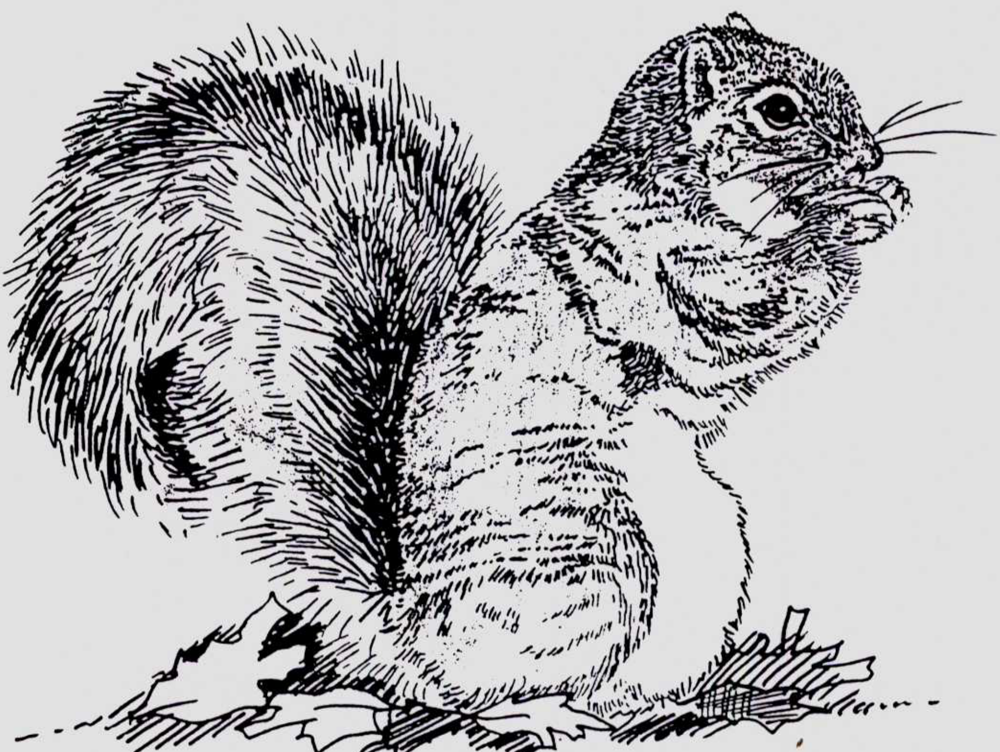
Delmarva Fox Squirrel
(Sciurus niger cinereus)

Recovery Plan



SECOND REVISION

U.S. Fish and Wildlife Service, Northeast Region

Delmarva Fox Squirrel (*Sciurus niger cinereus*)
RECOVERY PLAN

- Second Revision -

Prepared by

Delmarva Fox Squirrel Recovery Team

for

Northeast Region
U.S. Fish and Wildlife Service
Hadley, Massachusetts

Approved: ______________________________
Regional Director
U.S. Fish and Wildlife Service, Northeast Region

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DELMARVA FOX SQUIRREL RECOVERY TEAM

Dr. Nancy D. Moncrief
(Team Leader)
Virginia Museum of Natural History
1001 Douglas Avenue
Martinsville, VA 24112
(703) 666-8614

Mr. Irvin W. Ailes
Chincoteague National Wildlife Refuge
P.O. Box 62
Chincoteague, VA 23336
(804) 336-6122

Mr. William Giese
Blackwater National Wildlife Refuge
2145 Key Wallace Drive
Cambridge, MD 21613
(410) 228-2692

Ms. Judy Jacobs
U.S. Fish and Wildlife Service
Annapolis Field Office
1825 Virginia Street
Annapolis, MD 21401
(410) 269-5448

Mr. Ken M. Reynolds
Delaware Fish and Wildlife
89 Kings Highway
P.O. Box 1401
Dover, DE 19903
(302) 739-5297

Ms. Karen Terwilliger
Virginia Game and Inland Fisheries
P.O. Box 11104
Richmond, VA 23230
(804) 367-6913

Mr. Glenn D. Therres
Maryland Department of Natural Resources
P.O. Box 68
Wye Mills, MD 21679
(410) 827-8612

Dr. Michael A. Steele
(Team member as of 1993)
Department of Biology
Wilkes University
Wilkes-Barre, PA 18766
(717) 824-4651

The Recovery Team wishes to extend its utmost appreciation to Dr. Raymond D. Dueser, Team Leader from 1988 to 1991, for his guidance and continuing contributions to the recovery of the Delmarva fox squirrel. This revised recovery plan incorporates the results of his studies and many of his ideas in updating the recovery program for this endangered species.

EXECUTIVE SUMMARY

Delmarva Fox Squirrel Revised Recovery Plan

This revised recovery plan focuses primarily on determining the current distribution and habitat requirements of the Delmarva fox squirrel and on implementing habitat protection within its remaining natural range. Successful establishment of translocated populations will also be required for full recovery.

Current Status: Although the current population level appears to be stable, *Sciurus niger cinereus* has undergone a significant decline from historical levels, primarily due to loss of habitat. Although unsubstantiated, over-hunting may also have affected insular populations during this decline. The natural population of the subspecies now occurs in four counties in Maryland, representing less than 10% of its historical range. The squirrel has also been introduced to 17 sites within its historical range, and at least 11 of these translocations appear to be successful. The Delmarva fox squirrel's forested habitat is susceptible to continued loss and fragmentation through overcutting and land use changes, although this is balanced to some extent by regeneration of forest resources. *S. n. cinereus* was listed as Federally endangered in 1967.

Habitat Requirements: *S. n. cinereus* occupies mature pine and hardwood forests, both bottomland and upland, with a relatively open understory. Forest areas that contain a variety of nut and suitable seed-bearing trees, over-age trees with hollows for den sites, and nearby supplemental food sources are preferred. Food abundance, disease, and predation affect squirrel numbers from year to year.

Recovery Objective: To delist the Delmarva fox squirrel by increasing its population and protecting its habitat, so that it can persist as a viable, self-sustaining component of its ecosystem.

Recovery Criteria: The Delmarva fox squirrel can be reclassified to threatened status when: (1) ecological requirements and distribution within the remaining natural range are understood sufficiently to permit effective management, (2) benchmark populations are shown to be stable or expanding based on at least five years of data, and (3) ten translocated colonies are successfully established throughout the historical range. Delisting will be considered when, in addition to the above: (4) five additional (post-1990) colonies are established outside of the remaining natural range, (5) periodic monitoring shows that translocated populations have persisted over the recovery period, (6) mechanisms that ensure perpetuation of suitable habitat at a level sufficient to allow for desired distribution are in place and implemented within all counties in which the species occurs, and (7) mechanisms are in place and implemented to ensure protection of new populations, to allow for expansion, and to provide inter-population corridors to permit gene flow among populations.

Actions Needed:

1. Determine the population status and distribution of the Delmarva fox squirrel.
2. Determine Delmarva fox squirrel habitat availability and use.
3. Protect Delmarva fox squirrels and their habitat.
4. Implement appropriate 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.

Projected Costs ($000):

YEAR	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	NEED 6	TOTAL
FY1	26	34.5		3	10		73.5
FY2	29.8	34.5	2.5	12	12	11.5	102.3
FY3	29.8	22.5	5	15	20	7.5	99.8
FY4-17	82.5	45	225	73	75	8	508.5
TOTAL	168.1	146.5	232.5	103	117	27	784.1

DELISTING MAY BE INITIATED IN THE YEAR 2010 (contingent on the fate of established populations and success at habitat protection).

* * *

The following recovery plan is the second revision of the Delmarva Fox Squirrel Recovery Plan. Based upon information obtained from previous planning efforts (U.S. Fish and Wildlife Service 1979, 1983) and accomplishments of the recovery program to date, this plan defines a continuing course of action for protecting and recovering the endangered Delmarva fox squirrel (*Sciurus niger cinereus*), also known as the Delmarva Peninsula fox squirrel. Recovery objectives will be attained and funds made available contingent on budgetary constraints affecting the parties involved, as well as the need to address other priorities.

This approved plan does not necessarily represent the views or official position of any individuals or agencies other than the U.S. Fish and Wildlife Service. Recovery plans are subject to revision as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1993. Delmarva Fox Squirrel (*Sciurus niger cinereus*) Recovery Plan, Second Revision. Hadley, Massachusetts. 104 pp.

Additional copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
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TABLE OF CONTENTS

PART I: INTRODUCTION 1

Description 2
Distribution and Status 3
Habitat Requirements and Ecology 7
Continuing Threats 12
Conservation Measures 15
Translocations 15
1991 Experimental Translocation 21
Determination of Colony Persistence 22
Habitat Suitability Assessment 23
Study of Chincoteague NWR Population 25
Chincoteague NWR Ecological Study 26
Chincoteague NWR Experimental Translocations 28
Searches for Virginia Release Sites 29
Genetic Variation and Implications for Translocations 29
Recovery Strategy 34

PART II: RECOVERY 41

Recovery Objective 41
Recovery Tasks 43
Literature Cited 59

PART III: IMPLEMENTATION 65

APPENDIX A. Forest Trend Data
APPENDIX B. Habitat Evaluation Methods
APPENDIX C. Capture and Handling Protocol
APPENDIX D. Release Protocol
APPENDIX E. Guidelines for Monitoring Benchmark Sites
APPENDIX F. Procedures for Saving and Submitting Roadkills
APPENDIX G. Habitat Management Guidelines
APPENDIX H. Release Site and Source Site Localities
APPENDIX I. List of Reviewers

LIST OF FIGURES AND TABLES

Figure 1. Geographic range and subspecies distribution of the fox squirrel, *Sciurus niger* 4
Figure 2. Distribution of *Sciurus niger cinereus* 5

Table 1. Release and source sites for translocations of the Delmarva fox squirrel 16
Table 2. Performance of translocated Delmarva fox squirrels . . 19

PART I: INTRODUCTION

The Delmarva fox squirrel (Sciurus niger cinereus) was listed as Federally endangered in 1967 (Federal Register 32:4001). The endemic population occurs only in four counties in eastern Maryland, representing less than 10% of the species' apparent historical range (Taylor 1976). While the Delmarva fox squirrel was extirpated as a native element of the fauna in Pennsylvania, Delaware, and Virginia, populations have been reintroduced at sites in these states. The exact causes for the Delmarva fox squirrel's decline are unknown, although forest clearing and changing patterns of land use throughout its range evidently contributed significantly to its endangerment (Taylor 1973).

Sciurus niger cinereus has been assigned a recovery priority of 9 in a system ranging from a high of 1 to a low of 18 (Federal Register 48:43103). This ranking is based on a moderate degree of threat and a high potential for recovery, as well as the squirrel's taxonomic standing as a subspecies. Recovery priorities, which are assigned to all listed species, affect scheduling and funding of recovery activities.

The original recovery plan, approved in 1979 and revised in 1983, emphasized (1) the need to identify optimum habitat for the squirrel and (2) use of this information to translocate Delmarva fox squirrels into suitable habitat outside currently occupied areas but within their historical range. These actions, in conjunction with habitat protection, constituted an initial strategy for expanding the distribution of the species in the wild and ensuring long-term availability of habitat.

This second revision of the Delmarva fox squirrel recovery plan uses the information garnered from past recovery activities to update objectives and specify further recovery needs. It endeavors to define measurable criteria that will allow periodic assessment of recovery progress, and to outline a program that will result in the timely attainment of recovery objectives.

DESCRIPTION

Sciurus niger cinereus, a mammal in the order Rodentia, was named by Linnaeus in 1758; synonyms include S. n. neglectus Gray and S. niger bryanti Bailey (Hall 1981). The type locality for this subspecies was restricted to Cambridge, Dorchester County, Maryland by Barkalow (1956). Other common names for the subspecies include Delmarva peninsula, Bryant, and peninsula fox squirrel, as well as gray, big-gray, stump-eared (Handley and Gordon 1979), and cat squirrel (Olstein and Koziol 1989).

Sciurus niger cinereus is a large, heavy-bodied tree squirrel with an unusually full, fluffy tail. From base to tip, including hairs, the tail is 32-39 cm long and can be fanned to a width of 15 cm (Handley and Gordon 1979). Upper parts of the body are predominantly whitish gray, occasionally with a buffy cast (summer pelage, or any worn pelage with underfur showing on surface); the underparts and feet are white; the snout and crown are often white or whitish, or colored like adjacent parts of dorsum; cheeks are whitish, and ears are whitish or buffy; and the tail is black and white with a white margin dorsally, and grayish with a submarginal black band and white margin ventrally. Melanistic individuals with black head, black lateral line, black fore and hind extremities, and a grizzled black and white body are rare (Dozier and Hall 1944; Barkalow 1954, 1956). Average measurements of 36 individuals (18 female, 18 male) from Dorchester County, Maryland are: total length, 581 mm; tail length, 272 mm; hindfoot, 77 mm; and ear, 31 mm (N.D.

Moncrief, Virginia Museum of Natural History, pers. comm.). Adult body mass ranges from 0.8 to 1.4 kg (Poole 1944). Sciurus niger cinereus resembles the gray squirrel, S. carolinensis Gmelin, but is larger, has a fuller tail, and a uniformly colored (not darker medially) dorsum (Handley and Gordon 1979).

DISTRIBUTION AND STATUS

Sciurus niger is found throughout the eastern United States from western New York and southern Pennsylvania to Florida, west to the High Plains, and from Coahuila, Mexico, and Texas to North Dakota and Manitoba, Canada (Figure 1). Its distribution extends westward through tree-lined river valleys in Colorado, Wyoming, and Montana. The species has been widely introduced in many places beyond its natural range.

Sciurus niger has ten named subspecies (Hall 1981, Figure 1). The subspecies Sciurus niger cinereus formerly occurred throughout the Delmarva Peninsula and into southeastern Pennsylvania and southern New Jersey (Rhoads 1903; Poole 1932, 1944; Allen 1942; Handley and Patton 1947; Mansueti 1952; Taylor 1973). Remnant populations of this subspecies persist naturally only in portions of Kent, Queen Anne's, Talbot, and Dorchester Counties on the Eastern Shore of Maryland (Taylor and Flyger 1974). The Delmarva fox squirrel has been translocated into Caroline, Cecil, Kent, Somerset, Wicomico, and Worcester Counties, Maryland (1979 to 1991); Sussex County, Delaware (1984 to 1987); Chester County, Pennsylvania (1987 and 1988); and Accomack (Chincoteague National Wildlife Refuge [NWR], 1968 to 1971) and Northhampton Counties (1982 and 1983) in Virginia. Figure 2 shows the historical and current distribution of S. n. cinereus, including translocation sites.

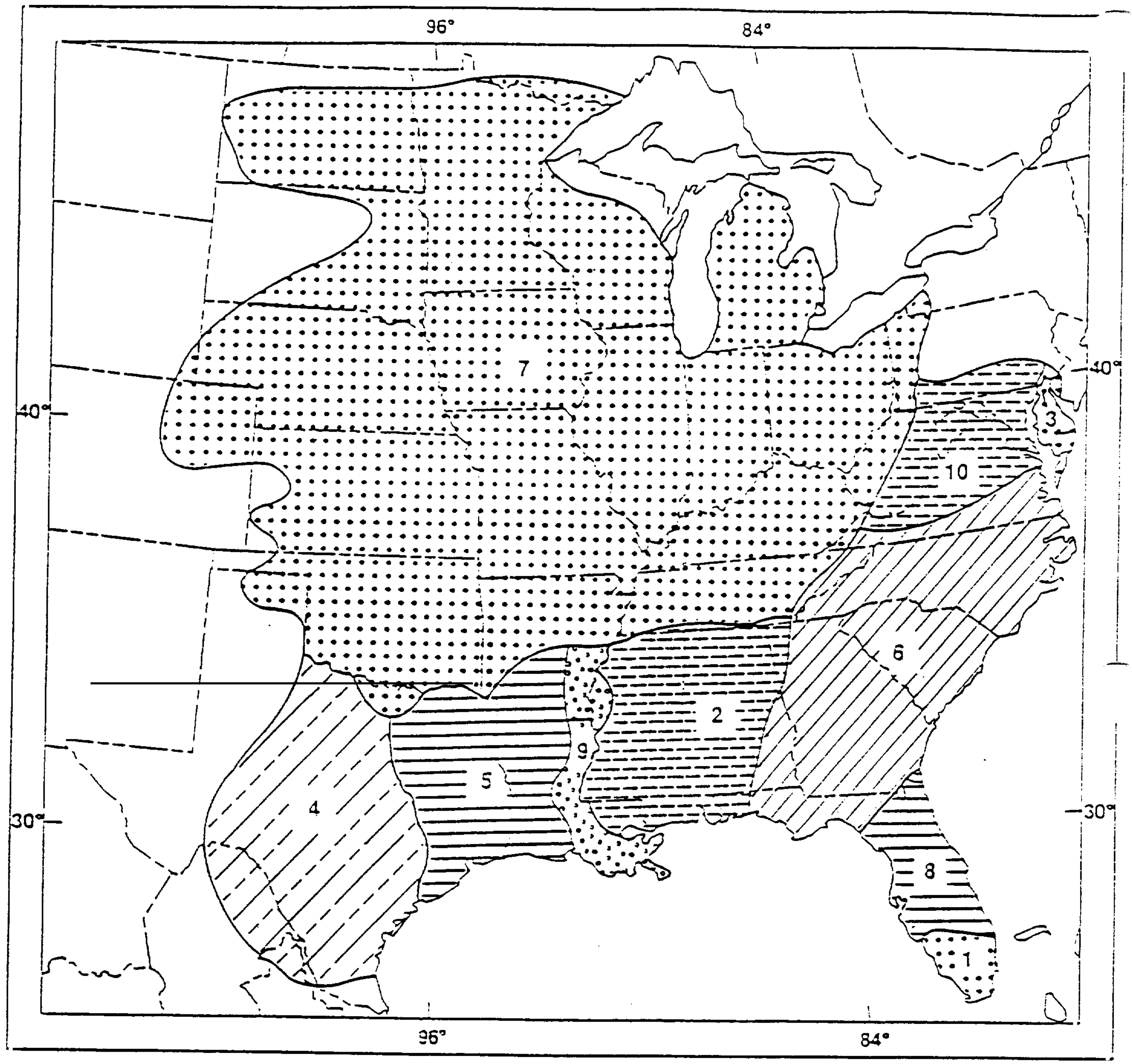

Figure 1. Geographic range and subspecies distribution of the fox squirrel, Sciurus niger: 1 = S n. avicennia; 2 = S. n. bachmani; 3 = S. n. cinereus; 4 = S. n. limitis; 5 = S. n. ludovicianus; 6 = S. n. niger; 7 = S. n. rufiventer; 8 = S. n. shermani; 9 = S. n. subauratus; 10 = S. n. vulpinus.

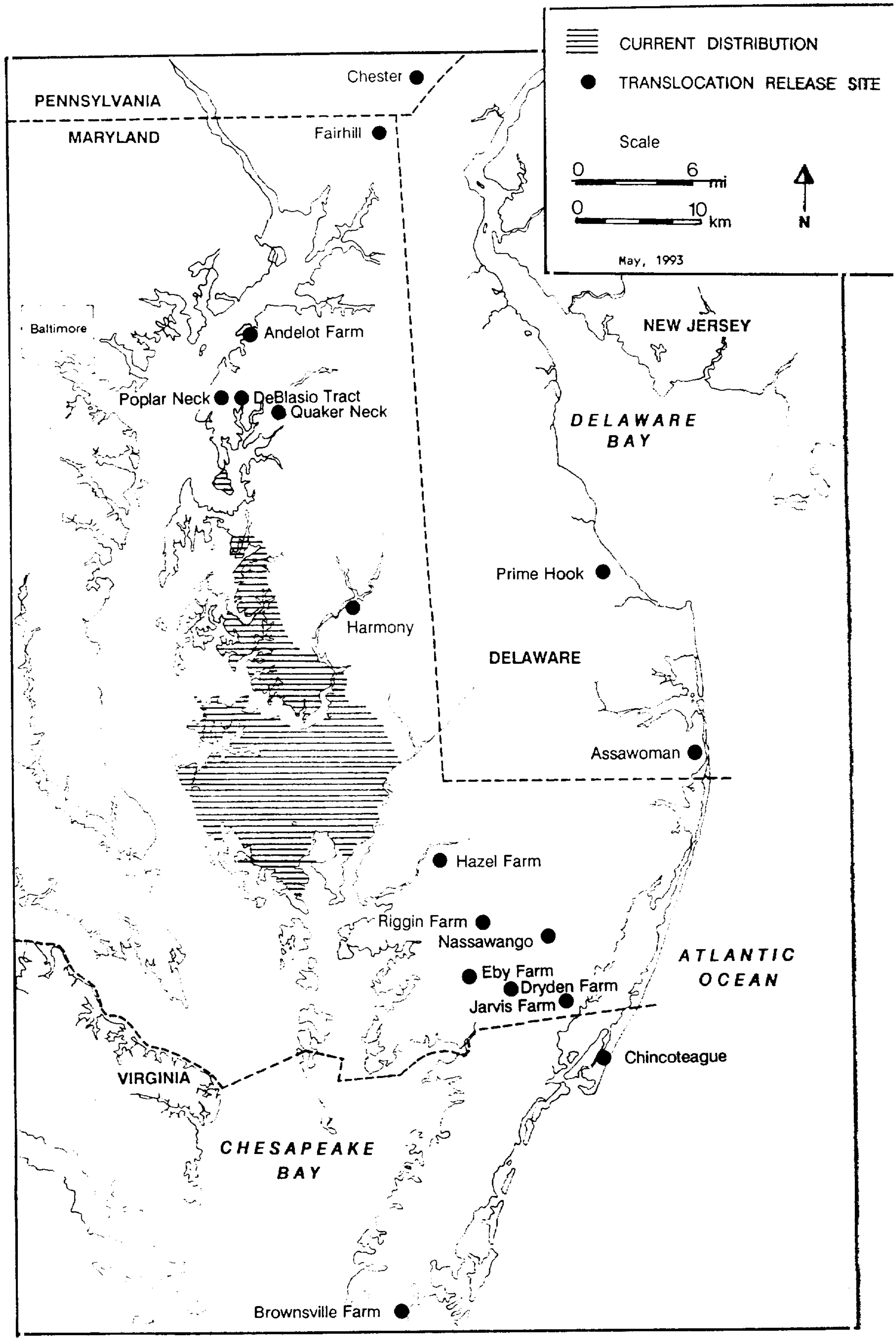

Figure 2. Distribution of Sciurus niger cinereus

Numbers of S. niger vary from year to year depending on weather, the effects of diseases and predators, and abundance of food, particularly that suitable for winter storage (Nixon and Hansen 1987, Weigl et al. 1989). Although few density estimates and no long-term population data currently are available for S. n. cinereus, the subspecies typically is observed in low densities, and populations may be adversely affected by reductions in numbers of only a few individuals.

In 1990, seven benchmark sites (see Figure 2) were established to monitor Delmarva fox squirrel population status for recovery purposes. Six of these sites (i.e., Hayes Farm, the Jarrett and Egypt Road tracts on Blackwater NWR, Eastern Neck NWR, Wye Island Natural Resource Management Area, and LeCompte Wildlife Manangement Area) are located within the squirrel's remaining natural range in Maryland; the seventh is the site of the introduced population on Chincoteague NWR in Virginia. Because absolute densities of Delmarva fox squirrels are difficult or impossible to determine (due to the effects of factors such as weather and available forage on capture success), the benchmark sites were established to provide long-term population data rather than absolute density estimates. The site sample was selected with the intent of monitoring population trends within habitats that are either (1) relatively self-sustaining or (2) undergoing long-range management for the primary purpose of Delmarva fox squirrel maintenance. If these benchmark populations are shown to be stable or expanding over time -- and if known occupied or identified potential habitat remains available at current levels -- it may be assumed that the population at large is viable. The status of Delmarva fox squirrels at all translocation sites is also being monitored. Monitoring activities and results at these sites are discussed under Conservation Measures.

Trapping data available to date show various density figures. Flyger and Smith (1980) captured only 24 individuals in two years on a 261-hectare farm, and Lustig and Flyger (1976) captured only 26 individuals on four study areas over an 11-year period. Maryland

Department of Natural Resources (DNR) (unpubl. data) trapped 28 individuals in 275 trap days on 31 ha in 1989. Population densities of other southeastern fox squirrel subspecies are known to be typically less than one animal per hectare (Weigl *et al.* 1989). Additionally, while Taylor (unpubl. data) documented a ratio of about one Delmarva squirrel to eight gray squirrels from 1977 through 1980 (USFWS 1983), recent trapping efforts at the benchmark sites in Maryland resulted in a ratio of one Delmarva fox squirrel to 1.5 gray squirrels.

HABITAT REQUIREMENTS AND ECOLOGY

Dozier and Hall (1944) described the preferred habitat of *S. n. cinereus* as "old-growth loblolly pine, *Pinus taeda*, forests" or "deep deciduous swamps or backwoods but nearly always close to or adjacent to pine woods." Taylor and Flyger (1974) expressed a different view: "Contrary to popular local opinion, this fox squirrel does not require, or prefer, loblolly pine," but "does prefer mature timber with a minimum of underbrush." Delmarva fox squirrels on Chincoteague NWR were found to be most abundant in areas of larger overstory trees, higher densities of soft mast-producing hardwoods, and lower densities of pines (Larson 1990).

It is now evident that southeastern fox squirrels are highly opportunistic in their habitat preferences (M. Steele, *in litt.*, 1992). Throughout its range, *S. n. cinereus* is most often found in open, park-like forest of mature loblolly pine and oak (*Quercus* spp.), or in mixed stands of pine, beech (*Fagus* spp.), and sweetgum (*Liquidambar* spp.) (Dueser *et al.* 1988). Both upland and bottomland forest are occupied. Forests that (1) contain a variety of nut and suitable seed-bearing trees, (2) contain over-age trees with hollows useful as den sites, and (3) have corn and soybean fields nearby are especially attractive to fox squirrels (Brown and Yeager 1945, Allen 1952, Golley 1962) including *S. n. cinereus* (Taylor 1976). Fox squirrels in North Carolina (S. n. niger) showed a marked preference (>80%) for open, mature pine-oak habitat and pine/hardwood ecotones (Weigl et al. 1989). During the summer, the squirrels preferred hardwood and wetland forests.

Based on Taylor's (1976) data, Dueser et al. (1988) developed a habitat suitability model, which indicated that sites where fox squirrels were present had a higher percentage of large (>30 cm dbh) trees, a lower percentage of shrub groundcover, and a slightly lower understory density than did sites where squirrels were not found. This model proved reliable at predicting the outcome of Delmarva fox squirrel translocations at various sites, and continues to be used in site selection for translocations.

In 1990, using methods similar to those used in Taylor's (1976) study (i.e., personal interviews with local landowners and others), G.W. Willey (pers. comm.) reported 30 pine forest sites on Maryland's Eastern Shore where Delmarva fox squirrels had been observed. The majority of these sites did not correspond to Dueser et al.'s model of "fox squirrel present" sites, primarily due to the smaller average tree diameter on the pine forest sites. As a result, the 1988 habitat suitability model has been expanded to include the variables that characterized these additional sites. Nevertheless, the original model effectively characterized habitat tolerances of the Delmarva fox squirrel, as indicated by the results of translocation attempts. It is likely that the forest types available to the Delmarva fox squirrel today differ markedly from the old-growth, predominantly hardwood forests in which these animals may have evolved. The relative importance of pine versus hardwood habitat remains to be determined.

The food habits of the fox squirrel appear to be identical to those of the gray (Smith and Follmer 1972), even where they co-exist. However, the latter conclusion is based primarily on western populations of these species. Concurrent food habit studies of co-existing populations of southeastern fox squirrels and gray squirrels are unavailable (J. Edwards, Clemson University, pers. comm.)

Both the fox squirrel and the gray squirrel feed heavily on mast (primarily oak, hickory, beech, walnut, and loblolly pine), and become fat during the fall when food is plentiful. Like other southeastern fox squirrels, Delmarva fox squirrels feed largely on mature green pine cones during late summer and early fall if such forage is available (Weigl et al. 1989, Larson 1990). Fox squirrels, including S. n. cinereus, bury stores of nuts and seeds, a large percentage of which are relocated, apparently by odor (Allen 1943, Stapanian and Smith 1978); however, no attempt to cache or defend pine cones was observed in S. niger niger by Weigl et al. (1989).

As the winter progresses, food becomes scarce and, in poor mast years, the animals become thin or emaciated (USFWS 1983). At such times, mange (Cnemidoptes), which is probably enzootic, becomes epizootic and results in high mortality (USFWS 1983).

During the spring, Delmarva fox squirrels feed extensively on tree buds and flowers, and will consume large quantities of fungi (including some of the mushrooms known to be poisonous to humans), insects, fruit, seeds, and occasionally bird eggs and young (USFWS 1983). Larson (1990) found that, at Chincoteague NWR, individuals switched from reliance on pine and oak mast in the fall/early winter to heavy use of soft mast hardwoods (primarily maple and oaks) in the late winter and spring months. This seasonal change corresponded to a significant decrease ($p < 0.05$) in mean adult body mass from the fall/early winter (972 g) to late winter/spring (900 g). The change in diet occurs during the spring breeding season, indicating that spring food resource availability may be a limiting factor on fox squirrel abundance. This seasonal diet regimen is shared by other southeastern subspecies of fox squirrels (Weigl et al. 1989).

Fox squirrels are more cursorial and less agile, slower, and more deliberate in their movements than are gray squirrels (Dozier and Hall 1944). When a fox squirrel moves from one tree to another, it usually descends to the ground rather than leaping from tree to tree as do gray squirrels. Activity levels vary with season and food supply, with most activity occurring during the morning and early afternoon. Activity is reduced during cold or inclement weather. The fox squirrel is shy and often wary, and relatively quiet; its call is deeper than that of the gray squirrel. When disturbed or excited, it may fan out its tail, thereby increasing its apparent size (Dozier and Hall 1944).

Potential predators of adult fox squirrels include both red and gray foxes (Vulpes vulpes, Urocyon cinereoargenteus), weasels and mink (Mustela spp.), and great horned owls (Bubo virginianus) (Lowery 1974, Weigl et al. 1989). Although these species are normally active at night, whereas fox squirrels are usually active only in daylight, some overlap of activity periods occurs at dusk, during which predation may occur. In addition, hawks (especially red-tailed hawks, Buteo jamaicensis) have been observed to prey upon fox squirrels; many anecdotal accounts are cited in Kiltie (1989). Bald eagles (Haliaeetus leucocephalus) and golden eagles (Aquila chrysaetos) have been observed taking Delmarva fox squirrels at Blackwater NWR (W. Giese, U.S. Fish and Wildlife Service, pers. comm). Nestlings and young squirrels are vulnerable to raccoons (Procyon lotor), opossums (Didelphis virginiana), and rat snakes (Elaphe obsoleta) (Weigl et al. 1989). Delmarva fox squirrels are also preyed upon by domestic dogs and cats.

Average home ranges of southeastern fox squirrels are generally larger (> 15 hectares; Hilliard 1979, Edwards 1986, Weigl et al. 1989) than those of western fox squirrels (5 ha or less) (Ha 1983). Thus, a given area likely will support fewer individual southeastern fox squirrels than the midwestern subspecies, and management practices for Delmarva fox squirrels should not be based on research conducted in the midwestern United States. Home range sizes for the

Delmarva fox squirrel are related to habitat type, and variation within the subspecies is substantial: Flyger and Smith (1980) estimated home range size for S. n. cinereus in an agricultural landscape as 30 ha, while mean home ranges for the insular Chincoteague NWR population (on Assateague Island) were estimated to be 4.1 ha (Larson 1990).

Fox squirrels throughout the range of the species prefer dens in tree hollows (Allen 1952, Nixon and Hansen 1987), which provide maximum safety for young and the best protection from cold or wet weather. Fox squirrels also construct nests composed of leaves and twigs (Dozier and Hall 1944, Allen 1952). Leaf nests vary from small day shelters and feeding platforms to large, well insulated winter and rearing nests (Weigl et al. 1989). Nests of the insular S. n. cinereus population at Chincoteague NWR are most often situated in crotches in a tree trunk, in tangles of vines on a trunk, or toward the ends of larger branches, 10 to 15 m above the ground (B.J. Larson, University of Virginia, pers. comm.).

Most mating occurs in late winter and early spring (Lustig and Flyger 1976). On Chincoteague NWR, only 15% of litters or lactating females were observed in the fall, indicating that the spring breeding season is the most important period for recruitment of young into the population (Larson 1990); this is substantiated for North Carolina fox squirrels by Weigl et al. (1989). Gestation lasts about 44 days (Asdell 1964), and most young are born in February, March, and April; there is a smaller birth peak in July and August. Delmarva fox squirrel litter size is one to six (average 4: Dozier and Hall 1944; average 2.25: Lustig and Flyger 1976; average 1.7: Larson 1990). Weigl et al. (1989) reported food supply to be the critical factor governing reproductive performance in North Carolina populations of S. niger. Fox squirrels are polygamous, and the female raises the young by herself. In Florida populations of S. niger, young are dependent on their mothers for about three months (Moore 1957).

CONTINUING THREATS

As noted in the 1983 recovery plan, timber harvest, short-rotation pine forestry, and forest conversion to agriculture and/or structural development (housing, roads, industry) constitute broad threats to Delmarva fox squirrels and their habitat.

The human population within the Delmarva fox squirrel's historical range has increased significantly in recent years. In Maryland's nine Eastern Shore counties, the human population increased 14% between 1980 and 1990; by the year 2000, a 23% increase from 1980 is projected (Maryland Forest, Park and Wildlife Service 1989). Increases within the lower shore counties (Dorchester, Worcester, Somerset, and Wicomico) were slightly less than within the upper shore counties (Cecil, Kent, Queen Anne's, Talbot, and Caroline), at +13% and +15% respectively. Projections to the year 2000 suggest this trend will continue.

Similarly, Delaware's three counties experienced a 13% increase in growth between 1980 and 1990 (Delaware Population Consortium 1989). If the current 1.8% annual increase continues, Delaware's population by the year 2000 will be up by 30% from 1980. The greatest increase in Delaware (22%) has occurred in Sussex County, where the only two colonies of S. n. cinereus (both translocations) in the state occur.

Such increases in human population -- with associated demands for housing, services, and industry -- have brought about significant land use changes within the Delmarva fox squirrel's historical range. In addition, shifts in forest type and size class may substantially affect Delmarva fox squirrel habitat suitability. Forest composition changes on the Delmarva Peninsula are characterized below and reviewed in greater detail in Appendix A. Data have not been obtained for the Pennsylvania portion of the squirrel's range.

Delaware

Forest land in Delaware decreased by 1.6% to 3.7% between 1972 and 1986 (Ferguson and Mayer 1974, Frieswyk and DiGiovanni 1989, Mackenzie 1989). Losses occurred in hardwood, mixed-forest, and coniferous types -- including an apparent complete elimination of pond pine (*Pinus serotina*) and a loss of Virginia pine (*Pinus virginiana*). These forests were converted for agricultural, housing, and industrial uses. Although loblolly showed an apparent increase, sawtimber class loblolly decreased by 30%. Overall, overcutting and lack of reforestation led to a major decline in the larger size classes. Indications are that the forests of Delaware will contain primarily smaller trees for several decades (Delaware Department of Agriculture 1991).

In contrast to the pine situation, the oak/hickory forest type increased over the 14-year period. Although significant increases were noted in all size classes, 67% of these hardwoods appear to be in the smaller range of sawtimber (Frieswyk and DiGiovanni 1989); thus, it will be some time before these trees become optimal size for Delmarva fox squirrels. In addition, the overall increase in the oak/hickory forest type is due largely to pine or oak/pine stands being reclassified to oak/hickory following cutting of the pine component as well as lack of pine reforestation in clear-cut pine stands (R. Tjaden, Delaware State Forester, pers.comm).

Maryland

Up to a 7% loss of forest land occurred on Maryland's Eastern Shore (excluding Cecil County) between 1973 and 1990 (Frieswyk and DiGiovanni 1988, Maryland Office of Planning 1990). Agricultural land also decreased, while housing and industrial land uses increased. The Maryland Forest, Park and Wildlife Service (1989) projected further loss of forest land due to continued increases in the human population on the Eastern Shore.

On the lower Eastern Shore, loblolly pine declined by 29% between 1976 and 1986 (Frieswyk and DiGiovanni 1988). The loblolly sawtimber class was reduced by 30%, and most of the remaining sawtimber appears to be in the smaller range (this can be contrasted with significant increases in sawtimber acreage for oak/pine and oak/hickory). Significant reductions were also noted in the seedling/sapling class for loblolly.

Virginia

U.S. Forest Service surveys (Brown and Craver 1985) estimate a loss of 5,573 ha of forest on the Eastern Shore of Virginia between 1976 and 1985. These surveys showed a reduction in the oak/pine and oak/hickory forest types that was, however, offset by increases in the loblolly/shortleaf and oak/gum types. This probably reflects more intensive pine management in Virginia than in the other states during that time period (R. Tjaden pers. comm.).

Overall, it is evident that a significant amount of forest has been lost on the Delmarva Peninsula over the last two decades. Human population growth projections suggest that this trend may continue unless effective conservation measures are put in place. Past forestry practices that have favored the oak/hickory type in some areas may benefit Delmarva fox squirrels if stands are allowed to mature; however, the loss of pine in recent years is of concern to foresters, and some efforts appear to be underway to encourage increased pine management (R. Tjaden pers. comm.). Intensive short-rotation, pine-monoculture management may not be beneficial to Delmarva fox squirrels. Future trends in land use and forest management must be monitored closely and actions taken when needed to ensure the long-term recovery of *S. n. cinereus.*

Rangewide, the potentially devastating effects of forest pest infestations, including gypsy moths (*Lymantria dispar*) and southern pine beetles (*Dendroctonus frontalis*), must also be taken into account. For instance, the only extant population of *S. n. cinereus* in Virginia lives in overly mature loblolly pine forest on a barrier island in a region where southern pine beetles have been documented (Dueser and Terwilliger 1987). Along with beetles, storms and other factors causing forest die-off constitute threats to the survival of this insular population. In addition, because the Chincoteague NWR population is insular and remote from mainland Delmarva fox squirrel populations, there is little chance of natural dispersal to or recruitment from other populations.

Accidental Delmarva fox squirrel mortality is most frequently attributed to being struck by automobiles and to hunters who mistake Delmarva fox squirrels for gray squirrels. Although unsubstantiated, over-hunting of Delmarva fox squirrels is thought to have contributed to past declines (G. Therres pers. comm.). Illegal hunting is not considered a threat at this time.

CONSERVATION MEASURES

The first revision of the Delmarva Fox Squirrel Recovery Plan (USFWS 1983) called for an ambitious, closely monitored program of public information, squirrel habitat management, and squirrel population management. This program was only partially implemented. The record indicates that although important activities were conducted periodically in each of the four recovery states (Delaware, Maryland, Pennsylvania, and Virginia), other recovery tasks remain to be carried out. In assessing future recovery needs for the Delmarva fox squirrel, the recovery team has attempted to reconstruct and summarize recovery accomplishments to date, as detailed below.

Translocations

Translocations have figured prominently in the Delmarva fox squirrel recovery program. The 1983 plan emphasized the use of translocations to re-populate suitable habitat within the squirrel's historical range, with the aims of reducing the probability of catastrophic or chance extinction, restoring ecological diversity, and broadening involvement in the conservation effort. A translocation was to be deemed "successful" when a new reproductive population established on or near the release site had persisted for at least five years and increased beyond the original group size (USFWS 1983).

Through 1990, operational translocations of the Delmarva fox squirrel were performed at 11 locations in Maryland (G. Therres unpubl. data), two in Virginia (Dueser and Terwilliger 1987), two in Delaware (Reynolds 1988), and one in Pennsylvania (Dunn 1989) (Table 1; also refer to Figure 2). These 16 translocations entailed the release of 264 squirrels, an average of 16.5 animals per site and 6.8 animals per release date. The sex ratio of the released squirrels at each site ranged from 0.7 to 1.3 males per female, and the vast majority of translocated squirrels were adults. Fourteen squirrels died of "stress" while being trapped, transported, or caged prior to release. At least 15 fatalities (6% of 264 squirrels) were detected during post-release monitoring, with most of these attributed to predation.

During this time, 83 squirrels were radio-collared for post-release tracking. Radio-tracking usually involved the determination of 1-5 radio locations per week for the first 30 days following release, with less frequent tracking subsequently for periods of up to seven months. Collared squirrels were observed to move from 0.16 to 8.8 kilometers (straight-line distance) from the release site during the first 30 days following release; average distance moved during this period varied among the 16 sites from 0.48 to 5.1 km. Initial long-distance dispersal often was followed by a return to the vicinity of the release site, so that relocation distances over the first 180 days typically were less than the maximum "wandering" distances observed during the first 30 days. A conspicuous exception is the case of three squirrels which moved approximately 7.4 km (straight-line distance) from the release site at Poplar Neck to the

Table 1. Release and source sites for translocations of the Delmarva fox squirrel. Source sites except Accomack Co., Virginia, were in Maryland.

Release Site	Release County	Source Site	Source County	Number of Animals Released	[sex ratio, male;female]	Year(s)	Number of Releases
Maryland							
Poplar Neck	Kent	Blackwater	Dorchester	14[2]	[1.0]	1979,80[1]	2[1]
DeBlasio Tract	Kent	Blackwater	Dorchester	5[2]	[0.7]	1980,83[2]	2[2]
Quaker Neck	Kent	Wye Island	Queen Anne's	16[2]	[?]	1980,81[1]	3[1]
Dryden Farm	Somerset	Various	Dorchester	9[1]	[0.8]	1981[1]	2[1]
Eby Farm	Somerset	Various	Dorchester	9[1]	[0.8]	1981[1]	2[1]
Fairhill	Cecil	Various	Dorchester	14[1]	[?]	1980,82[1]	3[1]
Riggin Farm	Somerset	Various	Dorchester	26[2]	[1.2[2]]	1983,84,85	3[2]
Jarvis Farm	Worcester	Various	Dorchester	8[2]	[1.0]	1982[1],84[2]	2[2]
Nassawango	Worcester	?	?	5[2]	[0.7[2]]	1978	1[2]
Hazel Farm	Wicomico	Various	Dorchester	20[2]	[1.3[2]]	1986,87,88[2]	3[2]
Harmony	Caroline	Various	Dorchester	30[2]	[1.3]	1989[2]	2[2]
Andelot Farm	Kent	Various	Dorchester	17[3,4]	[0.7[3]]	1991[3]	2[3]
		Wye Institute	Queen Anne's	4[3]	[3.0[3]]	1991	1[3]
Virginia							
Chincoteague	Accomack	Blackwater	Dorchester	12[5]	[?]	1968,70[5]	2[5]
		Eastern Neck	Kent	22[5,6]	[?]	1968,70,71[5]	3[5]
Brownsville Farm	Northampton	Chincoteague	Accomack	24[5]	[?]	1982,83[5]	3[5]
Delaware							
Assawoman	Sussex	Blackwater	Dorchester	13[7]	[0.86]	1984,85[7]	2[7]
Prime Hook	Sussex	Blackwater	Dorchester	17[2]	[0.80[8]]	1986,87[7]	3[7]

Table 1. Continued.

Release		Source				
Site	County	Site	County	Number of Animals Released [sex ratio, male;female]	Year(s)	Number of Releases
		Pennsylvania				
Chester[10]	Chester	Various	Dorchester	11[9] [0.57[9]]	1987,88[9]	2[9]
		Wye Island	Queen Anne's	9[9] [1.25[9]]	1987,88[9]	2[9]

1 data from 1983 Recovery Plan
2 according to data compiled by Ray Dueser, personal communication 10 April 1992; unless noted otherwise, Dueser's values agree with values obtained from other sources
3 personal communication, Glenn Therres; report at DFS Recovery Team Meeting, 4 March 1992
4 9 known post-release deaths; personal communication, Glenn Therres; report at DFS Recovery Team Meeting, 4 March 1992
5 Dueser and Terwilliger 1987
6 4 known post-release deaths; Dueser and Terwilliger 1987
7 personal communication, Ken Reynolds; report at DFS Recovery Team Meeting, 4 March 1992
8 Dunn 1989
9 1 pre-release mortality?
10 6 known post-release deaths, 1 from Dorchester Cty and 5 from Queen Anne's Cty; Dunn, 1989

settlement site at DeBlasio Tract (both sites are on Remington Farms) where they settled, bred, and established a population. At the pre-1991 sites most extensively monitored, 41% of the collars (25 out of 61) failed prematurely, and 17% (9 out of 54) were lost.

Post-release behavior of translocated squirrels varied significantly among release sites (Table 2). Released animals exhibited very low to very high site fidelity. Released individuals were recaptured at most sites, with most recaptures occurring within 180 days following release. One male squirrel at Assawoman was released as an adult in May 1985 and recaptured periodically until January 1990, when it died of injuries resulting from a fall. Reproduction, recruitment (new adults observed), and/or recent sightings (1990-present) have been reported for a total of twelve sites. While eight sites in Maryland have been live-trapped during the past three years, a systematic effort to determine current population status on all release sites is still needed.

Although post-release monitoring has been sparse or too short-term to determine whether a new reproductive population has been established, the majority of sites seem to have been successful, including the DeBlasio tract (Remington Farms), Quaker Neck, Eby Farm, Riggin Farm, Jarvis Farm, Hazel Farm, and possibly Harmony in Maryland, Chincoteague NWR in Virginia, and Assawoman Wildlife Management Area and Prime Hook NWR in Delaware. Six sites are either thought to have failed or the outcome is unknown. These sites include Dryden Farm, Poplar Neck (the squirrels moved to the DeBlasio tract), Fairhill, and Nassawango in Maryland; Brownsville Farm in Virginia; and possibly the Chester site in Pennsylvania, where S. n. cinereus were last observed in 1988.

Table 2. Performance of translocated Delmarva fox squirrels.

Site	Fidelity	Evidence of Reproduction (litters observed)	Recaptures	New adults observed	Sighting within last 3 years
		Maryland			
DeBlasio Tract	High	Yes (4)	Yes	Yes	Yes[1]
Quaker Neck	High	Yes (1)	Yes	Yes	Yes[1]
Dryden Farm	Low	No	No	No	No[2]
Eby Farm	High	Yes	Yes	Yes	Yes[1]
Poplar Neck	Low	Yes[3]	Yes	No	No
Fairhill	Low	No	No	No	No
Riggin Farm	Low	Yes	Yes	Yes	Yes[1]
Jarvis Farm	High	Yes	No	Yes	Yes[1]
Nassawango	---	---	---	---	No
Hazel Farm	High	Yes[4]	Yes	Yes	Yes[1]
Harmony	High	Yes	Yes	Yes	Yes[1]
Andelot	High	No	No	No	Yes[5]
		Virginia			
Chincoteague	High	Yes	Yes	Yes	Yes[1]
Brownsville Farm	Low	No	Yes	Yes	Yes[6]
		Delaware			
Assawoman	Low(Au) High(Sp)	Yes	Yes	Yes	Yes[1]
Prime Hook	High	Yes	Yes	Yes	Yes[1]
		Pennsylvania			
Chester	High	No	No	No	No[7]

[1] captures in 1990, 1991, and/or 1992

[2] unconfirmed reports by farmers (1991)

[3] litter born one month after release of female

[4] lactating female captured

[5] released in 1991

[6] last sighting in 1991 per letter 1 May 1992 from Terwilliger to Moncrief

[7] last sighting in 1988

1991 Experimental Translocation at Andelot Farm

In order to better understand the behavior and movement patterns of individuals immediately after release, an experimental translocation was conducted at Andelot Farm, Kent County, Maryland in 1991 (G. Therres and P. Bendel, Maryland Department of Natural Resources, pers. comm.). This site was selected because it scored high on Dueser's habitat suitability model (Dueser et al. 1988) and because it is considered to be secure habitat (G. Therres pers. comm.). Twenty-one animals were released during the initial phase of the translocation: 13 in May 1991 and eight in October 1991. The sex ratio was 10 males: 11 females. With the exception of one male that escaped at the release site in May, each individual was ear-tagged and fitted with a radio collar prior to release, then monitored for at least 90 days following release or until death was confirmed. During the monitoring periods, the location of each animal was determined at least once per day for the first 60 days, then every other day thereafter. A total of 1449 observations (location/squirrel/day) was made during the spring (May-August 1991) and fall (October 1991-January 1992) study periods (G. Therres and P. Bendel pers. comm.).

Nine squirrels, three females and six males, died following release (G. Therres and P. Bendel pers. comm.). One female died in the holding cage (in May) prior to release; this animal was not counted as part of the 21 released individuals. Seven (two females, five males) of the 13 animals released in May were found dead; four of these animals died within 90 days of their release, and three died between the spring and fall monitoring periods. Two (one female, one male) of the eight animals released in October died within 90 days of their release. Subsequent mortality is unknown because monitoring was discontinued in January 1992. Although there were no direct observations of predators taking any of the released animals, the condition of carcasses led Therres and Bendel (pers. comm.) to conclude that predation was the major cause of death.

Movement from the release cage was variable. The maximum straightline distance moved by any individual was 3719 m from the release cage by a fall-released male. However, 79% of all observations were within 1000 m of the release cage, and 54% occurred within 500 m. The individual that moved 3719 m did not settle at that distance; rather, it was observed to move back toward the release cage. General trends (which have yet to be confirmed by statistical tests) suggest that males moved farther than females, and spring-released animals moved farther from the release cage than did fall-released animals (G. Therres and P. Bendel pers. comm.). Spring-released animals became less active as mid-summer approached.

According to G. Therres (pers. comm.), a key result of this experimental release is that, although some squirrels dispersed a substantial distance from the release cage, most individuals returned to the woodlot in which they were released (or to adjacent wooded areas), staying within 1000 m of the release cage, by the end of the monitoring period (January 1992). Because of the high post-release mortality (as of March, 1992, nine of 21 animals were known dead), a supplemental release of 22 individuals (13 males to nine females) was conducted at this site in October 1992. All but one (which escaped) of these squirrels were ear-tagged; none was radio-collared. This site will be censused by live-trapping and nest-box checks for several years in an attempt to track individual mortality and overall success of this translocation.

<u>Determination of Colony Persistence</u>

Taylor (1976) determined the locations of Delmarva fox squirrel populations in Maryland in 1971 through interviews with local residents, farmers, biologists, game wardens, foresters, and others having knowledge of this squirrel. He located 36 sites that were occupied by the fox squirrel and 18 comparable sites that were occupied only by the gray squirrel, and evaluated the habitat at these sites using the methods described in Appendix B.

Using the same methodology, Therres and Willey (1988) resurveyed these 54 sites in 1988 to determine current population status of the fox squirrel at each site and to describe any habitat changes that may have occurred in the 17 years between surveys. They found one local extinction (which had occurred on a formerly occupied site at the periphery of the known range, on property that had experienced no habitat alteration) and one local colonization over the 17-year period. The estimated annual extinction and colonization rates were thus nearly identical, at 0.002 and 0.003 local populations per site per year, respectively. These results suggest a stable range-wide population since 1971. It should be noted, however, that these conclusions are based on observations only, unsupported by other censusing techniques such as trapping or nest box surveys, and population densities cannot be estimated at this time.

Habitat Suitability Assessment

Using Taylor's (1976) database of 36 sites occupied by _S. n. cinereus_ and 18 unoccupied sites, Dueser _et al_. (1988) developed a model for predicting Delmarva fox squirrel habitat suitability. Analysis of habitat structure, forest composition, and landscape dimensions at each of Taylor's 54 sites showed that structural variables discriminated between occupied and unoccupied groups better than did compositional variables, and the latter discriminated better than did landscape variables.

Dueser (pers. comm.) later examined 30 pine forest sites (each of which had several times more pine than did any of Taylor's 54 sites) where _S. n. cinereus_ was known to occur (G.W. Willey, Maryland Department of Natural Resources, pers. obs.). He found that the 1988 habitat suitability model classified only eight of the 30 occupied pine sites as suitable habitat, even though all the pine sites were known to have fox squirrels present (R. Dueser, Utah State University, pers. comm.). Thus, according to the 1988 model, 22 of the 30 occupied pine sites were classified as "unoccupied."

In an effort to determine why these 22 sites were misclassified, R. Dueser (pers. comm.) re-examined the 1988 model, comparing characteristics of the occupied pine sites to Taylor's sites. For each site, five habitat variables were analyzed: (1) percent trees > 30 cm dbh, (2) percent crown cover, (3) percent shrub-ground cover, (4) density of understory vegetation, and (5) percent pine composition. Analysis revealed that the occupied pine sites had a much smaller percentage of large trees, a relatively closed canopy, sparse shrub-ground cover, low understory density, and a relatively high percentage of pines (Dueser pers. comm.). Importantly, Dueser (pers. comm.) also found more difference between the occupied pine sites and Taylor's 54 sites than between Taylor's occupied and unoccupied sites.

R. Dueser (pers. comm.) then modified the 1988 model to include the characteristics of the occupied pine sites, and evaluated the difference between the two versions. To do this, he compared (1) all 66 occupied sites (i.e., Taylor's occupied sites and the occupied pine sites) with Taylor's 36 occupied sites, and (2) all 66 occupied sites with Taylor's 18 unoccupied sites. Results showed that, by including the occupied pine sites, the 1988 model's habitat characterization would have placed less emphasis on large trees, greater emphasis on pine composition, and more emphasis on canopy closure and low shrub-ground cover (Dueser pers. comm.). Similarly, the difference between occupied and unoccupied habitat would have included less emphasis on large trees and more emphasis on crown closure.

Comparisons between the 1988 model and a revised model incorporating the occupied pine sites revealed that the relative weightings of the five habitat variables are unchanged in the revised model (R. Dueser pers. comm.). In the revised model, the percent of large trees, amount of crown cover, and percent shrub-ground cover continue to be the dominant variables in discriminating between occupied and unoccupied sites.

Finally, R. Dueser (pers. comm.) evaluated 36 unclassified sites using the 1988 model and the revised model. The classification of these 36 sites differed between models for 12 (33%) of the sites, which were classified as unoccupied by the original model and occupied by the revised model (Dueser pers. comm.). Thus, Dueser et al.'s (1988) model of suitable habitat for the Delmarva fox squirrel has been expanded by the incorporation of the 30 occupied pine sites; this revised model remains to be tested.

Study of Chincoteague NWR Population

Between 1968 and 1971, 40 Delmarva fox squirrels (total) were captured from two Maryland source populations, Blackwater NWR in Dorchester County and Eastern Neck NWR in Kent County, and introduced to Chincoteague NWR in Accomack County, Virginia (Dueser and Terwilliger 1987). Although the animals appeared to be healthy when captured (G.W. Willey pers. comm.), six individuals died prior to release, and at least four died within a few days following release. Effectively, then, 30 squirrels were translocated, comprising a mix of sexes and ages (subadults and adults). Conditions at the Chincoteague release site were favorable: no gray squirrels were present (although they have been present on the refuge since 1979), and natural food supplies were supplemented with shelled corn in the vicinity of release (I.W. Ailes, Chincoteague NWR, pers. comm.). This introduced population has been monitored by personnel of the U.S. Fish and Wildlife Service and the Virginia Department of Game and Inland Fisheries.

The 30 surviving squirrels gave rise to a growing population. The first young squirrel was sighted in the summer of 1971, and three more were seen in 1972. Nine young squirrels were observed using the supplemental feeders during the spring and summer of 1974, and it was estimated at this time that the population had dispersed from the original release area of approximately 40 ha to an occupied area of approximately 317 ha. To initiate a standardized census procedure, 175 nest boxes were deployed in August 1976. Nest-box inspections were conducted semi-annually (spring and winter) from 1977 to 1984. These inspections are now conducted only during the winter (January or February) and at night, when the squirrels are most likely to occupy the boxes. Captured animals are examined for condition and relative age, and since 1988 have been marked for individual observation using the protocol in Appendix C.

Winter census records since 1978 reveal a variable but self-sustaining population. The number of fox squirrels observed in the 175 next boxes has ranged from nine (1981) to 57 (1978); much of this variation is attributed to the weather conditions prevailing on census days. Approximately 40 individuals are observed on average on snowy or stormy days, when the squirrels are most likely to remain in the nest, while only 14 individuals are observed on average on clear days, when the squirrels are likely to be active. While absolute abundance can only be speculated, it appears that the Chincoteague NWR population is well-established; in fact, this population has been sufficiently productive to serve as a source of animals for introduction attempts on the northern end of the refuge (I.W. Ailes pers. comm.) and on the Virginia mainland at Brownsville Farm in Northampton County (Dueser and Terwilliger 1987).

Chincoteague NWR Ecological Study

Larson (1990) investigated the relationship between food habits, food availability, forest structure, and population dynamics of Delmarva fox squirrels on Chincoteague NWR in order to (1) assess factors that could affect long-term viability of this insular population and (2) evaluate the importance of habitat quality on squirrel distribution and fitness. Radio telemetry was used to estimate home range areas and observe feeding behavior, and observation of lactating females and litters during nest box checks was used to ascertain breeding season and litter size.

Larson (1990) obtained information for the Chincoteague NWR population of Delmarva fox squirrels in all three population viability analysis categories described by Gilpin and Soulé (1986): the environment, population structure and fitness, and population phenotype. Study findings thus have implications not only for the Chincoteague NWR population, but for indigenous and translocated mainland populations of S. n. cinereus as well. Conclusions from Larson (1990) not discussed previously are as follows:

- On Chincoteague NWR, Delmarva fox squirrels exhibit traits of both western (smaller home-range areas) and southeastern (larger body mass) subspecies of S. niger.

- Large areas of marsh or open water may act as effective barriers to movement. (Larson and Dueser [1991] found that water depth [$\geq$ 0.3 m] may be more important than width in creating this barrier).

- Fox squirrels in the "best quality" habitat and with higher squirrel abundance (Woodland Trail on Chincoteague NWR) may be exhibiting density dependent responses, including smaller adult body mass, male-biased sex ratios, and smaller home-range areas in comparison to other study sites. This response is probably due to the combined effects of higher food resource availability and barriers to dispersal.

- The genetic consequences of limited movement (e.g., inbreeding depression causing smaller litter sizes, high juvenile mortality, physical anomalies, and loss of long-term adaptive potential) may be the most important immediate concern in evaluating long-term viability for this isolated population.

- The increase and maintenance of forest corridors connecting forest tracts on Chincoteague NWR should help encourage movement and gene flow among sub-populations.

- Maintaining an adequate year-round food supply on Chincoteague NWR (i.e., mature pine with mast-producing hardwoods such as maples and oaks, but also wax myrtle, fruiting shrubs, and vines) may be more important in sustaining populations in the long term than using prescribed burning or other management techniques to open up the understory if such management also destroys food resources.

Chincoteague NWR Experimental Translocations

Experimental translocations were conducted from October to December 1990 within Chincoteague NWR in order to test the hypothesis that relatively large areas of dry grassland, marsh, or open water act as deterrents to movement or dispersal in Delmarva fox squirrels (Larson and Dueser 1991). A total of seven individuals were translocated 1.3 to 1.9 km through contiguous forest (three control animals) or across hypothetical habitat barriers between forest tracts (four experimental animals), and subsequently monitored to observe movement behavior. All seven individuals returned to their original sites of capture; control animals returned within three hours, whereas return times for experimental animals ranged between 0.08 and 73 days.

Squirrels in the experimental group travelled greater distances and spent more time attempting to return to the capture site than did control animals, because open water $\geq$ 0.3 m in depth acted as an effective deterrent to movement. Study findings indicate that on Chincoteague NWR, Delmarva fox squirrel movement among forest tracts separated by open water may be limited, and dispersal rates among disjunct areas may be significantly lower (by $\geq$ 46%) than dispersal rates among forested areas that are contiguous or interconnected by forested corridors. Larson and Dueser (1991) also found that Delmarva fox squirrels readily crossed short distances of non-forested, dry areas separating forest tracts, not surprising in light of the reported mobility of Delmarva fox squirrels in agricultural landscapes (Flyger and Smith 1980, Hilliard 1979).

According to Larson and Dueser (1991), the "distance factor" (Wilcove et al. 1986) affecting dispersal of Delmarva fox squirrels between forest tracts still warrants investigation. Although grassland and marsh were not observed to be barriers to movement of Delmarva fox squirrels over short distances, these habitats may be barriers to dispersal of the squirrels over longer distances. Larson and Dueser's (1991) results emphasize the need for continued study of the dynamics of squirrel movement patterns and the consequences of these patterns for re-establishing and maintaining viable populations of Delmarva fox squirrels.

Searches for Virginia Release Sites

Searches for potential release sites in Accomack and Northampton Counties (through extensive site visits, interviews with local residents and landowners, and study of aerial photography) failed to yield any possibilities (Dueser 1989). Ensuing discussions with Eastern Shore of Virginia NWR staff, however, were encouraging in that future habitat management on the refuge may take into account the requirements of S. n. cinereus. Further, a number of sites in Virginia have been classified as suitable using the original and revised habitat suitability models (Dueser et al. 1988, R. Dueser pers. comm.).

Genetic Variation in Delmarva Fox Squirrels and Implications for Translocations

Morgan and Quattro's (1986) analysis of 57 Delmarva fox squirrels from Eastern Neck NWR and Dorchester County, Maryland, reported no electrophoretically detectable variation at 23 loci scored from blood. They attributed the lack of variation in the populations they surveyed to genetic bottlenecking (Nei et al. 1975) and the fact that populations of S. n. cinereus on Eastern Neck NWR were introduced from Blackwater NWR in 1966; Taylor (1976) noted further that Delmarva fox squirrels were released from Dorchester County onto Eastern Neck Island prior to 1966.

To provide information about genetic variation in populations of S. n. cinereus in the context of a more general survey of electrophoretic variation in other populations of fox squirrels, Moncrief and Dueser (1991) compared genetic variation within and among populations of fox squirrels (Sciurus niger) using data from 41 presumptive genetic loci assayed by horizontal starch-gel electrophoresis. The primary focus of their study was Delmarva fox squirrels (S. n. cinereus) from Chincoteague NWR and Dorchester County, Maryland.

In contrast to Morgan and Quattro's (1986) findings, Moncrief and Dueser (1991) reported that S. n. cinereus is not devoid of detectable genetic variation; they found values for mean heterozygosity and mean number of alleles per locus in Delmarva fox squirrels that are comparable to those present in other eastern populations of fox squirrels. According to the findings of Moncrief and Dueser (1991), the Chincoteague NWR and Dorchester County populations of Delmarva fox squirrels exhibit comparable levels of heterozygosity (H = 0.037 and 0.038, respectively). Allelic diversity (measured as mean number of alleles per locus) is also comparable: the values were 1.11 and 1.17 for Chincoteague NWR and Dorchester County, respectively. Furthermore, Moncrief and Dueser (1991) found that allozymic variation in Delmarva fox squirrel populations is similar to that found in fox squirrel populations from western Maryland, western Virginia, and central Georgia; H ranged from 0.019 to 0.040, and mean number of alleles per locus ranged from 1.09 to 1.11 for those populations.

Moreover, the Chincoteague NWR population, which was established by no more than 30 individuals (Dueser and Terwilliger 1987), is not totally homozygous, and it did not exhibit significant deviations from Hardy-Weinberg expectations for those loci at which there is variation. Apparently, the genetic variation present in the Dorchester County source population was represented in those individuals that founded the Chincoteague population during the 1968-1971 translocations. This finding is encouraging, but does not alter the fact that the long-term future of the Chincoteague NWR population is uncertain (Dueser and Terwilliger 1987), in part due to its precarious and insular location on a barrier island.

Moncrief and Dueser (1991) detected an allele (MPI^{C}) in S. n. cinereus that is not present in any other population of S. niger examined to date, including 14 western populations analyzed by Moncrief (1987). The MPI^{C} allele may, therefore, be informative as a genetic marker, representing genetic variation that distinguishes Delmarva fox squirrels from other subspecies of fox squirrels, and that is more easily quantified than the differences in coat coloration that exist among subspecies. Analyses of other populations of eastern fox squirrels, especially those from within and adjacent to the historical range of S. n cinereus (Delaware, Pennsylvania, New Jersey), are necessary before this allele can be considered unique and characteristic of Delmarva fox squirrels. In any event, there is detectable genetic variation in populations of Delmarva fox squirrels, and this variation measured using electrophoresis is more easily quantified than variation in coat coloration, which certainly exists in populations of S. n. cinereus (N.D. Moncrief pers. comm.). Additional biochemical techniques (e.g., restriction site analysis and sequencing of mitochondrial and nuclear DNA) should reveal additional quantifiable genetic variation within and among S. n. cinereus populations. The challenge for researchers using those techniques to study Delmarva fox squirrels will be in discovering which gene loci exhibit variation within or among Delmarva fox squirrel populations, but not so much variation that the data are uninformative.

Leberg (1990) and Schonewald-Cox (1983) present lucid summaries of genetic factors that must be considered when designing programs to conserve wild populations of organisms. It is not clear which genetics issues are most critical for management of wild populations, because most of the research in this area has been done in agricultural and laboratory settings, where populations are maintained in artificial environments and natural selection is not a factor in survivability (Leberg 1990). However, in light of the general agreement that genetic variation (in the form of heterozygous individuals and an array of alleles) is necessary for the short- and long-term success of natural populations (Soulé 1986), several recommendations can be made for future DFS translocations.

First, the act of obtaining animals for translocations must not substantially deplete the number of individuals in the source population, because this may precipitate inbreeding among the remaining Delmarva fox squirrels in the source population.

Second, the results reported by Moncrief and Dueser (1991) indicate that 30 Delmarva fox squirrels may provide a sufficient number of founders to reflect much of the variation present in the source population. Therefore, each Delmarva fox squirrel translocation should consist of no fewer than 30 animals (introduced over two or three releases, if necessary). In light of the high mortality (at least 43% post-release deaths) documented for the Andelot Farm translocation (G. Therres and P. Bendel pers. comm.), at least 40 animals should be released, if at all possible. The sex ratio of males to females should be as close to 1:1 as possible (Leberg 1990).

Third, individuals should be obtained from multiple source sites. Releasing animals from several source populations will increase the chances of representing all the genetic variation present in the naturally remaining populations, and it will minimize any negative effects (such as inbreeding) of removing individuals from source populations because fewer animals will be removed from each population. Populations that were established by translocation should not serve as source populations for additional translocations, because of the negative genetic effects of serial bottlenecking (McCommas and Bryant 1990).

Fourth, consideration must be given to weighing the geographic distance necessary to prevent translocated individuals from returning to their original capture site against the distance that prevents interbreeding (and can cause inbreeding in isolated populations). One strategy might be to translocate animals to sites within the dispersal range of individuals so that eventual overlap (and interbreeding) between populations can occur. This would mimic, in part, the leading edge of a naturally expanding species' range. Population establishment in naturally expanding species occurs just beyond the periphery of existing populations; it does not "leap-frog" over uninhabitated areas, then "fill-in" back toward the core of the species' range. Results of experimental translocations conducted at Chincoteague NWR (Larson and Dueser 1991) suggest this is the case with Delmarva fox squirrels. This information, in combination with the restricted movement of Delmarva fox squirrels at release sites (G. Therres and P. Bendel pers. comm.), emphasizes the need to select translocation sites that are proximal to the periphery of the existing natural distribution or to established populations.

In order to effectively accomplish Delmarva fox squirrel translocations, complete records of translocation activities must be maintained. Essential data include the identification numbers and sex of each individual, the exact locality of the source populations from which each individual is obtained, the capture date, the exact locality at which each individual is released, the release date, the length of time each animal is held prior to release, and conditions under which each animal is held and released (see the protocols in Appendices C and D).

In their review of successful and failed translocations, Griffith et al. (1989) reported findings that support these recommendations. They stated that "population persistence is more likely when the number of founders is large ...[, and]... high genetic diversity among founders may also enhance persistence" (Griffith et al. 1989:477). They found that successful translocations were also associated with high density source populations. Importantly, Griffith et al. (1989:478) reported that they "were unable to directly evaluate genetic heterogeneity, [or] sex and age composition... for released animals because of inadequate response to survey questions." This inadequate response undoubtedly was due, in part, to incomplete recordkeeping. They advised that "Those planning translocations should adopt rigorous data recording procedures...It is critical that both failures and successes be adequately documented" (Griffith et al. 1989:479).

Genetic variation is only one of several factors that must be considered in designing translocation programs; information concerning the ecology and history of the source populations must also be obtained prior to the initiation of any translocation program (Griffith et al. 1989). Assenting the importance of genetic variation within populations, demographic factors are undoubtedly a strong determinant of the persistence of populations of S. n. cinereus (M.A. Cantrell, in litt., 1992). For example, the actual availability of a mate is as critical as the choice of mates (M.A. Cantrell, in litt., 1992). Bearing in mind that non-genetic and genetic considerations may be of equal importance, management of Delmarva fox squirrel populations should be targeted toward a balance of genetic and demographic fitness, because one cannot be achieved without the other, and populations cannot persist in the absence of either.

RECOVERY STRATEGY

The 1983 recovery plan for S. n. cinereus called for protection of existing populations, translocation of individuals to suitable protected sites within the historical range, and selective habitat management (USFWS 1983). These efforts will be continued through an integrated strategy of further study and monitoring, continued translocations, and habitat protection. The primary aims of this approach are (1) to assure the long-term availability of habitat needed to maintain both natural and introduced populations, and (2) to assure the long-term continuance of a stable or expanding population throughout a significant portion of the Delmarva fox squirrel's historical range.

The main thrust of the continuing Delmarva fox squirrel recovery program will be to protect the habitat of both naturally occurring and translocated populations. Identification of changing land uses and associated changes or losses of fox squirrel habitat in the four recovery states will be required in order to implement broad habitat protection measures. Due to the extent of occupied and potential habitat in the region, protection of Delmarva fox squirrel populations and their habitat will entail the use of a variety of measures, including both regulatory and land protection tools. Emphasis will be given to broad-scale land use planning efforts and to encouraging county-wide ordinances that will aid in protection of Delmarva fox squirrels on private lands. There is sufficient latitude in the habitat requirements of the Delmarva fox squirrel to allow reconciliation of many agricultural/forestry land management practices with conservation measures. This suggests private landowner cooperation can, and will, continue to be both responsive and contributory to the recovery of this endangered species (G. Taylor, in litt., 1992). Where appropriate and feasible, consideration will be given to site-specific management agreements and plans, conservation easements, and land acquisition efforts.

Emphasis will be given to managing both occupied and potential habitat identified as suitable for translocations. The Delmarva fox squirrel responds well to management; it is also known that the Delmarva fox squirrel reacts positively to declines in the population of its niche competitor, the gray squirrel (G. Taylor, in litt., 1992). During years of prolonged hard mast crop failures on the Eastern Shore of Maryland, Delmarva fox squirrels have been observed to increase, colonizing marginal habitat, while gray squirrels have been observed to decrease (G. Taylor, in litt., 1992). This confirms not only the vigor of the population, but also its potential for positive response to management (G. Taylor, in litt., 1992).

Protection of the squirrel's habitat will be enhanced through continuing the educational and public information aspects of recovery. Management guidelines will be made available, and, where appropriate, training will be offered to landowners and land managers in an effort to achieve the understanding and expertise needed to preserve Delmarva fox squirrel habitat within the dynamic context of forest management and use of forest resources in the region.

Studies conducted to date have addressed many issues concerning identification of suitable Delmarva fox squirrel habitat and factors affecting translocations, and have added much to the general knowledge of _S. n. cinereus_ biology. Knowledge of habitat requirements, factors affecting long-term population viability, genetic variation, dispersal rates and movement patterns, and life history have a direct bearing on future recovery efforts. However, there are still a number of unknown factors that may substantially affect the outcome of the continuing recovery program, particularly in regard to future translocations. Key study needs include the following:

- Dueser _et al._'s habitat suitability model needs further testing and possibly refinement, and the application of this model to identifying potential release sites needs to be systematized. Further comparative studies should be made of the species' habitat use and demography in pine versus hardwood habitats within the remaining natural range. (See Recovery Task 2.3.)

- The findings of Larson (1990) regarding dispersal behavior, habitat requirements, and population dynamics within insular, translocated populations should be evaluated within a naturally occurring population in Maryland. (See Tasks 1.2 and 2.1.)

- Minimum size of source and founder populations for translocations needs further clarification (in part using information obtained in Task 1.23). This has a strong relation

To provide information about genetic variation in populations of S. n. cinereus in the context of a more general survey of electrophoretic variation in other populations of fox squirrels, Moncrief and Dueser (1991) compared genetic variation within and among populations of fox squirrels (Sciurus niger) using data from 41 presumptive genetic loci assayed by horizontal starch-gel electrophoresis. The primary focus of their study was Delmarva fox squirrels (S. n. cinereus) from Chincoteague NWR and Dorchester County, Maryland.

In contrast to Morgan and Quattro's (1986) findings, Moncrief and Dueser (1991) reported that S. n. cinereus is not devoid of detectable genetic variation; they found values for mean heterozygosity and mean number of alleles per locus in Delmarva fox squirrels that are comparable to those present in other eastern populations of fox squirrels. According to the findings of Moncrief and Dueser (1991), the Chincoteague NWR and Dorchester County populations of Delmarva fox squirrels exhibit comparable levels of heterozygosity (H = 0.037 and 0.038, respectively). Allelic diversity (measured as mean number of alleles per locus) is also comparable: the values were 1.11 and 1.17 for Chincoteague NWR and Dorchester County, respectively. Furthermore, Moncrief and Dueser (1991) found that allozymic variation in Delmarva fox squirrel populations is similar to that found in fox squirrel populations from western Maryland, western Virginia, and central Georgia; H ranged from 0.019 to 0.040, and mean number of alleles per locus ranged from 1.09 to 1.11 for those populations.

Moreover, the Chincoteague NWR population, which was established by no more than 30 individuals (Dueser and Terwilliger 1987), is not totally homozygous, and it did not exhibit significant deviations from Hardy-Weinberg expectations for those loci at which there is variation. Apparently, the genetic variation present in the Dorchester County source population was represented in those individuals that founded the Chincoteague population during the 1968-1971 translocations. This finding is encouraging, but does not alter more intensive monitoring at some sites. Results from previous translocations will be used to define specific questions that remain to be answered about the determinants of successful establishment of translocated populations. A sample of subsequent translocation efforts will then be organized and designed to allow an experimental evaluation of such questions. This will enable researchers and managers to learn more about the animal's biology, the effects of habitat quality on re-establishment, and the effectiveness of various translocation procedures.

Translocation efforts will be based on the following premise, articulated in Griffith et al. (1989:479): "We may reduce the need for and increase the success of translocations if we can improve our ability to identify potentially tenuous situations and act before we are faced with a rescue... [and] ...Because of the low success of translocations of low numbers of endangered, threatened or sensitive species, even in excellent habitat quality, it is clear that translocation must be considered long before it becomes a last resort for these species -- before density has become low and populations are in decline. Both of these traits are associated with low chances of successful translocation."

All future translocations will take into account a variety of factors, including the suitability of the habitat, the social biology of the subspecies, the genetics of the source populations, and genetic considerations for survival of translocated populations (Soulé 1986, Dueser and Terwilliger 1987, Leberg 1990). Additionally, the seasonal timing of releases, abundance of predators at the release sites, the ways in which translocated individuals are handled prior to release, and similarity of habitat at the source and release site will be given careful consideration.

Results reported by Larson and Dueser (1991) and Therres and Bendel (unpubl. data) emphasize the need to select translocation sites that are proximal to the periphery of the existing natural distribution. In addition, population expansion will be facilitated by selecting new release sites in proximity to existing translocation sites. Every translocation effort will be fully documented (Griffith et al. 1989) and monitored to determine failure or success as well as indicate areas of improvement in methodology.

This recovery strategy will involve using a team approach. The recovery team will act as an oversight committee, with Federal, state, and university personnel performing research and management tasks. Implementation of habitat protection and establishment of a comprehensive data base of biological, ecological, and translocation information will be coordinated by U.S. Fish and Wildlife Service personnel.

PART II: RECOVERY

RECOVERY OBJECTIVE

The long-range objective of the Delmarva fox squirrel recovery program is to restore this endangered species to a secure status within its former range. Sciurus niger cinereus will be removed from the Federal list of endangered and threatened wildlife and plants when the following reclassification and delisting conditions are met.

Reclassification of the Delmarva fox squirrel from endangered to threatened status will be considered when:

1. Ecological requirements and distribution within the remaining natural range are understood sufficiently to permit effective management.

2. The following seven benchmark populations (six within the remaining natural range and the introduced Chincoteague NWR population) are shown, according to the protocol outlined in Appendix E, to be stable or expanding based on at least five years of data:

Maryland	Hayes Farm Blackwater NWR -- Jarrett Tract Blackwater NWR -- Egypt Road Eastern Neck NWR Wye Island Natural Resource Management Area LeCompte Wildlife Management Area
Virginia	Chincoteague NWR

The five year monitoring period will begin as soon after plan approval as possible. The five-year period will be retroactive for those sites on which monitoring has already begun.

3. Ten new colonies are established within the species' historical range. Translocations that may contribute to the accomplishment of this condition have already been conducted.

An introduced population will be considered established when the conditions listed under either A or B below are met:

A. Five or more years after the last release:
- One or more lactating females and at least one other adult are captured on the area, **or**
- Two or more juveniles and at least one adult are captured on the area.

OR

B. Eight or more years after the last release:
- At least three fox squirrels (other than originally released squirrels) are captured on the site,
  and
- At least one juvenile squirrel is captured, **or**
- The overall condition of the three squirrels referred to above indicates that captured animals are healthy.

The squirrel will be considered for delisting[1] when, in addition to the above:

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

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

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[1] Any state regulations adopted subsequent to delisting must ensure the secure status of the species.

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

7. Mechanisms are in place to ensure protection and monitoring of new populations, to allow for expansion, and to provide inter-population corridors to permit gene flow among populations.

RECOVERY TASKS

1. Determine the current population status of the Delmarva fox squirrel.

 1.1 Determine the current distribution of the Delmarva fox squirrel.

  1.11 Maintain up-to-date records of all known populations. There is a critical need to synthesize information that is presently available in a variety of forms for the State of Maryland. All occupied locations will be given standard names, mapped on USGS topographic sheets, entered into a tabular list by county and UTM coordinates, and ultimately entered into a GIS database (see Task 2.2). This map data will then be regularly updated through ongoing survey activities, as described in Task 1.12. Maryland DNR has the pertinent information available to begin this mapping activity, and known locations of fox squirrels in the State have been mapped roughly on county maps.

  1.12 Develop a reporting system for additional squirrel sightings. Maryland DNR has outlined a plan for an ongoing reporting system, which will include procedures for soliciting, receiving, and recording information on squirrel sightings from throughout the range. Reports from state and Federal personnel, hunters, birdwatchers, and other knowledgeable observers can be useful for documenting both regional distribution and population abundance. Procedures (for use by trained observers) for reporting squirrel sightings will be developed. Information to be reported will include date, name, and address of observer; location of sighting; type of sighting (e.g., active animal or roadkill); and additional information.

1.13 Determine the distribution of the Delmarva fox squirrel in those portions of its historical range where present occurrence is uncertain. Areas of potential habitat will be prioritized from highest probability of squirrel presence to lowest, based on what is known about habitat requirements, as well as what is learned about habitat use through Task 2. Then, contingent upon available funding, searches for additional squirrel populations will be conducted in order to develop as comprehensive a picture as possible of occupied habitat.

If additional populations are found, this will be treated as a revision of the existing range, not as a range expansion, inasmuch as the squirrels may have been there all along. Range expansion will be inferred only when a search area in which no squirrels are found is later found to have squirrels present.

1.2 Determine Delmarva fox squirrel population dynamics and trends.

1.21 Estimate persistence rates of known Delmarva fox squirrel populations, and colonization rates for unoccupied sites. Although the stability of extant squirrel populations is being assessed and further data on persistence is being obtained through efforts to confirm establishment at release sites, for the most part this task has been completed. Taylor's (1976) sites were resurveyed by Therres and Willey (1988), repeating Taylor's methods, to determine how many sites remained occupied. Therres and Willey also resurveyed Taylor's unoccupied sites to determine if they had been colonized by the Delmarva fox squirrel since the early 1970s. It should be kept in mind that all these surveys have been based on observations only (i.e., presence of Delmarva fox squirrels on these sites was not confirmed by trapping or nest box inspections).

1.22 Monitor Delmarva fox squirrel population dynamics at benchmark sites. The seven benchmark sites listed in the recovery objective have been designated for systematic, long-term monitoring of Delmarva fox squirrel population trends, and a standard monitoring procedure (see Appendix E) was instituted on several of the benchmark sites in 1991. This procedure is designed to document Delmarva fox squirrel abundance, population structure (by age and sex), reproductive activity, growth rates, and movements (immigration and emigration). A combination of nest box inspections and live trapping will be used for long-term population monitoring. Monitoring will be incorporated into an annual work plan for each benchmark site; the work plan will include a section assessing nest box use and the merits of continuing this practice.

Benchmark sites censused using only one technique include Eastern Neck NWR (trapping) and Chincoteague NWR (nest box checks); future work plans for these sites will incorporate standard procedures to the extent deemed appropriate by the recovery team. The Jarrett tract on Blackwater NWR and Hayes Farm were censused for the first time in 1992, and censusing will be continued for at least five years.

1.23 Determine the current status of the Delmarva fox squirrel on pre-1990 translocation release sites. The presence of the Delmarva fox squirrel on six release sites in Maryland, two in Delaware, and at Chincoteague NWR in Virginia was verified 1992 (see Table 2). In the future, data will be collected to determine whether populations at these and other release sites (see Task 5.4) are stable or expanding, using parameters based on population data obtained at benchmark sites.

1.3 Determine the condition and health of Delmarva fox squirrel populations.

1.31 Monitor Delmarva fox squirrel condition and health. Persons engaged in routine population monitoring will be trained to perform an external veterinary examination of every animal they handle. The examination protocol appears in Appendix C. Veterinary personnel of the U.S.Fish and Wildlife Service or the Center for Disease Control will provide training to trappers and handlers.

1.32 Implement a procedure for necropsy and subsequent disposition of road-killed or other deceased specimens. This procedure is being developed, in conjunction with veterinary staff at Patuxent

Research Center and National Wildlife Disease Laboratory, to maximize the amount of information obtained from each animal and ensure preservation of specimens at appropriate repositories. A proposed protocol appears in Appendix F.

1.33 Perform contaminants analyses on squirrel carcasses. The Delmarva fox squirrel occupies a landscape that is heavily influenced by production agriculture, and the squirrel makes frequent use of agricultural crops and produce as a food source (Taylor 1976). It is thus possible that pesticides and other agricultural chemicals have an effect on squirrel biology. A procedure will be devised for collecting, processing, and analyzing carcasses for selected environmental contaminants. Copies of any results of such analyses involving pesticides, as well as all related incident information, will be sent to the U.S. Environmental Protection Agency's Ecological Effects Branch, Office of Pesticide Programs.

1.4 Describe the genetic structure of the Delmarva fox squirrel subspecies and its relationship to other fox squirrel subspecies. According to Moncrief and Dueser (1991), the Chincoteague NWR and Dorchester County populations of Delmarva fox squirrel exhibit comparable levels of heterozygosity. Further, these two populations possess an electrophoretically detectable genetic attribute (MPI^{c}) not present in any other population of S. niger examined to date (Morgan and Quattro 1986, Moncrief 1987, Moncrief and Dueser 1991). Other populations of eastern fox squirrels, especially those from within and adjacent to the historical range of S. n cinereus (Delaware, Pennsylvania, and New Jersey), will be analyzed to determine whether this allele can be considered unique and characteristic of Delmarva fox squirrel. Emphasis will be placed on understanding genetic differences among Delmarva fox squirrels and (a) the subspecies in central Pennsylvania to the north, and (b) _S. niger niger_ populations to the south.

In addition, other biochemical techniques (e.g., restriction site analysis and sequencing of mitochondrial and nuclear DNA) will be used to further determine quantifiable genetic variation within and among _S. n. cinereus_ populations.

2. Determine Delmarva fox squirrel habitat availability and use.

2.1 Describe habitat use and requirements of populations within the current natural range. A study will be initiated in Maryland to (1) determine the minimal forest age and stand conditions required for site occupancy by the Delmarva fox squirrel; (2) compare the demography of populations occupying stands of different type, age, and condition; and (3) examine the effects of stand age and condition on squirrel activity and dispersal between sites. This will involve mark-release-recapture and radio telemetry techniques. The data derived from these efforts will also provide insight into dispersal and movement in naturally occurring populations.

2.2 Develop an integrated habitat protection strategy using remote-sensing procedures and a geographic information system (GIS). Procedures for synthesizing knowledge of potential translocation sites, dispersal corridors, available habitat patches, development and agricultural centers, and private and public land holdings with established squirrel populations will be developed. The ability to estimate habitat quality, suitability, and abundance from remotely-sensed data is vital for appraising habitat availability, monitoring land use trends in the vicinity of established populations, and pre-screening potential translocation sites.

The development of this remote-sensing system will require habitat use data obtained from Task 2.1. Important considerations include proposed applications, type and source of remote imagery, scale and resolution of imagery, type and scale of important landscape features, image processing procedures, amount and type of ground-truthing and calibration, and procedures for site evaluation.

A GIS will be used to integrate all landscape components so that suitable corridors and translocation sites can be evaluated on a biogeographic level before conducting habitat assessments and ground-truthing. Maryland is currently developing GIS mapping techniques for forest interior breeding birds, and it is likely that this technology will prove applicable for assessment of Delmarva fox squirrel habitat availability. Delaware and Virginia are considering similar mapping techniques.

2.3 Field test and define applications for the habitat suitability model. The habitat suitability model developed by Dueser et al. (1988) has been revised (R. Dueser in litt. 1992) to include variables characterizing pine sites known to be occupied by Delmarva fox squirrels. This model will be field tested, and applications for the model will be described.

2.4 Map available habitat. Using the results of the habitat studies defined in Task 2.1, the remote-sensing procedures described in Task 2.2, and the habitat suitability model tested in Task 2.3, forest habitat that is currently and potentially available for Delmarva fox squirrel use will be mapped and incorporated into the GIS referred to in Tasks 1.11 and 2.2.

3. <u>Protect Delmarva fox squirrels and their habitat.</u> The Delmarva fox squirrel is imperiled primarily by loss and fragmentation of habitat. Threats to occupied and potential habitat will be monitored and addressed through a variety of mechanisms.

3.1 <u>Monitor current and potential threats to the squirrels and/or their habitat.</u> Threats such as changing land uses or forests pests (e.g., gypsy moths) will be monitored in order to identify their effects upon occupied and potential habitat, and in order to develop contingency or long-term control strategies.

3.2 <u>Contact and solicit the support of private landowners and public land managers in protecting both occupied and potential Delmarva fox squirrel habitat.</u> Using educational and informational materials developed in Task 6, along with a coordinated program of personal contacts, landowners and managers will be apprised of their responsibilities under the Endangered Species Act as well as opportunities to help in the recovery of this endangered animal.

As one important instance of such opportunities, the Forest Stewardship Program, a relatively new private landowner incentive program that provides opportunities for compatible management practices for Delmarva fox squirrels, has been developed. One component of this program, SIP-8, Wildlife Habitat Improvement, allows cost sharing for practices such as prescribed burning and wildlife openings that lead to restoration or improvement of existing wildlife habitat. Further, SIP-9, Threatened and Endangered Species Protection, allows cost sharing for the practices compatible or supportive of such protection.

Forest stewardship plans can therefore be written for any private landowner and can be tailored to Delmarva fox squirrel management through the recommended forestry practices of wildlife corridors, wildlife thinnings, and tree shelters (which can help create the proper stand conditions), and the nest box snag options (which can provide suitable shelter). County foresters and state wildlife biologists are encouraged to work with landowners to develop sound management plans that can meet both Delmarva fox squirrel and landowner objectives.

3.3 Coordinate with state and Federal regulatory and law enforcement authorities to ensure compliance with existing laws. Federal, state, and local laws and regulations governing protection of endangered and threatened species will be fully enforced. In addition, the enforcement capability of existing regulations will be strengthened where possible, and non-traditional avenues for endangered species protection that may benefit the Delmarva fox squirrel will be investigated. The latter may include laws such as Maryland regulations governing growth management, in which localities must show in a comprehensive plan how they plan to preserve natural areas, including sensitive habitats.

Section 7 and Section 9 Endangered Species Act responsibilities will continue to be carried out to avoid direct and secondary impacts to populations and/or their habitat.

3.4 Enlist the participation of counties in habitat protection planning. County planning and zoning authorities will be apprised of their responsibilities to protect the Delmarva fox squirrel and its habitat. This will require extensive coordination as well as a dedicated effort to work with local timber interests and real estate developers.

Various opportunities to protect habitat will be considered, including zoning ordinances to limit residential densities, road construction, and development, as well as incentives to encourage compatible timber management practices. In areas of potential habitat, counties will be encouraged to require determination of Delmarva fox squirrel status as part of their permit issuance procedures.

3.5 Pursue non-regulatory land protection alternatives. This effort could include incentives such as tax breaks, as well as recognition from public or private conservation agencies. In addition, management agreements and conservation easements will be considered for both occupied and potential habitat. Purchase of important tracts will be considered if necessary to protect release sites or core population. In considering land acquisition, focus will be placed upon existing habitat, but tracts will also be evaluated for their juxtaposition for landscape linkages. Consideration will be given to creating or restoring habitat on non-forested areas, which could be used as demonstration projects for private and industrial landowners and developers.

4. Devise and implement a habitat management scheme.

4.1 Determine effects of timber management and other land use practices on the Delmarva fox squirrel. Squirrel survival will be assessed (1) on sites previously treated with standard timber management practices; (2) before and after treatment on commercial or private timber land; (3) before and after burning and/or timberstand improvement on public lands, particularly on National Wildlife Refuges such as Blackwater NWR; and (4) on sites undergoing other land use changes such as low-density housing development. This study may be conducted in conjunction with Task 2.1. The habitat restoration/creation demonstration projects mentioned in Task 3.5 could serve as experimental areas for refining management practices and strategies.

4.2 Develop and refine guidelines for prescriptive habitat management for the Delmarva fox squirrel. Interim guidelines, subject to revision, appear in Appendix G. Based on the results of Tasks 4.1 - 4.4, these guidelines will be revised as warranted.

4.3 Develop and implement guidelines for habitat management on public lands occupied by the Delmarva fox squirrel. Refuge managers at Blackwater, Chincoteague, Eastern Neck, and Prime Hook National Wildlife Refuges, in consultation with the recovery team, will develop and implement specific habitat management actions. Each refuge will complete a Forest Management Plan, which will identify objectives and activities for maintaining optimum Delmarva fox squirrel habitat within refuge boundaries. The U.S. Fish and Wildlife Service's Division of Refuges and Wildlife will specify annual management activities in work advice documents.

4.4 Monitor outcome of prescriptive habitat management. Effects of management activities, past and future, will be assessed in terms of benefits and any detrimental impacts on Delmarva fox squirrels. On the Chincoteague, Blackwater, Eastern Neck, and Prime Hook NWR sites, monitoring the effects of management practices should be an integral part of annual work plans. Coordination meetings for refuge managers, the U.S. Fish and Wildlife Service zone biologist, and recovery team members will be held as needed to assess management practices and update management recommendations for these lands.

5. Plan and conduct additional translocations of the Delmarva fox squirrel to unoccupied portions of the range.

Releases that have apparently been successful demonstrate the utility of translocations; however, before further operational translocations are conducted, a number of technical questions should be resolved. The 1991 Andelot Farm experimental translocation was conducted to gain insight into the post-release movements and mortality of individuals. Future translocations will incorporate the knowledge gained from that translocation, as well as the full range of considerations discussed in Part I of this plan.

5.1 Define characteristics and minimum size of source populations for translocations, as well as characteristics and minimum number of squirrels per release. These considerations are addressed in the protocol established in Appendix D. As information is gained through other recovery tasks, requirements will be further specified, and the release protocol will be modified accordingly. All releases will be fully documented according to the guidelines presented in Appendices C, D, and H.

5.2 Supplement previous translocations that have small (less than 24 individuals) founder populations (see Appendix D and Table 1). Existing translocation sites will be supplemented with additional squirrel releases as needed to meet the definition of an established population and ensure genetic viability. In particular, the Andelot Farm release site, supplemented in October 1992, will be monitored (using annual nest box checks and biennial live trapping) in the near term to determine population trends and habitat use.

5.3 Identify additional release sites. Selected sites will be those that: (1) score high on the revised habitat suitability model, (2) have a low probability of being colonized naturally, (3) have ample room to expand via habitat corridors to adjacent areas of suitable habitat, and (4) are located on public or protected private land, or have signed landowner agreements to protect the sites. In order to prevent isolation and inbreeding, consideration will be given to establishing new populations within the dispersal distance of an already occupied site. Release and source site localities will be documented as specified in Appendix H.

Potential sites, including tentative candidates, for future translocations will be identified as soon as possible or feasible. Cooperative agreements with landowners will be considered as a preliminary step, even though actual translocations for certain sites may not occur for several years. This would allow the opportunity for some long-term management regimes prior to translocation.

5.4 Continue releases, as appropriate, and monitor release sites according to established protocols. In addition to operational releases, controlled experimental translocations will be pursued if needed to address the question of whether successful (or unsuccessful) establishment of translocated populations is due to differences in habitat quality or, alternatively, to variability in translocation procedures (e.g., hard- versus soft-release techniques). A replicated, two-way study design that tests the dual effects of habitat quality (defined by Dueser's model) and some modification in translocation procedure on the success of translocations will be used if experimental translocations are implemented.

6. Foster increased public awareness of the squirrel's status and recovery needs. The following media and outreach efforts will

be used on National Wildlife Refuges, state management areas, and in civic and educational settings.

6.1 Prepare and distribute information brochures. The Maryland Department of Natural Resources has prepared a brochure providing general information about the Delmarva fox squirrel and its recovery needs. This brochure is now being distributed widely. In an additional effort, a brochure describing management guidelines for landowners and managers will be prepared and used as an educational tool.

6.2 Prepare news media information. A segment on the Delmarva fox squirrel that was aired on Maryland public television will be made available for showing elsewhere. Press releases will be disseminated as recovery activities are implemented.

6.3 Prepare a slide program suitable for professional and general education, and, optionally, prepare a film on the Delmarva fox squirrel.

6.4 Provide lecture services to interested groups. This task is ongoing.

6.5 Construct exhibits/displays. Traveling exhibits and/or displays for use at visitor centers and other facilities will be developed.

6.6 Utilize roadkills for educational and research purposes. Roadkilled specimens will be used in presentations to school and civic groups, in interpretive programs at refuges and state wildlife management areas, and/or in displays. In addition, specimens will be submitted to researchers conducting genetic analyses and other studies requiring, for instance, blood or tissue samples.

7. <u>Track recovery progress and update the recovery plan as needed</u>. The recovery team will continue to coordinate implementation of recovery activites in cooperation with the U.S. Fish and Wildlife Service and other involved agencies. This will be achieved through recovery team meetings to be held annually in late fall or early spring, periodic meetings to coordinate management activities on refuges and other public lands, and the involvement of a U.S. Fish and Wildlife Service recovery implementation coordinator. Key to this effort will be coordination of habitat protection strategies, monitoring of recovery accomplishments and needs, compilation and dissemination of data through the establishment of a comprehensive data base, and updating of the recovery program based on new information and identified needs.

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PART III: IMPLEMENTATION

The Implementation Schedule lists and ranks tasks that should be undertaken within the next three years in order to progress with recovery of the Delmarva fox squirrel. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in order of priority.

Key to Implementation Schedule Column 1

Task priorities are set according to the following standards:

Priority 1:	Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2:	Those actions that must be taken to prevent a significant decline in species population, or some other significant impact short of extinction.
Priority 3:	All other actions necessary to provide for full recovery of the species.

Key to Agency Designations in Column 5

USFWS	=	U.S. Fish and Wildlife Service
R5 ES	=	Region 5, Division of Ecological Services, U.S. Fish and Wildlife Service
R5 RW	=	Region 5, Division of Refuges and Wildlife
LAB	=	Madison Laboratory
PWRC	=	Patuxent Wildlife Research Center
DE, MD, PA, VA	=	Delaware, Maryland, Pennsylvania, and Virginia state natural resource agencies
PI	=	Private research or academic institutions
CO	=	Private conservation organizations

IMPLEMENTATION SCHEDULE
Delmarva Fox Squirrel Recovery Plan

Second Revision, June 1993

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates($000) FY1	FY2	FY3	Comments
2	Maintain up-to-date records of all known populations.	1.11	Ongoing	R5 ES, RW	DE, MD PA, VA	1.5	1	1	+ $1000/yr for FY4-17.
2	Determine distribution in portions of the historical range where present occurrence is uncertain.	1.13	Ongoing	R5 RW	DE, MD, PA, VA	3	10	10	+ $10,000/yr in FY4-5, and $1000/yr for FY6-17.
2	Monitor population dynamics at benchmark sites.	1.22	At least 5 years	R5 RW	MD, VA	7.5	7.5	7.5	+ $7500/yr in FY4-5.
2	Determine status of squirrels on translocation release sites.	1.23	1 year	R5 RW	DE, MD, PA, VA	2.5			Initial effort completed. Some followup needed.
2	Monitor squirrel condition and health.	1.31	Ongoing	R5 RW	DE, MD, PA, VA				Will be implemented in conjunction with Tasks 1.22 and 1.23.
2	Describe habitat use and requirements of naturally occurring populations.	2.1	3 years	R5 RW	MD, PI	15	15	15	
2	Monitor threats to the squirrels and/or their habitat.	3.1	Ongoing	R5 RW	DE, MD, PA, VA				Will be implemented in conjunction with Tasks 1.11, 1.13, 1.22, 1.23, and 2.1.
2	Contact and solicit the support of land owners and managers to protect both occupied and potential habitat.	3.2	Ongoing	R5 ES	DE, MD, PA, VA, CO				Will be implemented during course of other protection efforts.
2	Coordinate with state and Federal regulatory and law enforcement authorities to ensure compliance with existing laws.	3.3	Ongoing	R5 ES	DE, MD, PA, VA				Will be conducted during course of normal operations.

Second Revision, Delmarva Fox Squirrel Implementation Schedule, June 1993

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates($000) FY1	Cost Estimates($000) FY2	Cost Estimates($000) FY3	Comments
2	Enlist the participation of counties in habitat protection planning.	3.4	15 years	R5 ES	DE, MD, PA, VA		2.5	5	Strategic planning in FY2-3. Implementation thereafter. FY4-17 costs = $25,000.
2	Pursue non-regulatory land protection alternatives.	3.5	Ongoing	R5 ES	DE, MD, PA, VA				Rough estimate for land acquisition = $200,000.
2	Determine effects of timber management and other land use practices on the Delmarva fox squirrel.	4.1	Periodic	R5 RW	MD		3	3	Assessments conducted periodically. FY4-17 costs = $9000.
2	Develop and refine guidelines for prescriptive habitat management for the squirrel.	4.2	Periodic	R5 ES	DE, MD, PA, VA				Draft guidelines completed. Periodic refinement anticipated.
2	Develop and implement guidelines for habitat management on public lands occupied by the squirrel.	4.3	Ongoing	R5 RW	DE, MD, VA	3	7	10	Specific guidelines to be developed in FY1 and 2. Periodic implementation thereafter. FY4-17 costs = $50,000.
2	Monitor outcome of prescriptive habitat management.	4.4	Ongoing	R5 RW	DE, MD, VA		2	2	+ $2000/every other year. FY4-17 costs = $14,000.
2	Supplement previous translocations that have small founder populations.	5.2	3 years	R5 RW	DE, MD	5	5	5	
3	Develop and use a reporting system for additional squirrel sightings.	1.12	Ongoing	R5 RW	DE, MD, PA, VA	0.5	0.5	0.5	+ $500/yr for FY4-17.
3	Estimate persistence rates of known populations, and colonization rates for unoccupied sites.	1.21	1 year		MD				Do after new status information becomes available.

Second Revision, Delmarva Fox Squirrel Recovery Implementation Schedule, June 1993

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimates($000)			Comments
				USFWS	Other	FY1	FY2	FY3	
3	Implement a procedure for necropsy and subsequent disposition of deceased specimens.	1.32	Ongoing	LAB					No costs itemized.
3	Perform contaminants analyses on squirrel carcasses.	1.33	1 year to develop process	PWRC		1	0.75	0.75	Analyses triggered by spot checks during necropsy procedures. FY4-17 costs = $4500.
3	Describe the genetic structure of the Delmarva fox squirrel subspecies and its relation to other fox squirrel subspecies.	1.4	3-5 years		VA, PI	10	10	10	Initial phase completed; next phase requires DNA analyses. $5000/yr in FY4-5.
3	Develop an integrated habitat protection strategy using remote-sensing procedures and a GIS.	2.2	5 years		DE, MD, PA, VA	7.5	7.5	7.5	+ $7500/yr in FY4-5.
3	Field test and define applications for habitat suitability model.	2.3	2 years		MD, PI	2	2		Costs are for field testing.
3	Map available habitat, and update as needed.	2.4	2 years initial effort.		DE, MD, PA, VA	10	10		FY4-17 updating costs = $30,000.
3	Define characteristics and minimum size of source populations for translocations, and characteristics and minimum number of squirrels per release.	5.1		R5 RW	DE, MD, VA			0.5	Initial protocol developed. Costs are for refinement. $500/yr in FY5 and 10.
3	Identify additional potential release sites.	5.3	3 years	R5 ES	DE, MD, PA, VA		2	2	+ $2000/yr for FY4-5.
3	Continue releases, as appropriate, and monitor release sites according to established protocols.	5.4	Ongoing	R5 RW	DE, MD, PA, VA	5	5	12.5	+ $5000/yr for FY4-17.

Second Revision, Delmarva Fox Squirrel Recovery Implementation Schedule, June 1993

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates($000) FY1	FY2	FY3	Comments
3	Prepare and distribute information brochures.	6.1	2 years	R5 ES	DE, MD, PA, VA		4.5	2.5	Includes reprint costs and development of management guidelines brochure.
3	Prepare news media information.	6.2	Ongoing	R5 ES	DE, MD, PA, VA				
3	Prepare a slide program and, optionally, a film on Delmarva fox squirrels.	6.3	3 years	R5 ES, RW	DE, MD, PA, VA		2		+ $8000 in FY4 for film production.
3	Provide lecture services to interested groups.	6.4	Ongoing	R5 ES, RW	DE, MD, PA, VA				
3	Construct exhibits/displays.	6.5	2 years	R5 RW	DE, MD, PA, VA		5	5	
3	Utilize roadkills for educational and research purposes.	6.6	Ongoing	R5 RW	DE, MD, VA, PI				
3	Track recovery progress and update recovery plan as needed.	7	Ongoing	R5 ES	DE, MD, PA, VA				

APPENDICES

CONTENTS:

A. Forest Trend Data
B. Habitat Evaluation Methods
C. Capture and Handling Protocol
D. Release Protocol
E. Guidelines for Monitoring Benchmark Sites
F. Procedures for Saving and Submitting Roadkills
G. Habitat Management Guidelines
H. Release Site and Source Site Localities
I. List of Reviewers

APPENDIX A

Forest Trend Data

Delaware

U.S. Forest Service surveys, based on ground plot sampling techniques, indicated that forest land in Delaware decreased by 1.6% (from 154,837 to 152,327 ha) between 1972 and 1986 (Ferguson and Mayer 1974, Frieswyk and DiGiovanni 1989). In a separate study using digitized analysis of land use change maps, Mackenzie (1989) calculated a net loss of 5,795 ha (3.7%) of forest lands in the state between 1974 and 1984. According to Mackenzie's study, 3,594 ha were converted to agriculture and 2,185 ha to housing and industry. Losses among the hardwood type, mixed-forest type, and coniferous type were 2,336 ha, 1,690 ha, and 1,769 ha respectively.

The U.S. Forest Service surveys further indicated that the loblolly/short-leaf forest type decreased by 3% (1,174 ha) between 1972 and 1986, reflecting an apparent complete elimination of pond pine (*Pinus serotina*) and a 2,792-ha loss of Virginia pine (*Pinus virginiana*). Although loblolly pine (*Pinus taeda*) showed an apparent increase of 3,440 ha, sawtimber class loblolly decreased by 30% (7,001 ha) while the sapling/seedling class increased by 9,713 ha. Softwood removals during the period exceeded growth by 1.1:1.0; softwood removals prior to 1972 also exceeded growth, and little attention was given to pine reforestation (Ferguson and Mayer 1974). This overcutting and lack of reforestation led to the major decline in the larger size classes. Further, according to the state's Forest Stewardship Program, "Lags in reforestation, regeneration management and gypsy moth induced mortality indicate the future forests of Delaware will contain primarily smaller trees for several decades" (Delaware Department of Agriculture 1991).

In contrast to the pine situation, the oak/hickory forest type showed an increase of 19,061 ha over the 14-year period. Significant increases were noted in all size classes, with the largest (13,760 ha) in the sawtimber class. Most (67%) of these hardwoods, however, appear to be in the smaller range of sawtimber, between 11"-14.9" dbh (Frieswyk and DiGiovanni 1989); it will be some time before these trees become optimal size for Delmarva fox squirrels. In addition, the overall increase in the oak/hickory forest type is due largely to pine or oak/pine stands being reclassified to oak/hickory following cutting of the pine component as well as reversion of clear-cut pine stands to oak/hickory where no pine reforestation was conducted (R. Tjaden, Delaware State Forester, pers.comm).

Maryland

U.S. Forest Service surveys indicated a 7% loss (20,154 ha) of forest land on Maryland's Eastern Shore (excluding Cecil County) between 1976 and 1986 (Frieswyk and DiGiovanni 1989); of this total, an estimated 11,170 ha were lost from Dorchester, Somerset, Wicomico, and Worcester Counties. The Maryland Office of Planning (1990) found 10,894 ha and 4,720 ha lost from forest land and agricultural land, respectively, between 1973 and 1990. During the same period, an increase of 13,308 ha was devoted to housing and 1,779 ha to industry, with 65% of this conversion occurring in the five upper shore counties. Conversion of forest land appeared about equally split between the upper and lower shore counties. The disparity in forest loss figures between the Forest Service survey and the Maryland State report can be attributed to differences in survey technique. A white paper prepared by the Maryland Forest, Park and Wildlife Service (1989) projected that by the year 2000 the human population on the Eastern Shore will increase by another 20,000 residents, with an estimated loss of 8,357 ha of forest land.

Comparative changes in forest type and size class during the 1976-1986 period could be evaluated only for the lower Eastern Shore (Frieswyk and DiGiovanni 1988). Loblolly pine declined by 29% (80,453 ha to 57,507 ha) during the 10-year period, and the loblolly sawtimber class was reduced by 14,488 ha, a 30% reduction identical to that in Delaware. Unlike Delaware, significant reductions were also noted in the seedling/sapling class for loblolly (5,099 ha). Significant increases in sawtimber acreage for oak/pine (13,638 ha) and oak/hickory (11,412 ha) were noted. As in Delaware, the majority of the sawtimber appears to be in the smaller range; the 1986 U.S. Forest Service survey indicated that 68% of the saw log trees in the oak/hickory type were in the 11"-14.9" dbh class.

Virginia

U.S. Forest Service surveys (Brown and Craver 1985) estimate a loss of 5,573 ha of forest on the Eastern Shore of Virginia between 1976 and 1985. These surveys showed a reduction in the oak/pine and oak/hickory forest types of an estimated 3,253 ha and 5,882 ha, respectively. This loss was, however, offset by increases of 1,771 ha and 1,793 ha, respectively, in the loblolly/shortleaf and oak/gum types, probably reflecting more intensive pine management in Virginia than in the other states between the mid-1970s and mid-1980s (R. Tjaden pers. comm.).

Overall, it is evident that -- despite differences in numbers generated by different surveys -- a significant amount of forest has been lost on the Delmarva Peninsula over the last two decades. Human population growth projections suggest that this trend may continue unless effective conservation measures are put in place. Past forestry practices that have favored the oak/hickory type in some areas may benefit Delmarva fox squirrels if stands are allowed to mature; however, the loss of pine in recent years is of concern to foresters, and some efforts appear to be underway to encourage increased pine management (R. Tjaden pers. comm.). Intensive short-rotation, pine-monoculture management may not be beneficial to Delmarva fox squirrels. Future trends in land use and forest management must be monitored closely and actions taken when needed to ensure the long-term recovery of S. n. cinereus.

APPENDIX B

Habitat Evaluation Methods

Taken from "Methods Used in Describing the Habitat of S. niger cinereus in Maryland" (Taylor 1976)

Many methods exist for describing habitat types by different parameters (Stamp 1934, Christian and Perry 1953, Kuchler 1949, Cottam and Curtis 1949, Garrison 1949, and Holdsworth et al. 1936). Most of these methods employ a transect over which the vegetation is sampled, but involve rigorous and time consuming sample techniques.

The method I used was chosen because it allowed a single worker to collect data, it was quick enough (yet accurate for comparative purposes) to allow sampling of several areas over a restricted period of time, and also provided necessary data that the above methods could not. The method chosen is similar to that employed by Emlen (1956) for describing avian habitat. Desired parameters are rated on a data sheet, which, after completion, describes the habitat in the area of the transect. All transects were run by myself, to insure consistency of observations.

A sample of the data sheet employed in describing squirrel habitat is shown in the attachment. Tree species composition of the sampled areas was collected to determine if areas of different vegetative structure were preferred by one squirrel or the other(i.e., gray squirrels versus fox squirrels). It would also indicate whether the ratio of coniferous to deciduous species was an important factor in determine habitat preference. Other subspecies of fox squirrels have exhibited a preference for areas with mature, large trees, thus tree size was studied. The percent overstory, the percent understory cover, and the composition of the understory relate to the density of the understory, a parameter found to have been important in habitat preferences exhibited by other subspecies of fox squirrels. The presence of water was recorded to determine whether or not the Delmarva fox squirrel preferred areas adjacent to water. (More plausible is the fact that the water may determine the presence of this squirrel indirectly through its effect on the vegetation). Soil also influences the type of vegetative cover. Barren areas, structures, and adjacent land use all relate to the presence of agricultural areas situated near squirrel habitat.

From the data collected during the range survey, fifty-four areas, of habitat where both squirrel species were present, and also where only the gray squirrel occurred, were selected in which to describe the squirrel habitat. All transects were run in June, July, August and September to provide for similar observation conditions. At each of the selected areas, the habitat was characterized in the following manner. One transect of 200 meters long and four meters wide was measured. The transect was run through an area most representative of the habitat type of the entire stand, based on a preliminary examination. When it was known that S. niger cinereus was concentrated in one particular area of the sampled woodlot, a transect was run there. One transect per stand was chosen since preliminary tests indicated that there was no significant difference (at the five percent level) between one, two, and three transects run in the same stand.

The identity and size of each tree in the transect was recorded. Tree sizes were broken into four classes and were measured at diameter breast height (dbh). The four size classes included 5-20 cm dbh, 20.1-30 cm dbh, 30.1-50 cm dbh, and 50+ dbh.

Overstory in the transect was subjectively measured by estimating (by overhead visual inspection on the entire transect) the amount of light obscured by the forest canopy. Results were valid for comparative purposes.

The composition of the understory vegetation was recorded. The percent understory from ground level to two meters high was also noted (understory vegetation is believed to be an important factor in predator concealment). On each transect, twenty small, white, circular discs (approximately fifteen cm in diameter) were distributed in a random direction at even intervals (approximately every ten meters) on the transect. After distribution of the discs, the transect was walked again, and at each disc, the author (from a standing position (2 m) over the disc), estimated the amount of that disc that was covered by vegetation. The ratio of those discs covered (50 percent or more) by vegetation to those uncovered (less than 50 percent) by vegetation was used as an indicator of the percentage understory.

Density of the understory was estimated by rating the difficulty of traversing the transect. Four classes were employed, including easy, moderate, moderately difficult, and difficult.

The presence or absence of water and its nature (either standing or running) was recorded. The presence and type of barren areas, structures, and use of the land adjacent to the squirrel habitat being described was also recorded. Adjacent land use fell into the category of agricultural, silvicultural, recreational, or orchard. In agricultural or orchard areas, the type of crop being grown was recorded.

In addition, at each transect, photographs were taken to visually portray the type of habitat being studied. Giles (1971) stresses the value of photographic material in describing and especially comparing habitat changes or differences.

Fox Squirrel Habitat Data Form

See Over For Instructions

Location ______________________ Date ______________

County ______________________ Observer(s) ______________

Compass bearing ______________ Forest area (ha) ______________

Tree Species /DBH	5-20 cm	20.1-30 cm	30.1-50 cm	50+ cm
Loblolly pine				
Scrub pine				
Tulip tree				
Red gum				
Black gum				
Red maple				
Holly				
White oak				
Swamp white oak				
Water oak				
Black oak				
Southern red oak				
Willow oak				
Beech				
Hickory				
Carpinus				
Dogwood				
Cherry				

Canopy closure (sighting tube; 20 pts) ______________

Understory-ground cover (disk; 20 pts) ______________

Understory thickness (1 easy, 2 mod., 3 mod. diff., 4 diff.) ____

Understory composition ______________________

____

Dist. (m) to -- Surf. H_2O ______ Structure ______ Road ______

Adj. land use -- Agri. ____ Silv. ____ Rec. ____ Orch. ____ Past. ____

Soil type(s) ______________________

Comments ______________________

Fox Squirrel Habitat Data Form -- Instructions

Location: Permanent name of study site.

Compass bearing: Compass orientation of main axis of transect.

Forest area: Area (hectares) of continuous forest on study site.

Trees: Diameter at Breast Height (in centimeters) at 4.5 feet. Record tally mark for appropriate Tree Species-DBH combination.

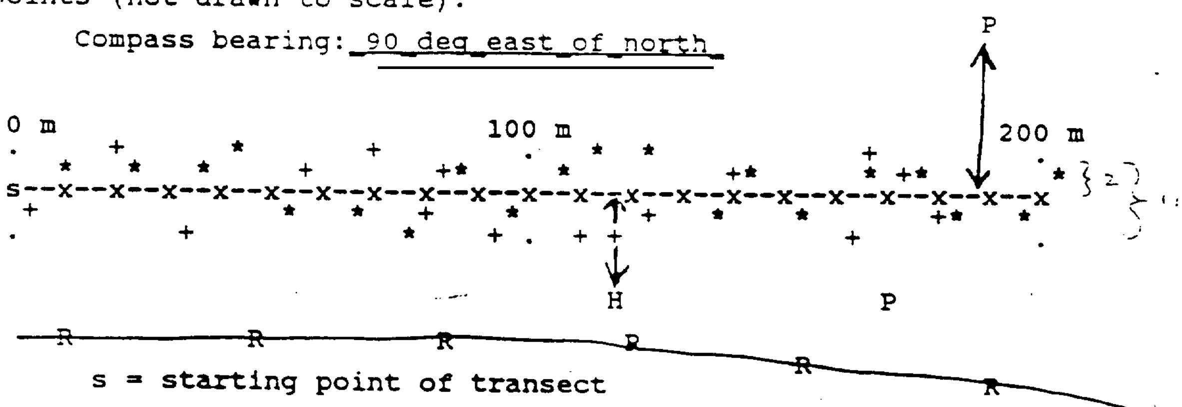
Canopy closure: Vertical sighting of forest canopy (present or absent) with sighting tube every 10 m along transect (20 sample points total). Record tally mark for every sample point at which there is "canopy present" in field of view of the sighting tube. Percent canopy closure = (number of tally marks / 20) * 100.

Understory-ground cover: Vertical sighting of understory and ground-level vegetation above a 15-cm diameter white disk laying on the ground at 20 random sample points on transect. Record tally mark for every sample point at which there is "vegetation present" in vertical field of view between eye of observer and disk. Percent understory = (number of tally marks / 20) * 100.

Understory thickness: Difficulty of traversing transect. 1 = easy to traverse through sparse understory (i.e., can walk with ease and at least 100 m along transect); 2 = moderate (i.e., can walk with ease and see 75 - 100 m along transect); 3 = moderately difficult to traverse through dense understory (i.e., can walk with effort and see 25 - 75 m along transect); 4 = difficult to traverse (i.e., a jungle).

Schematic diagram of 2 m wide x 200 m long transect and sample points (not drawn to scale):

Compass bearing: 90 deg east of north



s = starting point of transect

+ = trees to be identified and measured for DBH

x = flagged station on center line of transect (20 sample points for sighting of canopy closure)

* = 20 sample points for sighting of understory-ground level vegetation

H = house (structure)

P = pond (surface water)

R = road

SAMPLE

Fox Squirrel Habitat Data Form

See Over For Instructions

Location Robert Dryden Farm Date 8/23/86

County Somerset, MD Observer(s) Queen, Dooley

Compass bearing 180° (due S) Forest area (ha) ______

Tree Species /DBH	5-20 cm	20.1-30 cm	30.1-50 cm	50+ cm
Loblolly pine			3	
Scrub pine				
Tulip tree				
Red gum	7	4	10	
Black gum	6		1	
Red maple	25	9	1	1
Holly	12			
White oak			1	
Swamp white oak			1	
Water oak				
Black oak				1
Southern red oak				
Willow oak			1	
Beech				
Hickory				
Carpinus				
Dogwood	1			
Cherry				
Sum	51	13	18	2

Canopy closure (sighting tube: 20 pts) 𝍸 𝍸 𝍸 𝍸 20/20

Understory-ground cover (disk: 20 pts) 𝍸 |||| 9/20

Understory thickness (1 easy, 2 mod., 3 mod. diff., 4 diff.) 2

Understory composition B'gum, R'gum, R maple

Ground — jewelweed, knotweed, ferns (80%) cover

Dist. (m) to -- Surf. H_2O ______ Structure 150 Road 200

Adj. land use -- Agri. ✓ Silv. ____ Rec. ____ Orch. ____ Past. ____

Soil type(s) ______

Comments Difficulty 2 because of many small down branches and logs

APPENDIX C

Capture and Handling Protocol

For Demographic and Morphological Data
Without Use of Anesthesia

I. EQUIPMENT

1. * ear tags (#1 monel)
2. * ear tag pliers
3. * 1 Kg suspended weight scale (5 g increments or less)
4. * 2 Kg suspended weight scale (10 g increments or less)
5. cloth cones with zipper -- general specifications: 62.5 cm (25") in length, large opening = 35 cm (14") diameter, small opening no more than 2.5 cm (1"), zipper extends entire length of cone with a width of 3 cm (1.13"), material is a lightweight, tightly woven, no-stretch synthetic (see attachment for sketch).
6. clothesline
7. 6" ruler
8. protective gloves (leather if possible)
9. data sheet, waterproof if possible (see attachment)
10. pencils
11. small, hand-held magnifier (for accurate ear-tag number identification)

* This equipment can be obtained from: Wildlife Materials, Inc., Rt. 1, Carbondale, Il 62901; (618) 549-6330, 549-2242, FAX (618) 457-3340, Telex 940103 WU PUBTLX BSN

Catalogue for ordering ear tags (# 1 monel) and ear tag pliers can be obtained from:

National Band & Tag Co.
721 York St.
P.O. Box 430
Newport, KY 41072-0430
Telephone (606) 261-2035
FAX (606) 261-TAGS (8247)
Office hours 8-12 and 1-4 EST

Catalogue for ordering weight scales can be obtained from:

Forestry Suppliers, Inc.
205 W. Rankin St.
P.O. Box 8397
Jackson, MS 39284-8397
Telephone 1-800-647-5386
FAX 1-800-543-4203

II. DATA

1. ** Sex
2. ** Age (external genitalia and tail pelage - Taber 1971, Flyger and Gates 1982; see attachments):
   Testicle condition (abdominal, inguinal, scrotal)
   Nipples (small - not pigmented, large - pigmented, lactating - pigmented and swollen)
3. Coat condition (good, average, poor)
4. Mass (g)
5. Ear tag numbers
6. Fate
7. Comments:
   a) overall coat color (e.g., black, silver, light silver)
   b) external parasites (usually fleas, ticks)
   c) eye, ear, and teeth anomalies (e.g., cataracts)
   d) distinctive scars or color patterns (e.g., white forehead, black mask)
8. Site/nest box number
9. Weather conditions

** This information is <u>critical</u> and should always be recorded first.

III. GENERAL PROCEDURE

A fox squirrel can be coerced from a nest box into a cloth cone by opening the nest box door just enough for a hand to be inserted into the bottom of the box to rustle the nest material (with the other hand covering the opening at the top portion of the door, so the animal does not escape by that route). Usually, the animal will exit the box through the squirrel entrance hole and enter the cloth cone.

Once the animal is confined in the cloth cone:

BEGIN WITH THE REAR: Record SEX and AGE characteristics first. Note TESTES CONDITION and NIPPLE PIGMENTATION, and MEASURE TESTES if necessary (see Taber 1971). Genital characteristics are reliable depending on what one is trying to interpret. Once the testes have descended into a pigmented scrotum, that animal is an adult male at least 10-11 months old, and that condition does not change regardless of whether it is the mating season or not. Similarly, a female with pigmented teats has attained a similar age. That pigmentation persists but may fade with the years and become indistinct unless she has additional pregnancies (which she invariably does). So it is possible to determine maturity based on sexual characteristics when these characteristics are distinct. The TAIL PELAGE can also be used to age fox squirrels (see Taber); genital characteristics are not always distinct. Check the TAIL, BODY, and STOMACH AREA for PARASITES and COAT CONDITION and COLOR. Use the clothesline to securely tie the cone at the rear and WEIGH the squirrel (the "hook" at the bottom of the scale should fit into the hole in the zipper lock).

MOVE ON TO THE HEAD: With clothesline secure, or assistant holding the rear of the cone closed, slowly unzipper the HEAD region -- if the opening is too large the animal can easily escape out the front of the cone. Once the head is exposed, CHECK THE EAR TAG NUMBERS (using the hand-held magnifier, if necessary), or EAR-TAG the individual. Ear tags should be attached to the lower, outside portion of the ear and should never be crimped, or closed onto the ear surface (i.e., ear tags should fit like a circular earring, only connecting with the ear surface where they puncture the ear). Otherwise, skin-sloughing can occur, resulting in the loss of all or a portion of an ear.

After ear-tagging, check the EYES, EARS, and TEETH for anomalies. Check for IDENTIFYING CHARACTERISTICS.

The squirrel should be RELEASED BACK INTO THE NEST BOX. This can be accomplished by placing the head into the entrance hole and peeling the zipper back all the way (it may be a tight squeeze, but it works!).

NOTE: AGEING fox squirrels can be difficult, so it is critical that methods are consistent: please record all methods and detailed genital characteristics, particularly for animals which are not obviously adults.

IMPORTANT: Be aware of the status of your animal -- squirrels can quickly go into irreversible shock. Keep a close eye on breathing behavior, and try to constrict the animal as little as possible.

IV. REFERENCES

Flyger, V. and J.E. Gates. 1982. Fox and gray squirrels, *Sciurus niger*, *S. carolinensis* and their allies. Pp. 209-229 *in* Chapman, J.A. and G.A. Feldhammer (eds.): Wild Mammals of North America. Johns Hopkins Univ. Press, Baltimore, MD.

Taber, R.D. 1971. Criteria of sex and age. Pp. 373-381 *in* Giles, R.H. (ed.): Wildlife Management Techniques, Third Edition. The Wildlife Society, Washington, D.C.

FOX SQUIRREL DATA FORM

Site: Weather:
Date: Handlers:

BOX	SPECIES	SEX	AGE	TEST	NIP	COAT	WT. (g)	EAR TAGS		FATE	COMMENTS (EYES, TEETH, COAT, CO PARASITES?)
								L	R		

CODES
SPECIES: DFS=Delmarva Fox Squirrel, GS=Gray Squirrel
AGE: A=Adult/Subadult, J=Juvenile
TESTES: A=Abdominal, I=Inguinal, S=Scrotal
NIPPLES: N=Non-pigmented, P=Pigmented, L=Lactating
COAT: G=Good, A=Average, P=Poor
FATE: 1=New Cap. Released, 2=Recapture Released, 3=New Cap. Removed, 4=Recapture, Removed, 5=New Cap. Dead, 6=Recapture Dead

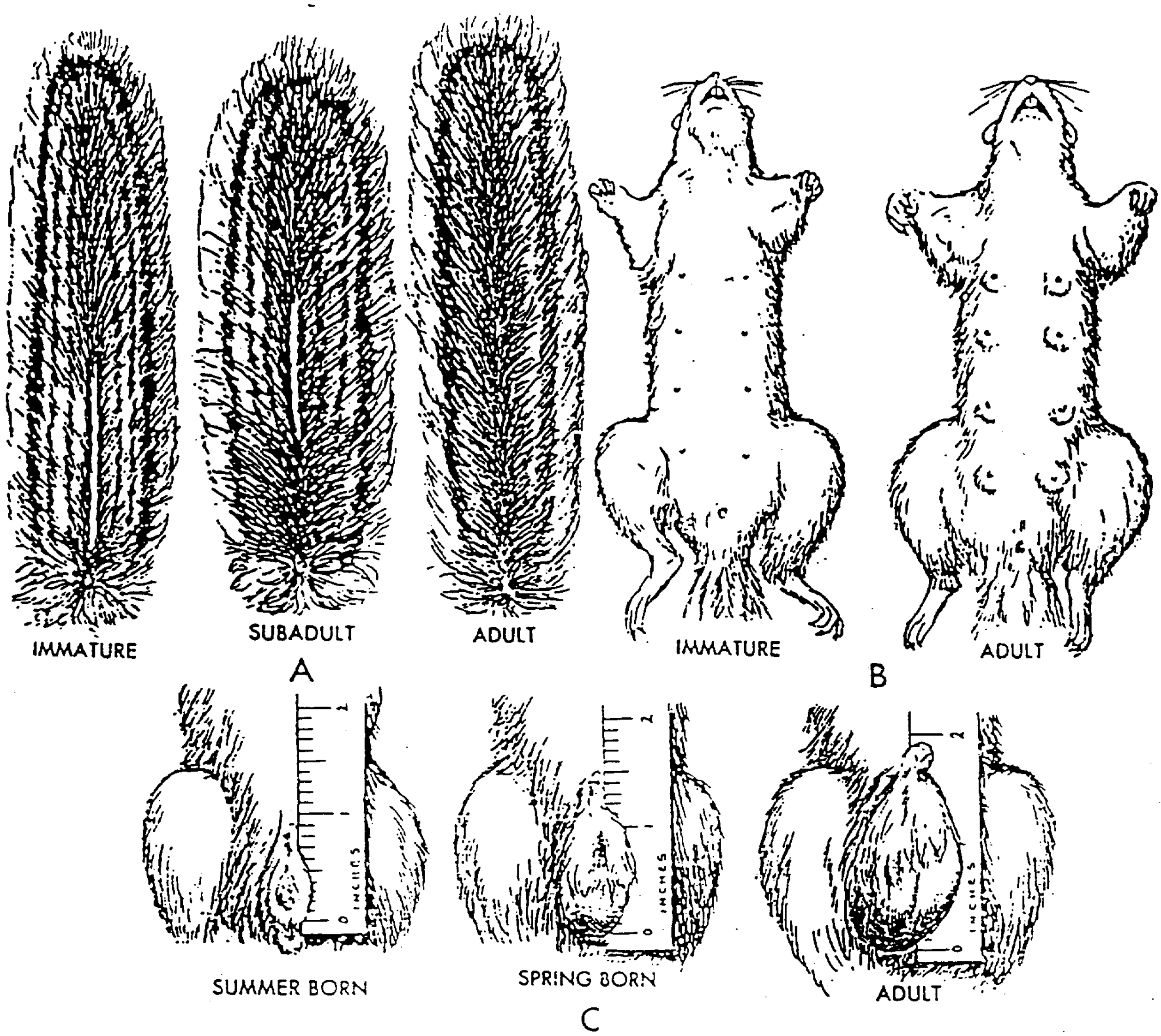


Fig. 20.34. Sex and age criteria for squirrels *A* Age may be determined by examination of the ventral surface of the tail. *Left:* Juvenile, the shorter secondary hairs are absent on the lower side of the tail bone. *Center:* Subadults, short appressed hairs are present on lower third of the tail bone. *Right:* The appressed hairs obscure the outline of the tail bone in the adult (after Sharp 1958). *B* Mastology of the female squirrel. *Left:* Juvenile, with nipples minute and barely discernable. *Right:* Lactating adult, nipples black pigmented with most of hair worn off. *C* Scrotal measurements of male squirrels. *Left:* Summer born, the testes are abdominal and the skin is just beginning to pigment. *Center:* Spring born, the testes are large and the scrotum is pigmented but it is heavily furred. *Right:* Adult has shed most of the fur from the scrotum (after Allen 1943; from Godin 1960).

From: Taber, R.D. 1971. Criteria of sex and age. pp. 373-381, In: Giles, R.H. (ed.), Wildlife management techniques. Third edition. The Wildlife Society, Washington, D.C.

APPENDIX D

Delmarva Fox Squirrel Release Protocol

I. Site selection:

1. Release site should have sufficient acreage of appropriate habitat on-site or contiguous with the site to support a viable fox squirrel population.

2. Release site should be located in an area that allows for dispersal beyond the original release site to accommodate an expanding population.

3. Release site should score above average on Dueser's habitat model.

4. Site should be protected from incompatible habitat alterations for a period of at least 10 years.

5. Access for release and monitoring purposes must be guaranteed by the landowner.

6. Give priority to sites on which squirrel hunting is not allowed.

7. A written landowner agreement should be pursued.

II. Site preparation:

1. Select exact location for release on-site and, if a holding cage is to be used, move holding cage to this location.

2. At least six nest boxes must be available in the holding cage.

3. Food and water should be provided in the holding cage.

4. Place a minimum of 50 nest boxes throughout the forest in which the release occurs and adjacent wooded areas. Boxes should be placed at 100 m intervals.

III. Source animals:

1. Source animals should be trapped from habitat similar to that in which they are to be released (i.e. hardwoods to hardwoods or pine to pine).

2. Source animals should come from at least 2 different populations; source populations should not have been founded by previous translocations.

3. The number of individuals taken from each site should be at a level that will not significantly impact the remaining population, except in situations were the source site is scheduled for timber harvest or land use change.

4. Live traps of sufficient size should be used, baited with corn or an alternative bait.

5. Prebaiting may be considered, but is not essential.

6. Trapping should not occur in adverse weather (e.g., heavy downpours or temperatures, below 40°F or above 85°F).

7. Any lactating females trapped should be released at the point of capture immediately.

8. Upon capture, pack live trap with leaf material to provide shelter for squirrel during transport.

9. Transport squirrel immediately to release cage, if at all possible. If not, hold source animals in a holding cage nearby, then transport to release cage later in nest box.

IV. Release methodology:

1. If possible, process each animal prior to placing in holding cage if a holding cage is being used. Processing includes ear tagging, sexing, weighing, health screening, and radio instrumenting (optional). Refer to handling protocol for details.

2. No more than six individuals should be held in the holding cage at one time, and these animals should be held no longer than two days.

3. Sex ratio of squirrels released should be 1:1 or in favor of females.

4. A minimum of 24 to 30 individuals should be released at a given site within a one year period.

5. On the day of release, ensure that all radio transmitters are working properly.

6. To release: encourage squirrels into nest boxes in holding cage, block entrance to box, move box outside of holding cage, then open door.

7. Preferred season of release is fall. Spring releases may be considered. No releases should occur summer or winter.

V. Post-release monitoring:

1. Monitoring of radio-instrumented animals should occur as frequently as possible during the first 30 days post release, but at least one location per individual should be secured each week. Given the rate of transmitter failure in previous releases, a refinement in transmitter design may increase the accuracy of post-release monitoring. The use of cayenne pepper embedded in silicone is recommended to deter chewing by other squirrels (M.A. Cantrell, in litt., 1992).

2. Radio locations should be obtained at least once a month for the next five months following release.

3. Nest boxes should be monitored during the winter in a manner similar to that used on benchmark sites.

4. Live trapping should occur at least every other spring.

5. All new individuals caught should be ear tagged, sexed, weighed, and screened for health conditions.

6. Five years after the last release, live trapping should be conducted during the spring in an attempt to document breeding (as represented by a lactating female).

7. Eight years after the last release, if the population has not been determined established, live trapping should be conducted to document unmarked individuals in the population.

APPENDIX E

Guidelines for Monitoring Benchmark Sites and Managing Nest Boxes

Monitoring on Benchmark Sites

A total of seven benchmark sites have been identified where Delmarva fox squirrels exist in the remaining historical range of this species:

Maryland	Hayes Farm
	Blackwater NWR -- Jarrett Tract
	Blackwater NWR -- Egypt Road
	Eastern Neck NWR
	Wye Island Natural Resource Management Area
	LeCompte Wildlife Management Area
Virginia	Chincoteague NWR

Six of these sites are in public ownership and the seventh site is privately owned; however, the landowner is interested in protecting the integrity of the Delmarva fox squirrel population present. In order to monitor the status of the population in these core areas, a permanent study area will be established on each site, with uniform sampling methods and systematic censusing adopted. Although each benchmark area is different and thus surveys will not be comparable, these monitoring techniques will provide trend data, production success data, and health data on each population. This data will be collected through a mark-recapture survey composed of a nest box check followed by a trapping effort in the survey unit. The nest box checks and trapping efforts will allow site managers the opportunity to monitor Delmarva fox squirrel health conditions, and will also provide the opportunity for genetic sampling of each benchmark population. This standardized censusing procedure will be implemented in each site by 1993 and will be continued for at least five years.

Each benchmark site manager/staff will identify a block of woodland (50-100 acres in size) which supports an optimum population of Delmarva fox squirrels. Each site manager will then place a minimum of 50 squirrel nest boxes throughout the area, sampling all areas (edge, interior) of the available habitat. Construction plans for nest boxes are included in Attachment 1 of this appendix. Nest boxes will be places approximately 12-15 feet above the ground, in a manner such that the entrance hole is available. The box must be detachable from the tree, as nest boxes must be taken down when boxes are checked. Boxes should be in place early in the year in order to allow squirrels to investigate the boxes' cavities and commence nest building prior to winter checks.

Nest boxes will be checked in mid-winter during the months of January and February. All nest box checks will be conducted between the evening hours of 8:00 p.m. and 4:00 a.m. during periods of cold weather, preferably with snow cover if available. These weather conditions should optimize Delmarva fox squirrel use of nest boxes. Nest boxes must be well-marked, so that locations can be easily found in the dark. Activity, noise, and talking should be kept to a minimum to prevent squirrels from exiting nest boxes prior to checking. Head lamps are suggested to allow use of both hands during nest box removal. A ladder of sufficient length will be utilized to reach the nest box. The entrance hole must be plugged to prevent squirrel escape. The nest box will be taken to the ground, where a catch cage or bag will be utilized to capture the squirrels as they exit the box. A note of caution: nest boxes may hold multiple squirrels, so the entrance hole should be plugged after each squirrel exits. Captured squirrels will then be processed (see tagging and data collection procedures). It is suggested that no anesthesia be used during ear tagging, as monitoring of squirrel recovery will be extremely difficult during night checks. (It is recommended that all persons involved with nest box checks wear light-weight leather gloves to prevent scratches yet allow gentle handling of squirrels. It is further suggested that persons involved with tagging operations should have preventative rabies inoculations, and that all bites be treated with rabies as a possibility.) After data collection and tagging, squirrels should be placed back in the nest box with the entrance hole plugged, the nest box placed back in the tree, and the entrance hole unplugged.

The second portion of this mark-recapture effort will be conducted in the spring. The capture effort will utilize live traps. Traps will be placed in study areas in the immediate vicinity of the nest boxes; a minimum of 50 traps (Tomahawk #106) is recommended. Five days of prebaiting will be required, with daily replacement of bait. The last several days of prebaiting should be conducted with bait placement in the trap, which will be wired open, in order to familiarize the squirrels with entering the traps. Trapping will be conducted for three days following the pre-bait period. No trapping will be conducted when the temperature is below 40°F or with heavy precipitation. Traps will be set at dawn and checked at approximately 10:00 a.m. and 4:00 p.m., and then closed. Trap checks and squirrel releases should be completed prior to dusk to allow squirrels to return to nest or cavity. All untagged squirrels captured will be eartagged and health screened according to established procedures.

The number of squirrels in the sample plot can thus be estimated using the ratio of marked squirrels to unmarked squirrels captured during the two capture methods. This population estimate is developed utilizing the Lincoln/Peterson Indexes for mark recapture and performing regression analysis. By sampling the study area and utilizing these capture methods, each site manager can evaluate population trends and examine reproductive success and survival. Further, the health screening allows the manager to get a general idea of health status, and also permits sampling of blood for genetic monitoring of each benchmark site.

Nest Box Managment Protocol

I. PLACEMENT AND MAINTENANCE

A. Height -- the bottom of the nest box should be 3.4 m (11 ft) minimum to 4 m (13 ft) from the tree base
B. Distance between boxes -- 100 m
C. Set boxes along as straight a line as possible (use a compass bearing)
D. Bearing of box entrance hole -- best if not to the northeast (i.e., direction of prevailing storm winds)
E. Tree size -- not less than 30 cm dbh
F. Reflectors -- to help with location in the dark
G. Number of boxes per site -- 50
H. Status checks -- annual pre-check of nest box condition; should be completed by the end of November (squirrels begin to use boxes in December). Boxes should be checked for open doors, clogged entrances, presence of wasps or bees, holes due to rotten wood, etc.

II. GUIDELINES FOR ANNUAL NEST BOX CHECK

A. Time of year -- Jan/Feb or during coldest extended period
B. Weather conditions -- Must be consistent from year to year. Dueser (unpubl. data) has shown that the largest number of captures occurs when there is at least light precipitation of some kind (preferably snow). This criterion seems to be more important than temperature; it increases the probability of captures in areas where squirrels exist but are not abundant.
C. Temperature -- 28-40° F is probably best; in < 28°F weather, there is a greater risk of squirrels (and handlers!) exhibiting hypothermia.
D. Time of day/night -- to begin not less than one hour after dark (usually 8 p.m. or later) to avoid waking squirrels when approaching boxes, which results in escapes.
E. Number of people -- one or two teams of at least two people(but not more than three) should be adequate to check 50 boxes in one evening if complicated procedures such as blood collection are not being conducted.

III. EQUIPMENT (per team)

A. Squirrel handling supplies (see Appendix B, Capture Protocol)
B. Lightweight 3.4 m (11 ft) or taller aluminum ladder
C. Headlamps and flashlights with extra batteries
D. Wire cutters
E. Clipboard and waterproof data sheets
F. Large rag or towel to plug box hole

IV. HELPFUL HINTS

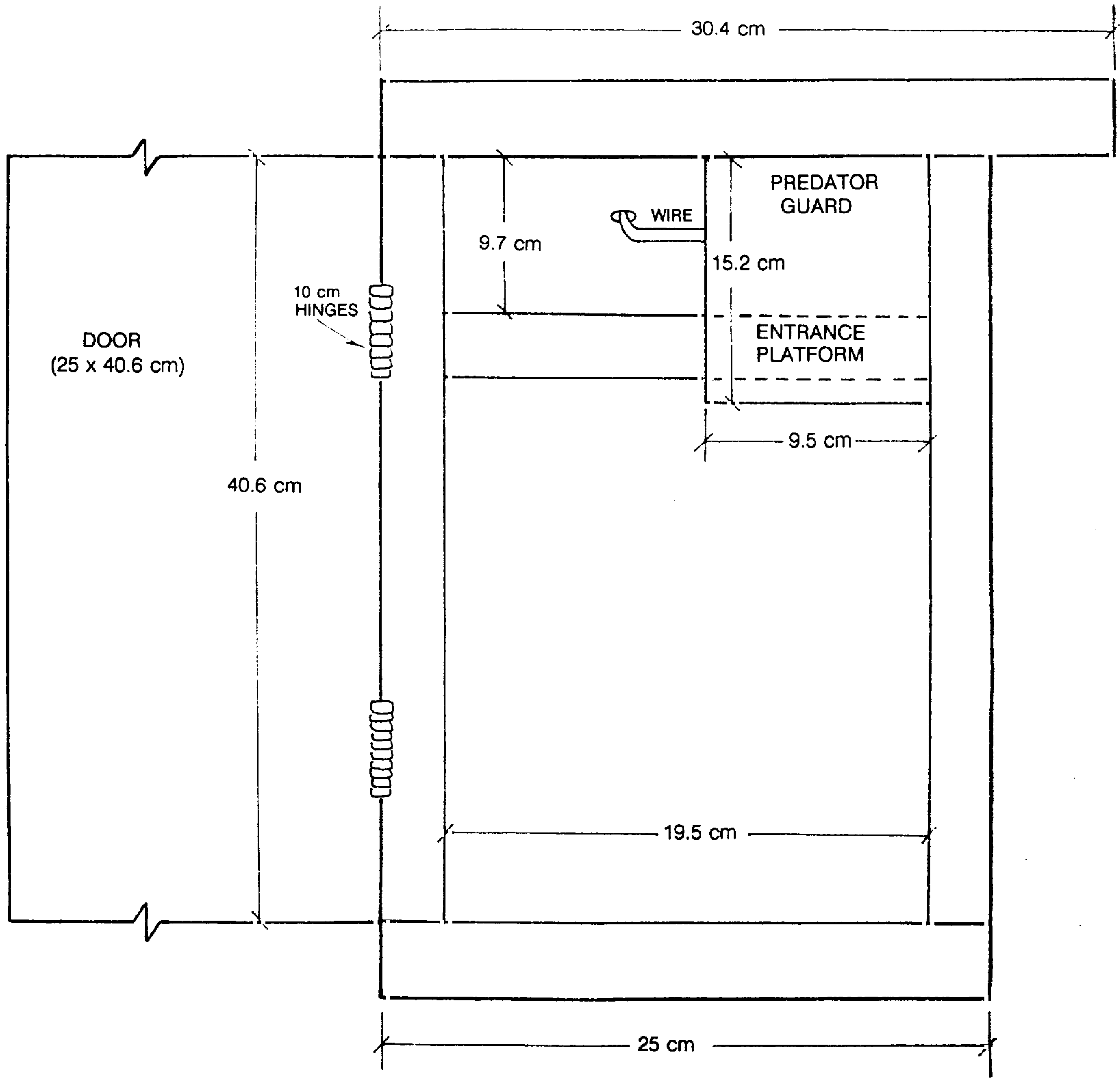
When approaching the nest box:
Avoid talking, keep light as subdued as possible and <u>never</u> direct light at the nest box entrance hole.

When up on the ladder:
Make sure the rag fits <u>tightly</u> in the entrance hole before attempting to carry the nest box down.

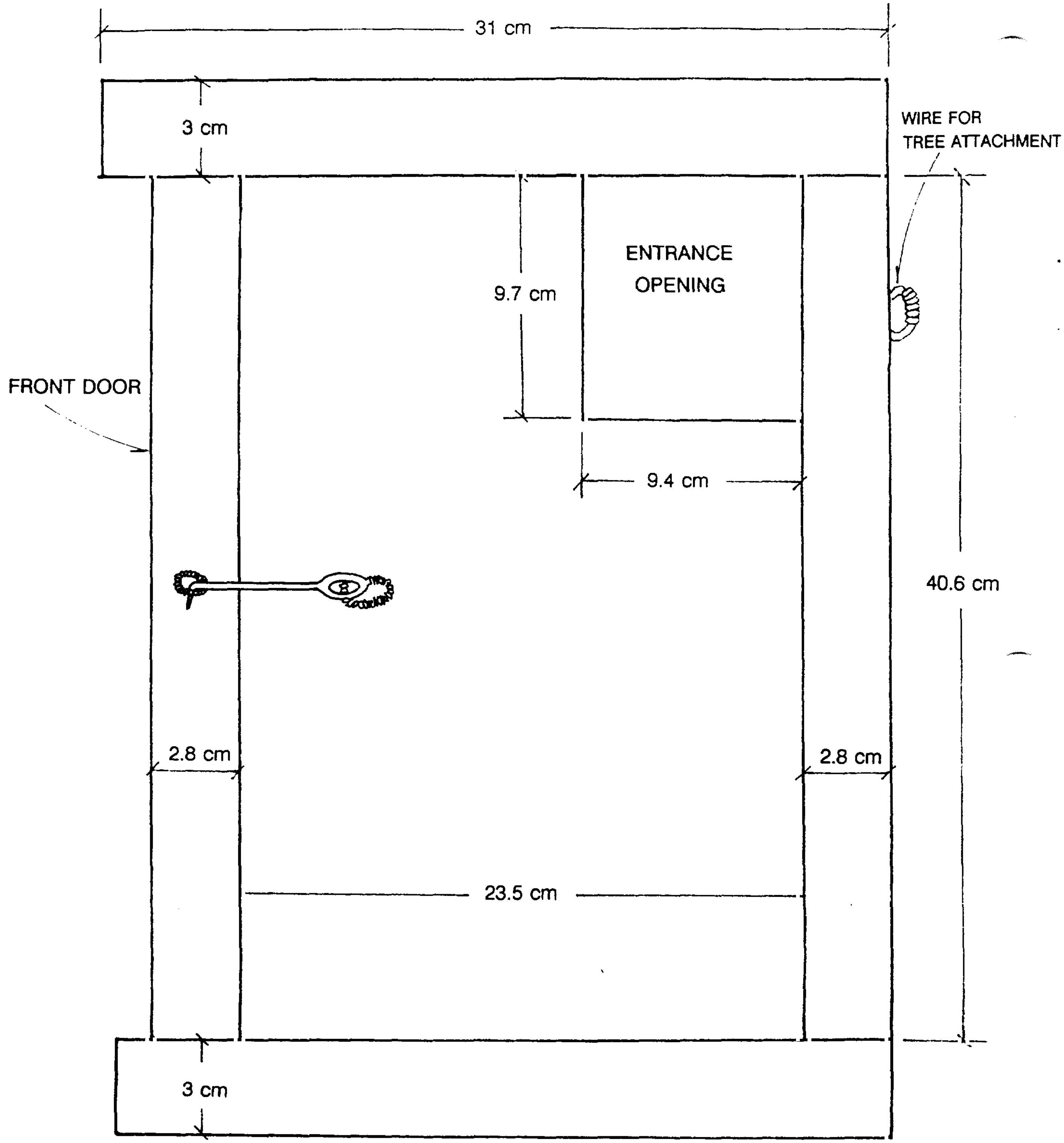
Once the nest box is on the ground:
The same procedure to get the squirrel into the handling cone can be used that is described in the Capture Protocol. It also helps to direct the light of a headlamp at the entrance hole at this point.

Always try to return squirrels to the nest box after handling, particularly in bad weather. Squirrels can be held temporarily in cones while others are being handled.

FRONT VIEW (INTERIOR)



SIDE VIEW



31 cm
3 cm
WIRE FOR
TREE ATTACHMENT
ENTRANCE
OPENING
9.7 cm
FRONT DOOR
9.4 cm
40.6 cm
2.8 cm
2.8 cm
23.5 cm
3 cm

LIST OF WOOD PIECES NECESSARY TO CONSTRUCT BOXES

SIZE (cm)	NUMBER
* 23.5 x 40.6 x 2.8	2 (sides)
31 x 30.4 x 3	1 (top)
31 x 25 x 3	1 (bottom)
25 x 40.6 x 2.8	2 (front and rear)
9.5 x 15.2 x 2.8	1 (predator guard)
9.4 x 19.5 x 3.5	1 (entrance platform)

* width x height x diameter

APPENDIX F

Procedures for Saving Roadkills

Each individual should be placed in a separate ziploc storage bag. The following information should be recorded in soft pencil on stiff paper for each individual and placed inside the bag with the specimen (if the animal is wet or bloody, seal the paper with recorded data in a separate, smaller, ziploc baggy to prevent it from becoming soaked and disintegrating) :

Date of collection: when it was found; **month, date, year**

Locality of collection: where it was found (be as specific as possible, using landmarks on readily available highway maps); use the format: **STATE: County; X mi**les **N**orth or **S**outh, **X mi**les **E**ast or **W**est **specific locality.** For example:

> **MARYLAND: Queen Anne's Co.; 3 mi. S**, 5 mi. **E** Centreville
> **MARYLAND: Dorchester Co.; 2 mi. N**, 3 mi. **W Cambridge**
> **DELAWARE: Sussex Co.; 3 mi. N jct. Hwy 753 and 789**

Note: THE LOCALITY IS THE MOST ESSENTIAL PIECE OF INFORMATION ASSOCIATED WITH THE SPECIMEN. MISSING OR INACCURATE LOCALITY INFORMATION GREATLY REDUCES THE SCIENTIFIC VALUE OF THE SPECIMEN.

Collector: who found it; **first name, last name, address**, and **phone number** (in case information needs to be verified)

Comments: any comments the collector might have, anything unusual about the site at which the animals was found, time of day, weather, etc; e.g., **two other DFS found nearby on the same date**

APPENDIX G

Delmarva Fox Squirrel Habitat Management Guidelines

These guidelines were prepared to assist landowners, biologists, foresters, and land managers in deciding how to conserve appropriate habitat for Delmarva fox squirrels on a given tract of land. These are strictly guidelines, not requirements. It is recommended that consultation be sought with the appropriate endangered species biologist for site specific recommendations.

Since loss of mature forest habitat is the primary threat to the Delmarva fox squirrel, the protection of some appropriate habitat is necessary. However, total habitat preservation is not essential.

Guidelines for timber harvesting:

1. At least 15 to 25% of suitable Delmarva fox squirrel woodlands should remain unharvested on-site for large timber operations. If this is not possible, there should be appropriately protected habitat adjacent to the site.

2. A minimum of 10 acres of suitable Delmarva fox squirrel habitat should remain unharvested on small timber operations.

3. If possible, the habitat to be retained should occur as a contiguous block of woodland.

4. Forested nontidal wetlands, buffers along streams or wetlands, or other required forest retention areas may be considered if the habitat is suitable for Delmarva fox squirrels.

5. Preference for habitat retention should be given to those forest stands in the sawtimber size class not considered overmature.

6. Preference for habitat retention should be given to those wooded areas adjacent to agricultural lands.

7. For selective harvesting or timber stand improvement (TSI), den trees and trees with leaf nests should be retained. Also, 1 or 2 large beech trees per acre should be retained.

Guidelines for habitat improvement:

1. Release mast producing trees such as oaks, hickories, and beech with timber stand improvement techniques.

2. Thin or remove undesirable understory shrubs.

3. Leave 2 to 3 rows of unharvested corn around field edges.

Guidelines for residential development:

1. At least 25% of forested acreage should remain undeveloped on-site, with a minimum of at least 10 acres retained. If this is not possible, there should be appropriately protected habitat adjacent to the site.

2. As much contiguous wooded acreage as possible should be retained.

3. Required forested buffers, such as buffers along streams or nontidal wetlands, should be expanded to at least 100 ft and preferably 300 ft in width.

4. Retention of mast producing trees such as oaks, hickories, and beech should be encouraged.

APPENDIX H

Release sites localities and
localities of source sites for each release:

Note: Specific localities will follow format shown in Appendix E.

1) **Release:** Poplar Neck (Remington Farms in 1983 plan)
   Specific locality: Kent Co., 4 mi. S, 3.25 mi. W Fairlee
   Source: Blackwater NWR (Wildlife Trail Woods)
   Specific locality: Dorchester Co., 3.5 mi. S Church Creek

2) **Release:** DeBlasio Tract
   Specific locality: Kent Co., 3 mi. S, 2 mi. W Fairlee
   Source: Blackwater NWR (Kentuck Swamp)
   Specific locality: Dorchester Co., 3.5 mi. S Church Creek

3) **Release:** Quaker Neck (Chestertown in 1983 plan)
   Specific locality: Kent Co., 0.75 mi. N, 2.5 mi. E Pomona
   Source: Wye Island
   Specific locality: Queen Anne's Co., 5 mi. SW Wye Mills

4) **Release:** Dryden Farm
   Specific locality: Somerset Co., 4.5 mi. W, 0.25 mi. S Pocomoke City
   Source: E.S. Adkins Woods
   Lewis Farm
   Blackwater Farms
   Hayes Woods
   Specific locality: Dorchester Co., 2.5 mi. SW Buckton

5) **Release:** Eby Farm
   Specific locality: Somerset Co., 3.5 mi. W, 0.25 mi. S Pocomoke City
   Source: Russell Baker Farms - New Bridge Road - 3 mi. W Vienna
   LeCompte WMA - Steele Neck Road - 3 mi. W Vienna
   Edgar Farm - Maple Dam Road - 5 mi. S Cambridge
   Specific locality: Dorchester Co., see source locations

6) **Release:** Fairhill
   Specific locality: Cecil Co., 2 mi. E, 1.25 mi. N Fairhill
   Source: Blackwater Farms - Kentuck Swamp
   Bowman Farms - Kentuck Swamp
   Brown Farm - Kentuck Swamp
   Specific locality: Dorchester Co., 2.5 mi. S Church Creek

7) **Release:** Riggin Farm
   Specific locality: Somerset Co., 3 mi. E Wellington
   Source: Russell Baker Farm - New Bridge Road
   LeCompte WMA - Steele Neck Road
   Specific locality: Dorchester Co., 3 mi. W Vienna

8) **Release:** Jarvis Farm
Specific locality: Worcester Co., 2 mi. E, 1.5 mi. N Stockton
Source: Chespeake Woods - Greenbrier Swamp
E.S. Adkins - Greenbrier Swamp
Robert Hayes - Greenbrier Swamp
Specific locality: Dorchester Co., 2 mi. SW Buckton

9) **Release:** Nassawango
Specific locality:Worcester Co., 1.75 mi. W 0.5 mi. S Snow Hill
Source: Russell Baker Farm
Specific locality: 3 mi. W Vienna

10) **Release:** Hazel Farm
Specific locality: Wicomico Co., 1.5 mi. N, 4 mi. W Allen
Source: ?
Specific locality: ?

11) **Release:** Harmony
Specific locality: Caroline Co., 2.5 mi. N, 0.5 mi. W Harmony
Source: ?
Specific locality: ?

12) **Release:** Andelot Farm
Specific locality: Kent Co., 3.5 mi. N, 3.5 mi W Worton
Source: ?
Specific locality: Dorchester Co., Queen Anne's Co.?

13) **Release:** Chincoteague
Specific locality: Accomack Co., Assateague Island
Source: Blackwater
Specific locality: Dorchester Co., ?
Source: Eastern Neck
Specific locality: Kent Co., Eastern Neck NWR

14) **Release:** Brownsville Farm
Specific locality: Northampton Co., 2 mi. E Nassawadox
Source: Chincoteague
Specific locality: Accomack Co., Assateague Island

15) **Release:** Assawoman
Specific locality: Sussex Co., ?
Source: Blackwater
Specific locality: Dorchester Co.,
?

16) **Release:** Prime Hook
Specific locality: Sussex Co., ?
Source: Blackwater
Specific locality: Dorchester Co., ?

17) **Release:** Chester
Specific locality: Chester Co., ?
Source: Various
Specific locality: Dorchester Co., ?
Source: Wye Island
Specific locality: Queen Anne's Co., ?

APPENDIX I

List of Reviewers
for Second Revision DFS Recovery Plan

Lloyd Alexander
Delaware Division of Fish and Wildlife
P.O. Box 1401
Dover, DE 19903

Glenn Carowan, Jr.
Blackwater National Wildlife Refuge
2145 Key Wallace Drive
Cambridge, MD 21613

Dr. Jack Cranford
Department of Biology and Museum of Natural History
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Dr. Raymond D. Dueser
Department of Fisheries and Wildlife
College of Natural Resources
Utah State University
Logan, UT 84322-5210

John W. Edwards
Department of Forestry
Clemson University
Clemson, SC 29634

Mike Fies
Virginia Department of Game and Inland Fisheries
1229 Cedars Court
Charlottesville, VA 22903

Dr. Vagn Flyger
Department of Animal Sciences
University of Maryland
College Park, MD 20742

Lisa Gelvin-Innvaer
Delaware Division of Fish and Wildlife
P.O. Box 1401
Dover, DE 19903

Thomas Goettel
Eastern Neck National Wildlife Refuge
Route 2, Box 225
Rock Hall, MD 21661

Dr. Charles Handley
MRC-NHB108 (Mammals)
Smithsonian Institution
Washington, D.C. 20560

Jerry Hassinger
Box 174
Elizabethville, PA 17023

Dr. Nicholas Holler
Alabama Cooperative Fish and Wildlife Unit
331 Fuchess Hall
Auburn University
Auburn, AL 36849-5415

George F. O'Shea
Prime Hook National Wildlife Refuge
Route 3, Box 195
Milton, DE 19968

John Schroer
Chincoteague National Wildlife Refuge
P.O. Box 62
Chincoteague, VA 23336

Dr. Michael A. Steele
Department of Biology
Wilkes University
Wilkes-Barre, PA 18766

Dr. Phil Tappe
Department of Forest Resources
University of Arkansas, Monticello
Monticello, AR 71655

Dr. Gary Taylor
International Association of Fish and Wildlife Agencies
Suite 534
444 N. Capitol Street, N.W.
Washington, D.C. 20001

Dr. Peter Weigl
Department of Biology
Wake Forest University
Winston-Salem, NC 27109

Guy W. Willey, Sr.
101 East Appleby Avenue
Cambridge, MD 21613

John Wolflin
U.S. Fish and Wildlife Service
Annapolis Field Office
1825 Virginia Street
Annapolis, MD 21401