Microhabitat characteristics of American black bear nest dens

Donald A. Martorello[1] and Michael R. Pelton

Department of Forestry, Wildlife and Fisheries, University of Tennessee, P.O. Box 1071, Knoxville, TN 37901-1071, USA

Abstract: We investigated denning ecology of 31 American black bears (*Ursus americanus*) on the Neuse-Pamlico Peninsula (NPP) in eastern North Carolina, 1994–96. Twenty bears used nest dens, 2 used excavated ground dens, 1 used a tree den, and 8 were undetermined. We measured 6 microhabitat characteristics around nest dens and random sites and compared them to determine if bears selected specific microhabitat characteristics for nest den sites. Characteristics of nest and random sites differed significantly. Shrub height was greater at nest sites than random sites. Similarly, stem density was greater at nest sites than random sites, and cover density was greater at nest sites compared with random sites. Thick understory cover may be a prerequisite for nest dens on the NPP. If management goals include maintaining suitable nest den habitat, areas with thick understory habitat should be retained.

Key words: American black bear, denning, habitat selection, *Ursus americanus*, winter dormancy

Ursus 14(1):21–26 (2003)

Winter dormancy is an important and critical period for American black bears (Hellgren 1998). During winter dormancy female bears give birth to cubs, provide maternal care to those cubs, and escape the period when natural forage is least abundant (Hamilton and Marchinton 1980, Oli et al. 1997). As such, the availability of secure den sites may be important for increasing cub and adult survival and minimizing energy expenditures (Johnson and Pelton 1981, Alt 1984, Hellgren and Vaughan 1989, Oli et al. 1997, Hellgren 1998).

Numerous authors have investigated the denning ecology of black bears using a variety of den types, such as excavated ground cavities (Johnson and Pelton 1981), elevated tree cavities (Johnson and Pelton 1981, Weaver and Pelton 1994, White et al. 2001), ground level tree cavities (Jonkel and Cowan 1971, Johnson and Pelton 1981, Beecham et al. 1983), rock crevices (Johnson and Pelton 1981, LeCount 1983), brush piles (i.e., logging slash, felled tree tops; Hellgren and Vaughan 1989, Weaver and Pelton 1994, White et al. 2001), and other den types where bears were enclosed in a cavity (Jonkel and Cowan 1971). However, black bear studies along the Southeastern Coastal Plain have documented repeated occurrence of nest dens (i.e., nesting structure surrounded by vegetation; Hamilton and Marchinton 1980, Abler 1985, Smith 1985, Hellgren and Vaughan 1989, Wooding and Hardisky 1992, Weaver and Pelton 1994, Folta 1998, White et al. 2001).

Unlike cavity type dens, nest dens have no physical barrier between the wintering bear and ambient weather or disturbances from animals and humans. Rather, vegetation and woody debris typically provide the only security to bears occupying nest dens. As such, the level of security provided by the microhabitat likely serve a vital role in cub survival, energy expenditures, and den abandonment (Hamilton and Marchinton 1980, Hellgren and Vaughan 1989). Yet we found only limited information on characteristics of vegetation associated with nest dens (Lombardo 1993), and we found no test to determine if bears select specific habitat characteristics for nesting sites. Given the occurrence of nest dens throughout the Southeastern Coastal Plain, a quantitative description of suitable nest den habitat is needed. To that end, we investigated the denning ecology of black bears in coastal North Carolina. Our objectives were to evaluate prevalence of nest dens for wintering black bears and determine if bears selected specific microhabitat characteristics when selecting a nest site.

[1]Present address: Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501-1091, USA, email: martodam@dfw.wa.gov

Study area

The Neuse–Pamlico Peninsula (NPP), North Carolina, was a 150,000-ha area in eastern North Carolina

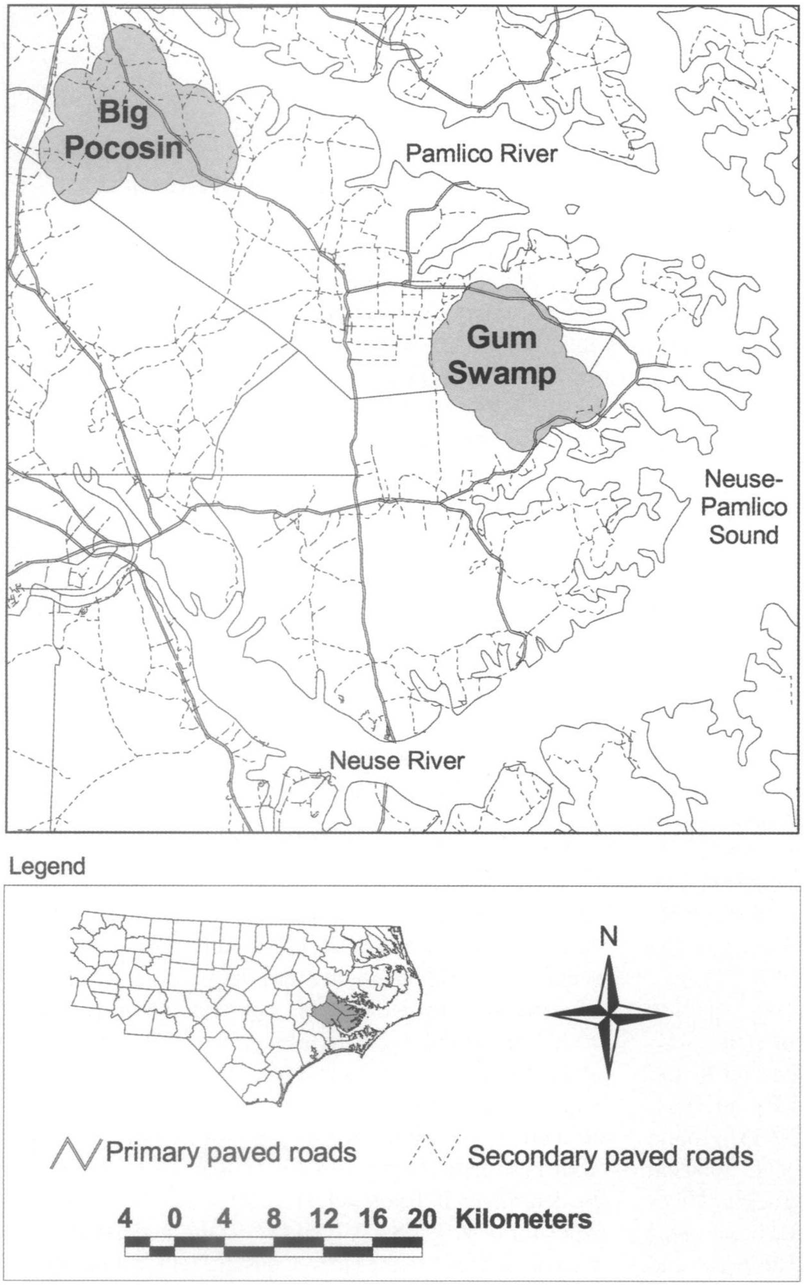

Fig. 1. Big Pocosin and Gum Swamp study areas, Neuse–Pamlico Peninsula, North Carolina, USA, 1994–96.

bordered by the Pamlico River to the north, the Neuse River to the south, and the Pamlico Sound to the east (Fig. 1). The peninsula contained parts of Beaufort and Craven counties and all of Pamlico County.

The peninsula was comprised of a mosaic of human developments, agricultural lands, and forested lands, including managed pine forests, hardwoods, mixed pine–hardwoods, pocosins, and marshes. Pine habitat was predominantly loblolly pine (*Pinus taeda*) plantations managed in short-rotations for pulp products. Bottomland hardwood forests, pocosins, and marshes typically were near swamp and stream edges and were flooded periodically. Forestry and agriculture were the dominant land uses on the peninsula. The NPP was comprised about 70% forested lands and 27% agricultural lands (Martorello 1998).

We established 2 study areas within the NPP (Fig. 1). The Gum Swamp study area encompassed 119 km^2 on the eastern half of the peninsula, within Pamlico and Beaufort counties. The Big Pocosin study area encompassed 149 km^2 on the western half of the peninsula, within Pamlico, Beaufort, and Craven counties.

The NPP had a mild subtropical climate. Summers were characterized as hot and humid and winters were cool to mild with an occasional freeze. Average summer and winter temperatures were 24.4°C and 7.2°C, respectively. Annual average precipitation was 142 cm, ranging from 20.3 cm in July to 6.7 cm in November and predominantly consisting of rain with an occasional snow flurry. Elevations ranged from 0–19 m.

Methods

Capturing and monitoring

Project personnel captured black bears with modified Aldrich spring-activated foot snares (Johnson and Pelton 1980) during May–August from 1994 to 1996. Personnel fitted a subset of captured bears with a radiocollar equipped with a mortality and activity sensor (Telonics, Mesa, Arizona, USA). Immobilization and handling procedures followed methods described by Martorello (1998) and adhered to University of Tennessee protocol #777 for use of live vertebrates. All captured bears were released on site.

Table 1. Habitat characteristics measured within black bear den site and dependent random site plots, North Carolina, 1994–96.

Characteristic	Units	Sampling technique
Overstory (>2.5 m)		
Canopy cover	%	spherical densiometer (Strickler 1959)
dbh	m	dbh tape measure
Tree number	#	direct count
Nest to tree distance	m	tape measure
Tree height	m	clinometer
Basal area	m^2	calculated from tree height
Shrub (≤2.5 m)		
Cover density	%	Nudds cover board (Nudd 1977)
Sapling number	#	direct count
Shrub height	cm	centimeter stick
Shrub stem density	$\#/m^2$	Daubenmire frame (Daubenmire 1959)
Shrub stem diameter	mm	calipers/Daubenmire frame

Following release, project personnel located radio-collared bears 1–4 times/week to estimate den entrance and emergence dates. After 3 consecutive locations in the same area, personnel visually located the bear (except from 15 Jan to 28 Feb) to determine fate (dead, alive, or dropped collar) and activity (denning or mobile). We estimated den entrance dates as the midpoint between the last recorded movement and the first date of a series of static locations (O'Pezio et al. 1983); we used the reverse procedure to estimate den emergence dates. During the winter dormancy period, project personnel visually identified den type and the exact location of the den for each radiocollared bear.

Den characteristics

For bears that used a nest den, we collected microhabitat characteristics at the nest site and at a dependent random site within 2 weeks following den emergence (see exception below). We defined random sites as sites in a random direction and distance (30–500 m) from the nest, but within the same overstory habitat type as the nest den. We chose this criterion to reduce variability from changes in overstory characteristics. We used 7 vegetation types to characterize den sites: loblolly pine plantation, hardwood forest, mixed pine–hardwood forest, swamp, pocosin, low vegetation, and agriculture. We classified vegetation types according to the tree species dominating the overstory (≥70% of the canopy cover). We considered sites to be mixed pine–hardwood when 1 type (pine or hardwood) did not dominate the canopy. We classified non-forested vegetation types according to the plant forms that occupied ≥70% of the vegetation.

For nest dens, we measured vegetative characteristics within a 0.04-ha circular plot (11.25 m radius) centered at the nest site or random point (Schmutz et al. 1989). We sampled den site characteristics in the overstory (>2.5 m) and shrub (≤2.5 m) layers (Table 1). Overstory characteristics included canopy cover, diameter-at-breast-height (dbh), number of trees, and tree height. We calculated basal area for each plot from tree height (Husch et al. 1972). Shrub layer characteristics included cover density (horizontal and vertical cover), sapling frequency, shrub height, stem density, and stem diameter. We sampled paired den and random sites on the same day and assumed random sites were not den sites.

Several bears denned until mid–April. Consequently, we had a brief window of time to sample those nest dens and random sites to avoid bias from spring green-up. As a result, some den sites from the 1994 winter were sampled the following winter, when the herbaceous material was absent. Therefore, the results may be biased because plots sampled 1 year after the bears denned at the sites may not reflect the vegetation that was present when the bears selected the sites. To determine if the variables we sampled differed by the effects of 1 years' growth, we used a Student's *t*-test to compare nest sites that were sampled in the same year they were occupied to nest sites that were sampled the winter after they were occupied. We found that nest characteristics did not differ due to 1 year's growth ($P = 0.06-0.76$, Martorello 1998); therefore, we pooled all nest sites.

We used univariate logistic regression and correlation coefficients to reduce the number of variables prior to the analysis (Hosmer and Lemeshow 1989). Using logistic regression, we discarded variables with $\alpha \geq 0.25$ (Mickey and Greenland 1989). Because nest and random plots were paired, we calculated difference scores for each variable. We discarded variables (difference scores) that had a correlation coefficient

Table 2. Microhabitat statistics of black bear den sites (n = 16) in the Big Pocosin and Gum Swamp study areas, North Carolina, USA, 1994–96.

Variable	Mean	SE	Range
Canopy cover (%)	73.73	6.11	0.00–93.20
Basal area (m^2)	0.79	0.12	0.00–1.53
Shrub height (cm)	74.32	3.78	37.75–91.94
Shrub stem density (m^2)	18.16	2.84	7.26–52.26
Shrub stem diameter (mm)	0.64	0.05	0.36–0.99
Cover density (%)	71.74	3.78	44.50–97.80

$\geq$0.70. We used the multivariate analysis of variance Hotelling's T^2 statistic (SAS Institute, Inc. 1985) to determine if microhabitat characteristics differed between nest and random sites. We compared the overall test to $\alpha_I = 0.05$. If the overall test resulted in rejecting H_o, we compared the subtests to $\alpha_S = \alpha_I/p$, where p equaled the number of subtests.

Results

Denning

Den type and date. Twenty-eight of the 31 bears we investigated denned during winter. Five re-denned: 3 moved to a new den site after the researcher investigation and 2 moved to new sites for unknown reasons. Average den entrance (n = 14) and emergence (n = 4) dates were 3 January and 14 April during the 1994–95 winter, respectively. Similarly, average den entrance (n = 13) and emergence (n = 8) dates were 24 December and 8 April during the 1995–96 winter, respectively.

We visually confirmed den type of 23 dens and found 20 nest dens, 2 excavated ground dens, and 1 tree den. We were unable to locate 5 den sites. Nests typically were oval-shaped bowls constructed of leaves, pine needles, and small woody stems. Nest bowls (n = 14) averaged 71.8 × 93.3 cm across and 5.6 cm high. One ground den was in a mature pine stand, excavated at the base of a pine tree. The den was caved in when we revisited the site after the bear emerged. The second ground den was in a 2-year-old pine stand, where the bear burrowed into a windrow. The tree den was in a 272 cm dbh bald cypress (*Taxodium distichum*). The entrance hole was 13.3 m above the ground and the cavity was 2.7 m beneath the entrance.

Microhabitat characteristics. We collected microhabitat data on 16 nest sites and 16 dependent random sites (Table 2). The nest sites were from 3 male bears, 4 female bears with cubs, 2 female bears with yearlings, and 7 female bears whose reproductive status was unknown. All 16 bears were adults; the mean age for males and females was 8.0 and 5.0 years old, respectively. Ten of 16 nests were in pine, 3 were in mixed pine–hardwood, 2 were in shrub, and 1 was in hardwood. Based on logistic regression, we excluded canopy cover from the analysis ($\chi^2 = 0.275$, 1 df, $P = 0.600$). We excluded basal area ($r = -0.776$, $P \leq 0.001$) and stem diameter ($r = 0.699$, $P = 0.003$) based on their high correlation with cover density and shrub height, respectively.

We detected an overall difference between nest and random sites ($F = 11.553$; 3, 13 df; $P \leq 0.001$; Table 3). Shrub height was greater ($F = 13.60$; 1, 15 df; $P = 0.002$) at nest sites ($\bar{x} = 74.3$, SE = 3.8, $n = 16$) than random sites ($\bar{x} = 47.6$, SE = 5.3, $n = 16$). Similarly, stem density was greater ($F = 10.40$; 1, 15 df; $P = 0.006$) at nest sites ($\bar{x} = 18.2$, SE = 2.8, $n = 16$) than random sites ($\bar{x} = 7.5$, SE = 1.3, $n = 16$) and cover density was greater ($F = 38.92$; 1, 15 df; $P \leq 0.001$) at nest sites ($\bar{x} = 71.7$, SE = 3.8, $n = 16$) than random sites ($\bar{x} = 40.8$, SE = 2.2, $n = 16$).

Discussion

For black bear populations along the Southeastern Coastal Plain, use of excavated ground dens is uncommon because of the low elevation and periodic flooding during winter (Hellgren and Vaughan 1989, White et al. 2001). Use of large hollow trees as dens has been documented in the Southeastern Coastal Plain (Hellgren and Vaughan 1989, Weaver and Pelton 1994, Folta 1998, White et al. 2001), but few suitable den trees remain because of the intense land use practices common throughout the region. As such, black bears have adapted to using brush and nest dens. Given the periodic flooding and intensive commercial forestry practices on the NPP, use of nest dens was expected on our study and was consistent with other Southeastern Coastal Plain bear studies (Hamilton and Marchinton 1980, Abler 1985, Hellgren and Vaughan 1989, Wooding and Hardisky 1992, Weaver and Pelton 1994, Folta 1998).

Weaver and Pelton (1994) and White et al. (2001) speculated that bears prefer tree and excavated ground dens over nest or brush dens. From a theoretical basis, we agree with this statement, as cavity den types likely provide greater protection to wintering bears from weather and disturbance. However, our study indicates that when cavity den types are rare or absent, bears predominantly use nest dens.

Past studies subjectively described the vegetation surrounding nest dens as thick, dense cover (Hamilton and Marchinton 1980, Smith 1985, Hellgren and Vaughan 1989, Lombardo 1993). On Camp LeJeune,

Table 3. Microhabitat characteristics of black bear den sites (n = 16) and dependent random sites, Big Pocosin and Gum Swamp study areas, North Carolina, USA, 1994–96.

Variable	Site	Mean	SE	Range	df	F	P
Shrub height (cm)	use	74.32	3.78	37.75–91.94			
	random	47.58	5.35	6.38–80.13	1, 15	13.600	0.002
Shrub stem density (m^2)	use	18.16	2.84	7.26–52.26			
	random	7.50	1.26	1.26–20.00	1, 15	10.400	0.006
Cover density (%)	use	71.74	3.78	44.50–97.80			
	random	40.82	2.23	24.50–57.50	1, 15	38.920	$\leq$0.001
Overall					3, 13	11.553	$\leq$0.001

North Carolina, Lombardo (1993) found that the cover density at nest sites was higher than random sites. Our study confirmed Lombardo's results and further identified suitable nest den habitat. We found that within a macrohabitat type, bears selected for greater shrub height ($\bar{x}$ = 74.32 cm, range = 37.75–91.94), shrub stem density ($\bar{x}$ = 18.16 m^2, range = 7.26–52.26), and cover density ($\bar{x}$ = 71.74%, range = 44.5–97.80) than if selection were random. We consider microhabitat with these characteristics to be suitable nest sites. These variables contribute to the overall density of the vegetation and, in this study, nest den habitat can be described as thick, almost impenetrable habitat.

The thick cover associated with nest sites probably functioned as a protective barrier between the denning bear and human or animal disturbances (i.e., hunters, loggers, dogs, deer [*Odocoileus virginianus*], and other bears) (Hamilton 1978, Lombardo 1993). We believe that the thick vegetation not only discouraged people and animals from traveling through it, but may have allowed denning bears to quickly detect intruders (Hamilton 1978, Lombardo 1993). During most of our den investigations, the denning bear detected the project personnel's presence (i.e., the activity switch would change or cubs would cry) at 15–20 m from the den site. Only once did personnel see a denning bear without being detected by the bear. Bears that were not accompanied by cubs often abandoned the nest (8 of 16 den investigations; 3 males and 5 females) without being heard or seen by the researcher. On 2 of 16 den investigations, the bear returned to the nest moments after personnel left. Females with cubs typically did not leave the nest site, and personnel identified the nest location by the sound of the cubs. Lombardo (1993) also found that females with cubs had a high site fidelity to the nest when disturbed. During our study only 1 female with cubs left her nest. During the den investigation she moved her cubs to a site about 150 m away.

We encountered a few problems in determining if bears selected specific habitat characteristics for nest dens, most of which related to the time it took to sample the dens during the window of time between bear emergence and spring green-up. Locating denning bears also was a problem. The vegetation was usually so thick that unless personnel could get within 15 m of the bear, they could not locate the site after the bear emerged. Therefore, some dens were never sampled. If these sites were all nest dens, our analyses on nest sites may be biased, because we only sampled dens that personnel could find. If these dens were nests, our results probably are conservative. That is, the overall thickness of the vegetation surrounding nest sites may be greater than our results suggest.

Management implications

One component of managing a black bear population is managing den sites for bears. In many areas of coastal North Carolina, the availability of ground and tree dens are limited, and bears often use nest dens. We identified and described suitable microhabitat characteristics for nest dens in coastal North Carolina. We believe this information may be useful for managers of black bear populations in the Southeastern Coastal Plain. If maintaining nest den habitat is a management objective, areas of suitable denning habitat should be retained and human activity in the forest should be minimized to prevent disturbance to denning bears. If winter silvicultural practices are planned, denning chronology and areas with suitable nest den habitat should be considered.

Acknowledgments

We thank B.D. Leopold and M.R. Vaughan for reviewing the manuscript. We also thank M.D. Jones, R.C. Maddrey, H.E. Martorello, J. Scalf, and D. Telesco for assisting with data collection. F. Edelmann and F.T. van Manen provide assistance with sampling design. This study was funded by Weyerhaeuser Company, The National Council for Air and Stream Improvement, North Carolina Wildlife Resource Commission, International Paper Company, Union Camp, Camp Younts Foundation, North Carolina Bear Hunters Association, and the University of Tennessee.

Literature cited

ABLER, W.A. 1985. Bear population dynamics on a study area in southeastern Georgia. Final Report. Georgia Department of Natural Resources, Atlanta, Georgia, USA.

ALT, G.L. 1984. Black bear cub mortality due to flooding of natal dens. Journal of Wildlife Management 48:1432–1434.

BEECHAM, J.J., D.G. REYNOLDS, AND M.G. HORNOCKER. 1983. Black bear denning activities and den characteristics in west-central Idaho. International Conference on Bear Research and Management 5:79–86.

DAUBERMIRE, R. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:44–64.

FOLTA, J.E. 1998. Reproduction, survival, and denning ecology of black bears on the Dare County Peninsula, North Carolina. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

HAMILTON, R.J. 1978. Ecology of the black bear in southeastern North Carolina. Thesis, University of Georgia, Athens, Georgia, USA.

———, AND R.L. MARCHINTON. 1980. Denning and related activities of black bears in the coastal plain of North Carolina. International Conference on Bear Research and Management 4:121–126.

HELLGREN, E.C. 1998. Physiology of hibernation in bears. Ursus 10:467–477.

———, AND M.R. VAUGHAN. 1989. Denning ecology of black bears in a southeastern wetland. Journal of Wildlife Management 53:347–353.

HOSMER, D.W., JR., AND S. LEMESHOW. 1989. Applied logistic regression. John Wiley and Sons, New York, New York, USA.

HUSCH, B., C.I. MILLER, AND T.W. BEERS. 1972. Forest mensuration. Second edition. Ronald Press, New York, New York, USA.

JOHNSON, K.G., AND M.R. PELTON. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46–54.

———, AND ———. 1981. Selection and availability of dens for black bears in Tennessee. Journal of Wildlife Management 41:111–119.

JONKEL, C.J., AND I. MC T. COWAN. 1971. The black bear in the spruce–fir forest. Wildlife Monograph 27.

LECOUNT, A.L. 1983. Denning ecology of black bears in central Arizona. International Conference on Bear Research and Management 5:71–78.

LOMBARDO, C.A. 1993. The population ecology of black bears on Camp LeJeune, North Carolina. Thesis, University of Tennessee, Knoxville, USA.

MARTORELLO, D.A. 1998. Ecology of black bears in coastal North Carolina. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

MICKEY, J., AND S. GREENLAND. 1989. A study of the impact of confounder-selection criteria on effect estimation. American Journal of Epidemiology 129:125–137.

NUDD, T.D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5:113–117.

OLI, M.K., H.A. JACOBSON, AND B.D. LEOPOLD. 1997. Denning ecology of black bears in the White River National Wildlife Refuge, Arkansas. Journal of Wildlife Management 61: 700–706.

O'PEZIO, J., S.H. CLARKE, AND C. HACKFORD. 1983. Chronology of denning by black bears in the Catskill region of New York. New York Fish and Game Journal 30:1–11.

SAS INSTITUTE, INC. 1985. SAS/STAT Guide for Personal Computers, Version 6 edition. SAS Institute, Inc., Cary, North Carolina, USA.

SCHMUTZ, J.A., C.E. BRAUN, AND W.F. ANDELT. 1989. Nest habitat of Rio Grande wild turkeys. Wilson Bulletin 101: 591–598.

SMITH, T.R. 1985. Ecology of black bears in the bottomland hardwood forest in Arkansas. Dissertation, University of Tennessee, Knoxville, Tennessee, USA.

STRICKLER, C.S. 1959. Use of the densiometer to estimate density of forest canopy on permanent sample plots. U.S. Forest Service, Resource Note NW-180, City, State, USA.

WEAVER, K.M., AND M.R. PELTON. 1994. Denning ecology of black bears in the Tensas river basin of Louisiana. International Conference on Bear Research and Management 9(1):427–433.

WHITE, H.T., J.L. BOWMAN, H.A. JACOBSON, B.D. LEOPOLD, AND W.P. SMITH. 2001. Forest management and female black bear denning. Journal of Wildlife Management 65:34–40.

WOODING, J.B., AND T.S. HARDISKY. 1992. Denning by black bears in northcentral Florida. Journal of Mammalogy 73: 895–898.

Received: 28 May 2001
Accepted: 19 January 2002
Associate Editor: G.V. Hilderbrand