Technical Report SERDP-98-5
March 1998

US Army Corps
of Engineers
Waterways Experiment
Station

Strategic Environmental Research and Development Program

Species Profile: Pine Snake (*Pituophis melanoleucus* spp.) on Military Installations in the Southeastern United States

by Robert A. Jordan, The Nature Conservancy

Prepared for Headquarters, U.S. Army Corps of Engineers

PRINTED ON RECYCLED PAPER

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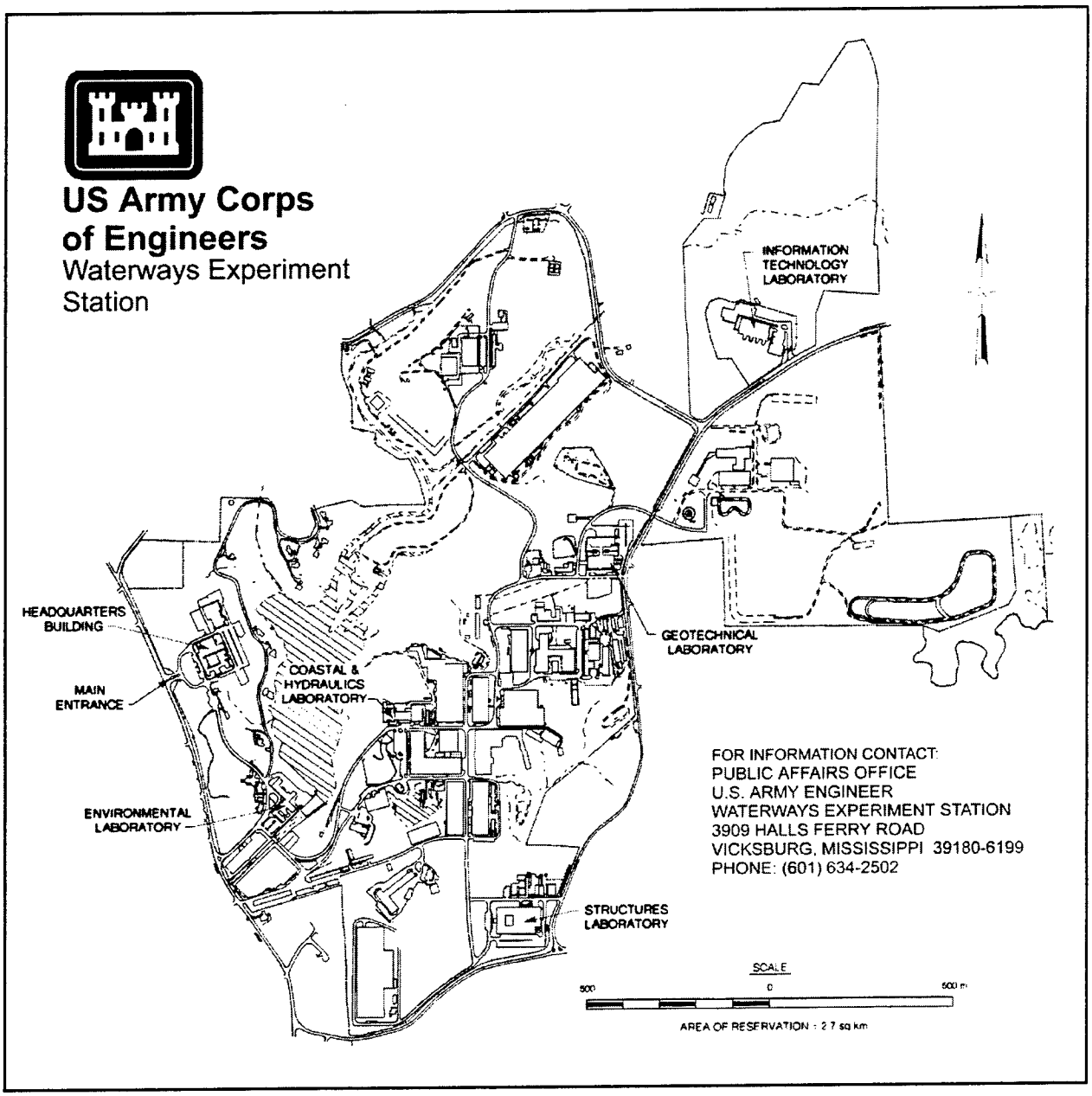
Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



Waterways Experiment Station Cataloging-in-Publication Data

Jordan, Robert A.

Species profile : Pine snake (*Pituophis melanoleucus* spp.) on military installations in the Southeastern United States / by Robert A. Jordan ; prepared for U.S. Army Corps of Engineers.

25 p. : ill. ; 28 cm. — (Technical report ; SERDP-98-5)

Includes bibliographic references.

1. Pituophis melanoleucus — Speciation — United States. 2. Reptiles — Speciation — United States. 3. Endangered species. I. United States. Army. Corps of Engineers. II. U.S. Army Engineer Waterways Experiment Station. III. Strategic Environmental Research and Development Program (U.S.) IV. Title. VII. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; SERDP-98-5.

TA7 W34 no.SERDP-98-5

Preface

The work described in this report was authorized by the Strategic Environmental Research and Development Program (SERDP), Washington, DC. The work was performed under the SERDP study entitled "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Mr. Brad Smith was Executive Director, SERDP.

This report was modified from The Nature Conservancy's (TNC) Element Stewardship Abstract (ESA) for "The Pine Snake" authored by Mr. Robert A. Jordan. Mr. Jordan is currently employed by Ducks Unlimited, Lyndhurst, NJ. The original ESA for the species was prepared under contract with the U.S. Army Construction Engineering Research Laboratories (CERL), Natural Resources Division, Champaign, IL, for a document titled "Integrated Endangered Species Management Recommendations for Army Installations in the Southeastern United States: Assessment of Army-Wide Guidelines for the Red-Cockaded Woodpecker on Associated Endangered, Threatened, and Candidate Species."

Report review was provided by Ms. Shirley Burgdorf and Mr. D. Craig Rudolph, Wildlife Habitat and Silviculture Laboratory, Southern Research Station, U.S. Forest Service. The U.S. Army Engineer Waterways Experiment Station (WES) technical review was provided by Mr. Chester O. Martin, Ms. Dena Dickerson, and Dr. Richard A. Fischer, Environmental Laboratory (EL), WES. Mr. Martin, WES, and Ms. Ann-Marie Trame, Land Management Laboratory, CERL, were Principal Investigators for the regional guidelines work unit. Dr. Fischer, WES, managed and coordinated preparation of species profiles for this study.

This report was prepared under the general supervision of Dr. Michael F. Passmore, Chief, Stewardship Branch, Natural Resources Division (NRD), EL; Dr. Dave Tazik, Chief, NRD; and Dr. John Harrison, Director, EL.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Robin R. Cababa, EN, was Commander.

This report should be cited as:

Jordan, R. A. (1998). "Species profile: Pine snakes (*Pituophis melanoleucus* spp.) on military installations in the southeastern United States," Technical Report SERDP-98-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Species Profile: Pine Snake
(*Pituophis melanoleucus* spp.)

Photo by John Palis

Taxonomy

Class	Reptilia
Order	Squamata
Family	Colubridae
Genus/species	*Pituophis melanoleucus*
Other Common Names	Bullsnake

Description

At least 15 subspecies of *Pituophis melanoleucus* are recognized.[1] The following general description applies to the four subspecies that occur east of the Mississippi River: northern pine snake (*P. m. melanoleucus*), Florida pine snake (*P. m. mugitus*), black pine snake (*P. m. lodingi*), and Louisiana pine snake (*P. m. ruthveni*).[2]

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1 Description follows Ernst and Barbour (1989), unless otherwise noted. More detailed descriptions can be found below in Distribution and numbers.

2 Unfortunately, there is little available literature on pine snakes that addresses the apparent significant variability in morphology, ecology, and behavior among the subspecies. Therefore, information available for one subspecies or population should not always be assumed to be applicable to other subspecies (D. Craig Rudolph, Personal Communication, 1997).

Pine snakes are large (to 2.54 m (8.3 ft)), white, tan, and black serpents with a notably enlarged rostral plate, dark bars on the supralabials, a dark bar usually extending from the eye downward onto the supralabials, another dark bar extending diagonally downward from the eye to the corner of the mouth, and four prefrontal scales. Body scales are keeled with apical pits and occur in 25 to 31 rows anteriorly, 27 to 37 rows at midbody, and 19 to 27 rows near the anal vent. The anal plate is single or undivided. The rostral plate partially divides the internasals. The nasal scale is divided, and on each side of the head are a loreal, 1 to 2 or 3 preoculars, 2 to 6 postoculars, several temporals, 6 to 9 supralabials, and 10 to 15 infralabials. There are 194 to 233 ventrals (males having 44 to 63 subcaudals, females 29 to 57). Extensive data on body length and age of maturity in male and female pine snakes have not been reported (Ernst and Barbour 1989), although Burger and Zappalorti (1991) report that 98 gravid northern pine snake females average 121 cm (47 in.) snout to vent length (range 91 to 143 cm (36 to 56 in.)).

The tails of male pine snakes are 11 to 14 percent as long as the total body length; females have tails only 10 to 12 percent of total body length. The body is large and moderately stout with a head that appears small for its body size (Ditmars 1907). Coloration is quite variable (see subspecies accounts under Distribution and numbers).

Similar Species

Pine snakes may be confused with rat snakes (*Elaphe* spp.) and kingsnakes (*Lampropeltis* spp.), which have only two prefrontal scales. Also, rat snakes have a divided anal plate. Whipsnakes (*Masticophis* spp.), racers (*Coluber* spp.), and indigo snakes (*Drymarchon* spp.) have smooth body scales.

Status

Legal designation

Federal. The four subspecies of the pine snake in the southeastern United States were candidate species (C2) for listing as either threatened or endangered by the U.S. Fish and Wildlife Service (USFWS). However, the USFWS discontinued the designation of C2 species as candidates for listing (50 CFR 17; 28 February 1996). The pine snake in the southeastern United States is considered to be a species of concern, but more biological research and field study are needed to resolve its conservation status.

State. The State of Florida lists the Florida pine snake as a species of special concern due to declining numbers, and the Florida Game and Fresh Water Fish Commission has imposed a possession limit of one snake per person (Franz 1992). The black pine snake is endangered in Mississippi. The Louisiana pine snake is endangered in Texas. State Natural Heritage Program rankings for pine snake subspecies are provided in Table 1.

Table 1
Status of Pine Snake Subspecies Based on Natural Heritage Program Information (The Nature Conservancy 1997)

Species	AL	GA	LA	MS	NC	SC	TX
P. m. melanoleucus	S3[1]	S3	N/A[2]	N/A	S3	?[3]	N/A
P. m. mugitus	S2[4]	S3	N/A	N/A	N/A	N/A	N/A
P. m. lodingi	S2	N/A	S1[5]	?	N/A	N/A	N/A
P. m. ruthveni	N/A	N/A	S3	N/A	N/A	N/A	?

[1] S3 = Rare or uncommon in State; rare and local throughout range or in a special habitat (on order of 21 to 100 occurrences).
[2] N/A = Not Applicable.
[3] ? = Status unknown.
[4] S2 = Imperiled in the State because of rarity (6 to 20 occurrences).
[5] S1 = Critically imperiled in State because of extreme rarity (five or fewer occurrences).

Military installations

Table 2 represents the known status of pine snakes on military installations in the southeastern United States.

Distribution and numbers

Pine snakes are not common anywhere in the geographic range (Wright and Wright 1957), and no published information exists regarding pine snake population densities.

The northern pine snake is found in the pine (*Pinus* spp.) barrens of southern New Jersey, the coastal plain of North Carolina and South Carolina, the mountains of western Virginia west to Tennessee, southern Kentucky, and south to northern Alabama and Georgia. It is characteristically a large, white to pinkish-cream snake with distinct black body blotches that become somewhat less distinct and brown toward the tail. It intergrades with the Florida pine snake in central Alabama (Mount 1975), Georgia, and southern South Carolina (Neill 1941).

The Florida pine snake is found from southeastern South Carolina, west to Mobile Bay, Alabama, and south on peninsular Florida to Charlotte, Palm Beach, and Dade counties. It is a tan to gray-brown or rusty-brown snake with faded, indistinct, blotched pattern. The belly is pale, and the darker dorsal blotches often cover the upper portions of the ventral scales. Adults range in length from 91 to 228 cm (36 to 90 in.) (Franz 1992).

The black pine snake is found only in southwestern Alabama, southeastern Mississippi, and the extreme eastern portion of southern Louisiana (Figure 1). It is a nearly or totally uniform black or dark brown snake with reddish or white snout and labials. This subspecies intergrades with the Florida pine snake in southern Alabama and western Florida (Mount 1975).

Table 2
Known Status of Pine Snakes on Military Installations in the Southeastern United States

State	Installation	Status on Installation
AL	Fort Rucker	Documented onsite.
	Fort McClellan; Pelham Range	Potential; "Northern pine snakes are infrequently encountered but are known to occur in Calhoun county... Seemingly suitable habitat exists on Pelham Range" (Alabama Natural Heritage Program 1994).
	Anniston Army Depot	Potential *(P. m. melanoleucus)*.
FL	Eglin Air Force Base (AFB)	Documented onsite (*P. m. mugitus*).
	Tyndall AFB	Potential (Stephen Shea, Personal Communication, 1996).
	Camp Blanding	Documented onsite (*P. m. mugitus*).
GA	Fort Gordon	Potential (*P. m. melanoleucus*).
	Fort Stewart	Documented onsite (*P. m. mugitus)*; 7 populations, 10 individuals documented (The Nature Conservancy 1995).
	Fort Benning	Documented onsite (*P. m. melanoleucus*).
SC	Fort Jackson	Potential (*P. m. melanoleucus*).
LA	Fort Polk	Documented onsite (*P. m. ruthveni*) (Hart and Lester 1993). Four documented sightings from 1995-96 and four of these individuals have been radiomarked (Kenneth Moore, Personal Communication, 1996; Shirley Burgdorf, Personal Communication, 1997).
MS	Camp Shelby	Documented onsite (*P. m. lodingi*); 13 have been radiomarked during 1994-96 (Shirley Burgdorf, Personal Communication, 1997).
NC	Fort Bragg	Documented onsite *(P. m. melanoleucus)*.

The Louisiana pine snake is known only from eight west-central Louisiana parishes and eight east-central Texas counties (Dixon 1987) (Figure 1). It is considered one of the rarest and least understood snakes in North America (Thomas et al. 1976; Tennant 1984; Rudolph and Burgdorf, In Press). This subspecies often is confused with the true bull snake (*P. m. sayi*), which occurs in Texas. The Louisiana pine snake is recognized by an anterior dorsal pattern that differs from the posterior region. Dark-brown blotches on the anterior dorsum are crowded together, while those on the posterior dorsum are well-defined and widely spaced (Young and Vandeventer 1988). Also, the rostral scale (nose) is higher than it is wide (Conant 1956).

The mature pine and sandhill habitats favored by pine snakes continue to decline in abundance in the Southeast, so that habitat loss and fragmentation are the primary threats to the species survival.

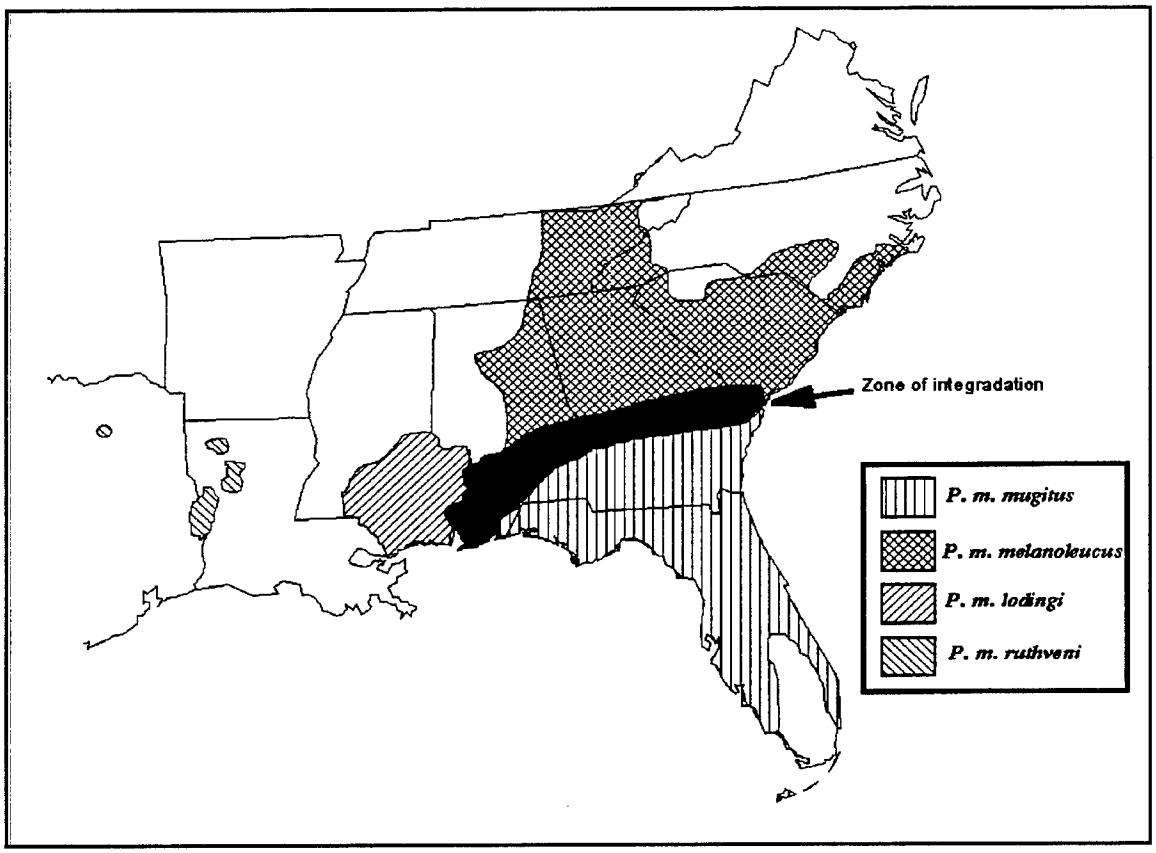

Figure 1. Approximate distribution of pine snakes in the southeastern United States (from Thomas et al. 1976, Jennings and Fritts 1983, Sweet and Parker 1990, and Reichling 1995)

Life History and Ecology

The ecology of pine snakes across their range remains poorly known. Published information tends to be incomplete or anecdotal, and few recent studies have been published. The majority of recent work has been done in the Pine Barrens of New Jersey (Zappalorti et al. 1983, Zappalorti and Burger 1985, Burger and Zappalorti 1986, Burger et al. 1988, Burger 1989,1990), where the northern pine snake occurs as a disjunct population at the northern extreme of the species range (Sweet and Parker 1990). Recent work also has been conducted on the Louisiana pine snake (Young and Vendeventer 1988; Reichling 1995; Rudolph and Burgdorf, In Press; Rudolph et al., In Press).

Reproduction and development

Females appear to have an annual breeding cycle (Fitch 1970, Zappalorti et al. 1983). The mating period extends from April to early June over much of the species range (Ernst and Barbour 1989), perhaps extending into the winter in Florida (Ashton and Ashton 1981). Eggs are laid during June, July, and August (Ernst and Barbour 1989). In New Jersey, oviposition (i.e., egg-laying) is completed in a 2-week period in any given year (Burger and Zappalorti 1991). Nest sites include burrows excavated by the female

in loose soil (Moore 1893, Zappalorti et al. 1983, Burger and Zappalorti 1991), beneath large rocks or logs, or possibly in small mammal burrows (Ernst and Barbour 1989, Franz 1992). Nests have been recorded to be as much as 25 to 30 cm (9.8 to 11.8 in.) deep and may be reused by some subspecies in subsequent years (Burger and Zappalorti 1991). Excavation takes 2 to 4 days to complete (Burger and Zappalorti 1991).

Burger and Zappalorti (1986, 1991) described 93 nest sites of northern pine snakes in the pinelands of New Jersey. All sites were located in large unvegetated clearings or along roads or railroad beds with less than 10-percent tree cover in pitch pine (*Pinus rigida*)-scrub oak (*Quercus ilicifolia*) xeric uplands. Clearings were usually man-made (only 1 of 20 clearings appeared to be naturally created by fire). Nests were excavated in exposed, unvegetated soft-packed sand with little or no humus. Clearings used for nesting averaged 166 m (166 ft) long and 79.2 m (260 ft) wide with slopes less than 14 deg. Ground cover averaged less than 5 percent over the entire nest, less over the mouth and egg chamber.

Snakes appeared to select a particular range of sand hardness that provided ease of digging but was not too soft to promote cave-ins. Soil moisture may be important in site selection (Burger and Zappalorti 1986, 1991). Nests ranged between 90 and 305 cm ($\bar{x}$ = 187.6 cm) (35.4 and 120.1 in.; $\bar{x}$ = 73.8 in.) in length, averaged about 14 cm (5.5 in.) wide, and eggs were found at an average depth of about 21 cm (8.3 in.) below the surface. Burger and Zappalorti (1986) suggested that man-made clearings were crucial to nesting ecology in the New Jersey Pine Barrens and may have improved nesting habitat for this disjunct population at the northern extent of its range.

Clutches of 3 to 24 eggs have been reported (Wright and Wright 1957, Zappalorti et al. 1983); Reichling (1988) documented a clinal variation in clutch size of captive pine snakes with smallest clutches occurring in the Louisiana pine snake. Zappalorti et al. (1983) reported that 35 clutches of northern pine snakes in New Jersey contained 3 to 14 eggs. Burger and Zappalorti (1991) reported a mean northern pine snake clutch size of 9.5 (range 4 to 16) that was significantly and positively correlated with female snout-to-vent length. Franz (1992) reported an average clutch size of 5.6 eggs for Florida pine snakes. Females often nest communally (Parker and Brown 1972, Burger and Zappalorti 1986, Ernst and Barbour 1989), so that higher clutch numbers may reflect more than one clutch.

Incubation typically takes 50 to 100 days, with 70 to 75 days most common (Ernst and Barbour 1989). Hatchlings emerge in August and September at total body lengths of 222 to 256 mm (8.7 to 10.1 in.). Hatchlings are dull in color at emergence, but brighten after shedding. Bowler (1977) reported a record longevity of 22 years, 5 months.

Hibernation

The pine snake hibernates during the winter over most of its range. Hibernacula have been reported in mammal burrows (Schroder 1950, Fitch 1958) where they have occasionally been found with the black racer (*Coluber constrictor*). Louisiana pine snakes

hibernate almost exclusively in Baird's pocket gopher (*Geomys breviceps*) burrows; black pine snakes use burned or decayed stump holes and root channels almost exclusively. Only single individuals have been found in excavated Louisiana and black pine snake hibernacula, and there was little if any indication of modification of the site by the snake (D. Craig Rudolph, Personal Communication, 1997). Hibernacula of northern pine snakes are apparently used repeatedly (Fitch 1958, Burger et al. 1988).

Burger et al. (1988) described seven northern pine snake hibernacula excavated in the New Jersey Pine Barrens. Seventy-three percent of hibernacula were located adjacent to fallen logs, with entrance tunnels following decaying roots into the soil. Hibernacula were characterized by lower surface and soil temperature, higher surrounding leaf cover ($\bar{x}$ = 55 percent), were closer to trees ($\bar{x}$ = 130 cm (51.2 in.) to closest tree), and had more trees within 10 m ($\bar{x}$ = 138 trees) than random points in clearings. In general, hibernacula were relatively more protected sites than random points and were less vulnerable to daily temperature fluctuations. Unlike the southern United States pine snake subspecies, hibernacula of northern pine snakes appeared to have been excavated by the snakes themselves.

Hibernacula described by Burger et al. (1988) typically had an average of eight side chambers and 6.4 m (21 ft) of tunnels. Except for hatchlings, most snakes in hibernacula were located in individual chambers off the main tunnel and not in groups. All snakes were found at depths of 50 to 111 cm (19.7 to 43.7 in.) ($\bar{x}$ = 79 cm (31.1 in.)). All hibernacula were within 100 m (328 ft) of nesting sites, and most were only 10 to 15 m (32.8 to 49.2 ft) from nest chambers.

Food habits

Pine snakes feed primarily on small mammals (Hamilton and Pollack 1956, Wright and Wright 1957, Minton 1972, Ernst and Barbour 1989, Franz 1992). Pine snakes are also known to feed on birds and their eggs, lizards, small snakes and snake eggs, and insects (Ernst and Barbour 1989, Franz 1992). Similar to many other snake species, pine snakes forage actively and locate prey either by olfaction or sight (Dyrkacz and Corn 1974, Chiszar et al. 1980). Florida and Louisiana pine snakes appear to actively locate soil mounds of pocket gophers and may burrow to capture gophers in their burrows (Carpenter 1982; Rudolph and Burgdorf, In Press).

Home range and movements

Pine snakes have relatively restricted home ranges for their size, and males are reported to engage in dominance combat (Ernst and Barbour 1989). Imler (1945) recaptured 11 snakes that had moved less than 100 m (328 ft), but reported one snake moving 2.4 km (1.5 miles). Fitch (1958) reported movements between captures of 94, 128, and 823 m (308, 420, and 2,700 ft). Radiotelemetered snakes in Kansas moved an average of 142 m (466 ft) in a day (Fitch and Shirer 1971).

Macartney et al. (1988) reported a home range of a male pine snake of 1.2 ha (3 acres), while that of a female was 2.1 ha (5.2 acres). In contrast, Franz (1992) reported home

ranges of two radiotracked female Florida pine snakes of 11 and 12 ha (27.5 and 30 acres). Three males used areas two to eight times as large. D. Craig Rudolph (Personal Communication, 1997) suggested home ranges of Louisiana and black pine snakes are considerably larger than most published home ranges of pines snakes. For example, Rudolph and Burgdorf (In Press) reported a mean home range size of 27.7 ha (68 acres) for the Louisiana subspecies.

Burger and Zappalorti (1988) reported the movements and habitat use of 10 radiomarked northern pine snakes in the pinelands of southern New Jersey. Snakes tended to be found in dense vegetation that provided shade and moist, cool ground cover. Snakes were either inactive (41 percent), basking (36 percent), moving (20 percent), or nesting (3 percent). Pine snakes occurred primarily (93 percent of locations) in pitch pine-scrub oak (*Q. marilandica*) uplands (50- to 80-percent pine) and avoided Atlantic white cedar (*Chamaecyparis thyoides*) swamps and lowland pine areas. They spent roughly equal amounts of time in human-altered and relatively undisturbed habitats. There were no major seasonal habitat shifts other than at nesting and hibernation. Early successional habitats in sites that had been previously disturbed by human activity appear to be of crucial importance in both foraging and nesting (Zappalorti and Burger 1985). Snakes remained under wet leaves or inside hollow logs during periods of very high or very low temperatures.

Pine snakes utilize summer dens, apparently to escape extreme summer temperatures (Fitch 1956, Zappalorti et al. 1983, Burger et al. 1988). Florida pine snakes seek out open habitats surrounded by wetlands during drought (Franz 1992). Franz (1992) also reported Florida pine snakes actively seek burrows of gopher tortoises (*Gopherus polyphemus*) as shelter. Louisiana pine snakes primarily use the burrows of pocket gophers (Rudolph and Burgdorf, In Press), but also may use gopher tortoise and armadillo burrows (*Dasypus novemcinctus*) (Dundee and Rossman 1989; Dena Dickerson, Personal Communication, 1997).

Other

The pine snake, aided by its pointed snout and enlarged rostral scale, is an accomplished burrower in loose soil (Franz 1992). Carpenter (1982) estimated that burrowing snakes (*P. m. sayi*) could move up to 3,400 cm^3 (207 $in.^3$) of soil in an hour.

Pine snakes hiss loudly when confronted, sometimes flattening their head, inflating their neck to appear larger, rattling their tail, and often lunging at the intruder (Behler and King 1985; Dena Dickerson, Personal Communication, 1997).

Habitat Requirements

Pine snakes are typically found in areas of sandy soil (which facilitates burrowing) dominated by scrub pines and shrubs, flat sandy pine barrens, sandhills, and dry mountain ridges (Walker 1965, Conant 1975, Wright and Wright 1957, Ernst and Barbour

1989). More midwestern subspecies (e.g., *P. m. sayi*) inhabit grasslands with clumps of vegetation and sandy soil (Ernst and Barbour 1989). In New Jersey, the northern pine snake is restricted to the open Pine Barrens of the southern portion of the State (Zappalorti et al. 1983). In North Carolina, it is a species of longleaf pine (*P. palustris*) sandhills. Gibbons and Semlitsch (1991) described its habitat as sandy old fields and turkey oak (*Q. laevis*)-pine forests. The Florida pine snake is found in xeric sites, occurring primarily in longleaf pine-turkey oak woodlands, but also in sand pine (*P. clausa*) scrub, pine flatwoods on well-drained soils, and old fields on former sandhill sites (Franz 1992). Louisiana pine snakes are restricted to longleaf pine forests and second growth longleaf pine-blackjack oak (*Q. marilandica*) associations (Fugler 1955, Walker 1965). Wright and Wright (1957) reported that the Louisiana pine snake is primarily associated with longleaf pine forests of Louisiana and Texas at elevations between 31 and 153 m (100 and 500 ft). Louisiana pine snakes in Texas spend most of their time in longleaf pine savanna habitat in close association with pocket gopher populations. Most observations of radiomarked individuals were on low, broad ridges overlain with well-drained soils. Vegetation was comprised of a pine overstory with moderate to sparse midstory and a well-developed herbaceous understory dominated with grasses (Rudolph and Burgdorf, In Press).

Impacts and Cause of Decline

Habitat degradation

As with many sandhill-dependent organisms, outright loss of habitat occurs when land is converted to agriculture, housing, or single-species pine plantations. Remaining areas are degraded so that their suitability for pine snakes is greatly diminished. Zappalorti (Personal Communication, 1994) listed habitat fragmentation as the primary threat to northern pine snake survival in New Jersey. Development of the New Jersey Pinelands has led to increased human access to previously remote areas, greater off-road recreational use, and ultimately increased paved roadways and traffic. The overall distribution of the pine snake in New Jersey continues to shrink as the human population grows (Zampella, Personal Communication, 1994; Zappalorti, Personal Communication, 1994).

Commercial logging of limited longleaf pine habitats and subsequent planting to unburned pine plantations have contributed to the disappearance of the Louisiana pine snake. This subspecies is intimately associated with longleaf pine savanna habitat that historically had a frequent fire history; thus, Louisiana pine snakes should be adapted to a frequent fire regime. Rudolph and Burgdorf (In Press) hypothesized that because of the close association of Louisiana pine snakes with pocket gophers, habitat alterations that have decreased pocket gopher abundance and distribution have subsequently led to pine snake declines in Texas and Louisiana.

Predation

Predators on pine snakes are poorly known, although Burger (1989, 1990) suggested kingsnakes (*Lampropeltis* spp.) may eat some individuals. Burger et al. (1992) reported on predation on hibernating and nesting northern pine snakes in New Jersey. Seven of forty hibernacula (17.5 percent) and 49 of 201 (24.3 percent) nests surveyed were predated by red foxes (*Vulpes fulva*), striped skunks (*Mephitis mephitis*), and short-tailed shrews (*Blarina brevicauda*). In Mississippi, raccoons (*Procyon lotor*), crows (*Corvus brachyrhynchos*), and fire ants (*Solenopsis* spp.) are a problem (Dena Dickerson, Personal Communication, 1997). Females do not cover nest entrances or fill entrance tunnels, and the pile of excavated sand left at the nest entrance would appear to flag predators. The low rates of predation reported may be explained by the long entrance tunnels leading to nest chambers (as much as 100 cm (39.4 in.) in length), which may mask the odors of nesting snakes or make digging up nests too much effort for most predators (Burger and Zappalorti 1991).

Pine snakes are large and conspicuous, making them a relatively easy mark for people who kill snakes on sight. Their apparently low population densities and fossorial habits may assist them here, but several authors report numerous encounters with pine snakes on relatively open habitats and roadways (Burger and Zappalorti 1988, Gibbons and Semlitsch 1991). Franz (1992) reported that Florida pine snake numbers have been seriously declining in the last 20 years. Threats are listed as excessive collecting, road mortality, and habitat alteration. Automobiles and pet trade collecting account for considerable mortality in the New Jersey Pinelands (Zappalorti, Personal Communication, 1994) and pesticide use may be of considerable concern (Ernst and Barbour 1989).

Military training (adapted from Trame and Harper 1997)

Mechanized training. Mechanized military training can alter natural plant communities through impacts to soils and subsequently cause soil erosion. Intense use of tactical land vehicles (both tracked and wheeled) can cause extensive soil disturbance, which may destroy gopher tortoise and gopher burrows in which pine snakes may nest or seek refuge.

Bivouacs. Military bivouacs, which involve a combination of vehicle and non-mechanized trampling, represent a serious source of soil compaction and related impacts to sandhill habitat. Sustained high levels of trampling can ultimately eliminate vegetation.

Fire. Military training can impact native communities and associated species by fragmenting the fuel sources needed to carry fire over large areas. Native ground cover, especially grasses, are essential fuel sources that allow large areas to burn. Bunchgrasses are often eliminated in bivouac sites, assembly areas, and tank-maneuver areas through direct destruction or soil compaction. Areas that do not burn undergo a change in species composition and become increasingly shaded through time, resulting in loss of the natural community.

The alteration of the historic fire regime is likely the major factor leading to decline of Louisiana pine snakes and may also be the case with other pine snake subspecies (D. Craig Rudolph, Personal Communication, 1997). The reintroduction of fire resulting from activities such as live arms firing and use of incendiary devices may be potentially beneficial to sandhill organisms. The frequency of ignition on military installations, especially in high hazard impact areas, often produces a fire regime over large areas at a frequency that resembles presettlement natural fire return intervals. This encourages a mosaic burn pattern and enhances conditions for the fire-adapted species in southern pine woodlands (Gulf Engineers and Consultants, Inc., and Geo-Marine, Inc., 1994; LeBlond et al. 1994).

Inventory and Monitoring

Population monitoring is needed to determine the status of the different subspecies of pine snakes in southeastern States and, in particular, whether the often reported low densities are a reflection of rarity or of its secretive nature. Long-term monitoring programs in New Jersey should be reproduced in the Southeast with emphasis on systematic census in all potentially suitable habitats.

The primary method for censusing most pine snake subspecies has consisted of walking transects through suitable habitat. Pine snakes are large and conspicuous and are often encountered on relatively open habitats and along roadways (Burger and Zappalorti 1988, Gibbons and Semlitsch 1991). Louisiana pine snakes must be trapped due to their rarity (D. Craig Rudolph, Personal Communication, 1997).

Gibbons and Semlitsch (1991) reported that pine snakes at the Savannah River Plant in Georgia were typically found from June through October. They were captured most often during daylight along roads. Burger and Zappalorti (1988) showed that activity patterns of male and female northern pine snakes differed: females were more active in June, apparently due to nest excavation, whereas males were most active in August while returning to hibernacula. Males tended to disperse farther from point of capture than females. Overall, both sexes were most active during May, probably signifying breeding activity.

Zappalorti (Personal Communication, 1994) believed that accurate censusing of northern pine snakes is behavior dependent and requires repeated sampling during the year. In New Jersey, he recommended censuses should be made at the end of hibernation in mid-April to early May, during the nesting season, and again in the fall. Snakes are much harder to locate after dispersal.

Burger and Zappalorti (1988), Franz (1992), and Rudolph et al. (In Press) have effectively used implanted radiotelemetry to elucidate pine snake movement and behavior patterns. Where information on specific habitat and range requirements are required, the cost of such methods, both in equipment and human resources, may be justified.

Bennett (Personal Communication, 1994) pointed out that pine snakes are typically a relatively abundant animal in xeric upland areas at the Savannah River Ecology Laboratory. However, Williams (Personal Communication, 1994) reported that pine snakes were rarely seen on the Carolina Sandhills National Wildlife Refuge. Bennett (Personal Communication, 1994) suggested that pine snakes were never abundant and are distributed in localized populations where they are often fairly common. Systematic searches and long-term monitoring of populations are required to determine actual status of the pine snake across its range. The status of pine snake subspecies is monitored by Heritage Programs throughout the southeastern United States

Management and Protection

Pine snake population levels are poorly known across the species range. Apparently declining numbers in the Southeast appear to be related to the status of mature, xeric pine and sandhill habitats upon which it depends. Recovery/persistence of pine snake populations depends on the preservation of large tracts of remaining forest, restoration of disturbed forest, and provision of habitat linkages to prevent fragmentation of existing populations of these wide-ranging snakes.

Habitat protection

Many of the last remaining large areas of longleaf pine-turkey oak sandhills and forest are found on U.S. Forest Service and military lands. Many of these areas are being managed for recovery of the red-cockaded woodpecker (*Picoides borealis*). Management prescriptions for this species should generally be beneficial for pine snakes. Those national forests and military installations that manage for the woodpecker have instituted programs of growing season controlled burns (2- to 3-year intervals), hardwood midstory control, and restoration of longleaf pine on suitable sites.

Management of public lands offers the best opportunities for protection of large, contiguous areas of mature pine and pine-oak forest habitats with such protection efforts often being driven by recovery of the red-cockaded woodpecker. Management plans for the woodpecker should be adapted to take into account the requirements of the pine snake and other species, particularly when the needs of the species do not conflict.

Good quality habitat appears to be characterized by xeric, pine-dominated or pine-oak (50- to 80-percent pine) woodland with an open, low understory established on sandy soils. Longleaf pine sandhills appear to represent critical habitat over much of the Southeast. Pine snakes also require forest openings, with level, well-drained sandy soils and little shrub cover, as nesting and hibernation sites. Moler (1992) suggested that habitat protection for the indigo snake (*D. corais couperi*), a slightly larger snake with similar reported home range size ($\approx$ 10 ha (24.7 acres)) should focus on large tracts of at least 1,000 ha (2,471 acres). Zappalorti (Personal Communication, 1994) suggested that northern pine snake populations are probably secure on large protected areas, including the 14,160-ha (35,000-acre) Wharton State Forest in the New Jersey Pine Barrens, but habitat

fragmentation on private lands puts the snake under increasing pressure. Because pine snakes may use relatively large areas, Zappalorti (Personal Communication, 1994) suggested that preserves designed to effectively manage northern pine snakes should be somewhat more than 405 ha (1,000 acres) of pine forest and mixed pine-oak stands. As for indigo snakes and gopher tortoises in the Southeast (see Wilson et al. 1997), managed tracts of mature pine-oak forest should be large enough to support periodic low-intensity fire.

Of primary importance to the preservation of the pine snake is the maintenance of suitable habitats. The management needs of the longleaf pine sandhill habitat have been well researched. The hardwood midstory should be controlled in order to achieve an open stand and a well-developed herbaceous ground cover dominated primarily by wiregrass (*Aristida stricta*), or in east Texas, bluestem (*Andropogon* spp.). To avoid interference with the snake's fossorial habits, low-intensity site preparation methods (e.g., burning) should be used rather than more intensive methods (e.g., root raking, chopping). Growing season burning provides the best means of achieving these goals (see below).

Reducing physical impediments to burning, including roads and habitat fragmentation, may help reduce the isolation of subpopulations. Preservation of the mature pine-oak forest must also include protection for adjacent lowland habitats. Mature pine forest is not the only habitat type used or required by pine snakes, and it need not occur in single large units. A mosaic of habitats, with a substantial mature pine-oak component and access to bottomland forest, should be managed to approximate natural conditions.

Prescribed burning

Regular prescribed fire is highly desirable for the maintenance and improvement of pine snake habitat because it acts to reduce the shrub and midstory woody vegetation and promotes a well-established herbaceous layer. Zappalorti (Personal Communication, 1994) pointed out that growing season fires may have adverse impacts on northern pine snakes in some cases and suggested that winter fires, where appropriate, would avoid impacts, as snakes would tend to be in hibernacula. Rudolph et al. (In Press) demonstrated that radiomarked Louisiana pine snakes were able to easily escape approaching fire by retreating into underground burrows. In addition, S. Burgdorf (Personal Communication, 1997) suggested that pine snake habitat in east Texas and Louisiana is in poor to marginal condition and winter prescribed burns likely would not adequately reduce woody understory. Thus, at least for Louisiana pine snakes, growing-season fire potentially can be prescribed to improve habitat. Additional research is needed to ascertain the effects of fire on Florida and black pine snakes, but results likely would be similar because these two subspecies also occur in habitats with a frequent fire-return interval.

Concern for the red-cockaded woodpecker has generated increased interest in the preservation and restoration of the longleaf pine forest ecosystem. In general, management recommendations for woodpecker habitat, as outlined in the U.S. Forest Service Regional Wildlife Habitat Management Handbook, would apply equally well to the pine snake. Williams (Personal Communication, 1994) pointed out that pine snakes are often

observed in areas managed for red-cockaded woodpeckers. In particular, institution of a regime of regular prescribed fires on a 2- to 3-year rotation to control the hardwood mid-story, maximize the regeneration and growth of ground cover, and prepare a suitable seedbed for longleaf pine, is important to the maintenance of open pine stands suitable for pine snake habitat.

Natural fire breaks (topographic features, wetland boundaries) should be favored over artificial means of controlling fire, since use of natural breaks would more closely mimic natural ecosystem processes. Use of heavy equipment to construct berms or fire lanes should be minimized to avoid negative impacts to ground-layer vegetation, soil stability, and pine snake burrow systems. Mechanical fire management should be prohibited within 7.6 m (25 ft) of known pine snake burrow entrances.

Hardwood control and pine thinning

In general, the hardwood and pine thinning guidelines, to the extent that they restore or promote the maintenance of an open, parklike stand of mature pine-oak forest, should benefit the pine snake. Chemical and mechanical methods of hardwood control should employ best management practices to avoid soil disturbance, destruction of ground-layer vegetation, and nontarget effects of herbicides.

Erosion control

Concerted efforts to reduce and prevent soil erosion within red-cockaded woodpecker habitat management units (HMUs) would have a beneficial effect on pine snake habitats by maintaining the integrity of herbaceous layers and pine snake burrow systems. Native vegetation should be used wherever possible, and nonnative species should be avoided. Mechanical means of erosion control should maintain the natural contours of the surrounding topography and ensure the integrity of natural hydrologic processes.

Longleaf pine regeneration

In general, reestablishment of longleaf pine and the regeneration of existing longleaf pine stands would increase the available habitats for the pine snake. Natural regeneration methods should be used in order to avoid high-impact artificial means. Site preparation should employ fire where possible rather than mechanical methods such as discing or chopping. Site preparation should avoid a 7.6-m (25-ft) buffer around known pine snake burrow entrances (some snake burrows can be recognized by small size and a distinctive pile of excavated sand on one side of the opening (Burger and Zappalorti 1991)). Slash piles and fallen trees should be retained where possible to provide refugia.

Extractive land uses

Pine straw raking has been shown to destroy ground-layer vegetation and longleaf pine seedlings and to cause or exacerbate erosion problems. In the long term, removal of pine straw fuels may also alter fire regimes. Thus, pine straw removal would have negative impacts on pine snakes. Timber harvest that shifts forest stands toward longer

rotations and replaces offsite pines and hardwoods with longleaf pine should restore natural fire, hydrologic, and nutrient dynamics in plant communities. Forest management should minimize adverse impacts to wiregrass and other herbaceous ground-layer species. Forestry practices should avoid a 7.6-m (25-ft) buffer around known pine snake burrow entrances.

Because Louisiana pine snakes are closely associated with pocket gophers, disturbances to areas having high densities of pocket gopher burrows should be avoided. Black pine snakes are heavily dependent on stumps for hibernacula. In areas where black pine snakes are known to occur, the practice of stump removal for naval stores (e.g., turpentine or "fatwood") should be discouraged (D. Craig Rudolph, Personal Communication, 1997).

Artificial dens

Zappalorti (Personal Communication, 1994) pointed out that direct effective management options to increase breeding success of northern pine snakes include the creation of artificial dens (Frier and Zappalorti 1983), establishment of suitable nesting habitat (through clearing of vegetation and construction of hibernacula), and management of the surrounding forest to achieve the open, high light environment required by nesting females. Zappalorti and coworkers (e.g., Frier and Zappalorit 1983) have had considerable success in the construction of northern pine snake hibernacula in the New Jersey Pine Barrens. However, Shirley Burgdorf (Personal Communication, 1997) suggested this may not work with all subspecies of pine snakes.

Training restrictions

Restrictions on training activities within red-cockaded woodpecker HMUs, to the extent that they minimize disturbance to vegetation and soils, should benefit pine snakes. Vehicular traffic on roadways should be monitored to reduce soil erosion, and off-road traffic should be prohibited, as it is highly deleterious to ground cover, soil structure, and hydrologic patterns. Where off-road traffic is unavoidable, it should be prohibited from within 25 ft of known pine snake burrows as well as from within 15 m (50 ft) of red-cockaded woodpecker cavity trees.

Education

Finally, education aimed at altering public opinion concerning snakes in general, and the common tendency to kill snakes on sight, is needed. Installation education programs should be directed to both soldiers and their dependents. Education might also be successfully aimed at private owners or leaseholders of large tracts of sandhill habitats adjacent to installations, where snakes may come in contact with agricultural workers, loggers, and hunters. Efforts should emphasize the harmless and beneficial nature of pine snakes.

Research Needs

The ecology and population status of pine snakes remains poorly understood throughout its range (Franz 1992). Information is needed concerning the spatial ecology of pine snakes, particularly in response to an increasingly fragmented habitat (Durner and Gates 1993).

Care should be taken in interpreting habitat use information from radiomarked pine snakes. Burger and Zappalorti (1988) demonstrated that the habitat selection of radiomarked northern pine snakes in New Jersey differed appreciably from the apparent habitat selection of hand-captured or randomly encountered snakes (i.e., they are usually most often seen in open areas, which are not necessarily where snakes spend most of their time). Additional research on this topic is warranted.

The majority of detailed research on the pine snake has been done in New Jersey, a disjunct population at the northern extreme of the species' geographic range (Sweet and Parker 1990). Similar studies should be conducted on the movements, behavior, and reproductive ecology of pine snakes in southern pine and pine-oak forests.

Home range sizes, movement patterns across different habitat types, and viable population densities must be reliably investigated to provide information necessary for management of existing populations. Research is also needed to develop appropriate, cost-effective methods to monitor both population trends and habitat requirements in managed landscapes. Zampella (Personal Communication, 1994) points out that published accounts of habitat descriptions may reflect the fact that snakes are easier to spot during random searches on some habitats (e.g., powerline rights-of-way, roadsides) and may be biased against habitats that are more difficult to search. He stressed the need for more systematic searches of available habitats.

Literature Cited

Alabama Natural Heritage Program. 1994. Natural heritage inventory of Fort McClellan, Pelham Range: Federal endangered, threatened, candidate species and State-listed species. Alabama Natural Heritage Program, Alabama Dept. of Cons. and Nat. Res., State Lands Division, Montgomery, AL.

Ashton, R. E., Jr., and P. S. Ashton. 1981. Handbook of reptiles and amphibians of Florida. Part 1. The snakes. Windward Publishing, Incorporated, Miami, FL.

Behler, J. L., and F. W. King. 1985. The Audubon Society field guide to North American reptiles and amphibians. Alfred A. Knopf, Incorporated, NY.

Bowler, J. K. 1977. Longevity of reptiles and amphibians in North American collections. Society for the Study of Amphibians and Reptiles Miscellaneous Publication Herpetol. Circ. 6:1-32.

Burger, J. 1989. Approach to conspecific and avoidance of predator chemical cues by pine snakes (*Pituophis melanoleucus*). Journal of Chemical Ecology 15: 799-806.

Burger, J. 1990. Response of hatchling pine snakes (*Pituophis melanoleucus*) to chemical cues of sympatric snakes. Copeia 1990: 1160-1163.

Burger, J., and R. T. Zappalorti. 1986. Nest site selection by pine snakes, *Pituophis melanoleucus*, in the New Jersey Pine Barrens. Copeia 1986: 116-121.

Burger, J., and R. T. Zappalorti. 1988. Habitat use in free-ranging pine snakes, *Pituophis melanoleucus*, in New Jersey Pine Barrens. Herpetologica 44: 48-55.

Burger, J., and R. T. Zappalorti. 1991. Nesting behavior of pine snakes (*Pituophis melanoleucus melanoleucus*) in the New Jersey Pine Barrens. Journal of Herpetology 25:152-160.

Burger, J., R. T. Zappalorti, M. Gochfeld, W. I. Boarman, M. Caffrey, V. Doig, S. D. Garber, B. Lauro, M. Mikovsky, C. Safina, and J. Saliva. 1988. Hibernacula and summer dens of pine snakes (*Pituophis melanoleucus*) in the New Jersey Pine Barrens. Journal of Herpetology 22:425-433.

Burger, J., R. T. Zappalorti, J. Dowdell, T. Georgiadis, J. Hill, and M. Gochfeld. 1992. Subterranean predation on pine snakes (*Pituophis melanoleucus*). Journal of Herpetology 26:259-263.

Carpenter, C. C. 1982. The bullsnake as an excavator. Journal of Herpetology 16: 394-401.

Chiszar, D., V. Lipetz, K. Scudder, and E. Pasenello. 1980. Rate of tongue flickings by bull snakes and pine snakes (*Pituophis melanoleucus*) during exposure to food and nonfood odors. Herpetologica 36: 225-231.

Conant, R. 1956. A review of two rare pine snakes from the Gulf Coastal Plain. American Mus. Novit. 1781:1-31.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Company, Boston, MA.

Ditmars, R. E. 1907. The reptile book. Doubleday, Page and Co., New York, NY.

Dixon, J. R. 1987. Amphibians and reptiles of Texas. Texas A&M University Press, College Station, TX.

Dundee, H. A., and D. A. Rossman. 1989. The amphibians and reptiles of Louisiana. Louisiana State University Press, Baton Rouge.

Durner, G. M., and J. E. Gates. 1993. Spatial ecology of black rat snakes on Remington Farms, Maryland. Journal of Wildlife Management 57:812-826.

Dyrkacz, S., and M. J. Corn. 1974. Response of naive, neonate bullsnakes to water extracts of potential prey items. Herpetological Review 5:74.

Ernst, C. H., and R. W. Barbour. 1989. Snakes of eastern North America. George Mason University Press, Fairfax, VA.

Fitch, H. S. 1956. Temperature responses in free-living amphibians and reptiles in northeastern Kansas. University of Kansas Publ. Museum of Natural History 8:417-476.

Fitch, H. S. 1958. Home ranges, territories, and seasonal movements of vertebrates of the Natural History Reservation. University of Kansas Publ. Museum of Natural History 11:63-326.

Fitch, H. S. 1970. Reproductive cycles in lizards and snakes. University of Kansas Museum of Natural History, Miscellaneous Publication 52:1-247.

Fitch, H. S., and H. W. Shirer. 1971. A radiotelemetric study of spatial relationships in some common snakes. Copeia 1971:118-128.

Franz, R. 1992. Florida pine snake. pp. 254-258. *In* P. E. Moler (ed.). Rare and endangered biota of Florida. Vol. 3. Amphibians and reptiles. University Press of Florida, Gainesville.

Frier, J., and R. T. Zappalorti. 1983. Reptile and amphibian management techniques. Transactions of the Wildlife Society 40:142-148.

Fugler, C. M. 1955. New locality records for the Louisiana pine snake, *Pituophis catenifer ruthveni* Stull. Herpetologica 11:24.

Gibbons, J. W., and R. D. Semlitsch. 1991. Guide to the reptiles and amphibians of the Savannah River Site. University of Georgia Press, Athens.

Gulf Engineers and Consultants, Inc., and Geo-Marine, Inc. 1994. Final report, rare, threatened and endangered species survey and their habitat at Fort Benning, Georgia. Contract No. DACW21-89-0016. Baton Rouge, LA.

Hamilton, W. J., Jr., and J. A. Pollack. 1956. The food of some colubrid snakes from Fort Benning, Georgia. Ecology 37: 519-526.

Hart, B. L., and G. D. Lester. 1993. Natural communities and sensitive species assessment on Fort Polk Military Reservation, Louisiana. Final Report submitted to Department of the Army Corps of Engineers, Memphis, Tennessee, by The Nature Conservancy, Arlington, VA.

Imler, R. H. 1945. Bullsnakes and their control on a Nebraska wildlife refuge. Journal of Wildlife Management 9:265-273.

Jennings, R. D., and T. H. Fritts. 1983. The status of the black pine snake *Pituophis melanoleucus lodingi* and the Louisiana pine snake *Pituophis melanoleucus ruthveni.* U.S. Fish and Wildlife Service and University of New Mexico Museum of Southwestern Biology.

Leblond, R. J., J. O. Fussell, and A. L. Braswell. 1994. Inventory of the rare species, natural communities, and critical areas of the Camp Lejeune Marine Corps Base, North Carolina. North Carolina Natural Heritage Program, DPR, Department Environment, Health, and Natural Resources, Raleigh, NC.

Macartney, J. M., P. T. Gregory, and K.W. Larsen. 1988. A tabular survey of data on movements and home ranges of snakes. Journal of Herpetology 22:61-73.

Minton, S. A., Jr. 1972. Amphibians and reptiles of Indiana. Indiana Academy of Science Monograph 3:1-346.

Moler, P. E. 1992. Eastern indigo snake. pp. 181-186. *In* P. E. Moler (ed.). Rare and endangered biota of Florida. Vol. 3. Amphibians and reptiles. University Press of Florida, Gainesville.

Moore, J. M. 1893. The eggs of *Pituophis melanoleucus.* American Naturalist 27: 878-885.

Mount, R. H. 1975. The reptiles and amphibians of Alabama. Auburn University Agricultural Experiment Station, AL.

Neill, W. T. 1941. Notes on pine snakes from Georgia and South Carolina. Copeia 1941:56.

Parker, W. S., and W. S. Brown. 1972. Telemetric study of movements and oviposition of two female *Masticophis t. taeniatus*. Copeia 1972:892-895.

Reichling, S. B. 1988. Reproduction in captive Louisiana pine snakes (*Pituophis melanoluecus ruthveni*). Herpetological Review 19:77-78.

Reichling, S. B. 1995. The taxonomic status of the Louisiana pine snake (*Pituophis melanoleucus ruthveni*) and its relevance to the evolutionary species concept. Journal of Herpetology 29:186-198.

Rudolph, D. C. Avoidance of fire by Louisiana pine snakes. Herpetological Review, In Press.

Rudolph, D. C., and S. J. Burgdorf. Timber rattlesnake and Louisiana pine snakes of the West Gulf Coastal Plain: Hypotheses of decline. Texas Journal of Science, In Press.

Rudolph, D. C., S. J. Burgdorf, J. C. Tull, M. Ealy, R. N. Conner, R. R. Schaefer, and R. R. Fleet. Avoidance of fire by Louisiana pine snakes, *Pituophis melanoleucus ruthveni*. Herpetological Review, In Press.

Schroder, R. C. 1950. Hibernation of blue racers and bull snakes in western Illinois. Natural History Misc. 75:1-2.

Sweet, S. S., and W. S. Parker. 1990. *Pituophis melanoleucus*: Pine, bull, and gopher snakes. Cat. American Amphibian Rept. 474.11-474.8.

Tennant, A. 1984. The snakes of Texas. Texas Monthly Press, Austin.

The Nature Conservancy. 1995. Fort Stewart inventory, final report. U.S. Department of Defense, Dept. of the Army, Headquarters 24th Mechanized Division, Fort Stewart, GA.

The Nature Conservancy. 1997. U.S. Natural Heritage Programs. World Wide Web URL: *http://www.heritage.tnc.org/nhp/us*.

Thomas, R., B. J. Davis, and M. R. Culbertson. 1976. Notes on variation and range of the Louisiana pine snake, *Pituophis melanoleucus ruthveni*, Stull (Reptilia, Serpentes, Colubridae). Journal of Herpetology 10:252-254.

Trame, A. M., and M. G. Harper. 1997. Potential military impacts to selected plant communities in the southeastern United States. Natural Resources Division, U.S.Army Construction Engineering Laboratories, Champaign, IL.

Walker, J. M. 1965. Notes on two rare Louisiana serpents. Herpetologica 21:159-160.

Wilson, D. S., H. R. Mushinsky, and R. A. Fischer. 1997. Species profile: Gopher tortoise (*Gopherus polyphemus*) on military installations in the southeastern United States. Technical Report SERDP-97-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Wright, A. H., and A. A. Wright. 1957. Handbook of snakes of the United States and Canada. 2 vols. Comstock Publishing Associates, Ithaca, NY.

Young, R. A., and T. L. Vandeventer. 1988. Recent observations on the Louisiana pine snake (*Pituophis melanoleucus ruthveni*). Bulletin of the Chicago Herpetological Society 23:203-207.

Zappalorti, R. T., and J. Burger. 1985. On the importance of disturbed sites to habitat selection by pine snakes in the pine barrens of New Jersey. Environmental Conservation 12:358-361.

Zappalorti, R. T., E. W. Johnson, and Z. Leszczynski. 1983. The ecology of the northern pine snake, *Pituophis melanoleucus* (Daudin) (Reptilia, Serpentes, Colubridae) in southern New Jersey, with special notes on habitat and nesting behavior. Bulletin of of the Chicago Herpetological Society 18:57-72.

Personal Communications

Bennett, S. 1994. Coordinator, South Carolina Heritage Trust, Columbia, SC.

Burgdorf, Shirley. 1997. Wildlife Biologist, Wildlife Habitat and Silviculture Lab, Southern Research Station, U.S. Forest Service, P.O. Box 7600, SFA Station, Nacogdoches, TX 75962. 409-569-7981 (*c_burgdorfsj@titan.sfasu.edu*).

Dickerson, Dena O. 1997. U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180. 601-634-3772.

Moore, Kenneth. 1996. Biologist, Fort Polk, Louisiana. ATTN: AFZX-PW-E, Fort Polk, LA 71459-7100. 318-531-6088.

Rudolph, D. Craig. 1997. Research Ecologist, Wildlife Habitat and Silviculture Lab, Southern Research Station, U.S. Forest Service, P.O. Box 7600, SFA Station, Nacogdoches, TX 75962. 409-569-7981.

Shea, Stephen. 1996. Wildlife Biologist, Tyndall AFB. 325 CES/CEV, 119 Alabama Avenue, Tyndall AFB, FL 32403-5014. 904-283-2641.

Williams, L. 1994. Assistant Refuge Manager, Carolina Sandhills National Wildlife Refuge, McBee, SC.

Zampella, R. A. 1994. New Jersey Pinelands Commission, New Lisbon, NJ.

Zappalorti, R. T. 1994. Hepetological Associates, Forked River, NJ.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
March 1998

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
Species Profile: Pine Snake (*Pituophis melanoleucus* spp.) on Military Installations in the Southeastern United States

5. FUNDING NUMBERS

6. AUTHOR(S)
Robert A. Jordan

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
The Nature Conservancy
Southeastern Regional Office
P.O. Box 2267
Chapel Hill, NC 27515-2267

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000;
U.S. Army Engineer Waterways Experiment Station
3909 Hall Ferry Road, Vicksburg, MS 39180-6199

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
Technical Report SERDP-98-5

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report addresses the four subspecies of pine snake (*Pituophis melanoleucus*) that occur east of the Mississippi River: northern pine snake (*P. m. melanoleucus*), Florida pine snake (*P. m. mugitus*), black pine snake (*P. m. lodingi*), and Louisiana pine snake (*P. m. ruthveni*). These subspecies typically inhabit areas of sandy soil dominated by scrub pines and shrubs, flat sandy pine barrens, sandhills, and dry mountain ridges. Pine snakes in the southeastern United States are former candidate species for listing as threatened or endangered by the U.S. Fish and Wildlife Service. The Louisiana subspecies is considered one of the rarest and least understood snakes in North America. Habitat loss and fragmentation appear to be the primary threats to the continued survival of pine snakes. Pine snakes have been documented on several military installations in the Southeast. This report is one of a series of Species Profiles being developed for threatened, endangered, and sensitive species inhabiting southeastern United States plant communities. The work is being conducted as part of the Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). The report is designed to supplement information provided in plant community management reports for major United States plant communities found on military installations. Information provided on pine snakes includes status, life history and ecology, habitat requirements, impacts and cause of decline, management and protection, and inventory and monitoring.

14. SUBJECT TERMS
DoD installations
Pine snake
Plant communities
Sandhill habitat
SERDP
Species profile
Threatened and Endangered species

15. NUMBER OF PAGES
25

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		