UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Department of Fish. & Wildl. Sci.
VPISU
Blacksburg, VA 24060
7 December 1987

Jim Oland
Refuge Manager
GDS National Wildlife Refuge
Box 349
Suffolk, VA 23434

Dear Jim:

Enclosed please find some results of my work. They have been a long time coming, I know, but my other responsibilities have kept me from effectively working on the data collected over the past 2 years. The denning information is complete except for some analysis of den habitat selection. The table of food habits information is complete. I expect the final version of my dissertation to be completed by August 1988. Until then, I will be sending the Refuge updates on my progress so that questions can be answered.

Hope that you had a successful and safe deer season and that you have a successful sojourn in your position.

Sincerely,

Eric C. Hellgren

Eric C. Hellgren

P. S. Could you give a copy of the food habits table to Don Schwab? Thanks.

Ralph -
Use for write up in
87 NR
Marty

1987
FILE
SECY.
CLK
MWK

Table x. Frequency and aggregate percentage of all food items identified in 533 black bear scats collected within and surrounding Great Dismal Swamp National Wildlife Refuge, Virginia-North Carolina, 1984-1986.

Food Item	Spring (N = 106)		Early Summer (N = 141)		Late Summer (N = 64)		Early Fall (N = 140)		Late Fall (N = 78)		Winter (N = 6)		Entire Year (N = 533)	
	Freq.	Agg. %	Freq.	Agg. %	Freq.	Agg. %	Freq.	Agg. %	Freq.	Agg. %	Freq.	Agg. %	Freq.	Agg. %
Graminae		**8**		**8**		**6**		**1**		**4**				**5**
Arundinaria gigantea	9[1]	4	18	8	23	6	15	1	12	4			15	4
Other	12	4	4	T[2]	2	T			3	T			4	1
Forbs				**18**		**10**		**6**		**1**				**9**
Aralia spinosa (f)[3]							16	4	3	1			5	1
Lespedeza spp. (h)[3]			1	T									T	T
Phytolaca americana (f)					17	9	7	2	13	T			6	2
Phytolaca americana (h)					6	1	1	T					1	T
Rubus spp. (f)			29	18									8	5
Rubus spp. (h)			9	T									T	T
Silphium perfoliatum (f)					2	T	1	T					T	T
Ferns	19	2	17	2	11	1	11	1					12	1
Moss			1	T	2	T							T	T
Algae			1	T			1	1					T	T
Tree Fruit		**T**		**29**		**2**		**65**		**12**				**27**
Pinus					2	T							T	T
Acer rubrum	5	T					1	T					1	T
Asimina triloba					2	T							T	T
Diospyros virginia							1	T					T	T
Liriodendron tulipera							1	T					T	T
Nyssa aquatica							1	T	1	T			T	T
Nyssa sylvatica			1	T	22	2	61	33	6	3			20	9
Prunus serotina			37	29	2	T							10	8
Quercus spp.							34	32	10	9			10	10
Symplocos tinctoria							1	T					T	T
Shrub Fruit		**2**		**16**		**7**		**3**		**41**		**1**		**13**
Ilex coriacea					20	7	5	1					4	1
Ilex glabra							2	1	41	30			7	5
Ilex opaca							1	T	5	T	17	T	1	T
Ilex verticillata							2	1	21	11			4	2
Persea borbonia									6	T			1	T
Gaylussacia spp.			1	T									T	T
Vaccinium spp.	7	2	26	16									8	5
Vine Fruit		**T**		**1**		**13**		**9**		**14**		**63**		**7**
Lonicera japonica									3	1			T	T
Smilax spp.	8	T	1	T	5	T	11	1	40	13	66	63	12	3
Vitis spp.			4	1	27	13	16	8					8	4

Table x (continued)

Food Item	Spring		Early Summer		Late Summer		Early Fall		Late Fall		Winter		Entire Year	
	Freq.	Agg. Vol.	Freq.	Agg. Vol.	Freq.	Agg. Vol.	Freq.	Agg. Vol.	Freq.	Agg. Vol.	Freq.	Agg. Vol.	Freq.	Agg. Vol.
Crops		**5**		**9**		**35**		**9**		**13**		**2**		**12**
Corn (f)	2	1	9	8	37	29	9	6	8	5	17	2	11	8
Corn (h)			3	1	23	6	5	1					5	1
Oats	1	1											T	T
Wheat	4	3											1	1
Peanuts					1	T	2	2	9	8			2	2
Tree, Shrub and Vine Vegetable Matter		**52**		**7**		**6**		**3**		**9**		**T**		**14**
Magnolia virginiana[4]	43	31	6	2					3	T			11	7
Smilax spp.[4]	38	21	14	5	9	5	4	1	21	7	50	1	17	7
Chamaecyparis thyoides	1	T			2	T	1	T	5	T			1	T
Acer rubrum			1	T			1	T					1	T
Nyssa sylvatica	1	T			2	T	4	T					2	T
Prunus serotina			9	T									2	T
Quercus spp.							1	T	1	T			1	T
Ilex coriacea					8	T	2	T	1	T			2	T
Ilex glabra	1	T	1	T			1	T	29	2			5	T
Ilex opaca			1	T									T	T
Ilex verticillata					2	T			1	T			T	T
Vaccinium spp.			7	T									2	T
Vitis spp.					3	T	1	T					1	T
Animal Matter		**3**		**3**		**6**		**2**		**3**		**35**		**3**
Hymenoptera														
Formicidae	42	2	40	1	37	4	4	T					25	1
Vespidae	1	T	1	T	11	1	1	T			17	T	2	T
Coleoptera	11	T	15	T	31	1	20	T	4	T			16	T
Isoptera	2	T											T	T
Endoparasites			1	T					4	T			1	T
Sylvilagus floridanus	1	T			2	T	1	T					1	T
Didelphis virginanus					2	T							T	T
Odocoileus virginanus	2	1	6	T	3	T	2	1	12	3			5	1
Ursus americanus[5]	6	T	9	1	19	T	4	T	3	T	33	35	8	T
Bait scraps	2	T	4	1			2	1					2	T
Unknown	2	T					1	T					1	T
Debris		**8**		**2**		**9**		**1**		**T**		**T**		**3**
Soil	12	5	9	1	16	7	1	1					7	2
Other(bark,leaf, etc)	32	3	24	1	41	2	11	T	13	T	17	T	23	1
Unidentified		**20**		**5**		**4**		**T**		**3**		**T**		**6**
Ground vegetation[4]	30	18	23	3	8	3	7	T	5	1	17	T	14	5
Other(fruit,leaf,etc)	9	2	3	2	3	1	4	T	15	2			8	1

[1] Percentage values are rounded to the nearest whole number
[2] Indicates trace amount (< 0.5 %)
[3] f = fruit, h = herbaceous material (stems, leaves)
[4] Spring aggregate volume estimates for Magnolia virginiana and Smilax spp. are minimum estimates. If identifiable leaf parts were found, these were included in frequency data. However, if scat contents were too finely ground to estimate individual species volumes, contents were considered unidentifiable ground vegetation.
[5] Remains of Ursus americanus occurred in 41 scats. Four scats contained evidence of cannibalism (claws, bone, tissue). The remainder were associated with grooming activities.

3 December 1987

Eric C. Hellgren
Department of Fisheries and Wildlife Sciences
Virginia Polytech. Inst. and State Univ.
Blacksburg, VA 24061

DENNING ECOLOGY OF BLACK BEARS (*Ursus americanus*) IN GREAT DISMAL SWAMP

ERIC C. HELLGREN, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

MICHAEL R. VAUGHAN, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Abstract: Available information on black bear denning ecology in southeastern wetland populations for management and conservation purposes is limited. We investigated black bear den characteristics and denning chronology in the Great Dismal Swamp (GDS) of Virginia and North Carolina. Thirty-five bears (26 female, 9 male) were radiomonitored throughout the winters of 1984-85, 1985-86, and 1986-87. Five bears remained active throughout the winter. Den types included 14 elaborate ground nests, 11 excavated ground cavities, 2 ground-level tree cavities, 1 above-ground-level tree cavity, and 1 den in a stump. Bears denned in all habitats, including evergreen shrub pocosin, maple-gum, pine-maple, and Atlantic white cedar types. Three dens were in areas of inundation. Females with cubs entered dens earlier ($p < 0.02$) than all other bears ($N = 6$, 15 Dec $\pm$ 6 days vs. $N = 17$, 3 Jan $\pm$ 4 d). They also emerged later ($P < 0.001$) than other bears (14 April $\pm$ 4 d vs. 23 March $\pm$ 2 d). Length of denning ranged from 53 to 131 d and averaged 119 $\pm$ 4 d for females with cubs and 78 $\pm$ 4 d for other age-sex groups. Denning periods were among the shortest reported. Although den site availability was not estimated, dry den sites did not appear to be limited. Large den trees may not be necessary for successful denning and reproduction in certain southeastern wetlands because bears can use dense cover and microelevational factors to overwinter.

Denning behavior of American black bears in southeastern wetland environments is not clearly understood, though the importance of denning habitat to bears, particularly females rearing cubs, has been recognized. Potential den sites in southeastern wetlands may be limited due to periodic flooding. For example, in a seasonally flooded bottomland in Arkansas, Smith (1985) reported that all females utilized above-ground tree cavities. Males used either tree cavities or elaborate ground nests located in forest gaps. Availability of dry den sites may play a role in limiting female productivity in wetlands. Alt (1984) noted that partial or total litter loss due to flooding of natal dens reduced productivity in northeastern Pennsylvania. Dens should be dry throughout winter so that midwinter abandonment due to high water does not occur (Hamilton and Marchinton 1980, Smith 1985). The impact of management actions, such as timber harvest, prescribed burning, and surface water manipulation on den site availability and bear productivity in southeastern wetlands can not be assessed with available data. The objectives of this study were to characterize denning chronology and requirements of black bears in the Great Dismal Swamp (GDS), a 700-km^2 forested wetland on the Virginia-North Carolina border. Information from this project will be used to aid in planning management actions which may impact the bear population in GDS National Wildlife Refuge, a 410-km^2 tract of the GDS.

We would like to acknowledge the cooperation of the U. S. Fish and Wildl. Serv., Va. Comm. Game and Inland Fish. (VCGIF), N. C. Wildl. Resour. Comm. (NCWRC), and the Dep. of Fish. and Wildl. Sci., Virginia Polytechnic Institute and State Univ. Particularly helpful were D. J. Schwab of VCGIF , R. D. McClanahan of NCWRC, and the entire staff of GDS National Wildlife Refuge. Technical assistance was ably provided by W. M. Lane, J. Polisar, and K. Meddleton. This project was funded by the U. S. Fish and Wildl. Serv. Use of trade names does not imply endorsement of commercial products by the U. S. Fish and Wildlife Service.

MATERIALS AND METHODS

Study Area

Field work was conducted from April 1984 to August 1986 and from December 1986 to March 1987 on the 410 km^2 Great Dismal Swamp National Wildlife Refuge (GDSNWR), part of the 700 km^2 Great Dismal Swamp (GDS). GDS is a forested wetland located on the Virginia-North Carolina border on the mid-Atlantic Coastal Plain. Circular Lake Drummond, about 4 km in diameter, is centrally located within the Swamp. An east-west gradient of approximately 19 cm/km characterizes the generally flat Swamp (Gammon and Carter 1978). Mean temperatures for December, January, February, and March are 3.6 C, 3.8 C, 4.9 C, and 9.1 C, respectively. Precipitation averages 37 cm during this period, with snow light and irregular (U. S. Dept. of Commerce 1984-1985).

The vegetative composition of GDS includes a variety of herbaceous plants, evergreen and deciduous shrubs, vines, and deciduous and evergreen, broad-leaved or needle-leaved tree species (Gammon and Carter 1978). Virtually the entire GDS has been harvested for timber beginning in the late 1700's. Besides timber harvest, the vegetative community has been disturbed by fire, ditching, road-building, and changes in the hydrologic regime. The major forest cover type is the red maple(*Acer rubrum*)-black tupelo (*Nyssa sylvatica*) association. Other major tree species are loblolly pine (*Pinus taeda*), pond pine (*P serotina*), and sweetgum(*Liquidambar styraciflua*). Remnant stands of bald cypress (*Taxodium distichum*)-water tupelo (*N. aquatica*) and Atlantic white cedar (*Chamaecypaeus thyoides*) also exist (Gammon and Carter 1978). Dense inkberry (*Ilex glabra*)-dominated shrub communities, or pocosins, with a thin canopy cover part of the study area southeast of Lake Drummond.

Trapping and Handling

Bears were captured using Aldrich spring-activated cable snares. Trapped bears were immobilized with a 2:1 mixture of ketamine hydrochloride (Ketaset) and xylazine hydrochloride (Rompun) at a concentration of 300 mg/ml. Initial dosage rate was 6.6 mg/kg estimated body weight and drugs were administered by blow-gun dart syringe (Lochmiller and Grant 1983), jabstick, or dart rifle.

All bears were sexed and weighed (to the nearest 1 kg). The first premolar was extracted for aging by cementum annuli analysis (Willey 1974). Numbered plastic ear tags were placed in the ears of each bear. In addition, an identification number was tattooed inside each bear's upper lip for permanent identification. Selected bears were equipped with radio-transmitter collars (Telonics,Inc., Mesa, Az) in the 164-165 MHz range with a 5-minute delay motion sensor. A breakaway cotton spacer was inserted in each collar.

Denning and Winter Activity

Bears were radiotracked to dens in winter. Bears that failed to den (winter-active bears) were relocated 3 to 7 times weekly by ground or aerial tracking. Den entry dates were defined as the midpoint between the last recorded movement and the first of a series of stationary signals (O'Pezio et al. 1983). Den emergence dates were defined as the midpoint between the last denning location and the first location away from the den (O'Pezio et al. 1983). Because 16 of 23 denning chronologies were measured during the winter of 1985-86, chronology data were pooled across years. Den chronology data were analyzed by two-way analysis of variance with age and sex as variables to examine for differences between cohorts with respect to length of denning. Data from all age-sex cohorts except females with newborn cubs were pooled and reanalyzed by a Student's t-test with cubs/no cubs as the main effect.

Dens of adult females known to be without yearlings at the beginning of the denning period were visited. Attempts were made to immobilize mothers and weigh and sex cubs. Following emergence, dens were visited and den characteristics measured. Den values measured (if applicable depending on den type - nest, ground cavity, tree cavity) included den entrance width, den entrance height, den cavity height, den cavity width, nest length, nest width, nest material thickness, height of tree cavity above ground, height of den floor above ground, den cavity length, and entrance aspect.

RESULTS

Thirty-five bears (26 female, 9 male) were radiomonitored during winter in the course of the study. Five bears (14 %) remained active throughout the winter (Hellgren and Vaughan 1986). Dens of 29 bears were located, while denning chronology data were collected for 23 animals.

Denning periods ranged from 53 to 131 days. Females with cubs (Table 1) entered dens earlier ($p < 0.02$) than all other bears ($N = 17$, 3 Jan $\pm$ 4 d) and emerged later ($p < 0.001$) than all other groups (23 Mar $\pm$ 2 d). Denning periods of females with cubs were thus longer ($p < 0.001$) than other age-sex groups (78 $\pm$ 4 d). The similarity of denning chronology among bear cohorts is illustrated in Table 1.

Dens were found in several habitats. Among deciduous types, 6 (21%) were found in maple-gum cover type (the most common type found in GDS), 2 (7%) were located in maple habitat, and 1 (3%) was found in a gum-cypress stand. Dens selected in evergreen types included 9 (31%) in pine or pine-maple types and 3 (10%) in Atlantic white cedar forest. Eight (28%) dens were located in evergreen shrub pocosins or regenerating clearcuts (10-15 years old). This last group of habitats is characterized by a sparse canopy and extremely dense stands of ericaceous shrubs, particularly *Ilex* sp. and fetterbush (*Lyonia lucida*). Although these habitat types make up a small percentage of the available area (? %), they provide important denning sites. The cover value of these stands was illustrated during one den location attempt in a pocosin thicket. We approached within 2 m of the denned bear and went around the den on 3 sides without seeing sign of the den. We subsequently found the den when the bear emerged.

Twenty-nine dens of radio-collared bears were located and measured. Den types were elaborate ground nests, excavated ground cavities, ground-level tree cavities, an above ground tree cavity, and a den in a stump. Fourteen bears (10 female [including 3 with newborn cubs], 4 male) used ground nests constructed of debris raked from around the site. Common items utilized in nest construction were red bay (*Persea borbonia*) and fetterbush leaves, greenbriar (*Smilax* sp.) vines, switchcane (*Arundinaria gigantea*) leaves and stems, loblolly pine needles, and twigs. Four of the nests were located at the base of large red maple or loblolly pine trees and 2 were on small hummocks in inundated areas. Several nest dens had secondary nests associated with them. One pregnant adult female built a nest den in a rotting stump of a bald cypress in an inundated area.

Excavated ground cavities were used as hibernacula by 10 females (11 dens). These cavities were either dug into small hummocks of vegetation surrounding old stumps or rotting logs, or located under root systems of red maple trees. Beds in cavity dens were constructed of like material as the nest dens. Only one cavity, abandoned by an adult female due to disturbance by investigators, contained water during the winter.

Tree dens were used by only 3 bears. Two adult males used ground-level cavities in black gum trees of 65 cm and 107 cm dbh. Both of these trees had large butt swells 117 cm and 196 cm in diameter. One adult female denned with yearlings in a large bald cypress.

Den bed sizes varied among age-sex groups (Table 2). Males and females with newborn cubs constructed larger ($p < 0.05$) beds than other reproductive classes of females. Den dimensions did not vary among groups, although male dens tended to be wider ($p = 0.054$) than dens of solitary females and females with yearlings (Table 2). Den entrances of cavity dens had north, south, east and west aspects numbering 7, 3, 2, and 2, respectively.

DISCUSSION

The predominant use of ground dens in GDS was not expected. Twenty-eight of 29 dens were at or just above ground level, with 22 of 23 female bears using ground dens. In a bottomland hardwood forest in Arkansas, females used above-ground tree cavities exclusively ($N = 34$) although dry ridges and second bottom terraces were available to bears within or near their home ranges; male bears used ground nest dens and tree dens with nearly equal frequency ($N = 13$ and $N = 15$, respectively) (Smith 1985). Smith (1985) hypothesized that tree cavities were crucial to reproductive fitness in bottomland hardwood forests. Data on bear denning behavior in other southeastern wetland environments is scarce. Hamilton and Marchinton (1980) described one ground nest den in a Carolina bay and suggested that most dens in Carolina bay habitat were probably ground nests surrounded by dense cover. Limited information indicates that bears use ground nests in the Okefenokee Swamp in Georgia (Abler 1985) and in northern Florida (Maehr, pers. commun.).

The nearly exclusive use of ground dens in GDS may have been due to a number of factors. The entire GDS has been harvested for timber and few trees of adequate size for bear den formation remain. Certain areas of the GDS, such as around Lake Drummond, along the western periphery, and in the Pasquotank River, appear to contain a number of potential tree den sites. However, these areas need to be sampled to estimate tree den availability.

Dense cover and microelevational changes also allow bears to utilize ground dens. Three ground nests were located in areas of flooding, but were positioned on hummocks of soil and vegetation 10-30 cm above mean ground level. Other dens were located in areas with a water table sufficiently below the soil surface that the dens did not become flooded. In general, the water table has dropped and the GDS become drier since colonial times due to extensive ditching (Lichtler and Walker 1979). The ditches have modified natural water flow patterns, allowing surface water to be shunted rapidly through the Swamp instead of remaining for several months (Carter et al. 1977). As a result, the areal extent of flooding in GDS is probably much less than historical levels. The extremely dense vegetation found throughout the GDS provides excellent cover for denning bears as well. For example, 28% of dens were found in evergreen shrub-dominated habitats, which are virtually impenetrable at times.

Considerable selective pressure should exist on bears to choose secure dens which enhance productivity (Johnson et al. 1978). A model developed by Johnson et al. (1978) that simulated winter heat loss for black bears indicated that percent winter heat loss increased from 23% in closed tree dens to 38% in open ground dens. They suggested that energetic savings from choosing tree cavities would enhance survival and reproduction, as parturition and lactation occur in winter dens. In GDS, excavated ground dens were dry and secure. Flat topography and dense cover likely minimize heat loss due to wind convection. Ground cavities are thus probably similar to tree dens in terms of heat retention characteristics. Johnson et al.'s (1978) hypothesis would predict that productivity and survival would be greater in ground cavities than in ground nests. In our study, mean litter size was 2.25 ($N=4$) in cavities and 2.0 ($N=4$) in nests. Median weights of newborn cubs measured in mid March-early April was 2.6 kg ($N=7$) in cavities and 1.7 kg ($N=7$) in nests (Wilcoxon Rank Sum $W=49$, $p>0.1$). We obtained no data on cub survival, although cub remains (claws, fur) were found in a nest den 2 days following maternal emergence. Productivity differences between den types may not be evident on a short-term basis. Long-term study is needed to determine if lifetime productivity is compromised by ground nesting, e. g. is length of time between litters greater in ground nesters due to the extra energy demands of nesting in the open? Flooding and human disturbance may be stronger selective forces on den site selection than solely energetics (Rogers 1987), particularly in southeastern wetlands, such as GDS, that have very mild winter climates (Hamilton and Marchinton 1980, Smith 1985, Hellgren and Vaughan 1986).

Sizes of ground dens (nests and cavities) were similar to den dimensions reported in other wetland environments (Hamilton and Marchinton 1980, Abler 1985, Smith 1985). Nest dens were also similar in size and shape to temporary winter beds located in Great Smoky Mountains National Park (Johnson and Pelton 1983). The oval shape of den nests and winter beds reflects the energy-conserving, curled position of sleeping, denned bears (Johnson and Pelton 1979). It appeared that ground dens, particularly cavities, were just large enough to accomodate the bear. This characteristic of bear dens has been observed in several other studies (Tietje and Ruff 1980, Novick et al. 1981, Beecham et al. 1983). No tunnels were seen leading into den chambers in GDS, although tunnels are common in other areas (Tietje and Ruff 1980, Beecham et al. 1983).

Denning chronology of GDS bears was similar to bears denning in other southeastern wetlands. Smith (1985) reported that females with cubs denned for an average of 134 days in an Arkansas bottomland compared to 119 days in the present study. However, mean entry date was identical for each study (15 Dec). The later emergence dates in Arkansas may have been due to the limited ability of cubs to traverse flooded areas, thus stranding family groups in den trees until floodwaters receded (Smith 1985). Females with yearlings and adult males denned for an average of 81 days and 76 days, respectively, in Arkansas (Smith 1985) compared to 82 days for both in GDS. In Carolina bay habitat in southeastern North Carolina, 250 km south of GDS, Hamilton and Marchinton (1980) reported that denning periods averaged 102 days (range:85-113) for 4 females and 1 male. Bear denning periods in GDS were, on the average, 11-48 days shorter than denning periods in other regions with mild winter climates, such as coastal Washington (Lindzey and Meslow 1976), southern California (Novick et al. 1981), Tennessee (Johnson and Pelton 1980), and Arizona (LeCount 1983).

Females which gave birth in the den were the first cohort to enter dens and the last to emerge from dens (Table 1). This pattern of denning chronology has been observed in many other bear populations (Erickson 1964, Jonkel and Cowan 1971, Lindzey and Meslow 1976, Johnson and Pelton 1980, Tietje and

Ruff 1980, Novick et al. 1981, Smith 1985, Schwartz et al. 1986). Several other studies have demonstrated that adult females as a group enter earlier and emerge later than other bear cohorts (LeCount 1980, Beecham et al. 1983, O'Pezio et al. 1983, Kolenosky and Strathearn 1986). The implications of this strategy to bear population management have been recognized (i. e. a late autumn hunting season affords an increased probability of protection to the early denning, reproductive female cohort [O'Pezio et al. 1983]). Limited cub mobility has been cited as the reason for the extremely late emergence dates of females with newborn cubs (Lindzey and Meslow 1976, LeCount 1983, Smith 1985), although physiological state of the female may also play a role. In our study, changes in radio signal strength and clarity from radioed bears combined with close radiotracking (< 50m) indicated that females with cubs often (at least 4 of 6 instances) emerged from dens 10 to 12 days before vacating the immediate den site. We used abandonment of the den site as the emergence date due to the difficulty of determining when mothers actually "emerged" from dens only to rest 5m from the den. Similar behavior has been reported for females with cubs in coastal Washington (Lindzey and Meslow 1976), Alberta (Tietje and Ruff 1980), Arizona (LeCount 1980), and New York (O'Pezio et al. 1983).

Reasons for the early den entry dates among adult females remain speculative. Johnson and Pelton (1980) expanded upon Pengelley and Asmundsen's (1972) hypothesis of mammalian hibernation and suggested that bears have evolved a flexible, endogenous circannual rhythm tied to annual plant cycles as the ultimate denning mechanism. Physiological readiness and the general timing of dormancy are controlled by the endogenous rhythm, with integration of a number of proximate factors cueing the final stimulus to den. Suggested proximate den entry and den emergence cues include photoperiod, food availability, bear nutritional condition, and weather effects. Perhaps adult females, and pregnant females in particular, are more sensitive to these cues or have a lower threshold to den than other bear cohorts. Long-term captive studies of black bear under controlled conditions of temperature and photoperiod with concomitant physiological sampling are necessary to test for an endogenous circannual rhythm.

MANAGEMENT IMPLICATIONS

Results from this study indicate that in some southeastern wetlands, elevated cavities in large trees are not necessary for successful denning and reproduction of black bears. The presence of dense cover and microelevational relief, along with the absence of human disturbance, enables bears in GDS to use ground dens. It is likely that bears in other Atlantic Coastal Plain populations, which occur in primarily pocosin and Carolina bay habitats (Monschein 1981), use similar dens. Den trees may be crucial to female reproductive fitness in habitats with relatively deep (> lm) winter flooding, such as bottomland hardwoods (Smith 1985). We believe that den availability is not a problem in southeastern wetlands if bears are provided with habitat patches large enough to offer seclusion from human disturbance.

Planned management activities on GDSNWR include timber harvest, surface water manipulation. and burning (U. S. Fish and Wildlife Service 1986). If winter burns are planned, denning chronology of adult females with newborn cubs (mid-December to mid-April) should be considered. Surface water manipulation, which is planned to enhance and maintain the Swamp's wetland character, should not induce winter flooding to depths (perhaps > 1.5m) which would completely inundate all potential denning hummocks. Timber harvest would not seriously impact tree den availability due to the lack of extant den trees. However, hollow trees with diameters in excess of 1m should be left standing.

LITERATURE CITED

Abler, W. A. 1985. Bear population dynamics on a study area in southeast Georgia. Georgia Dep. Nat. Resour., Atlanta. Final Rep. 91pp.

Alt, G. L. 1984. Black bear cub mortality due to flooding of natal dens. J. Wildl. Manage. 48:1432-1434.

Beecham, J. 1983. Black bear denning activities and den characteristics in West-central Idaho. Int. Conf. Bear Res. and Manage. 5:79-86.

Carter, V., M. K. Garrett, L. Shima, and P. Gammon. 1977. The Great Dismal Swamp: Management of a hydrologic resource with the aid of remote sensing. Water Resour. Bull. 13:1-12.

Erickson, A. W., J. Nellor, and G. A. Petrides. 1964. The black bear in Michigan. Mich. State Univ. Agr. Exp. Sta. Bull. No. 4. 102pp.

Gammon, P. T., and V. Carter. 1978. Vegetation mapping with seasonal color infrared photographs. Photogramm. Eng. Remote Sens. 45:87-97.

Hamilton, R. J., and R. L. Marchinton. 1980. Denning and related activities of black bears in the coastal plain of North Carolina. Int. Conf. Bear Res. and Manage. 4:121-126.

Hellgren, E. C., and M. R. Vaughan. 1986. Home range and movements of winter-active black bears in the Great Dismal Swamp of Virginia and North Carolina. Int. Conf. Bear Res. and Manage. 7: in press.

Johnson, K. G., and M. R. Pelton. 1983. Bedding behavior of black bears in Tennessee. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies. 37:237-243.

-----, and -----. 1980. Environmental relationships and the denning period of black bears in Tennessee. J. Mammal. 61:653-660.

-----, and -----. 1979. Denning behavior of black bears in the Great Smoky Mountains National Park. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 33:239-249.

------, D. O. Johnson, and M. R. Pelton. 1978. Simulation of winter heat loss for a black bear in a closed tree den. Eastern Black Bear Workshop 4:155-166.

Jonkel, C. J., and I. McT. Cowan. 1971. The black bear in the spruce-fir forest. Wildl. Monogr. 27. 57pp.

Kolenosky, G. B., and S. M. Strathearn. 1986. Winter denning of black bears in east central Ontario. Int. Conf. Bear Res. and Manage. 7: in press.

LeCount, A. L. 1983. Denning ecology of black bears in central Arizona. Int. Conf. Bear Res. and Manage. 5:71-78.

Lichtler, W. F., and P. N. Walker. 1979. Hydrology of the Dismal Swamp. Pages 140-168 *in* P. W. Kirk, Jr., ed. The Great Dismal Swamp. Univ. Press of Virginia, Charlottesville.

Lindzey, F. G., and E.C. Meslow. 1976. Winter dormancy in black bears in southwestern Washington. J. Wildl. Manage. 40:408-415.

Lochmiller, R. L., and W. E.Grant. 1983. A sodium bicarbonate-acid powered blow-gun syringe for remote injection of wildlife. J. Wildl. Dis. 19:48-51.

Monschein, T. D. 1981. Values of pocosins to game and fish species in North Carolina. Pages 155-170 *in* C. J. Richardson, ed. Pocosin Wetlands, an integrated analysis of Coastal Plain freshwater bogs in North Carolina. Hutchinson Ross Publ., Stroudsburg, PA.

Novick, H. J., J. M. Siperek, and G. R. Stewart. 1981. Denning characteristics of black bears, *Ursus americanus*, in the San Bernardino Mountains of southern California. Calif. Fish and Game 67:52-61.

O'Pezio, J, S. H. Clarke, and C. Hackford. 1983. Chronology of denning by black bears (*Ursus americanus*) in the Catskill region of New York [USA]. New York Fish and Game J. 30:1-11.

Pengelley, E. T., and S. J. Asmundsen. 1972. An analysis of the mechanisms by which mammalian hibernators synchronize their behavioral physiology with the environment. Pages 637-655 *in* F. E. South, J. P. Hannon, J. R. Willis, E. T. Pengelley, N. R. Alpert, eds. Hibernation and hypothermia - perspectives and challenges. Elseview Publ. Co., New York.

Rogers, L. L. 1976. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildl. Monogr. 97. 72pp.

Schwartz, C. C., A. W. Franzmann, and D. C. Johnson. 1983. Black bear predation on moose. Alaska Dep. Fish and Game Fed. Aid in Wildl. Rest. Final Rep., W-17-10, W-17-11, W-21-1, W-21-2, W-22-1. 135pp.

Smith, T. R. 1985. Ecology of black bears in a bottomland hardwood forest in Arkansas. Ph. D. Thesis, Univ. Tennessee, Knoxville. 209pp.

Tietje, W. D., and R. L. Ruff. 1980. Denning behavior of black bears in boreal forest of Alberta. J. Wildl. Manage. 44:858-870.

U. S. Dept. of Commerce. 1984-1985. Climatological data Virginia. Natl. Oceanic and Atmos. Admin., Asheville, N.C.

U. S. Fish and Wildlife Service. 1986. Draft environmental impact statement for the Great Dismal Swamp National Wildlife Refuge Master Plan. Region 5, Newton Corner, MA.

Willey, C. H. 1974. Aging black bears from first premolar tooth sections. J. Wildl. Manage. 38:97-100.

Table 1. Denning chronology of black bears in Great Dismal Swamp, Virginia and North Carolina during 1984-1986.

Age-Sex Group	N	Mean Entry Date	Mean Emergence Date	Denning Period	Range
Females with Cubs	6	15 Dec ± 6 d[1]	14 Apr ± 3 d	119 ± 4 d	106-131 d
Solitary Females	9	2 Jan ± 5 d	21 Mar ± 2 d	74 ± 6 d	53-105 d
Females with Yearlings	4	2 Jan ± 8 d	25 Mar ± 4 d	82 ± 11 d	61-114 d
Males	4	5 Jan ± 10 d	27 Mar ± 3 d	82 ± 7 d	71-111 d

[1] mean ± se .

Table 2. Characteristics of ground dens used by black bears in the Great Dismal Swamp, Virginia and North Carolina during 1984-1986 (mean ± se).

		Bed Dimensions				Den Dimensions				
Group	N	Length(cm)	Width(cm)	Depth(cm)	N	Entrance height(cm)	Entrance width(cm)	Den height(cm)	Den length(cm)	Den width(cm)
Solitary Females	10	65 ± 4a[1]	56 ± 4	22 ± 2	6-9	38 ± 5	48 ± 5	54 ± 7	123 ± 13	95 ± 10
Females with Cubs	8	83 ± 5bc	75 ± 7	21 ± 5	4-5	43 ± 4	50 ± 2	58 ± 3	139 ± 11	109 ± 11
Females with Yrlgs	3	66 ± 7ab	57 ± 4	24 ± 6	2	28 ± 9	53 ± 0	55 ± 5	137 ± 17	90 ± 3
Males	5	88 ± 7c	73 ± 7	26 ± 5	5	---	---	---	143 ± 14	140 ± 14
F-ratio		4.79	2.78	0.27		0.54	0.26	0.12	0.53	3.11
p-value		0.01	0.06	0.84		0.59	0.85	0.88	0.66	0.054

[1]Values with different letters within a column differ ($p < 0.05$).

MACROHABITAT USE BY BLACK BEARS IN A SOUTHEASTERN WETLAND

ERIC C. HELLGREN,[1] Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061
MICHAEL R. VAUGHAN, Virginia Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildlife Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061
DEAN F. STAUFFER, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Abstract: We determined habitat use by black bears (*Ursus americanus*) in the Great Dismal Swamp of Virginia and North Carolina by radiotracking 24 female and 16 male bears. On a year-round basis, females preferred ($P < 0.05$) pocosins and mesic areas and males preferred gum-cypress (*Nyssa* spp.–*Taxodium distichum*) and maple-coniferous (*Acer* spp.–*Pinus* spp.) stands. Females preferred ($P < 0.05$) pocosins and disturbed areas during summer months, mesic and gum-cypress habitats in early fall, and pocosins in late fall. Females used maple-dominated habitats less ($P < 0.05$) than their availability throughout the year. Roads were preferred ($P < 0.05$) by females during all seasons except early fall, when females made excursions to feeding areas far from roads. Maintenance and enhancement of pocosins, mature gum, oak (*Quercus* spp.), and disturbed habitats would benefit black bears in southeastern wetlands by providing a wide variety of natural foods throughout the year.

J. WILDL. MANAGE. 55(3):442–448

Black bear populations in the Atlantic Coastal Plain are restricted to fragmented areas, primarily swamps and pocosins, which are wetlands characterized by dense stands of broadleaf evergreen shrubs, organic soils, and long hydroperiods (Sharitz and Gibbons 1982). Habitat destruction continues this fragmentation. For example, in eastern North Carolina between 1962 and 1979, 33% (3,000 km^2) of pocosins were totally developed, i.e., drained and/or ditched, for agriculture, forestry, or industry (Richardson et al. 1981). Such wetland development in the Coastal Plain led Monschein (1981) and Zeveloff (1983) to advocate pocosin conservation to save remaining black bear populations. Reserves large enough to conserve black bears would probably account for the needs of most other species (Zeveloff 1983).

Although pocosins provide the last large blocks of bear habitat in the Atlantic Coastal Plain, there is limited evidence (Hardy 1974) on the value of pocosins to black bears relative to other habitat types. Black bears may be found in pocosins merely because pocosins are the only available habitat. Carolina bays, a forested wetland type vegetatively similar to pocosins, received the greatest use by black bears and contributed the greatest amount of food to the annual diet of any habitat studied in southeastern North Carolina (Landers et al. 1979). Bears also used hardwood swamps and oak ridges for feeding and escape cover (Landers et al. 1979).

Our main objective was to determine seasonal habitat preferences of black bears in Great Dismal Swamp, an 850-km^2 forested wetland on the Virginia and North Carolina border that contains a mosaic of habitat types including pocosins. Our secondary objective was to determine the effect of roads on the distribution of black bears. A better understanding of habitat use is needed to develop recommendations for managing black bears in the Great Dismal Swamp National Wildlife Refuge (NWR) and other Atlantic Coastal Plain populations. This descriptive study is also prerequisite to the development of testable hypotheses on black bear behavioral ecology in southeastern wetlands. We hypothesized that the distribution and availability of food would be a major factor in determining habitat use by bears.

We thank the U.S. Fish and Wildlife Service (USFWS), Virginia Department of Game and Inland Fisheries, North Carolina Wildlife Resources Commission, North Carolina State Parks Department, and the Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University. Particularly helpful were D. J. Schwab, R. D. McClanahan, and the entire staff of Great Dismal Swamp NWR. Technical field assistance was provided by W.

[1] Present address: Caesar Kleberg Wildlife Research Institute, Texas A&I University, Kingsville, TX 78363.

Table 1. Habitat categories developed from Gammon and Carter's (1979) vegetation cover map of Great Dismal Swamp, Virginia and North Carolina, for black bear habitat use/availability analysis, 1984–86.

Category	Area		Description
	ha	%	
Disturbed-new	167	0.3	Burned or timber harvested between 1974 and 1984
Disturbed-old	1,010	1.8	Burned or timber harvested between 1964 and 1974
Grass	428	0.8	Canebrakes, dominated by *Arundinaria gigantea*
Gum-cypress	6,577	11.8	Dominated by *Taxodium distichum* and *Nyssa* spp.
Lake Drummond	1,294		Open water; not considered available
Maple	5,891	10.6	Dominated by *Acer rubrum*
Maple-coniferous	9,895	17.8	*Acer rubrum* mixed with *Pinus* spp. or *Chamaecyparis thyoides*
Maple-gum	16,107	29.2	*Acer rubrum* mixed with *Nyssa sylvatica*
Mesic	1,650	3.0	Upland hardwoods (*Quercus* spp. and *Fagus americanus*)
Pine	5,122	9.2	Dominated by *Pinus* spp., especially *P. taeda*
Pine-maple	3,408	6.1	*Pinus*-dominated with *Acer rubrum* subdominant
Pocosin	1,951	3.5	Shrub and small tree communities dominated by evergreen bays and hollies (*Ilex* spp.)
White cedar	3,232	5.8	Dominated by *Chamaecyparis thyoides*

M. Lane, J. R. Polisar, and K. M. Meddleton. A. B. Jones, Jr. and G. T. M. Schildwachter assisted with digitizing and data manipulation. This project was funded by the USFWS. Use of trade names does not imply endorsement of commercial products by the USFWS.

STUDY AREA

We conducted fieldwork from June 1984 to August 1986 on a 555-km^2 study area located on the Great Dismal Swamp NWR, on Dismal Swamp State Park (57.5 km^2), and on adjacent private land. Great Dismal Swamp is flat, with a west to east slope of about 19 cm/km (Gammon and Carter 1979). Mean temperatures for January and July are 5.1 C and 26.0 C, respectively (Lichtler and Walker 1979). Annual precipitation averages 120 cm, with light and irregular snowfall (Natl. Oceanic and Atmos. Adm. 1984, 1985).

For plant species we used scientific nomenclature advocated by Radford et al. (1968). We obtained information on vegetative communities of the Great Dismal Swamp from Musselmann et al. (1977), Gammon and Carter (1979), and USFWS (1986). The 243 specific vegetative communities distinguished by Gammon and Carter (1979) were grouped into 12 habitats based on dominant canopy classes (Table 1) for analysis of bear habitat preferences.

The vegetative communities of Great Dismal Swamp have been disturbed since the late 1700's by timber harvest, fire, ditching, drainage, and road-building. Due to extensive ditching, the water table has dropped, and the Great Dismal Swamp has become drier since colonial times (Lichtler and Walker 1979). The ditches have modified natural water flow patterns, allowing surface water to be shunted rapidly through the Swamp instead of remaining for several months (Carter et al. 1977). Organic soils, or peats, dominate the study area, with mineral soils restricted to the western periphery of the Swamp and eastern outflow areas (USFWS 1986:E-7-E-11). About 250 km of sand or peat roads crisscross the study area. Roads, generally built with spoil from ditch construction, are adjacent and parallel to ditches.

METHODS

Collection and Analysis of Telemetry Data

Trapping and handling were described by Hellgren and Vaughan (1989). Trapping was conducted within 100 m of roads. All captured females (except 2 yearlings) were radiocollared. Males were chosen for radiocollaring to provide a distribution of size classes. Locations of radio-equipped bears were estimated 1–7 times weekly between 0700 and 2100 hours by triangulation with hand-held receiving equipment from 2–3 points on refuge or state roads. Flights were conducted 2–4 times monthly to locate bears with aircraft-mounted receiving equipment. Location estimates of radio-collared bears were plotted by computer with TELEM software (Koeln 1980) and were assigned Universal Transverse Mercator grid coordinates.

We used ground location estimates for habitat preference analysis only if they met the following criteria: ≤150 m from observer and 2 bearings separated by at least 45°; or if >150 m from observer, then the triangulated location was used if at least 3 bearings were taken within 30 minutes and were separated by at least 45°. In addition, we used only locations collected by the senior author, except for visual or aural (bear was heard moving) observations by other technical personnel.

Mean bearing error was 1.9°, and the standard deviation of error associated with hand-held equipment averaged ±5.1° (n = 25). Virtually all radiotracking was done from roads, with 32% of female radio locations distanced <200 m from roads, 23% 200–400 m from roads, and 29% 400–800 m from roads (Hellgren 1988:228). The areas of 90% error polygons averaged 0.7, 2.3, and 9.7 ha for these distance categories, respectively. Low use of areas >800 m from roads was not due to inability to locate female bears because females were located during >95% of attempts. Males were considerably more difficult to locate.

We analyzed location data to detect seasonal changes in habitat preferences and changes in bear distribution relative to roads. Five seasons were designated based on changes in plant phenology and shifts in bear food habits: spring (den emergence–15 Jun), early summer (16 Jun–31 Jul), late summer (1 Aug–15 Sep), early fall (16 Sep–15 Nov), and late fall (16 Nov–den entry or 15 Jan). Early fall season dates varied slightly for individual bears depending upon when they moved to take advantage of mast concentrations outside their spring–summer ranges. Coordinates for radio locations were merged with a digitized version of the vegetation cover map prepared by Gammon and Carter (1979) to determine patterns of habitat use by collared bears. We redigitized habitat changes, such as timber harvest and burns, that occurred since original digitizing of the cover map. Habitat stand size (n = 181) averaged 311 ± 51 (SE) ha. The smallest habitat stand digitized was 9 ha.

Habitat Preference Analysis

We analyzed habitat preference in 2 ways. The proportions of habitats over the entire study area were considered to be available habitat for males, and the proportions of radio locations in each habitat were used to represent relative use. Because female home ranges did not cover the entire study area, a composite range formed by uniting convex polygon home ranges of the 18 individuals for which we calculated total home ranges was considered available habitat. Habitats containing radio locations of these 18 females were considered habitats used. We then compared habitat availability to habitat use for females. Years were pooled because of small sample sizes during the first 9 months of the study. Data were pooled across bears because analyses at the individual animal level indicated similar habitat use patterns among individuals (Hellgren 1988:103–105). Few radio locations (n = 48) were collected in forested and agricultural lands outside the study area boundary, and they were not used to compare habitat use to availability.

Preference or avoidance of individual habitats was determined by the method of Neu et al. (1974) using Chi-square analysis and Bonferronni Z-statistics to control the experimentwise error probability at P = 0.05. If habitats were used proportionately more or less (P < 0.05) than available, they were considered preferred or avoided, respectively.

Totals of 1,717 radio locations from 24 females and 530 radio locations from 16 males were used to compare habitat use to habitat availability and to identify seasonal habitat preferences. The range of locations per bear per season for females was 22–61 in spring, 12–30 in early summer, 11–22 in late summer, 7–39 in early fall, 8–33 in late fall, and 48–298 year-round. For males, the ranges were 11–33, 6–20, 7–17, 6–24, 10–23, and 28–142 for similar seasons, respectively. Location estimates were considered independent because only 1 location per day was used for analysis. Swihart and Slade (1985) stated that an approximation of independence of successive observations is likely achieved in studies with long (>24 hr) interlocation intervals. For males, to meet sample size requirements for Chi-square expected values, old and new disturbed areas were combined into 1 habitat category (disturbed), and early and late summer were combined into 1 season (summer).

The effect of telemetry error on wildlife habitat selection has been of much interest recently (White and Garrott 1986, Nams 1989). Our determination of habitat use may have been affected by telemetry error, especially for radio locations on habitat edges, but it is unlikely that our results and conclusions were affected. For example, the power of testing for habitat selection is reduced by telemetry imprecision (White and Garrott 1986, Nams 1989), suggesting that our detection of habitat selection is actually conservative. In addition, because Great Dismal Swamp contains large, homogeneous habitat stands, the ratio of telemetry error to habitat size was very small (see above). Nams (1989) showed that small error/habitat ratios were associated with low habitat selection bias, i.e., low rate of habitat misclassification.

Distribution of Bears Relative to Roads

We compared distances of female bear radio locations to Great Dismal Swamp roads among seasons and to random points to assess the effect of roads on bear distribution. We observed radioed bears in roads or road margins 46 times, but these observations (distance to road = 0 m) were not included in the analysis to make the test more conservative. An additional 42 sightings of unmarked bears on roads were made by the senior author. All other radio location data within the study area boundary that met the above bearing and time criteria were used for this analysis, regardless of observer. Mean distance to road was determined for each bear for each season. Differences between mean distances for each pair of seasons and differences for each season relative to random distances were compared with paired t-tests. The null hypothesis was that the mean difference between mean distances was zero. Because 15 comparisons were made, alpha was set at 0.005. Distances from roads also were grouped into 5 categories: <100, 100–199, 200–399, 400–800, and >800 m. We used Chi-square and Bonferroni Z-statistics to compare the distribution of radio location and random distances from roads. Male data were not used in these analyses due to small seasonal sample sizes and to biases associated with difficulty in locating radio-collared males.

RESULTS

Seasonal Habitat Preferences

On a year-round basis, females preferred mesic and pocosin habitats (Table 2). Seasonally, pocosins were preferred during all seasons except early fall, when cypress-gum and mesic habitats were used greater than their availability (Table 2). Use of pocosins was especially heavy during late summer and late fall, with 28.0 and 32.3%, respectively, of female radio locations occurring in these habitats, which comprised only 4.1% of the available area.

Habitats dominated by maple were used less than their availability throughout the year (Table 2). White cedar, maple-coniferous, maple-gum, and pine-maple habitats were avoided on a year-round basis. Maple-coniferous type was avoided 4 of 5 seasons, and maple-gum type was avoided 3 of 5 seasons. Pine-maple and maple types were each avoided during 1 season. These results are of considerable importance, because maple-dominated stands cover about 60% of the study area and, if left unmanaged, are predicted to almost wholly dominate the Great Dismal Swamp within 100 years (USFWS 1986).

Males preferred gum-cypress and maple-coniferous habitats on a year-round basis (Table 3). Only maple-coniferous forest type was preferred during any given season(s). One particular stand classified as maple-coniferous contained small patches of productive gum trees and was used heavily by 4 radio-collared adult male bears during fall 1984. Pocosins were used more than their availability during summer and late fall, although they were not significantly ($P < 0.05$) preferred.

Similar to females, males avoided maple-dominated habitat types. Maple-gum and pine-maple habitats were avoided on a year-round basis (Table 3). Pine and maple-gum were also used less than their availability during 3 of 4 seasons. Pocosins were avoided during spring and early fall (Table 3), which coincided with periods of least use by females (Table 2).

Proximity to Roads

Paired t-tests indicated that female bears were located significantly ($P < 0.005$) closer to roads than random locations (974 ± 31 m, $n = 952$) during all seasons except early fall. Early fall radio locations of female bears were significantly ($P < 0.005$) farther from roads (840 ± 32 m, $n = 466$) than during spring (421 ± 12 m, $n = 668$), late summer (320 ± 17 m, $n = 254$), and late fall (453 ± 19 m, $n = 495$). Early summer locations tended to be closer ($P = 0.009$) to roads (390 ± 19 m, $n = 320$) than during early fall.

Chi-square analysis indicated that all areas <800 m from roads were used by females more than expected throughout the year, with areas ≥ 800 m from roads used less than expected (Table 4). A seasonal breakdown revealed that zones <200 m from roads were used more than expected during each season except early fall (Table 4).

Bears were sighted 88 times in roads. Bear

Table 2. Seasonal habitat use versus habitat availability for female black bears in Great Dismal Swamp, Virginia and North Carolina, 1984–86.[a]

Habitat type	% available	% used					
		All yr	Spring	Early summer	Late summer	Early fall	Late fall
White cedar	8.6	6.8−	10.8	4.9−	3.0−	3.9−	8.2
Cypress-gum	5.7	6.9	2.8−	3.1	3.0	16.8+	9.5
Maple-coniferous	26.9	16.7−	26.1	12.0−	15.1−	15.3−	9.5−
Maple-gum	16.8	12.8−	8.0−	13.9	10.8−	23.4	9.5−
Maple	9.6	8.3	8.0	8.6	14.7	7.8	4.3−
Mesic hardwoods	1.7	5.2+	0.0−	2.2	3.4	17.7+	4.6
Disturbed areas new	0.6	1.1	0.2	0.3	4.3	1.2	0.9
Disturbed areas old	3.8	5.2	3.4	12.0+	5.2	1.5−	5.2
Pine	17.6	16.1	26.7+	20.1	8.6−	5.4−	12.2−
Pine-maple	4.5	3.2−	2.6	4.6	3.9	1.5−	4.0
Pocosin	4.1	17.8+	11.4+	18.2+	28.0+	5.7	32.3+
n locations		1,717	499	324	232	334	328
n bears		24	19	18	14	22	22

[a] + = used more ($P \leq 0.05$) than expected, − = used less ($P \leq 0.05$) than expected.

sightings were categorized as road crossings (35%), feeding or traveling (51%), and unclassified (14%). Roads served as travel corridors, perhaps to facilitate travel through the dense vegetation of Great Dismal Swamp. Single sets of bear tracks on roads sometimes extended for >1 km. Mark trees, primarily loblolly pine, were commonly on road margins. Abandoned logging roads and railroads also were used as bear travel corridors. These features often had longtime bear trails, with deep, permanent footprints in the substrate and numerous mark trees.

DISCUSSION

Our study provides the first specific evidence of the value of pocosins as black bear habitat. Our data, combined with the work of Landers et al. (1979), document the importance of pocosin habitat to black bears in the Southeast. Pocosins were important to female black bears throughout the year, especially in late summer and fall. These seasons coincided with ripening of fruits of *Ilex* spp. shrubs and *Smilax* spp. vines, which bears ate extensively (Hellgren and Vaughan 1988). Pocosins also provided denning habitat (Hellgren and Vaughan 1989). Male black bears did not show as strong a preference for pocosins as did females, although pocosin use by males was heaviest during summer and late fall.

Productive stands of mast-bearing trees in the fall, primarily mesic and gum-cypress habitats,

Table 3. Seasonal habitat use versus habitat availability for male black bears in Great Dismal Swamp, Virginia and North Carolina, 1984–86.[a]

Habitat type	% available	% used				
		All yr	Spring	Summer[b]	Early fall	Late fall
White cedar	5.8	5.1	5.3	2.4	0.0−	14.2
Grass	0.8	0.9	0.5	3.2	0.0−	0.0−
Cypress-gum	11.8	17.9+	19.7	14.5	16.7	20.4
Maple-coniferous	17.8	33.2+	37.2+	25.8	41.7+	24.5
Maple-gum	29.2	13.8−	12.2−	4.8−	23.3	16.3−
Maple	10.6	9.1	9.6	12.9	7.5	5.1
Mesic hardwoods	3.0	2.1	2.7	1.6	3.3	0.0−
Disturbed areas[b]	2.1	3.6	6.4	4.0	1.7	0.0−
Pine	9.2	6.4	3.7−	16.9	2.5−	3.1−
Pine-maple	6.1	3.4−	1.6−	2.4	2.5	9.2
Pocosin	3.5	4.5	1.1−	11.2	0.8−	7.1
n locations		530	188	124	120	98
n bears		16	9	8	8	8

[a] + = used more ($P \leq 0.05$) than expected, − = used less ($P \leq 0.05$) than expected.
[b] Early and late summer and new and old disturbed areas combined because of small sample size.

Table 4. Female black bear radio locations in relation to roads in Great Dismal Swamp, Virginia and North Carolina, 1984–86.

Distance to nearest road (m)	% expected[a]	% used					
		All yr	Spring	Early summer	Late summer	Early fall	Late fall
<100	10.7	16.5+[b]	15.5+	21.9+	22.8+	5.2−	22.0+
100–199	8.0	15.5+	15.4+	19.1+	20.1+	9.0	17.0+
200–399	14.8	22.9+	27.4+	22.2+	28.0+	17.0	20.4
400–799	23.7	28.6+	30.2+	24.4	25.6	33.7+	26.1
>800	42.8	16.5−	11.7−	12.5−	3.5−	35.2−	14.5−
n locations	952	2,203	668	320	254	466	495
n bears		24	19	18	14	22	22

[a] Expected values calculated from random points.
[b] + = used more ($P \leq 0.05$) than expected, − = used less ($P \leq 0.05$) than expected.

were another important habitat component for black bears in Great Dismal Swamp. Bear habitat selection in Great Dismal Swamp in fall was tied to stands with abundant soft and hard mast-bearing trees (black gum and oaks), as in other southeastern wetlands (Hardy 1974, Landers et al. 1979, Smith 1985). Hellgren and Vaughan (1988) reported that black gum and oak mast comprised 65% of the early fall diet of black bears in Great Dismal Swamp. Large contiguous hardwood swamps with dense vegetation and expanses of water also appear to be escape cover during the fall hunting season and provide foraging and denning habitat during winter (Landers et al. 1979).

The importance of disturbed areas—road margins, burns, and regenerating clearcuts—to black bears in the completely forested Swamp was evidenced by habitat use, food habits (Hellgren and Vaughan 1988), and distributional data. Old clearcuts and burns (10–20 yr old) are good producers of soft mast, such as fruits of blueberry (*Vaccinium* spp.), black cherry (*Prunus serotina*), and blackberry (*Rubus* spp.) (Hellgren and Vaughan 1988). Road margins were frequently used by bears for feeding on important food plants such as wild black cherry, blackberry, pokeberry (*Phytolacca americana*), devil's walking stick (*Aralia spinosa*), switchcane, and greenbriar (Hellgren and Vaughan 1988). Roads have also been found to attract bears in other unharvested and protected populations (Carr and Pelton 1984, Smith 1985, Garner 1986). Bears generally avoid roads in harvested areas with unrestricted road use (Hamilton 1978, Carr and Pelton 1984, Garner 1986).

Our radio-marked sample may have been "road-happy" because of trapping near roads. However, home ranges of radio-collared females covered almost the entire study area south of Lake Drummond. When locations from only these females were compared to random points generated in the southern region, females preferred ($P < 0.005$) roads except during early fall (Hellgren 1988:229), when excursions were made. In addition, 4 females captured en route to fall feeding areas did not cross roads after returning to their spring–summer ranges.

Our data provide a descriptive base to develop testable hypotheses of black bear behavioral ecology in the Atlantic Coastal Plain. For example, it might be hypothesized that, based on the high selectivity of female bears for pocosin habitat during active and denning (Hellgren and Vaughan 1989) periods, lifetime reproductive output of females with pocosins within their home ranges is greater than those without pocosins. Experimental planting of roadside strips of soft mast-producing plants and control of public road access could address the role of these factors in influencing bear use of roads and road margins. Our data also predict that black bears should select local stands of high berry and mast production within favored habitats during summer and fall.

MANAGEMENT IMPLICATIONS

Plans for managing bear populations in the Atlantic Coastal Plain should include guidelines to maintain and enhance forest openings (e.g., roadside margins, burns), pocosins, and stands of mature gum and oaks. Forest openings will be maintained in Great Dismal Swamp NWR by prescribed burns, small (<5 ha) permanent clearings, and 10-m-wide roadside strips (USFWS 1986). Maintenance and enhancement of shrub pocosins, through prescribed burns and rollerchopping, and cypress-gum communities, through surface water manipulation, also are planned. These management activities should benefit black bears by providing food-producing habitats (Hellgren and Vaughan 1988). Retarding succession to red maple-dominated forest types is another important consideration in black bear habitat management in this area. Limiting public access to roads will also be beneficial to black bears by allowing undisturbed use of roads and roadside margins as feeding and traveling corridors. In harvested populations with unrestricted vehicle use, managers should consider the effects of roadside management on bear vulnerability (Hellgren and Vaughan 1988).

LITERATURE CITED

CARR, P. C., AND M. R. PELTON. 1984. Proximity of adult female black bears to limited access roads. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 38:70–77.

CARTER, V., M. K. GARRETT, L. SHIMA, AND P. GAMMON. 1977. The Great Dismal Swamp: management of a hydrologic resource with the aid of remote sensing. Water Resour. Bull. 13:1–12.

GAMMON, P. T., AND V. CARTER. 1979. Vegetation mapping with seasonal color infrared photographs. Photogrammetry Eng. and Remote Sensing 45:87–97.

GARNER, N. P. 1986. Seasonal movements, habitat selection, and food habits of black bears (*Ursus americanus*) in Shenandoah National Park, Virginia. M.S. Thesis, Virginia Polytechnic Institute and State Univ., Blacksburg. 104pp.

HAMILTON, R. J. 1978. Ecology of the black bear in southeastern North Carolina. M.S. Thesis, Univ. Georgia, Athens. 214pp.

HARDY, D. M. 1974. Habitat requirements of the black bear in Dare County, North Carolina. M.S. Thesis, Virginia Polytechnic Institute and State Univ., Blacksburg. 121pp.

HELLGREN, E. C. 1988. Ecology and physiology of a black bear (*Ursus americanus*) population in Great Dismal Swamp and reproductive physiology in the captive female black bear. Ph.D. Thesis, Virginia Polytechnic Institute and State Univ., Blacksburg. 231pp.

———, AND M. R. VAUGHAN. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia-North Carolina. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 42:295–305.

———, AND ———. 1989. Denning ecology of black bears in a southeastern wetland. J. Wildl. Manage. 53:347–353.

KOELN, G. T. 1980. A computer technique for analyzing radio-telemetry data. Proc. Natl. Wild Turkey Symp. 4:262–271.

LANDERS, J. L., R. J. HAMILTON, A. S. JOHNSON, AND R. L. MARCHINTON. 1979. Foods and habitat of black bears in southeastern North Carolina. J. Wildl. Manage. 43:143–153.

LICHTLER, W. F., AND P. N. WALKER. 1979. Hydrology of the Dismal Swamp. Pages 140–168 *in* P. W. Kirk, Jr., ed. The Great Dismal Swamp. Univ. Press of Virginia, Charlottesville.

MONSCHEIN, T. D. 1981. Values of pocosins to game and fish species in North Carolina. Pages 155–170 *in* C. J. Richardson, ed. Pocosin wetlands, an integrated analysis of Coastal Plain freshwater bogs in North Carolina. Hutchinson Ross Publ., Stroudsburg, Pa.

MUSSELMANN, L. J., D. L. NICKRENT, AND G. F. LEVY. 1977. Contribution towards the vascular flora of the Great Dismal Swamp. Rhodora 79(818):240–268.

NAMS, V. O. 1989. Effects of radiotelemetry error on sample size and bias when testing for habitat selection. Can. J. Zool. 67:1631–1636.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. 1984. Climatological data: Virginia, annual summary. Natl. Climatic Cent., Asheville, N.C. 28pp.

———. 1985. Climatological data: Virginia, annual summary. Natl. Climatic Cent., Asheville, N.C. 20pp.

NEU, C. W., C. R. BYERS, AND J. M. PEEK. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541–545.

RADFORD, A. E., H. E. AHLES, AND C. R. BELL. 1968. Manual of the vascular flora of the Carolinas. Univ. North Carolina Press, Chapel Hill. 1,183pp.

RICHARDSON, C. J., R. EVANS, AND D. CARR. 1981. Pocosins: an ecosystem in transition. Pages 3–19 *in* C. J. Richardson, ed. Pocosin wetlands, an integrated analysis of Coastal Plain freshwater bogs in North Carolina. Hutchinson Ross Publ., Stroudsburg, Pa.

SHARITZ, R. R., AND J. W. GIBBONS. 1982. The ecology of southeastern shrub bogs (pocosins) and Carolina bays: a community profile. U.S. Fish Wildl. Serv., Div. of Biol. Serv., Washington, D.C. FWS/OBS-82/04. 93pp.

SMITH, T. R. 1985. Ecology of black bears in a bottomland hardwood forest in Arkansas. Ph.D. Thesis, Univ. Tennessee, Knoxville. 209pp.

SWIHART, R. K., AND N. A. SLADE. 1985. Testing for independence of observations in animal movements. Ecology 66:1176–1184.

U.S. FISH AND WILDLIFE SERVICE. 1986. Draft environmental impact statement for the Great Dismal Swamp National Wildlife Refuge master plan. Reg. 5, Newton Corner, Mass. 230pp.

WHITE, G. C., AND R. A. GARROTT. 1986. Effects of biotelemetry triangulation error on detecting habitat selection. J. Wildl. Manage. 50:509–513.

ZEVELOFF, S. I. 1983. Island biogeographic considerations for pocosin wildlife conservation. J. Elisha Mitchell Sci. Soc. 99:69–77.

Received 14 April 1989.
Accepted 8 January 1991.
Associate Editor: Brooks.