Notes on the Geographical and Ecological Distribution of Relict Populations of *Synaptomys cooperi* (Rodentia: Arvicolidae) from Eastern North Carolina

MARY K. CLARK
North Carolina State Museum of Natural Sciences
P.O. Box 29555
Raleigh, North Carolina 27626-0555

AND

MICHAEL S. MITCHELL AND KENT S. KARRIKER
North Carolina State University, The Wildlife Program,
Department of Forestry
Raleigh, North Carolina 27695-8002

ABSTRACT—As part of a study to evaluate the effects of forest management on North Carolina pocosin communities, small mammals were trapped between May 1991 and May 1992 in 15 stands in Carteret, Craven and Jones counties, North Carolina. Captures included three *Synaptomys cooperi*, extending the known range of the species in eastern North Carolina about 170 km south of Dismal Swamp localities. These specimens, and others collected since 1977, indicate that the paucity of records between 1896 and the 1970s is the result of ineffective trapping methods and insufficient fieldwork in appropriate habitat. *S. cooperi* is more widely distributed in eastern North Carolina than previously reported. Populations are disjunct and appear to be Pleistocene relicts.

The southern bog lemming, *Synaptomys cooperi*, occurs in eastern North America (Fig. 1) from southeastern Canada west to western Minnesota, and south to southwestern Kansas, northeastern Arkansas, southeastern Tennessee, and western North Carolina (Linzey 1983.). A population in the Dismal Swamp in Virginia and North Carolina is disjunct and is recognized as a separate subspecies, *S. c. helaletes* (Wetzel 1955). For almost a century this subspecies was known only from 24 specimens collected between 1895 and 1898 (Handley 1979). Between 1977 and 1980, field work in the Dismal Swamp (Rose 1981) and in adjacent areas in northeastern North Carolina yielded additional specimens of *S. c. helaletes*, some from new localities, but all in close proximity to the Dismal Swamp (Rose 1981, Lee et al. 1982). This subspecies is now con-

sidered to be common in many habitats in that area (Rose et al. 1990, Handley 1991).

Before 1989 *S. cooperi* had been reported in eastern North Carolina only from Gates, Pasquotank, and Perquimans counties (Brimley 1905, Rose 1981, Lee et al. 1982). After intensive trapping on the Dare Country mainland, often in what might be regarded as optimal habitat for the species, Clark et al. (1985) concluded that *S. cooperi* did not occur south of the Albemarle-Pamlico peninsula. Four specimens collected between 1989 and 1992 proved that conclusion erroneous. An *S. cooperi* was captured in Beaufort County in 1989 (Webster et al. 1992), and in 1991 and 1992 M.S.M. and K.S.K. captured three *S. cooperi* in Jones and Craven counties in the Croatan National Forest. The National Forest captures were about 170 km south of the southernmost Dismal Swamp record and approximately 57 km south of the Beaufort County record.

To better understand populations of *S. cooperi* in the Dismal Swamp and eastern North Carolina (Fig. 1), we describe the circumstances of the National Forest captures, review the ecology of these populations in southeastern Virginia and eastern North Carolina, and discuss the disjunct distribution of this species in the region.

METHODS

Study site description—Small mammals were trapped in and around the Croatan National Forest in parts of Carteret, Jones and Craven counties (Fig. 1). The 382,716-ha National Forest is generally bounded by the Neuse River to the north, the Trent and White Oak rivers to the west, White Oak River and Bogue Sound to the south, and the Atlantic Ocean to the east. There are five spring-fed shallow lakes totaling 10,617 ha in the National Forest. The wide variety of habitat types there includes timberlands, sand ridges, long-leaf pine (*Pinus palustris*) savannah, blackgum-cypress (*Nyssa sylvatica-Taxodium* spp.) swamp, Carolina bays, and some of the largest pocosins in the state.

Pocosins are distinct freshwater wetlands formed on deep peat deposits. Dominant pocosin vegetation includes evergreen shrubs (*Cyrilla racemiflora, Ilex coriacea, I. glabra, Lyonia lucida*), dwarf pond pine (*Pinus serotina*), and bay trees (*Gordonia lasianthus, Magnolia virginiana, Persea borbonia*). Pocosins can vary considerably in species composition, tree density, and stature of the vegetation (Ash et al. 1983). Pocosins where all of the vegetation is stunted and the community is dominated by shrubs are called

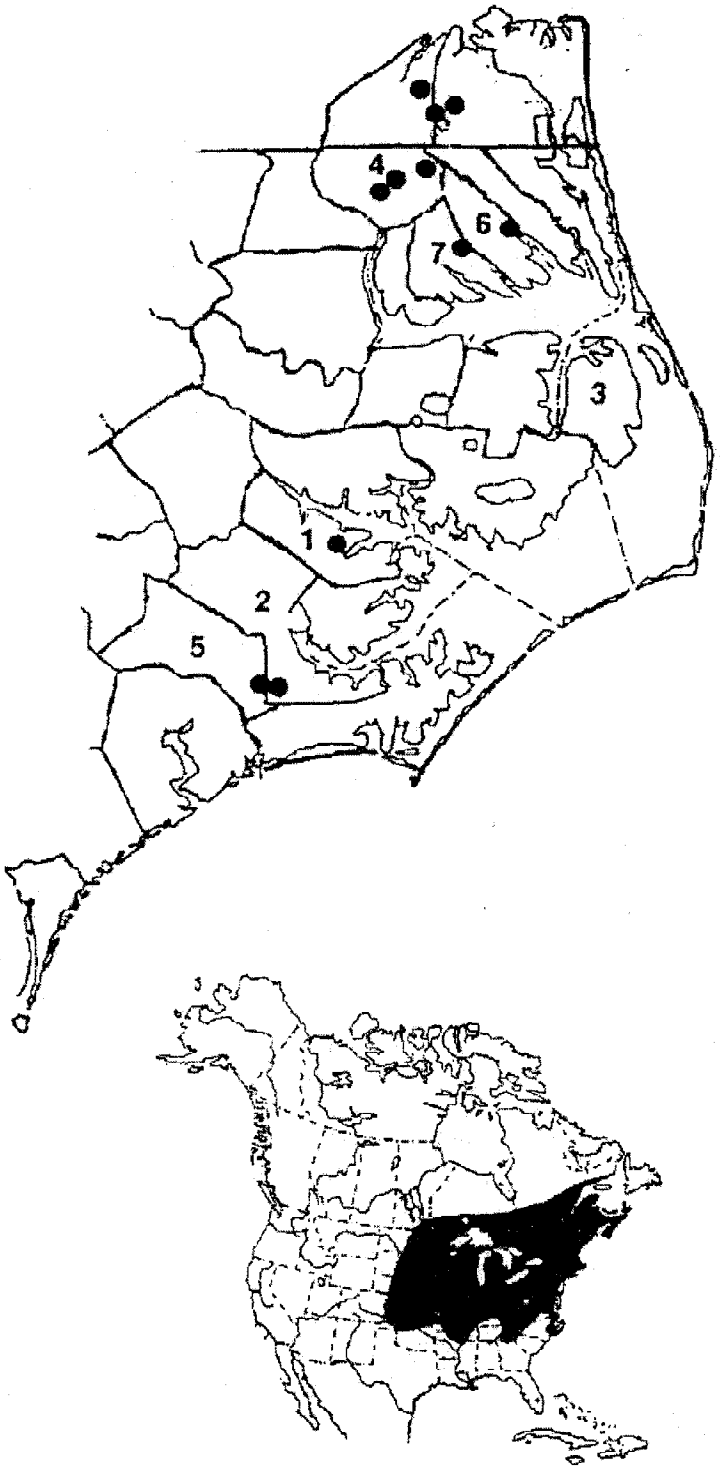

Fig. 1. The locations of records of *S. cooperi* from eastern Virginia and North Carolina are indicated by dots. Dots in Virginia represent specimens from the Dismal Swamp. Counties in North Carolina discussed in the text are identified by numbers: 1. Beaufort, 2. Craven, 3. Dare, 4. Gates, 5. Jones, 6. Pasquotank, and 7. Perquimans. The blackened area on the map of North America shows the current range of *Synaptomys cooperi*.

short pocosins. Tall pocosins are characterized by a taller understory and are generally dominated by pond pines.

To establish baseline data on pocosin mammals and to describe the changes in these communities associated with intensive forest management, M.S.M. and K.S.K. selected 15 stands in natural and managed pocosin communities for small mammal sampling. Three stands each represented five treatments: three managed habitats—open canopy, closed canopy, and thinned—and two natural stands—short pocosin and tall pocosin. The nine managed stands were in pine plantations on the periphery of the Croatan National Forest (on Weyerhaeuser Company land), and the six natural pocosin areas were within the Croatan National Forest.

One short pocosin stand was in the interior of the Great Lake Pocosin, and one tall pocosin stand was on its periphery. The highest elevations in the National Forest are in the Great Lake Pocosin, which has no history of anthropogenic modification and is one of the largest contiguous expanses of short pocosin in the state.

Small mammal trapping—Trapping was conducted for three field seasons: summer 1991, winter 1992, and summer 1992. Snap traps and pitfall traps were used each field season. Snap traps were active for 5 consecutive nights; pitfall traps were active 7. One-hundred snap traps (Museum Specials and Victor rat traps), baited with a mixture of peanut butter, rolled oats, and raisins, were set in each stand. There were five trap-lines per stand. In the first two field seasons pitfall traps were located at the end of each trap-line. Pitfalls with drift fences were added in the interior of each stand in the last field season (see Mitchell 1992 for details).

Vegetation sampling—Vegetation data were collected to provide a context for interpreting faunal community structure. Parameters for overstory, shrub layer, herbaceous vegetation, and fallen dead material were evaluated for each stand (see Mitchell 1992 and Karriker 1993 for details).

Specimen identification—Specimens collected were deposited in the North Carolina State Museum of Natural Sciences (NCSM) where they were identified and were placed in the research collection as vouchers. Skull measurements used by Wetzel (1955) to separate subspecies of *S. cooperi* were compared to measurements taken from the skulls of two specimens (NCSM 6778 and NCSM 7190) collected in the National Forest. The skull of the other specimen (NCSM 7191) was that of a juvenile and was not compared because Wetzel analyzed only adults.

Table 2. Percent cover and dominant species in the canopy, midstory, and understory of sampled treatments, Croatan National Forest, 1991 and 1992.

	Canopy		Shrub		Herbaceous	
Treatment	% cover	Species	% cover	Species	% cover	Species
Managed stands						
Open canopy	11	*Pinus taeda*	56	*Lyonia lucida* *P. taeda*	79	*Adropogon* spp. *Arundinaria gigantea*
Closed canopy	98	*P. taeda*	58	*Ilex* spp. *L. lucida*	16	*Osmunda cinnamonea* *Smilax* spp.
Thinned	91	*P. taeda*	59	*Ilex* spp. *L. lucida*	24	*Eupatorium capillofolium* *Rubus* spp.
Natural						
Short pocosin	4	*P. serotina*	97	*L. lucida* *Zenobia pulverulenta*	16	*O. cinnamonea* *Smilax* spp.
Tall pocosin	97	*P. serotina* *P. taeda*	67	*L. lucida* *Cyrilla racemiflora*	4	*A. gigantea* *Smilax* spp.

Capture success varied considerably between field seasons with rates of 2.5, 2.1, and 6.5% recorded for each respective season. Species composition within the treatments was relatively consistent among the field seasons.

Three *S. cooperi* were trapped in 2 of the 15 stands. Two were taken in snap traps, one in a pitfall trap. All captures of *Synaptomys* were from natural pocosin stands associated with the Great Lake Pocosin. Two were taken in the short pocosin stand, and one was taken from the periphery at the tall pocosin stand.

Vegetation sampling—The percent cover and dominant species in the canopy, midstory, and understory of all sampled treatments is presented in Table 2. The short pocosin stand where two *S. cooperi* were taken was dominated by shrubs that rarely exceeded 1 m in height. It had an open canopy primarily composed of pond pine (*Pinus serotina*) with a few loblolly bay trees (*Gordonia lasianthus*). Trees were sparsely distributed, stunted, and poorly developed. Dominant shrubs were fetterbush (*Lyonia lucida*), titi (*Cyrilla racemiflora*), red bay (*Persea borbonia*), loblolly bay, young pond pine, zenobia (*Zenobia pulverulenta*), and sweetbell (*Leucothoe* spp.). Dominant herbaceous species included cinnamon fern (*Osmunda cinnamonea*), pitcher plant (*Sarracenia* spp.), and sphagnum moss (*Sphagnum* spp.)

The average height of the overstory in the tall pocosin stand where one *S. cooperi* was captured was 13 m. Dominant trees were pond pine and loblolly bay; the shrub layer height averaged 1.5-3 m. The most common shrubs were fetterbush, loblolly bay, small gallberry (*Ilex glabra*), titi, and huckleberry (*Gaylussacia* sp.). There was little herbaceous vegetation, only sparsely distributed *Smilax*.

Specimen identification—Based on geographic proximity, the specimens are expected to represent *S. c. helaletes*, a race previously regarded as endemic to the Dismal Swamp region. The subspecific identity of the National Forest specimens is not clear from the skull measurements. We compared these measurements to those of the *S. c. stonei* and *S. c. helaletes* specimens that were measured by Wetzel (1955) (Table 3). Wetzel's conservative treatment of the adult category precludes subspecific determination by skull measurements because none of the National Forest specimens had all characteristics used by Wetzel to place them in the adult category.

DISCUSSION

The habits of the southern bog lemming certainly contribute to the low capture rates for this rodent. A. K. Fisher found *Synaptomys*

Table 3. Summary of selected cranial measurements from 10 adult *Synaptomys cooperi helaletes* and 26 adult *S. c. stonei* from the Southern Appalachians (Wetzel 1955) compared to measurements of two specimens (NCSM 6778, NCSM 7190) taken in the Croatan National Forest, 1991 and 1992.

	S. c. stonei		*S. c. helaletes*			
Measurements	$\bar{x}$	SD	$\bar{x}$	SD	NCSM 6778	NCSM 7190
Width of upper incisors	3.5	0.01	4.0	0.03	3.9	3.8
Condylobasilar length	24.8	0.08	25.1	0.20	25.2	24.7
Nasal width	3.4	0.04	3.5	0.07	3.2	3.6
Zygomatic width	16.7	0.11	17.1	0.22	16.4	16.4
Height of skull	10.1	0.08	10.5	0.17	9.3	9.2

"hard to catch, because it will not take any sort of bait; the only way to capture it is to set a trap in its runway" (cited in Handley 1979:325). Rose et al. (1990) described *S. c. helaletes* as an enigmatic study subject, noting that sign was observed 10 months before they caught 11 *S. c. helaletes* in only a few weeks. There is some evidence that pitfall traps and live traps might be more effective than snap traps for capturing *S. c. helaletes* (Rose et al. 1981, Rose et al. 1990). We could not compare trapping methods for *S. cooperi* in the National Forest because only three individuals were caught.

Insufficient field effort in appropriate habitat might also account for low capture rates. Previous studies (Handley 1979, Breidling et al. 1983) in the Great Dismal Swamp only sampled forested sites. Rose (1981) trapped both forested and nonforested sites in the Dismal Swamp, and all of his *S. c. helaletes* captures were from nonforested areas. Rose's study sites varied from purely herbaceous vegetation to natural or planted pine stands up to 15 years old. Some were taken from a grassy remnant marsh, others were captured under an electrical powerline where the 40-m-wide right-of-way was dominated by giant cane (*Arundinaria gigantea*) and softstem rush (*Juncus effusus*). Rose (1981) stated that as long as grasses remained in the understory, *S. c. helaletes* persisted.

A review of the habitat descriptions from other captures demonstrates that *S. c. helaletes* can be found in a variety of successional communities. The data tag for a specimen (AMNH 265071) captured in Gatesville, Gates County, reads "young-2-3' pine plantation on cleared forest land." The Pasquotank County specimen (NCSM 4019) obtained from a barn owl pellet certainly came from

open habitat. The Beaufort County specimen was captured in a pitfall trap set in the ecotone between communities characterized as a xeric pine savannah and a lowland pocosin (Webster et al. 1992). There is no detailed habitat information available for the Perquimans County record (Brimley 1905) or for two other specimens (NCSM 2654 and NCSM 4019) taken in the Dismal Swamp area. Although trapping in the Croatan National Forest yielded specimens from only unmanaged stands, it is clear from other efforts that some human alterations create habitats suitable for this lemming.

There are few structural differences between the three short pocosin stands sampled in the National Forest that could account for the presence of *Synaptomys* in one and not in the other two. Drainage in the Great Lake Pocosin is limited to ditches associated with roads on the pocosin's boundary, remote from its interior. By contrast, the other two stands of short pocosin where no *Synaptomys* were caught were considerably smaller and were bounded on at least two sides by ditches. The Great Lake Pocosin interior has a greater degree of surface saturation than the other areas, as evidenced by the abundance of *Sphagnum* observed in the interior.

The lack of records of *S. c. helaletes* from 1897 to the 1980s was once believed to be the result of changes in habitats caused by human activities (Handley 1979), particularly those involving changes in the water table. Rose (1981) concluded that fire prevention probably had a greater negative effect on *Synaptomys* habitat than did draining and ditching because the exclusion of fire reduced the number and size of natural openings. Succession in pocosin communities is naturally suppressed; therefore, pocosins provide a diverse assemblage of early successional habitats. These habitats are one of the few natural, open canopy plant communities in the southeastern Coastal Plain. Lee (1986) considered that pocosins might have provided the only available local habitat for many early successional birds before colonial development. Pocosins appear to play a similar role for *S. cooperi* in eastern North Carolina.

Because *S. cooperi* has now been captured both to the north and south of the Albemarle-Pamlico peninsula, one would assume that *Synaptomys* can be found in appropriate habitat on the peninsula as well. Dare County has large expanses of pocosin and other wetlands, and it is separated from the Dismal Swamp area only by Albemarle Sound. No *Synaptomys* were taken in the 1980s on the Dare County mainland even though it was intensively trapped by both Clark et al. (1985) and by U.S. Fish and Wildlife Service personnel at the Alligator River National Wildlife Refuge (Mike

than previously believed (Paradiso 1959, Lee 1987), and records reported here demonstrate a similar distributional pattern for *Synaptomys cooperi*.

Although we were unable to make a subspecific determination from the National Forest sample of *S. cooperi*, further taxonomic investigation is warranted. Eight of the 13 cranial measurements used by Wetzel to distinguish the *S. cooperi* subspecies did not show significant differences between *stonei* and *helaletes*. The unclear subspecific identity of the specimens reported here could be a result of a wider and more southern distribution of *S. c. stonei* in the past. Individuals captured in southeastern North Carolina might be a relict population of that race, or represent an intergrade between *S. c. stonei* and *helaletes*.

CONCLUSIONS

In general, the new records of *S. cooperi*, along with the recent captures of other small mammals in eastern North Carolina that were once thought to have narrower distributions, emphasize the need for more small mammal investigations in wetlands and associated habitats. Considering the wide variety of early successional habitats that *S. cooperi* has been captured in, and the abundance of those habitats in eastern North Carolina, it seems reasonable to expect that *S. cooperi* is widespread there. Based on the National Forest trapping results and other studies, it appears that populations in this region are disjunct.

More specimens of *S. cooperi* are needed to better understand the taxonomy of these disjunct populations. Future surveys for *S. cooperi* should include trap methods other than snap-trapping and should encompass a variety of both natural and managed early successional communities.

ACKNOWLEDGMENTS—Field studies were conducted in part to fulfill the requirements for graduate degrees pursued by M. S. Mitchell and K. S. Karriker at North Carolina State University under the guidance of committee members R. A. Lancia, E. J. Jones, and K. H. Pollock. Funding, by Weyerhaeuser Company and the National Council of the Paper Industry for Air and Stream Improvement (NCASI), was administered by M. A. Melchoirs and T. B. Wigley. Croatan National Forest employees, in particular Warren Starnes, helped with stand selection and provided numerous other services. We thank D. Drake, C. Jordan, M. Lusk, L. Sadler, and R. Stanley for assistance with mammal trapping. We also thank D. S. Lee, R. K. Rose, and an anonymous reviewer for their many helpful comments.

LITERATURE CITED

Ash, A. N., C. B. McDonald, Emilie S. Kane, and C. A. Pories. 1983. Natural and modified pocosins: literature synthesis and management options. United States Fish and Wildlife Service, Division of Biological Services, Washington, D.C. FWS/OBS-83/04.

Breidling, F. E., F. P. Day, Jr., and R. K. Rose. 1983. An evaluation of small rodents in four Dismal Swamp plant communities. Virginia Journal of Science. 34:14–28.

Brimley, C. S. 1905. A descriptive catalog of the mammals of North Carolina, exclusive of the Cetacea. Journal of the Elisha Mitchell Scientific Society 21:1–32.

Clark, M. K., D. S. Lee, and J. B. Funderburg, Jr. 1985. The mammal fauna of Carolina bays, pocosins, and associated communities in North Carolina: An overview. Brimleyana 11:1–38.

Doutt, J. K., C. A. Heppenstall, and J. E. Guilday. 1973. Mammals of Pennsylvania. Third Edition. Pennsylvania Game Commission, Harrisburg.

Handley, C. O., Jr. 1979. Mammals of the Dismal Swamp: An historical account. Pages 297–357 *in* The Great Dismal Swamp (P. W. Kirk, editor). University Press Virginia, Charlottesville.

Handley, C. O., Jr. 1991. Mammals. Pages 551–552 *in* Virginia's endangered species: Proceedings of a symposium (K. Terwilliger, editor). McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Karriker, K. S. 1993. Effects of intensive silviculture on breeding and wintering birds in North Carolina pocosins. MS Thesis. North Carolina State University, Raleigh.

Lee, D. S. 1986. Pocosin breeding bird fauna. American Birds. 40:1263–1273.

Lee, D. S. 1987. Star-nosed mole on the Delmarva Peninsula: Zoogeographic and systematic problems of a boreal species in the South. The Maryland Naturalist. 31:44–57.

Lee, D. S., J. B. Funderburg, Jr., and M. K. Clark. 1982. A distributional survey of North Carolina mammals. Occasional Papers of the North Carolina Biological Survey. North Carolina State Museum, Raleigh.

Linzey, A. V. 1983. *Synaptomys cooperi*. Mammalian species. Number 210. American Society of Mammalogists.

Mitchell, M. S. 1992. The effects of intensive forest management on the mammal communities of selected stands of North Carolina pocosin habitats. MS Thesis. North Carolina State University, Raleigh.

Paradiso, J. 1959. A new star-nosed mole (*Condylura*) from the southeastern United States. Proceedings of the Biological Society of Washington 72:103–108.

Rose, R. K. 1981. *Synaptomys* not extinct in the Dismal Swamp. Journal of Mammalogy 62:844–845.

Rose, R. K., R. K. Everton, J. F. Stankavich, and J. W. Walke. 1990. Small mammals in the Great Dismal Swamp of Virginia and North Carolina. Brimleyana. 16:87–101.

Webster, W. D., A. P. Smith, and K. W. Markham. 1992. A noteworthy distributional record for the Dismal Swamp bog lemming (*Synaptomys cooperi helaletes*) in North Carolina. The Journal of the Elisha Mitchell Scientific Society 108:89–90.

Wetzel, R. M. 1955. Speciation and dispersal of the southern bog lemming, *Synaptomys cooperi* (Baird). Journal of Mammalogy 36:1–20.

Accepted 29 September 1992