Bocetti email 9/16/2009).

3. When we see one DFS along the edge of a forest track, we can generally assume this indicates that more than one squirrel is living within the woodland, i.e. that the woodland is occupied by breeding DFS. The DFS sightings generally occur along the edge of woodlots because DFS are more visible to more people on the edge of the woods. However, camera surveys confirm that while DFS are more visible along the forest edge, they occupy the middle of forest patches as well (CBFO GIS data). This does not mean they are spread evenly throughout the woods and will be detected at every camera. They are frequently patchily distributed in large woodlands and will not generally be captured on every camera, but their distribution is not restricted to forest edges.

4. Probability of detecting DFS on cameras is generally related to the relative abundance of DFS on a site. When cameras are placed on sites with known abundance from trapping, the percentage of the camera days with DFS detections is correlated to the abundance of DFS. For example, 10 cameras, each active for 10 days, results in 100 camera days; and if we detected DFS on 25 of those camera days, it would be detected on 25 percent of the camera days. In the table below, the percentage of camera days with pictures is compared to known number of individuals captured during trapping on the same site. There is a strong relationship between the number of individuals captured and the percentage of camera days with pictures. While this may seem to be expected, it is possible that a few individuals might visit all the bait stations and be captured on film at all sites resulting in little difference in camera detections despite differences in animal abundance. However, this does not appear to be the case, and there is a strong relationship between the number of individual animals trapped and the percentage of camera days with DFS detections (correlation of the nine sets of points is 0.88).

Note that at most sites the camera survey was conducted simultaneously with the trapping (indicated with an *). It is possible that the cameras perform more poorly than normal in these situations because there was additional bait away from the camera stations, at other trap sites. Thus, there was some bait attracting animals away from the cameras. This may have been the cause of the poor camera results at Riggin, which had the lowest number of DFS. However, overall there is still a strong relationship among the sites.

Comparison of the Percentage of camera days with DFS detections and numbers of DFS trapped from locations with paired trapping and camera surveys. (T=translocations, C= core of range, *simultaneous trapping and camera surveys). (r=0.88)			
	Site	**DFS abundance (# individual DFS Trapped)**	**percent of camera days with DFS Pictures**
T	Riggin*	2	0 percent
T	Dryden*	3	8 percent
T	Jarvis*	3	5 percent
T	Hazel Farm*	4	5 percent
C	Blackwater-Greenbriar	5	22 percent
T	Eby Farm*	7	30 percent
C	Blackwater-Jarrett	11	68 percent
C	Blackwater-Egypt	15	68 percent
C	Cambridge Commons*	15	39 percent



5. Our known occupied forest is a subset of all actual occupied forest. Because of the way we delineate occupied forest, and because we require a documented sighting or evidence of occupancy from cameras or traps, we know our defined occupied forest is a smaller subset of the actual occupied forest. This is partly because we stop drawing occupied forest at roads and fields, and DFS can cross roads and fields; thus, there are woods where DFS are likely to occur between two areas of documented presence. There are also areas where DFS are likely to occur but where we do not have many observers in the area or cannot get access to the land; thus, we do not have documentation of their occurrence. This is especially true for forest tracts at the ends of roads and peninsulas. Thus, the acres of DFS occupied forest that we can document is an underestimate of the true acres of occupied forest.

6. Delmarva fox squirrel observations from knowledgeable citizens are reliable. Once people have seen a few DFS, they can easily distinguish them from gray squirrels, and most of the biologists, naturalists, and interested public that live in these areas are very familiar with this species and can recognize it. This species is not hard to identify once citizens are familiar with it, and much easier to identify than many bird species.

In addition, we insist that observers report only animals that they were able to watch long enough to be 100 percent confident of the identification. We are not interested in observations that begin with "I thought I saw…" or "It almost looked like…". We are interested only in observations that begin with "I watched a DFS as it was…". In the past, and in the future, the reliability of sightings has been determined through discussion with the observer by G. Therres, C. Keller, or the recommendation of repeated observers (e.g. G. Willey, B. Giese and others) vouching for the reliability of additional observers. In the future, reports of sightings will be considered credible in the same way, or through discussion with the observers, or if photographs of DFS are provided.

In summary, several features of the life history of this animal make it well suited for occupancy monitoring: it has high site fidelity, animals tend to stay in an area despite habitat disturbances, and populations are not erratic but tend to be persistent over time. The DFS presence in a woodlot in one year, and again 5 to 10 years later, is highly likely to reflect presence in the years between those assessments. While it is most visible on the edges of woods, it occupies the interior portions as well. The DFS is not difficult to distinguish from gray squirrels and knowledgeable observers can provide reliable sightings that help to map the range and distribution of this animal. Camera surveys can be used to confirm occupancy where sightings do not occur and can be used to assess absence from a site. These features make this animal well suited for monitoring using occupancy over time.

Appendix D. Maryland Department of Natural Resources Plan for Monitoring and Management of the Delmarva Fox Squirrel Post-delisting.

I. Anticipated State Listing Status after Federal Delisting: Species in Need of Conservation. The MDDNR expects to reclassify the DFS to a "Species in Need of Conservation." With this classification, under the authority of the Maryland Nongame and Endangered Species Conservation Act, the species will be protected from take, export, possession, sale, offer for sale, transport, or shipping without a permit. Permits are issued only for scientific research or educational purposes. Incidental take does not require a permit.

II. State Lands where DFS monitoring and management will occur:

State Property	Monitoring	Management
Wye Island NRMA	Will map sightings to describe occupancy	Per current management plan
LeCompte WMA	Will map sightings to describe occupancy	Per current management plan
Linkwood WMA	Will map sightings to describe occupancy	Per current management plan
Chesapeake Forest Lands	Will map sightings to describe occupancy	Per current management plan
E. A. Vaughn WMA	Will map sightings to describe occupancy	Per current management plan
Fishing Bay WMA	Will map sightings to describe occupancy	Per current management plan
Taylors Island WMA	Will map sightings to describe occupancy	Per current management plan

I. Other Management Actions Expected:

Reestablish additional populations throughout the species' historical range in Maryland. Reintroduction, through the translocation of wild-caught DFS, has proven to be an effective technique for reestablishing populations in the species' historical range. There are many suitable, but unoccupied, forested areas on the lower and upper Eastern Shore of Maryland that could support DFSs. The MDDNR will consider reinitiating a reintroduction program in these areas.

Maintain the closed-season status for hunting DFS. Hunting pressure may have contributed to the population decline and range contraction of this species; therefore, the MDDNR will continue to prohibit hunting of this species.

The MDDNR will continue to work with the timber industry on the Eastern Shore to encourage a viable sawtimber industry. Producing sawtimber-sized trees provides private landowners the economic incentive to maintain habitat for the DFS.

Appendix E. Delaware Natural Resources and the Environmental Plan for Monitoring and Management of the Delmarva Fox Squirrel Post-delisting

1. Anticipated State Listing Status after Federal Delisting: State Endangered

2. State Lands where DFS occur and monitoring or management will occur for DFS (*dependent on available funding and staff*):

State Property	DFS Occurrence	Monitoring	Management
Nanticoke WMA – Pete Gum and Dorman Tracks	Yes	Camera surveys	Per management plan DNREC 2014 or most current plan.
Nanticoke WMA – Red House Landing tract	Yes	Camera surveys	Per management plan DNREC 2014 or most current plan.
Prime Hook State Lands (adjacent to Prime Hook NWR)	No	Camera surveys	Per management plan DNREC 2014 or most current plan.

3. Other Management Actions Anticipated: The DNREC has completed a Management Plan for DFS in Delaware (DNREC 2014). The plan includes monitoring known sites (including those listed in the table above), evaluating reports of squirrel sightings, developing habitat management recommendations and determining methods to expand the species' range in Delaware. The plan describes a goal of doubling the Delaware population distribution by conducting two translocations. Five potential sites are identified and evaluated, though final actions will depend on willing landowners, public support, and funding.

Appendix F. Virginia Department of Game and Inland Fisheries Plan for Monitoring and Management of the Delmarva Fox Squirrel Post-delisting

I. Anticipated State Listing Status after Federal Delisting: Endangered

II. State Lands where DFS occur and monitoring and management will occur for DFS:

The DFS is not currently on any State-owned lands in Virginia. However, one potential translocation site that is in the process of being purchased by VDGIF was qualitatively evaluated several years ago for its suitability to support DFS. It is located in Accomack County, approximately 25 miles south of the nearest viable DFS populations in Worcester County, Maryland. The Level Ponds tract, encompassing approximately 480 acres, contains a mix of uplands, and estuarine and palustrine forested habitats. The preliminary suitability assessment revealed that this property and adjacent privately owned properties, including those owned by the Conservation Fund, may collectively serve as a suitable translocation site if appropriate forestry restoration and management actions are employed.

III. Other Management Actions Anticipated:

Virginia has evaluated the potential for additional translocations into Accomack County. In 2007, a DFS Safe Harbor Project, funded through the Landowner Incentive Program (LIP), was initiated to identify private lands with suitable DFS habitat and to establish a safe harbor program (and draft agreement) that could encourage owners of those lands to allow the release of DFS on their properties without undo regulatory burden. Considerable progress was made but no willing landowners were identified while the species was listed. After delisting of the DFS, translocations will be considered and evaluated using the tools developed through the LIP funding.