HABITAT CHARACTERISTICS OF FEMALE BLACK BEAR DENS IN NORTHWESTERN ARKANSAS

STEPHEN G. HAYES,[1] Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, Box 1071, Knoxville, TN 37901-1071
MICHAEL R. PELTON, Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, Box 1071, Knoxville, TN 37901-1071

Abstract: Twenty-nine radio-collared female black bears (*Ursus americanus*) were tracked to 48 den sites during winters 1988-89 and 1989-90, in the Ouachita and Ozark mountains of Arkansas, to study den selection and habitat. Bears on both areas used rock cavity dens most often (66.6%), followed by excavations (12.5%), clearcuts (12.5%), open nests (4.2%), and tree cavities (4.2%). Multivariate models detected significant habitat component differences among rock, excavation, and clearcut dens ($P < 0.05$). Black bears selected dens that were physically different, but functionally similar. Rock cavity dens occurred on steep slopes, within structurally secure cavities, far from external disturbances. Excavation and clearcut dens lacked permanent structure, but security was compensated by dense understory vegetation and increased horizontal cover. It is not known if survival was also compensated at excavation and clearcut dens; this question should be addressed so reliable information on the relationship between den-type availability and cub production and survival can be incorporated into bear management plans.

Int. Conf. Bear Res. and Manage. 9(1):411-418

Winter dormancy in black bears has evolved as a direct result of winter stress. Winter stress occurs when seasonal food shortages combine with severe weather to reduce survival rates in a given population. Winter dormancy occurs at a den site and allows the bear to overcome winter stress by minimizing energetic losses. The success of dormancy depends on several factors including food availability, weather, and the ability of the den site to reduce energetic losses. Excessive energetic losses can occur through exposure to severe weather or if predatory disturbance forces the bear to relocate. In each case, the quality of the den site determines what effect weather and predatory disturbance will have on the bear.

Den-site selection varies widely across North America. Black bears have denned in excavations (Tietje and Ruff 1980, Beecham et al. 1983, Schwartz et al. 1987), hollow logs and the base of hollow trees (Jonkel and Cowan 1971, Pelton et al. 1980, Johnson and Pelton 1981, Beecham et al. 1983), above-ground tree cavities (Pelton et al. 1980, Johnson and Pelton 1981, Beecham et al. 1983, Smith 1985, Schwartz et al. 1987), depressions and open nests (Hamilton and Marchinton 1980, Hugie 1982, Alt 1984, Hellgren and Vaughan 1989), and rock cavities (Beecham et al. 1983, LeCount 1983, Alt 1984, Schwartz et al. 1987).

Den selection is a function of availability (Johnson and Pelton 1981) and natural selection (Johnson et al. 1978). Variation in den selection occurs because different habitats experience different environmental conditions and provide different denning options for bears. Evolutionary forces may also influence den selection by increasing the reproductive fitness of genotypes that den where energetic losses are minimized.

In 1987, a wide-scale black bear research project was initiated to study the ecology of black bears in the Arkansas Highlands. One aspect of the research focused on use and characteristics of dens selected by females from 2 black bear populations. Objectives were to (1) document den use and describe den habitat in the Arkansas Highlands, (2) quantify den, physical, and vegetative habitat differences by den type, and (3) use den type comparisons to examine the relationship between den type and den habitat.

The project was funded under provisions the Pittman-Robertson Act, administered by the Arkansas Game and Fish Commission. Additional funding and assistance was provided by the U.S. Department of Agriculture (USDA) Forest Service, the University of Arkansas, and the University of Tennessee. We thank numerous faculty and staff at each university and agency for field and technical support during this project.

STUDY AREAS

Research was conducted on 2 study areas in the Interior Highlands province of Arkansas (Fig. 1). The Dry Creek study area is on the Cold Springs Ranger District of the Ouachita National Forest in Logan, Scott, and Yell counties. Dry Creek lies within the Ouachita Mountains, which were formed by vaulting of sedimentary rock along an east-west belt (Crow 1974). Topography is dominated by long, parallel ridges that

[1] Present address: USDA Forest Service, 1201 Ironwood Drive, Coeur d'Alene, ID 83814.

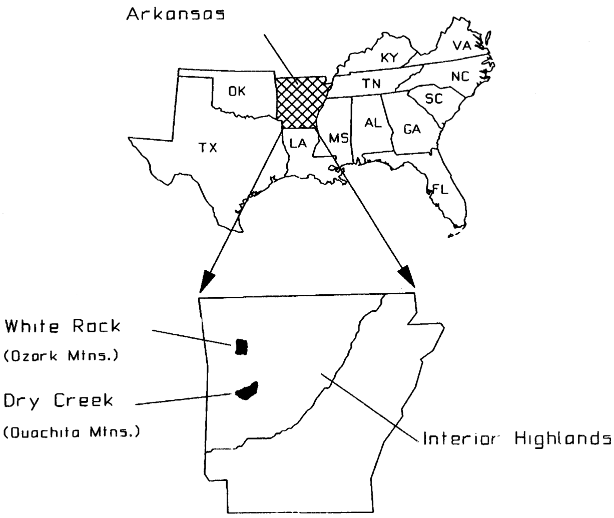

Fig. 1. Black bear study areas with reference to the Interior Highlands province of Arkansas.

are cut by seasonal streams, which create steep drainages with frequent rock outcrops and benches. Elevations range from 146 to 743 m. Soils are generally poor and thin, formed from a variety of sandstones, novaculites, cherts, and shales (Johnston 1984). The most common soils are Mountainburg, Enders, Linker, and Nella (Vodrazka 1989).

The north-south facing slopes formed by the east-west ridges in the Ouachita Mountains create sharp ecotones on the Dry Creek study area. At lower elevations on north slopes, northern red oak (*Quercus rubra*), white oak (*Q. alba*), hickory (*Carya* spp.), blackgum (*Nyssa sylvatica*), elm (*Ulmus* spp.), black cherry (*Prunus serotina*), red and sugar maple (*Acer rubrum*, *A. saccharum*), and ash (*Fraxinus* spp.) are common. Blackjack oak (*Q. marilandica*), post oak (*Q. stellata*), and shortleaf pine (*Pinus echinata*) occur at higher elevations on poorer sites. A mixed forest of oak, hickory, and shortleaf pine is common on south-facing slopes.

Through the broken canopy of the mixed pine-hardwood forest, intolerant understory plants such as low and highbush blueberry (*Vaccinium* spp.), blackberry (*Rubus* spp.), and grape (*Vitus* spp.) are common. Other understory species include dogwood (*Cornus florida*), Eastern hophornbeam (*Ostrya virginiana*), serviceberry (*Amelanchier arborea*), redbud (*Cercis canadensis*), and devil's walking stick (*Aralia spinosa*).

The White Rock study area is in the Boston Mountain Ranger District of the Ozark National Forest in Franklin and Madison counties. White Rock lies within the Boston Mountains of the Ozark Plateau, a mountainous region formed from erosion of an uplifted dome (Crow 1974). Topography is variable and rough, with rock bluffs and outcrops common. Elevations range from 177 to 688 m. Parent material and soils are similar to those on Dry Creek. With the exception of Allen soils, all are thin and highly erodible (Vodrazka et al. 1969).

Forest vegetation in the Ozark Mountains is principally an upland hardwood forest. Shortleaf pine does occur on the White Rock study area, but mainly on the south-facing slopes near the Mulberry River. Oaks and hickories dominate but blackgum, black cherry, ash, elm, and maple are common. Under the closed canopy, poison ivy (*Toxicodendron radicans*), Carolina buckthorn (*Rhamnus caroliniana*), Ohio buckeye (*Aesculus glabra*), and witch hazel (*Hamamelis vernalis*) are common.

The climate on both areas is humid subtropical. Annual precipitation is 118 cm on Dry Creek and 115 cm on White Rock. Winter and spring are the wettest seasons and fall the driest (Reinhold 1969). The mean annual low and high temperatures (1931-60) range from 5.4 to 27.7°C on Dry Creek and 3.3 to 25.8°C on White Rock (Reinhold 1969). Winter temperatures may drop below -18°C and summer temperatures often exceed 38°C (Skiles 1980).

Landuse consists of commercial logging and recreational activities. Timber management on Dry Creek focuses on shortleaf pine harvest and regeneration, while emphasis on White Rock is placed upon hardwood production. Recreational demands include hunting, fishing, camping, and the use of all-terrain vehicles.

METHODS

Bears were captured with modified Aldrich spring-activated leg snares (Johnson and Pelton 1980) and barrel traps during the summers of 1988 and 1989. We immobilized bears with a combination of ketamine hydrochloride (Bristol Laboratories, Syracuse, N.Y.), xylazine hydrochloride (Haver-Lockhart, Inc. Shawnee, Kans.), and mepivacine hydrochloride (Winthrop Laboratories, New York, N.Y.) at a dose of 200mg/100mg/10mg respectively, per 45.5 kg body weight (Cook 1984). We administered the drug intramuscularly with darts attached to a jab pole or from projectile syringes fired from a CO_2 pistol (CAP-CHUR, Palmer Chemical and Equipment Company, Douglasville, Ga.).

Individuals were eartagged, given numbered lip tattoos, and reproductively mature females were fitted with two-year radiotransmitters (Telonics Telemetry Consultants, Mesa, Ariz.). An upper first premolar was extracted for determining age, blood was collected, and standard body measurements were taken.

During the first week of February in 1989 and 1990, we located dens using ground homing techniques with a 4-element handheld Yagi antenna and a TR-4 Telonics receiver. At the den site, we immobilized the female and any yearlings using the same methods employed during summer trapping. The female and offspring were removed from the den, weighed, and measured.

Dens were classified as 1 of 6 types: rock bluff, rock creek, clearcut, excavation, tree cavity, or nest. Den characteristics were measured according to den type. At dens associated with trees (tree cavities, excavations), tree species was recorded, height was measured with a clinometer, and diameter at breast height (dbh) was measured with a diameter tape. At dens in clearcuts, distance of den from forest edge, clearcut size, age, regeneration type, and brushpile size were recorded. The size of all dens (except clearcuts and nests) was determined by measuring height, length, and width of the cavity. Because dens were shaped irregularly, volumes were spatially dissected into simple geometric shapes (e.g., spheres, cones, cylinders) measured separately and then summed. For cave, tree, and excavation dens, size and aspect of the entrance were measured. Distance of the bed from the entrance was measured (except clearcuts and nests), as was bed size and bedding material volume.

Horizontal and vertical cover measurements were made from the entrance of each den and from a random point 15 m from the den. Fifteen meters was judged an appropriate distance to remove the structural cover of the den from the measurement. Random vs. den cover comparisons were made to measure the den structure's ability to provide cover. Den entrance cover was used to compare cover differences among den types. Horizontal cover was measured with a Nudds density pole (Griffith and Youtie 1988) using the standard horizontal cover technique (Nudds 1977). Vertical (canopy) cover was measured using a spherical densiometer (Lemmon 1956). Slope was determined using a clinometer and aspect of slope was determined with a compass. Elevation of the site was determined from 7.5 minute quadrangular maps.

After bears emerged from dens each spring, sites were revisited to measure vegetative characteristics. Diameter of overstory (trees >10.2cm dbh) species were measured within a 196 m^2 plot centered on the den to calculate basal area. Height and age were quantified by measuring and boring 2 or 3 representative individuals in the plot. Understory and ground vegetation were measured within a 28 m^2 subplot. Complete stem counts were made by species within the subplot.

Differences between habitat components of den types were examined using canonical discriminant function models (PROC CANDISC, SAS 1985). Multivariate normality was assumed if all of the variables in the model were normal. Before multivariate comparisons, normality was tested by examining W statistics (PROC UNIVARIATE NORMAL, SAS 1985). Nonnormal variables were transformed using log functions or dropped from the analysis. Homogeneity of within covariance matrices was also examined (PROC DISCRIM POOL=TEST, SAS 1985). Multivariate comparisons were made only when covariance matrices were equal at the 0.10 level of alpha.

The objective of using canonical discriminant function models was to determine which habitat variables distinguished each den type. Habitat variables with the lowest canonical correlations were sequentially dropped from initial models until P values fell below the critical level of alpha (0.05). Tests of significance between mean vectors were made using Hotelling-Lawley Trace when there were 2 levels of the class variable, and Roy's Greatest Root for more than 2 levels.

Because of nonnormality, univariate comparisons of horizontal and vertical cover between den and random points were made using the Wilcoxon rank sum test (PROC NPAR1WAY, SAS 1985). Horizontal cover at den entrances was compared among den types using an unbalanced ANOVA (PROC GLM, SAS 1985). Aspect was converted to a class variable by grouping easterly slopes (45-135°), southerly slopes (136-225°), westerly slopes (226-315°), and northerly slopes (316-44°), and analyzed using frequency analysis.

Availability of denning habitat was measured by searching random transects in a stratified random sample of cover types throughout each study area. Searches were made for rock, tree, excavation, clearcut (brushpile), and hollow log dens. Before sampling, stands on national forest lands were stratified, selected stands were located by orienteering, and a 100 m by 150 m plot was sampled parallel to the slope. The plot size was increased to 100 m by 220 m midway through the sampling period.

Trees were only classified as potential den sites if their dbh was ≥90 cm, which was 6 cm larger than the dbh used by Johnson (1978). This size was selected because bears in the Arkansas Highlands are significantly larger than those in Great Smoky Mountains National Park (Clark 1988), and measurements on only 1 known Arkansas Highland tree den (100.5 cm) were available at the time the criterion was set.

If a tree met the size criterion, it was classified as a potential den if a cavity was present. Down trees with cavities also were searched and classified, as were brushpiles in clearcuts. If a rock outcrop or bluff occurred in a transect, the structure was searched for a cavity. Cavities were only classified as potential den sites if the entrance dimensions had a minimum diameter of 40 cm. This figure was based on chest circumference measurements of Arkansas Highland bears during winter, and entrance measurements of 22 den sites. Sample sizes were not large enough to warrant statistical comparisons of use and availability.

RESULTS

Den Visits

Twenty-nine radio-collared female bears were radiotracked to 48 den sites during winters 1988-89 and 1989-90. Forty-five individuals were immobilized, reproductive status was determined, and measurements were taken. Three bears could not be handled during winter because of defensive behavior and dens located deep within rock cavities.

Bears located during consecutive years were treated as independent observations because the correlation between individual bears and their den measurements was low between different years. Further, rate of den reuse was low (13.6%), so we assumed that little competition occurred for dens within home ranges of individuals.

Den Use

Thirty-two (66.6%) of 48 bears denned in rock cavities. The remainder denned in excavations (12.5%), clearcuts (12.5%), open nests (4.2%), and tree cavities (4.2%).

Rock Dens.—Two different types of rock cavity dens were used during the study. Rock-bluff dens were located along bluff lines and benches in rock cavities, and rock-creek dens were rock cavities located in or along creek bottoms. On White Rock, 12 (52.2%) of 23 dens were in rock bluffs, and 3 (13.0%) were in rock creeks. On Dry Creek, 10 (40%) of 25 dens were in rock creeks, and only 7 (28%) were in rock bluffs.

Clearcuts.—Only bears on White Rock used clearcuts for den sites. Of 6 bears that denned in clearcuts, 3 selected brushpiles left after logging, and 3 selected excavations within clearcuts. These dens were pooled into the same den category because they had similar physical and vegetative characteristics. The mean age of clearcuts used was 2 $\pm$ 1 (SE) years. The mean distance from den to clearcut edge was 39 $\pm$ 9 (SE) m and the average brushpile size was 51 $\pm$ 29.63 (SE) m^2.

Excavation Dens.—Two types of excavation dens were used; excavations in clearcuts (6.3%) and excavations in timber (12.5%). On White Rock, 1 den (4.3%) was an excavation in timber and 3 (13%) were excavations in clearcuts. On Dry Creek, all 5 (20%) excavation dens were in timber. For analysis, excavations in timber and excavations in clearcuts were classified into separate groups. In all cases, the den was associated with a tree. Five of 9 (55.6%) were dug into the cavity left by the root mass of a fallen tree, 3 (33.3%) were under roots of a standing tree, and 1 (11.1%) was along the bole of a fallen tree.

Open Nests.—Two bears on Dry Creek denned in open nests of hardwood leaves within mature hardwood stands adjacent to "typical" den habitat. One female with 3 yearlings bedded next to a large (55 cm dbh) northern red oak at the base of an extensive rock bluff which may have contained a more secure cavity. The other nest, occupied by a 17-year-old barren female, was within 3 m of a freshly dug excavation den. Its volume would have easily contained the 100 kg female, but it showed no signs of occupation. Kolenosky and Strathearn (1987) observed bears using nests adjacent to winter dens during the predenning period in east-central Ontario. The nest dens observed during this study could have been predenning nests that were never vacated during the mild winter of 1989-90.

Tree Cavities.—One bear on each study area selected the cavity of a tree for a den site. On White Rock, a cavity at the base of a 77.5 cm dbh white oak was utilized, and on Dry Creek a 100.5 cm dbh white oak with an entrance 8.7 m above ground was used. Both females had newborn cubs (2 on White Rock and 3 on Dry Creek).

Den Availability

Random searches for rock, brush, and tree cavity dens on each study area produced markedly different results. Twenty-two potential dens were located in 61 transects on White Rock, but no dens were found on 48 transects on Dry Creek. The total search area was 120.2 ha on White Rock and 91.6 ha on Dry Creek. Den availability corresponded closely with den use on

Table 1. Den use and availability of black bear dens on White Rock study area, Arkansas 1988-90.

Den type	Den use (n = 20)	Den availability (n = 22)
Rock cavity	66.7%	77.3%
Brushpile (clearcut)	12.5%	9.1%
Tree cavity	4.2%	4.5%
Hollow log	0.0%	9.1%

White Rock (Table 1). Although statistical comparisons were not made, it appears that den types were selected in proportion to availability. No excavation dens were located in the search; most likely a result of the susceptibility of excavation dens to destruction by flooding.

The lack of den sites at Dry Creek may be a result of the sampling technique, as well as lower denning habitat availability compared to White Rock. Random transects were centered in forest stands and sampling occurred across elevation contours. Because USDA Forest Service stand boundaries normally occur along creek bottoms, none of the transects bisected streams. Therefore, the most commonly selected type of denning habitat on Dry Creek, creek bottoms (40%), was never sampled for availability.

Den Habitat

Cover.—Nonparametric comparisons indicated that vertical cover differed between den entrances and random points 15 m from the entrance (P = 0.001, n = 47). Mean percentage of vertical cover at den entrances was 91.1% and 80.3% at random points. Horizontal cover also was significantly greater at den entrances than random points (P = 0.001, n = 47). Mean percentage of horizontal cover at den entrances was 89.7% and 80.0% at random points. Cover was most dense when measured within 0.5 m of the ground and became less dense as distances from the ground increased.

Aspect.—Overall, bears selected dens on south (32.6%, n = 15) and west (28.3%, n = 13) slopes at higher frequencies than on east (23.9%, n = 11) and north (15.2%, n = 7). On Dry Creek, 41.7% (n = 10) of dens were on south slopes, 29.1% (n = 7) were on west slopes, 16.7% (n = 4) were on east slopes, and 12.5% (n = 3) were on north slopes. On White Rock dens were more evenly distributed across the 4 aspects (31.8% n = 7/east, 22.7% n = 5/south, 27.3% n = 6/west, 18.2% n = 4/north).

Slope aspect has been variable in previous studies (Beecham et al. 1983, LeCount 1983, Wathen et al. 1986, Schwartz et al. 1987) and is likely related to den availability. The aspect distinction between Dry Creek and White Rock is most likely the result of topographical differences between areas. Irregular topography on White Rock produces hillsides with a variety of aspects while Dry Creek has east-west ridges that form north-south facing slopes. Rock bluffs occurred on both slopes at Dry Creek, but most bears (72.8%) chose dens on south- and west-facing slopes. If dens are available on north and south slopes, southern slopes may be preferred.

Flooding.—Flooding was observed within 7 dens: 3 excavation dens, and 4 rock-creek dens. Flooding occurred during periods of heavy rain when saturated soils flooded excavations, or when rising stream levels forced water into rock cavities along creeks. Overall, 4 (30.1%) of 13 rock-creek dens flooded, and 3 (33.3%) of 9 excavation dens flooded. Six (27.3%) of 22 dens examined in 1989 were flooded compared to 2 (7.7%) of 26 in 1990. The difference between years was the result of a dry winter in 1989-90.

Two females with newborn cubs approximately 4-5 weeks old emerged from their dens during a torrential rainstorm (8.5 cm in 24 hrs). The cubs (litter sizes of 2 and 3, respectively) had been carried out of the dens and were exposed to the heavy rain and 4°C temperature. One den was an excavation, and the other was a rock-creek den. Selection of a rock den by a third female in a creek likely resulted in cub mortality. The den of this bear had water flowing through the interior of the den and the bedding material was saturated. One offspring was dead and had been pushed out of the bed when the den was entered on 19 February 1989. The live cub was sneezing and had difficulty respiring, but survived through the winter of 1989-90

Bedding Material.—Most dens contained elaborately prepared den beds. Large volumes of hardwood leaves were taken into the den and formed in the shape of a nest. In 2 dens on Dry Creek dry grass was used as bedding material, with extensive areas (100 m^2) outside the den mowed by the bear.

Volumes of bedding material ranged from 0 to 1,490 L. The mean volume of bedding material in White Rock dens was 319 L (n = 22), and 268 L (n = 21) in Dry Creek dens. Generally, females with yearlings had larger den beds and larger volumes of bedding material than females with newborn cubs. Bedding material is important as a source of insulation and for buffering the effects of den flooding. In 14 dens, the bed was constructed on a base of small branches and the leaves were laid over this mat. Beds with this design may have drained water more effectively.

Comparisons by Den Type

Habitat comparisons between den types were made using 3 separate models. The first model compared rock-creek dens (n = 13) and rock-bluff dens (n = 18). No significant differences were found between mean vectors before (P = 0.808) or after variable reduction (P = 0.305), so rock-bluff and creek dens were combined in subsequent analyses. Rock den, excavation, and clearcut variables were then compared. Since dens in clearcuts had no overstory or den cavity structure, these variables were excluded from the analysis. A third model, which included overstory and den measurement variables, was used to compare habitat between rock and excavation dens.

Habitat differences among rock (n = 31), excavations in timber (n = 6), and clearcut dens (excavations and brushpiles, n = 5) were detected (P = 0.001). The model that provided the greatest discriminating power contained slope and understory stem density (Fig. 2). Clearcut dens were on gentle slopes (12.0° ± 1.7° SE) and had high understory stem densities (37,269/ha ± 6,278 SE). Excavations in timber and rock dens were on steep slopes (25.7° ± 2.0° SE and 28.0° ± 1.3° SE respectively), but had lower understory stem densities (13,846/ha ± 3,512 SE and 10,639/ha ± 1,452 SE, respectively).

When overstory and den measurement variables were considered, differences were also detected between rock dens and excavations in timber (P = 0.047). The most discriminating model contained overall mean dbh, total den volume, and entrance to den bed distance (Fig. 3). Mean dbh of overstory and total den volume were the variables with the highest canonical correlations, followed by bed/entrance distance. Excavation dens were in smaller stands of timber (18.7cm dbh ± 1.4 SE) and had less total volume (1,051L ± 150 SE) than rock dens (22.47cm dbh ± 0.7 SE, 2,455L ± 435 SE). Further, den beds at excavations were closer to entrances (73.7cm ± 4.6 SE) than rock dens (138.1cm ± 17.6 SE).

Horizontal cover at den entrances varied among rock, excavation, and clearcut dens (P = 0.045), with horizontal cover at clearcuts (96.5%) greater than at excavation (66.3%) or rock dens (71.6%, P = 0.025 and 0.020, respectively). Differences were not significant between rock and excavation dens. Cover estimates provided a measure of how well the dense vegetation concealed the den. Increased vegetation density at clearcut dens provided more cover than at rock or excavation dens; but at excavation dens the

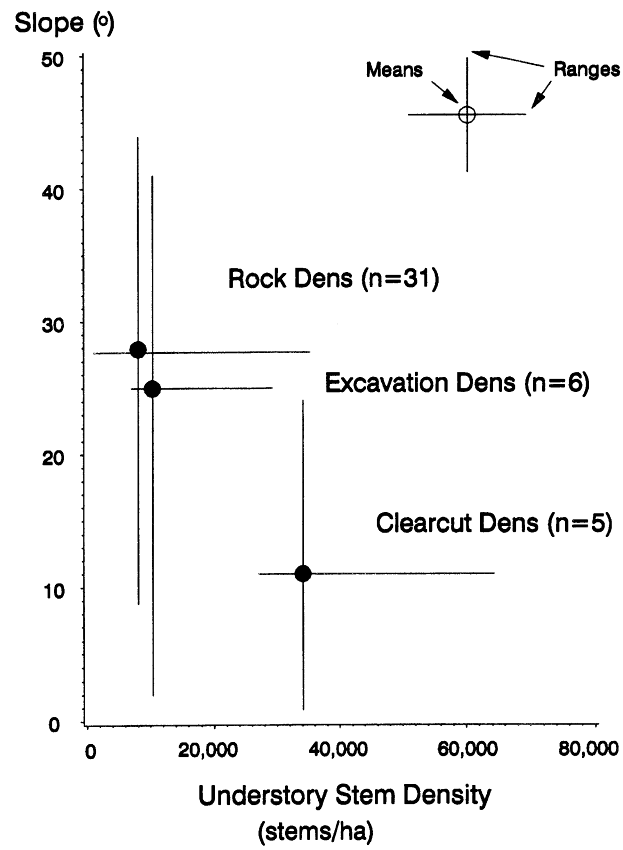

Fig. 2. Means and ranges of slope and understory stem density among rock, excavation, and clearcut black bear dens, Arkansas Highlands.

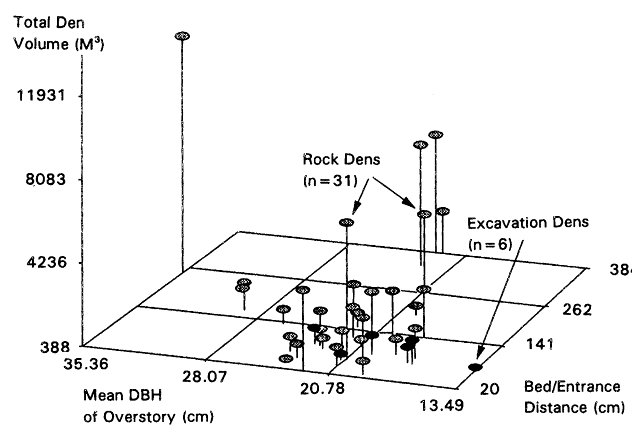

Fig. 3. Distribution of den volume, mean dbh, and bed/entrance measurements at rock and excavation black bear dens, Arkansas Highlands.

increased density of vegetation was not enough to provide more cover than rock dens.

DISCUSSION

Female black bears in the Arkansas Highlands used a variety of den types in habitats that differed significantly. The habitat differences between rock, excavation, and clearcut (brushpile) dens may be the result of a gradient of structural security among den types. Rock-bluff and rock-creek dens were not associated with understory vegetation, but they provided bears with a high degree of structural security because they were located on steep slopes with den beds deep in resilient structures. Rock-creek dens were prone to flooding and therefore not as secure as rock-bluff dens. Clearcut dens were the most accessible and provided the least amount of structural security. However, clearcut (brushpile) dens had the highest correlation with understory vegetation and provided the largest amount of horizontal cover. Excavation dens had more structural security than brushpile dens and less understory vegetation. But unless the excavation was located in a clearcut, increased vegetation density was not great enough to increase horizontal cover. Further, excavation dens were unstable, prone to flooding, and had beds close to den entrances, not at the end of tunnels (Beecham et al. 1983, Schwartz et al. 1987).

An increase in dependence on vegetation around the den site can be attributed to a decrease in the structural security of the den itself. The relationship can be expressed as a negative correlation between structural security and habitat cover (Fig. 4.) Denning occurred in areas that were physically different, but functionally similar. In other areas with variable den habitat, site selection has followed this relationship. In Idaho, for example, Beecham et al. (1983) documented black bear denning in dense vegetation below 1,800 m and in open vegetation above 1,800 m. Dens below 1,800 m lacked snow cover but were compensated by dense vegetation; dens above 1,800 m lacked vegetative cover but were compensated by deep snow (Beecham et al. 1983). In Tennessee, Wathen et al. (1986) observed habitat differences between ground and tree dens. Ground dens occurred on better drained upland soils and were associated with dense to moderate understories. Most tree dens had moderate to light understory, and some had no understory (Wathen et al. 1986).

In areas where denning structures are limited, dense understory vegetation is the principal component of den habitat (LeCount 1983, Kolenosky and Strathearn 1987, Hellgren and Vaughan 1989). Dense, impenetrable vegetation may reduce heat loss from wind and the chance of human disturbance (Hellgren and Vaughan 1989), but open dens can not provide the thermodynamic cover of an enclosed den, especially during periods of severe weather. Severe weather may negatively affect survival of bears denning in open nests.

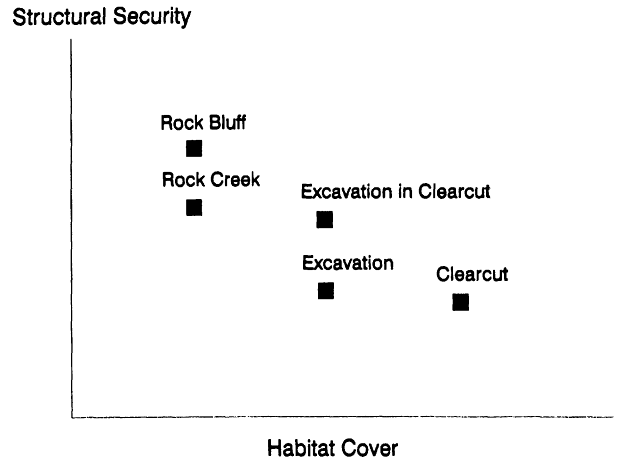

Fig. 4. Hypothetical relationship between den type, structural security, and habitat cover.

Den selection is a process where bears minimize energetic losses. Individuals that take advantage of secure den habitat minimize their exposure to severe weather and predatory disturbance. In the Arkansas Highlands, black bears use rock dens more often than other den types. While rock dens provide a high degree of cover and are located in inaccessible areas, it is not known if females denning in rock dens produce more cubs, or cubs with greater survival rates, than females denning in other den types.

MANAGEMENT IMPLICATIONS

Reduced structural security at den types can be offset by increased habitat cover, implying that habitat cover can compensate survival when structurally secure dens are not available. Long-term studies of cub production and survival by den type need to be conducted, as suggested by Hellgren and Vaughan (1989), to test this hypothesis. In areas where habitats are being modified by resource extraction and industrial development, black bear populations may experience changes or declines in denning options. Reliable information on the relationship between den-type availability and cub production and survival will be an important element of black bear management in these areas.

LITERATURE CITED

ALT, G.L. 1984. Reuse of black bear dens in northeastern Pennsylvania. J. Wildl. Manage. 48:236-239.

BEECHAM, J.J., D.G. REYNOLDS, AND M.G. HORNOCKER. 1983. Black bear denning activities and den characteristics in west-central Idaho. Int. Conf. Bear Res. and Manage. 5:79-86.

CLARK, J.D. 1988. Arkansas status report. Proc. Ninth East. Workshop on Black Bear Res. and Manage. 9:4-7.

COOK, B. 1984. Chemical immobilization of black bears in Great Smoky Mountains National Park. Proc. Seventh East. Workshop on Black Bear Res. and Manage. 7:79-81.

CROW, C.T. 1974. Arkansas natural area plan. Arkansas Dep. of Planning. Little Rock, Ark. 246pp.

GRIFFITH, B., AND B.A. YOUTIE. 1988. Two devices for estimating foliage density and deer hiding cover. Wildl. Soc. Bull. 16:206-210.

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. 1989. Denning ecology of black bears in a southeastern wetland. J. Wildl. Manage. 53:347-353.

HUGIE, R.D. 1982. Black bear ecology and management in the northern conifer/deciduous forest of Maine. Ph.D. Diss., Univ. of Montana, Missoula. 203pp.

JOHNSON, K.G. 1978. Den ecology of black bears (*Ursus americanus*) in the Great Smoky Mountains National Park. M.S. Thesis, Univ. of Tennessee, Knoxville. 107pp.

_____, AND M.R. PELTON. 1980. Prebaiting and snaring techniques for black bears. Wildl. Soc. Bull. 8:46-54.

_____, AND _____. 1981. Selection and availability of dens for black bears in Tennessee. J. Wildl. Manage. 45:111-119.

_____, D.O. JOHNSON, AND M.R. PELTON. 1978. Simulation of winter heat loss for a black bear in a closed tree den. Proc. Fourth East. Workshop on Black Bear Res. and Manage. 4:155-166.

JOHNSTON, J.E.T. 1984. Stratigraphy of the Stanley group (Mississippian) in the central Ouachita mountains of western Pushmataha County, Oklahoma. M.S. Thesis, Univ. of Arkansas. 84pp.

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. 1987. Winter denning of black bears in east-central Ontario. Int. Conf. Bear Res. and Manage. 7:305-316.

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

LEMMON, P.E. 1956. A spherical densiometer for estimating forest overstory density. For. Sci. 2:314-320.

NUDDS, T.D. 1977. Quantifying the vegetative structure of wildlife cover. Wildl. Soc. Bull. 5:113-117.

PELTON, M.R., L.E. BEEMAN, AND D.C. EAGAR. 1980. Den selection by black bears in the Great Smoky Mountains National Park. Int. Conf. Bear Res. and Manage. 4:149-151.

REINHOLD, R.O. 1969. Climates of the states: Arkansas. U.S. Government Printing Office. Washington, D.C. 18pp.

SAS INSTITUTE INC. 1985. SAS users guide: basics. SAS Inst. Inc., Cary, N.C. 1,290pp.

SCHWARTZ, C.C., S.D. MILLER, AND A.W. FRANZMANN. 1987. Denning ecology of three black bear populations in Alaska. Int. Conf. Bear Res. and Manage. 7:281-291.

SKILES, A. 1980. Arkansas climate atlas. Arkansas Energy Office. Little Rock, Ark. 93pp.

SMITH, T.R. 1985. Ecology of black bears in a bottomland hardwood forest in Arkansas. Ph.D. Diss., Univ. of Tennessee, Knoxville. 208pp.

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

VODRAZKA, F.M. 1989. Soil survey of Yell County, Arkansas. U.S. Dep. of Agric., Soil Conserv. Ser. and For. Ser. in cooperation with Ark. Agric. Exp. Stn. Washington, D.C. 163pp.

_____, F.H. STEPHENS, W.K. GODDARD, AND J.W. SPOTTS. 1969. Soil Survey of Franklin County, Arkansas. U.S. Dep. of Agric., Soil Conserv. Ser. and For. Ser. in cooperation with Ark. Agric. Exp. Stn. Washington, D.C. 96pp.

WATHEN, W.G., K.G. JOHNSON, AND M.R. PELTON. 1986. Characteristics of black bear dens in the southern Appalachian region. Int. Conf. Bear Res. and Manage. 6:119-127.