

HOME RANGE AND MOVEMENTS OF WINTER-ACTIVE BLACK BEARS IN THE GREAT DISMAL SWAMP

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Abstract: During May 1984, we initiated a study of black bear (*Ursus americanus*) ecology on the 410 km² Great Dismal Swamp Wildlife Refuge, a forested wetland in eastern Virginia and North Carolina. Two male bears (ages 3 and 4) and 2 females (ages 3 and 7) remained active during winter 1984–85. Eight other bears (5 males, 3 females) denned for 70–131 days in excavated ground cavities ($N = 3$), ground-level tree cavities ($N = 2$), and ground nests ($N = 3$). Winter home ranges, determined by the modified minimum area method, were 1.9 km² for males and 2.4 km² for females. Annual home ranges for these bears, based on monitoring for 7–12 months, averaged 29.6 km² and 17.8 km² for males and females, respectively. Distance between consecutive-day relocations, an index of movement, was less in winter than in fall and spring. We observed 3 of the winter-active bears primarily in pocosin-type habitat dominated by evergreen shrubs and vines and the 4th in an inundated cypress-gum swamp. Preliminary analysis of scats, evidence of feeding activity, and visual observation indicated that bears were consuming fruits of greenbrier (*Smilax* spp.) and holly (*Ilex* spp.). Serum levels of urea nitrogen and creatinine for a 3-year-old female captured on 4 February 1985 were not indicative of a physiologically hibernating condition. Although occasional instances of nondenning behavior in black bears have been reported from areas with mild climates, the high frequency of winter activity we observed is unprecedented. Mild winter temperatures, lack of persistent snow cover, and diverse food items in the Great Dismal Swamp may be factors contributing to the high degree of bear winter activity.

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Winter dormancy and denning are characteristic winter behavior of the American black bear throughout its range. Length of denning appears to vary with latitude. Denning periods of 6 months or longer have been reported in northern black bear populations (Idaho: Amstrup and Beecham 1976, Minnesota: Rogers 1977, Alberta: Tietje and Ruff 1980). In southern populations, the length of denning decreases to 2 or 3 months (North Carolina: Hamilton and Marchinton 1980, California: Novick et al. 1981, Arkansas: Smith 1985) where mild winter climates and longer periods of food availability prevail. Several radio-telemetry studies have anecdotally reported instances of winter-active bears, i.e., bears that failed to den. Hamilton and Marchinton (1980) and Smith (1985) each reported 2 winter-active subadult males in coastal North Carolina and eastern Arkansas, respectively. Alt et al. (1976) and Garner (unpubl. data) have noted winter activity in adult females with yearlings in Pennsylvania and Virginia, respectively. Preliminary data from a population in Osceola National Forest in north-central Florida suggested that males and subadult females do not den but restrict their movements during winter (D. Maehr, pers. commun.), however, home ranges or movements in winter-active black bears have not been reported.

Denning and the accompanying metabolic state of hibernation (Nelson et al. 1983) in black bears are energy-conserving adaptations to decreased food availability and severe winter climatic conditions. Johnson and Pelton (1980) have theorized that hibernation and denning are ultimately synchronized with the environment by a flexible endogenous cir-

cannual rhythm that ties bear physiology and behavior to annual plant cycles. Several environmental and internal cues, such as weather conditions, food availability, and bear nutritional condition, interact to provide the proximate stimulus to den. A study of these cues would facilitate modeling of the relationship between the environment and winter dormancy. Ecological study of winter-active bears would provide insight into the relative importance of the proximate factors that induce winter dormancy, particularly in regions with mild climates. This paper describes home range, movements, and other aspects of ecology in winter-active black bears in the Great Dismal Swamp (GDS).

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STUDY AREA

The 850-km² GDS is a forested wetland in eastern Virginia and North Carolina on the Atlantic Coastal Plain (Fig. 1). Mean annual precipitation is 120 cm, distributed rather evenly throughout the year. Mean monthly temperatures, measured 5 km northwest of the study area at Lake Kilby, range from 25.5 C in

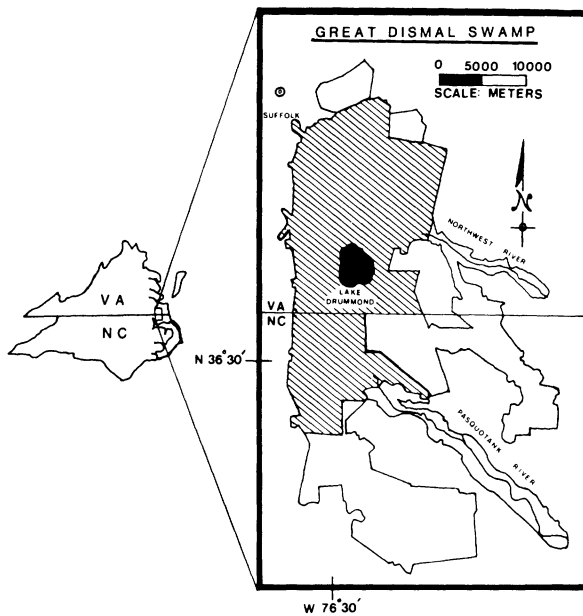


Fig. 1. Location of the Great Dismal Swamp (GDS) in Virginia and North Carolina. GDS National Wildlife Refuge is the hatched portion.

July to 3.8 C in January (U.S. Dep. of Commerce 1984–1985). Lake Drummond, about 4 km in diameter, is centrally located within the GDS. A west-east slope of approximately 19 cm/km characterizes the generally flat swamp (Gammon and Carter 1978). Field work was conducted on the 410-km² GDS National Wildlife Refuge.

The vegetative composition of the GDS includes a variety of herbaceous plants, evergreen and deciduous shrubs, and deciduous and evergreen, broad-leaved or needle-leaved tree species (Gammon and Carter 1978). Timber on virtually the entire GDS has been harvested, beginning in the late 18th century. Besides timber harvesting, the vegetative community has been disturbed by fire, extensive ditching, and road-building, which has changed the hydrologic regime. The major forest cover type is the red maple (*Acer rubrum*)-swamp black gum (*Nyssa sylvatica*) association. Other major cover types are pine (*Pinus* spp.), bald cypress (*Taxodium distichum*)-gum (*Nyssa* spp.), Atlantic white cedar (*Chamaecypares thyoides*) and evergreen shrub pocosins (Gammon and Carter 1978). Isolated mesic sites support oak (*Quercus* spp.)-beech (*Fagus grandifolia*) associations. Portions of the GDS are flooded during winter, particularly along the western edge of the swamp.

MATERIALS AND METHODS

We trapped bears from June to December 1984 using Aldrich foot snares and immobilized them with a 2:1 mixture of ketamine hydrochloride and xylazine at a concentration of 300 mg/ml. Initial dosage was 6.6 mg/kg estimated body weight, and drugs were administered by blow-gun dart syringe (Lochmiller and Grant 1983), jabstick, or Cap-chur gun. All bears were weighed, measured and ear-tagged. The 1st premolar was extracted to determine age by cementum annuli (Willey 1974). Blood samples were collected from a femoral vein using a vacuum tube assembly. Serum chemistry analyses were performed by Pathologist's Service Professional Associates (PSPA), Inc. (Atlanta, Ga.), using a Technicon autoanalyzer SMAC-2 (reference to this or any other product or trade name does not imply endorsement by the U.S. Government). Procedures were specified by the manufacturer and modified by PSPA.

We fitted selected bears with radiotransmitter collars (Telonics, Inc., Mesa, Ariz.) in the 164–165 Mhz range with a 5-min delay motion sensor and inserted a breakaway cotton spacer in each collar. With handheld receiving equipment, we relocated animals 3–7 times weekly by triangulation using bearings from 3 to 4 points on refuge or state roads. Flights were conducted 2–4 times monthly to relocate bears using aircraft-mounted receiving equipment. Telemetry locations were plotted on U.S.G.S. 1:24,000 topographic maps and assigned grid coordinates based on the Universal Transverse Mercator (UTM) system.

We radio-tracked bears to dens in winter and defined entry dates as the midpoint between the last recorded movement and the 1st of a series of stationary signals (O'Pezio et al. 1983). Date of den emergence was defined as the midpoint between the last denning location and the 1st radio location away from the den (O'Pezio et al. 1983). We then ground-truthed dens to determine site characteristics.

Telemetry data was processed by Telem (Koeln 1980), and home range was determined by the modified minimum area method (Harvey and Barbour 1965). Movements were indexed by distances between consecutive locations 12–36 hours apart. Gross habitat use was determined by matching grid coordinates of bear relocations with the vegetative cover map prepared by Gammon and Carter (1978) from color infrared photography and by site visits to areas frequented by collared bears. To avoid disturbing the bears, we visited sites when collared bears had left

the area. We collected scats and noted evidence of bear activity during site visits.

RESULTS

Twelve bears (7 male, 5 female) were monitored during winter 1984–85. Eight bears (5 male, 3 female) exhibited denning behavior, whereas 4 bears (2 male, 2 female) remained active.

Denning Behavior

We monitored 7 instrumented bears until they denned (Table 1). Dates of den entry ranged from 10 December to 19 January. An eighth bear, 9-year-old male 14, was infrequently monitored and date of den entry could not be precisely determined.

Dates of den emergence ($N = 6$) ranged from 20 March to 20 April. Emergence was not determined for 8-year-old male 12 due to collar failure and male 14 due to disturbance by researchers. Male 14 abandoned an elaborate ground nest on 11 February 1985 and never redenned. Researchers disturbed 9-year-old female 27 twice (7 February and 4 March 1985), but she redenned each time and was active by 20 March 1985.

Monitored bears used 3 types of dens on the GDS: ground nests, excavated ground cavities, and ground-level tree cavities. Three bears used ground nests woven of leaves, twigs, pine needles, and vines at the base of a tree. Alternate beds were found near 2 of the nests. Two adult females used excavated ground cavities, including 1 used as a natal den. Researchers disturbed both bears in their initial dens; the bears then constructed new dens 200 and 600 m away. All 4 cavities were dug into a mound of vegetation surrounding old tree stumps in dense, shrub-dominated habitats. Standing water was found in only 1 of the abandoned dens. Two adult males used basal cavities

in large gum trees. Neither of these trees was in inundated habitats during winter 1984–85.

Winter Activity

We recorded 193 relocations for 4 active bears during the winter monitoring period; 575 relocations were used to calculate annual ranges based on monitoring periods of 7–12 months (Table 2).

The annual and winter ranges of male bears 10 and 19, which were relocated for 41 and 42 days, respectively, during the 90-day winter period, overlapped extensively (Fig. 2). During winter, they were frequently located < 500 m apart. Both males spent the winter months in cover types with a sparse canopy and an extremely dense shrub layer, dominated by fetterbush (*Lyonia lucida*), evergreen hollies, and bays (sweet bay [*Magnolia virginica*] and red bay [*Persea borbonica*]), and woven with greenbriar vines. Bear 10 lost his collar on 10 March in a nearly impenetrable thicket of these broad-leaved evergreen shrubs and small trees. These bears were less active during winter, as indexed by distances between consecutive-day locations (Table 2), however, neither male remained at a site for more than 2 days at a time and daily movements exceeded 400 m. Although no scats were collected from this area, it is likely the animals were feeding on berries of greenbriar and holly (see following discussion).

Adult female 28 was relocated 43 times during winter. Her winter home range was the largest, and her daily movements the greatest of the 4 winter-active bears (Table 2). Teat appearance and poor condition (e.g., weight of 55 kg) observed during her capture on 26 October 1984 indicated she may have produced cubs the preceding winter; however, no young were seen at the trap site and bear 28 was not seen again until recaptured on 1 August 1985. The upper basin of the Pasquotank River formed most of bear 28's winter range (Fig. 3). This area was char-

Table 1. Denning chronology of black bears in Great Dismal Swamp, Virginia-North Carolina, during winter 1984–85.

Age	Sex	Reproductive status	<i>N</i>	\bar{x} Entry	\bar{x} Emergence	Days denned
Ad	M	—	4	12 Jan	31 Mar ^a	76
Ad	F	Barren	2	30 Dec	21 Mar	82
Ad	F	Pregnant	1	10 Dec	20 Apr	131

^a $N = 3$

Table 2. Annual and winter home ranges^a and seasonal^b movements in radio-monitored winter-active black bears in Great Dismal Swamp, Virginia-North Carolina.

Animal ID	Sex	Age (yrs)	Monitoring period	Home range (km ²)		Distance between consecutive daily locations (km)			N Relocations
				Annual	Winter	Fall	Winter	Spring	
10	M	3	24 Jul 1984–10 Mar 1985	21.0	0.9	1.6	0.4	—	95
19	M	4	1 Sep 1984–9 Jul 1985	38.1	2.8	1.2	0.4	1.0	143
17	F	3	14 Aug 1984–3 Aug 1985	18.2	0.4	1.4	0.2	1.0	202
28	F	7	26 Oct 1984–3 Aug 1985	17.3	4.5	1.7	0.6	1.1	135

^a Determined by modified minimum area method (Harvey and Barbour 1965).

^b Fall: 21 Sep–20 Dec; Winter: 21 Dec–20 Mar; Spring: 21 Mar–20 Jun.

acterized by an inundated cypress-gum cover type with a deciduous understory, primarily sweet pepperbush (*Clethra alnifolia*). Greenbriar vines occurred throughout the area.

Bear 28 moved daily except during early January, when 6 relocations between 2 January and 14 January placed her in the same locality. We attempted to locate her den or nest site on 14 January, but the attempt was aborted due to dense cover within 30 m of the bear. By 18 January, the bear had moved

approximately 600 m northeast. A ground nest, a clawed and damaged American holly, and 3 fresh scats containing seeds of American holly and greenbriar were found at the 1st site. The bear remained active throughout the rest of the winter. Subsequent site visits provided additional evidence of feeding activity. On 13 March bear 28 crossed Insurance Ditch (Fig. 3), headed north, and left the Pasquotank River drainage.

Subadult female 17, relocated 67 times during the winter, exhibited the most restricted activity of the winter-active bears (Table 2). She remained near Myrtle Ditch (Fig. 3) from early December until late February. Distances between consecutive daily locations commonly ranged 100–200 m. Movements of this magnitude could be detected because this bear was generally <200 m from Myrtle Ditch and she moved parallel to the ditch. Radio fixes were taken from the associated roadbed. Telemetric data indicated that bear 17 bedded down between 18 January and 22 January, 500 m west of Myrtle Ditch. She remained bedded from 22–27 January. This period of inactivity (18–27 January) coincided with the coldest temperatures ever recorded in southeastern Virginia: -18°C on 20 January and -21°C on 21 January (U.S. Dep. of Commerce 1984–1985). A 900 m movement between 27 January and 28 January placed her within 40 m of Myrtle Ditch. Habitats selected by the bear during winter were an inkberry-dominated shrub community and a pine cover type with evergreen understory (Gammon and Carter 1978). Both are characterized by dense ground cover.

Evidence of undisturbed movement and feeding activity in bear 17 occurred throughout the winter. She crossed Myrtle Ditch on 24 December, 1 January, and 15 February and sprung a trap baited with a fresh white-tailed deer (*Odocoileus virginianus*) carcass on 2 February. Bear 17 was recaptured on a

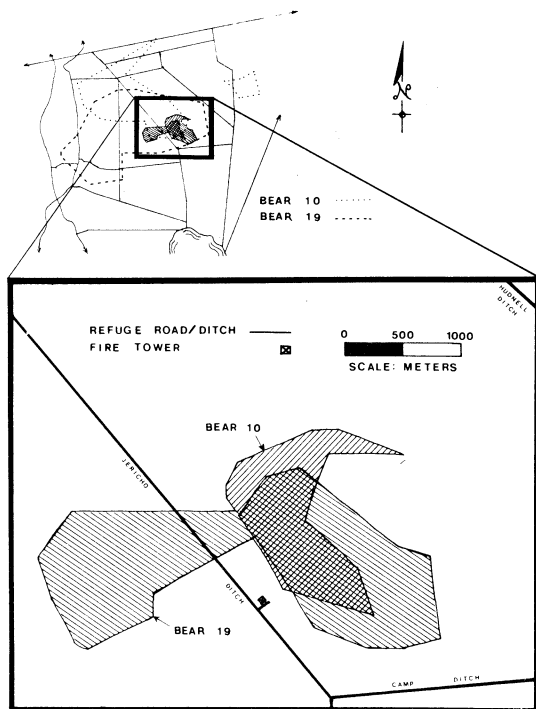


Fig. 2. Annual and winter (inset) home ranges of 3-year-old (bear 10) and 4-year-old (bear 19) male black bears in the Great Dismal Swamp, Virginia-North Carolina, during 1984–85.

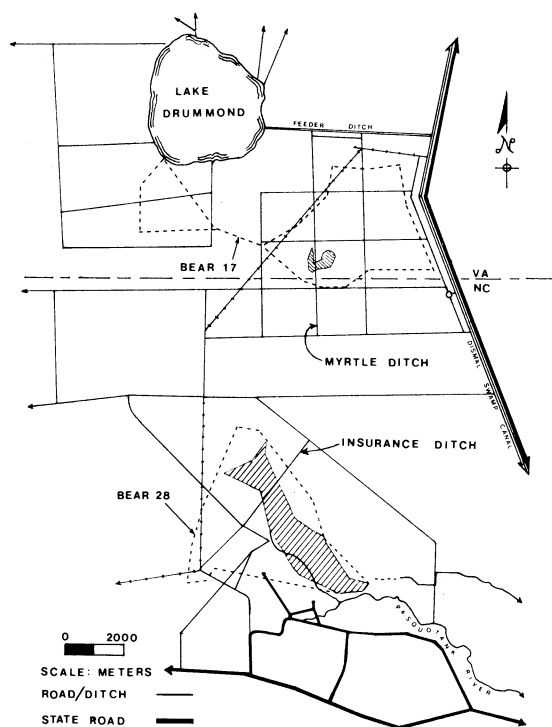


Fig. 3. Annual and winter (hatched) home ranges of 3-year-old (bear 17) and 6-year-old (bear 28) female black bears in the Great Dismal Swamp, Virginia-North Carolina, during 1984-85.

trailset baited with deer meat on 4 February. She appeared lethargic at the trap site. She weighed 48 kg, an increase of 7 kg from her original capture weight on 14 August 1984. Rectal temperature was 36.5 C 16 min following immobilization. Blood samples were collected 8 and 48 min following immobilization and analyzed for serum chemical parameters (Table 3). We observed this bear feeding on a greenbriar vine draped on a red maple on Myrtle Ditch road on 18 February. Later examination of the area in which she was observed yielded 2 fresh scats containing greenbriar seeds and leaves.

DISCUSSION

The 2 main characteristics of winter dormancy in black bears are denning behavior and hibernation physiology (Nelson et al. 1983). Our data indicate some black bears can circumvent 1 (denning) and perhaps both of these characteristics during winter. Denning chronology of radio-monitored bears that entered the dormant state was similar to that of other

southeastern bear populations (Hamilton and Marchinton 1980, Johnson and Pelton 1980, Smith 1985). Thus, bears in the GDS are able to den and hibernate; however, denned and winter-active bears apparently differ in their response to the proximate stimuli necessary to induce and maintain winter dormancy.

Factors regulating duration of bear winter dormancy include weather effects, photoperiod, food availability, and bear nutritional condition. Climatic effects (e.g., precipitation, temperature, wind, barometric pressure) have been correlated to date of den entry (Jonkel and Cowan 1971, Lindzey and Meslow 1976, Johnson and Pelton 1980) and den emergence (Novick et al. 1981). Subadult female 17 was briefly inactive during extremely cold weather, however, other winter-active bears did not behave in this manner. Temperature and precipitation data (Table 4) indicate that winter 1984-85 was a normal, mild winter in the GDS, albeit with a warm December and a cold January. Snow cover never exceeded 8 cm nor lingered more than a few days. Other southeastern bear populations experience even milder winter climates (Hamilton and Marchinton 1980, Maehr and Brady 1984, Smith 1985).

Food availability has also been implicated as a regulatory factor in bear winter dormancy (Jonkel and Cowan 1971, Johnson and Pelton 1980, O'Pezio et al. 1983). Indeed, winter dormancy is ultimately an energy-conserving adaptation to a decreased food supply. However, a number of available winter foods occur in the GDS. Preliminary examination of winter scats and evidence of feeding activity indicate that bears were feeding on fruits of greenbriar and evergreen hollies. Other Atlantic Coastal Plain bear population studies (Hardy 1974, Daniels 1978, Landers

Table 3. Serum chemical parameters in 2 blood samples collected from a winter-active subadult female black bear on 4 February 1985 in Great Dismal Swamp, Virginia-North Carolina.

Parameter (mg/dl)	Sampling time post immobilization	
	8 min	48 min
Urea nitrogen (UN)	45	42
Creatinine (C)	1.4	1.4
UN/C ratio	32.1	30.0
Uric acid	1.1	0.9
Cholesterol	132	140
Triglycerides	152	181
Glucose	158	217

Table 4. Mean temperature and precipitation during winter 1984–85 and 30-year normal readings at Suffolk Lake Kilby Station.^a

Month	Temperature (C)		Precipitation (cm)	
	Winter 1984–85	Normal	Winter 1984–85	Normal
December	9.1	3.6	6.7	8.7
January	0.4	3.8	11.8 ^a	10.2
February	4.3	4.9	9.7	9.2
March	10.1	9.1	6.7	10.2

^a Five km northwest of Great Dismal Swamp study area (U.S. Dep. of Commerce 1984–1985).

^b 12.2 cm of snow.

et al. 1979) have reported similar findings from limited winter scat samples.

Habitat selection by winter-active bears reflected food preferences. Three of the 4 bears monitored in this study used pocosin habitats, which are freshwater wetland ecosystems characterized by broad-leaved evergreen shrubs or low trees growing on poorly drained organic soil (Sharitz and Gibbons 1982). Pocosins in the GDS are dominated by dense stands of holly (Gammon and Carter 1978) and woven profusely with greenbriar. Such areas provide a concentrated winter food supply, which may have contributed to the bears' reduced movements and home range size. The 4th animal, bear 28, used a more open habitat (cypress-gum cover type) most of the winter and moved through a larger range than other winter-active individuals. Comparative data on winter home range and movements are limited. Hardy (1974) monitored an adult male during winter that used an area of 2.0 km² of primarily pocosin habitat dominated by greenbriar and inkberry. Due to research-related disturbances, it was unknown if the bear became dormant or remained active (Hardy 1974:70). Winter home ranges of 2 adult females with yearlings in Shenandoah National Park, VA were 0.8 and 0.9 km² (Garner, unpubl. data). These bears primarily used dense thickets of evergreen mountain laurel (*Kalmia latifolia*).

Nutritional condition, which is related to food availability, may also affect timing of bear dormancy (Lindzey and Meslow 1976, Smith 1985). Three of the 4 winter-active bears in this study were subadults (Table 2); the 4th, an adult female, may have produced cubs the preceding winter. Smith (1985) and Hamilton and Marchinton (1980) suggested that subadult males may fail to den in mild southeastern regions because fat reserves are low in this age-class. Females with yearlings, another sex/age group under nutritional stress, have been reported to be active

throughout winter (Alt et al. 1976, Garner, unpubl. data).

Lindzey and Meslow (1976) proposed that a certain physiological condition was a prerequisite to denning and that weather factors proximately stimulate denning behavior. Smith (1985), expanding on Lindzey and Meslow's (1976) hypothesis, suggested that body weight:stored fat ratio is the ultimate prerequisite for dormancy. Both papers argued that denning may be stimulated if a net energy loss occurs during foraging, even if a high body weight:stored fat ratio has not been attained. For example, in Montana, bears den regardless of nutritional condition (Jonkel and Cowan 1971). Subsequently, postdenning yearling survival is lower following years of food scarcity (Rogers 1983), presumably because fat reserves become depleted during denning and the stressful postdenning period. Nevertheless, in northern regions, with virtually no winter food supply and severe climatic conditions, dormancy would be selectively advantageous over energy-deficient foraging (Smith 1985). Thus, nutritional condition may play a lesser role in induction and maintenance of dormancy in these areas (Lindzey and Meslow 1976). In southern regions, like the GDS, a number of winter food items, mild temperatures, and little or no snow cover may allow an energetic choice. If the net energetic balance of winter foraging is greater than that of denning, it would be adaptive to remain active during winter. This strategy may be particularly important for bears that have not stored adequate body fat (Smith 1985), such as rapidly growing subadults and adult females recovering from the nutritional stress of lactation. Comparative data on condition changes and survival in denned and winter-active bears are lacking.

This study provides limited evidence that winter-active bears also fail to achieve the metabolic state of hibernation (Nelson et al. 1983). The urea nitrogen/creatinine (UN/C) ratio of 2 blood samples from

a winter-active bear captured in February was not indicative of hibernation (Table 3). Nelson et al. (1984) reported that a urea/creatinine ratio of <10 (or a UN/C ratio of <4.66) is indicative of black bear hibernation. Winter-active bears were also feeding and defecating, atypical of black bear hibernation physiology (Nelson et al. 1983). Scat composition and texture resembled that of scats found during other seasons, rather than dense, mucous-covered fecal plugs found near bear dens (Johnson 1978, Hamilton and Marchinton 1980, Smith 1985). More physiological information, such as data on blood chemistry, urine chemistry, endocrinology, and body temperature, is necessary to determine whether winter-active black bears circumvent hibernation physiology as well as denning behavior.

Johnson and Pelton (1980) hypothesized that bears evolved a flexible, endogenous circannual rhythm as the ultimate denning mechanism. They suggested that neural integration of a number of environmental cues provides the proximate stimulus to den and hibernate. Changes in these cues may change or "phase" portions of the rhythm. This study provides evidence that under certain conditions (e.g., mild climate, lack of snow cover, moderate food availability, low body fat deposits), the endogenous rhythm is phased to circumvent denning behavior and hibernation physiology.

The role of photoperiod in bear dormancy should not be ignored. Rate of day-length change and absolute photoperiod vary widely throughout black bear range and may explain much of the variation in denning chronology between boreal and southern populations.

Modeling the relationship between proximate factors and denning chronology may provide predictions for degree of winter activity in southern regions of the black bear's range and give further insight into what triggers bear winter dormancy.

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