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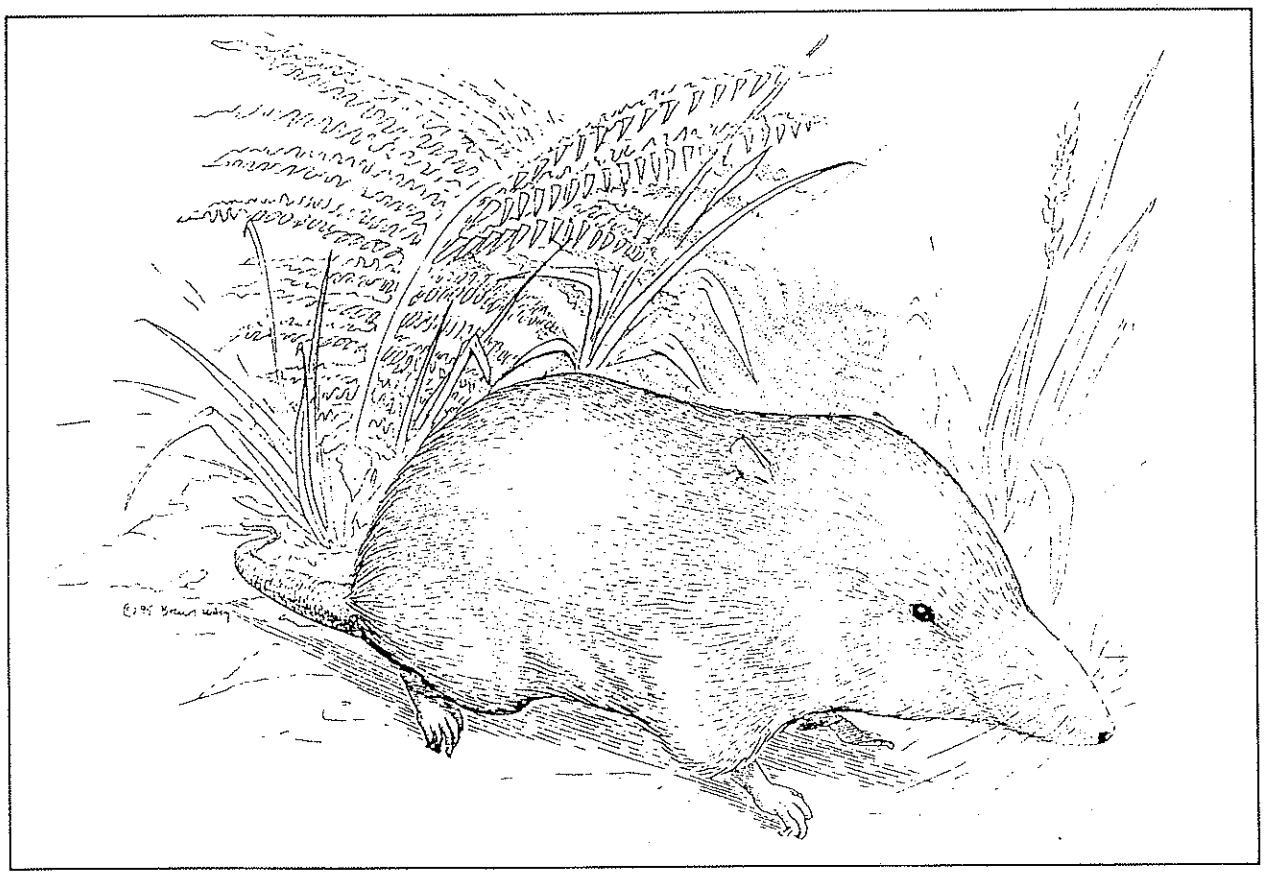
DISMAL SWAMP SOUTHEASTERN SHREW

(*Sorex longirostris fisheri* Merriam)

RECOVERY PLAN



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U.S. Fish and Wildlife Service
Hadley, Massachusetts

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Sorex longirostris fisheri
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Katherine Brown-Wing

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RECOVERY PLAN

Prepared by:

Robert K. Rose and Judy Jacobs

in cooperation with the

Dismal Swamp Shrew
Recovery Team

and

Chesapeake Bay Field Office
Virginia Field Office
U.S. Fish and Wildlife Service

Approved: _____
Regional Director, Region Five
U.S. Fish and Wildlife Service

Date: 9-29-94

Updated: _____

Date: 6-13-95

EXECUTIVE SUMMARY
Dismal Swamp Southeastern Shrew Recovery Plan

Current Status: The Dismal Swamp southeastern shrew (*Sorex longirostris fisheri*), listed as a threatened species in September 1986, is known to occur within the historic boundaries of the Dismal Swamp of southeastern Virginia and northeastern North Carolina. In addition, recent preliminary findings indicate that *S. l. fisheri* may have a significantly broader distribution than previously thought. This recovery plan is predicated upon the supposition, which requires further verification, that the Dismal Swamp subspecies is widespread throughout the coastal plain of southeastern Virginia and North Carolina. Further evidence is also needed regarding differentiation between *S. l. fisheri* and the nominate subspecies, *S. l. longirostris.*

Habitat Requirements and Limiting Factors: Historically, *S. l. fisheri* was thought to occupy wetland habitat within the Dismal Swamp. The Dismal Swamp once extended over 2200 square miles, but, having been ditched and drained for two centuries, now comprises fewer than 320 square miles. Some 189 square miles of habitat are protected within the Great Dismal Swamp National Wildlife Refuge and adjacent State Park land in North Carolina. Outside the Refuge and State Park, areas of the historic Dismal Swamp are being rapidly lost to agriculture, silviculture, and urbanization. Within the Refuge, changes in the swamp's hydrologic regime have resulted in succession to a more mesic habitat type, possibly allowing hybridization with *S. l. longirostris.*

If it is verified that the subspecies *S. l. fisheri* is widespread throughout the North Carolina coastal plain in addition to its Dismal Swamp habitat, and, further, that this shrew occupies more habitat types than previously thought, threats to its survival through habitat loss and hybridization will be greatly diminished.

Recovery Objective: To delist the Dismal Swamp southeastern shrew.

Recovery Criteria: *Sorex longirostris fisheri* will be considered for delisting if and when: (1) it is determined, through sampling and analysis of specimens, that the shrew is distributed throughout the coastal plain from southeastern Virginia to at least as far south as Wilmington, North Carolina; and (2) it is shown, through assessment of projected land uses and known proposed projects, that the shrew is free from pervasive threats to its survival. If, during the course of these investigations, it is determined that the distribution of *S. l. fisheri* is local to the historic Dismal Swamp, additional conditions (long-range habitat protection and management) will become necessary for delisting.

Actions Needed:

1. Resolve questions concerning the status of *S. l. fisheri*, including an understanding of its taxonomy, distribution, and habitat requirements outside the Dismal Swamp, and an assessment of projected land use across the shrew's known range.
2. Continue to work with landowners and appropriate regulatory authorities as required to protect this listed species.
3. Based upon distribution and taxonomic study findings, determine a future course of action for *S. l. fisheri* recovery.

Projected Costs ($000):

YEAR	NEED 1	NEED 2	NEED 3	TOTAL
FY 1	42.0	6.0		48.0
FY 2	15.0	6.0	6.0	27.0
Total	57.0	12.0	6.0	75.0

Time Frame: Assuming that study findings show widespread distribution of *S. l. fisheri*, delisting will be proposed in 1996.

ACKNOWLEDGMENTS

The original draft of this plan was prepared by Dr. Robert K. Rose, Dismal Swamp southeastern shrew recovery team leader, who deserves much credit for laying the biological foundation for the shrew recovery program as well as coordinating team input. Ms. Judy Jacobs worked with the shrew recovery team to provide a thoughtful critique and additional information, leading to a draft plan that was deemed sufficient for public review.

Comments received on the draft plan resulted in substantial modifications, bringing the plan more into line with current questions regarding the shrew's taxonomy and distribution. Ms. Mary Parkin, Region Five Endangered Species Recovery Coordinator, took on the task of incorporating these concerns into this document, attempting to ensure that changes were consistent with the import of the comments, all available information, and, ultimately, the considered position of the recovery team.

The resulting document, a Service product that has moved through several stages, thus derives from the combined efforts of the recovery team and involved Service personnel. While the plan is responsive to current thinking regarding shrew recovery, no claims are made for completeness or conclusive answers. The plan describes a short-term strategy for bridging a recovery impasse with respect to this species, and full allowance is made for future changes in the recovery program based on what is learned during the next one to two years.

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* * *

The following recovery plan, updated shortly after its original approval to address further concerns of the recovery team, delineates a practical course of action for protecting and recovering the threatened Dismal Swamp southeastern shrew (*Sorex longirostris fisheri*). Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This recovery plan, prepared by the Dismal Swamp Shrew Recovery Team in cooperation with the U.S. Fish and Wildlife Service, does not necessarily represent the views or official position of any individuals or agencies involved in its formulation, other than the U.S. Fish and Wildlife Service. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks. This plan, in particular, will be subject to change pending the outcome of near-term taxonomic and distributional studies.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1995. Dismal Swamp Southeastern Shrew (*Sorex longirostris fisheri*) Recovery Plan. Hadley, Massachusetts. 50pp.

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
or
1-800-582-3421

Cost varies according to number of pages.

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PART I: INTRODUCTION

The southeastern shrew (*Sorex longirostris* Bachman), so named because it is found in the southeastern United States (Figure 1), is considered to comprise three subspecies: the Dismal Swamp southeastern shrew (*Sorex longirostris fisheri*) from areas of Virginia and North Carolina, *S. l. eionis* from areas of Florida, and *S. l. longirostris* from the rest of the species' range. *Sorex longirostris fisheri* was listed as threatened on September 26, 1986 by virtue of extensive alteration of its known habitat and possible genetic intermixing with the more widespread and common subspecies, *S. l. longirostris*. Morphological studies conducted by (Jones *et al.* 1991) confirmed the validity of *S. l. fisheri* as a distinct subspecies, thereby providing the basis for further recovery efforts. The Dismal Swamp southeastern shrew has been assigned a recovery priority number[1] of 9, based on (1) a moderate degree of threat, (2) a high potential for recovery, and (3) its taxonomic standing as a subspecies.

Preliminary findings from recent investigations in North Carolina indicate that *Sorex longirostris fisheri* may be substantially more widespread than previously thought (W.D. Webster, University of North Carolina, pers. comm. 1994). This recovery plan is predicated upon that likelihood, which must be verified through further analyses. Recovery will focus on the provisional strategy of resolving the remaining questions about the shrew's distribution and taxonomy (both of which have an essential bearing on its listing status and/or future conservation efforts), thus allowing continued attention to recovery while closing gaps in the body of information about this southeastern shrew subspecies.

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[1] Recovery priority numbers ranging from a high of 1C to a low of 18 are determined for all species listed pursuant to the Endangered Species Act of 1973, as amended. These numbers are based on criteria defined in the Federal Register (Vol. 48, No. 184). A listed taxon with a ranking of 1C receives the highest priority for the development and implementation of recovery plans.

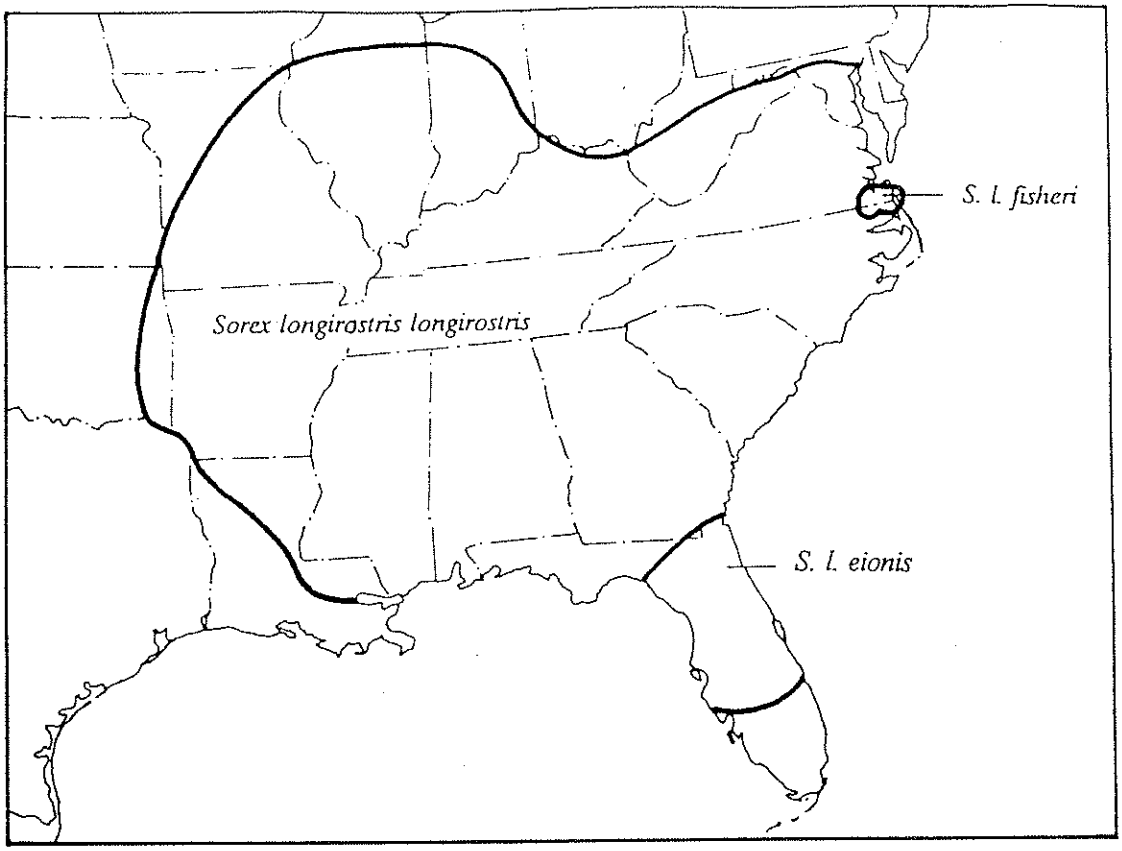

FIGURE 1. DISTRIBUTION OF SOREX LONGIROSTRIS FISHERI, S. L. EIONIS, AND S. L. LONGIROSTRIS (AFTER JONES *ET AL.* 1991)

DESCRIPTION AND TAXONOMY

The Dismal Swamp southeastern shrew is a small, long-tailed shrew with a brown back, slightly paler underparts, buffy feet, and a relatively short, broad nose (Handley 1980). It was first described as a species, *Sorex fisheri*, by C.H. Merriam (1895). Merriam (1895) based the description of *fisheri* on four specimens trapped in canebrakes near Lake Drummond, Virginia, by A.K. Fisher of the U.S. Department of Agriculture's Bureau of Biological Surveys during the first collections made in the Great Dismal Swamp. Jackson (1928) subsequently reduced *S. fisheri* to a subspecies of the southeastern shrew, *Sorex longirostris* Bachman.

Three subspecies of southeastern shrew are currently recognized: *Sorex longirostris eionis*, originally thought to be restricted to the vicinity of Homosassa Springs (Hall 1981), but recently shown to occur more widely throughout peninsular Florida (Jones *et al.* 1991); *S. l. fisheri* from the region of the Great Dismal Swamp in Virginia and North Carolina; and *S. l. longirostris* from the rest of the distributional range, which extends as far west as Louisiana, Arkansas, and Missouri, and northeast through Illinois and Indiana, Ohio, and Maryland. The taxonomic status of these three subspecies was examined by Jones *et al.* (1991) using specimens from previous studies in the Dismal Swamp vicinity, and another large series of specimens from Virginia collected at the Blackwater Ecological Preserve of Old Dominion University in Isle of Wight County. Jones *et al.* (1991) verified substantial size differences among the three taxa. Both of the more isolated subspecies were shown to average nearly 20 percent longer in total body length (96.0 mm for 11 *eionis* and 97.7 mm for six *fisheri*) than the nominate subspecies (81.9 mm for 270 *longirostris* from Alabama and Georgia). This study thus confirmed the subspecific status of *S. l. fisheri*.

Most recently, W.D. Webster, a mammalogist at the University of North Carolina in Wilmington, took several specimens from his studies in northeastern North Carolina (as well as some from his collections in southeastern Virginia), along with specimens collected near New Bern and Wilmington, North Carolina, to the National Museum of Natural History for consultation with mammal curator, C.O. Handley, Jr., an expert in the systematics/taxonomy of North American shrews (W.D. Webster, University of North Carolina, Wilmington, pers. comm. 1994). There, comparisons were made between those specimens and specimens of *Sorex longirostris fisheri* that had been collected in the Dismal Swamp (the locality where the type specimens were collected 99 years ago). Specimens from coastal North Carolina were found to be similar to early specimens from the Dismal Swamp. Although these larger shrews, perhaps all referable to *S. l. fisheri*, appeared to be clearly differentiated from the upland *longirostris*, it is not evident at this time whether all the large coastal *Sorex* belong to the same taxon (R.K. Rose, Old Dominion University, *in litt.* 1994).

Jones *et al.* (1991) also commented on a sample of large specimens from coastal South Carolina. Substantiation is needed regarding the taxonomy of these large *Sorex*

throughout the area within which specimens have been collected in order to verify the range boundaries and distribution patterns of *Sorex longirostris fisheri*.

Background on *Sorex longirostris* Bachman

The genus *Sorex* is a Holarctic and generally boreal genus; in the far north, *Sorex* species and microtine rodents dominate the mammalian fauna. Where species and populations of *Sorex* occur at more southerly latitudes, they are usually found at high elevations. The southeastern shrew, *Sorex longirostris* Bachman, is exceptional, having a southerly distribution at low elevations.

Throughout much of its range *Sorex longirostris* is the only long-tailed shrew. In the Appalachian region and at the northern limits of its distribution, *Sorex longirostris* is sympatric with *S. hoyi*, which is considerably smaller, and with *S. cinereus*, which it closely resembles; however, the tail of *S. longirostris* is relatively shorter than that of *S. cinereus*, and the teeth of the two species show considerable differences. According to French (1980a), the unicuspids are more crowded and the molariform teeth are relatively smaller in *S. longirostris* than in *S. cinereus*. Also, both upper and lower incisors are relatively much smaller in *S. longirostris* than in *S. cinereus*. Although *S. longirostris* can often be distinguished from other eastern *Sorex* because the third upper unicuspid is smaller than the fourth, this tooth character is variable; French (1980a) found the third and fourth unicuspids to be of equal size in 20 of 100 specimens from Alabama and Georgia. Regarding weight, Webster *et al.* (1984) reported that six adult *S. longirostris* averaged 3.8 grams in weight (range = 3.0-4.5), and French (1980a) reported that 110 *S. l. longirostris* from Alabama and Georgia averaged 3.25 grams in weight (there was no significant difference between age classes).

The present range of *Sorex longirostris* extends through eastern Louisiana, eastern Oklahoma, and Missouri, then eastward through central Illinois and Indiana, southern Ohio, and Maryland. Populations of southeastern shrews are known from near sea level to at least 760 m elevation (Pagels and Handley 1989). Particularly in the north, collection records often coincide with large rivers, such as the Ohio, Mississippi, and Wabash Rivers. It is unclear whether the populations in western Arkansas, Oklahoma, and northern

Missouri are disjunct or if the lack of intervening records merely represents a study gap elsewhere in the three states.

Bachman (1837) described *Sorex longirostris* from two specimens taken on the Hume Plantation on Cat Island at the mouth of the Santee River, South Carolina. For the next 130 years, the southeastern shrew continued to be recorded as an uncommon or rare species wherever it was found, primarily because it was rarely taken in live or snap traps. Dusi (1951) found the second Alabama specimen dead on a dirt road; he later found another dead specimen, and recovered a third from an owl pellet before catching two more in snap traps (Dusi 1959). Foreman (1956) found three specimens dead in live traps near Durham, North Carolina. Lindsay (1960) found the first Indiana specimen dead on the campus of Hanover College in Jefferson County, which extended the species' known range across most of southern Indiana. The first specimen from Missouri was taken in a snap trap by Brown (1961) in a rather dry grassy glade, whereas other early state records were of specimens captured by hand while overturning debris (Goodpaster and Hoffmeister 1952) or by finding nests in rotting logs (Negus and Dundee 1965).

Tuttle (1964) caught 23 southeastern shrews with pitfall traps after having caught three specimens with snap traps on the same site in Tennessee. Tuttle's study raised the possibility that pitfall traps were superior to other methods for catching southeastern shrews. Apparently the only significant number ever taken with snap traps was the 24 shrews collected by Smith *et al.* (1974) during one month of trapping in each of six years on a forested site in South Carolina.

In the early 1970s, French (1975) collected more than 400 southeastern shrews using pitfall traps made from No. 10 tin cans (15 cm diameter). In the course of his research, French collected more specimens in Alabama and Georgia than were housed in all museums in North America. Abruptly, the study of the southeastern shrew became feasible, and it became apparent that the shrew was not as rare as previously believed. With pitfall traps it became possible to catch more than accidental specimens and to learn much about the habitat relationships, sex ratios, reproductive season and output, and even relative population density of *Sorex longirostris*. It also became possible to collect more substantial series of specimens for use in taxonomic studies.

DISTRIBUTION

The distribution of *Sorex longirostris fisheri* is considered to coincide with the historical boundaries of the Great Dismal Swamp of extreme southeastern Virginia and adjacent North Carolina (Rose 1983), pending substantiation of current data suggesting the possibility of more widespread distribution (W.D. Webster pers. comm.). After the collection of the original type series by A.K. Fisher (Merriam 1895), additional *S. l. fisheri* specimens were collected from similar habitats in the Dismal Swamp between 1895 and 1902, of which 16 are in the collections at the National Museum of Natural History in Washington, D.C. Handley (1979) estimated that 19 specimens of *S. l. fisheri* were known, including one he caught in 1953 near Wallaceton, Virginia. Thus, in the past, *S. l. fisheri* was known from fewer than 20 specimens, all taken from the Dismal Swamp.

In late winter and early spring of 1980, Rose (1981) used pitfall traps to collect 15 specimens from the northwest section of the Great Dismal Swamp National Wildlife Refuge in Suffolk, Virginia. Fourteen were taken between 23 February and 2 May under the electrical powerline right-of-way that crosses Jericho Ditch, and the other specimen was taken under the same powerline about 8 km northeast of the first location. Pitfall trapping was conducted at this second location between 10 April and 21 May 1980. Based on their large size (95.8 $\pm$ 2.3 mm, range 91-102 mm), these specimens seemed to be referable to *S. l. fisheri* despite the previous rarity of that taxon in collections.

During the period December 1980 to July 1982, 37 sites in the vicinity of the historic Dismal Swamp were trapped with pitfall traps to compare the distribution of the Dismal Swamp subspecies with that of the nominate subspecies of southeastern shrew. Based on the results of a discriminant function analysis of standard external body measurements (Rose 1983, Everton 1985), specimens referable to *S. l. fisheri* were collected at eight locations, five in the Refuge and three nearby, all within the historic Dismal Swamp. The results of the discriminant analysis indicated that the largest *Sorex longirostris* were located within the Refuge and the smallest *Sorex* were located at greater distances away from the Refuge, whereas specimens of intermediate size tended to be associated with the margins of the Refuge. These results suggested that interbreeding of the two subspecies might be occurring, particularly at the margins of the Refuge.

Further study of *Sorex* was conducted from October 1986 through June 1989, focusing within the Refuge but also including outlying areas of the historic Dismal Swamp. Particular emphasis was placed on determining whether the nominate subspecies might be moving into the historic Swamp and interbreeding there with *S. l. fisheri* (Padgett 1991). Consequently, shrews were sought along roadways as well as along transects not associated with man-made entryways into the Swamp. In addition, plots were established in recently cleared forest sites and in uncut sites. Findings from this study indicated: (1) that there was no strong evidence that *S. l. longirostris* was using the roadways to enter the interior of the Refuge, and (2) that *S. l. fisheri* was restricted to the historic Dismal Swamp. A study designed to further delineate the distributions of *S. l. fisheri* and *S. l. longirostris* was conducted from 1989 to 1991 (Erdle and Pagels 1992). This study involved sampling of much of the historic Dismal Swamp east of the Refuge and north of the Virginia-North Carolina state line. Shrews referable to both taxa, as well as intergrades, were represented in the sample of 26 *Sorex* taken, supporting the hypothesis that *S. l. longirostris* may be moving into areas of the historic Dismal Swamp.

In comparison with Virginia, the distribution of *S. l. fisheri* in North Carolina needs much more study (this, in turn, will trigger the need for further review of Virginia data in light of study findings). Locations of *Sorex longirostris* captured through 1992 in northeastern North Carolina are summarized by Webster (1987, 1992). These records indicated captures of *S. l. fisheri* in Currituck, Camden, Gates, and Pasquotank counties (an individual taken from Perquimans County was considered by Rhoads and Young (1897) to be a *longirostris-fisheri* intergrade). Webster (1992) also provided a map of potential shrew habitat, showing locations requiring additional study.

Preliminary findings from W.D. Webster's most recent investigations (unpubl. data) indicate that large shrews referable to *S. l. fisheri* may occur throughout the coastal plain from southeastern Virginia to at least Wilmington, North Carolina (R.K. Rose *in litt.* 1994). During a visit to the North Carolina State Museum of Natural Sciences in May 1994, W.D. Webster (*in litt.* 1994) found a relatively large series of shrews that he presumed to be *S. l. fisheri* from Croatan National Forest (Jones, Craven, and Carteret counties). The State Museum also had, among others, specimens of *S. l. fisheri* from Chowan, Bladen, and Brunswick counties. W.D. Webster (*in litt.* 1994) has also collected *S. l. fisheri* near the

town of Warsaw in Duplin County. This site is approximately midway between Wilmington, where *S. l. fisheri* presumably occurs, and Raleigh, where *S. l. longirostris* occurs.

W.D. Webster (*in litt.* 1994) surmises from these preliminary findings that *S. l. fisheri* is distributed along the coastal counties in North Carolina and further speculates that *S. l. fisheri* is widespread in the inner coastal plain in the southern part of the State. The U.S. Fish and Wildlife Service now recognizes the possibility, provisionally and subject to change pending further analyses, that this taxon may occur throughout the coastal plain of North Carolina; however, in accordance with the recovery team's position, the North Carolina specimens will not be regarded as *fisheri* until this is verified through more stringent studies (including further morphometrics and genetic analysis) and peer review. Consideration should also be given to the suggestion by Jones *et al.* (1991) that *S. l. fisheri* may also occur in coastal South Carolina.

HABITAT USE

The historic Dismal Swamp, a forested wetland community, is characterized by substantial winter flooding, variable soils including deep organic layers, and a mosaic of habitat types (Lichtler and Walker 1979, Carter 1988). Within the Dismal Swamp, *S. l. fisheri* is found in a range of habitats including recently clearcut and regenerating forests, young pine plantations, grassy and brushy roadsides, young forests with shrubs and saplings, and mature pine and deciduous forests. In general, highest densities of Dismal Swamp southeastern shrews have been observed in early successional stage habitats, and lowest densities in mature forests (Everton 1985). Despite supporting lower densities, mature forests are likely to be important to the survival of these shrews during periods of drought or fire.

Further detail is available regarding habitat use at the species level. The habitat of the type locality for *Sorex longirostris* in South Carolina was a moist to wet area, as were the locations of many specimens reported in early studies. However, Brimley (1919) found *S. longirostris* only in upland grassy areas and took none from the woods near

Raleigh, North Carolina. Others, including Tuttle (1964) in Tennessee, Dusi (1951, 1959) in Alabama, Rose (1980) in Indiana, Mock and Kivett (1980) in Missouri, Webster *et al.* (1984) in North Carolina, and Pagels and Handley (1989) in Virginia, reported populations from old-field habitats. Still others (e.g., Goodpaster and Hoffmeister 1952, Foreman 1956, Tuttle 1964, Negus and Dundee 1965, Smith *et al.* 1974, Rose 1980, and Pagels *et al.* 1982) reported catching southeastern shrews in dry, even sandy, areas that were often forested. Thus, from the earliest reports, capture data indicated that the southeastern shrew could tolerate a range of habitats, from fairly dry to wet and from grassy old-fields to mature pine and deciduous forests. Like its southerly distribution in low elevations, the wide range of habitats used by *S. longirostris* also is unusual for the genus.

French (1980a, 1980c) reported the following numbers of individuals per 100 trap nights in various habitats in Alabama and Georgia: 0.3 southeastern shrews in hardwood-dominated floodplain forests, 1.1 shrews in freshwater grassy marsh with rotting logs, 0.03 shrews in upland mixed pine-hardwood forest, and 0.05 shrews in upland old-field habitat. French concluded that the *Sorex longirostris* in his study areas required a thick ground cover and was most frequently trapped where the understory was dominated by blackberry, rushes, sedges, and grasses. On other sites, particularly in forests, the ground cover almost always included Japanese honeysuckle (*Lonicera japonica*), a prostrate non-native vine (French 1980b). In a mature hardwood forest in southeastern North Carolina, shrews were most abundant under tangles of honeysuckle, poison ivy (*Toxicodendron radicans*), and greenbrier (*Smilax* spp.) (Webster *et al.* 1984).

With his large-scale pitfall trapping study, French (1980a, 1980c) also was able to estimate densities for the first time. He estimated densities of 30 southeastern shrews/ha at the "head of a beaver swamp," and 44 southeastern shrews/ha nearby on a slightly larger site. Thus, in these locations at least, southeastern shrews were a common, perhaps the most common, small mammal. This has been borne out in North Carolina surveys conducted in 1989 and 1994 (CZR 1994), which showed the southeastern shrew to occupy a wide variety of habitats, and, indeed, to be one of the most common small mammals trapped.

LIFE HISTORY

Apart from a litter of five young found in a nest in the Dismal Swamp in 1905, little is known about reproduction or other life history features of *Sorex longirostris fisheri*. It is likely that this shrew generally fits the same life history patterns that have been observed by French (1980a, 1980b) for *S. longirostris*. In the absence of data specific to *S. l. fisheri*, information available for *S. l. longirostris* is discussed below.

Jackson (1928) reported that *Sorex longirostris* undergo two molts, the first in spring (late March to early June) and the second in autumn (October). Old hair is first replaced on the back, then on the sides, venter, and rump.

French (1980a) reviewed reproductive data from previous studies, including information from the labels of the museum specimens of 15 pregnant females from six states. These females contained from 1-6 embryos, for a mean of 3.9 embryos per female. Nine pregnant females collected by French (1975) in Alabama and Georgia also had from 1-6 embryos, for a mean of 3.67 embryos per female. In Indiana, French (1980c) collected 13 pregnant *S. longirostris*, which averaged 4.55 embryos/female with a range of 4-6 embryos per female. These sample sizes are too small to determine whether southeastern shrews in northern populations actually have larger litters, although this pattern has been observed in some other species of small mammals. In Indiana, the dates of pregnancy range from 8 April to 25 September, whereas in Alabama and Georgia the first pregnant female was observed on 31 March and the last one on 6 October. These studies suggest that the southeastern shrew has a six-month breeding season, with litters averaging approximately four young. Shrews in the genus *Sorex* generally have two or more litters per year (Churchfield 1990).

Young shrews grow rapidly and, unlike many small mammals, are almost adult size when they leave the nest. French (1980a) observed nearly grown *S. longirostris* nestlings measuring 71 and 72 mm, and also caught a lactating female together with her still-dependent offspring measuring 76, 78, and 78 mm. Thus, shrews appear to remain in

the nest for their entire period of growth and development. Even after leaving the nest, their early wanderings may be in association with the mother.

Nearly 80 percent of the diets of seven southeastern shrews from Indiana consisted of spiders, Lepidoptera (butterfly and moth) larvae, slugs and snails, vegetation, and centipedes (Whitaker and Mumford 1972). French (1980b) likewise found that spiders and Lepidoptera were commonly present in the stomachs of 102 specimens, also from Indiana; Gryllidae (crickets), adult Coleoptera (beetles), and harvestmen were next in abundance.

Because few southeastern shrews have been caught alive and with present techniques are too small to be fitted with radio transmitters, there is little information about daily activity patterns. Southeastern shrews probably behave similarly to other species of shrews that have been studied (Churchfield 1990). Shrews forage intermittently throughout the day and night in all seasons, seem to have highest levels of activity associated with rainfall and periods of high humidity, and do much of their foraging in the leaf litter or in tunnels in the upper layers of the soil.

Southeastern shrews are subject to some predation, with the most frequently reported predators being Barn Owls and domestic cats. Other known predators include the Barred Owl, cottonmouth, domestic dog, and opossum (French 1980a). However, the number of dead shrews found in the woods and on roads suggests that many predators reject the shrews, probably because of the bad taste associated with their musk glands.

REASONS FOR LISTING AND CONTINUING THREATS

Reasons for Listing

The two main reasons for the 1986 listing of the Dismal Swamp southeastern shrew as a threatened species were: (1) habitat loss and alteration, and (2) possible loss of genetic integrity through interbreeding with the nominate subspecies. These concerns, which may be alleviated if *S. l. fisheri* is shown to be more widespread than previously thought, are summarized below and detailed in Appendix A.

The Dismal Swamp originally extended from the Elizabeth and Nansemond Rivers in Virginia south to the Albemarle Sound in North Carolina, and at the beginning of the 20th century, the Dismal Swamp still occupied some 2,000 to 2,200 square miles (5,200 to 5,700 square kilometers). Today, however, fewer than 320 square miles (830 square kilometers) of the original Swamp remain; of this, some 189 square miles of habitat are protected within the Great Dismal Swamp National Wildlife Refuge and the Great Dismal Swamp State Park in North Carolina.

Meanwhile, remnants of the historic Dismal Swamp outside Refuge and State Park boundaries are disappearing due to development associated with the rapid growth of the Hampton Roads metropolitan area of southeastern Virginia. Agricultural and (particularly in North Carolina) silvicultural conversion also contribute significantly to habitat loss.

Even within the Refuge, extensive habitat alteration has occurred. Since the late 1700s, approximately 250 miles (400 km) of ditches have been built inside present Refuge boundaries. The effect of these ditches has been to lower the water table significantly, thus changing the vegetational characteristics of the Great Dismal Swamp. Furthermore, naturally occurring burns that once maintained sections of the original Swamp in various stages of biological succession have been prevented or suppressed since the establishment of the Refuge in 1974. As a consequence, the former Dismal Swamp, a heterogeneous mosaic of large tracts of bald cypress, Atlantic white cedar, and canebrake, has been supplanted by a more homogeneous, mesic wetland dominated by a rapidly maturing red maple and black gum forest (Laderman 1989).

The recent human-induced progression toward a homogeneous mature hardwood forest in the Swamp, more representative of habitat conditions of the surrounding region, leads to the possibility that the more common and presumably more generally adapted nominate subspecies could invade the Dismal Swamp and genetically overwhelm the existing populations of *S. l. fisheri*, which are, again presumably, more specifically adapted to historical Swamp conditions.

Continuing Threats

Should further evidence verify that *S. l. fisheri* is more widespread than previously thought, the threat of endangerment due to habitat loss and/or genetic swamping by the upland subspecies could be significantly reduced or alleviated altogether. These and additional threats posed for *S. l. fisheri*, including effects of contaminants, cannot be considered apart from the context of its distribution and abundance. Therefore, a discussion of habitat-based and biological threats that are tied to the presumption of a localized distribution is presented more fully in Appendix A, and will be reconsidered as a driving factor of the Dismal Swamp southeastern shrew recovery program if and when this presumption is verified.

CONSERVATION MEASURES

Conservation measures taken since the shrew's listing have focused primarily on: (1) morphometric analysis to verify its standing as a subspecies, (2) regulatory protection, and (3) habitat management within the boundaries of the Great Dismal Swamp National Wildlife Refuge and the adjacent State Park aimed at providing both direct and incidental benefits to the shrew.

Taxonomic and distributional studies conducted since 1986 for the shrew include:

- the study by Jones *et al.* (1991), which verified substantial morphological differences among the three *Sorex longirostris* subspecies and affirmed the subspecific status of *S. l. fisheri*,
- studies by Padgett (1991) and Erdle and Pagels (1992) investigating whether the nominate subspecies might be moving into the historic Swamp and interbreeding there with *S. l. fisheri*,
- surveys to determine the distribution of *S. l. fisheri* in North Carolina (Webster 1987, 1992), and
- investigations by Webster (R.K. Rose *in litt.* 1994) comparing specimens recently collected as far south as Wilmington, North Carolina, with museum specimens known to be *S. l. fisheri*.

Findings from these studies have been summarized in preceding sections of this plan. Habitat use and life history information for the Dismal Swamp southeastern shrew is lacking; the utility of such studies for shrew recovery must be weighed against the need to collect specimens -- thus causing take -- to pursue this type of research. Information available on the more common and widespread subspecies, *S. l. longirostris*, has been applied, to the extent possible, to *S. l. fisheri*.

Regulatory protection for the shrew both within and outside Refuge and State Park boundaries has included several formal Section 7 consultations, resulting in management solutions that have protected and conserved appropriate wetland habitat while allowing project proposals to proceed. Habitat management efforts have been focused primarily within the Refuge and the adjacent State Park. Management activities in these lands have been constrained by considerations of the potential for interbreeding between *S. l. longirostris* and *S. l. fisheri*, and informal intra-Service consultations have been conducted to ensure that management conducted for other purposes does not jeopardize the shrew. Refuge managers have been active participants in defining and implementing measures to protect the shrew on public lands.

RECOVERY STRATEGY

Jones *et al.* (1991) and preliminary findings reported by W.D. Webster (unpubl. data) introduce the possibility that large *Sorex longirostris* referable to *S. l. fisheri* may occur in much more of coastal North Carolina and possibly even in coastal South Carolina than heretofore thought. This pattern is similar to the still poorly documented pattern that appears to exist for large *Blarina*, which have been found to be more widely distributed in coastal North Carolina than previously thought. If *S. l. fisheri* does indeed occur through a large area of the Carolina coastal plain, this will have a significant and fundamental bearing on its listing status, and will diffuse the current conservation focus on shrews in the Dismal Swamp proper.

Resolution of the uncertainties relating to the distribution of *S. l. fisheri* in coastal North Carolina and South Carolina thus warrant the top priority of the recovery program

for this species. This is particularly cogent given the absence of evidence showing that *S. l. fisheri* will decline in the foreseeable future in the Great Dismal Swamp NWR and adjacent State Park under current habitat management practices.

Morphometric analyses and genetic studies regarding the level of similarity among *Sorex longirostris* from different locations (including collection and analysis of specimens clearly referable to *S. l. longirostris* and larger specimens presumed to be *S. l. fisheri* from Virginia and along the coastal plain in North Carolina) will be the prevalent recovery activity in the near term for this species. In addition to examining the amount of introgression between the subspecies, more understanding about the distinctiveness among the large coastal *Sorex* (e.g., are they all *fisheri* or do they constitute different taxa?) is necessary before *S. l. fisheri* status can accurately be assessed.

Two possible recovery scenarios persist. The first assumes near-term confirmation that the distribution of *S. l. fisheri* is widespread. Under this scenario, studies to delineate *S. l. fisheri* distribution patterns will be conducted, and a determination will be made as to whether viable, self-sustaining populations of the shrew currently exist in the wild and whether the shrew is thus relatively free from threats to its survival.

The second scenario assumes that *Sorex longirostris fisheri* will prove to be a Dismal Swamp endemic, as heretofore thought. If this scenario prevails, habitat conservation and biological measures will be implemented as discussed in Appendix A, subject to any modifications indicated by new data. This will entail revision of the Dismal Swamp Southeastern Shrew Recovery Plan.

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PART II: RECOVERY

RECOVERY OBJECTIVE

The objective of the *Sorex longirostris fisheri* recovery program is to assure long-term viability of this taxon in the wild, thereby allowing its removal from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). Delisting will be considered if and when the following conditions are met:

1. Distributional studies and taxonomic analyses confirm that the subspecies occurs throughout the Atlantic coastal plain from southeastern Virginia to at least as far south as Wilmington, North Carolina. Demographic and genetic factors should indicate the potential for long-term biological viability.

2. The subspecies is free from pervasive threats to its survival, as indicated by qualitative assessment of projected land uses and known proposed projects across its known range.

The studies needed to reach closure on the question of the shrew's status will, if fully funded, take between one and two years to complete; delisting could, therefore, be proposed sometime before 1997. *However, in the event that future studies confirm a more localized distribution or show that this shrew is subject to pervasive threats, achievement of the additional conditions presented in Appendix A will be required before the Dismal Swamp southeastern shrew is considered for delisting.*

RECOVERY TASKS

In order to effectively address the recovery objective stated above, the provisional recovery program in this plan focuses only on resolving the overriding issue of the shrew's status while continuing to employ, pursuant to the Endangered Species Act, available regulatory authorities to ensure continued protection of this taxon as long as it is listed. Those recovery tasks that address the threats to a more localized distribution are documented in Appendix A.

I. Resolve questions concerning the distribution and taxonomy of *Sorex longirostris fisheri*, including an understanding of its habitat requirements. This is an immediate need. Questions have surfaced in the recent past concerning distinctions among the large coastal southeastern shrews currently hypothesized to be *S. l. fisheri*, the subspecific status of this taxon, its overall range, and patterns of distribution within this range. These questions should be addressed systematically through surveys, morphometric analyses, and genetic studies -- with all necessary scientific input -- in order to conclude the issue of the shrew's status. Additional specimens will be needed to understand both the genetic and distributional attributes of southeastern shrews (see Appendix B for a trapping protocol).

A recovery team meeting was convened in December 1994 to assess the available data (e.g., specimen sizes and characteristics of collection sites) and provide recommendations for study proposals, including methodologies and time frames, that adequately address all questions pertaining to the shrew's biological status, as well as its listing and recovery status under the Endangered Species Act. The team should consult with independent experts, as appropriate, to review the scientific merit of the recommendations and findings.

1.1 Determine the distribution of *Sorex longirostris fisheri*. The distribution of *S. l. fisheri* within the Great Dismal Swamp National Wildlife Refuge is fairly well known (Rose 1983, Everton 1985, Padgett 1991). Approximately 95 percent of specimens taken within the Refuge to date are referable to *S. l. fisheri* (Padgett 1991, Jones *et al.* 1991). Additional studies should extend

outward from the Refuge, with particular attention to the species' distribution and abundance in North Carolina. Data are especially needed along the fall-line in North Carolina; although biologists have a fair idea of where the zones of contact between *S. l. fisheri* and *S. l. longirostris* are in Virginia, little is known about the western extent of these shrews in North Carolina. Collection of additional specimens will be necessary throughout the North Carolina coastal plain to document the distributional limits of both subspecies.

These studies should incorporate the results of any separate surveys conducted pursuant to Sections 7 or 10 of the Endangered Species Act, including negative data on areas that have been surveyed with no shrews found. The State of North Carolina has recently appropriated funds for a biological inventory of the Great Dismal Swamp State Natural Area and Dare County Bombing Range. This inventory work will include small mammal surveys and should provide further data on the distribution of *S. l. fisheri*. Other opportunities to assess distributional patterns and establish range boundaries elsewhere in the coastal plain of North Carolina should be identified.

1.2 Review morphometrics and conduct genetic studies on the level of similarity and distinctiveness of *Sorex longirostris* subspecies from different locations. Morphometrics supported by rigorous statistical analyses, as well as supplemental studies that include genetic information from specimens clearly referable to *S. l. longirostris* and *S. l. fisheri* and from large shrews in Virginia and the coastal plain in southern North Carolina, should be pursued. Molecular techniques (e.g., mitochondrial DNA and allozyme electrophoresis) should be used to examine questions relating to the genetics of these taxa, including the level of genetic distinctiveness of southeastern shrews in the zone of contact, such as in southeastern Virginia where specimens of different sizes (small, medium, and large) have been taken together. These studies should elucidate the shrew's taxonomic status as well as the level of introgression between the subspecies. However,

should findings from genetics investigations prove to be inconclusive, this will not deter taxonomic determinations based on morphometric analyses.

1.3 Assess projected habitat availability across the shrew's known range. Using available land use maps and other data, habitat availability and threats to continued availability should be qualitatively assessed across the shrew's range (as delineated pursuant to Tasks 1.1 and 1.2). This should lead to a determination of the shrew's relative level of rangewide security or endangerment based on all currently available information.

2. Continue to work with landowners and appropriate regulatory authorities as required to protect *Sorex longirostris fisheri* given its status as a Federally listed species. As long as the Dismal Swamp southeastern shrew is listed as a threatened species, all shrews determined to be *S. l. fisheri* will be afforded the protections provided under the Endangered Species Act.

2.1 Continue to protect these shrews and their habitat through the Section 7 consultation process and Section 10 permitting procedures. Section 7 consultations will be initiated on all Federally funded, conducted, or authorized projects that may affect *S. l. fisheri*. These consultations should ascertain the presence and maximize the survival potential of *S. l. fisheri* populations.

Based on its management history since the establishment of Great Dismal Swamp National Wildlife Refuge in 1974, activities within the Refuge that are conducted for the express and primary purpose of restoring or conserving the ecological integrity of the swamp system will be regarded, by definition, as contributing to the recovery of the Dismal Swamp southeastern shrew. These activities should be documented in the approved Forest Management Plan for the Refuge (U.S. Fish and Wildlife Service 1988) and/or other relevant Refuge management plans. Management proposals will be reviewed as per permit conditions, and intra-Service consultations will be conducted accordingly.

On private lands, Section 10 permits will be required for non-Federal activities that may result in the take (incidental to otherwise legal activities) of *Sorex longirostris fisheri*. Permit applicants as well as participants in the Section 7 consultation process will be informed in a timely fashion about new information regarding the status of this species.

2.2 Disseminate information summarizing known *S. l. fisheri* distribution to all stakeholders in the recovery process. Landowners, developers, and managers should be apprised of known and presumed *S. l. fisheri* habitat in both Virginia and North Carolina so that they can comply with their legal obligations under the Endangered Species Act. A fact sheet and map based on current known distribution have been prepared for Virginia; the text of the fact sheet is presented in Appendix C. Copies of the map and fact sheet will be available shortly from the U.S. Fish and Wildlife Service's Virginia Field Office. A similar product should be prepared for the North Carolina part of the shrew's range.

2.3 Coordinate with State and Federal law enforcement authorities to ensure compliance with existing laws. All Federal, State, and local laws governing protection of endangered and threatened species and their habitats will continue to be enforced.

3. Review findings from the taxonomic and distributional studies described under Task 1, and determine a future course of action regarding the listing and recovery of *Sorex longirostris fisheri*. Possible outcomes of the investigations conducted under Task 1 include: (1) *S. l. fisheri* may be sufficiently distinct to merit, once again, species status; (2) an additional taxon could be identified among coastal shrews, in which case *S. l. fisheri* might again be defined as endemic to the historic Dismal Swamp; or (3) *S. l. fisheri* will be found to be distributed throughout much or most of the coastal plain from south of Norfolk, Virginia to Wilmington, North Carolina (and possibly farther south), most likely obviating the threat of habitat loss to the species' persistence (unless the results of Task 1.3 indicate pervasive threats to the shrew across its range).

Each of these outcomes points to a different recovery solution: either (1) immediately delist on the basis of widespread distribution and abundance of *Sorex longirostris fisheri*, or (2) return to the habitat conservation focus needed for a more localized, and thus more threatened, distribution. When study results are available for review, an appropriate forum for evaluating the findings and making recommendations for future action should be initiated by the Service and the Dismal Swamp southeastern shrew recovery team. At that point (or sooner as indicated by emerging information), delisting will be proposed or this recovery plan will be slated for revision.

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PART III: IMPLEMENTATION

The Implementation Schedule lists and ranks tasks that should be undertaken in order to implement recovery of *Sorex longirostris fisheri*. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision.

KEY TO ABBREVIATIONS USED IN IMPLEMENTATION SCHEDULE:

Key to task priorities in 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 abbreviations in Column 5

FWS	-	U.S. Fish and Wildlife Service
R4, R5 ES	-	FWS Regions 4 and 5, Division of Ecological Services
LE	-	FWS Regions 4 and 5, Law Enforcement
GDSNWR	-	Great Dismal Swamp National Wildlife Refuge
NCWRC	-	North Carolina Wildlife Resources Commission
NCNHP	-	North Carolina Natural Heritage Program
VADNH	-	Virginia Department of Conservation and Recreation, Division of Natural Heritage
VDGIF	-	Virginia Department of Game and Inland Fisheries

IMPLEMENTATION SCHEDULE
Dismal Swamp Southeastern Shrew Recovery Plan

May 1995

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates ($000) FY1	Cost Estimates ($000) FY2	Comments
2	Determine the distribution of *Sorex longirostris fisheri.*	1.1	2 years	R4, R5 ES	NCWRC VDGIF Private (academia)	30.0	5.0	More survey work needed in NC.
2	Review morphometrics and conduct supplemental genetic studies to determine the level of similarity and distinctiveness of *Sorex longirostris* subspecies from different locations.	1.2	2 years	R4, R5 ES	NCWRC VDGIF Private (academia)	12.0	5.0	Labwork, chemicals.
2	Continue to protect these shrews and their habitat through Section 7 consultations and Section 10 permitting.	2.1	2 years	R4, R5 ES GDSNWR	EPA COE			Staff time; costs not itemized.
2	Coordinate with State and Federal law enforcement authorities to ensure compliance with existing laws.	2.3	2 years	R4, R5 ES R4, R5 LE	NCWRC VDGIF			Staff time; costs not itemized.
3	Assess projected habitat availability across the shrew's known range.	1.3	1 year	R4, R5 ES	NCWRC VDGIF		5.0	Will involve qualitative assessment of land use maps and other available data.
3	Disseminate information summarizing known *S. l. fisheri* distribution to all stakeholders in the recovery process.	2.2	2 years	R4, R5 ES GDSNWR	NCWRC VDGIF	6.0	6.0	Update as additional data is obtained.
3	Review findings from the taxonomic and distributional studies described under Task 1, and determine a future course of action regarding the listing and recovery of *Sorex longirostris fisheri.*	3	1 year	R4, R5 ES GDSNWR	NCWRC NCNHP VADNH VDGIF Private		6.0	Cost of a meeting to evaluate the shrew's status and define future recovery actions.

APPENDIX A

ADDITIONAL RECOVERY CONSIDERATIONS, Pending Distribution Study Results

The following information will be taken into account if near-term distribution and taxonomic studies show that *Sorex longirostris fisheri* is endemic to the historic Dismal Swamp.

Supplementary Background

THREATS

Assuming that its distribution is limited to the historic Dismal Swamp, *Sorex longirostris fisheri* is threatened by direct loss and alteration of its habitat. The Dismal Swamp originally extended from the Elizabeth and Nansemond Rivers in Virginia south to the Albemarle Sound in North Carolina. Ditching and clearing of the land for agriculture and timbering began in the late 18th century, with such notables as George Washington contributing to the process. Due to the unique clay layers underlying the swamp, not all of these early efforts at drainage were entirely successful (Rose 1992), and at the beginning of the 20th century, the Dismal Swamp still occupied some 2,000 to 2,200 square miles (5,200 to 5,700 square kilometers). Today, however, fewer than 320 square miles (830 square kilometers) of the original swamp remain, amounting to a reduction of over 85 percent since the turn of the century (U. S. Fish and Wildlife Service 1982). Some 167 square miles of swamp habitat are now protected within the Great Dismal Swamp National Wildlife Refuge, and an additional 22 square miles are protected in the Great Dismal Swamp State Park in North Carolina.

Those remnants of the historic Dismal Swamp outside Refuge and State Park boundaries are quickly disappearing due to development associated with the rapid growth of the Hampton Roads metropolitan area of southeastern Virginia. Agricultural and (particularly in North Carolina) silvicultural conversion also contribute significantly to habitat loss. In the vicinity of Elizabeth City, North Carolina, for example, two contiguous tracts totalling some 32,000 acres of wetlands have been cleared and drained within the past 20 years. In addition to these contiguous tracts, many smaller areas within the historic Dismal Swamp of North Carolina have been ditched and cleared in a piecemeal fashion. In Virginia, a comparison of U.S.G.S. 7.5-minute topographic maps to recent aerial photography revealed a collective loss of some 2,600 acres of forested land, scattered over four maps portraying the Dismal Swamp (Tiner and Foulis 1994; S. Martin, U.S. Army Corps of Engineers, pers. comm. 1993).

Even within the Refuge, extensive habitat alteration has occurred. Since the late 1700s, approximately 250 miles (400 km) of ditches have been built within the present Refuge boundaries. The effect of these ditches has been to lower the water table significantly, thus changing the vegetational characteristics of the Great Dismal Swamp. Furthermore, naturally occurring burns, which once maintained sections of the original swamp in various stages of biological succession, have been prevented or suppressed since the establishment of the Refuge in 1974. As a consequence, the former Dismal Swamp, a heterogeneous mosaic of large tracts of bald cypress, Atlantic white cedar, and canebrake, has been replaced by a more homogeneous, mesic wetland dominated by a rapidly maturing red maple and black gum forest (Laderman 1989). Restoration of the pristine swamp conditions, including water levels and drainage patterns, is precluded by the need to maintain firebreaks and access roads for management within the swamp ecosystem; these needs will continue to disrupt both surface and groundwater flow through the swamp.

Loss of genetic integrity through interbreeding: It is presumed that the Dismal Swamp southeastern shrew developed its distinctive size and coloration while geographically or ecologically isolated within the Great Dismal Swamp during the Holocene (Handley 1979). The recent human-induced progression toward homogeneous mature hardwood forest, more representative of habitat conditions of the surrounding region, leads to the possibility that the more common and presumably more generally adapted nominate subspecies could invade the Dismal Swamp and genetically overwhelm the existing populations of *S. l. fisheri*, which are more specifically adapted to historical swamp conditions.

Pollution: Contaminant studies designed to examine whether pollution or other environmental contaminants have affected the status of southeastern shrews in the Dismal Swamp were conducted on the Refuge in 1987 and 1989 (Ryan *et al.* 1992). These studies focused on contaminant residues in soils, sediments, surface waters, fish, white-footed mice (*Peromyscus leucopus*), and short-tailed shrews (*Blarina brevicauda*), which are most similar to *S. l. fisheri* in diet. *Blarina* showed elevated levels of lead, mercury, and several organochlorine pesticides as compared with controls; however, none of the contaminants studied was judged to be at a harmful level, and the studies concluded that contaminants in the Dismal Swamp are not a serious threat to *S. l. fisheri*. Nonetheless, potential sources of pollution in the vicinity of the Refuge could pose future threats to this small insectivore. For example, all waters draining the Suffolk City Landfill, a former designated Superfund site, enter the Refuge. This landfill received industrial and domestic wastes, as well as 30 tons of organophosphate pesticides, which were buried in the 1970s (Ryan *et al.* 1992). In addition, automobile junkyards border the Refuge to the north and are located adjacent to East Ditch, which flows directly into the swamp. Agricultural runoff from fields to the west of the Refuge could be an additional source of contaminant input to the swamp.

Taking of individual shrews: At present, the only known method for studying or monitoring Dismal Swamp southeastern shrews involves lethal collection with pitfall traps, and researchers have been permitted to take limited numbers of *S. l. fisheri* individuals in order to gain an understanding of their taxonomy, ecology, and distribution. Research considered imperative to recovery of the Dismal Swamp southeastern shrew thus poses the dilemma of having to take individuals in order to conserve the taxon. Because these shrews have a high reproductive potential and rapid maturation rate, limited collection of

individuals is not considered detrimental to healthy populations, although more widespread mortality associated with loss or permanent alteration of habitat continues to constitute the primary threat to the survival of this subspecies.

Other threats: There is no evidence that competition with other shrew species, predation, or disease has contributed to the threatened status of the Dismal Swamp southeastern shrew.

RECOVERY STRATEGY

Under the scenario that assumes that *Sorex longirostris fisheri* will prove to be a Dismal Swamp endemic, as heretofore thought, the resolution of interbreeding issues is of initial importance in providing direction for future recovery activities. Whether further data support or refute the *S. l. longirostris* "invasion" hypothesis, it is clear that *S. l. fisheri* has experienced a tremendous loss of its Dismal Swamp habitat over the past two centuries. As an assumed Dismal Swamp endemic, *S. l. fisheri* is most likely adapted to environmental conditions that favor retention of wetland qualities (flooding, organic soils, high humidity, and slow rates of leaf litter and organic soil decomposition). Any widespread destruction of these qualities, whether by ditching, forest clearing, fire during drought, or by rapid decomposition resulting from a lowered water table, serve as potential limiting factors for *S. l. fisheri.*

Under this scenario, slowing or reversing changes in the wetland habitat is the cornerstone of the recovery process for *S. l. fisheri.* Recovery actions will focus on *restoring* and *maintaining* the original character of the Dismal Swamp. Much of the restoration effort will occur within Refuge boundaries, where ditches have led to the lowering of the water table but habitat has not been irrevocably altered. With proper use of existing water control structures, it may be possible to restore something approaching the original hydrological regime of the Dismal Swamp. On a limited, experimental basis, efforts may also be made to restore or maintain the habitat mosaic nature of the original swamp through controlled burns or certain forestry practices, although care must be taken not to create conditions favoring *S. l. longirostris.*

Outside Refuge boundaries, recovery efforts will focus on maintaining unfragmented tracts of existing shrew habitat that might otherwise be developed or altered. Protection of relatively large, contiguous tracts of habitat is considered essential to the survival and recovery of the shrew if it is shown to be endemic to the Dismal Swamp. Thus, the approach to recovery under this scenario is two-pronged, relying on actions taken both within and outside current Refuge boundaries.

Supplementary Recovery Objectives and Tasks

RECOVERY OBJECTIVE

If studies confirm that the shrew's range is restricted to areas of the historic Dismal Swamp, the following conditions will be considered necessary for delisting the Dismal Swamp southeastern shrew:

1. Six publicly owned "resource conservation areas," three in Virginia and three in North Carolina), of at least 5000 contiguous acres (2270 ha) each are established and maintained outside the present Great Dismal Swamp National Wildlife Refuge management area;

2. Hydrological factors affecting shrew habitat and distribution are understood, and the hydrological integrity of the resource conservation areas and of the Refuge is secured;

3. The long-term effects on the shrew of habitat manipulations, especially within the Refuge management area, are understood, and management actions necessary to perpetuate the shrew within the Refuge have been implemented; and

4. It is determined that "genetic swamping" by *Sorex longirostris longirostris* is not occurring.

If habitat conservation becomes a condition of recovery and the following recovery tasks are implemented on schedule, delisting may be initiated in the year 2002.

ADDITIONAL RECOVERY TASKS

1. Assess the distribution of *S. l. longirostris* at the margins of the historic Dismal Swamp. The resolution of the interbreeding question requires an understanding of the distribution, habitats, and range of body sizes of *S. l. longirostris* in the vicinity of *S. l. fisheri*. Populations located within 20-30 miles of the historic Dismal Swamp will have the greatest value for study, particularly populations occurring in habitats similar to those found in the Dismal Swamp. This study could reveal locations in which the two subspecies are in close proximity, perhaps even in contact, and therefore where the existence of intergrades might be sought.

2. Maintain an appropriate water regime for restoring natural ecological processes and conserving *S. l. fisheri* habitat within the Great Dismal Swamp ecosystem. Initially, this effort will focus on habitat within Refuge boundaries. If shown to be feasible and appropriate, these efforts would be eventually extended to the swamp conservation areas defined in the recovery objective.

   Although little is known about the relationship between hydrology and *S. l. fisheri* population density in the swamp, it is evident that an intact wetland regime is important in maintaining hydrophytic vegetation, and may be essential for maintaining preferred shrew microhabitats and food sources. Because the swamp's

natural hydrological cycle has been disrupted over the course of centuries, water management is needed to duplicate, to some extent, natural events. Appropriate control of the swamp's water resources will hinge on adequate knowledge of its hydrological cycle.

In general, the flooding cycle results in inundation from December through March (sometimes longer) in large sections of the Refuge and throughout many other areas of the historic Dismal Swamp, with some habitats being flooded more deeply or for longer periods than others. The study design should consider off-Refuge activities that can affect water levels within the Refuge. The U.S. Geological Survey (USGS) and Virginia Polytechnic Institute and State University have submitted a proposal to study the hydrology of the Refuge and surrounding areas (Giles 1992). The results of this study would address many of the general water resource issues facing the Refuge, and would benefit shrew recovery by providing a basis for understanding the management requirements for perpetuation of the swamp ecosystem as a whole.

2.1 Assemble and interpret existing hydrological data. Several hydrological studies have been conducted in the Refuge (Carter 1988, Day *et al.* 1988, Lichtler and Walker 1979), which have provided details of flooding in the various parts of the Refuge throughout the year. This information needs to be examined and analyzed in order to identify further data needs and direct Refuge water management in the interim. Current water management on the Refuge focuses on reading staff gauges and managing water in the ditches; the above studies could shed light on more appropriate timing for opening and closing certain water control structures to enhance the wetland characteristics of the forest.

A hydrological study of the North Landing River is now in progress. Results of this study, when available, should also be examined for their application to Refuge water management practices.

2.2 Determine frequency, duration, seasonality, and extent of inundation or soil saturation under existing conditions. The relationship between the Refuge's existing hydrologic regime and *S. l. fisheri* habitat quality needs to be better understood. To accomplish this, water levels will have to be continuously monitored at established stations throughout the Refuge for several years, and the effects of off-Refuge land management on groundwater and surface water conditions in the swamp will need to be determined. The goal of this study would be to develop a Refuge water budget and model for water management (which could entail installation of new water control structures or changes in operation of existing structures) designed to restore and maintain the swamp ecosystem. The study should culminate in a very specific *Refuge Water Management Plan* describing monitoring and actions to be taken year-round and under different rainfall and temperature regimes. This study, which should be funded from multiple sources, would serve both shrew recovery needs and the overall goals of swamp ecosystem.

2.3 Incorporate results of the hydrological study into Refuge management practices. Implementation of the *Refuge Water Management Plan* will

require not only training for personnel in field operations but also the acquisition and use of appropriate computerized databases for effective data collection and interpretation. Baseline topographical information, at 1-foot contour intervals, should be incorporated into the Refuge's geographic information system in order to model surface water accurately. Satellite imagery of the Great Dismal Swamp watershed should also be obtained at a maximum 5-year interval in order to assess large-scale land use and vegetational patterns within and near the Refuge. These databases and equipment would serve multiple management uses, including shrew recovery.

2.4 Study the effects of specific management practices on duration and extent of inundation or saturation. The baseline information from Tasks 2.1 and 2.2 should be used to determine the hydrologic effects of various experimental and operational resource management practices on the Refuge. For example, the impacts of forest management, road maintenance, prescribed burns, and other management practices should be monitored to determine short- and long-term effects on the swamp's hydrology. This effort, which will require additional seasonal personnel, would aid in monitoring shrew recovery progress as well as evaluating the effectiveness of management techniques designed to restore and maintain the original characteristics of the swamp.

3. Design and implement Refuge management practices that will specifically benefit *S. l. fisheri*. Maintenance and recovery of the Dismal Swamp southeastern shrew is a goal compatible with the Refuge's overall mission of restoring the swamp's original character. Beyond that, however, certain management actions must be taken specifically for the shrew to achieve full recovery.

3.1 Monitor the distribution of *S. longirostris* subspecies within the Refuge. Permanent pitfall stations set up at strategic locations (e.g., deep within the Refuge, along canals and other potential travel corridors, near Refuge boundaries, along habitat "edges", and areas where habitat manipulations have occurred or are planned) will help biologists ascertain whether subspecies distribution in the swamp is changing over the long term. Barring a major environmental disaster in the Dismal Swamp that could necessitate more frequent trapping, monitoring at 5-year intervals is recommended.

3.2 Build shrew recovery considerations into the Refuge development and management decision-making process. This task focuses specifically on the shrew and a recognition that certain management activities can have unanticipated results. For example, use of heavy equipment in management operations often results in soil compaction and changes in local near-surface hydrology, and burning may result in the destruction of organic soils, leaf litter, and other structural habitat components. Therefore, management techniques (e.g., hand-cutting versus bulldozing or herbicide application, brushpiling versus brush removal, and the timing of fires) should be evaluated carefully prior to implementing habitat-altering projects within the Refuge. When the effects of proposed management activities on

shrews or their habitat cannot be predicted, the status of shrews should be monitored both before and for several seasons after implementation. Monitoring would consist of pitfall arrays as described in Task 3.1, and could be done in conjunction with this task.

As appropriate, management-oriented research should also be conducted off-Refuge in swamp conservation areas, or on State, County, or Department of Defense lands (e.g., NSGA Northwest, North Carolina Game Lands, or Northwest River Park). Research participants could include the U.S. Navy, the Virginia Department of Forestry, the Virginia Department of Game and Inland Fisheries, the North Carolina Wildlife Resources Commission, and State Natural Heritage Programs.

3.3 Continue study of environmental contaminants in surface water. Data have already been collected concerning the presence of contaminants in the water, sediments, fishes, and two species of small mammals in the Refuge. Further studies should be conducted to determine the amount, quality, and types of other contaminants entering the Refuge, and their effects on invertebrates and vertebrates. Known landfills and auto junkyards should be closely monitored as potential sources of contamination.

4. Identify and protect *S. l. fisheri* and its historic Dismal Swamp habitat outside Refuge boundaries. If studies show a relatively localized distribution, full recovery of the Dismal Swamp southeastern shrew will be tied to protection of significant amounts of shrew habitat outside current Refuge boundaries. Study results should provide a basis for delineating swamp conservation area boundaries. Distributional and taxonomic data will be used to proceed with land protection efforts to offset habitat loss and conversion, which are occurring rapidly, affecting *fisheri* directly and promoting the possibilities for contact and genetic exchange with *S. l. longirostris*.

Areas important for maintaining *S. l. fisheri* throughout its historical range should be identified. These areas should comprise tracts that are sufficiently large and unfragmented to incorporate all of the shrew's ecological requirements and to allow Dismal Swamp shrew movement and genetic interchange without promoting introgression of *Sorex longirostris longirostris*. Prime areas should be delineated as shrew conservation areas, and protection needs should be prioritized. This planning process should be conducted within the framework of comprehensive watershed protection programs involving local governments and landowners.

Habitat "banking" -- similar to that used to protect large tracts of wetlands pursuant to Section 404 of the Clean Water Act -- will be considered as a primary means of protection. The idea of "shrew habitat conservation banking" is at the conceptual stage; many details must be worked out before such a plan could be implemented. Also, it should be emphasized that *shrew habitat protection and wetlands protection are distinct processes regulated by separate laws and must be dealt with individually.* However, the establishment of some sort of a habitat bank for the Dismal Swamp shrew may be the only practical way to achieve protection of the large contiguous tracts necessary for shrew recovery.

5. Prepare public education materials, as appropriate. A fact sheet and accompanying map informing the public about the protected status of the shrew, its distribution, protection needs, and legal obligations is in process. A display and/or program should also be prepared to educate local citizens about the shrew and its habitat. Area schools should be informed of the existence of these educational materials and encouraged to organize field trips to the Refuge.

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Additional Information for Implementing Recovery

RESPONSIBLE AGENCIES

U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
The Nature Conservancy

NOTE: Because the recovery tasks described in this appendix are not scheduled for the next three fiscal years, a supplemental implementation schedule is not included at this time.

APPENDIX B.

PROTOCOL FOR TRAPPING SOUTHEASTERN SHREWS (*Sorex longirostris*)

The trapping protocol described here is designed to make the results of all future trapping comparable with those of previous studies. Specifically, these methods should be used when trapping for the Dismal Swamp southeastern shrew, *Sorex longirostris fisheri*, a Federally-listed small mammal restricted in distribution to southeastern Virginia and northeastern North Carolina. Because *S. l. fisheri* is protected by Federal law, a special permit must be obtained from either the Virginia Department of Game and Inland Fisheries (Richmond) or the North Carolina Wildlife Resources Commission (Raleigh). Summaries of data (including negative surveys) should be sent to Dr. N. Moncrief, Virginia Museum of Natural History, 1001 Douglas Avenue, Martinsville, VA 24112. Specimens should be deposited in a central location: U.S. National Museum, Virginia Museum of Natural History, or North Carolina Museum of Life Sciences. Permits should be conditioned to require these reports and deposition of specimens in a particular location.

When surveying a site, determine the number of habitat types that are present, and establish two or more replicate study grids in each habitat type. For instance, if the study site has areas of 5-year old pine plantation, recently clearcut land, and 20-year old pine plantation, then two study grids should be placed in each of the three habitat types. Small sites will usually have at least two habitat types, and large sites rarely have more than five habitat types.

Each study plot is set only on one "habitat type," such as the 20-year old pine plantation in the above example. On each study plot, **measure a 5 X 5 square grid with 12.5 m intervals** for the placement of the pitfall traps. This grid, **50 m on a side,** encloses an area of 0.25 ha, and permits quick calculations of the number of animals per hectare (ha) of each species. You will need **a zone of similar habitat at least 6 m wide** around the perimeter of this grid. If the patch of habitat will not support a square grid with a border of the same habitat, change the shape of the grid to 4 X 6, 3 X 8, or even 2 X 12.

By doing so, you create more edge to grid, which probably doesn't alter results greatly in survey work of this kind.

Once the grid is measured, place one pitfall trap near each coordinate on the grid (each of which can be marked with a surveyor's flag or with colored flagging). The **pitfall traps should be of #10 cans,** set in the ground with the top of the can flush with the soil surface. These cans, about 22 cm high and 15 cm in diameter (9 by 6 inches), are the size used for restaurant food. A commercially available (Iwan) auger is used to drill a 15 cm hole that nicely accommodates the #10 can. When drilling the hole, try to minimize the disturbance of the area around the pitfall trap so that shrews will not detect barriers or bare soil just before running into the pitfall trap. The **pitfall traps are unbaited and without drift fences.**

Each pitfall trap is filled with 2-5 inches of water. Since Dismal Swamp southeastern shrews frequently live in seasonally flooded habitats, it sometimes is necessary to make some adjustments to accommodate flooding. Use a carpenter's awl to punch four or five holes midway up the side of each can. This will permit water to enter the can as the water table rises near the surface. Without these holes, the can will pop out of the ground, due to its buoyancy as the water table moves upward. If the water table continues to rise, the entire can will be filled with water, and it then ceases to be a trap. (Shrews that enter the water at the top of the can will merely swim to the other side.) Preservative (such as formaldehyde[2]) can be added to the water to preserve the specimens, especially during warm weather, if the traps are not checked daily.

Trapping on each study grid should be conducted for **at least 30 consecutive days.** The traps should be checked as needed, at least weekly, and more often in the warmer months. More water or formaldehyde may be added, as needed. Specimens captured

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[2] The use of formalin can be an asset if the traps cannot be checked at least once a week, but it can also inhibit the cleaning activities of dermestids and often compromises the quality of the cleaned skull; for instance, (1) a skull may retain formalin-impregnated tissue that dermestids avoid, (2) a skull may be moderately to severely damaged when soaked to remove the formalin if dermestids eat the tissue along with segments of the thin softened bone of the cranium, or (3) a skull may be reasonably well_cleaned but have moderately to severely warped cranial bones. These problems are further exacerbated if the specimen is placed whole in a jar of formalin or alcohol as soon as it is collected without first removing the skull (T. French, Massachusetts Division of Fisheries and Wildlife, *in litt.* 1994).

should be removed from the cans and placed in plastic bags with labels that include date and grid number; location of shrews within the grid will be less useful information in survey work. Later (perhaps after they have been frozen), the small mammals need to be identified as to subspecies by a curator or other expert.

Pitfall trapping[3] can be conducted at any season, but because shrew activity is associated with periods of high humidity or rainfall, trapping should be extended after a prolonged drought. Similarly, trapping may have to be suspended (or the period of trapping extended) due to prolonged flooding of the site.

[3] One of the great advantages of pitfall trapping is that virtually every skull should be unbroken and in near-perfect condition, even if the specimen is not perfectly fresh. It should be a high priority to ensure that when specimens are taken, they are properly cleaned and preserved. Skull measurements are far more dependable and diagnostic than standard body measurements. It is advisable to use genetic or cranial morphometrics as diagnostic characters and not external body measurements (T. French *in litt.*1994)

APPENDIX C.

SAMPLE DISMAL SWAMP SOUTHEASTERN SHREW FACT SHEET

DISMAL SWAMP SOUTHEASTERN SHREW
(Sorex longirostris fisheri)

- On October 27, 1986 the Dismal Swamp southeastern shrew was added to the U.S. Fish and Wildlife Service's list of threatened species.

- The Dismal Swamp southeastern shrew is known to occur within the historic boundaries of the Great Dismal Swamp of extreme southeastern Virginia and adjacent portions of North Carolina, although some of this area is no longer suitable shrew habitat. Studies to determine the shrew's distribution in North Carolina are currently underway.

- Possible threats facing the Dismal Swamp southeastern shrew are habitat loss and modification, and interbreeding with the more common upland southeastern shrew.

- The Dismal Swamp southeastern shrew is protected throughout its range by the Federal Endangered Species Act. This Act prevents the "take" of species listed as threatened or endangered. Take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct. Harm consists of acts that may include significant habitat modification or degradation that results in the killing or injury of individuals by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. This species is also protected by Virginia's Endangered Species Act.

- The map on the other side indicates areas in Virginia that <u>may</u> contain the Dismal Swamp southeastern shrew if appropriate habitat exists. This map may be modified as new information becomes available. If you are planning any land-altering activities within the shaded areas, please contact one of these agencies:

Virginia Department of Game
and Inland Fisheries
P.O. Box 11104
Richmond, Virginia 23230
(804) 367-1000

U.S. Fish and Wildlife Service
Virginia Field Office
P.O. Box 480
White Marsh, Virginia 23183
(804) 693-6694

[INSERT PICTURE OF SHREW]

Virginia and North Carolina are home to the Dismal Swamp southeastern shrew *(Sorex longirostris fisheri)*, a diminutive mammal measuring less than four inches in length. It has a long tail, brown back, slightly paler underparts, and buffy feet (Handley 1979). This shrew probably developed its distinctive size and coloration while geographically or ecologically isolated from its smaller, more upland relative, *Sorex longirostris longirostris*.

The Dismal Swamp southeastern shrew lives in leaf litter where it feeds on small insects and may have two or more litters of four young each year. Within the historic Dismal Swamp, the shrew lives in a variety of habitats. In general, highest shrew densities are found in early successional habitats such as recent clearcuts and regenerating forests, with lowest densities in mature forests. Despite supporting lower densities, mature forests are important to the survival of these shrews during periods of drought or fire. Little else is known about the biology of this shrew.

Although a portion of the shrew's habitat was protected through the establishment of the Great Dismal Swamp National Wildlife Refuge in 1974, areas of the historic Dismal Swamp that remain outside the Refuge continue to be lost to development. The original Dismal Swamp has been reduced in size by 85% since the early 1900s (U.S. Fish and Wildlife Service 1988), and ditching has altered the character of the remnant swamp, making it less wet. In addition, naturally occurring fires and human-related activities such as burning and grazing, which once maintained sections of the swamp in various stages of biological succession, no longer occur.

Current threats facing the Dismal Swamp southeastern shrew appear to be: (1) direct habitat loss due to development and conversion for agriculture and silviculture, (2) modification of suitable habitat to a more upland condition through draining of wetlands, and (3) interbreeding with *Sorex longirostris longirostris*. Human alterations to the Dismal Swamp are rapidly changing the physical character of the habitat. As conditions within the Dismal Swamp continue to change from wet to dry, it can be assumed that the more common, dry-site adapted southeastern shrew will invade this newly available habitat, breeding with and replacing the Dismal Swamp southeastern shrew. If it is verified that the Dismal Swamp southeastern shrew has a relatively limited distribution, the cornerstone of the recovery process for the shrew will be slowing and reversing these habitat changes. This can be done by maintaining and restoring forested wetland habitats within the historic Dismal Swamp.

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Text and layout prepared by the Dismal Swamp Southeastern Shrew Recovery Team (November 1993).

APPENDIX D

LIST OF REVIEWERS

The U.S. Fish and Wildlife Service wishes to thank all those who took the time to review and comment on the draft Dismal Swamp Southeastern Shrew Recovery Plan. As a result of comments regarding the distribution and taxonomic status of the shrew, substantial changes were made to the plan, which is now much more provisional and short-term in nature. Most other comments pertained to the habitat conservation recommendations in the draft plan, and have been incorporated into Appendix A in this document. Comments regarding habitat conservation will be revisited if this need once again becomes central to full recovery of the Dismal Swamp southeastern shrew. All comments are available for review upon request; they will be on file in the Virginia Field Office of the U.S. Fish and Wildlife Service.

Independent peer review was solicited from three individuals, and a response was received from one of these reviewers, Dr. Tom French of the Massachusetts Natural Heritage Program. Dr. French's comments focused on the need to resolve the uncertainties surrounding the distribution and taxonomy of the Dismal Swamp southeastern shrew subspecies, and the potential significance of managing the Dismal Swamp ecosystem for recovery of this listed taxon. This plan captures the spirit and intent of those comments. He also provided several informational and editorial comments that have been incorporated into the final plan.

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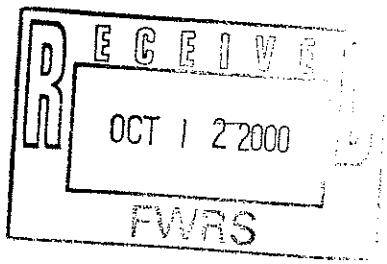

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