PRESENT STATUS AND HABITAT SURVEY OF THE DELMARVA FOX SQUIRREL (*SCIURUS NIGER CINEREUS*) WITH A DISCUSSION OF REASONS FOR ITS DECLINE

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ABSTRACT

Although the Delmarva fox squirrel was once distributed through southeastern Pennsylvania, Delaware, the Eastern Shore of Maryland, and two counties in Virginia, it now occurs only in portions of four Eastern Shore counties in Maryland. This study has shown that the Delmarva squirrel prefers forest habitat areas with an open understory. This trait has also been demonstrated for other subspecies of fox squirrels. It is postulated that lumbering and development have been major determinants in reducing the numbers of the Delmarva fox squirrel.

INTRODUCTION

The Delmarva fox squirrel, *Sciurus niger cinereus*, is a large, grayish colored tree squirrel, inhabiting the State of Maryland. Extinct over most of its former range, it is now confined to portions of four counties on the Eastern Shore of Maryland. The Delmarva squirrel has also been introduced onto Chincoteague Island, Virginia, a Federal Wildlife Refuge. This particular subspecies of the fox squirrel has been placed on the rare and endangered list by the United States Department of the Interior (1970). The State of Maryland has prohibited hunting of this squirrel since 1971, and has established a game refuge for it, south of Vienna, in Dorchester County. It also occupies two Federal refuges. Nevertheless, this animal faces total extinction unless more positive actions are developed to prevent it.

HISTORY

The Delmarva squirrel once ranged through Delaware and the eastern shore of Maryland, plus Chester, Delaware, and Lancaster counties in Pennsylvania (Poole 1944). Paradiso (1969) also indicates its occurrence in Northern Virginia, in Northampton and Accomack counties. There is also some evidence to indicate that this subspecies was once found in parts of New Jersey (Rhoads 1903). The type specimen of this subspecies comes from near Wilmington, Delaware, collected around 1865 (Poole 1944). Rhoads (1903), indicates that by the turn of the twentieth century, this squirrel had been exterminated in New Jersey, and was found only occasionally in the Pennsylvania counties bordering the lower Susquehanna River. Poole (1932), an authority on Pennsylvania mammals, suggested that the Delmarva squirrel was extremely rare in Pennsylvania after 1906. No information has been found pertaining to the final observation of this squirrel in Delaware, but this subspecies was probably not common in Delaware or Pennsylvania after 1900.

A meaningful deduction concerning the former distribution of the Delmarva squirrel can be made from the literature. Evidence from the literature indicates that the distribution of this squirrel has always been patchy, and discontinuous. This pattern of distribution seems to conform with the distribution of other eastern fox squirrel subspecies, and is exemplified by the relatively large number (six) of subspecies found in the eastern United States (Hamilton 1943).

The present range of the Delmarva subspecies was determined in 1971 by conducting personal interviews with game officials and landowners who were familiar with the squirrel. It was learned that this squirrel is now confined to portions of Kent, Queen Annes, Talbot, and Dorchester counties in Maryland. (Figure 1). Once again, its spotty distribution was demonstrated but nowhere was the population found to be numerous.

Little is known about this animal and no one has attempted to estimate the size of the total remaining population. Prior to the 1971 survey, most authorities agreed that its numbers were rapidly declining. Dr. Vagn Flyger at the University of Maryland, characterizes the Delmarva squirrel as threatened with imminent extinction (personal communication). Frequent comments elicited during the 1971 survey emphasized that, while up to 15 to 20 years ago the squirrel was still fairly prevalent, its presence now is only marginal in a few areas.

The 1971 survey yielded another important point. With the exception of one area, a Federal refuge, the Delmarva squirrel does *not* occur anywhere to the exclusion of the gray squirrel, *S. carolinensis*. This will be elaborated on later.

Little has been published concerning the habits and habitat of the Delmarva squirrel. Abbott (1890:500), writing about the squirrel in New Jersey, says, "They seem to prefer a clump of large, shell bark hickories, with open ground

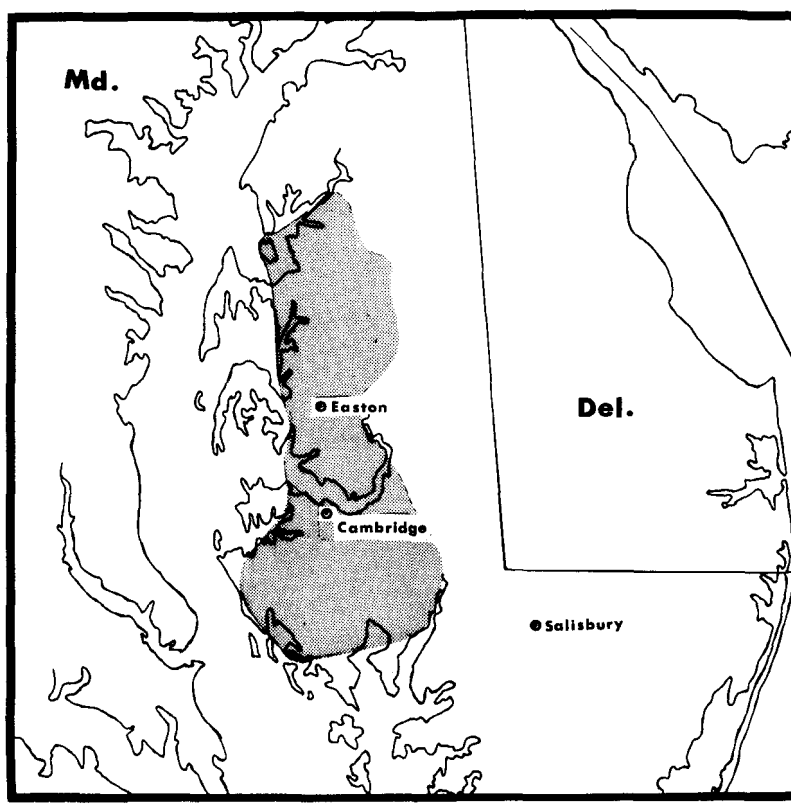

Figure 1. Area included in the range of the Delmarva fox squirrel, according to the 1971 survey.

about them". Rhoads (1903) states that they are more terrestrial than the gray squirrel, less agile, and perhaps more partial to swampy ground than the gray. Poole (1932), comments that these squirrels are perfectly at home on the ground. Dozier and Hall (1944:5), concluded that the Delmarva preferred "...old growth loblolly pine (*Pinus taeda*) forests where an abundance of their preferred food, the seeds of these trees, is available. They are also found in deep deciduous swamps or backwoods but nearly always close to or adjacent to pine woods." Rhodes (1971, unpublished data), in a study on the Blackwater National Wildlife Refuge in Dorchester County, Maryland, indicates that this squirrel prefers open stands of large pine with little undergrowth and a close proximity to water. Flyger (personal communication) indicates that these squirrels are frequently observed up to 0.5 miles from the nearest woods feeding on agricultural crops. This observation has been borne out by myself and several other workers familiar with this species. During field work in 1972 and 1973, I observed, that, unlike the gray squirrel, the Delmarva squirrel does not immediately retreat to the safety of the trees when startled. Rather, it will remain on the ground, retreating for a few yards, and then stopping. Only if it is pressured will it take to the trees, and even then it seldom scurries to the top, a trait so characteristic of the gray squirrel. The Delmarva squirrel has also been observed to use the ground as an escape route if an attempt to shoot it out of a tree fails (Flyger, personal communication). The gray squirrel, however, utilizes the tree crowns as an escape.

Published data on the habitat of other subspecies of fox squirrels and gray squirrels is substantial. All observations indicate that fox squirrels prefer small woodlots with little undergrowth and much edge; in contrast, gray squirrels prefer large, densely forested areas. Allen (1943), describes the "ideal" fox squirrel habitat in Michigan as mature, oak-hickory woodland, broken into small units with maximum edge, and connected by small wooded strips serving as squirrel travel lanes. Many such woodlots are adjacent to fields used for growing agricultural crops. The oaks and hickories, he says, are varied with food producing trees of other woodland types, such as elm, beech and maple. Baumgartner (1943) describes the fox squirrel habitat in Ohio as consisting of small, isolated farm woodlots of five to three hundred acres, the larger comprising several small woodlots. He states that, in the larger areas, fox squirrels live in and along the forest and on open ridge tops. Species composition of the habitats is variable, but mostly oak-hickory. Baumgartner points out that wooded ravines and streams make good travel lanes between small, isolated woodlots. Chapman (1938) contrasts the habitat of the fox squirrel with the habitat of the gray squirrel in Ohio. The gray squirrel habitat there consists of heavily forested tracts and lies on a rugged, hilly, unglaciated portion of southern Ohio. The forest vegetation, he continues, is chiefly oak-hickory. He concludes that approximately ninety percent of the gray squirrel habitat in Ohio is forested, while only ten percent is in open areas, such as farm land. Nixon and Donohoe (1968) support these observations in a later paper. Goodrum (1938), working in Texas, observes that gray squirrels exhibit a distinct preference for lowland, poorly drained areas, while fox squirrels prefer upland creeks and well drained bottom-lands. He contends that drainage of low, bottom-land contributed to the decline of the gray squirrel. He suggests that in areas where drainage has occurred, fox squirrels have prospered at the expense of the grays. (It should be noted that these effects on the distribution of the squirrels is a result of the vegetation, not the direct effect of water). Large, unborken forests of bottom-lands must be conserved if gray squirrels are to remain, he concludes. In Illinois, Brown and Yeager (1945) observed that fox squirrels are found on farm and forested areas, and in cities and villages. Outside of some urban communities, gray squirrels are restricted to heavily wooded areas, generally to those

having abundant ground cover and brushy understory. They divide Illinois into two distinct types of habitat. One type, the black prairie habitat, is overwhelmingly agricultural with small woodlots, wooded streams, fencerows and hedgerows, and farmyards with scattered trees or groves. In these areas, they say, the fox squirrel occurs exclusively, except in a few villages. The other type of Illinois squirrel habitat is the woodland type, which has a vastly larger total wooded area and much larger wooded tracts than the former. Both species inhabit this second type, they conclude, but the grays are restricted to areas having heavy forest cover. Seton, as quoted in MacClintock (1970) says that fox squirrels inhabit groves of timber interspersed with open country; the oak "islands" of the Mid-western states between forest and prairie, and the wooded streams of the prairie are ideal fox squirrel habitat. He concludes that dense, mature, hardwoods are preferred by the Eastern gray squirrel. Madson (1964:10) describes the fox squirrel's habitat as one characterized by open timber and small groves. In contract, he notes that the gray squirrel is commonly found in big forests with mature hardwoods, with "understories of smaller trees and shrubs, where the trees are dense enough so that the squirrel can easily travel through the crowns". Bakken (1952) found a highly significant correlation between the percentage of Wisconsin counties in timber and the ratio of gray squirrels to fox squirrels. As the percentage of a county in timber increased, the ratio of gray to fox squirrels increased. He also determined that as the percentage of salable timber in the counties increased, the gray to fox squirrel ratio decreased. Bakken's results suggests again that fox squirrels prefer small woodlots of large, open timber. Fox squirrels in Georgia, according to Golley (1962:100), occur in both hardwood and pine woodlands, "where they appear to be more tolerant of open conditions than are the gray squirrels." The gray squirrel, he continues, is found primarily in hardwood forests of oak-hickory composition. In southwestern Georgia, gray squirrels are restricted to hardwood bottom-lands, whereas the fox squirrel is most common in the pine uplands. Finally, Smith and Follmer (1972:88) observed that "on the University of Missouri golf course, fox squirrels nest and forage in the trees scattered between fairways, and gray squirrels nest and forage in the dense woods surrounding the course."

Thus the literature well supports the coexistence of gray and fox squirrels in the same habitat. Bakken (1952) concludes that fox and gray squirrels essentially overlap in ranges, except in the northeastern United States. There is a sixty-seven percent overlap of the fox squirrels range with the gray squirrels, while eighty-eight percent of the gray squirrel range overlaps the fox squirrel range. In the Southeastern United States, the two species inhabit separate but adjoining habitats, he observes. Where ecological differences between the two species are less marked, they inhabit the same area, but tend to be more abundant in slightly different habitats. Overlap of preferred habitat, he states, depends on the topography of the land, the plant composition, tree density, and the size of timbered areas. Coexistence occurs where habitat utilization overlaps or along edges of adjacent habitats, exclusive to each species. Coexistence is most evident, Bakken concludes, in the western and northern portions of the range of both species.

METHODS OF DESCRIBING THE HABITAT OF THE DELMARVA SQUIRREL

During the latter half of 1972 and the first half of 1973, a survey was made of the present habitats of the Delmarva squirrel. From the 1971 range study, areas were chosen where it was determined that both the Delmarva squirrel and the gray squirrel were present, and areas were chosen where the gray squirrel occurs

exclusive of the fox squirrel. Fifty study areas were chosen at random from the previously acquired distribution data, and characterized in the manner described below.

At each site, one transect of 200 meters long by four meters wide was described. A transect was conducted in an area selected to be representative of the entire stand of trees, chosen by examining the stand first (for example, in a mixed deciduous-coniferous stand of trees, I did not choose an area of pure pine in which to conduct the transect, although its presence might have been recorded.) Exceptions to this occurred when it was known that the Delmarva squirrel was concentrated in one area of the woodlot. One transect was chosen since preliminary tests indicated that there was no significant difference (at the 5% level) between one, two, and three transects taken in the same locality.

In each transect, the number of individuals of each tree species, in four different classes of tree size, was recorded. Those classes included 2 to 7.9 inches diameter at breast height (d.b.h.), 8 to 11.9 inches d.b.h., 12 to 19.9 inches d.b.h., and greater than 20 inches d.b.h. Canopy cover (percentage of overstory) was subjectively estimated by approximating the amount of light obscured by the canopy foliage. The amount of understory growth from ground level to four meters in height was estimated by evenly distributing twenty white, metal discs (one every ten meters) in a random direction on the transect line. The ratio of "covered" to "uncovered" discs was calculated and multiplied by one hundred to serve as a measure of the percentage of understory cover. A subjective estimate of the density of the understory was made by rating the difficulty of traversing the transect into one of four classes: easy, moderate, moderately difficult, and difficult. The presence or absence of water, and its nature, either standing or running, was recorded and the use of land adjacent to the woodlot in which that transect was located was indicated. Precision instrumentation was sacrified for greater coverage of the Delmarva species range, in a reasonable amount of time. Emlen (1956) successfully employed a similar method in describing avian habitats.

I felt that these parameters adequately measured those factors which might be important in determining the presence of the Delmarva squirrel.

DISCUSSION OF RESULTS AND REASONS FOR THE DECLINE OF THE DELMARVA SQUIRREL

The results of the study appear in Table 1. An examination of the table readily reveals that the most apparent difference among the parameters studied was in the percentage understory. In areas with both the Delmarva squirrel and the gray squirrel, the mean percentage understory was 29.7±3.8 percent, while in areas inhabited solely by the gray squirrel, this value was 71.5±4.9 percent. A test of equality of means (Sokal and Rohlf 1969) indicated a highly significant difference between the two areas. ($P < 0.001$). The difference between these values is certainly biologically significant, since it indicates the presence of very little undergrowth in one area and the presence of a good deal of understory vegetation in the other. The amount of understory in the habitat of the Delmarva squirrel agrees well with the published findings on other subspecies of *S. niger*.

The comparison between the two habitat areas of the percentage of tree species of greater than 12 inches d.b.h. was also significant ($P < 0.05$). A test of the percentage of overstory, an indicator of tree size, was again significant ($P < 0.01$). The abundance of larger trees in the habitat of the Delmarva squirrel appears to have biological implications. The higher percentage of trees greater than 12 inches d.b.h. in locations containing both gray and fox squirrels (32.1±2.8 percent) compared to the locations containing only gray squirrels (23.1±2.7 percent) suggests a trend toward larger trees in areas of fox squirrel

inhabitation. Certainly, large trees are necessary for the continued existence of either of these two species since they provide den and nesting sites, as well as sustained yields of mast (Colin 1957). Other workers, however, have observed that fox squirrel habitats exhibit larger tree sizes than do gray squirrel habitats. This work tends to support this trend.

Table 1. Comparison of Habitat Parameters Between Areas With Fox and Gray Squirrels(A) and Areas with Gray Squirrels Only(B).

Site	Percentage of Trees Greater than 12 inches d.b.h.	Percentage Overstory	Percentage Understory	Percentage of Coniferous Trees
A				
3	39.0	90.0	45.0	tra
4	45.5	85.0	50.0	15.0
5	47.0	85.0	20.0	8.0
7	14.0	95.0	20.0	4.0
8	32.5	90.0	30.0	16.0
12	35.5	85.0	20.0	3.0
13	22.0	80.0	25.0	6.0
14	23.0	80.0	20.0	38.0
16	26.5	85.0	15.0	tr
17	18.0	95.0	20.0	15.0
18	47.0	80.0	30.0	36.0
21	26.5	90.0	20.0	26.5
22	59.0	80.0	45.0	13.5
23	26.0	75.0	60.0	3.0
24	30.0	70.0	60.0	16.5
25	30.0	90.0	15.0	30.0
27	25.0	85.0	10.0	tr
$\bar{x}$ ± S.E.	32.14 ± 2.89	84.70 ± 1.63	29.70 ± 3.89	13.73 ± 3.00
B				
1	24.0	75.0	85.0	6.0
2	15.0	55.0	80.0	tr
6	40.0	85.0	50.0	tr
9	36.5	85.0	80.0	tr
10	25.0	95.0	80.0	tr
11	31.5	80.0	65.0	3.5
15	16.0	80.0	60.0	3.0
19	19.0	65.0	35.0	45.5
20	30.0	50.0	80.0	54.5
26	12.0	45.0	85.0	21.5
28	21.0	65.0	95.0	36.0
29	25.0	55.0	85.0	19.0
30	6.0	80.0	50.0	2.0
$\bar{x}$ ± S.E.	23.15 ± 2.70	70.38 ± 4.30	71.53 ± 4.90	15.00 ± 5.20

a trace = < 1%. In the calculation of x, trace was figured as 1%.

The comparison of the percentages of coniferous tree species of the two squirrel habitats yielded a value of $p > 0.5$, indicating no significant difference in the ratio of the coniferous to deciduous composition of the two habitats. This result apparently clears up a much contested point. Dozier and Hall (1944), and others, have suggested that the Delmarva squirrel prefers stands of loblolly pine. This work does not support these views. In addition, an interesting correlation can be made with the past distribution of this squirrel, and the distribution of loblolly pine. As previously indicated, the Delmarva subspecies was formerly distributed in southeastern Pennsylvania, in the drainage of the lower Susquehanna River. Braun (1950) indicates that the loblolly pine was never distributed that far inland. The loblolly, she says, is one of the major components of the Oak-Pine forest region, which is transitional between the central deciduous forest and the evergreen forests of the Southeast. On the Coastal Plain of Maryland, Delaware, and New Jersey, this forest region is prevalent. However, over southeastern Pennsylvania and northern Maryland in areas which are included in the former range of the Delmarva squirrel, the Oak-Chestnut forest region is prevalent. Oaks - red oak, white oak, chestnut oak, and scarlet oak - are the principal components, along with hemlock and white pine in some of the secondary communities. Until the blight, early in this century, chestnut was also a constituent of most of the oak communities in this forest region, according to Braun. Sargent (1933) indicates the distribution of the loblolly pine to be from Cape May, New Jersey, through southern Delaware and eastern Maryland, south, Thus, the apparent association of the Delmarva squirrel with loblolly pine in Maryland is evidently related to the scarcity of understory growth in stands of trees of predominantly coniferous nature. The squirrel indeed utilizes the seeds of the loblolly species, but apparently not to the exclusion of seeds and fruits of deciduous trees.

The present distribution of the Delmarva squirrel appears to be closely associated with the presence of water. Many areas of its distribution are situated in lowland, swampy areas, or adjacent to creeks and tributaries running into the Chesapeake Bay. There are three possible explanations for this. First, Rhodes (1903), suggested that the Delmarva squirrel was more partial to swampy areas than the gray squirrel. Certainly, in its former distribution, it was closely associated with water on the Coastal Plain of New Jersey and Delaware, and in the drainage of the Susquehanna River. Again, though, the effect of water is probably indirect, through its effect on the vegetation of the area. Second, the difficulty in reaching these areas might forestall the logging of the timer in these areas. And, third, many of the tributaries of the Chesapeake Bay are bordered by large, agricultural estates. The majority of these are, and have been, closed to public hunting. In addition, landowners have been reluctant to sell their timber, so that stands of large trees remain.

Maryland's Eastern Shore has been and remains largely an agricultural region. The most prevalent crops include corn, soybeans, and a winter grain. Consequently, as agriculture was introduced into the Eastern Shore, and the Eastern United States in general, it opened up the large, almost continuous, deciduous forest that covered the east coast. As a result, the Eastern Shore of Maryland consists to a large extent of small woodlots scattered among fields of crops, and bordering the many small creeks on the Coastal Plain. Agriculture has the effect of producing many ecotones. Why this development has not been beneficial to the fox squirrel, instead of detrimental, is indeed puzzling.

Allen (1943) indicates that settlement and agriculture work to the fox squirrel's advantage and the gray squirrel's detriment. He indicates that as the thinning of the huge eastern forest was accomplished, the gray squirrel, once prevalent over the entire eastern states, was gradually replaced by the fox squirrel. Fox squirrels now inhabit the entire lower half of the southern peninsula of Michigan, where they were unknown before the 1850's (Allen 1943). The

cycle, however, appears to be now returning to the gray squirrel. In the Kellogg Bird Sanctuary, where Allen did much of his classic work on fox squirrel management, Johnson (1973) indicates that gray squirrels now outnumber the fox squirrels. The woodlot there has become overgrown and the gray squirrels have replaced the fox squirrels. Why the opening up of Maryland's Eastern Shore has not benefitted the Delmarva squirrel is presently unresolved.

Before speculating on reasons for the decline of the Delmarva subspecies, I would like to comment on the observed preference of fox squirrels for open stands of timber. This apparent preference in habitat is essentially all that is segregating these two species in certain areas. This argument is defended by an examination of the literature. Gray and fox squirrel ranges do overlap, as indicated earlier, and where they do, the fox squirrels exhibit a preference for open woods (Bakken 1952, Johnson 1973). Bakken postulates that if there had been a competition for resources in the evolution of these two species, they would have evolved ecological distinctions, or ecologically distinct ranges. They haven't.

Food and nesting sites are the two most important considerations for squirrel inhabitation (Colin 1957). In a recent paper, Smith and Follmer (1972:88) have determined that gray and fox squirrels showed similar preference for a number of different natural foods. They postulated that if food preference be used as a basis of niche differentiation, then each species should select foods on which it was more efficient, thus reducing the energy output by the species for the amount of energy obtained. No basis for this conclusion, however, exists from their observations. They conclude that "there is no evidence of any differential abilities in food utilization that might be of competitive significance." Nixon, Worley, and McClain (1968) state that gray and fox squirrels are considered to have similar food habits especially when they coexist. Brown and Yeager (1945) point to a great similarity in the two species where food habits are concerned.

Thus, the available knowledge indicates that in areas of coexistence, the preference for an open understory allows gray and fox squirrels to coexist in the same habitat. What is the reason for this observed preference? There is some evidence to indicate that predation may have been at least a partial determinant of this. It has been previously stated that fox squirrels are more terrestrial and less agile than the gray squirrel. These traits could conceivably increase the vulnerability of fox squirrels to predatory attack. Most authorities agree that man exerts, at present, a major influence on squirrel numbers. Brown and Yeager (1945) suggests that natural predation has little effect on squirrel numbers. They state that adult squirrels, especially the gray, are too active and alert to be taken. Keith (1956), however, presents evidence that predatory birds (various species of hawks and horned owl, especially) and fox, coyote, bobcat, and mountain lion are successful in capturing squirrels. Raccoons may take a substantial number of young (Flyger, personal communication). However, before man's widespread influence on natural exosystems, there was certainly a greater influence of natural predation on squirrel abundance than is observed now. The terrestrial fox squirrel, less agile than the gray, would be at a considerable disadvantage in a forest with a brushy understory. Ambushing is an often observed method of attacking by foxes, bobcats, and other predators. Schaller (1967), in his classic work on the Indian tiger and its prey, indicates that animals in high, dense grass had a larger proportion of losses to tigers than those which preferred shorter grass. This same worker (Schaller 1972) indicates a similar situation with respect to lions. Height and density of the vegetation influence the ease with which the predator can stalk his prey without being detected. Schaller indicates that approximately seventy-five percent of the plains animals that were attacked by lions were near some sort of cover when caught. Woodland hunting was easier, he says, because of the many widespread thickets. Prides of woodlands lion hunt during the day as well as the night, he concludes. Mech (1970) indicates that wolves, while stalking prey, sneak as close

as possible to their prey before the final rush.

Cover, then, is an obvious advantage to a stalking predator. Fox squirrels would certainly gain an advantage by inhabiting areas with a lack of cover. In addition, Rosenzweig (1966) indicates large size to be an advantage in discouraging predatory attacks. The fox squirrel is approximately 1.5 times as large as the gray squirrel. In this respect, Rosenweig and Winakur (1969) present an analogous case with species of desert rodents. Kangaroo rats (*Dipodomys* spp.) were observed to inhabit areas associated with a sparseness of vegetation. Pocket mice (*Perognathus* spp.), a member of the same family as the kangaroo rat but smaller in size, were observed to inhabit areas associated with a denseness of vegetation. Rosenzweig and Winakur concluded that competition was responsible for the complementarity of the habitats. They also noted though, that in some cases, competitive coexistence was accounted for by the different specializations needed to escape predation in different environments.

While predation may have greatly influenced the habitat preferences thus exhibited, there were probably other influences also. Janzen (1967) and others suggest that while total mast production may be low in areas of open or patchy woods, individual tree production is high, due to limited competition with neighboring trees. Smith and Follmer (1972) conclude that where mast is concentrated, foraging time is reduced, and more can be consumed per unit time to support the larger body size of fox squirrels. The need for an abundant, concentrated food supply may also have influenced habitat preferences. Thus, distinct preferences in habitat in areas of coexistence of both species, allows continued coexistence by reducing competition for food resources.

The terrestrial behavior of the fox squirrel was probably quite influential in the colonization of agricultural areas by this species. The apparent utilization of agricultural products by fox squirrels is readily observed, and well supported in the literature. Corn is particularly exploited by this species. In addition, soybeans, wheat, oats, apples and other field and fruit crops are utilized by the fox squirrel (Brown and Yeager 1945). The Delmarva subspecies is no exception. The most frequent sightings of this squirrel has occurred while it was enroute to or from agricultural crops.

Gray squirrels, on the other hand, very seldom utilize agricultural products. Flyger (personal communication) indicates that only in time of ultimate necessity will they venture from the security of their home woods. Chapman (1938) observes that corn is never used by gray squirrels unless there is a marked deficiency in nuts and acorns. This is probably a consequence of the availability of corn. Gray squirrels will readily take corn if it is offered to them, but will seldom leave their home woodlot to obtain it. Thus it appears that the fox squirrel increased at the expense of the gray when the eastern deciduous forest was opened up, partly because of its terrestrial nature.

That the Delmarva squirrel has declined in numbers and range is evident. Why it has is not as easy to determine. As we have seen, its distribution was always patchy, and the range of the gray squirrel has always overlapped it. The Delmarva subspecies did not increase its range in response to the opening up of the eastern Coastal Plain by agriculture. Rather, it lost ground to the gray squirrel. Two reasons will be postulated to explain this, at least partially: hunting and lumbering.

Color phases of the Delmarva squirrel vary, but the most common is a light, steel gray color dorsally, a blackish-gray tail, white ears, a white undersides, and a white patch on the muzzle. Thus, even though the Delmarva squirrel is approximately 1.5 times as large as the gray squirrel, its coat is of a very similar appearance, though even a lighter gray than the gray squirrel. Over the sights of a firearm, the distinction becomes almost negligible except to the knowledgable observer. In addition, many residents of the Eastern Shore consider the Delmarva subspecies to be "just a big gray squirrel", thus greatly enhancing its

value as a hunting trophy. In fact, many local people still refer to *S. niger cinereus* as the "gray squirrel", and *S. carolinensis* as the "fox squirrel"! Nonetheless, the Delmarva subspecies was once widely hunted, as many of the older local residents have informed me. Even now that hunting of the squirrel is prohibited, it will remain hard to enforce this law due to the difficulty of an immediate recognition of distinction between the two species.

The primary reason postulated for the decline of the Delmarva squirrel is lumbering. Lumbering of the Eastern United States started some two hundred years ago, and intensified dramatically with the American Industrial Revolution (Widner 1968). In fact, the lumbering industry in 1860 was centered in Pennsylvania along the Susquehanna River (Brown 1947). Fox squirrel preference for big timber has already been noted. As the big timber was removed, so was much of the area that provided the Delmarva squirrel with an open understory habitat. The Delmarva squirrel is now forced to compete directly with the gray squirrel for food and nesting resources. With the loss of preferred habitat, coexistence of the two species is virtually impossible. Open agression is probably not widespread. Rhodes (1971 unpublished data) observed none during a study on the Blackwater National Wildlife Refuge near Cambridge, Maryland. Brown and Yeager (1945) also observed no open competitive strife between fox and gray squirrels. Since the logging, however, a situation has developed where interspecific competition occurs. The Delmarva squirrel, forced out of its own preferred habitat by logging and at disproportionately lower numbers than the gray squirrel, is at a competitive disadvantage.

A test of this hypothesis may be made by examining the population of Delmarva squirrels on Eastern Neck Island on the Federal wildlife refuge southwest of Chestertown, Maryland. This is the only area where the Delmarva squirrel occurs to the exclusion of the gray squirrel. This population is not endemic, however. One gentleman, a fur trapper and dealer by trade, informed me that his father trapped the original population of these squirrels from Dorchester County and transplanted them onto Eastern Neck Island, sometime around 1920, before it was a Federal refuge. I have no reason to doubt this information. Regardless, the Delmarva squirrels on the island can be observed to be exploiting every available squirrel niche. The vegetation on Eastern Neck is variable, and the Delmarva species can be observed in areas with a luxuriant understory growth, as well as in areas of open understory. Corn is also grown there.

Maryland's Eastern Shore has undergone rapid growth since the Chesapeake Bay Bridge was completed in the early 1950's. With increasing demands for resort and vacation areas, this trend toward development is expected to continue. Increased demands for houses on the Eastern Shore is accelerating the rate of lumbering. Thus, more squirrel habitat is being destroyed. The gray squirrel will adapt to this "domestication" of its environment as it has in many suburban areas. The Delmarva squirrel will not. Even though fox squirrels are the familiar species in towns and on campuses in the Midwest, the numbers of the Delmarva subspecies will not permit it to retain any hold, or to colonize any "new" habitat brought about by these changes, in its struggle against the gray squirrel.

In addition, there has been a recurring desire in Maryland to log out all the big hardwood and replace it with stands of pure loblolly pine, in the interest of future Maryland lumbering. This process would be detrimental to both species, since stands of pure species seldom provide good habitat for any game species.

In addition, the effects of lumbering prohibits fox squirrel habitat from developing. At the point where the trees become of a salable size, they aren't large enough to provide sufficient food and den sites for squirrel utilization. At this point also, the understory is desne and heavy. Thus before the woods attain a sufficient state of maturity to support a population of squirrels, it is harvested.

Can anything be done to aid the plight of the Delmarva squirrel? Possibly. At present, the low numbers of this squirrel limits what can be done. Primarily, a life history study of this squirrel should be conducted. This present study has hopefully served as a basis for more sophisticated studies. We must know more about this subspecies if we are to attempt to help it.

Initially, though, some steps may be taken. First, education of the public, both hunting and non-hunting, should be implemented to make it aware of this squirrel's dilemma. Second, in areas where the Delmarva squirrel is now present, it should be encouraged to increase there. Encouragement could be accomplished by erecting nest boxes for the use of this squirrel, and by reducing the gray squirrel, either through trapping or shooting, from this same area. Many landowners whose property is included in the range of the Delmarva squirrel appear to be quite willing to help in this respect. Controlled hunting of the gray squirrel, by themselves or their associates, would eliminate the need for trapping by game personnel. Thirdly, again in areas where the Delmarva squirrel is now present, where feasible, controlled elimination of the understory in adjacent woodlots could be attempted to encourage utilization by the squirrel; Federal or state refuges might be good areas to initiate such an experiment. This approach should be used in conjunction with method two outlined above.

In summary, then, the following points may be advanced: 1). The Delmarva fox squirrel has declined in range and numbers until it is now confined to portions of four Eastern Shore counties in Maryland. 2). Fox squirrels and gray squirrels do coexist, separated by a preference of fox squirrels for small stands of large timber and open understory, largely in agricultural areas. Gray squirrels prefer large unbroken tracts of forested areas with dense understory. 3). The Delmarva squirrel has been most closely associated in its present range with areas of open understory. Its range almost entirely now overlaps with that of the gray squirrel. 4). The most likely explanation for at least part of the habitat preference exhibited by these two species is predation. 5). The range and numbers of the Delmarva squirrel is being further reduced by man's influence on the Eastern Shore squirrel habitat, predominantly through lumbering and development.

It is hoped that this study will increase the awareness of scientists and the public to the plight of the Delmarva fox squirrel. For without any assistance from man, this splendid animal faces almost certain extinction.

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