Building a Predictive Model of Delmarva Fox Squirrel *(Sciurus niger cinereus)* Occurrence Using Infrared Photomonitors

Charisa M. Morris

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Dean F. Stauffer, Chair
James D. Fraser
Marcella J. Kelly

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ABSTRACT

Habitat modeling can assist in managing potentially widespread but poorly known biological resources such as the federally endangered Delmarva fox squirrel (DFS; *Sciurus niger cinereus*). The ability to predict or identify suitable habitat is a necessary component of this species' recovery. Habitat identification is also an important consideration when evaluating impacts of land development on this species distribution, which is limited to the Delmarva Peninsula. The goal of this study was to build a predictive model of DFS occurrence that can be used towards the effective management of this species.

I developed 5 a′ priori global models to predict DFS occurrence based on literature review, past models, and professional experience. I used infrared photomonitors to document habitat use of Delmarva fox squirrels at 27 of 86 sites in the southern Maryland portion of the Delmarva Peninsula. All data were collected on the U.S. Fish and Wildlife Service Chesapeake Marshlands National Wildlife Refuge in Dorchester County, Maryland. Preliminary analyses of 27 DFS present (p) and 59 DFS absent (a) sites suggested that DFS use in my study area was significantly (Wilcoxon Mann-Whitney, $P \leq 0.10$) correlated with tree stems > 50 cm dbh/ha ($\bar{x}_p = 16 \pm 3.8$, $\bar{x}_a = 8 \pm 2.2$), tree stems > 40 cm dbh/ha ($\bar{x}_p = 49 \pm 8.1$, $\bar{x}_a = 33 \pm 5.5$), understory height ($\bar{x}_p = 11$ m $\pm$ 0.8, $\bar{x}_a = 9$ m $\pm$ 0.5), overstory canopy height ($\bar{x}_p = 31$ m $\pm$ 0.6, $\bar{x}_a = 28$ m $\pm$ 0.6), percent overstory cover ($\bar{x}_p = 82 \pm 3.9$, $\bar{x}_a = 73 \pm 3.1$), shrub stems/ha ($\bar{x}_p = 8068$

± 3218, $\bar{x}_a$ = 11,119 ± 2189), and distance from agricultural fields ($\bar{x}_p$ = 964 m ± 10, $\bar{x}_a$ = 1308 m ± 103). Chi-square analysis indicated a correlation with shrub evenness (observed on 7% of DFS present sites and 21% of DFS absent sites). Using logistic regression and the Information Theoretic approach, I developed 7 model sets (5 a priori and 2 post hoc) to predict the probability of Delmarva fox squirrel habitat use as a function of micro- and macro-habitat characteristics.

Of over 200 total model arrays tested, the model that fit the statistical, biological, and pragmatic criteria postulated was a post hoc integrated model: *DFS use = percent overstory cover + shrub evenness + overstory canopy height.* This model was determined to be the best of its subset ($w_i = 0.54$), had a high percent concordance (>75%), a significant likelihood ratio ($P = 0.0015$), and the lowest AIC_c value (98.3) observed. Employing this predictive model of Delmarva fox squirrel occurrence can benefit recovery and consultation processes by facilitating systematic rangewide survey efforts and simplifying site screenings.

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Introduction

The Delmarva fox squirrel (*Sciurus niger cinereus*) was declared endangered in 1967 by the U.S. Fish and Wildlife Service (Federal Register 1967 32 FR. 4001). This large-bodied diurnal tree squirrel is a subspecies of *Sciurus niger*, and is among the largest tree squirrels in North America (Whitaker 1997). Because Delmarva fox squirrels (DFS) are restricted to the Delmarva Peninsula, they are geographically separated from the more common fox squirrel varieties, specifically *S. n. vulpinus* to the west and *S. n. niger* to the south. Delmarva fox squirrels are, however, sympatric with the Eastern gray squirrel *(Sciurus carolinensis).* Though these two species can bear a striking resemblance from a distance, the DFS is larger, has a signature large and bushy fox-like tail, and has more of a silvery or salt and pepper pelage than the smaller and 'browner' gray squirrel (Figure 1). Rarely, partially melanistic individuals are observed with black markings on the head, body, and/or extremities, or with an overall smoky appearance.

The Delmarva Peninsula is 290 km long, and separates the Chesapeake Bay on the west from Delaware Bay and the Atlantic Ocean on the east. The historic distribution of the Delmarva fox squirrel included the Delmarva Peninsula and extended into southeastern Pennsylvania and southern New Jersey (Taylor 1973). Delmarva fox squirrels now naturally occur in approximately 13.5% of that range, specifically in Queen Annes, Talbot, Caroline, and Dorchester Counties, Maryland, and Sussex County, Delaware (USFWS 1993). In an attempt to recover the species, 17 translocation sites were established from 1968 to 1989 by moving 264 squirrels from several remnant populations to long-unoccupied sites within the historical range. At each site, 8-12 individuals were released during the spring or fall over a 1-3 year period (average 16.5

DFS/site). Translocation sites were in Caroline, Kent, Somerset, Wicomico, and Worcester Counties, Maryland; Sussex County, Delaware; Chester County Pennsylvania; and Accomack and Northhampton Counties, Virginia. After 1990, 6 locations received supplemental squirrels in an attempt to increase the average number of squirrels to 24 squirrels per site (USFWS 1993).

All reports of DFS occurrence are digitized and maintained by the U.S. Fish and Wildlife Service (USFWS) in a Geographic Information System (GIS). Original DFS locations, as documented in the 1993 Recovery Plan range map, were obtained from Taylor's (1976) findings and Maryland Department of Natural Resources (MDDNR) reports (USFWS 2003a). Between 1990 and 2001, 1503 hectares of additional occupied area were reported and entered into the GIS database (Figure 2) (USFWS 2003b). Updates to the DFS range were obtained primarily through reports of observations, roadkill reports, investigative live-trapping, and infrared photomonitors (C. Keller, USFWS, pers. comm.).

Delmarva fox squirrels are found in mature forest stands with relatively open understory (Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). Large trees provide mast, den and nest sites, cover from predators, and protection from extreme temperatures. The presence of *Pinus* spp. near or within a forest stand is thought by some to also play an important role in habitat selection (Weigl *et al.* 1989, Dueser *et al.* 1988, Edwards 1986, Dozier and Hall 1944). Plant species composition has been found to be less important than factors such as stand age, understory thickness, and diversity of plant species when considering critical characteristics of DFS habitat (Tappe and Guynn 1998, Weigl *et al.*

1989, Dueser *et al.* 1988, Taylor 1973). The importance of plant species diversity might also explain past study results indicating a higher than expected use of edges by southeastern fox squirrels (Weigl *et al.* 1989, Kantola 1986, Nixon *et al.* 1980, Taylor 1976).

The USFWS (1993) reported that Delmarva fox squirrels feed heavily on oak *(Quercus* sp.*)*, hickory *(Carya* sp.*)*, beech *(Fagus grandifolia)*, walnut *(Juglans nigra)*, and loblolly pine *(P. taeda)* in the fall. Paglione (1996) stated that fall, specifically October to January, is the most important food production period of the year because of the abundance of acorns and nuts. From January to March, DFS feed on remnants of the fall mast production (Paglione 1996). Soft mast hardwoods such as maple *(Acer* sp.*)* are also important in late winter and early spring (USFWS 1993). During the spring, DFS eat tree buds, flowers, and large quantities of fungi, insects, fruit, seeds, and occasionally bird eggs and young (USFWS 1983). In late summer and early fall, they can be seen feeding on mature green pine cones, pine cone seeds, berries, fruits, and fungi (USFWS 1993, Paglione 1996).

Reasons for Decline

The initial decline of the Delmarva fox squirrel has been generally attributed to forest loss and fragmentation due primarily to agriculture, and secondarily to forestry, between 1700 and 1900 (USFWS 2003a). Hunting pressure within the fragmented populations that remained may have accelerated the decline of this species (USFWS 2003a). Hunting of this subspecies has been banned since 1972, and forests now are rarely cleared for agriculture within this species' range. Rather, commercial and residential development, timber harvest, short-rotation pine forestry, and other anthropogenic factors such as vehicle strikes have replaced agriculture and hunting as primary threats to this species (USFWS 1993, 2003a). Though natural threats such as predation, disease, habitat curtailment due to sea-level rise, and competition with gray squirrels do exist, they do not represent an imminent hazard (USFWS 2003a).

Loss of habitat due to commercial and residential development on the Delmarva Peninsula is by far the most immediate threat to this species. Indeed, the USFWS (2003a:17) stated that "the effects of development within or around DFS habitat, particularly when exacerbated by adverse effects of timber harvest, forest pests or disease, or vehicle strikes, continue to impair the species' recovery and threaten its survival in a limited but significant portion of its current range." Delmarva fox squirrels are most abundant in the tri-county area of Queen Anne, Talbot, and Dorchester Counties, Maryland, occurring on 16% of the total land area within these counties (USFWS 2003a). Between 1985 and 1997, the development rate within this tri-county area averaged 436 ha developed/year (Ratnaswamy *et al.* 2001). Increasing development rates and decreasing forest cover are trends apparent in all 8 Maryland counties occupied by DFS (Table 1). Human populations on Maryland's eastern shore increased 14% between 1980 and 1990, and this trend is expected to continue (USFWS 1993). The inevitable loss of habitat that will result from this trend is tempered by the Endangered Species Act of 1973, which requires the USFWS and NMFS (National Marine Fisheries Service) to determine whether federal or private actions threaten listed species and their habitats.

Consultation

Under the Endangered Species Act of 1973 , any Federal agency must consult under section 7 to "insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species" (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*: page 16). Any individual without federal nexus that risks "taking" a listed species must consult under section 10 to obtain an incidental take permit. This permit is only issued if the "take" in question is proven to be "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*: page 31).

The US Fish and Wildlife Service is the lead federal agency for Delmarva fox squirrels, and processes approximately 250 DFS consultations each year (M. Ratnaswamy, USFWS, pers. comm.). Project assessment begins by consulting GIS range data for an initial risk assessment. If the proposed project is within 3 miles of known DFS occurrence, aerial photography records are used to identify any forest areas that are present within the project impact area. If a project impacts a forested area, a site visit is necessary to determine if the forest present has characteristics consistent with known DFS habitat. Site visits sometimes require a minimum of 1 hour of transect work to collect data for the existing habitat model, and are time and labor intensive. Because habitat information is an important consideration in the decision-making process, a habitat model that could predict the probability of Delmarva fox squirrel occurrence would promote more effective and efficient diagnoses of incoming projects.

Habitat models

The ability to predict or identify suitable habitat is an important first step for adequate management of potentially widespread but poorly known biological resources such as endangered species (Pearson *et al.* 1999 *in* Odom 2001). Indeed, managers often use measures of habitat conditions as indices of potential population status (Block *et al.* 1998). The most general level of using habitat as a surrogate measure for populations is the evaluation of wildlife habitat as an indicator of a species' potential presence. Habitat models constructed from presence/absence studies, rather than from detailed demographic data, may allow for rapid assessment of where species "ought" to occur, but cannot be used to manage for viable population levels (Van Horne 1983). However, evaluation at the presence/absence level of resolution can allow more solid inference to be made regarding use or no use, and avoids 'habitat quality' designations that are more easily affected by bias and misinterpretation of species-habitat relationships (Van Horne 1983).

Five years after DFS were placed on the endangered species list, Taylor (1973) conducted landowner interviews to ascertain where Delmarva fox squirrels remained in 5 eastern shore counties of Maryland. He then compared the habitat characteristics of the 36 forest parcels where Delmarva fox squirrels were present with the 18 where they were absent. Gray squirrels were present on all 54 sites. Taylor (1973) completed 1 transect (200m x 4m) on each site to ensure consistency of observation and reduce observer bias. Variables measured included number of trees by species in size classes (5-20 cm DBH, 20.1-30 cm DBH, 30.1-50 cm DBH, and ≥50 cm DBH), percent tree crown cover, percent understory cover (understory defined as stems <5 cm DBH), understory density, and understory species composition. Though Taylor (1976) found no difference in vegetation species composition among the sites, he did find that sites with Delmarva fox squirrels had larger trees and less understory than unoccupied sites.

In the USFWS Habitat Suitability Index Model (Allen 1982) for the eastern fox squirrel *(Sciurus niger)*, variables given the most consideration regarding habitat suitability are percent canopy closure of mast producing trees (optimum from 40% - 60%), distance to available agricultural grain (optimum from 0-200 m), average overstory dbh (optimum ≥ 37.5 cm), percent overstory canopy closure (optimum from 20% - 60%), and percent shrub crown cover (optimum from 0-30%). However, Allen (1982) explicitly states that this model was not intended for subspecies, such as the Delmarva fox squirrel, that occupy the Outer Coastal Plain Forest or Southeastern Mixed Forest Province.

Dueser *et al.* (1988) developed a habitat suitability model based on Taylor's (1976) data. Using a random subset of Taylor's study areas, they examined 8 Maryland sites, 2 Virginia sites, and 5 sites at Chincoteague NWR, VA. They analyzed structure, composition, and landscape characteristics. The main factors measured were density of tree species in size classes, percent crown cover, percent understory cover, understory species composition, and understory density. The data were analyzed with 2-group discriminant analysis comparing "occupied" to "unoccupied" sites. This study revealed that occupied sites had more large trees (>30 cm dbh), lower percent shrub and ground cover, and slightly lower understory vegetation density than unoccupied sites. Though there were no clear-cut univariate differences between sites in forest composition, the dominant habitat used appeared to be small stands of large loblolly pine and mixed hardwood with a closed overstory, open understory, and high proportion of forest edge. Landscape variables did not appear to aid in discrimination between occupied and unoccupied sites in their analysis. Sites with DFS present were correctly classified 76% of the time with the discriminant model, based on a jack-knifing procedure.

However, when the model was applied to 30 other pine sites with known Delmarva fox squirrel presence (G.W. Willey, MD Department of Natural Resources, pers. obs.), it only correctly classified these sites as occupied 27% of the time (USFWS 1993). This led to a re-evaluation of the 1988 model. A revised model continued to use percent large trees, percent crown cover, and percent shrub-ground cover as the dominant variables; however, less emphasis was placed on large trees and greater emphasis was placed on pine composition, overstory canopy closure, and low shrub-ground cover (USFWS 1993). This revised version is the model currently used by USFWS personnel to support habitat determinations.

Photomonitors

Remote monitoring methods such as telemetry, automated sound recordings, and mechanical devices have been used for decades (Peterson 1998). Wildlife professionals have used cameras for presence studies, trail monitoring (Mathiasen and Madsen 2000), and population studies (Karanth and Nichols 1998, Mace *et al.* 1994). Kucera *et al.* (1993) authored the first major publication specifically about Trailmaster® Brand photomonitor (Trailmaster®, 10614 Widmer, Lenexa KS 66215). The Trailmaster® photomonitoring equipment under review consisted of a unit (transmitter) that emitted an infrared beam to a second unit (receiver). When an animal blocked the beam, the receiver sent a signal to a third unit (35 mm camera), triggering a photograph. In their review, Kucera *et al.* (1993, pg. 507) described the Trailmaster setup as "a reliable, versatile, and durable tool for remote monitoring of wildlife [that] researchers can adapt to a variety of uses."

Since its inception, remote wildlife photography has become a more accessible technology. Photomonitors are no longer restricted to wildlife professionals, but now have widespread use in recreational settings for activities including hunting. Evolving technology has produced smaller, faster, more capable equipment, including digital cameras. These units eliminate the delay involved with print development, allowing immediate photographic review of activity, reducing the cost of print material and increasing efficiency. Since the inception of this study, several digital set-ups have been shown to provide enough clarity to discriminate between animals as similar as the gray and fox squirrel (Niederriter Holly, Delaware Department of Natural Resources and Environmental Control, pers. com. 2003).

Although remote photography is convenient and effective, some problems may occur under even the best conditions. Vegetation can trigger the infrared beam if it is fast-growing or blown by wind, heavy rainfall can obscure the beam intermittently, units can be vandalized, units can record an excessive number of events for unknown reasons, extreme temperatures can affect functionality, and insects can burrow into units (Rice *et* *al.* 1995, Peterson 1998). Many other problems can be attributed to “human” error, though thorough training can alleviate these issues.

Trailmaster® offers a variety of systems for wildlife monitoring. Peterson (1998) examined the performance of the TM 500 Passive Monitor, a one unit set-up that photographs anything that enters an elliptical cone of sensitivity. She tracked the success of this unit against an observer recording the same animal activities. Results indicated these monitors underestimated events. The USFWS (C. Morris, unpublished data) reached the same conclusion after attempting to detect DFS presence with both TM 500 Passive Monitors and TM 1500 Active Monitors. In a later study (C. Morris, 2002, unpublished data), TM 1500 and TM 1550 (improved version of TM 1500) active photomonitors were found to have a higher DFS capture rate than live traps (# 103, Tomohawk Live Trap Co., Tomohawk, WI) set on the same site. Indeed, on some sites the photomonitors detected DFS when live-traps caught none or only gray squirrels. Photomonitors have the added convenience of year round applicability, whereas live-trapping is restricted to spring and fall months due to the effects of extreme temperature on animals exposed in traps. However, detection of DFS with any method during the early summer has lower success due to what Paglione (1996) termed the “disappearance period,” when fox squirrels become less active as temperatures are high and food supplies are declining. In the 2002 USFWS study, DFS were detected year round by photomonitors, but were more likely to be detected in spring or fall than summer or winter (C. Morris, unpublished data).

Recovery Goals

The Delmarva fox squirrel is one of the 75% of endangered species that have a recovery team (www.audubon.com). Recovery teams, which include representatives of public and private agencies and institutions, are convened to prepare recovery plans for individual species or ecosystems. Guided by the Endangered Species Act, the goal of the USFWS as identified by the Delmarva fox squirrel Recovery Team is to recover this species by increasing populations and protecting habitat (UWFWS 1993). To meet this goal, the team developed a list of 6 actions that are needed:

1. Determine population status and distribution.
2. Determine habitat availability and use.
3. Protect DFS and their habitat.
4. Devise and implement forest management practices to maintain suitable habitat for the squirrel.
5. Plan and conduct additional translocations to unoccupied portions of the range.
6. Foster increased public awareness of the squirrel's status and recovery needs.

In 1990, 7 benchmark sites were established to provide long term population data (Action 1). Two of these sites, Egypt and Jarrett Tracts, are located at Chesapeake Marshlands National Wildlife Refuge in Dorchester County, Maryland. This project, which used this refuge as a study site, will support Actions 1 through 5.

Objectives

The objectives of my project were to (1) identify habitat variables associated with Delmarva fox squirrel use, and (2) use this information to develop a habitat model that can be used to predict the probability that a particular tract constitutes potential Delmarva fox squirrel habitat. From September 2004 to December 2004, infrared photomonitors were deployed for 7 days at 86 points across central Dorchester County to detect Delmarva fox squirrel use. Measurements of forest structure and composition were also taken at these points. I used those data to investigate relationships between DFS use and overstory, understory, shrub cover, ground cover, composition, and landscape setting. I then used information-theoretic model selection to evaluate competing multivariate models of factors suspected to be related to Delmarva fox squirrel use.

The information obtained from this project can advance the recovery of the Delmarva fox squirrel by (1) identifying habitat variables that are associated with DFS presence, (2) expediting the informal consultation process by making habitat assessments simpler, and (3) identifying habitat measurements associated with DFS presence that can be recognized using an airborne profiling laser, thus facilitating the current need for a systematic rangewide survey of potential habitat for this species.

Study Area

The Delmarva Peninsula is named for the 3 states (Delaware, Maryland, and Virginia) that it comprises. The western coast of this peninsula houses Maryland’s Eastern shore, which is dominated by inlets and marshes. Dorchester County is the largest county on the

Eastern shore of Maryland (254,575 ha). With 142.5 persons/ km^2, Dorchester County has the lowest human density of all Maryland counties containing DFS (294 persons/km^2 average excluding Dorchester) (U.S. Census bureau). Dorchester County also has the largest area (35,733 ha) of DFS occurrence (Ratnaswamy *et al.* 2001). Approximately 24% of its 1490 square kilometers is occupied by DFS; this is almost twice that of Talbot County, which has the second highest frequency of known DFS occurrence (Ratnaswamy *et al.* 2001). Dorchester County's relatively flat topography is laced with tributaries of the Chesapeake Bay, consequently containing 39% of the entire State's wetlands (www.dnr.state.md.us/greenways/dorchester.html). Approximately 34% of Dorchester County lands are in agriculture and 39% is forested; however, of forested lands, only 6% are located on public property (www.nass.usda.gov/md/ dorchesteri.pdf). The majority of public forested lands are located along the southern shoreline of the county within the Chesapeake Marshlands National Wildlife Refuge (CMNWR) (Figure 3).

Formerly named Blackwater National Wildlife Refuge, CMNWR is a 9488 ha refuge that comprises 3389 ha of forest and 2803 ha of marsh. The remaining lands comprise open water, with relatively little area (<5%) developed with roads, buildings, and an intensively managed system of dikes, moist soil impoundments, and croplands (Eagle 2003). Most of the forest on the refuge is seasonally flooded, and the land is interlaced with ditches that were used to drain land for logging and agriculture. Common overstory species present on the refuge include white oak *(Quercus alba)*, red oak *(Q. rubra)*, black oak *(Q. velutina)*, willow oak *(Q. phellous)*, swamp oak *(Q. michauxii)*, beech *(Fagus grandifolia)*, red maple *(Acer rubrum)*, sweetgum *(Liquidambar styraciflua)*, blackgum *(Nyssa sylvatica)*, cherry *(Aronia arbutifolia)*, and pine *(Pinus taeda)*. Common understory species present include holly *(Ilex opaca),* high bush blueberry (*Vaccinium corymbosum*), low bush blueberry (*V. angustifolium*), pepperbush (*Clethra alnifolia*), bayberry *(Myrica cerifera),* greenbriar (*Smilax rotunifolia)*, and raspberry (*Rubus idaeus*). The 4 major cover types sampled within the refuge's forests, as defined for this project, were loblolly pine (no hardwoods are present in the stand), loblolly pine-mixed hardwood (loblolly pine and any mixed hardwoods, excluding oak), loblolly pine-oak (loblolly pine and any oak are present), and mixed hardwoods (no pine)**.** The 4 age classes used in this study were poletimber (all trees sampled < 30 cm dbh), sawtimber (all trees sampled < 40 cm dbh), mature (trees > 40 cm dbh were ≤ 13% of the sample), and very mature (trees > 40 cm dbh composed > 13 % of the sample). I used the 13% value in the age class cutoff to accurately reflect the natural distribution of the data.

Chesapeake Marshlands NWR was chosen in 1990 by the DFS recovery team to contain 2 of 7 population monitoring benchmark sites. These 7 benchmark sites, which are distributed rangewide, are used as a reference for the recovery status of the species and were routinely trapped to monitor population trends (Recovery Plan 1993). Based on estimates from these and other trapping efforts, the Blackwater DFS population appears stable (Giese, USFWS, pers. comm.). A conservative estimate of total DFS numbers on forested refuge lands is approximately 1000 individuals, assuming 1 DFS/ 2 ha (Giese, USFWS, pers. comm.). The average DFS home range (averaged across 3 seasons) on the refuge was found to be 12.78 ha (Paglione 1996).

Methods

Study Site Selection

A large portion of the Delmarva fox squirrel's range is inaccessible to public access due to private property status or lack of access routes. Chesapeake Marshlands National Wildlife Refuge not only offered high accessibility to a large area of potential DFS habitat, but Delmarva fox squirrels also appear to be most abundant in this southern portion of their known range (Ratnaswamy *et al.* 2001). Thus, the relatively high probability of failing to detect individuals during surveys for a naturally rare species is decreased. Therefore I assume that the lack of use of certain habitat types by Delmarva fox squirrels in this area was purposeful, rather than resulting from low density distribution.

Like other fox squirrel species, Delmarva fox squirrels are known to use non-traditional cover types such as crop fields and mast-producing pine thickets as supplemental feeding areas (Weigl *et al.* 1989, Kantola 1986, Nixon *et al.* 1980, Taylor 1976). Should records of such use be included in a process intended to generate a predictive model used to identify DFS habitat, the current definition of habitat would be broadened considerably. Under federal law (Endangered Species Act, 87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*), areas considered DFS habitat must be protected. To maintain reasonable and prudent regulatory applicability of my results, I limited biological inference to cover types that have been shown capable of supporting a breeding population of Delmarva fox squirrels.

I used a random sampling approach to select forested study sites within CMNWR. The refuge had established a 500 meter spaced grid in 2003 to sample baseline flora and fauna conditions refuge-wide (Figure 3). During the 2003 effort each gridpoint was located with GPS, and a metal post with a site-specific alpha-numeric identifier was placed at each location. Using GIS maps (Arcview GIS 3.3) overlaid with the GPS grid, I selected all gridpoints previously identified as forest by MD DNR GAP analysis (Rasberry *et al.* 2003). Of the 400 total gridpoints on the refuge, 134 were determined by DNR GAP to be within forested habitat (Table 2). Of these 134 points, 126 were visited and 86 were sampled. The 48 forested points that were eliminated from this study did not qualify because they were either misidentified (n = 6), inaccessible (n = 8), regenerating clearcuts (n = 5), or no longer viable forests due to saltwater inundation (n = 29).

I collected preliminary vegetation data on 25 sites from June 2004 to August 2004. I collected complete vegetation data and DFS use data on all 86 sites from September 2004 to December 2004.

Vegetation Sampling

Field measurements followed Noon's (1981) sampling protocol for forest habitats (Table 3). This comprehensive approach provided a complete representation of current site conditions. This also ensured I did not limit myself to a′ priori supposition, thus allowing more freedom and opportunity during my post hoc analysis.

I measured species composition, overstory, understory, shrub cover, and ground cover within a 0.04 ha circular plot (11.3 m radius) centered at each sampling point (Figure 4). Although some preliminary habitat data were collected between June 2004 and August

2004, all measurements that were seasonally affected (i.e., shrub and groundcover variables) were recorded concurrently with DFS sampling. Though no data were available to support the supposition that DFS may stop or start using an area due to seasonal fluctuation in vegetation structure, this coordination of measurements ensured we did not risk this sampling incongruity. I summarized field data to generate variables used to build habitat models (Table 4). Habitat data sheets are presented in Appendix I.

Shrub stem types were separated into 7 categories (Figure 5). Sparse grasses ($\leq$ 100 blades/ m^2) comprised stem type A, single bole shrubs over 15 cm (eg: high bush blueberry, pepperbush) comprised stem type B, single bole shrubs < 15 cm (eg: low bush blueberry) comprised stem type C, briar (eg: greenbrier, raspberry) comprised stem type D, short turf-like grasses comprised stem type E, and tall marsh grasses comprised stem type F. Stem type G was formed by pepperbush with regenerating seedlings evenly distributed across the ground. Stem types A – C have an irregular growth pattern, stem type D is generally clumped or irregular, and stem types E – G are usually evenly distributed.

Measurements of water depth and dispersion, log cover, snag size, and snag density were recorded on 80 of the 86 sites. However, tree mortality resulting from approximately a decade of saltwater intrusion confounded these variables. As a result, these variables were eliminated from the final analysis.

Landscape measurements

The position of a potential habitat parcel within the landscape could very well influence whether or not it is used by Delmarva fox squirrels. Therefore, I included landscape measurements such as distance to nearest agricultural field, distance to nearest road, patch size, and stand size in my analyses (Table 3). I defined a forest patch as a contiguous group of trees that was sufficiently uniform in species composition, arrangement of age classes, and condition to be a homogeneous and distinguishable unit (Smith 1962). A forest stand was defined as a contiguous group of patches with no apparent barriers to DFS movement. Distance to a road or agricultural field was measured pragmatically (i.e., not across barriers to DFS mobility such as wide water bodies or large expanses of marsh).

I used the Delmarva fox squirrel GIS database currently maintained by the USFWS Chesapeake Bay Field office to determine landscape measurements. Measurements were taken using digital ortho quarter quads (DOQQs) and the ArcView geodesic distance and area measurement tool. A precision of 100 linear feet and 5 acres is assumed.

Photomonitor Procedure

Delmarva fox squirrel presence was determined using an infrared photomonitor at each survey point. Photomonitoring provided a means of detecting Delmarva fox squirrels without the time, cost, labor or stress to the animal involved with live trapping. Though population estimates cannot be obtained from photomonitoring survey efforts because of the similarity in pelage among individuals of this species, basic presence data can be confidently secured using this technique.

A photomonitor was placed at the center of each 0.04 ha study plot for 7 days. The area in which vegetation sampling occurred (0.04 ha) was approximately 0.3 % of the estimated Delmarva fox squirrel home range (12.78 ha; Paglione 1996). Based on the

500 m spaced grid, the area associated with each gridpoint was 25 ha. I assumed the photomonitor's area of sensitivity did not cover this entire 25 ha, but rather was limited to areas from which the bait could be sighted by a squirrel. Because Dorchester County has almost consistently flat topography, the photomonitor's area of sensitivity thus only varied with understory density.

Trailmaster® brand (Goodson & Associates, Inc., Lenexa, Kansas, USA) TM1500 and TM1550 active monitors were used in this study. These monitors detect and photograph anything that breaks an invisible infrared beam (beam length $\leq$ 45 meters) emitted from a transmitter to a receiver (Figure 6). Units were usually secured to trees within 11.3 m of the central marker post. If no trees of the proper diameter (10 - 30 cm dbh) or spacing (1.5 – 5 m apart) were within the study plot , 5 cm x 10 cm x 1m stakes were used to secure the receiving unit. Beam length at the sampling points was $\leq$ 5 meters to decrease the opportunity for a non-target animal to break the beam. The beam was set 7-9 cm from the ground to ensure contact with the body of the squirrel. A weather resistant 35 mm camera (TM-351) with 400 ISO film was used for the photographs. For this project, the monitors were programmed to register all events but only photograph those occurring between 0500 and 2000 hours. Though Delmarva fox squirrels are known to be almost strictly diurnal (C. Morris, USFWS, unpublished data), I attempted to capture any crepuscular activity as well. Both the monitors and the cameras recorded events by date and time to the minute. The receiver was programmed to register an event once an animal interrupted the beam for at least 1/4 second. This restriction reduced photographs of falling vegetation or fast-moving deer. The TM-351 camera had a 5 minute delay between triggered photographs to reduce the possibility of an individual animal visit exhausting an entire roll of film.

A standard squirrel sized (48.26 cm x 15.24 cm x 15.24 cm) Tomahawk live trap (# 103, Tomahawk Live Trap Co., Tomahawk, WI) was wired open and placed at a right angle to the transmitter to direct squirrel movement in front of the beam. The trap also acted to reduce bait theft by raccoon and deer. The bait (cob corn) was partially obstructed with dowel rods or sticks to inhibit a non-target species (e.g., raccoon, deer, etc.) from immediately removing the bait. This impediment also indirectly produced more photographic opportunities as a squirrel circled the trap to investigate alternate means of reaching the bait.

Photomonitoring units were placed at the sampling point for 7 days between September and December, 2004. Units were only on each site for 7 days to ensure I was obtaining records of normal use rather than attracting DFS to a site with bait. Vegetation characteristics were measured at each point upon collection of the photomonitoring units; this allowed accurate representation of the sampling site at the time DFS use was ascertained, while assuring the human activity associated with sampling vegetation had no effect on DFS response. No photomonitoring data were collected during summer months because of a period of perceived inactivity in DFS, supposedly due to higher temperatures (Paglione 1996). Photomonitoring data sheets are presented in Appendix II.

Model Development

To capture the relationship between Delmarva fox squirrel site use and habitat characteristics, I developed 5 sets of a′ priori models using logistic regression and the

Information Theoretic approach (Burnham and Anderson 2002) (Table 5). All models included predictor variables chosen based on literature review, past models, and professional experience. However, the Percent Cover, Stem Density, and Landscape Models were proposed to provide predictive models that had the potential to be both accurate and easy to implement; variables with similar measurement approaches were grouped to allow more logistically efficient field application.

A′ priori Models

1. The Percent Cover Model attempted to capture percent cover measurements, which are part of the habitat model currently employed to determine the likelihood of a forest parcel being occupied by DFS. Overstory, understory, and ground coverage measurements capture the elements of forest structure that have been considered relevant to DFS habitat suitability (Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). The only structure level neglected by this model is shrub cover.
2. The Stem Density model attempted to capture not only shrub metrics, but overstory and understory density as well. As with percent cover, the uniform measurement technique of this model would simplify field application.
3. The Landscape Model was also intended to be a "one stop shop," allowing the user to predict the probability of DFS use from a map or a computer equipped with a Geographic Information System (GIS).
4. The Biological Model was based on current management practice and personal experience, and included all of the features I personally evaluate when analyzing a forest stand from a DFS management perspective. This model would involve more

detailed field measurements, and was the only original a′ priori model that considered plant species composition.

5. The Integrated Model was developed using a post hoc compilation of predictor variables chosen from the a′ priori model subsets that received the highest Akaike weights. The AIC weight (w_i) can be considered the probability that a particular model approximates the true process best, given the data and the set of candidate models. This post hoc model was dependent upon the results of the first model set runs; however, it has a′ priori support in that it is a compilation of predictor variables previously selected for model development.

Post Hoc Models

A sixth model was generated post hoc once a′ priori analyses were complete. Variables not chosen a′ priori were included in the post hoc model analysis if they exhibited a relationship to DFS presence at the univariate level. A seventh and final model was a post hoc compilation of a′ priori and post hoc predictor variables chosen from the model subsets that received the highest Akaike weights.

Current DFS Habitat Model

The DFS habitat model currently used to predict DFS presence (USFWS 1993, Dueser *et al.* 1988) featured 5 variables: percent canopy cover, percent understory (shrub) cover, percent of trees > 30 cm dbh, percent pine, and a shrub thickness index. The shrub thickness index is a rating of 1 – 4 estimated by whether it is easy, moderate, moderately difficult, or difficult for a person to walk through the shrub layer. This model was included in this study as a basis for comparison.

Analysis

I first used Wilcoxon-Mann-Whitney analyses to test for differences in habitat characteristics measured at DFS present versus DFS absent sites. In addition to analyzing habitat and landscape variables, I also tested the effect of weather (temperature, wind speed, precipitation) on DFS photo observations. Due to the exploratory nature of this endangered species study, I used $\alpha = 0.1$, which reduced the probability that I failed to detect a habitat variable useful in identifying DFS habitat. For nominal variables such as shrub stem type, I used Cohen's Kappa Coefficient (K) (Norman and Streiner 1999), which expresses the strength of association of the binary independent variable with the presence of DFS on a -1 to 1 scale (with 0 signifying no relationship).

Dueser *et al.* (1988) developed the original DFS habitat model using 2-group discriminant analysis. However, I chose logistic regression as the appropriate method for this modeling effort due to (1) the more relaxed assumptions of normality of independent variables (Hosmer and Lemeshow 1989), and (2) the ability of logistic regression to use both continuous and binary variables as predictor variables (North and Reynolds 1996).

To test for a relationship between DFS presence and each predictor variable, I conducted univariate logistic regression analyses. I assumed no masking of effects or interaction between variables. I evaluated goodness-of-fit using likelihood ratio chi-square statistics with a liberal cutoff of $P = 0.25$. Variables that met this criterion qualified for inclusion in post hoc models. Variables chosen a′ priori were retained for model analyses regardless of the strength of their relationship to DFS presence at the univariate level.

I then used logistic regression analyses to assess the 6 multivariate model sets developed to explain the relationship between DFS use and site condition. No 2 variables that were found to be correlated with $r \geq 0.7$ level were included together in a model set.

I used Akaike's Information Criterion (AIC) for model selection; however, because the sample size to variable ratio was < 40, I used AIC_c, corrected for small sample size bias (Burnham and Anderson 2002). I first ranked the 4 a′ priori model subsets by AIC_c; only those models within < 2 Δ_i (measured distance between AIC_c values) of the lowest (i.e., strongest) AIC_c value were selected for consideration in the final analyses. Models within these selected subsets were then compared using AIC_c, Akaike weights *(*w_i), likelihood ratio *P*, and percent concordance. After using information-theoretic model selection procedures to determine which models were most powerful from each of the 4 original model sets, I extracted those variables to create the fifth Integrated model. The post hoc model was a combination of these same variables and variables selected for inclusion during the univariate logistic regression analyses.

The current 5-variable Delmarva fox squirrel model (USFWS 1993, Dueser *et al.* 1988) was also analyzed for goodness of fit using logistic regression. After analysis, I applied the current DFS model to the vegetation data collected from the 86 sites to compare predicted occurrence with true occurrence. I generated and analyzed all models using the Logistic Procedure in SAS 9.1 (PROC LOGISTIC, SAS Institute, Cary, NC, USA).

Results

Trapping Results

I sampled 86 sites (trap nights = 602) for DFS presence from September 9, 2004 to December 22, 2004 in Dorchester County, Maryland. Delmarva fox squirrels were successfully photographed (i.e., present) on 27 of these sites. Four other groups of species were recorded incidentally across most sites: gray squirrel, deer (*Cervus nippon, Odocoileus virginianus*), raccoon, and birds (*Quiscalus quiscula, Cyanocitta cristata, Cardinalis cardinalis*) (Table 6). Delmarva fox squirrels composed 58% of all captures across sites where they were present. The majority of DFS (71%) were captured within the first 3 days, peaking on day 2 and decreasing thereafter (Figure 7). Gray squirrel, bird, and raccoon captures peaked on the first day and tapered off towards the cessation of each effort. Deer captures were minimal, and peaked on the fourth day (Figure 8). Trap success (catch per unit effort = (# photos/trap nights)*100)) was highest for DFS, followed by raccoon, gray squirrel, bird, and deer (Figure 9). Delmarva fox squirrels visited traps between 700 and 1700 hours, and the frequency of their visits appears to be bimodal with heightened activity in the mid-morning and mid-afternoon (Figure 10). I found no relationship between capture records and maximum and minimum daily temperature, average daily wind speed, and precipitation.

Habitat characteristics

*Overstory***.** The 3 most abundant overstory species (trees > 15 cm dbh) observed across sites were loblolly pine, red maple, and sweetgum (Table 7). There were more red maples in the overstory on sites with DFS present than those with DFS absent ($P = 0.069$, Table 7). Though DFS were most commonly found in loblolly/hardwood forests, the use based on availability was highest in loblolly/oak stands, then loblolly/hardwood, mixed hardwood, and pure loblolly stands, respectively (Figure 10). A Chi square analysis indicated that the proportional use of stand types was not homogenous (P = 0.051). This evaluation suggested a higher than expected use of loblolly-oak stands, and a lower than expected use of pure loblolly stands.

Sites with DFS present had higher overstory cover ($P = 0.06$, Table 8, Figure 11), taller overstory canopy height ($P = 0.001$, Table 8), and a higher density of trees >50 cm dbh ($P = 0.06$, Table 9).

Older stands were more likely to be used (Figure 12). Sites with DFS present had a higher density of stems >50 cm dbh, which were significant in the Wilcoxon ($P = 0.06$) test and logistic regression ($p = 0.09$) (Table 9, Figure 13). When tree stems were separated into density groups > and < 40 cm dbh, larger trees (dbh > 40 cm) had a higher density on sites with DFS present ($P = 0.03$, $p = 0.10$, Table 9). A higher proportion of trees were > 40 cm dbh ($P = 0.01$, Table 10), and composed of red maple (P=0.08, Table 10) on sites where DFS were present, compared to sites where they were absent.

Understory. The 3 most abundant understory species (trees < 15 cm dbh) observed across sites were red maple, pine, and holly (Table 11). There were more black gum on present sites ($P = 0.04$) and more pines on absent sites ($P = 0.07$, Table 11). Delmarva fox squirrels also used sites with taller understory canopy ($P = 0.066$, $p = 0.056$, Table 12).

Shrub cover. The most abundant 4 species found across sites were bayberry, greenbrier, blueberry, and pepperbush. Bayberry and pepperbush were found more ($P < 0.05$, logistic regression) on sites where DFS were not detected (31% and 44%, respectively) than on sites with DFS present (11% and 19%). Greenbrier and blueberry were found more ($P < 0.05$, logistic regression) on sites where DFS were present (89% and 78%, respectively) than on sites where DFS were absent (70% and 58%). Sites with DFS present had fewer shrub stems/ha ($P = 0.038$, Table 13). DFS presence was positively associated with the CV of shrub stems (i.e., DFS used sites with patchier stem distribution ($P = 0.06$, logistic regression, Table 13). DFS presence was negatively correlated with even shrub cover, which was strongly significant during univariate testing ($p = 0.0086$, Table 14). All shrub cover stem types sampled were represented on both sites used and not used by DFS. At an alpha = 0.10 (chi-square analysis), Delmarva fox squirrel use was correlated with the absence of stem class G (Table 15).

Ground cover. The coefficient of variation of forb cover was significantly different between sites ($P = 0.02$, $p = 0.02$, Table 16, Figure 15). All ground cover stem types sampled were represented on both sites used and not used by DFS. At an alpha = 0.10 (chi-square analysis), Delmarva fox squirrel use was correlated with the presence of stem class A (Table 15). Of 161 possible plant species, the mean number of species on present sites, absent sites, and sites eliminated from the sample were 17.1 species, 18.1 species, and 13.6 species, respectively.

Landscape. Of the 4 landscape variables analyzed, DFS presence was positively associated with proximity to agriculture (i.e., sites with DFS present were closer to agricultural fields than sites with DFS absent). This relationship was significant in all tests (P= 0.09, p = 0.04, Table 17). Patch size was also found significant in the univariate logistic regression (p = 0.0984, Table 17).

Model Development

Of the 24 predictor variables chosen a' priori, 15 were not significant in non-parametric tests, and 13 did not meet our univariate logistic regression criterion (p <0.25) for inclusion in full models (Table 5). Twelve variables not initially chosen for a′ priori models met the univariate logistic regression criterion; I considered 11 of these 12 to be biologically relevant, and retained them for use in post hoc model development. The unused variable was CVFORB (coefficient of variation of forb cover). The coefficient of variation measurements reflect the patchiness of a variable's distribution among the quadrants surveyed at each point. The CVFORB mean was higher on absent sites, which implies absent sites had patchier forb cover; however, this trend was actually due to an abundance of "0's" (i.e., no forb cover) on present sites. As a result, the CVFORB variable was discarded as invalid. Thirteen candidate variables were found not significant in both non-parametric tests and univariate logistic regression and were not used in the modeling process.

Percent Cover Model. The final models in this subset indicated a positive relationship between DFS presence with POVER (percent overstory cover), and a negative relationship to understory (PUNDER), forb (PFORB) and grass (PGRASS) cover.

Though all original predictor variables were retained in the final models (models with $AIC_c < 2.0$) (Table 18), POVER was included in 4 of the 6 final models. This variable's higher explanatory power was evident in Wilcoxon testing (P = 0.06), and it was the only independent variable in this model set that met the $P < 0.25$ criterion during the univariate analysis. Except for the model containing only POVER ($P = 0.078$), likelihood ratio P values were relatively high (> 0.1) across the set. The model containing only POVER had the highest Akaike weight (and lowest AIC_c value), but the concordance was higher for the model containing POVER and PUNDER (percent understory) as predictor variables.

Stem Density Model. All original predictor variables were retained in the final model subset except for DSIZE2 and DSIZE3 (density of trees in size class 2 and size class 3) (Table 19). The final models showed a positive relationship between DFS occurrence and DSIZE5 (density of trees > 50 cm dbh) and DSIZE4 (density of trees > 40 cm dbh), and a negative relationship to DBRIAR (density of briar stems), DSIZE1 (density of stems < 15 cm dbh), and DSHRUB (density of shrub stems). The variable DSIZE5 was found significant in non-parametric tests ($P = 0.06$), which was reflected in the Akaike weight and only Likelihood ratio P value for this model. However, this model also had the lowest percent concordance (36.9%), being one of three models with concordance below 50%. The variable DBRIAR was singly cast in the model with the second-highest Akaike weight, though percent concordance was well below 50% and the Likelihood ratio P was not significant. The well documented (Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944) biological relevance of an abundance of large trees and a minimal number of smaller stems to DFS was reflected in the 2 models with the highest concordance, which each contained a measure of large stem density (DSIZE5), and one of small stem density (DSHRUB and DSIZE1). However, the low percent concordance and high Likelihood ratio P values exhibited by this subset implied that stem density measures alone could not accurately represent the true character of areas used by DFS.

Landscape Model. All original predictor variables were retained in final landscape models (Table 20). The final models in this subset showed a positive relationship between DFS occurrence with DISTRD (distance from nearest road), PTCHSZ (patch size), and STNDSZ (stand size), and a negative relationship with DISTAG (distance from nearest crop field). DISTAG's relatively high explanatory power was indicated during nonparametric testing (P = 0.09), and this variable was included in 4 out of the 5 models (Table 20). Despite the landscape on the study site being minimally variable (i.e., large, contiguous forests), Likelihood ratio *P* values for all models in this subset were significant ($P \leq 0.10$), and percent concordance was moderate.

Biological Model. Six of the original 15 independent variables chosen for this model were retained in the biological model subset (Table 21). All variables except for DSHRUB (density of shrub stems) had met the $P = 0.25$ criterion during univariate analysis. The final models in this subset showed a positive relationship between DFS occurrence with percent of trees > 40 cm dbh (P45), percent overstory cover (POVER), shrub patchiness (CVSHRUB) and shrub stem density (DSHRUB), and a negative relationship with even shrub (SHEVEN) and ground (GREVEN) cover dispersion. The variable SHEVEN (even shrub cover) was present in all models. The model containing only SHEVEN had a likelihood ratio $P < 0.01$, and all other models had a likelihood ratio

0.03 >*P* > 0.01. The model containing SHEVEN, P45 and POVER had the highest percent concordance (71.2 %). This was not only the most powerful model in this subset, but also the most powerful and biologically comprehensive model from all a priori attempts.

Integrated Model. The predictor variables with the highest Akaike weight were used to create an Integrated model (Table 22). The final models in this subset featured a positive relationship of DFS occurrence with percent overstory cover (POVER) and density of trees > 50 cm dbh (DSIZE5), and a negative relationship with distance from nearest crop field (DISTAG) and SHEVEN. The variable SHEVEN was present in all models. This subset yielded several different models with strong predictive ability. All models had a likelihood ratio *P* < 0.05, and the 4 with the highest Akaike weights had a likelihood ratio *P* < 0.01. Percent concordance of most models was > 70%.

Post Hoc Model. Only variables chosen post hoc were included to develop these models; as a result, not all forest and landscape metrics were represented. Of the 11 predictor variables that met the post hoc inclusion criterion of P < 0.25 (univariate logistic analysis), 3 were retained in the final model subset (Table 23). The final models in this subset featured a positive relationship with overstory canopy height (AVGCH), understory canopy height), (AVGSCH), and percent red maple (PREDM). All models in this subset have high (> 73%) percent concordance, and were highly significant (< 0.002).

Integrated Post Hoc Model. The predictor variables from models with the highest Akaike weight from both a′ priori and post hoc model selection were used to create an Integrated *Post Hoc* model (Table 24). The final models in this subset featured a positive relationship of presence of DFS with overstory canopy height, understory canopy height, percent red maple, and percent overstory cover, and a negative relationship to even shrub cover. All models in this subset have high (> 75%) concordance. The model with the highest Akaike weight and a strong (75.2%) percent concordance included measures of overstory canopy closure, tree height, and shrub cover.

Currently used DFS Model (USFWS 1993, Dueser et al. 1988). This model featured 5 variables: percent canopy cover, percent understory (shrub) cover, percent of trees > 30 cm dbh, percent pine, and a shrub thickness index. Percent concordance of this model was 72.3%, the likelihood ratio was $P = 0.05$, and it had a 109.0 AIC_c value. Of the five variables, only the shrub index was significant ($P = 0.05$). When I applied the current DFS model to the vegetation data collected from the 86 sites to compare predicted occurrence with true occurrence, 55% of the “present” sites were predicted correctly, and 72% of the “absent” sites were predicted correctly. Overall, 67% of the predictions agreed with true observations.

Discussion

Endangered Species Overview

While the value of ensuring any one particular species does not become extinct can be debated, most arguments found in literature and media can be reduced to the central and popular concept of biological diversity (Noss 1990, Waples 1995). The idea that the loss of one element has an incomprehensible ripple effect across an entire community is a concept that promotes the blind maintenance of an ecological balance within a system. Regardless, given a particular time or culture, any species at risk might hold value to *somebody*; whether it is an aesthetic, economic, medical, biological, religious, or other value depends upon the perspective of the individual. In this paper, I will discuss the importance of the preservation of a species at risk as it relates to the enforcement of the Endangered Species Act.

The Endangered Species Act of 1973 (16 USC 1531-1544, 87 Stat. 884) is the legislation created to avoid or minimize anthropogenic or natural threats to species in decline, and is considered by some to be the most powerful environmental law ever enacted (Mann and Plummer 1995, Waples 1998). The Endangered Species Act (ESA) was created to manage the conflict that occurs at the human/imperiled species interface. Typically, that conflict commences with a competition for a resource; one that is needed by a listed species, and threatened by an action incidental to an otherwise lawful activity carried out by a project proponent.

Of the natural resource professionals charged with enforcing the ESA, some have found success in shifting their management paradigm from a reactive regulatory position to one involving a more proactive, public service platform. In this position, we assist project proponents by facilitating the design of low- or lower-impact projects in the spirit of species conservation and best management practices.

Across the board, natural resource agencies responsible for managing endangered species are becoming more comfortable with the idea of applicant enlightenment. By allowing more information to become available using no- or low- interaction methods such as the internet, the agency and project proponent alike benefit from reduced workloads, increased efficiency, and fewer impacts to species at risk, when feasible (i.e., due to the risk of collection, some species location information remains restricted).

Progressive thinking has also lead to improvements in the quality of site information brought to the table by particular project proponents. Natural resource professionals can share their expertise through publicly available guidance documents (e.g., habitat models) that can direct and assist in the data collection and transfer process. This detailed species and habitat material provides project proponents the tools they need to supply reviewers with reliable and informed site information. However, the facilitation of information transfer is only one of the benefits offered by developing a habitat model for the Delmarva fox squirrel.

Delmarva fox squirrel habitat models

The ability to confidently identify potential Delmarva fox squirrel habitat has two primary benefits. First, there exists a need to accurately assess project site conditions during ESA consultation project triage. Secondly, there is a need to reliably identify areas potentially occupied by DFS to determine current recovery status, as well as to accomplish post-delisting monitoring.

On a landscape with already-fragmented habitat, it is a challenge to protect the Delmarva fox squirrel in the face of burgeoning development. Endangered Species Act consultations on this species are frequent, and successful and efficient management of proposed projects is crucial. In the past, the need for a professional biological interpretation of site conditions resulted in many field hours wasted identifying sites that were clearly outside the realm of DFS habitat. Using a′ priori knowledge from past studies, as well as new advances in our knowledge of DFS habitat use, I sought to develop a habitat model that can allow regulatory bodies to describe precisely what basic site information is needed to assess a project’s potential impacts on DFS. By giving the project proponent the power to confidently provide such information, efficiency of project submittal and review is improved on the part of both parties.

I also strove to identify distinctive DFS habitat parameters that can be measured using LIDAR technology. This marriage of natural resource and remote measurement disciplines could provide a means to confidently focus range-wide survey efforts on areas that can actually support DFS populations. This ability would allow recovery biologists to manage recovery efforts across a landscape more effectively, and focus valuable research dollars to areas most likely to yield results. This same technique could also be used in post-delisting monitoring efforts to track the proportion of habitat available to DFS over time.

Essentially, I did not need to develop a comprehensive understanding of every factor and characteristic that draws a Delmarva fox squirrel to use a parcel. I simply needed to answer the question, “What is the minimum amount of information needed to point us in the right direction?” The information-theoretic approach using Akaike’s Information Criterion was the model-selection method that could best unearth the answer.

Modeling Overview

The validity of the broad and unwavering application of traditional statistics, i.e. null hypothesis testing, has been questioned in recent years. Though debating an existing paradigm is not a new concept in research, model selection by information-theoretic (IT) methods is now being offered as an alternative to the traditional statistical paradigm (Burnham and Anderson 2002. Indeed, the information theoretic approach is being used with increasing frequency in natural resource scientific explorations. Though maximum likelihood and model selection have been used in general statistics for decades (Aldrich 1997), the common use of this application in ecological studies has been growing in popularity since just before the turn of the century (Guthery 2005). I support the use of IT-AIC, and have used this approach in this study; however, I do not discredit the "silly" null hypothesis (Anderson *et al.* 2001 *in* Stephens *et al.* 2005) and the "useless" p-value (Loftus 1993) concept. Both the I-T and hypothesis testing approaches have merit, depending upon the situation. Borrowing heavily from Hobbs and Hillborn (2006), I will explain the difference between the 2 approaches as I see them in terms of both hypothesis and data variability.

In traditional null hypothesis testing, the hypothesis is fixed and the data are variable (Hobbs and Hillborn 2006). Indeed, after a univariate hypothesis is constructed, data are collected specifically to test that 1 assertion. The p-value, then, is offered as the probability of obtaining a value of the test statistic more extreme than the one observed, given the null hypothesis is true (Hobbs and Hillborn 2006). Essentially, p-values are statements describing the probability of extreme events that we have not observed (Royall 1997); consequently, they do not assess the strength of evidence supporting a hypothesis.

In information theoretic model comparison, the hypothesis is variable and the data are fixed. Indeed, this statistical approach investigates the likelihood of competing hypotheses (i.e., models) given the data (Hobbs and Hillborn 2006). This is the more appropriate statistical approach for studies testing multivariate patterns of causality, as it is not limited to the comparison of two complementary hypotheses (Stephens et al. 2005).

Though this approach presents the tempting ability to discover patterns and processes hidden in existing datasets, I avoided “data dredging” in this study by formulating models a′ priori, and then designing a study that allowed specific investigations into the validity of the parameter relationships within those models. In this sense, I also avoided “model dredging” by limiting my analysis to biologically sensible and informative hypotheses; otherwise, I may have simply discovered the “best” model from an array of biologically meaningless candidates (Stephens et al. 2005) by employing a ‘stepwise’ or ‘all possible subsets’ analysis. These approaches use automated data-driven variable selection schemes, rather than employing a more biologically sound (and cognizant) hypothesis-driven selection. However, I did use a post hoc analysis of biologically relevant parameters to ensure I did not limit discovery to those relationships defined a′ priori.

All model selection methods seek parsimony, and the ultimate goal of this exercise was indeed to find the most parsimonious model that could indicate whether an area might be used by the endangered Delmarva fox squirrel. Guthery *et al.* (2005) chastised the habit of creating a presumably biologically valid global model and then arbitrarily paring and rearranging it to get a presumably valid “best” model, which ironically invalidates the global model which was its source. They go on to acknowledge that this might actually be seen, not as model selection, but rather as a sensitivity analysis or magnitude of effects estimation. This determination applies to this study, which is based on a dataset collected specifically to determine which factors play a role in DFS use of a site. All parameters collected could legitimately be causally linked to DFS use of a site; as a result, all global models created a′ priori were legitimate. Though naturally part of the model selection process, the quest for parsimony in this study also has a very realistic basis. The model I was seeking to develop was to act as a screening step in field assessments (i.e., ESA consultation) and in LIDAR surveys (i.e., ESA recovery). Both of these applications require a general, but accurate, model that can be used to target potential sites for further analysis; quite simply, I needed to know what, at a bare minimum, could indicate whether or not DFS might use a site. Once a site was targeted for further analysis using a model, the ultimate determination of likelihood of true DFS occupancy would be made after considering the other candidate parameters from this study during a site visit.

Therefore, I sought a model that would allow simple and easy data collection, but one that would also provide a complete, though not exhaustive, "snapshot" of the site. The computer assigned relatively low AIC values to many models due to parsimony. While parsimony is desired, a model pared down beyond basic required habitat elements is unusable. The model that fit the statistical, biological, and pragmatic criteria was the post hoc integrated model:

DFS use = Percent overstory cover + shrub evenness + overstory canopy height

This model considers crown closure (POVER; percent overstory cover), shrub cover (SHEVEN; shrub evenness), and stand age (AVGCH; average overstory canopy height). It was determined to be the best of its subset ($w_i = 0.54$), had a high percent concordance (>75%), and a significant likelihood ratio ($P = 0.0015$). Most impressively, this model had the lowest AIC_c value (98.3) of all models developed, both a priori and post hoc; therefore, the evidence implies that this model fits the data better than any other one evaluated. The model is biologically credible and captures the essential DFS habitat characteristics of a site. Pragmatically, these parameters can be measured using LIDAR, and are also basic enough for any project proponent to report when submitting site information during ESA consultation.

I believe this model to be reliable and relevant. I have worked almost exclusively with Delmarva fox squirrels since 1999, and have accrued hundreds of hours of field and research experience with DFS. Based on this experience and discussions with leading experts on this species, I consider overstory cover, forest age, shrub and ground cover, and parcel size to be the basic habitat elements that should be included for a model to be fully representative of forest condition. The model directly addresses overstory cover and shrub cover. Though canopy height and dbh did not exhibit a direct correlation in this study, canopy height can be used as an indicator of forest age (Henry and Aarsson 1999). Parcel size is a basic habitat element that should also be included in the model, but it is a component of habitat that could not be adequately addressed by this study due to an abundance of contiguous forest sites. Few small parcels were sampled. This lack of fragmentation is not common in the range of the DFS, and additional studies would be needed to determine the minimum parcel size used by this species. Minimum suitable parcel size is most likely influenced by habitat quality and connectivity to larger parcels or other foraging areas. I suggest that this model can be applied to a parcel of any size, given it is connected to other parcels within a landscape (i.e., it would be senseless to apply this model to a small isolated parcel).

Tree species composition is another seemingly obvious basic consideration that should be included in a model; however, tree species variation is low within the range of the Delmarva fox squirrel. The risk of analyzing a mature forest containing tree species not used by DFS is minimal due to the limited forest systems that exist on the Delmarva Peninsula; therefore, appropriate composition can be assumed.

In summary, the likelihood of a forest having characteristics similar to forests used by DFS can be essentially captured by considering percent overstory cover, shrub evenness, and overstory canopy height. This very basic model is the minimum amount of information needed to point us in the right direction. However, this study yielded additional useful information that can help develop a more comprehensive understanding of forests used by DFS.

Current Hypotheses Supported by Results of this Study

Larger trees. Delmarva fox squirrels are known to use mature forest stands (Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). Large trees provide mast, den and nest sites, cover from predators, and protection from extreme temperatures. The traditional DFS model (Dueser *et al.* 1988) weighs the percentage of "larger trees" (trees > 30 cm dbh) heavily as an indicator of potential DFS occurrence on a site. Similarly, when considered in the context of the ESA regulatory process (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*), a forest must harbor trees > 12 inches dbh (30.48 cm) to be potential DFS habitat. This study indicated the presence of trees > 40 cm dbh to be a significant indicator of a site likely to be used by DFS. However, DFS were found on 4 sites where no trees > 40 cm dbh were measured, and on 1 site where no trees > 30 cm dbh were measured (however, this particular site was within a parcel containing larger trees). Overall, this study did not yield results that support the criterion for the >30 cm dbh cutoff that is currently used in DFS management practice. Rather, the evidence suggests recalibrating the model to put weight on stands with dbh > 40 cm. However, my dataset was collected in an area with a prevalence of mature forest, which differs significantly from other areas within the range of DFS. Therefore, it is plausible that DFS in more stressed areas (i.e., areas with reduced availability of mature stands) use stands with smaller trees, as they have reduced access to more mature forests. Because these more stressed populations are also at a greater risk of further habitat loss due to development, I do not recommend revising the current management hypothesis that DFS may use forests containing trees > 30 cm dbh.

Closed overstory. High percent overstory cover is also considered in the traditional DFS model (Dueser *et al.* 1988). However, the current model first considers the proportion of small trees (< 30 cm dbh) to large trees (>30 cm dbh). This hierarchy of structural consideration is validated by the results of this study. Percent overstory cover only becomes an asset once the presence of large trees is established. Large trees are ecologically relevant for DFS because they provide foraging, nesting, and resting cover. Past studies have shown that DFS may actually use leaf nests more often than cavities (Kendra Willet, USFWS, pers. comm.). Most trees > 20 cm dbh can produce mast and provide leaf nest sites; the fact that DFS use is associated with larger trees supports the hypothesis that tree size is important not only for nesting and high mast production, but also because of the effect large trees have on the suppression of forest floor growth. Indeed, some of the characteristics traditionally associated with sites used by DFS are quite often consequences of a mature closed overstory (i.e., open understory, low shrub and ground cover). This metric can be measured using LIDAR, and is one of the 3 parameters included in our "best" model.

Shrub cover. Optimal DFS habitat, according to current standards, has a very open, almost park-like understory (Conner *et al*. 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). Biological incentive for choosing areas like this may be ease of mobility, higher visual acuity for predator awareness and access to forage materials. The results of this study support the hypothesis that DFS use more open areas; indeed, DFS were found most often on sites with low shrub stem density, and less often on sites with high stem density and evenly dispersed shrubs. On sites where DFS occurrence was known prior to the study, DFS were not photographed using an area with even shrub cover (e.g.: pine thicket, marsh grasses), even when they were observed as close as 20 feet away in a more open area of the same parcel. Neither shrub composition nor shrub stem type appeared to play an important role in DFS site use; if any species of shrub-height vegetation was dispersed evenly throughout an area, that area was not used during our study. The traditional DFS model (Dueser *et al.* 1988) has 2 measures for shrub cover: point intercept counts (over a 200 meter transect) and a "difficulty for observer to traverse" rating. The results of this study support the suitability of some measure of shrub density or dispersion to help identify DFS habitat.

Ground cover. – The traditional DFS habitat model (Dueser *et al.* 1988) considers ground cover by analyzing point intercept counts. Though a shrub thickness index exists in this model (understory thickness estimated by whether it is easy, moderate, moderately difficult, or difficult for a person to walk through), this measure would not capture DFS mobility inhibitors at this level (it might be easy for humans, but difficult for DFS to traverse). Using the traditional model, sites with > 50% ground cover are considered not likely to be occupied by DFS. Though this study only contained 14 sites with grass or forb cover > 50%, only 3 of these sites were used by DFS. Areas with dense, even ground cover (turf-like grasses, etc) are presumably not used by DFS because they inhibit mobility; however, my limited dataset (the sites I sampled had low cover of grass and forbs) show no response to grass or forb cover (Table 16). Further study is needed to fully address this issue.

Proximity to Agriculture. – Most eastern fox squirrel species have a patchy and discontinuous range, and frequent areas adjacent to agricultural fields (Taylor and Flyger 1974). I could not observe variation in use according to patch or stand size, as the study site comprised many very large, contiguous parcels. However, at least 50% of points used by DFS were within 750 meters of an agricultural field (study average = 1200 meters) and the distance from used sites was significantly closer to agricultural fields than sites not used (Table 17). This evidence supports the hypothesis that relative proximity to fields may be important to DFS. However, results may be limited to fall seasons when agricultural fields are producing, and when the majority of this study was completed.

New Hypotheses Suggested by Results of this Study

Taller trees. Though Delmarva fox squirrel experts have always recognized the importance of large diameter trees for DFS habitat, the related measure of tree height has been largely overlooked. Though these 2 measures are not always directly correlated, they are related to the extent where DBH often suffices as a measure of tree size. When I measured tree height at points studied, I found trees on sites used by DFS significantly taller than those on sites not used by DFS. This discovery is significant with regard to remote forest metric measurement techniques such as LIDAR, and is also one of the three factors included in our "best" model.

Patchy shrub cover. – I evaluated the importance of shrub cover dispersion during this study; it appears high density shrub cover is tolerated on sites used by DFS if it is not evenly distributed. This runs counter to the traditional definition of "optimal" habitat (open, park-like understory; Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). Patchy shrub cover is most easily achieved by shrubs that form thickets such as raspberry, briar, highbush blueberry, etc. Trails and avenues typically weave throughout and among these growth forms, allowing easy travel across an apparently dense landscape. It is important to note that distribution must truly be "patchy;" if pathways only exist underneath of these forms (e.g., rabbit trails), the cover dispersion would be considered "even."

Briar Tolerance. When evaluating a site's potential to support DFS, due to its thick nature briar has long been considered undesirable (Conner *et al.* 1999, Paglione

1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). It has a thick and vigorous growth habit, and fits the description of exactly what should not be in the traditional open understory of optimal DFS habitat. However, DFS have been observed feeding on greenbrier berries in the midst of a thicket (pers. obs.), and have been captured in high densities on sites with massively thick greenbrier, such as Chincoteague National Wildlife Refuge's Woodland Trail. The results of this study indicate the presence of greenbrier has no apparent effect on the likelihood of a site being used by DFS. This may be because of the clumping habit of briar; sites with evenly distributed briar growth were not used.

Relevance of understory. Understory in this study was measured at the subcanopy level. Though DFS use was associated with sites that had taller understory, this relationship may be spurious due to natural correlations that exist in a forest system (i. e., taller overstory correlated with taller understory, closed overstory correlated with open understory). The results of this study imply that variation in structure or composition at the understory level has no apparent effect on DFS use of a forest parcel.

Analysis of Current DFS Habitat Model

DFS use = Percent overstory cover + Percent understory (shrub) cover + Percent of trees > 30 cm dbh + Percent pine + Shrub thickness index

Analysis of the model currently used to predict DFS presence (USFWS 1993, Dueser et al. 1988) indicated that the new model (DFS use = Percent overstory cover + shrub evenness + overstory canopy height) is a more accurate tool. Because I did not have a

100% capture success rate during this study, sites that were identified as “occupied” that actually had no recorded DFS activity cannot be addressed. However, just about half (45%) of the sites were misidentified as “unoccupied” when they actually had DFS present. This very interesting discrepancy does not appear to be attributable to any one predictor. Approximately half of the occupied sites misidentified as unoccupied had thick shrub or ground cover that was clumped, two of them had no trees > 30 cm dbh, and four of them had no pine component. However, these sites only clustered out together when sorted for average canopy height (75% > 30 m) and large trees (83% had trees > 40 cm dbh present), neither of which should have prompted an “unoccupied” prediction. This model’s poor predictive performance, as well as it’s high AIC_C value (109.0) indicate that it does not outcompete the Integrated Post Hoc Model produced by this study.

Airborne Profiling Laser Application

This study confirmed that DFS use is highly correlated with 3 forest metrics that can be successfully measured with an airborne laser profiling system. In a process that analyzed 6 model sets, and considered over 200 model combinations, average overstory canopy height, percent overstory cover, and shrub evenness were the 3 independent variables present in the most powerful model generated. These height and canopy closure metrics can be measured with Laser Imaging Detection and Ranging (LIDAR) (Nelson 1988, Means *et al*. 2000) to identify tall, dense stands that may support Delmarva fox squirrel populations.

Once identified by LIDAR as having forest characteristics consistent with sites used by DFS, forest parcels could subsequently be surveyed for DFS occurrence. Parcels containing previously unknown DFS populations could be uploaded to the current GIS database system maintained at the USFWS Chesapeake Bay Field Office, the recovery lead for this species. Although not all forest tracts with taller trees and closed canopy support a DFS population, identifying parcels with at least these characteristics advances the identification of potential DFS habitat. Once identified, sites can be further analyzed with a more detailed habitat survey or a DFS presence survey. A recently completed study in Delaware found that "78% of forest stands delineated by the airborne LIDAR profiler as being >20m tall, <80% canopy closure, and >120m long (along the flight path) were judged to be habitat suited to the DFS" (Nelson 2004, unpublished data).

Airborne LIDAR profiling data in conjunction with Line Intercept Sampling techniques and a GIS can be used to develop tabular or graphical summaries of height and canopy density classes (Figure 16) (Nelson 2004, unpublished data). LIDAR flightlines could be replicated regularly to produce updated graphs at desired intervals. In this manner, LIDAR can be used to monitor change in habitat-quality forest acreage over time, as well as identify potential release sites for DFS translocations.

Conclusion

DFS use in the Chesapeake Marshlands National Wildlife Refuge was positively correlated with tree stems > 50 cm dbh/ha, tree stems > 40 cm dbh/ha, understory height, overstory canopy height, and percent overstory cover, and negatively correlated with shrub stems/ha, shrub evenness, and distance from agricultural fields. Of over 200 total model arrays tested, the model found to be closest to the truth was the post hoc integrated model: *DFS use = percent overstory cover + shrub evenness + overstory canopy height.* Most other models selected had a measure of shrub cover and overstory, with an occasional reference to distance from agriculture.

The traditional belief that Delmarva fox squirrels use mature forests was supported by this study; however, many sites were used that did not conform to the open, almost park-like understory standard considered a fundamental component of preferred DFS habitat (Conner *et al.* 1999, Paglione 1996, Weigl *et al.* 1989, Dueser *et al.* 1988, Taylor and Flyger 1974, Taylor 1973, Dozier and Hall 1944). This disparity may be due to a number of factors. Should the perception that DFS prefer an open understory be true, the incongruity witnessed may be explained by the fact that the sites sampled in this study were uncommonly wet. Dorchester County has more hydric soils than most counties on the Delmarva Peninsula, and the sites sampled were often lowland forests heavily marbled with natural and man-made wetland furrows. These furrows, which provide clear lines of passage amid dense understory, usually do not exist in drier northern forests with similar understory cover. Therefore, in our study area DFS may have access to more dense sites because of these vegetation free corridors.

However, the perception that DFS prefer an open understory may actually be a misconception resulting from observer bias. Forest fauna are more difficult for the human eye to discern in dense vegetation. In addition, prey species such as squirrels are more prone to take cover when the rustling foliage of dense understory betrays an observer. Even the remote monitors used in this study could not neutralize this encumbrance, as this method was biased in dense foliage due to lack of bait visibility.

DFS were not detected by these monitors in areas of dense understory (e.g.: pine thicket, marsh grasses), even when they were personally observed as close as 20 feet away. This topic deserves further study, and future habitat investigations should strive to employ an unbiased method of DFS detection in high density understory settings.

In conclusion, the goal of the Endangered Species Act is the recovery of listed species to levels where protection under the Act is no longer necessary. Protection under the Act includes coordination with ESA designated agencies (e.g., consultation) to ensure potential impacts to animals, plants, or habitats do not preclude the recovery of a listed species. In this study, innovative statistical analyses (Burnham and Anderson 2002) were combined with field-level remote sensing technology to determine which habitat variables are associated with endangered Delmarva fox squirrel use. This information was used to develop a habitat model that can be used to predict the probability that a particular tract constitutes potential Delmarva fox squirrel habitat. This model will be combined with landscape-level remote sensing technology to assist in the recovery, as well as the post-delisting monitoring, of this endangered species. Finally, information technology will be used to broadcast this tool to project proponents via the internet, which will benefit Endangered Species Act consultation processes by clarifying and expediting information transfer.

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Figure 1. Comparisons of Delmarva fox squirrel *(Sciurus niger cinereus*, left) and gray squirrel *(Sciurus carolinensis*, right) size and pelage.

Figure 2. Recent changes in the distribution of the Delmarva fox squirrel across the Delmarva Peninsula. Updates obtained through surveys or opportunistic sightings by qualified individuals.

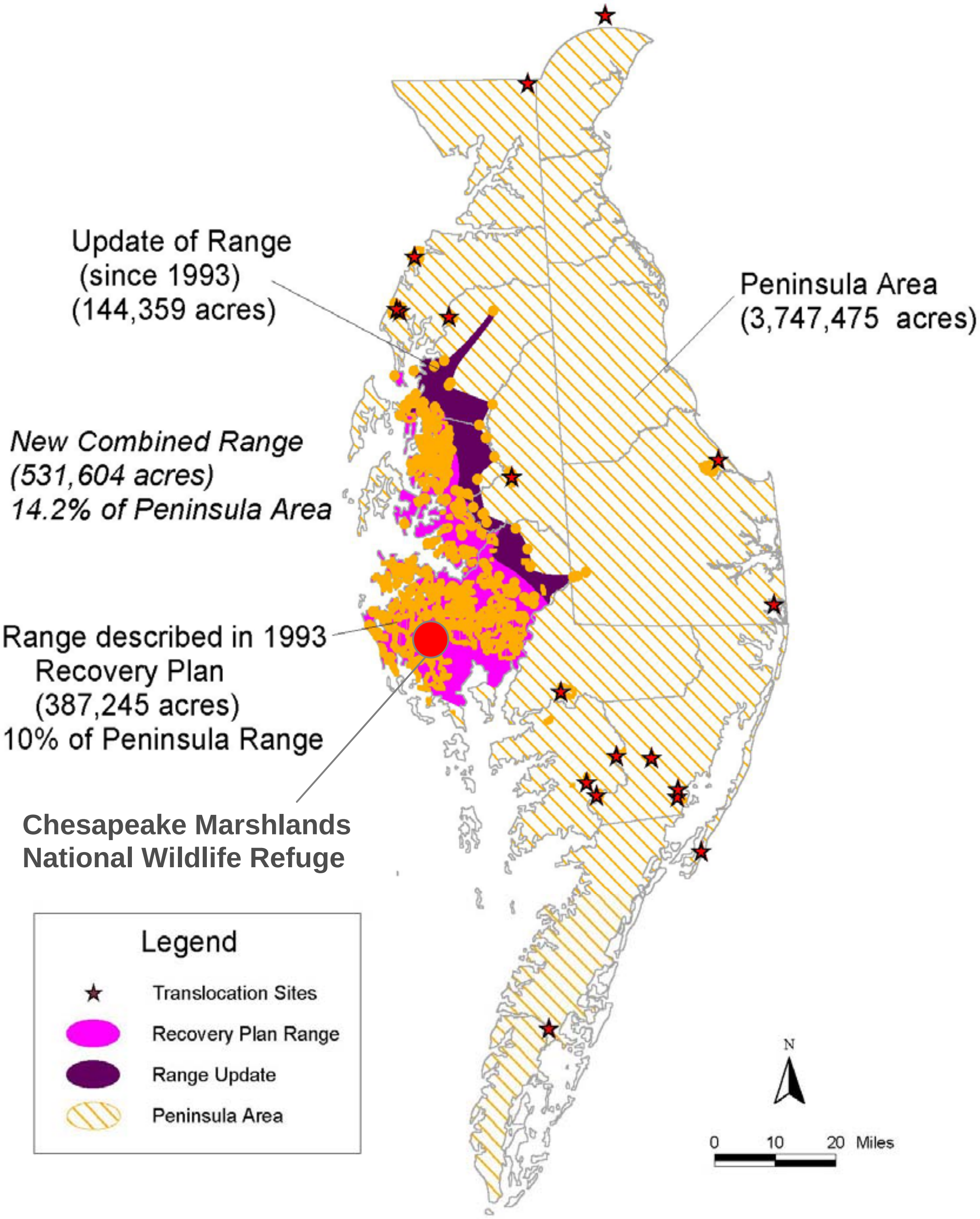


Figure 3. Location of gridpoints at a 500-m spacing on Chesapeake Marshlands NWR (formerly Blackwater NWR) in Dorchester County, Maryland, used to provide a sampling frame for Delmarva fox squirrel habitat and presence.

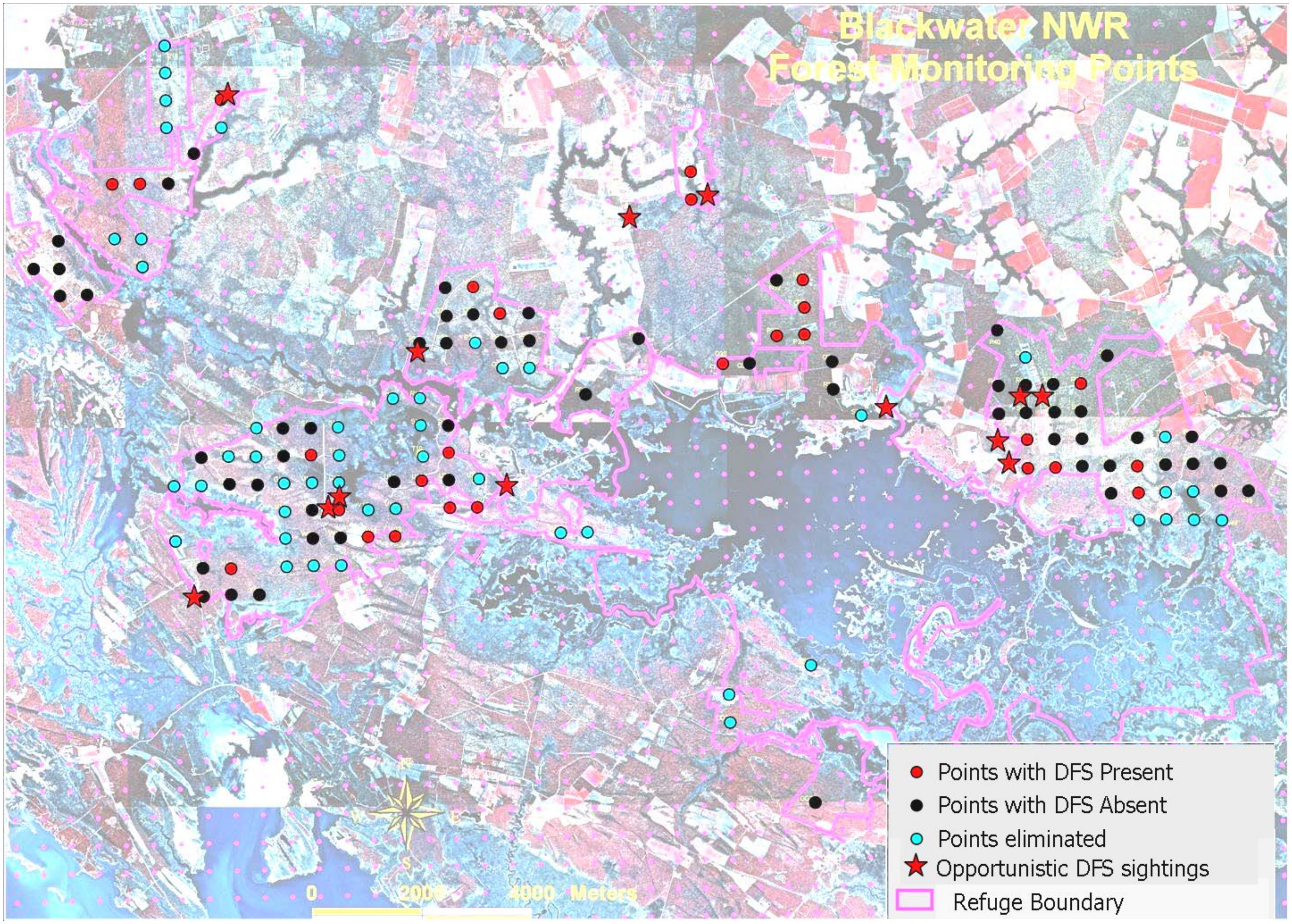


Figure 4. Circular plot (0.04 ha) used to estimate vegetation characteristics. Plot radius was 11.3 m.

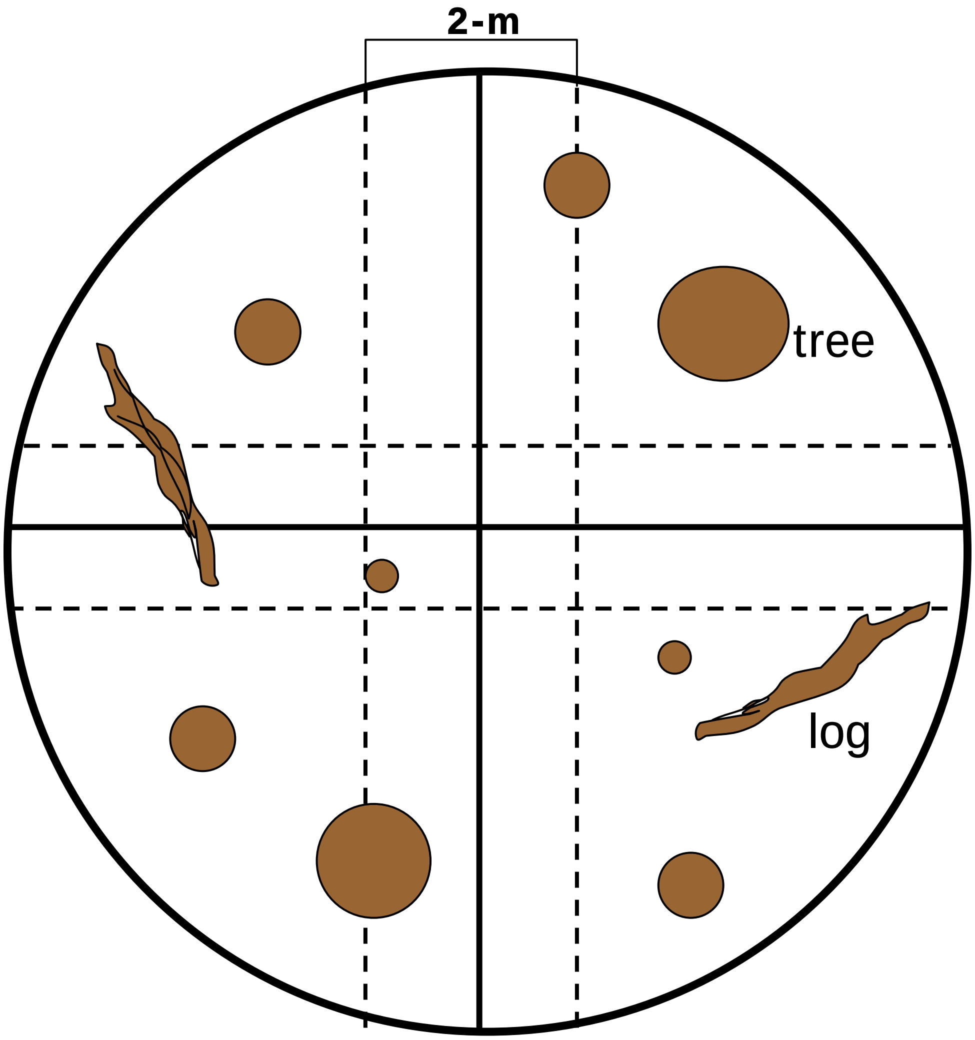


Figure 5. Major shrub and ground stem categories sampled during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004.

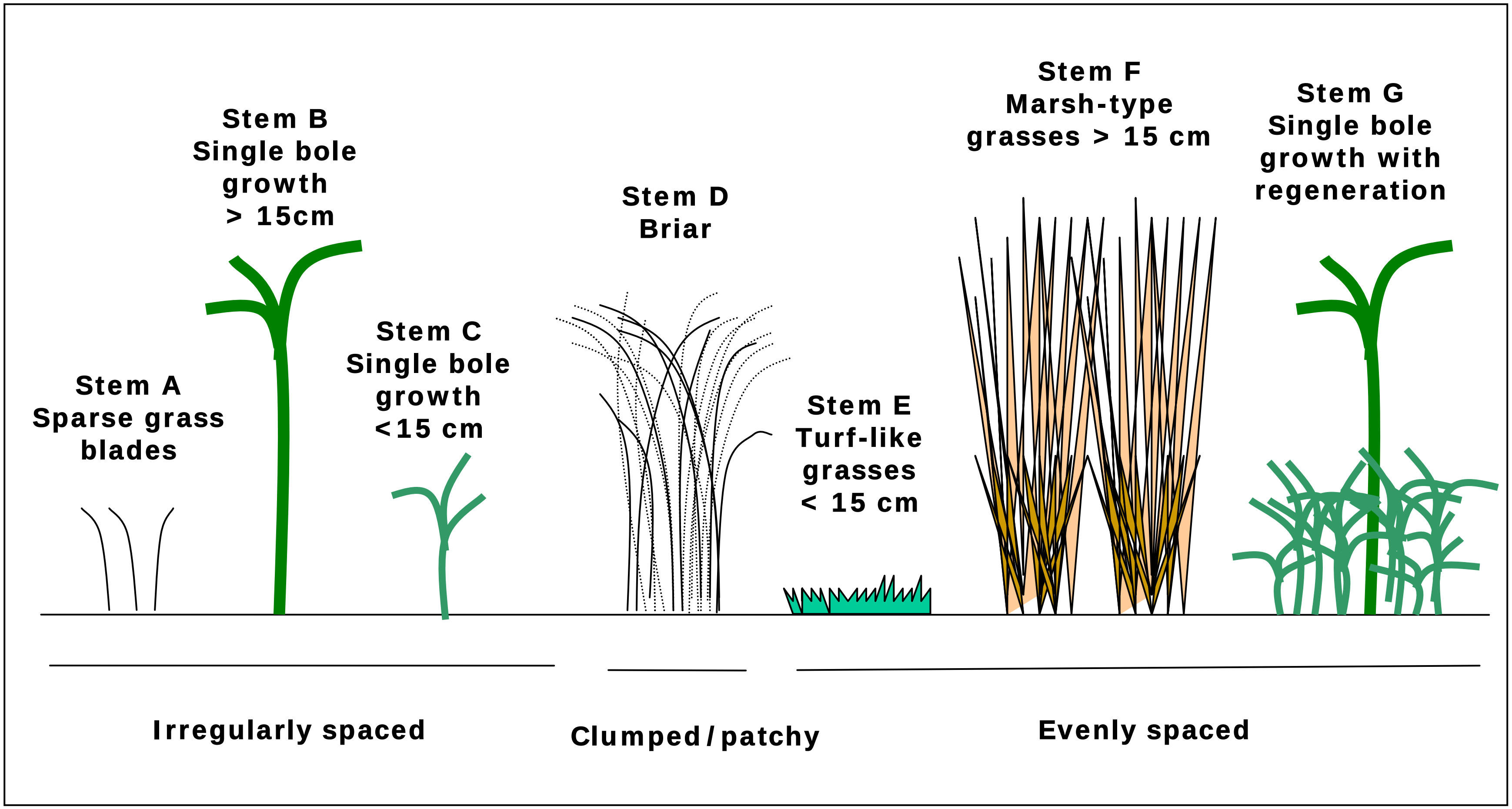
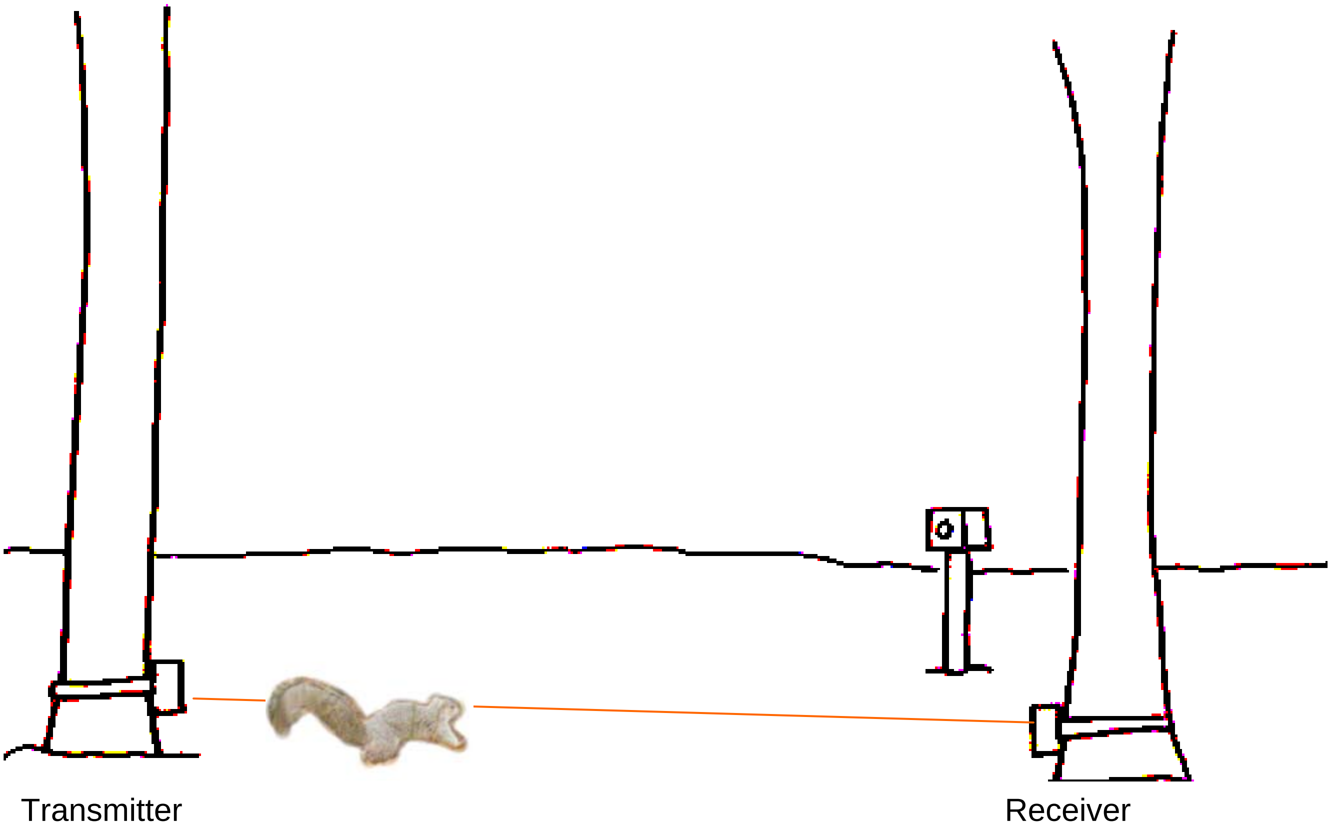


Figure 6. Trailmaster® brand TM-1550 Active infrared photomonitor set up. When an animal breaks the infrared beam that the transmitter sends to a window on the receiver, the camera takes a photograph.



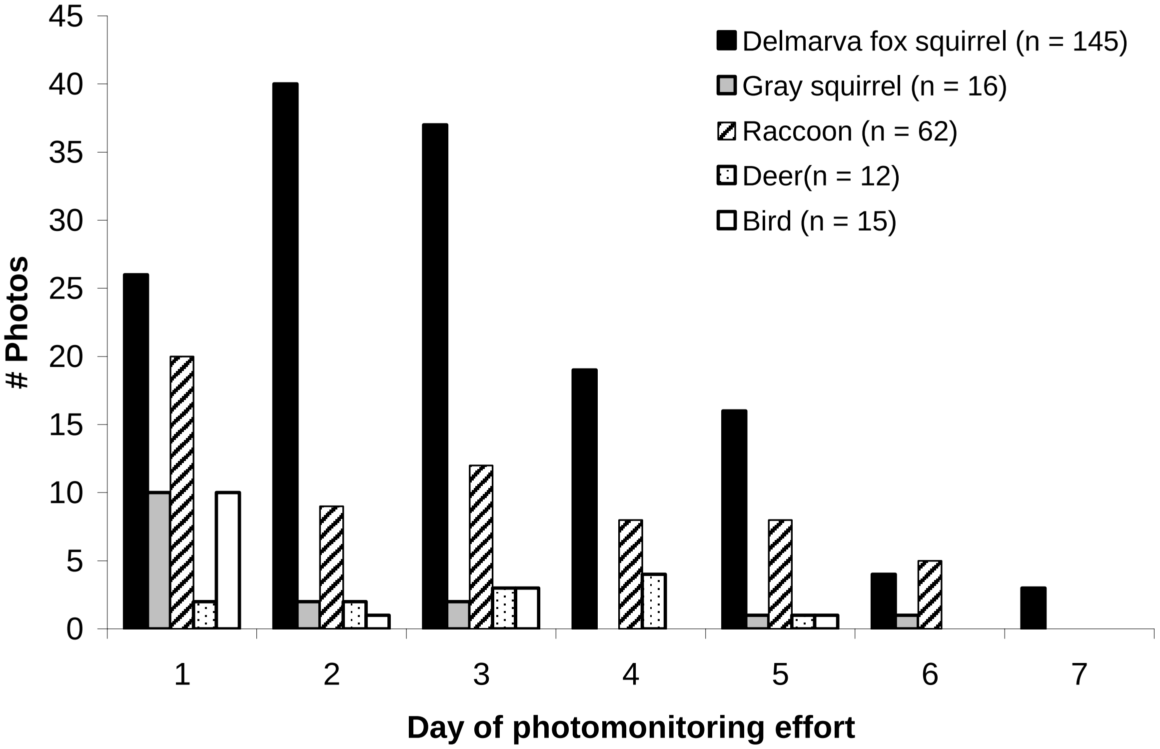


Figure 7. Photo captures (n = 187) by day during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004.

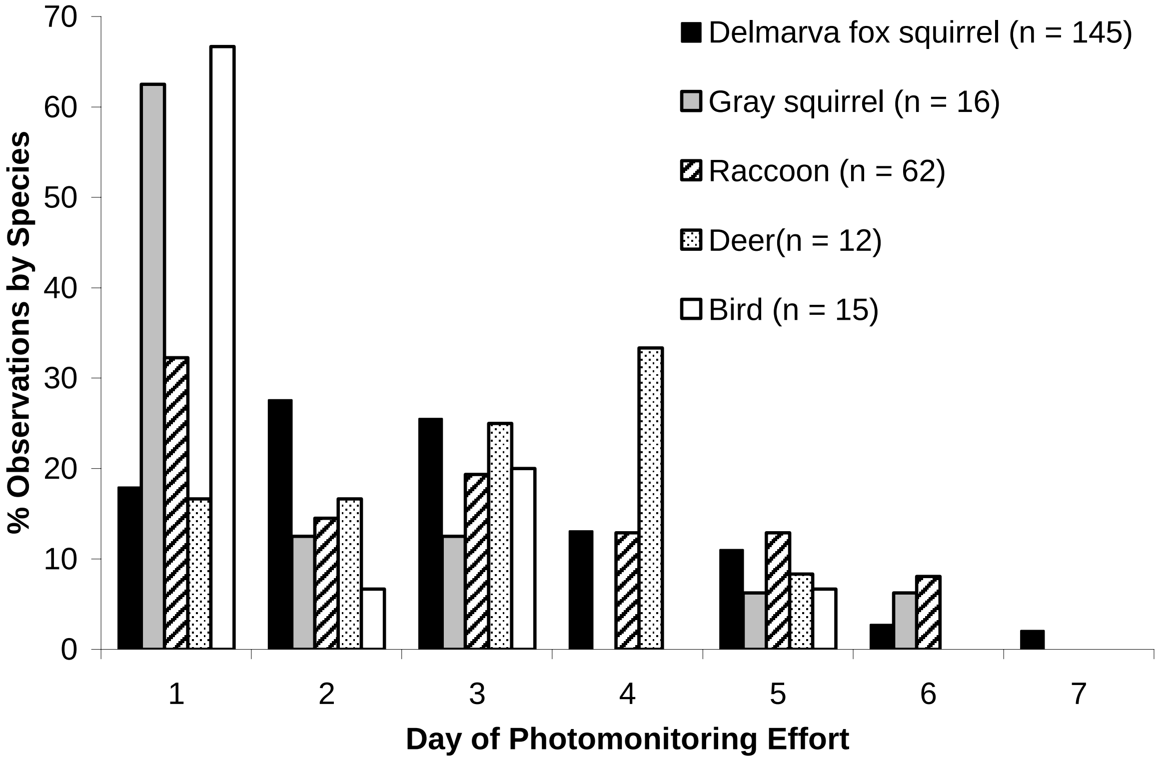


Figure 8. Relative capture rate (% of observations for each species) of species by day during a Delmarva fox squirrel sampling effort at 86 sites in Dorchester County, Maryland from September – December 2004.

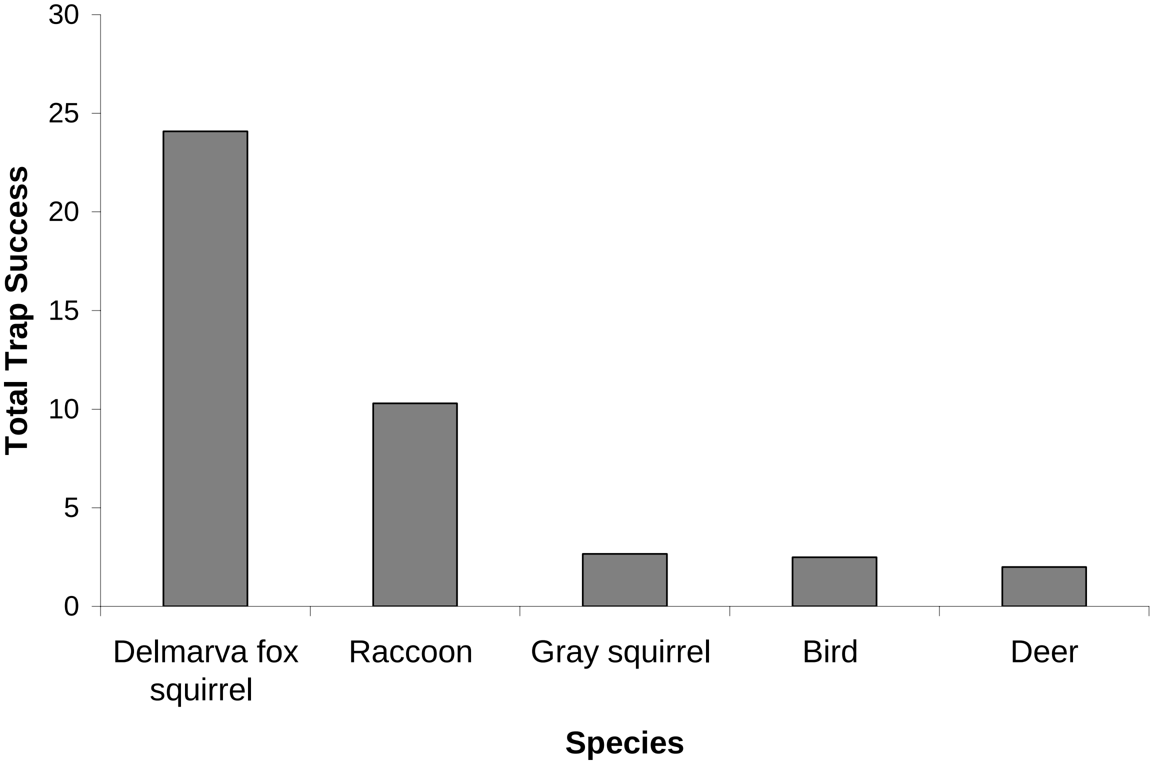


Figure 9. Total trap success (catch per unit effort) during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004.

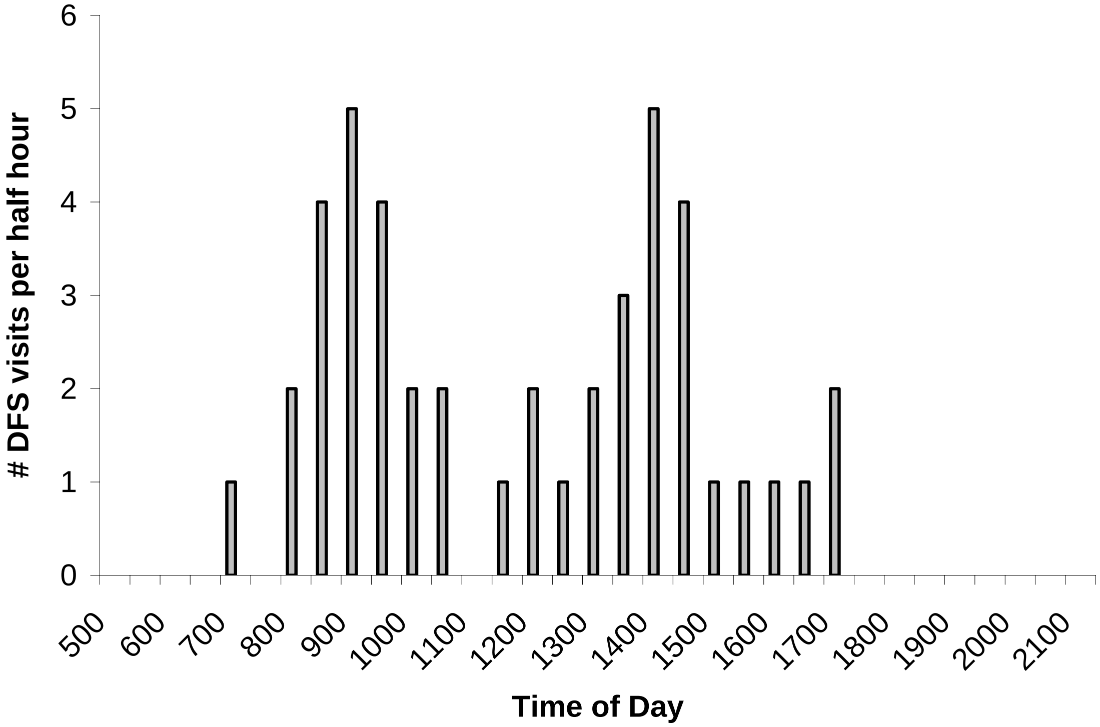


Figure 10. Total photo captures by hour of exposure during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004.

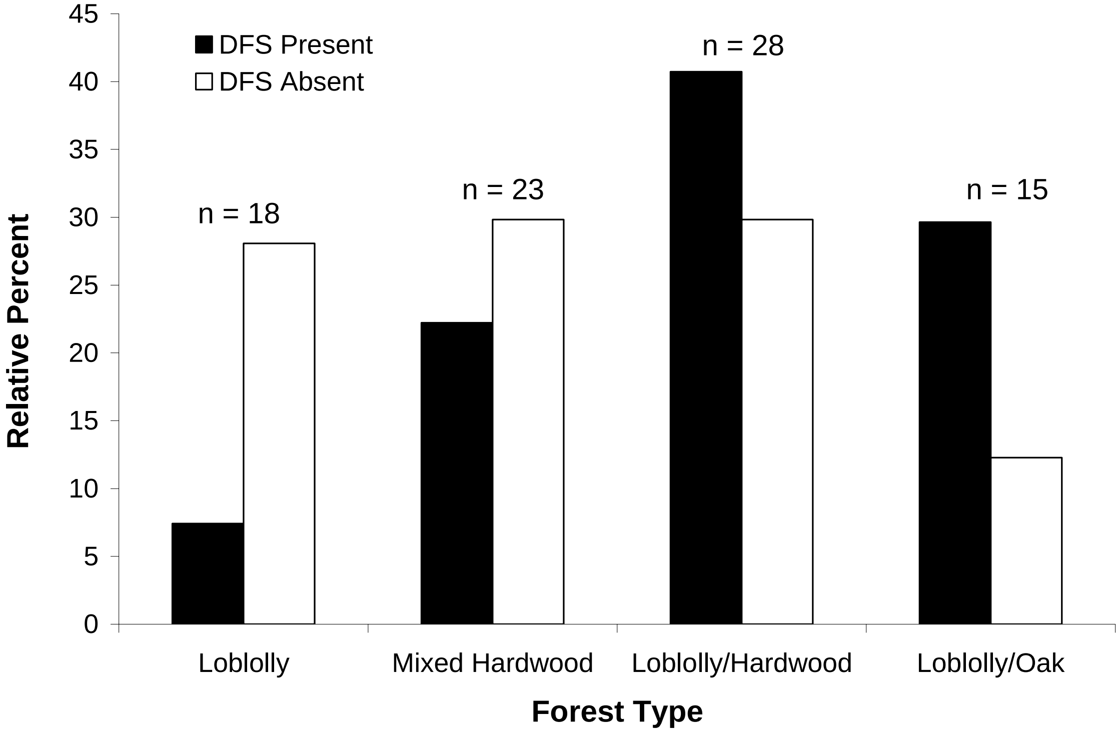


Figure 11. Relative percent of sampled forest types used and not used by DFS during a sampling effort in Dorchester County, Maryland from September – December 2004. The 4 major cover types represented are loblolly pine (no hardwoods are present in the stand), mixed hardwoods (no pine), loblolly pine-mixed hardwood (loblolly pine and any mixed hardwoods, excluding oak), and loblolly pine-oak (loblolly pine and any oak are present).

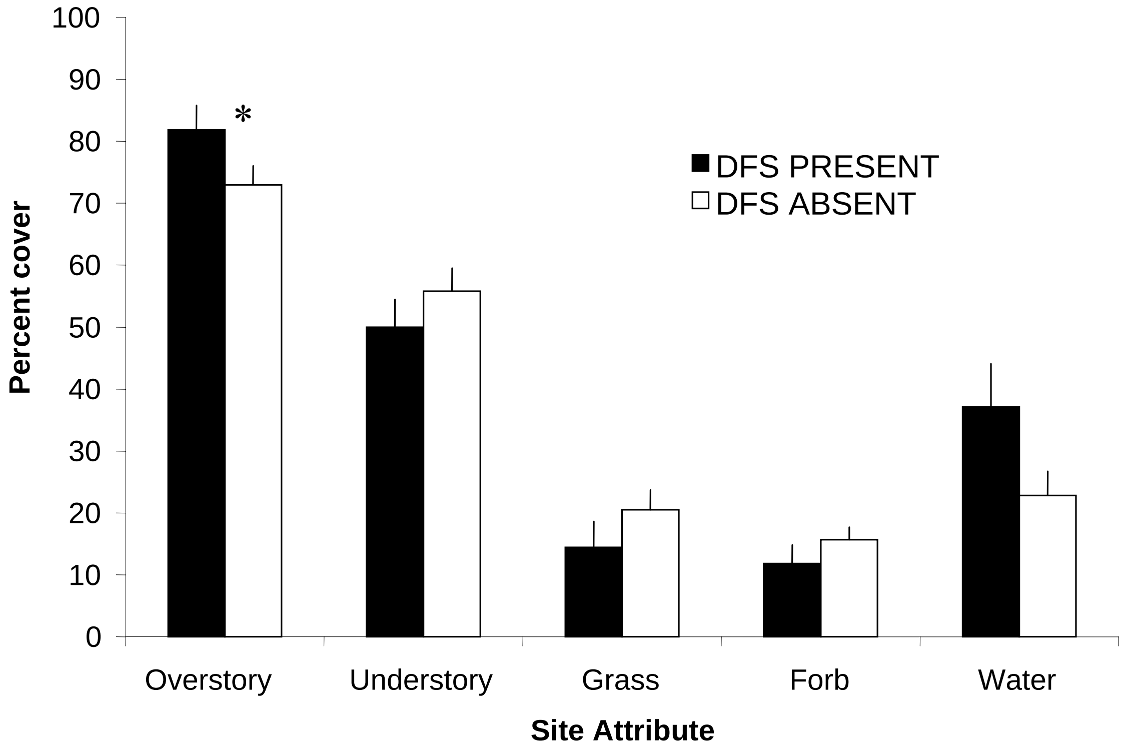


Figure 12. Means of cover variables recorded at plots with (n = 27) and without (n = 59) Delmarva fox squirrels during a sampling effort in Dorchester County, Maryland from September – December 2004. Vertical bars denote one standard error. An * indicates significance at the 0.1 α level (Wilcoxon-Mann-Whitney).

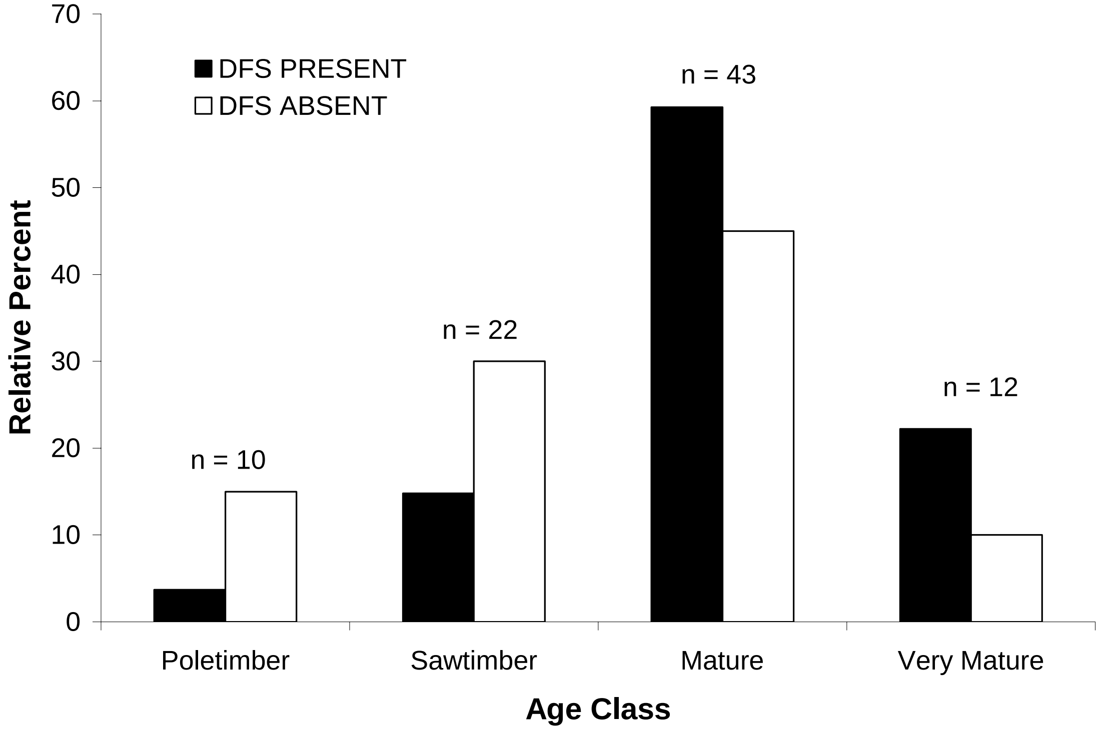


Figure 13. Relative percent of sampled forest stands by age class used and not used by Delmarva fox squirrels during a sampling effort in Dorchester County, Maryland from September – December 2004. The 4 major age classes represented are poletimber (all trees sampled < 30 cm dbh), sawtimber (all trees sampled < 40 cm dbh), mature (trees > 40 cm dbh were $\geq$ 13% of the sample), and very mature (trees > 40 cm dbh composed > 13 % of the sample).

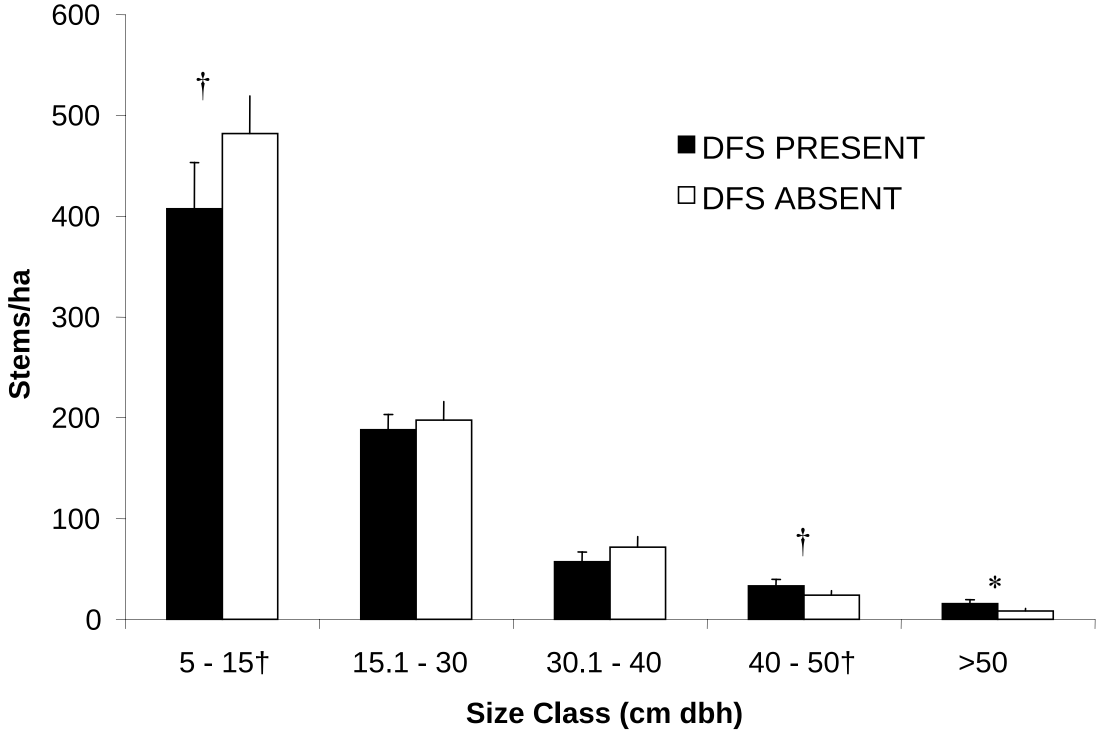


Figure 14. Density (#/ha) of trees by size class at sites where Delmarva fox squirrels were present (n = 27) and absent (n = 59) during a sampling effort in Dorchester County, Maryland from September – December 2004. Vertical bars denote one standard error. An * indicates significance at the 0.1 α level (Wilcoxon-Mann-Whitney). An † indicates the variable met the inclusion criteria of a 0.25 α level (Likelihood x^2).

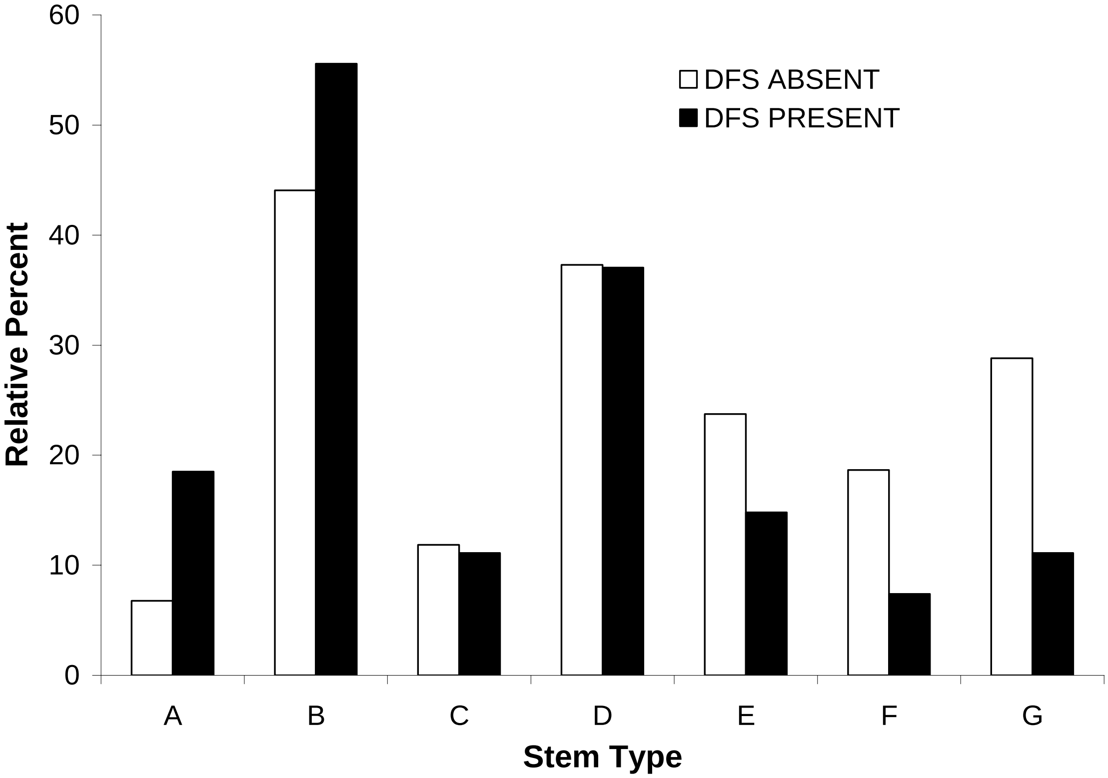


Figure 15. Relative percent of stem types used and not used by Delmarva fox squirrels during a sampling effort in Dorchester County, Maryland from September – December 2004. The 7 stem types represented are A: sparse grasses (5 to 50 blades/ m2), B: single bole shrubs > 15 cm, C: single bole shrubs < 15 cm, D: briar-like species, E: short turf-like grasses, F: tall marsh grasses, and G: single bole shrubs > 15 cm with vigorous ground-level regeneration.

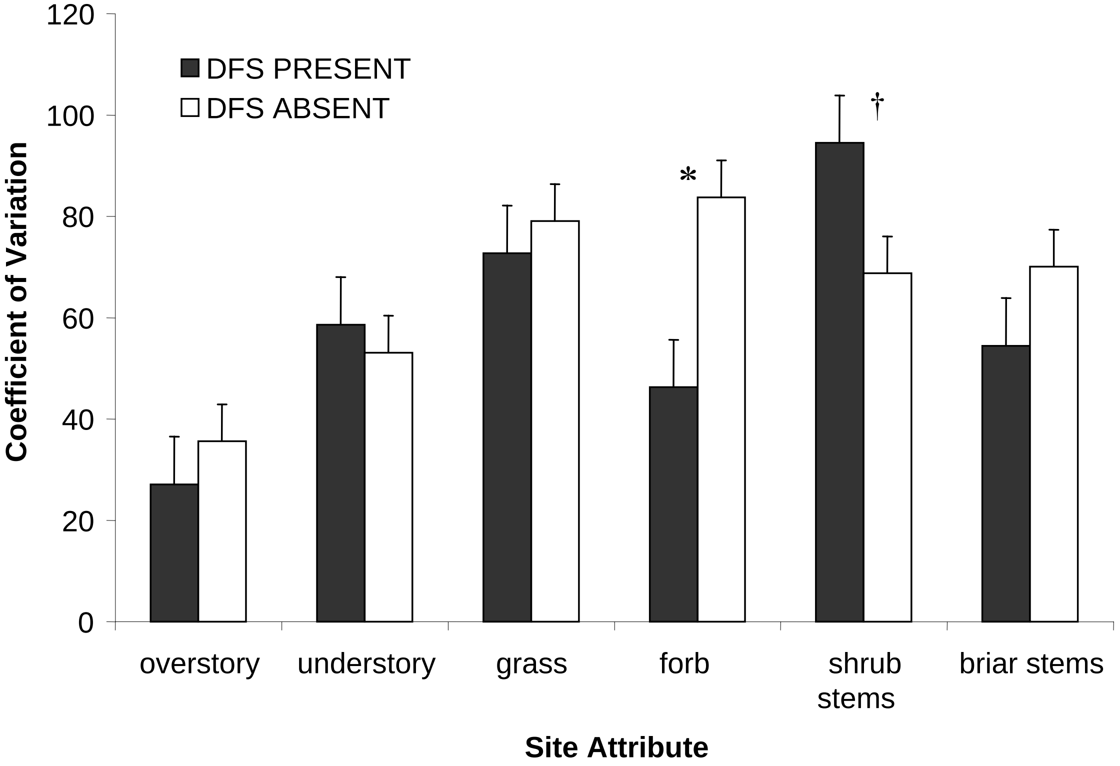


Figure 16. Coefficient of variation of habitat variables recorded at locations with (n = 27) and without (n = 59) Delmarva fox squirrels during a sampling effort in Dorchester County, Maryland from September – December 2004. Vertical bars denote one standard error. An * indicates significance at the 0.1 α level (Wilcoxon-Mann-Whitney). An † indicates the variable met the inclusion criteria of a 0.25 α level (Liklihood x^2).

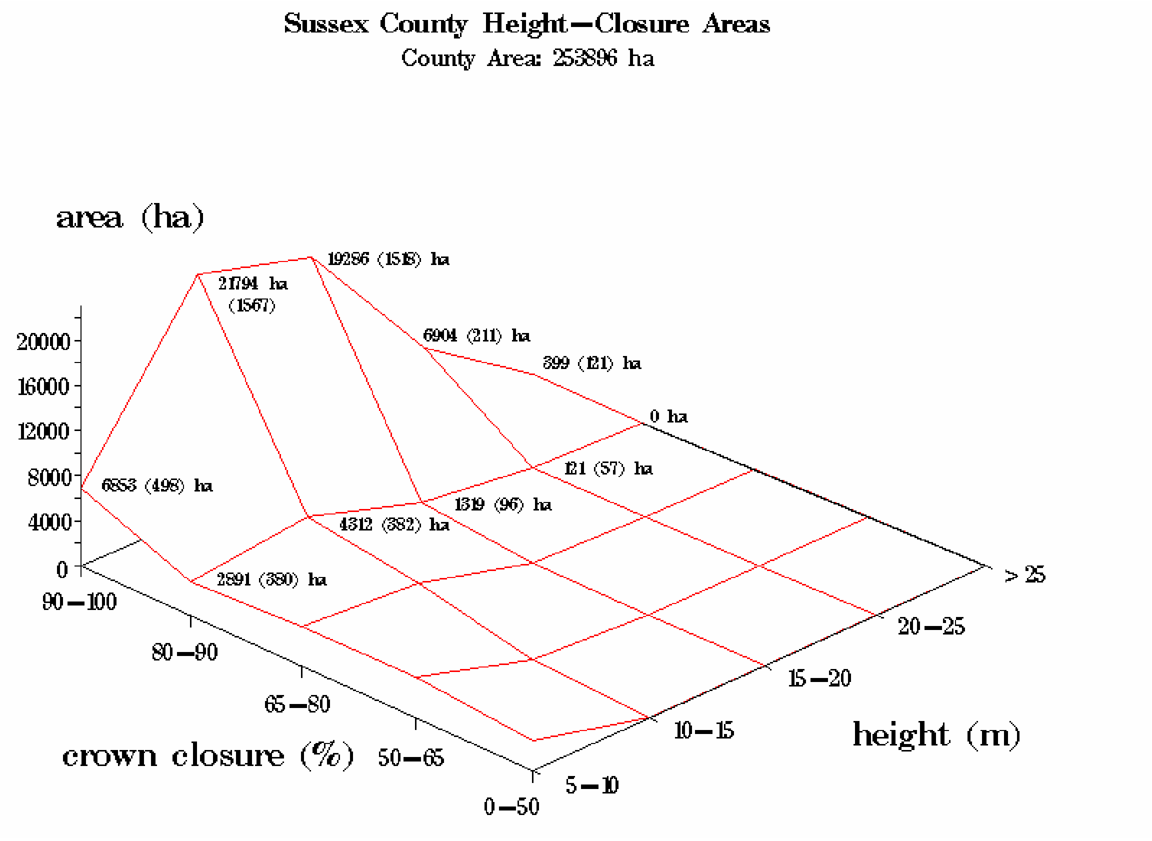


Figure 17. Example of crown closure classes in Sussex County, Delaware, as measured by an airborne laser profiler (Nelson 2004).

Table 1. Changes in developed land and forest cover in 8 Maryland counties occupied by Delmarva fox squirrels (Weller and Edwards 2001). The Tri-county area (Queen Annes, Talbot, and Dorchester Counties) has the highest density of Delmarva fox squirrels.

County	Change in Developed Land 1973-1997 (ha/year)	Change in Forest Land 1973-1997 (ha/year)
Kent	132	-101
Queen Anne's	284	-113
Talbot	227	-69
Caroline	331	-180
Dorchester	173	-145
Somerset	180	-62
Wicomico	338	-209
Worcester	196	-238
Tri-county Area	684	-326

Table 2. Distribution of 500-m interval inventory sampling points relative to available macrohabitats on Chesapeake Marshlands National Wildlife Refuge, 2004 (USFWS 2004).

Macrohabitat	Points (%)	Area (ha) on the refuge (%)
Forest	134 (33.5)	2911 (31)
Marsh	132 (33)	3281 (34.5)
Water	116 (29)	2610 (27.5)
Other	18 (4.5)	686 (7)
Total	400 (100)	9488 (100)

Updated to represent habitat changes observed in this study, 2004.

Table 3. Habitat variables recorded on each study site during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004. Data were collected in 0.04 ha circular plots (Noon 1981) centered on the camera trapping location.

Habitat Variable	Measurement Technique	Definition
Overstory		
Percent Overstory Cover	Ocular tube: Sighting up, 20 presence/absence readings taken along 2 perpendicular 22.6 m transects	The percent of a fixed area covered by the crown of trees dominant in the overstory.
Density of species by DBH class	DBH tape: Within circular plot, diameter 1.3 m above ground of all trees > 5 m tall.	Density of dominant trees. Categorized by species and size class (15.1 – 30cm dbh, 30.1-40 cm dbh, 40.1-50 cm dbh, and >50 cm dbh)
Overstory Height	Clinometer: Average of 2 readings of height.	The average height (m) of the overstory.
Understory		
Percent Understory Cover	Ocular tube: Sighting up, 20 presence/absence readings taken along 2 perpendicular 22.6 m transects	The percent cover of the layer formed by the crowns of trees beneath the overstory canopy that are subdominant.
Density of species by DBH class	DBH tape: Within circular plot, diameter 1.3 m above ground of all trees > 5 m tall.	Description of the layer formed by the crowns of trees beneath the overstory canopy that are subdominant. Categorized by species and size class (5-15 cm dbh, 15.1 – 30cm dbh)
Understory Height	Clinometer: Average of 2 readings of height.	The average height (m) of the understory.
Shrub Cover		
Shrub Stem Density	Count number of non-briar woody stems < 5 cm dbh along 2 perpendicular 22.6 m x 2 m transects. Count x 115 = # shrub stems/ha	The cover formed by plants that have persistent woody stems and a relatively low growth habit, and that generally produce several basal shoots instead of a single bole. It differs from a tree by its low stature and nonarborescent form. Usually < 5 m at maturity.
Briar Stem Density	Count number of briar stems along 2 perpendicular 22.6 m x 2 m transects. Count x 115 = # briar stems/ha	The cover formed by prickly plants or shrubs that grow in clumps or as single stems.

Table 3. continued.

Habitat Variable	Measurement Technique	Definition
Plant dispersion index	Recorded for ground (0-1 m tall) and shrub (>1 m and < 3 cm dbh) strata plants on site	Categories are Even (E), Irregular (I), Clumped (C)
Plant species composition	Species of all stems ≤ 5 m tall, shrubs, and ground cover	Description of the foliage layer beneath the overstory canopy categorized by genus and species; description of all shrubs, categorized by genus and species; description of all ground cover, categorized by genus and species
Ground Cover		
Percent Ground Cover	Ocular tube: 20 presence/absence readings will be taken along 2 perpendicular 22.6 m transects	The percent of ground cover on the soil surface. Soil can be exposed or covered with grass, forb, or water.
Water Depth	Ruler: Deepest water within circular plot.	Depth of water present. Categories include no water, ≤ 0.5 cm, 0.5 – 5 cm, 5.1 cm – 13 cm, > 13 cm.
Water Dispersion Index	Recorded for area within and immediately adjacent to circular plot.	Patterns of water cover within and around the immediate area of the photomonitor. Categories include depressions, ditches, land forms islands, land forms hummocks, no features.
Log Cover	Count of logs partially or entirely within circular plot	The fallen trunk of any tree >10cm diameter within length categories of <2m, 2 – 4 m, and >4m.
Landscape		
Patch size	Recorded using GIS data and aerial photos	A contiguous group of trees that is sufficiently uniform in species composition, arrangement of age classes, and condition to be a homogeneous and distinguishable unit (Smith 1962)

Table 3 Continued.

Habitat Variable	Measurement Technique	Definition
Stand size	Recorded using GIS data and aerial photos	A contiguous group of patches with no apparent barriers to DFS movement.
Distance to Agricultural Field	Recorded using GIS data and aerial photos	Distance over ground to the nearest accessible agricultural field.
Distance to Road	Recorded using GIS data and aerial photos	Distance over ground to the nearest paved road.

Table 4. Variables measured to develop models of habitat use for Delmarva fox squirrels on Chesapeake Marshlands NWR study sites in Dorchester County, Maryland from September – December 2004.

Variable	Description
Overstory	
POVER	Percent cover of overstory
AVGCH	Average overstory canopy height (m)
CVOVER	Coefficient of variation of overstory cover
DSIZE3	Density (stems/ha) of trees 30.1 – 40 cm dbh
DSIZE4	Density (stems/ha) of trees 40.1 – 50 cm dbh
DSIZE5	Density (stems/ha) of trees > 50 cm dbh
DSIZE45	Density (stems/ha) of trees ≥ 40 cm dbh
DSIZE123	Density (stems/ha) of trees < 40 cm dbh
P45	Percent of trees ≥ 40 cm dbh
P345	Percent of trees ≥ 30 cm dbh
Understory	
PUNDER	Percent cover of understory
AVGSCH	Average understory canopy height (m)
CVUNDER	Coefficient of variation of understory
DSIZE1	Density (stems/ha) of trees 5 – 15 cm dbh
DSIZE2	Density (stems/ha) of trees 15.1 – 30 cm dbh
P123	Percent of trees in size classes 1, 2 and 3
P12	Percent of trees in size classes 1 and 2
PSPINE	Percent of pine ≤30 cm dbh

Table 4. continued.

Variable	Description
Composition	
PREDM	Percent red maple
PMAST	Percent pine >15 cm dbh, oak and beech >30 cm dbh
POAK	Percent oak trees
PHOLLY	Percent holly trees
PLPINE	Percent pine >30 cm dbh
PBEECH	Percent beech
Shrub	
SHEVEN	Even shrub dispersion index (0, 1)
SHIR	Irregular shrub dispersion index (0, 1)
SHCLUM	Clumped shrub dispersion index (0, 1)
CVSHRUB	Coefficient of variation of shrub cover
DSHRUB	Density (stems/ha) of shrub cover
DBRIAR	Density (stems/ha) of briar stems
CVBRIAR	Coefficient of variation of BRIAR cover
STEMB	Stem type B: Single bole shrub > 15 cm high (0, 1)
STEMC	Stem type C: Single bole shrub < 15 cm high (0, 1)
STEMD	Stem type D: Briar and other thorny stems (0, 1)
STEMF	Stem type F: Grasses > 15 cm high (marsh type) (0, 1)
STEMG	Stem type G: Single bole with low growth regeneration (0, 1)
Ground cover	
GREVEN	Even ground cover dispersion index (0, 1)
GRIR	Irregular ground dispersion index (0, 1)
GRCLUM	Clumped ground dispersion index (0, 1)
PGRASS	Percent cover of grass
PFORB	Percent cover of forbs

Table 4. continued.

Variable	Description
CVFORB	Coefficient of variation of forb cover
CVGRASS	Coefficient of variation of grass cover
STEMA	Stem type A: Sparse grass (0, 1)
STEME	Stem type E: Grasses < 15 cm high (turf-like) (0, 1)
Landscape	
PTCHSZ	Area of patch as defined by dominant overstory cover type (ha)
STNDSZ	Area of stand as defined by contiguous traversable forestland (ha)
DISTAG	Distance to nearest agricultural field (m)
DISTRD	Distance to nearest road (m)

Table 5. Variable sets selected a′ priori to build models predicting Delmarva fox squirrel presence. Different combinations of variables were selected for models within each set. The Cover, Density, and Landscape variable sets represent variables recorded with different methods. The Biological set is based on current management practice and personal experience. All models were selected a′ priori and AIC was used to evaluate model fit to the data. The Integrated Model was developed using a post hoc compilation of predictor variables chosen from the a′ priori model subsets that received the highest Akaike weights. Sample size was 86 for all models (DFS present = 27, DFS absent = 59).

Model Set	Variables in Model Set
Cover	% overstory + %grass + % understory + % forb
Density	shrub stem/ha + density class 5 + density class 4 + density class 3 + density class 2 + density class 1 + briar stem/ha
Landscape	distance to agriculture + distance to road + stand size + patch size
Biological	% hardmast + % pine > 40 cm dbh + % overstory + % trees >40 cm dbh + density size class 1 + %grass + shrub stems/ha+ briar stems/ha+ shrubcv + briarcv + even ground cover + even shrub cover+ stemF + stem E + stand size
Integrated	% overstory + distance to agriculture + even shrub cover + density class 5

Table 6. Total photo-captures at 86 sites sampled for Delmarva fox squirrel presence in Dorchester County, Maryland from September – December 2004.

Species	Number of Photos (%)
Delmarva fox squirrel	145 (58)
Gray squirrel	16 (6)
Deer	12 (5)
Raccoon	62 (25)
Birds	15 (6)
TOTAL	**250 (100)**

Table 7. Density (stems/ha) of overstory (> 15 cm dbh) tree species at sites sampled for Delmarva fox squirrel presence in Dorchester County, Maryland from September – December 2004.

	Mean Density (#/ha) ± SE			
Species	DFS Present (n = 27)	DFS Absent (n = 59)	Z^a	*P*
Loblolly Pine	108 ± 20.67	153 ± 23.23	-0.44	0.657
Red Maple	78 ± 17.92	45 ± 8.65	1.82	**0.069**
Sweetgum	32 ± 6.12	22 ± 4.19	0.52	0.600
Snag[b]	22 ± 7.95	28 ± 9.95	0.11	0.915
Red/BlackOak	18 ± 6.23	14 ± 3.69	0.35	0.729
Swamp Oak	13 ± 3.86	8 ± 2.13	1.27	0.205
Willow Oak	7 ± 3.91	10 ± 2.70	-1.22	0.223
Blackgum	7 ± 2.53	8 ± 2.98	0.66	0.512
Beech	6 ± 3.08	9 ± 4.31	0.48	0.634
White Oak	7 ± 3.91	2 ± 1.10	1.18	0.237

[a] Differences tested with Wilcoxon-Mann-Whitney statistic

[b] Only 80 of the 86 sampled sites had snag data recorded.

Table 8. Results of statistical analyses of overstory characteristics at sites where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
Percent overstory	82 ± 3.9	73 ± 3.1	1.89	**0.06**	0.020	0.0121	3.102	**0.08**	1.020
CV of % overstory	27 ± 5.4	36 ± 5.1	-1.01	0.31	-0.0075	0.0076	1.107	0.29	0.993
Overstory height (m)	31 ± 0.6	28 ± 0.6	3.23	**0.001**	0.2128	0.0721	10.923	**0.001**	1.237

Table 9. Results of statistical analyses of tree size classes at sites where Delmarva fox squirrels were present and absent during a Delmarva fox squirrel sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean #/ha ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
5–15 cm dbh	407 ± 45.7	482 ± 37.3	-1.25	0.21	-0.0011	0.000924	1.466	0.23	0.999
15.1–30 cm dbh	188 ± 15.5	198 ± 18.1	0.29	0.77	-0.00068	0.00196	0.1239	0.72	0.999
30.1–40 cm dbh	57 ± 9.5	72 ± 10.4	-0.27	0.78	-0.00309	0.00366	0.7817	0.38	0.997
40.1–50 cm dbh	33 ± 6.5	24 ± 4.1	1.40	0.16	0.00841	0.00698	1.4424	0.23	1.008
> 50 cm dbh	16 ± 3.8	8 ± 2.2	1.89	**0.06**	0.0209	0.0125	2.8390	**0.09**	1.021
< 40 cm dbh	652 ± 50.9	752 ± 42.2	-1.36	0.17	-0.00115	0.000839	2.0322	0.15	0.999
> 40 cm dbh	49 ± 8.1	33 ± 5.5	2.17	**0.03**	0.00882	0.00544	2.6991	**0.10**	1.009

Table 10. Compositional and structural variables at sites where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean± SE		Wilcoxon statistic		Univariate logistic regression				
Variable (%)	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
Mast-producing trees[a]	21 ± 3.2	23 ± 2.9	0.051	0.96	-0.00634	0.012	0.3032	0.58	0.994
Pine > 40cm dbh	9 ± 1.7	9 ± 1.8	1.275	0.20	0.000911	0.019	0.0022	0.96	1.001
Trees > 40 cm dbh	8 ± 1.2	5 ± 1.1	2.478	**0.01**	0.0405	0.030	1.878	0.17	1.041
Oak	4 ± 1.1	2 ± 0.6	1.460	0.14	0.0681	0.047	2.1755	0.14	1.070
Trees < 40 cm dbh	92 ± 1.2	95 ± 1.1	-2.478	**0.01**	-0.0405	0.030	1.8779	0.17	0.960
Pine < 40 cm dbh	14 ± 4.0	24 ± 4.0	-1.479	0.14	-0.0149	0.010	2.6235	**0.10**	0.985
Red maple	29 ± 5.1	19 ± 2.8	1.752	**0.08**	0.0182	0.010	3.3757	**0.07**	1.018
Trees > 30 cm dbh	17 ± 2.0	16 ± 2.0	1.108	0.27	0.00562	0.017	0.1140	0.74	1.006
Holly	10 ± 2.7	12 ± 2.4	0.183	0.85	-0.00580	0.014	0.1745	0.68	0.994
Beech	3 ± 1.9	3 ± 1.5	0.772	0.44	0.00199	0.021	0.0093	0.92	1.002
Trees < 30 cm dbh	83 ± 2.0	84 ± 2.0	-1.108	0.27	-0.00562	0.017	0.1140	0.74	0.994

[a] Mast producing trees included pine, oak, and beech.

Table 11. Density (stems/ha) of understory (< 15 cm dbh) tree species at sites sampled for Delmarva fox squirrel presence in Dorchester County, Maryland from September – December 2004.

Variable	Mean Density (#/ha) ± SE		Z^a	P
	DFS Present (n = 27)	DFS Absent (n = 59)		
Red Maple	148 ± 36.1	100 ± 17.9	1.288	0.198
Holly	58 ± 15.6	91 ± 20.0	-0.074	0.941
Sweetgum	57 ± 16.5	76 ± 13.8	-0.873	0.383
Pine	46 ± 27.1	119 ± 32.2	-1.841	**0.066**
Blackgum	36 ± 13.8	24 ± 8.5	2.013	**0.044**
Snag [b]	35 ± 12.0	21 ± 5.4	1.127	0.260
Beech	14 ± 7.7	10 ± 6.0	0.876	0.381
Swamp Oak	7 ± 3.7	12 ± 5.1	-0.387	0.699
Red/BlackOak	6 ± 2.4	6 ± 3.0	0.971	0.332
White Oak	4 ± 2.2	4 ± 2.7	0.638	0.524
Willow Oak	2 ± 1.3	6 ± 2.1	-0.862	0.389
Other	1 ± 0.9	15 ± 6.4	-1.410	0.159
Cherry	1 ± 0.9	3 ± 2.4	0.029	0.977

[a] Differences tested with Wilcoxon-Mann-Whitney statistic

[b] Only 80 of the 86 sampled sites had snag data recorded.

Table 12. Mean, association, and univariate contribution of understory characteristics to the probability of Delmarva fox squirrel presence at sites where DFS were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
Percent understory	50 ± 4.5	56 ± 3.7	-1.21	0.23	-0.0080	0.0087	0.857	0.35	0.992
CV of % understory	59 ± 6.1	53 ± 6.4	1.63	**0.10**	0.00278	0.00513	0.287	0.59	1.003
Understory height (m)	11 ± 0.8	9 ± 0.5	1.84	**0.07**	0.1215	0.644	3.663	**0.06**	1.129

Table 13. Mean values of shrub cover characteristics at sites where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
Shrub stems/ha	8068 ± 3218	11,119 ± 2189	-2.07	**0.04**	-0.00001	0.000016	0.6589	0.42	1.0
CV of shrub stems/ha	95 ± 12.9	69 ± 6.6	1.59	0.11	0.0074	0.00399	3.5126	**0.06**	1.007
Briar stems/ha	3717 ± 1110	6651 ± 2026	-0.43	0.67	-0.00002	0.000024	1.0689	0.30	1.00
CV of briar stems/ha	54 ± 13.4	69 ± 9.2	-1.01	0.31	-0.0031	0.00345	0.8100	0.37	0.997

Table 14. Major shrub and ground stem categories sampled where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	% of observations with the class present		Chi^2	Univariate logistic regression			
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	*P*	Parameter Estimate	S.E.	Likelihood x^2	$P > x^2$
Even ground cover	6	15	**0.05**	-0.8138	0.5667	2.240	0.13
Irregular ground cover	28	24	0.49	0.3125	0.4660	0.451	0.50
Clumped ground cover	17	11	0.27	0.3987	0.5256	0.5663	0.45
Even shrub cover	7	21	**0.01**	-1.5592	0.6689	6.905	**0.01**
Irregular shrub cover	22	16	0.27	0.5213	0.4771	1.188	0.28
Clumped Shrub cover	20	13	0.15	0.6001	0.4795	1.558	0.21

Table 15. Major shrub and ground stem categories sampled where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Relative Frequency (%)		Chi^2	Univariate logistic regression			
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2
Stem class A	10	4	**0.098**	1.1394	0.7167	2.5243	**0.11**
Stem class B	36	26	0.322	0.4615	0.4677	0.9804	0.32
Stem class C	8	7	0.919	-0.0741	0.7329	0.0103	0.92
Stem class D	26	22	0.982	-0.0107	0.4809	0.0005	0.98
Stem class E	8	14	0.346	-0.5816	0.6222	0.9330	0.33
Stem class F	5	11	0.177	-1.0524	0.8073	2.0327	0.15
Stem class G	8	17	**0.071**	-1.1749	0.6765	3.5912	**0.06**

Table 16. Mean values of ground cover characteristics at sites where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	*Z*	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
% grass cover	14 ± 4.2	21 ± 3.2	-1.25	0.21	-0.0121	0.0112	1.295	0.25	0.988
CV % grass cover	73 ± 15.1	79 ± 9.5	-0.51	0.61	-0.0012	0.0032	0.139	0.71	0.999
% forb cover	12 ± 3.0	16 ± 2.0	-1.50	0.13	-0.0171	0.0161	1.192	0.28	0.983
CV % forb cover	46 ± 11.8	84 ± 9.4	-2.33	**0.02**	-0.0085	0.0038	5.610	**0.02**	0.992

Table 17. Mean values of landscape level characteristics at sites where Delmarva fox squirrels were present and absent during a sampling effort in Dorchester County, Maryland from September – December 2004.

	Mean ± SE		Wilcoxon statistic		Univariate logistic regression				
Variable	DFS Present (n = 27)	DFS Absent (n = 59)	Z	*P*	Parameter Estimate	S.E.	Likelihood x^2	P > x^2	Odds Ratio
Patch size (ha)	378 ± 83	244 ± 36	0.85	0.39	0.00109	0.00066	2.7308	0.10	1.001
Stand size (ha)	1993 ± 145	1900 ± 132	0.59	0.55	0.000108	0.00025	0.1856	0.67	1.00
Distance to agricultural fields (m)	964 ± 106	1308 ± 103	-1.70	**0.09**	-0.00069	0.000353	4.2316	**0.04**	0.999
Distance to roads (m)	919 ± 80	892 ± 79	0.72	0.47	0.000088	0.00042	0.0437	0.83	1.00

Table 18. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on percent cover characteristics. All models were selected a' priori and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here. Results for the full model set are in Appendix C.

Percent Cover Model	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P[a]	Percent Concordant[b]
Y = -2.3352 + 0.0200 (POVER)	2	108.1	0.0	0.19	3.102	0.078	58.1
Y = - 2.0970 + 0.0198 (POVER) + -0.0167 (PFORB)	3	109.1	1.0	0.11	4.211	0.122	65.3
Y = -1.9234 + 0.0206 (POVER) + -0.00868 (PUNDER)	3	109.3	1.2	0.10	4.050	0.132	67.4
Y = -0.5737 + -0.0121 (PGRASS)	2	109.9	1.8	0.08	1.295	0.255	50.2
Y = -0.5469 + -0.0171 (PFORB)	2	110.0	1.9	0.07	1.192	0.275	51.1
Y = -2.0804 + 0.0179 (POVER) + -0.00547 (PGRASS)	3	110.0	1.9	0.07	3.308	0.191	61.7

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 19. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on density of trees and shrubs. All models were selected a' priori and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here. Results for the full model set are in Appendix D.

Stem Density Model		K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P^a	Percent Concordant[b]
Y =	-1.0270 + 0.0209 (DSIZE5)	2	108.3	0.0	0.15	2.839	0.092	36.9
Y =	-0.6564 + -0.00002 (DBRIAR)	2	109.3	1.0	0.09	1.069	0.301	41.5
Y =	-0.6096 + -0.00090 (DSIZE1) + 0.0191 (DSIZE5)	3	109.5	1.2	0.08	3.774	0.152	64.7
Y =	-0.3004 + -0.00109 (DSIZE1)	2	109.7	1.4	0.08	1.466	0.226	57.4
Y =	-1.0212 + 0.00841 (DSIZE4)	2	109.7	1.4	0.08	1.442	0.230	45.3
Y =	-0.9166 + -0.00001 (DSHRUB) + 0.0204 (DSIZE5)	3	110.0	1.7	0.07	3.360	0.186	65.1
Y =	-1.1307 + 0.00494 (DSIZE4) + 0.0179 (DSIZE5)	3	110.1	1.8	0.06	3.261	0.196	58.8

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 20. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on landscape characteristics. All models were selected a' priori and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here. Results for the full model set are in Appendix E.

Landscape Model		K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P[a]	Percent Concordant[b]
Y =	-0.00187 + -0.00069(DISTAG)	2	106.9	0.0	0.22	4.23	0.04	61.3
Y =	-0.2671 + -0.00088 (DISTAG) + 0.000509 (DISTRD)	3	108.0	1.1	0.13	5.30	0.07	60.1
Y =	-0.3438 + -0.00056 (DISTAG) + 0.000652 (PTCHSZ)	3	108.3	1.4	0.11	5.06	0.08	63.2
Y =	-1.1143 + 0.00109 (PTCHSZ)	2	108.4	1.5	0.10	2.73	0.10	50.7
Y =	-0.03330 + -0.00073 (DISTAG) + 0.000192 (STNDSZ)	3	108.6	1.7	0.10	4.72	0.09	63.2

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 21. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on habitat characteristics thought to be biologically relevant, based on past literature review. All models were selected a' priori and AIC was used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here.

Biological Model		K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P[a]	Percent Concordant[b]
Y =	- 3909 + -1.4416 (SHEVEN)	2	104.3	0.0	0.13	6.87	0.009	36.1
Y =	-1.9778 + -1.3167 (SHEVEN) + 0.0161 (P45) +0.0175 (POVER)	4	104.6	0.3	0.11	10.91	0.012	71.2
Y =	-0.6143 + -1.3542 (SHEVEN) + 0.0171 (P45)	3	104.7	0.4	0.11	8.66	0.013	55.7
Y =	-0.2799 + -0.8822 (GREVEN) + -1.2254 (SHEVEN)	3	104.7	0.4	0.11	8.59	0.014	46.3
Y =	-1.4609 + 0.000012 (DSHRUB) + 0.0063 (CVSHRUB) + -1.4609 (SHEVEN)	4	106.3	2.0	0.05	9.22	0.027	68.5

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 22. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on a compilation of predictor variables with the highest Akaike weight. Weight (w_i) is the probability that a particular model is the best model. All models were selected a' priori and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here. Results for the full model set are in Appendix F.

Integrated Model (A' priori)	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P[a]	Percent Concordant[b]
Y = 0.3478 + -0.00067 (DISTAG) + -1.3901 (SHEVEN)	3	103.0	0.0	0.24	10.287	0.006	71.3
Y = -0.9497 + 0.0157 (POVER) + -0.00061 (DISTAG) + -1.3675 (SHEVEN)	4	103.4	0.4	0.19	12.067	0.007	74.0
Y = 0.1052 + -0.00061 (DISTAG) + -1.3281 (SHEVEN) + 0.0130 (DSIZE5)	4	104.2	1.2	0.13	11.275	0.010	72.3
Y = -0.3909 + -1.4416 (SHEVEN)	2	104.3	1.3	0.13	6.872	0.009	36.1
Y = -1.9778 + 0.0175 (POVER) + -1.3167 (SHEVEN) + 0.0161 (DSIZE5)	4	104.6	1.6	0.11	10.905	0.012	71.2
Y = -0.6143 + -1.3542 (SHEVEN) + 0.0171 (DSIZE5)	3	104.7	1.7	0.11	8.660	0.013	55.7
Y = -1.1842 + 0.0157 (POVER) + -0.00055 (DISTAG) + -1.3080 (SHEVEN) + 0.0127 (DSIZE5)	5	104.8	1.8	0.10	12.988	0.011	74.8

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 23. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on a compilation of predictor variables chosen post hoc. All models were selected post hoc and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here. Results for the full model set are in Appendix G.

Post Hoc Model	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P[a]	Percent Concordant[b]
Y = -7.9685 + 0.2217 (AVGCH) + 0.0650 (AVGSCH)	3	98.4	0.0	0.23	13.426	0.001	73.9
Y = -8.2615 + 0.2259 (AVGCH) + 0.0468 (AVGSCH) + 0.0136 (PREDM)	4	99.0	0.7	0.17	14.955	0.002	75.4
Y = -7.4899+ 0.2128 (AVGCH) + 0.0157 (PREDM)	3	99.4	1.1	0.14	13.119	0.001	73.2

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Table 24. Logistic regression models to predict presence of Delmarva fox squirrels (DFS) in Dorchester County, Maryland, September – December 2004 based on a based on a compilation of a' priori and post hoc predictor variables from models with the highest Akaike weight. Weight (w_i) is the probability that a particular model is the best model. All models were selected post hoc and AIC used to evaluate model fit to the data. Sample size was 86 (DFS present = 27, DFS absent = 59). Only models with Δ AIC < 2.0 are presented here.

Integrated Post Hoc Model	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio P^a	Percent Concordant[b]
Y = -6.9892 + 0.0155 (POVER) + -0.9709 (SHEVEN) + 0.1774 (AVGCH)	4	98.3	0.0	0.19	15.387	0.0015	75.2
Y = -6.2312 + 0.0106 (DENS5) + -0.9557 (SHEVEN) + 0.1716 (AVGCH) + 0.0539 (AVGSCH)	5	98.8	0.5	0.14	16.168	0.0028	76.6
Y = -8.2615 + 0.2259 (AVGCH) + 0.468 (AVGSCH) + 0.0136 (PREDM)	4	98.8	0.5	0.14	14.956	0.0019	75.4
Y = -7.0366 + 0.1987 (AVGCH) + -0.9987 (SHEVEN) + 0.0289 (AVGSCH) + 0.0147 (PREDM)	5	99.6	1.3	0.10	17.472	0.0016	78.4
Y = -7.7325 + 0.0140 (POVER) + 0.1931 (AVGCH) + -0.9314 (SHEVEN) + 0.0416 (AVGSCH)	5	100.1	1.8	0.08	17.190	0.0018	77.1

[a] The probability of not obtaining the data set, given that particular model

[b] The percent of points correctly predicted as present or absent by the model.

Appendix A.1. Vegetation plot protocol for a study determining habitat variables associated with Delmarva fox squirrel use in Dorchester County, MD, September - December 2004.

Vegetation Plot Protocol

US Fish and Wildlife Service, Chesapeake Marshlands NWR
Delmarva fox squirrel Photomonitoring Study 2004
Contact: Charisa Morris 410-573-4550

Note: A map with the 500 meter spaced grid layer will be provided.

Equipment List

1. DBH tape: for determining diameter of trees in plot
2. Clinometer: for determining overstory and understory heights
3. Nylon rope w/ 2m tick marks: for point intercept readings
4. Compass: for navigational assistance
5. GPS/batteries: for navigational assistance
6. 2 meter ½" PVC: for stem count measurements
7. Data forms, clipboard, pencils
8. Flagging: for marking trail
9. 4 pin flags: for marking transect terminus
10. Wasp spray: for nests within central post
11. Camera/batteries: for standard site samples
12. Tree & Shrub ID guide: for rare specimens

Procedure

1. Calculate compass bearing from vehicle/current GPS point to site using a map, compass, and GPS. ALWAYS GPS YOUR VEHICLE.

2. Once site post is found, spray wasp spray into the post, as 95% of the site posts house paper wasps, which will aggressively defend the post if not neutralized.

3. Slip looped end of nylon rope over tree, walk directly away from front of sign with rope end, counting shrub stems with ½" PVC while walking.

4. Once at end, place pin flag to mark terminus, and walk back to post, recording point intercept data.

5. Repeat steps 3 & 4 for three additional transects stemming from the central post, ultimately forming two orthogonal 11.3 meter transects with the central post at its axis.

6. Take the height of 2 overstory trees, 2 understory trees, and any other relevant structural characteristic.

7. List dominant understory species composition (eg: briar, pepperbush) and record plant dispersion index.

8. Tree counts can begin once the 1st quadrant is marked. Record species and dbh of each tree within each of the four transects.

Appendix A.2. Vegetation plot data sheet (scaled to fit).

Chesapeake Marshlands National Wildlife Refuge 2004 DFS Vegetative Data

Site: Unit:

Date: Observers:

Point Intercept:

	line 1					line 2					line 3					line 4					T
dominant																					
subdom																					
grass																					
forb																					
water																					

Shrub Stems @1m: L1 L2 L3 L4 T

Briar Stems: L1 L2 L3 L4 T

DFS level @ 15cm: L1 L2 L3 L4 T

Canopy Height: dominant: tree 1 tree 2 mean:

subdominant: tree 1 tree 2 mean:

Tree Count (# by size and species per quarter):

	5 - 15 cm DBH				15.1 - 30 cm DBH				30.1 - 40 cm DBH				40.1 - 50 cm DBH				> 50 cm DBH				T
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
white oak																					
r/b oak																					
will. oak																					
swmp oak																					
beech																					
hickory																					
red maple																					
sweetgum																					
poplar																					
blackgum																					
cherry																					
pine																					
holly																					

Plant dispersion index: ground cover shrub cover

(E): even matrix (I): irregular or uneven (SC): small clumps (LC): large clumps

(SR): small distinct rows or hedges (LR): large distinct rows or hedges

Logs (# by length per quarter):

0 - 2 meters				2.1 - 4 meters				>4 meters			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

Species composition:

Patch Size: Adjacent stand type:

Stand Size: Adjacent land use:

Notes:

Appendix B.1. Photomonitor protocol for a study determining presence or absence of Delmarva fox squirrels in Dorchester County, MD, September – December 2004.

Photomonitor Protocol
US Fish and Wildlife Service
Chesapeake Marshlands NWR
Delmarva fox squirrel Photomonitoring Study 2004
Contact: Charisa Morris 410-573-4550

TOOLS NEEDED

- fine sharpie marker
- coin
- phillips head screwdriver
- small mirror (optional)
- 24 exp 400 speed print film
- C-cell batteries
- camera batteries
- bait

CHECKING THE CAMERA

1. The photomonitor consists of 3 units (see attachment 1). ALWAYS approach from the camera side to avoid breaking the beam.

2. **Look through camera's viewfinder to determine if camera is still centered** (see attachment 2 for correct positioning of camera). If off center, make note on data sheet.

3. Unhook the camera cable from the camera (note the 3 prongs are inserted with the cable side down).

4. Unscrew camera from tripod and remove camera shield – **check and record # of photos taken** (the number on camera is the number of photos taken, not the number of photos left).

5. **If more than 17 photos have been taken, change the film.**

6. Rewind button is small, soft, andgrayand on the bottom of the black or silver cameras (use stick or pine needle to poke); multicolored scuba cameras are auto-rewind only, so (with hand placed in front of camera) exhaust the film.

7. On film canister, write with a Sharpie marker:
   - the initials of the site
   - the date collected
   - the camera it was collected from (C1, C2, C3, C4, etc)

8. Before replacing camera on the tripod, make sure no buttons have been pressed to change settings.
   BLACK/SILVER CAMERAS:
   - The LCD display should only have the number of photos taken (or if you just changed the film a '1' – there should never be a 0, as that means either all the film is used up or the new film needs to be repositioned), and a auto-flash signal.

Appendix B.1.2.

- It should never have an eye or an infinity symbol –if it does, press the mode button until it only has a number and the autoflash display. **If it displays a battery, replace the battery – you will need a coin to open the battery case**
- The date/time stamp (on the back of the camera) should always have the day first, then the time. There should be no bars over any of the numbers – if you see a bar, it is in set-up mode and the date and time will not be displayed – press the mode button until the correct mode is displayed with no bars.

MULTI-COLORED CAMERAS:

- Make sure the switch at the bottom of the camera is NOT on 'P'
- Turn the camera off then on to make sure the film has caught and the battery is working – to turn on, turn it once counterclockwise, to the flash position – **never have these scuba cameras on autoflash**
- The date/time stamp (on the back of the camera) should always have the day first, then the time. There should be no bars over any of the numbers – if you see a bar, it is in set-up mode and the date and time will not be displayed – press the mode button until the correct mode is displayed with no bars.

8. Replace camera on tripod, centering camera according to instructions in attachment 2, but DO NOT ATTACH CABLE YET.

CHECKING THE PHOTOMONITOR

(do this without moving the units (even an inch) or breaking the beam)

1. Check LCD display on the receiver – record # on sheet (including a dot if it has one)

2. If it says 'LO BATT,' replace the batteries – **you will need a screwdriver**

3. Make sure the cable is snug in the receiver

4. Slide a mirror or your hand underneath the transmitter. Turn it off and on once – if the red light flashes, it is okay. If the red light stays on, replace the batteries – **you will need a screwdriver**

5. If the trap has been moved, place it at a 90° angle to the transmitter, and refill it with bait

6. Return to receiver – press the 'SET UP' button until 'Set up' appears in the display.
    - once 'set up' is in the display, the red light facing the transmitter should flash (the actual beam is received by the shiny black circle beneath the red light)
    - if the red light is not flashing, line the receiver up with the transmitter using the sight line like a sight on a gun.
    - if the red light is flashing sporadically, it also needs to be realigned with the transmitter.

5. Once the red light flashes consistently, press 'TIME SET' to get out of set up mode.

6. Insert cable into camera with cable hanging down and secured on post (raccoons can tug it out otherwise).

7. Place hand in front of transmitter to make sure camera takes a picture.

Appendix B.2. Photomonitor troubleshooting guide for a study determining presence or absence of Delmarva fox squirrels in Dorchester County, MD, September – December 2004.

Troubleshooting guide for Photomonitor Project
US Fish and Wildlife Service
Chesapeake Marshlands NWR
Delmarva fox squirrel Photomonitoring Study 2004
Contact: Charisa Morris 410-573-4550

IF HAND IS PLACED THROUGH BEAM AND EVENT DOESN'T REGISTER:

Scenario #1: Receiver is not lined up with transmitter
Step 1: Hit "set up" until 'SET UP' appears in LCD display
Step 2: If red light does not blink, detach the transmitter from the tree and place it right in front of the receiver to see if it blinks – *if so, go to step 3, if not, after making sure both units are on, go to scenarios 3, 4, or 5*
Step 3: Adjust both units until light is blinking very steadily – (light can still blink if incorrectly aligned – need a fast, steady blink)
Step 4: Hit "set up" to get out of set up mode
Step 5: Place hand in front of monitor to see if event registers

Scenario #2: Receiver's event counter is full
Step 1: Press "set up" until red light is blinking and "SET UP" is in LCD display
Step 2: Press "R/O Advance" until "CLR" appears in LCD display
Step 3: Press "set up" to clear all event data

Scenario #3: Batteries in receiver (large box) are failing
Step 1: Turn off receiver
Step 2: Turn receiver back on and wait to see if 'LO BATT' flashes in LCD display
Step 3: If low batteries, unscrew back and replace with 4 C-Cell batteries: (make sure back is screwed back on right side up)

Scenario #4: Batteries in transmitter are failing
Step 1: Place hand or mirror underneath of transmitter (so as not to move it enough to break the alignment)
Step 2: Turn toggle switch off (wait 10 seconds)
Step 3: Turn toggle switch to "on"
Step 4: If red light simply flashes once, batteries are good
Step 5: If red light stays on, batteries need to be replaced (with 4 c-cell batteries)

Scenario #5: Internal malfunction in equipment
Step 1: Bring in the spares

IF CAMERA DOESN'T WORK

Scenario #1: Camera is not on
Step 1: On scuba (multicolored) cameras, turn dial to Flash (NOT to autoflash)

Appendix B.2.2.

Step 2. On all other cameras, slide "ON" button, and make sure only autoflash is on

Scenario #2: Cable is not connected properly
Step 1: Disconnect and reconnect cable at both ends
Step 2: Make sure that receiver end of cable is hooked into "camera output" not "printer output"
Step 3: Run hand along cable to assess if cable is damaged
Step 4: If all else fails, replace cable

Scenario #3: Film is exhausted or not loaded properly
Step 1: Check film counter – if film is expired, replace
Step 2: If film is new and hasn't caught on the cog, gently add short lengths to film tongue until it catches

Scenario #4: Battery is low
Step 1: On scuba camera, turn off then on – if light stays on, battery is low
Step 2: On all other cameras, see if lo battery display is in LCD display (cartoon battery)
Step 3: Use COIN to open battery door and replace battery

Scenario #5: Receiver is not set to send out data to camera
Step 1: Consult operations manual to set "camera on" and "camera off" times (on from 500 – 2100)

Scenario #6: Camera has internal malfunction
Step 1: Bring in the spare

Appendix B.3. Photomonitor data sheet for a study determining presence or absence of Delmarva fox squirrels in Dorchester County, MD, September – December 2004.

Field data sheet
US Fish and Wildlife Service
Chesapeake Marshlands NWR
Delmarva fox squirrel Photomonitoring Study 2004
Contact: Charisa Morris 410-573-4550

Date: ________________________________

Site: ________________________________

Observers: ____

Weather: ____

Station 1: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 2: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 3: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 4: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 5: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 6: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 7: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 8: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 9: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Station 10: # photos_______ Bait hit: Y N Film changed: Y N

Comments____

Appendix C. Percent Cover logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September – December 2004. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		*n*	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio *P*
Y =	β_0 + POVER	86	2	108.1	0.0	0.19	3.102	0.078
Y =	β_0 + POVER + Pforb	86	3	109.1	1.0	0.11	4.211	0.122
Y =	β_0 + POVER + punder	86	3	109.3	1.2	0.10	4.050	0.132
Y =	β_0 + Pgrass	86	2	109.9	1.8	0.08	1.295	0.255
Y =	β_0 + Pforb	86	2	110.0	1.9	0.07	1.192	0.275
Y =	β_0 + POVER + Pgrass	86	3	110.0	1.9	0.07	3.308	0.191
Y =	β_0 + punder	86	2	110.3	2.2	0.06	0.857	0.355
Y =	β_0 + punder + Pgrass	86	3	110.6	2.5	0.05	2.732	0.255
Y =	β_0 + POVER + punder + Pforb	86	4	110.7	2.6	0.05	4.820	0.186
Y =	β_0 + Pgrass + Pforb	86	3	110.8	2.7	0.05	2.511	0.285
Y =	β_0 + POVER + punder + Pgrass	86	4	111.0	2.9	0.04	4.503	0.212
Y =	β_0 + POVER + Pgrass + Pforb	86	4	111.1	3.0	0.04	4.430	0.218
Y =	β_0 + punder + Pforb	86	3	111.6	3.5	0.03	1.717	0.424
Y =	β_0 + punder + Pgrass + Pforb	86	4	112.0	4.0	0.03	3.481	0.323
Y =	β_0 + POVER + punder + Pgrass + Pforb	86	5	112.5	4.5	0.02	5.238	0.264

Appendix D. Stem density logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September – December 2004. All models were selected a’ priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		*n*	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio *P*
Y =	β_0 + DSIZE5	86	2	108.3	0.0	0.15	2.839	0.092
Y =	β_0 + Dbriar	86	2	109.3	1.0	0.09	1.069	0.301
Y =	β_0 + Dsize1 + DSIZE5	86	3	109.5	1.2	0.08	3.774	0.152
Y =	β_0 + Dsize1	86	2	109.7	1.4	0.08	1.466	0.226
Y =	β_0 + Dsize4	86	2	109.7	1.4	0.08	1.442	0.230
Y =	β_0 + Dshrub + DSIZE5	86	3	110.0	1.7	0.07	3.360	0.186
Y =	β_0 + Dsize4 + DSIZE5	86	3	110.1	1.8	0.06	3.261	0.196
Y =	β_0 + Dsize3	86	2	110.4	2.1	0.05	0.782	0.377
Y =	β_0 + Dshrub	86	2	110.5	2.2	0.05	0.659	0.417
Y =	β_0 + Dsize1 + Dsize4 + DSIZE5	86	4	111.3	3.0	0.03	4.184	0.242
Y =	β_0 + Dsize2	86	2	111.0	2.7	0.04	0.124	0.725
Y =	β_0 + Dsize3 + Dsize4 + DSIZE5	86	3	111.4	3.1	0.03	3.957	0.266
Y =	β_0 + Dshrub + Dbriar + Dsize4 + DSIZE5	86	5	111.9	3.6	0.03	5.096	0.278
Y =	β_0 + Dshrub + Dsize4 + DSIZE5	86	4	111.7	3.4	0.03	3.804	0.284
Y =	β_0 + Dsize1 + Dsize3 + Dsize4 + DSIZE5	86	5	112.0	3.7	0.02	5.745	0.219
Y =	β_0 + Dshrub + Dbriar + Dsize1 + Dsize2 + Dsize3	86	6	112.6	4.3	0.02	6.728	0.242
Y =	β_0 + Dshrub + Dbriar + Dsize1 + Dsize2 + Dsize3 + DSIZE5	86	7	113.7	5.4	0.01	8.047	0.235
Y =	β_0 + Dshrub + Dbriar + Dsize1 + Dsize2 + Dsize3 + Dsize4	86	7	113.9	5.6	0.01	7.807	0.253

Appendix D (continued). Stem density logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September – December 2004 based on stem density variables. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		*n*	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio *P*
Y =	β_0 + Dsize1 + Dsize2 + Dsize4 + DSIZE5	86	5	113.5	5.2	0.01	4.245	0.374
Y =	β_0 + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	5	113.8	5.5	0.01	3.988	0.408
Y =	β_0 + Dsize1 + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	6	114.2	5.9	0.01	5.932	0.313
Y =	β_0 + Dshrub + Dbriar + Dsize1 + Dsize2 + Dsize4 + DSIZE5	86	7	114.9	6.6	0.01	6.796	0.340
Y =	β_0 + Dshrub + Dsize1 + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	7	115.0	6.7	0.01	7.474	0.279
Y =	β_0 + Dshrub + Dbriar + Dsize1 + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	8	115.6	7.3	0.00	8.511	0.290
Y =	β_0 + Dbriar + Dsize1 + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	7	115.2	6.9	0.00	6.466	0.373
Y =	β_0 + Dshrub + Dbriar + Dsize2 + Dsize3 + Dsize4 + DSIZE5	86	7	116.1	7.8	0.00	5.604	0.469
Y =	β0 + Dshrub + Dbriar + Dsize1 + Dsize3 + Dsize4 + DSIZE5	86	7	113.2	4.9	0.01	8.508	0.203

Appendix E. Landscape variable logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		*n*	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio *P*
Y =	β0 + DISTAG	86	2	106.9	0.0	0.22	4.23	0.04
Y =	β0 + DISTAG + DISTRD	86	3	108.0	1.1	0.13	5.30	0.07
Y =	β0 + DISTAG + PTCHSZ	86	3	108.3	1.4	0.11	5.06	0.08
Y =	β0 + PTCHSZ	86	2	108.4	1.5	0.10	2.73	0.10
Y =	β0 + DISTAG + STNDSZ	86	3	108.6	1.7	0.10	4.72	0.09
Y =	β0 + DISTAG + DISTRD + PTCHSZ	86	4	109.4	2.5	0.06	6.13	0.11
Y =	β0 + DISTAG + STNDSZ + PTCHSZ	86	4	109.9	3.0	0.05	5.59	0.13
Y =	β0 + DISTAG + DISTRD + STNDSZ	86	4	110.0	3.1	0.05	5.56	0.14
Y =	β0 + STNDSZ + PTCHSZ	86	3	110.3	3.4	0.04	3.03	0.22
Y =	β0 + DISTRD + PTCHSZ	86	3	110.4	3.5	0.04	2.91	0.23
Y =	β0 + STNDSZ	86	2	111.0	4.1	0.03	0.19	0.67

Appendix E (continued). Landscape variable logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on landscape variables. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		*n*	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio *P*
Y =	β0 + DISTRD	86	2	111.1	4.2	0.03	0.04	0.83
Y =	β0 + DISTAG + DISTRD + STNDSZ + PTCHSZ	86	5	111.4	4.5	0.02	6.42	0.17
Y =	β0 + DISTRD + STNDSZ + PTCHSZ	86	4	112.4	5.5	0.01	3.11	0.37
Y =	β0 + DISTRD + STNDSZ	86	3	113.1	6.2	0.01	0.19	0.91

Appendix F. Biological logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model							K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio p
Y =	β_0 +	Sheven					2	104.3	0.0	0.13	6.872	0.009
Y =	β_0 +	Sheven +	Dsize5 +	Pcan			4	104.6	0.3	0.11	10.905	0.012
Y =	β_0 +	Sheven +	Dsize5				3	104.7	0.4	0.11	8.660	0.013
Y =	β_0 +	Greven +	Sheven				3	104.7	0.4	0.11	8.588	0.014
Y =	β_0 +	Dshrub +	Cvshrub +	Sheven			4	106.3	2.0	0.05	9.221	0.027
Y =	β_0 +	Dshrub +	Sheven +	Dsize5			4	106.8	2.5	0.04	8.76	0.033
Y =	β_0 +	Cvbriar					2	107.0	2.7	0.04	4.187	0.041
Y =	β_0 +	Cvshrub					2	107.7	3.4	0.12	3.513	0.061
Y =	β_0 +	Pcan					2	108.1	3.8	0.07	3.102	0.078
Y =	β_0 +	Dsize5					2	108.3	4.0	0.04	2.839	0.092
Y =	β_0 +	Cvshrub +	Cvbriar				3	108.9	4.6	0.01	4.404	0.111
Y =	β_0 +	Dshrub +	Dbriar +	Cvshrub +	Cvbriar +	Sheven	6	109.1	4.8	0.01	10.272	0.068
Y =	β_0 +	Fstem					2	109.1	4.8	0.01	2.033	0.154
Y =	β_0 +	Plarge					2	109.3	5.0	0.01	1.878	0.171
Y =	β_0 +	Dbriar					2	109.3	5.0	0.01	1.069	0.301
Y =	β_0 +	Dsize1					2	109.7	5.4	0.01	1.466	0.226
Y =	β_0 +	Pgrass					2	109.9	5.6	0.01	1.295	0.255
Y =	β_0 +	Estem					2	110.2	5.9	0.01	0.933	0.334
Y =	β_0 +	Greven					2	110.4	6.1	0.01	0.810	0.368
Y =	β_0 +	Dshrub					2	110.5	6.2	0.01	0.659	0.417
Y =	β_0 +	Dsize1 +	Dshrub +	Cvshrub +	Cvbriar +	Sheven	7	110.6	6.3	0.01	11.079	0.086
Y =	β_0 +	Dbriar +	Cvbriar				3	110.7	6.4	0.01	1.883	0.390
Y =	β_0 +	Pmast					2	110.9	6.6	0.01	0.303	0.582
Y =	β_0 +	Stndsz					2	111.0	6.7	0.00	0.186	0.667
Y =	β_0 +	Fstem +	Estem				3	111.0	6.7	0.00	2.322	0.313

Appendix F (continued). Biological logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model								K	AIC$_C$	Δ_i	w_i	X^2	Likelihood ratio p
Y =	β_0 +	Pcan +	Plarge +	Stndsz				4	111.1	6.8	0.00	4.441	0.218
Y =	β_0 +	Plpine						2	111.2	6.9	0.00	0.002	0.962
Y =	β_0 +	Pmast +	Plpine +	Pcan				4	111.3	7.0	0.00	4.185	0.242
Y =	β_0 +	Pmast +	Plpine					3	112.5	8.2	0.01	0.789	0.674
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge			5	112.6	8.3	0.01	5.212	0.266
Y =	β_0 +	Greven +	Fstem +	Estem +	Pgrass			5	113.2	8.9	0.01	4.612	0.330
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1		6	113.2	8.9	0.01	6.879	0.230
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	8	114.7	10.4	0.00	9.415	0.224
		Dbriar											
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub	7	114.8	10.5	0.00	7.668	0.264
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	9	115.2	10.9	0.00	11.444	0.178
		Dbriar +	Cvshrub										
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	10	116.1	11.8	0.00	13.068	0.160
		Dbriar +	Cvshrub +	Cvbriar									
Y =	β_0 +	Dshrub +	Dbriar +	Cvshrub +	Cvbriar +	Greven +	Sheven +	10	116.9	12.6	0.00	12.272	0.198
		Fstem +	Estem +	Pgrass									
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	12	117.1	12.8	0.00	17.429	0.096
		Dbriar +	Cvshrub +	Cvbriar +	Greven +	Sheven +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	12	117.6	13.3	0.00	16.981	0.108
		Dbriar +	Cvshrub +	Cvbriar +	Greven +	Sheven							
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	11	118.3	14.0	0.00	13.519	0.196
		Dbriar +	Cvshrub +	Cvbriar +	Greven								
Y =	β_0 +	Dsize1 +	Dshrub +	Dbriar +	Cvshrub +	Cvbriar +	Greven +	11	118.8	14.5	0.00	12.997	0.224
		Sheven +	Fstem +	Estem +	Pgrass								
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	13	120.3	16.0	0.00	16.984	0.150
		Dbriar +	Cvshrub +	Cvbriar +	Greven +	Sheven +	Fstem						

Appendix F (continued). Biological logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected a' priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model	K	AIC_C	Δ_i	w_i	X^2	Likelihood ratio p
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	12	120.6	16.3	0.00	14.703	0.197
Y = β_0 + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	12	121.0	16.7	0.00	13.547	0.259
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Pgrass + Stndsz	14	122.3	18.0	0.00	17.852	0.163
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Estem	14	123.0	18.7	0.00	17.152	0.193
Y = β0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dbriar + Cvbriar + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	14	123.9	19.6	0.00	16.304	0.233
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Cvshrub + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	14	124.4	20.1	0.00	16.555	0.221
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	14	124.7	20.4	0.00	15.451	0.280
Y = β_0 + Pmast + Plpine + Pcan + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	15	125.1	20.8	0.00	18.031	0.205
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar	15	125.1	20.8	0.00	18.021	0.206
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Estem + Stndsz	15	125.1	20.8	0.00	18.012	0.206
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Sheven + Fstem + Estem + Pgrass + Stndsz	15	125.2	20.9	0.00	17.971	0.208
Y = β_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dshrub + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Pgrass + Stndsz	15	125.3	21.0	0.00	17.862	0.213
Y = B_0 + Pmast + Plpine + Pcan + Plarge + Dsize1 + Dbriar + Cvshrub + Cvbriar + Greven + Sheven + Fstem + Estem + Pgrass + Stndsz	15	125.3	21.0	0.00	17.836	0.214

Appendix F (continued). Biological logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected a’ priori, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model									K	AIC$_C$	Δ_i	w_i	X^2	Likelihood ratio p
Y =	β_0 +	Pmast +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	Cvshrub +	15	125.3	21.0	0.00	17.794	0.216
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	Cvshrub +	Cvbriar +	14	125.7	21.4	0.00	14.502	0.340
		Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz							
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dshrub +	Dbriar +	Cvshrub +	15	125.9	21.6	0.00	17.256	0.243
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	15	125.9	21.6	0.00	17.233	0.244
		Cvshrub +	Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	15	125.9	21.6	0.00	17.233	0.244
		Cvshrub +	Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	15	126.1	21.8	0.00	17.031	0.255
		Cvshrub +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	14	126.1	21.8	0.00	14.074	0.369
		Cvshrub +	Cvbriar +	Fstem +	Estem +	Pgrass +	Stndsz							
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Cvshrub +	15	126.4	22.1	0.00	17.475	0.232
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	Cvshrub +	15	126.6	22.3	0.00	16.528	0.282
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	15	126.8	22.5	0.00	16.331	0.294
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	Cvshrub +	15	128.0	23.7	0.00	15.157	0.368
		Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +	Stndsz						
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	16	128.1	23.8	0.00	18.042	0.260
		Cvshrub +	Cvbriar +	Greven +	Sheven +	Fstem +	Estem +	Pgrass +						
		Stndsz												
Y =	β_0 +	Pmast +	Plpine +	Pcan +	Plarge +	Dsize1 +	Dshrub +	Dbriar +	15	128.6	24.3	0.00	14.564	0.409
		Cvshrub +	Cvbriar +	Greven +	Fstem +	Estem +	Pgrass +	Stndsz						

Appendix G. Post Hoc logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected post hoc, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		K	AIC_C	Δi	wi	X^2	Likelihood ratio p	Percent concordant
Y =	β0 + AVGCH + AVGSCH	3	98.36	0.00	0.23	13.43	0.0012	73.9
Y =	β0+ AVGCH+ AVGSCH+ PREDM	4	99.03	0.67	0.17	14.96	0.0019	75.4
Y =	β0+ AVGCH+ PREDM	3	99.44	1.08	0.14	13.12	0.0014	73.2
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK	5	100.95	2.59	0.06	15.29	0.0041	75.6
Y =	β0+ AVGCH+ PREDM+ + POAK	4	101.18	2.82	0.06	13.57	0.0035	73.8
Y =	β0+ AVGCH+ D45	3	101.35	2.99	0.05	11.21	0.0037	72.3
Y =	β0+ AVGCH+ PREDM+ D45	4	101.46	3.10	0.05	13.30	0.004	73.2
Y =	β0+ AVGCH+ + POAK+ D45	4	103.08	4.72	0.02	11.68	0.0086	72.4
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123	6	103.14	4.78	0.02	15.42	0.0087	75.4
Y =	β0+ AVGCH+ PREDM+ + POAK+ D45	5	103.15	4.79	0.02	13.87	0.0077	73.8
Y =	β0+ AVGCH+ AVGSCH+ PREDM + POAK+ P123+ PSPINE+ FCV	8	104.27	5.91	0.01	19.10	0.0079	78.9
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE	7	104.44	6.08	0.01	16.48	0.0114	77
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMG+ SHC+ D45+ D123	12	104.52	6.16	0.01	29.25	0.0021	83.4

Appendix G (continued). Post Hoc logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected post hoc, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model	K	AIC_C	Δi	wi	X^2	Likelihood ratio p	Percent concordant
Y = β0+ FCV+ STMG+ SHC	4	104.54	6.18	0.01	10.98	0.0118	66
Y = β0+ AVGCH+ PREDM+ + POAK+ FCV+ STMA+ STMG+ SHC+ D45	9	104.55	6.19	0.01	22.08	0.0048	79.8
Y = β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	104.75	6.39	0.01	29.02	0.0023	82.7
Y = β0+ FCV+ SHC	3	104.96	6.60	0.01	8.35	0.0153	65.4
Y = β0+ AVGCH+ AVGSCH+ PREDM+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	105.05	6.69	0.01	28.71	0.0025	83.7
Y = β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ D45 +D123	12	105.20	6.84	0.01	28.57	0.0026	82.7
Y = β0+ AVGCH+ AVGSCH+ P123+ FCV+ STMA+ STMG+ SHC+ D45+ D123	10	105.30	6.94	0.01	23.13	0.0059	79.7
Y = β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ D45+ D123	10	105.33	6.97	0.01	23.09	0.006	80.7
Y = β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG	10	105.81	7.45	0.01	22.61	0.0071	80.9
Y = β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D123	12	106.15	7.79	0.00	27.62	0.0037	84.3
Y = β0+ AVGSCH+ PREDM+ + POAK	4	106.20	7.84	0.00	7.79	0.0507	68.4
Y = β0+ AVGSCH+ PREDM	3	106.30	7.94	0.00	5.49	0.0643	63
Y = β0+ AVGCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	106.42	8.06	0.00	28.12	0.0031	82.9

Appendix G (continued). Post Hoc logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected post hoc, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		K	AIC_C	Δi	wi	X^2	Likelihood ratio p	Percent concordant
Y =	β0+ FCV+ STMA+ STMG	4	106.50	8.14	0.00	9.02	0.0291	65.5
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	106.70	8.34	0.00	27.07	0.0045	83.3
Y =	β0+ FCV+ STMA+ STMG+ SHC	5	106.75	8.39	0.00	11.03	0.0263	68.4
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA	9	106.75	8.39	0.00	19.11	0.0143	78.8
Y =	β0+ FCV+ STMA+ SHC	4	107.07	8.71	0.00	8.44	0.0377	66.7
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123 PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	13	107.08	8.72	0.00	29.47	0.0034	83.7
Y =	β0+ PREDM + POAK	3	107.62	9.26	0.00	5.66	0.058	65.4
Y =	β0+ FCV+ STMA	3	107.69	9.33	0.00	5.62	0.0601	62
Y =	β0+ AVGSCH+ PREDM+ + POAK+ P123	5	107.89	9.53	0.00	8.35	0.0795	71
Y =	β0+ PREDM+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	11	107.91	9.55	0.00	24.68	0.006	80.5
Y =	β0+ AVGCH+ AVGSCH+ PREDM + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC	11	107.99	9.63	0.00	23.07	0.0105	80.8
Y =	β0+ PREDM + POAK+ D45	4	108.27	9.91	0.00	7.24	0.0646	69.4
Y =	β0 + AVGCH + AVGSCH + PREDM + POAK+ P123+ PSPINE+ STMA+ STMG+ SHC+ D45+ D123	12	108.50	10.14	0.00	25.27	0.0083	81.5

Appendix G (continued). Post Hoc logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected post hoc, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model		K	AIC_C	Δi	wi	X^2	Likelihood ratio p	Percent concordant
Y =	β0+ AVGSCH+ PREDM+ POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	108.54	10.18	0.00	25.23	0.0084	80
Y =	β0+ STMG+ SHC	3	109.18	10.82	0.00	4.14	0.1265	41.2
Y =	β0+ AVGCH+ AVGSCH+ PREDM + POAK+ P123+ PSPINE+ FCV+ STMA+ SHC+ D45+ D123	12	109.23	10.87	0.00	24.54	0.0107	82.3
Y =	β0+ AVGSCH+ PREDM + POAK+ P123+ D123	6	109.24	10.88	0.00	9.32	0.0969	71.3
Y =	β0+ AVGSCH+ PREDM + POAK+ PSPINE+ D123	6	109.32	10.96	0.00	9.24	0.1	69.7
Y =	β0+ PSPINE+ D123	3	109.51	11.15	0.00	3.81	0.1492	62
Y =	β0 + POAK+ D45	3	109.56	11.20	0.00	3.76	0.1529	63.4
Y =	β0+ AVGCH+ AVGSCH+ + POAK+ P123+ PSPINE+ FCV+ STMA+ STMG+ SHC+ D45+ D123	12	109.76	11.40	0.00	24.00	0.0127	80.2
Y =	β0+ AVGSCH+ PREDM+ P123+ PSPINE+ D123	6	109.94	11.58	0.00	8.62	0.1252	70.2
Y =	β0+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE	6	110.20	11.84	0.00	8.35	0.1377	71
Y =	β0+ AVGCH+ AVGSCH+ PREDM+ + POAK+ P123 + PSPINE+ FCV+ STMA+ STMG+ SHC+ D45	12	110.57	12.21	0.00	23.20	0.0166	80.6
Y =	β0+ STMA+ STMG	3	110.60	12.24	0.00	2.72	0.2572	38
Y =	β0+ AVGSCH+ + POAK+ P123+ PSPINE+ D123	6	110.91	12.55	0.00	7.65	0.1766	70

Appendix G (continued). Post Hoc logistic regression models predicting presence of Delmarva fox squirrels (DFS) in Dorchester County, MD, September - December 2004 based on cover and landscape variables. All models were selected post hoc, and AIC was used to evaluate model fit to the data. Sample size was 86 (27 sites with DFS presence, 59 with DFS absent).

Model	K	AIC_C	Δi	wi	X^2	Likelihood ratio p	Percent concordant
Y = β0+ STMA+ STMG+ SHC	4	111.37	13.01	0.00	4.15	0.2461	49
Y = β0+ P123+ PSPINE+ D123	4	111.51	13.15	0.00	4.00	0.2613	64.9
Y = β0+ AVGSCH+ PREDM+ + POAK+ P123+ PSPINE+ D123	7	111.60	13.24	0.00	9.33	0.1557	71.3
Y = β0+ PREDM+ + POAK+ P123+ PSPINE+ D123	6	112.98	14.62	0.00	7.10	0.213	69.7
Y = β0 + POAK+ P123+ PSPINE+ D123	5	113.18	14.82	0.00	4.59	0.3318	66.1