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The Effects of Habitat Fragmentation and Loss on Dismal Swamp Mammals

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ABSTRACT

In the 1890's, 5 new species of small mammals were described from the Great Dismal Swamp of Virginia and North Carolina. Although since relegated to subspecies status, these taxa seem to have developed during the Holocene in association with the emergence of the Dismal Swamp. The Dismal Swamp, a forested wetland with a mosaic of vegetation types, formerly extended from the James River to the Albemarle Sound but has been shrinking since the 18th Century due to efforts to drain the land for cultivation. More recently, much of the historic Dismal Swamp has been fragmented into cities, subdivisions and industrial parks, and although more than 47,000 ha has been placed in a national wildlife refuge, habitat loss continues there through biological succession. Thus, the distinctive mammalian taxa of the region, together with disjunct populations of species of larger mammals, are threatened by habitat loss via destruction, succession, or fragmentation, and for some, interbreeding with upland subspecies.

Key Words: Dismal Swamp, distribution, endemic mammals, shrews, status, threats, wetlands.

INTRODUCTION

Four taxa of small mammals were described from specimens collected between 1895-1898 near Lake Drummond in the Dismal Swamp of Virginia (Handley, 1979), and a fifth species, a meadow vole, was described from a section of the Dismal Swamp in North Carolina (Rhoads and Young, 1897). These mammals are: *Blarina* [*brevicauda*] *telmalestes*, the Dismal Swamp short-tailed shrew; *Sorex* [*longirostris*] *fisheri,* the Dismal Swamp southeastern shrew; *Microtus* [*pennsylvanicus*] *nigrans*, the darkest race of meadow vole; *Ondatra* [*zibethicus*] *macrodon*, a large-toothed muskrat; and *Synaptomys* [*cooperi*] *helaletes*, the Dismal Swamp southern bog lemming. All 5 taxa were originally described as distinctive species but later taxonomic revisions have reduced these taxa to subspecies of the species shown in brackets.

Later studies revealed that *M. p. nigrans* and *O. z. macrodon* have distributions in coastal Virginia and North Carolina that extend well beyond the boundaries of the Dismal Swamp. However, the other 3 taxa, particularly the Dismal Swamp southeastern shrew and Dismal Swamp southern bog lemming, seemingly are restricted to the historic Dismal Swamp. (The distribution of *Blarina brevicauda telmalestes* is less well understood but probably now extends beyond the boundaries of the historic Dismal Swamp.) Thus, it is fair to assume that these 3 taxa of small mammals somehow have developed in association with the formation of the Dismal Swamp and are adapted to the Dismal Swamp environments. Although it is unclear how a swamp could serve as an isolating force or mechanism to separate

swamp from upland populations and thereby permit genetic and evolutionary divergence, the distributional evidence supports that viewpoint. Furthermore, if species have evolved in association with the Dismal Swamp, it is fair to assume that they are highly adapted to that environment and may have difficulty in surviving different conditions. Thus, the loss of Dismal Swamp habitat, by whatever means, poses a threat to these Dismal Swamp mammals.

Both shrews show a feature that is typical of small mammals on islands, i.e., they are larger than individuals from the nearby "mainland" (here, upland) subspecies. The Dismal Swamp southeastern shrew is about 25 % longer than the upland subspecies, *Sorex longirostris longirostris,* whereas the Dismal Swamp short-tailed shrew is 15-20% longer and often is 2-3 times heavier than small upland *Blarina*, now called *B. carolinensis*, the southern short-tailed shrew. Individuals of the latter species from the region weigh 6-8 g, and usually measure less than 100 mm. Thus, the size differences between Swamp shrews and upland shrews are striking, and in this regard too the Dismal Swamp seems to be acting as a biological island.

The purpose of this paper is to describe what is known about the present distributions of the Dismal Swamp endemics and to evaluate how the changes in land-use patterns now occurring in the region might alter the status and distribution of these and other Dismal Swamp mammals. Specifically, the swampland forests, seemingly crucial to the continued existence of these Dismal Swamp mammals, are disappearing at a steady rate, despite both laws protecting wetlands and the best efforts of state and federal agencies to acquire large tracts of Dismal Swamp and place them in reserves and refuges.

BACKGROUND AND REVIEW

The Great Dismal Swamp of eastern Virginia and North Carolina is a large forested wetland that has resisted more than 2 centuries of attempts to drain and convert the land to agriculture or other purposes. The primary reason for these failures relates to an impermeable fossiliferous clay, the Yorktown Formation, deposited during an early Miocene transgression (Oaks and Whitehead, 1979), that underlies 5 more permeable lagoonal deposits of Pleistocene age. Believed to have originated during the Sangamon Interglacial period of the Pleistocene, the Dismal Swamp slopes gently to the east from its discrete western boundary, the Suffolk Escarpment. Mean elevation in the Dismal Swamp falls approximately 20 cm per km to lowest elevations at the Deep Creek Swale and Fentress Rise, the old dune lines that form the more poorly defined eastern boundary. Thus, a combination of geological and topographical factors, particularly sub-surface layers and the natural drainage barriers, has created swamp that resists draining only in this section of the Mid-Atlantic Coastal Plain. The Dismal Swamp is unusual because it is "a finger of palustrine forest of the Coastal Plain, extended north yet oriented south because of high temperatures, high humidity, and a long growing season (Murray, 1965)."

Core samples collected throughout the Dismal Swamp have provided a history of plant succession through both pollen analysis and the distribution of peaty soils (Whitehead and Oaks, 1979). Swamp formation probably began along stream courses with the beginning of the retreat of the Wisconsinan glacier, about 11,000 to 12,000 ^{14}C years ago. By 10,600 ^{14}C years ago, the spruce-pine forest of the late

Pleistocene had been replaced by a variety of species typical of northern hardwood forests, which in turn was replaced (by 8200 ^{14}C years ago) by oaks, hickories and deciduous species of present forests in the Southeast. The peat marsh then was confined to stream beds until about 6,000 ^{14}C years ago, when it progressed inland and laterally across drainage divides. At this time, some southern swamp forest species were appearing, and peaty elements in the soils indicated an extended hydroperiod, producing swampy conditions. During the next 2,500 years, peat layers developed to cover virtually the entire Dismal Swamp, forests changed to the cypress-gum domination of today, and the water table was at or above the surface for significant periods each year. Thus, the present vegetation and conditions of the Dismal Swamp date from about 3,500 ^{14}C years ago, making this habitat a young feature in the region. The cypress-gum forest has been variable both spatially and temporally during these 3,500 years as a result of peat depth, fluctuations in water table, fires, and more recently by draining, logging, and other human disturbances. The Dismal Swamp at the time of settlement by Europeans was a mosaic of habitat types, including large tracts of Atlantic white cedar (*Chaemaecypris thyoides*), bald cypress (*Taxodium distichum*), cane (*Arundinaria gigantea*), probably with pond pine (*Pinus serotina*) and loblolly pines (*Pinus taeda*) on drier sites. Small patches (usually 1 ha) of slightly higher and drier habitat formed mesic islands (G. Levy, pers. comm.) that supported beeches and similar trees that are typical of upland forests in southeastern Virginia.

The former extent of the Dismal Swamp at the time of settlement by Europeans may never be known, but it probably stretched southward from the Chesapeake Bay (Norfolk) to the Albemarle Sound in North Carolina, and from the James River and its tributaries eastward to coastal dunes of different ages near the Atlantic Ocean. Fingers of swamp habitat along rivers or streams sometimes extended beyond the contiguous Dismal Swamp that was estimated to have been as large as 6,200 km^2 (Kearney, 1901). Low-lying swamp forests along the Northwest and Pasquotank Rivers and their feeder creeks are examples of these extensions from the core area of the Dismal Swamp.

LOSS OF DISMAL SWAMP HABITAT DUE TO HUMAN ACTIVITIES

During the 18th Century there were numerous development schemes to try to convert sections of the Dismal Swamp into farmland. George Washington was a member of a land company that sought to develop the Dismal Swamp for agriculture, and in 1768 he directed that a survey of an eastbound road ending at Lake Drummond be made. Washington Ditch, and many other ditches dug by slave labor, served the dual purpose of providing a waterway on which to float commercially valuable logs and an adjacent roadway (created by placement of the spoil from the ditch) for the mules or oxen that pulled those rafts of logs. Linking such ditches with those draining to the east served to help drain the water from the Swamp. Elsewhere in the mid- Atlantic coastal plain, these techniques were successful but these methods always failed in the Dismal Swamp, due to the impervious clays in the subsoils. When the cleared land finally was abandoned, it inevitably returned to swamp forest. Later, logging companies dug more ditches and made more roads (and even built narrow-gauged railways) as they exploited the large tracts of cypress and Atlantic white cedar, both important trees in

shipbuilding and as construction materials for the emerging cities and industries in the region (Frost and Musselman, 1987).

In 1812, the Dismal Swamp Canal was completed by the U. S. Army Corps of Engineers. Lying on the east side of the Dismal Swamp and now running parallel to US Route 17, this canal linked Norfolk with agricultural and commercial enterprises in coastal North Carolina. Later, a "feeder ditch" was constructed to connect Lake Drummond to the Dismal Swamp Canal; this scheme was designed to add water to the canal during periods of low flow. Regrettably, the engineers had neglected to plumb Lake Drummond, which despite its 1000-ha area has a mean depth of 1.3 m and hence has scarcely enough water to change the flow in the Dismal Swamp Canal. Even if the lake was 3 or 4 times deeper early in the 19th Century (as some notes from the period indicate), the volume of water in the lake is too small to raise water levels in the canal significantly. This withdrawal of water from Lake Drummond has helped lower the water table and hasten the drying of the Dismal Swamp, and therefore has contributed to the changes in vegetation.

Thus, in the last 200-300 years the extent of Dismal Swamp forests has shrunk considerably and the remnants have changed from a patchwork of Atlantic white cedar, bald cypress, and cane to forest increasingly dominated by red maple (*Acer rubrum*) and black (*Nyssa sylvatica*) and water gums (*N. aquatica*). Besides the changes in water table due to ditches and construction of the Dismal Swamp Canal, fire suppression and soil subsidence also have modified the swamp environment, thereby directly or indirectly influencing the biota, including the mammals. Recognizing the unusual biological features of the Dismal Swamp, the US Fish and Wildlife Service (USFWS) established the Great Dismal Swamp National Wildlife Refuge (GDSNWR) in 1974, using a large tract donated by the Union Camp Corporation as the core area.

THE DISMAL SWAMP MAMMAL FAUNA

The first collections of mammals were made in the Dismal Swamp during the 1895-1898 period by teams of investigators from the U. S. Department of Agriculture's Bureau of Biological Surveys. According to Handley (1979), who examined field notes and unpublished reports, the teams, headed by A. K. Fisher and Wm. Palmer, spent a total of 23 weeks making collections which were sent back to the Smithsonian Institution for identification and accession. The large shrews from the Dismal Swamp were described as new species (*Blarina* [*brevicauda*] *telmalestes* and *Sorex* [*longirostris*] *fisheri*) by C. Hart Merriam (1895a, 1895b), considered to be the father of American mammalogy and then the Director of the Bureau of Biological Surveys. Merriam (1896, 1897) described more of Fisher's collections from the Lake Drummond region when he named new species of southern bog lemming (*Synaptomys* [*cooperi*] *helaletes*) and of muskrat (*Ondatra* [*zibethicus*] *macrodon*), respectively.

Recently, the statuses of some Dismal Swamp taxa were questioned (Handley, 1979, 1980) because no specimens of Dismal Swamp southern bog lemming and only 1 specimen of Dismal Swamp southeastern shrew had been collected in this century. However, lines of pitfall traps set by Rose (1981a, 1981b) yielded 7 *Synaptomys* and 15 *Sorex longirostris* from locations near Jericho and East Ditches in the northwest corner of the GDSNWR. These findings led to a longer study of

Dismal Swamp mammals (Rose, 1983) that focused on these 2 species but also provided information about other small mammals too (Rose et al., 1990). The 3 Dismal Swamp endemics (Dismal Swamp subspecies of southeastern shrew, short-tailed shrew, and southern bog lemming) were the most numerous species taken in the pitfall traps. Some species, such as the eastern harvest mouse, *Reithrodontomys humulis*, were found to be far more common than previously believed, and 1 species, the hispid cotton rat, *Sigmodon hispidus*, was recorded for the first time from the Dismal Swamp. These studies, which used live trapping and nest box methods besides pitfall traps, failed to record any specimens of the cotton mouse, *Peromyscus gossypinus*, a common species in the Dismal Swamp during the surveys of the 1895-1898 period. The cotton mouse seems to have disappeared from the Swamp; none has been taken since the specimens collected near Corinth Chapel Road in Suffolk by D. Hayne and L. Dice in the 1930s (Dice, 1940).

The results of the field studies conducted in the Dismal Swamp during the 1980's indicate that the Dismal Swamp southeastern shrew (*S. l. fisheri*) is fairly widespread but seems to be restricted to the historic Dismal Swamp (Figure 1). In the upland habitats of the southeastern Virginia region, the smaller *S. l. longirostris* sometimes is common. Because the continued drying of the Dismal Swamp could permit the invasion of the upland subspecies into the Dismal Swamp, the USFWS considered introgression and genetic swamping to be substantial threats, and therefore listed *S. l. fisheri* as federally "threatened" (Federal Register, 26 September 1986). No critical habitat was designated, because the main threat lies in the loss of the taxon from genetic swamping. The Dismal Swamp southern bog lemming also was found in a range of early succesional habitats over an area of at least 1,000 km^2. Because a similar threat of interbreeding did not exist with *S. c. helaletes* (the nearest populations are in the mountains of western Virginia, perhaps 400 km away), southern bog lemmings were not considered to be in need of the protection of federal law. The distribution of the southern bog lemming in the region is approximately the same as shown in Figure 1. At present, *Sorex longirostris fisheri* has the protection of federal and state law with its status as "threatened" but the southern bog lemming, formerly a species of "special concern" in Virginia, has no legal status in the most recent listing of Virginia mammals, because its populations are widespread in the Dismal Swamp region and seemingly secure.

The genus *Blarina* continues to baffle. The more than 200 shrews collected to date in the region show no clear patterns of sorting themselves into small and large ones, as would be predicted by the sizes of *Blarina carolinensis*, which ranges from 6-8 g in the region, and the large *B.* [*brevicauda*] *telmalestes*, specimens of which can weigh up to 23 g. The smaller shrews are more or less restricted to grasslands and other openings of early successional habitat, and the larger shrews tend to be found in shrubby or forested locations, suggesting an ecological separation of *Blarina* species. There is a need for a comprehensive systematic and ecological study of the *Blarina* in the vicinity of the Dismal Swamp.

The disappearance of the cotton mouse is puzzling because it was among the most common small mammals collected during the first decade of study in the Dismal Swamp. *Peromyscus gossypinus*, often the most common woodland mouse in the forests of the Carolinas and Georgia, is at the northern edge of its distribution

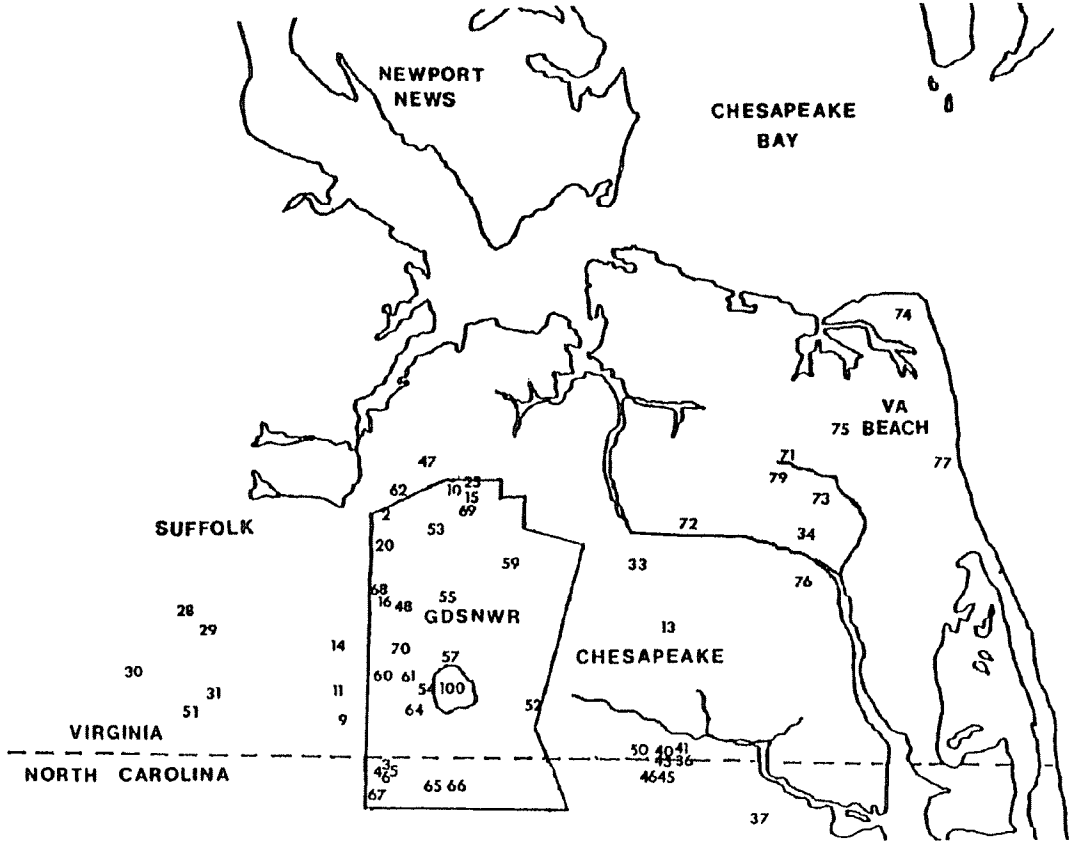

FIGURE 1. Map of southeastern Virginia and adjacent North Carolina showing the locations of capture (represented by the numbers) of the threatened Dismal Swamp southeastern shrew, *Sorex longirostris fisheri.*

in southern Virginia, which may be a contributing factor to its disappearance from the Dismal Swamp forests. Pockets of cotton mice persist along river bottoms of the Nottoway and Blackwater Rivers and cotton mice have been taken 12 miles downstream from Richmond at Presquile National Wildlife Refuge (near Hopewell) on the James River (Pagels, 1976). It would be speculation to suggest that the disappearance of the cotton mouse is due to qualitative changes in the habitats of the Dismal Swamp, but the general drying of the Dismal Swamp, and the related vegetational changes, could have contributed to its demise there. The fact that Virginia populations of *P. gossypinus* persist only in riparian habitat suggests a strong need of moisture or high humidity conditions, at least when coexisting with *P. leucopus*. The populations of *Peromyscus leucopus,* white-footed mouse, and *Ochrotomys nuttalli*, golden mouse, appear to be as common today as 100 years ago (Rose et al., 1990).

The Dismal Swamp has been important as the home for a disjunct population of black bears (*Ursus americanus*). Other bear populations were extirpated in the coastal plain and piedmont regions by the 1830's, but because access by road or boat was so difficult in the Dismal Swamp the bears could not be hunted to extinction there as they were elsewhere. Today the Dismal Swamp black bear population numbers about 300; a few are shot or hit by cars each year on the borders of the GDSNWR, and occasionally individuals from this population migrate widely, even into the heart of Portsmouth (D. Schwab, pers. comm.). The Dismal Swamp, and particularly the GDSNWR, also harbors populations of bobcats (*Lynx rufus*) and river otters (*Lutra canadensis*), 2 furbearers formerly heavily hunted and trapped for their pelts.

PROTECTION OF THE MAMMALS

The Dismal Swamp southeastern shrew is a federally protected threatened mammal, but *Synaptomys cooperi helaletes*, formerly a species of special concern in Virginia, seems secure after further studies in the early 1980s. Additional information on the status and distribution of these taxa continues to be collected. Specific studies are needed to measure the extent of introgression by *Sorex longirostris fisheri* populations by the upland *S. l. longirostris*, but these studies are exceedingly difficult to conduct because of the virtual impossibility of catching these animals alive. Clearly, karyological and DNA studies would yield the kinds of information needed to determine the real extent of the threat to Dismal Swamp shrews (*Sorex* and *Blarina*) by introgression from upland conspecifics or congeners.

For the larger mammals, the GDSNWR provides a refuge and sanctuary of sorts, where although the white-tailed deer are hunted, there is no hunting of black bears and no trapping of bobcats, river otters, or the beaver populations that are becoming reestablished there. Because large mammals require large areas to sustain their populations, with continued losses the GDSNWR and other public lands will be the remaining strongholds of these populations. However, small patches of Dismal Swamp forest that are not contiguous with the GDWNWR could continue to be important to the small mammals.

The continued loss of Dismal Swamp forest habitat will have progressive detrimental effects on the endemic mammals. As the area of Dismal Swamp habitat shrinks through a combination of factors, including ditching, fire suppression,

biological succession, fragmentation and conversion of land to agriculture or other uses, the mammals are faced with loss of the habitat conditions in which some of them diverged from the upland populations. Thus, the genetic integrity of some taxa, especially the southeastern shrew, is threatened as the separation, whether ecological or distributional, erodes between upland and Dismal Swamp taxa as the Swamp habitat is lost or fragmented.

STEPS LEADING TO THE PROTECTION/PRESERVATION OF DISMAL SWAMP HABITAT

State and federal agencies are striving to secure large tracts of Dismal Swamp habitat, and to manage these lands so that the distinctive nature of the Dismal Swamp can be retained. For example, the Virginia Natural Heritage Program recently secured over 500 ha of swamplands along the Northwest River, adjacent to a large tract of swampland already in Northwest River Park. The GDSNWR has been growing by acquisitions through gifts and purchases, and as of 1991 has an area of more than 47,000 contiguous ha. In an effort to restore a more swamp-like nature, the GDSNWR staff has installed water control structures on many of the canals, with the goal of retaining water in some sections of the Refuge (Swamp). Lengthening the flooding period for a few weeks longer than at present could have the effect of eliminating much of the red maple, and this alone likely would move those sections of the Swamp closer to what they once were. Furthermore, the GDSNWR staff has gained more control (from the US Army Corps of Engineers) over the flow of water from Lake Drummond into the Dismal Swamp Canal, and this too increases the potential for holding more water in Lake Drummond and ultimately of increasing the swamp-like nature of a large area nearby. The management plan for the GDSNWR, implemented in the late 1980s, calls for increasing vegetational diversity by the use of fires and clearcutting of small plots. These actions also are seen as benefitting Dismal Swamp mammals.

Most of the The Dismal Swamp clearly has fallen within the definition of "wetlands" as outlined by the agencies in charge of jurisdictional wetlands. In the summer of 1991 a new definition of wetland was proposed for review through autumn 1991. If this new definition is adopted, much of the land area that has been classified as wetlands in southeastern Virginia would be reclassified. Some people have estimated that as much as 80% of the Dismal Swamp would lose its wetlands classification if the most extreme definition is adopted. Such a change would have devastating effects on those species of mammals that either have evolved in association with the Dismal Swamp or have relied on the isolation afforded by large sections of impenetrable swamplands for their survival in the past. Thus, although large sections of privately owned swamplands are being purchased and preserved by state or federal agencies, much of the Dismal Swamp is currently threatened by greatly increased recent urban development in Virginia Beach, Chesapeake, and Suffolk, and an even greater threat looms with the possible change in the definition of wetlands.

FUTURE OUTLOOK FOR THE ENDEMIC SPECIES OF DISMAL SWAMP SMALL MAMMALS

Despite the prospects for continued loss and fragmentation of the Dismal Swamp ecosystem, there are some reasons for optimism that the 3 taxa of small

mammals will survive. As small mammals, southern bog lemmings and Dismal Swamp southeastern and short-tailed shrews can maintain modest population densities even on small tracts, a statement that cannot be made for medium-sized predators or larger mammals of almost any (feeding) type. Also, as small mammals they have large litters and have the potential to recover after their populations are seriously reduced by some external force (such as fire or the reduction of area of habitat because of prolonged flooding). All 3 species have the potential to produce 8-18 young during the one breeding season in which an individual might survive to breed. Furthermore, some current land-use practices in the region, especially forestry practices, often create large tracts of prime habitat for these 3 small mammals. After the land is cleared of trees, the stumps and debris are pushed into windrows and trees are planted between the windrows. After the grasses appear this habitat is quickly used by all 3 species of small mammals. All 3 species are good colonizers and readily find, occupy, and sometimes reach high densities in early successional stages of forest regeneration. Among the habitat types in the region, early successional stages of forest regeneration support the highest densities of all 3 species of small mammals. Thus, as long as substantial amounts of grasses endure (8-10 years), southern bog lemmings will persist, as will modest populations of the 2 shrew species. Once the grasses disappear, so do the southern bog lemmings. However, older forest habitat seems to support low densities of both species of shrew, perhaps 5 individuals/ha (Rose et al., 1990). Thus, shrew densities drop by 50- 80% from their highest levels, but they do persist in the maturing forests. The major threats to these small mammals lie not in the size of the habitat patches so much as in the drying of their habitats and, for some, the threat of interbreeding with upland populations.

By contrast, large mammals require large tracts of land, such as are afforded by the GDSNWR to populations of black bears and otters. If regional development continues at the present pace or is hastened by changes in the definition of wetlands, large mammals in the region may survive only in the Refuge, as the black bears have done for the past 150 years for other reasons.

In conclusion, the Dismal Swamp seems to have served as a refugium for some taxa of mammals, isolating some populations of small mammals and allowing them to diverge and even become morphologically distinct during the past 3,000 to 5,000 years. Thus, some taxa of small mammals seem to have evolved in association with the development of the Dismal Swamp, a forested swampland with long winter hydroperiod that has resisted 2-3 centuries of efforts to develop but now faces increased threats.

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