Distribution and Habitat Indices of Northern Pine Snakes in North Carolina

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Abstract: A survey of northern pine snake occurrences (*Pituophis m. melanoleucus*) was completed in North Carolina in 1990 to determine the distribution and habitat of this state-listed species of special concern. A total of 196 snakes at 163 locations was mapped and visited. Most of the snakes were killed by vehicular traffic. Sixteen pine snakes were recorded at 12 sites in 3 mountain counties, a single snake from each of 2 sites in 1 foothill county, and 26 snakes at 24 sites in 2 coastal counties. However, the majority of the snakes (78% of total) were recorded at 119 sites in 7 contiguous counties in the sandhills of central North Carolina. Most snakes were recorded in the vicinity of sandy soils, but several ($N = 12$) were observed in bottomlands. Data were recorded on several habitat variables at snake locations. The present study confirmed that northern pine snakes still have 3 population centers in North Carolina. Future studies, including the use of radiotelemetry, will help determine whether this species can co-exist with human activities in the remaining longleaf pine (*Pinus palustris*) ecosystem in North Carolina.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 50:271-279

The northern pine snake was granted protection in North Carolina under both federal and state designations as follows: U.S. status (U.S. Fish and Wildlife Service; USFWS)—a Candidate 2 (C2) until 1996 and currently a Federal Species of Concern, and North Carolina status since 1991 (N.C. Wildl. Resour. Commis.; NCWRC)—Special Concern (LeGrand and Hall 1995). The state listing reflects a required monitoring program for this species. The USFWS C2 listing for the entire pine snake complex defined the group as "a taxon for which there is some evidence of vulnerability, but for which there are not enough data to support listing as endangered or threatened at this time. Listing is warranted but precluded by other pending proposals of higher priority" (LeGrand and Hall 1995).

The northern pine snake belongs to a group of snakes comprised of 4 recognized subspecies: the Louisiana pine snake (*Pituophis melanoleucus ruthveni*), the black pine snake (*P. m. lodingi*), the Florida pine snake (*P. m. mugitus*), and the northern

pine snake. An additional 11 subspecies range from Illinois and Texas west to California and comprise the bull and gopher snake groups of the *Pituophis* genus (Sweet and Parker 1990). Detailed systematic relationships between these subspecies are discussed in Stull (1940), Wright and Wright (1957), and Reichling (1995). Notable in the distribution of the eastern forms is the disjunct population of the northern pine snake in the New Jersey Pine Barrens from the remaining southeastern United States which includes portions of Virginia, Kentucky, Tennessee, North Carolina, South Carolina, and Alabama (Conant and Collins 1991). In addition, there are areas of intergradation between the northern pine snake and the Florida pine snake along the South Carolina-Georgia border extending into Alabama (Sweet and Parker 1990).

One of the first accounts describing the pine snake in North Carolina was from the sandhills region where the species was recorded in Moore, Richmond, Brunswick, and New Hanover counties (Brimley 1944). Additional published accounts of the distribution of the northern pine snake in North Carolina vary from "possibly statewide" (DePoe et al. 1961) to only in western North Carolina, with the Florida pine snake ranging into southeastern North Carolina (Wright and Wright 1957). Recent accounts show 3 distinct populations (Martof et al. 1980, Conant and Collins 1991, Palmer and Braswell 1995). The objectives of this study were to locate all available observations of pine snakes in North Carolina, to update the status and distribution of this species, and to describe habitat variables at visited sites.

This survey was made possible with the help of a large number of amateur and professional herpetologists from the North Carolina Herpetological Society (NCHS) and the North Carolina Museum of Natural Sciences (NCMNS). Additional records and technical and logistical support were given by T. Sharpe and staff of the Sandhills Wildlife Depot (NCWRC) and the Wildlife Management-Endangered Species Section, Department of Defense, Ft. Bragg, North Carolina. We would also like to acknowledge the help of North Carolina State University personnel, including E. Allen, S. Buol, H. Devine, P. Doerr, J. McManus, R. Pegram, E. Seaman, J. Stucky, B. Wallingford, and T. Wentworth. Funding was provided by the Nongame and Endangered Wildlife Section of the NCWRC, the Nongame Small Grants Program and the citizens of North Carolina who contributed to the state tax refund to support this project. Additional funds and logistical support were received from R. Noble, Department of Zoology, North Carolina State University.

Methods

We tabulated records of northern pine snakes from road sightings (i.e., alive-on-road, AOR, and dead-on-road, DOR), museum records, local zoos, nature parks, environmental organizations, private collections, and amateur and commercial collectors in 1990. A mail survey was sent to 250 members of the NCHS informing them of the study and requesting any information regarding northern pine snake locations in the state. The survey requested accurate site locations (i.e., within 0.11 km of the nearest road intersection). General statements such as "my pine snake was collected in Moore County" were discarded. Interviews were also conducted with a small number of citizens who had been featured in local newspaper accounts concerning pine

snakes. Other records were developed when the survey crew found living or identifiable DOR pine snakes. All usable records were located on U.S. Geologic Survey (USGS) quadrangle maps and Department of Transportation county road maps to facilitate subsequent visits to locations.

Physiographic descriptions were compiled by taking habitat measurements from 1 or 2 randomly distanced, circular 0.04-ha plots placed perpendicular to each road location. Each location was assumed to be the center of a 42.74-ha circular home range (R. T. Zappalorti, unpubl. data). At each plot, we measured canopy closure (spherical densiometer), basal area (BA) (10X prism), the number of stems/plot, and percent slope. Shrub density to a 2-m height was estimated using a density board (Nudds 1977), with shrub layers differentiated from midstory by being ≤2.54-cm dbh. Importance values were calculated for canopy species (Bonham 1989). A rectangular 1-m^2 wooden frame was tossed backward over the head and ground cover of herbs was estimated by species in percentages. Litter type and depth were recorded. Examples of human disturbance were noted within sight distance of the plot center, including pine straw raking; recent burns; age and type of commercial forestry practices; deposition of trash and tin piles; the presence of light wood stumps, logs and other "natural" structures; barns and abandoned and active human habitation; and commercial poultry and golf course operations.

Additional analyses of the records from the 7 sandhill counties were performed. USGS topographic-orthophotoquad maps were used to identify construction activities, distance to water sources, type of road, and elevation above sea level at each location. Soil Conservation Service county soil maps were used to determine percent of area by soil type. Clear plastic grid circles were cut to the estimated diameter of home range size and centered over each map location. Each record was located to the nearest 162.46 m on a topographic quadrangle map. Records within 325 m of each other were considered to be the same location. Site locations, county outlines, and major highways were digitized using the GIS-ATLAS program, as was a soil map of prevalent sandhill soils.

Results and Discussion

A total of 196 usable records was gathered from all sources for 163 locations of northern pine snakes in 13 North Carolina counties (Fig. 1). Most records were obtained from files of the NCMNS (N = 81, 41% of total) and from members of the NCHS (N = 54, 28% of total). A number of records returned from NCHS members were duplicates of existing NCMNS records, and a number of older records of the NCMNS could not be used because they lacked a detailed description of the original locations. Most of the donated NCHS records obtained within the past 10 years were usable. A total of 22 new records (11% of total) was obtained by the senior author during the survey period.

Personnel of the Sandhills Depot, NCWRC, and the Ft. Bragg Wildlife Management-Endangered Species Section staff forwarded 28 records (14% of total). The importance of receiving information from these organizations is that the areas they manage (i.e., the Sandhills Gamelands—23,000 ha and Ft. Bragg—55,000 ha) repre-

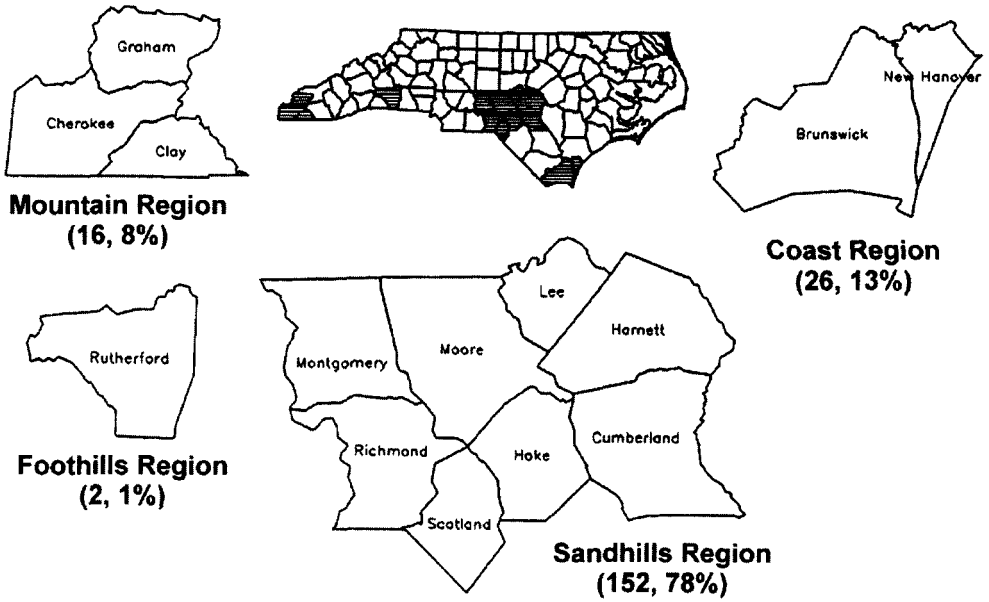

Figure 1. The 4 regions containing record locations of the northern pine snake in North Carolina. Numbers represent the region total followed by the percent of total sample. (Lee County had no record of pine snakes but does have typical sandhills soils.)

sent a sizeable portion of undeveloped sandhills longleaf pine habitat. Most of these lands are either too remote to be frequently used by the general public or are simply closed to all ingress for security reasons.

The overall reliability of records was good, because many of the NCMNS, NCHS, and survey team sightings were backed by voucher specimens. In the instances where uncollectable remains or AOR sightings were made, the above mentioned personnel were herpetologically-oriented individuals experienced in identifying specimens.

Distribution by Region

Mountain Region. In the mountain region a total of 15 locations (16 records, 8% of total) was visited in Graham, Cherokee, and Clay counties. The 2 sight records from Clay County represented new county records. Sites were scattered throughout Cherokee and Clay counties but there is some grouping of sites where they do occur. It is of some value to corroborate unrelated records reported from the same general area; however, with few total records available from this region, there remains the challenge of obtaining additional voucher specimens whenever possible. Based on newspaper accounts with photographs, several interviews were conducted with people who had killed pine snakes up to 10 years previously. Although vegetative and soil analyses were not performed at the mountain sites, observations indicate that locations varied from ridge habitats to bottomland riparian sites.

There were 8 (50% of mountain sites) records of pine snakes inhabiting cove-valley terrain with pastureland and disturbed residential areas. Other locations were situated on or adjacent to extensive national forest tracts, providing some protection to this species. Although 5 of the dates of occurrence were more than 30 years old, several were reported during the past decade and, in 1 instance, within 2 weeks of the investigator's interview date. Speculation concerning densities is beyond the scope of the data collected except to state that it is probably low. Movement of animals from the neighboring states of Tennessee, Georgia, and South Carolina into the adjacent valleys of North Carolina was proven for some species of herptiles and could partially explain the continued existence of the pine snake in this region (Bruce 1965; W. M. Palmer, pers. commun.).

Foothills Region. Two new locations were visited in Rutherford County. The first was in a red clay soil in a regenerating-pine plantation and the second was on a small nearby farm. The existence of occasional northern pine snakes along the border counties in North Carolina is not surprising as the species inhabits much of the entire state of South Carolina (Martof et al. 1980, Conant and Collins 1991). Movement into clay soil areas probably represents errant individuals attempting to locate more suitable habitat for their fossorial lifestyle; however, because the northern pine snake is known to live in habitats other than the porous, sandy soils of the sandhills and coastal regions in North Carolina (i.e., the mountain region), their occurrence in unlikely areas remains an interesting and, to date, unstudied phenomenon.

Coastal Region. The coastal region included New Hanover County with 1 location and Brunswick County with 25 locations (13% of total). In Brunswick County, most locations (18 of 25) were in well-drained, upland ridges of longleaf pine and turkey oak (*Quercus laevis*) habitat. Two DOR locations were situated along a roadway in the center of a large tract (ca. 402 km^2) of both private and public property known as the Green Swamp. Much of this land was ditched, drained, bedded, and planted to loblolly pine (*Pinus taeda*) in recent years. With only 2 records from this area, definitive conclusions concerning use of this habitat by northern pine snakes could not be determined. Whether these specimens were remnants of a relict group, dispersing animals or examples of a viable, growing population of pine snakes having adapted to changed habitat conditions is unknown. A need remains to investigate the use of such areas by this species in this region because of increasing rates of wetland conversion to this type of habitat, and because of the continuing loss of more typically used sandy, upland sites to residential and commercial development.

The distribution of locations in Brunswick County indicates that pine snakes have been found throughout the county since the early 1900s (NCMNS and W. M. Palmer, pers. commun.). There appeared to be some grouping of locations within several town limits including 1 that had 3 DOR pine snakes recorded in the 5 years prior to this study. Work by Burger and Zappalorti (1988) and Zappalorti and Burger (1986) in the New Jersey Pine Barrens indicated that human habitation and other disturbed sites were often used by pine snakes as food and cover resources.

Sandhills Region. The 152 locations from the sandhills region represent 78% of the survey records. Of the 8 counties included in this region, Richmond County had

the most records ($N = 54$), followed by Hoke ($N = 21$), Montgomery ($N = 20$), Moore ($N = 24$), and Scotland ($N = 24$) counties. Cumberland and Harnett counties had the fewest records with 4 and 5, respectively. Although Lee County had no pine snake record, it was included in the sandhills region because sandhill soils occur in the southern part of the county. The number of records and the number of locations are unequal because there were 15 occurrences where 2, and in one instance 3, snake locations were recorded within 325 m of the same site. For example, the survey team found an adult, AOR female pine snake on the shoulder of the road where 4 years previously another had been killed. The total number of locations in the sandhills region, therefore, was 119. Where sex and age could be determined from road kill records, the sex ratio was 26 M to 21 F; a total of 5 hatchlings, 16 subadults, and 19 adults was identifiable from the sample.

Habitat Use in the Sandhills Region

The first data base produced consisted of soil data from all 7 counties, consolidated by grouping similar soil types as to texture, moisture regime, and depth (Lee 1955, Daniels et al. 1984). The second data base was a list of soils found within the 42.74-ha estimated home range at each location. Dry sands totaled 4,817 ha (78%) of the soils mapped, followed by wet loams 745 ha (12%), and loamy sands 400 ha (6%). The remainder (3%) included urban areas, gravel, and alluvium. The occurrence of snake locations in dry sands was expected, but DOR records adjacent to bottomlands and other water sources indicated that pine snakes may use such habitats more frequently than previously believed. Comparison of soils identified in the sandhills region with those found in pine snake habitat in the Pine Barrens of New Jersey indicates similar soil types (R. T. Zappalorti and S. Buol, pers. commun.).

Pine snakes prefer pine, pine-oak, and oak-pine forest in the Pine Barrens but forage in all habitats including cedar swamps (Zappalorti and Burger 1986). Nest site selection is believed to be related to a greater amount of sunlight reaching the ground in open, sandy habitat used by pine snakes (Burger and Zappalorti 1991). In our study, half the plots had 90% or greater canopy closure, and 85 plots had more than 50% closure. Locations in longleaf pine had the greatest total percent cover of midstory and overstory species, the highest basal area, and the second greatest mean stems/plot. Importance values for locations in longleaf stands ranged from 3 to 100. Longleaf pine had 40 importance values greater than 32 and was the most frequent species in 35 of 96 plots. Locations in loblolly pine were second in total percent cover of midstory and overstory species, mean basal area, and mean stems/plot. Importance values of loblolly ranged from 1 to 100. The strong presence of loblolly pine in sample plots reflects the replacement of longleaf with the faster growing loblolly on many tracts (Ware et al. 1993). Data collected on turkey oak revealed that this species had the greatest stem density of any species on the sampled plots. Importance values of turkey oak ranged from 2 to 100. During site visitations, several bird nests were observed in low branches of turkey oaks that were likely within reach of pine snakes. As the number and size of turkey oaks continue to increase on tracts protected from fire, the effect on pine snakes is worthy of investigation.

Influence of Disturbance Factors in the Sandhills. Pine snakes use sites disturbed by humans in the New Jersey Pine Barrens (Zappalorti and Burger 1986). A human-disturbed habitat was defined in that study, as "any changed habitat regardless of the length of time since it was disturbed." In our study, a general breakdown of habitats adjacent to road locations were fields (24%), mixed pine/hardwoods (38%), and long-leaf pine stands (38%). Barns (28%), trash heaps (20%), and the presence of light wood stumps (12%) in the vicinity of longleaf pine tracts were also recorded. Of particular interest was the number of pine snake locations tabulated within 300 m of residential development (42%). This was expected because food (e.g., small mammals), and cover (e.g., trash and building materials) are often found near houses and barns. Three locations were adjacent to poultry-rearing operations.

In many longleaf pine-turkey oak-wire grass sites visited by the survey team, the only ground cover available after recent burning activity was light wood stumps. These resin saturated stumps and their lateral root systems remain intact for decades and may be critically important to the pine snake for thermal regulation, feeding, nesting, and as refugia from fire and predators. For example, the 18 sites with records that contained light wood stumps comprised 32% of all sandhills locations where longleaf pine either was present at the time of the survey or previously had been harvested.

Influence of Roads and Water in the Sandhills. Light-duty roads accounted for 56% of the pine snake locations, followed by medium-duty (24%), heavy-duty (14%), and unimproved roads (6%). The volume of traffic noted on major highways was extremely high during daylight hours when pine snakes are active. The majority of locations had at least intermittent water available within 610 m. Data indicate that most hypothetical home ranges were located within 610 m of a water source. Twelve sites were in bottomlands where roads crossed creeks or floodplains. Apparently, pine snakes use this habitat in North Carolina, but the purpose and duration are unknown.

The month of recorded occurrence was tabulated to examine activity patterns on an annual basis. A total of 141 'record months' ranged from 4 in March, followed by 110 (78% of total) from April through July with a drop in August ($N = 5$) and a small increase of 21 for September and October. Similar movement patterns have been noted in other regions where the pine snake is found (Zappalorti and Reinert 1994). Spring and early summer movements in the sandhill region of North Carolina probably reflect breeding and nesting behavior, while fall activity reflects movement to hibernacula.

Management Implications

This survey of the northern pine snake in North Carolina showed that snakes were located in 4 regions of the state, including Cherokee, Clay, and Graham counties in the mountain region, Rutherford County in the foothills region, Brunswick and New Hanover counties in the coastal region, and Cumberland, Harnett, Hoke, Montgomery, Moore, Richmond, and Scotland counties in the sandhills region. A general review of locations in the first 3 regions listed above suggests that the northern pine

snake is widely scattered and infrequently encountered. Pine snakes of the coastal region are vulnerable to a variety of direct and indirect impacts from man. It is questionable whether any pine snakes remain in New Hanover County, and the population of pine snakes in Brunswick County continues to come under increasing pressure from residential, recreational, commercial, and industrial development. Research is needed to identify whether pine snakes use converted pine plantations in the coastal region.

Surveys are needed in eastern North Carolina to determine if isolated populations of pine snakes occur in other locations where suitable habitat exists. Such surveys could identify areas for re-introduction of this species, if presently occupied habitats become uninhabitable, with attention to biological and management concerns (Dodd and Siegel 1991).

These data indicate that the pine snake population in the sandhills region is stable, based on continued yearly reports of both hatchling and adult animals killed by vehicles. Fortunately, there remain several extensive longleaf pine habitats in both public and private ownership in the sandhills region that are relatively free of large-scale changes in habitat (Schafale and Weakley 1990, Schafale 1994). We recommend that radiotelemetry studies be completed to assess seasonal and annual habitat requirements of this species in North Carolina.

The northern pine snake received no formal study in North Carolina prior to this survey. Its numbers and habitat continue to be impacted from a variety of human-induced factors. Direct losses occur from death by vehicles on expanding and intensely used roadways, and by insensitive homeowners and land managers. Although protected by law, unknown numbers are probably still caught by collectors for personal use and the commercial pet trade. Furthermore, indirect reduction in numbers of pine snakes can result from habitat loss attributed to changes in land use from forested and agricultural lands to recreational, residential, and industrial development. The impact on the pine snake from pine straw raking for the landscaping industry, forest harvest, and production practices including the pulling of light wood stumps, military use of sandhills habitat, golf course construction and maintenance protocols, and pesticide application on row and orchard crops remains unknown. We consider the northern pine snake to be an indicator species, much like the red-cockaded woodpecker (*Picoides borealis*), of a healthy longleaf pine ecosystem. Future research on population dynamics and habitat needs will help to insure that this species remains a viable part of North Carolina's natural heritage.

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