HABITAT USE BY FEMALE BLACK BEARS IN WESTERN MARYLAND

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ABSTRACT — Since receiving legal protection in 1972, Maryland's black bear (*Ursus americanus* Pallas) population has grown, and increased numbers of bear-human conflicts created a need for information on bears for management. Thus, we determined habitat use of female black bears in western Maryland by incorporating locations (n = 641) of 5 adult radio-collared bears into a geographical information system (GIS) to enable analyses of macro-habitat characteristics. Overall, bears selected mixed forest and wetlands, and habitat with high stream densities. Bears selected conifer stands throughout the year and residential areas during the spring-summer season. Variation in use of residential areas and habitat near streams appeared to be related to the availability of wetlands to individual bears. Bears avoided primary highways, but not other road classes, although females traveling with cubs selected habitat at lower road densities. To manage habitat for female black bears, we suggest maintaining wetlands and mixed forest habitats, enhancing understory cover in maturing deciduous forest, increasing conifer stands in areas where management for mature forest is unrealistic, and constructing wildlife underpasses on high-speed highways.

INTRODUCTION

In Maryland, black bears were abundant at the time of the first human settlements in the 1600s (Garner and Mathews 1992a). By 1850, uncontrolled timber harvesting and large-scale clearing for agriculture and development, compounded by a bounty, eliminated bears from all but the mountains of western Maryland. In 1954, the bounty was removed by the Maryland Department of Natural Resources (MDNR), and bears were afforded further protection in 1972 as a state threatened species. Legal protection, improved habitat, and relocation efforts in southwestern Pennsylvania enabled bears to reestablish in western Maryland (Garrett and Allegany counties). In 1985, the status of the black bear was changed to a game species with a closed season. Since

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that time, increased numbers of bear-human conflicts (i.e., damage to corn fields, beehives) resulted in a need for information on bears to manage the species (Garner and Mathews 1992a). In 1987 the population was estimated to be 150 – 170 individuals with age at primiparity of 3 years, and mean litter size of 3.1 cubs (Garner and Mathews 1992b). In 1991 cooperative research efforts were initiated between MDNR and Frostburg State University to document habitat use by female bears.

Black bears have been called a 'landscape species' (Samson and Huot 1998) because they can exploit a variety of vegetation associations that support their life requirements. They also are considered an indicator species (Pelton 2000); their presence indicates ecosystem integrity, whereas declines in distribution or numbers suggest ecosystem deterioration (Minta et al. 1999). Large geographic areas are required to accommodate large carnivores and management at the landscape level is necessary to maintain viable populations long-term (Sinclair et al. 2001). Landscape level characteristics that currently can be measured across the range of black bears include overstory vegetation, roads, streams, and areas of human activity (i.e., residential, agricultural, and mining areas). These characteristics can be used to determine habitat selection and create regional habitat-relation models for landscape indicator species like the black bear (Morrison et al. 1998). Many factors influence habitat selection by bears including abundance and distribution of food, water, and den sites, and social structure (age, sex, and reproductive status) (Rogers and Allen 1987).

Webster (1994) studied habitat use of adult female bears in western Maryland; 3 females were monitored April – December 1992, and 2 females were monitored April – August and April – June 1992. She noted the importance of deciduous forest to bears, stating that a critical percentage of forest may be required in home ranges to meet the needs of individuals. She also reported open habitats were avoided by bears, and use of habitat near streams varied, showing no particular trends. However, use of different habitats may have been masked due to grouping land use/land cover (LULC) categories for analyses because of low sample size. A subsequent analysis of habitat use by the 5 bears using Manly's Alpha selection index (Krebs 1989), indicated other habitat types (coniferous forest, wetlands, agricultural areas and reclaimed strip mines) were important to individual bears. We expanded on the research begun by Webster (1994) and examined additional habitat characteristics at bear locations. The objective of this study was to determine macro-habitat use by female black bears in western Maryland.

FIELD-SITE DESCRIPTION

Research was conducted primarily in Garrett County, Maryland. Garrett County is bordered on the north by Pennsylvania, and on the

west and south by West Virginia and the North Branch of the Potomac River, respectively. The study area was in the Allegheny Plateau district of the Appalachian Geographic Region (Fuller 1972). Elevations in the Allegheny Plateau range from 305 - 1,024 m (Webster 1994), but are generally above 457 m. Climate of Garrett County is considered humid continental (Weeks 1939), characterized by severe winters and mild to warm summers (Ahrens 1988). Mean annual precipitation was 127 cm. Mean January temperature was -1.8°C; mean maximum and minimum January temperatures were 3.9°C and -7.4°C, respectively. Mean July temperature was 19.6°C; mean maximum and minimum July temperatures were 26.6°C and 12.6°C, respectively.

The most common forest types in Garrett County were mixed oak and northern hardwood forests. Mixed oak forests consisted of pure or mixed stands of upland oaks [chestnut (*Quercus prinus* Linnaeus), northern red (*Q. rubra* Linnaeus), white (*Q. alba* Linnaeus), black (*Q. velutina* Lamarck), or scarlet (*Q. coccinea* Muenchhausen)]; associated tree species could be any timbered tree in the region. Northern hardwood forests were dominated by sugar maple (*Acer saccharum* Marsh), but could contain birch spp. (*Betula spp.*), American beech (*Fagus grandifolia* Sweet), American basswood (*Tilia americana* Linnaeus), black cherry (*Prunus serotina* Ehrhart), or other hardwoods. Other forest stand types included eastern hemlock (*Tsuga canadensis* Linnaeus), hardwood-hard pine (*Pinus* spp.), cove hardwoods, red maple (*A. rubrum* Linnaeus), black locust (*Robinia pseudo-acacia* Linnaeus), mixed hard pines, hardwood-white pine (*Pinus strobus* Linnaeus) and plantations. Forests were predominantly second-growth, and were 70 - 90 years old. Understory trees and shrubs included rhododendron (*Rhododendron maximum* Linnaeus), pink azalea (*R. nudiflorum* Michaux), mountain laurel (*Kalmia latifolia* Linnaeus), witch hazel (*Hamamelis virginiania* Linnaeus), dogwood (*Cornus alternifolia* Linnaeus), serviceberry (*Amelanchier arborea* Michaux), sassafras (*Sassafras albidum* Nuttall),and striped maple (*A. pensylvanicum* Linnaeus). The county contained 2 state forests, Savage River State Forest (82.5 km^2) and Potomac Garrett State Forest (27.4 km^2; Maryland Forest and Park Service 1992).

METHODS

Habitat selection was determined by analyzing landscape characteristics [e.g., LULC classes, proximity to roads and streams, and road and stream densities] at locations of 5 adult female black bears. Prior to our study, MDNR captured 4 female bears (#81, #14, #19, and #262) and instrumented them with radio-collars (Telonics, Mesa, AZ) using capture and immobilization techniques described in Webster (1994); bears were aged based on cementum annuli analysis (Willey 1974). We moni-

tored 3 bears (#s 81, 19, and 14; ages 8.5, 6.5, and 9.5 respectively) from shortly after den emergence (May) to den entrance in 1993 and 1994, and 2 bears (#s 262 and 267; ages 8.5 and 3.5 respectively) for 1 year each during that time. Bear #262 "slipped" her radio-collar during the winter of 1993-94 and was not monitored in 1994. However, bear #267 was captured by MDNR during November 1993 and we began monitoring her movements in May 1994. Bears #81, #14, and #19 were previously monitored in 1992 by Webster (1994). Our methods of radio-tracking and use of GIS to enable statistical analyses were similar to Webster (1994). We obtained locations of radio-collared black bears during daylight hours primarily with ground radio-telemetry techniques using a Telonics TR-2 receiver/scanner unit, an omni-directional antenna, a 2-element directional Yagi antenna, and headphones (Telonics, Mesa, AZ). Ground locations were determined remotely from triangulation of a minimum of 3 compass azimuths (see Quigley 1982 and Webster 1994). Telemetry error using this methodology was approximately 150 m (Webster 1994). By placing locations within 300-m diameter error circles we offset telemetry error, increasing the probability that the actual locations were accurately represented. We attempted to locate study animals 2-3 times per week. If a bear could not be located for 2 to 3 days, MDNR conducted aerial radio-tracking (Webster 1994) to determine its location. Ground and aerial locations were plotted on U.S. Geological Survey 7.5-minute topographic maps.

We used bear locations to determine annual indices of habitat selection in 1993 and 1994. Spring-summer indices were determined from locations obtained 24 May – 26 August 1993 and 15 May – 26 August 1994. Fall indices were determined from locations obtained 12 September until the bears denned; fall was separated from spring-summer seasons by a transition period (27 August – 11 September) when bears shifted their diet from soft to hard mast (Webster 1994).

We digitized triangulated bear locations into a GIS (PC ARC/Info, Environmental Systems Research Institute, Inc., Redlands, CA) from topographic maps. We imported database files containing coordinates of locations into a second GIS (Map and Imaging Processing System (MIPS); MicroImages, Inc., Lincoln, NE), and generated annual and seasonal home-range estimates using the minimum convex polygon method (MCP; White and Garrott 1990). Because MCP home-range estimates can include area outside true home ranges, MIPS allows users the option of generating home ranges using a modified MCP estimator using intermediate points to construct home-range boundaries. We used a modification factor of 0.5 so that the longest side of the polygon equaled one-half the greatest distance between the two most distant locations. Home ranges were subsequently converted back into ARC/Info coverages for analyses.

We assessed habitat use versus availability for female black bears using a digital LULC map (Maryland Office of Planning). We defined habitat use as the proportion of habitat types within 300-m diameter error circles surrounding bear locations; habitat availability was defined as the proportion of each LULC type within home-range polygons. We determined annual and seasonal habitat selection of female bears using Program Prefer (Northern Prairie Science Center, Jamestown, North Dakota) that calculates Johnson's (1980) rank selection index. The program ranked the proportions of habitats used by bears and those available within home ranges and used the difference in ranks to determine a relative selection index; significant differences among selected habitats were calculated using the multiple comparison procedure of Waller and Duncan (1969). We pooled some LULC categories for analyses because significant differences could not be measured unless the number of bears was equal to or greater than the number of habitats. Our sample size was 4 bears in 1993 and 4 in 1994, totaling 8 bear years. We combined brush and extractive habitats (primarily reclaimed strip mines) into one category, representing early successional habitats. We grouped cropland, pasture, orchards, and agricultural buildings into a category designated agriculture, and low-density residential, medium-density residential, high-density residential, and open-urban land into a category designated residential. Habitat selection of bears within years was determined using Manly's (1972) Alpha measure of selection. Manly's Alpha measures the probability that a particular habitat is selected when all habitats are equally available, although it does not distinguish significant differences among selected habitats (Krebs 1989).

We determined influences of roads and streams on habitat selection by black bears by comparing distances of triangulated and random locations to the nearest road and stream segments (U.S.G.S. Digital Line Graph files, U.S. Department of the Interior). Five classes of roads were identified: Class 1, all-weather, hard-surface, primary highways; Class 2, all-weather, hard-surface, secondary highways; Class 3, all-weather, improved surface, light-duty roads; Class 4, unimproved roads; and Class 5, off-road vehicle (ORV) and hiking trails.

We used the Wilcoxon-Mann-Whitney test for 2-sample populations (Dowdy and Wearden 1991, Zar 1999) to test the null hypothesis that bears were located at random distances to roads and streams. Tests were conducted using bear locations and an equal number of random points in bear home ranges. In addition, we calculated stream and road densities/ 1.0-km^2 circular areas surrounding bear and random locations, and used Wilcoxon-Mann-Whitney tests to test the hypotheses that bears selected habitat with relatively high stream and low road densities. We used $P < 0.10$ as the criterion for statistical significance for analyses of habitat use because our sample size was low, which reduced statistical power and increased the probability of Type 2 errors.

RESULTS

We obtained 641 locations for 5 adult female black bears during 1993 (mean = 2.3/week) and 1994 (mean = 2.9/week); 597 locations (93%) were from ground telemetry, 23 (4%) from sightings, and 21 (3%) from aerial telemetry. Three hundred and fifty locations were used to determine spring-summer indices of selection and 235 locations were used to determine fall indices. Fifteen of the 20 LULC types in Garrett County, Maryland were identified in home ranges of the 5 bears (Table 1). Black bears selected mixed forest and wetland habitats annually (P = 0.05; Table 2), although these habitats were not the most abundant habitats in

Table 1. Land use/land cover (LULC) classes in Garrett County, Maryland. LULC classes within home ranges of black bears are denoted by *. To enable analyses of habitat selection (Johnnson 1980) LULC categories were grouped. Categories denoted by an "A" were combined into one category designated brush/extractive; categories denoted by a "B" were combined into one category designated agriculture; and categories denoted by a "C" were combined into one category designated residential.

LULC classes	Classification definitions
Deciduous forest *	Forested areas in which the trees characteristically lose their leaves at the end of the growing season.
Conifer forest *	Forested areas in which the trees are characterized by persistent foliage throughout the year.
Mixed forest *	Forested areas in which neither deciduous nor conifer species dominate, but in which there are a combination of both types.
Brush * A	Areas which do not produce timber or other wood products, but may have cut-over timber stands, abandoned agriculture fields or pasture. These areas are characterized by vegetation types such as sumac, vines, rose, brambles, and tree seedlings.
Wetlands*	Forested or non-forested marshes, upland swamps, and wet areas.
Cropland *B	Field crops and forage crops.
Pasture *B	Land used for pasture, both permanent and rotated; grass.
Orchards/vineyards/horticulture*B	Areas of intensively managed commercial bush and tree crops, including areas used for fruit production, vineyards, sod and seed farms, nurseries, and green houses.
Agricultural building * C	Agricultural building, breeding and training facilities, storage facilities, built-up areas associated with a farmstead, small farm ponds, commercial fishing areas.
Low-density residential *C	Detached single-family/duplex dwelling units, yards and associated areas. Areas of more than 90% single-family/duplex dwelling units, with lot sizes of less than five acres but at least one-half acre (0.2 dwelling units/acre to 2 dwellings/acre.
Medium-density residential *C	Detached single-family/duplex, attached single-unit row housing, yards, and associated areas. Areas of more than 90% single-family/duplex dwelling units and attached single-unit row housing, with lot sizes of less than one-half acre, but at least one-eighth acre (2 dwelling units/acre to 8 dwelling units/acre).

home ranges of any of the bears (Table 3). In fact, mixed forest was least abundant in the home range of bear #81, and wetlands were least abundant and did not occur in home ranges of bears #14 and #19, respectively. Deciduous forest was the most abundant habitat type available to all bears (Table 3) and was used in proportion to availability, but selected less than mixed forest (Table 2). Conifer forest was selected equally to all habitat types (Table 2); however, individual selection of this habitat varied seasonally and annually (Table 4). Open habitats and those most altered by humans, including brush/extractive, agriculture, and residential areas, were selected less than forested habitats (Table 2). In spring-summer, residential areas were selected in addition to mixed forest and wetlands; conifer and agricultural habitats were avoided at this time. During fall, selection indices overlapped extensively.

Table 1, continued.

High-density residential *C	Attached single-unit row housing, garden apartments, high-rise apartments/condominiums, mobile homes, and trailer parks. Areas of more than 90% high-density residential units, with more than eight dwelling units per acre.
Commercial	Retail and wholesale services. Areas used primarily for the sale of products and services, including associated yards and parking areas.
Industrial	Manufacturing and industrial parks, including associated warehouses, storage yards, research laboratories, and parking areas.
Institutional	Elementary and secondary schools, middle schools, junior and senior high schools, public and private colleges and universities, military installations (built-up areas only, including buildings and storage, training, and similar areas), churches, medical and health facilities, correctional facilities, and government offices and facilities that are clearly separable from the surrounding land cover.
Extractive *B	Surface mining operations, including sand and gravel pits, quarries, coal surface mines, and deep coal mines. Status of activity (active vs. abandoned) is not distinguished.
Open urban land *C	Urban areas whose use does not require structures, or urban areas where non-conforming uses characterized by open land have become isolated. Included are golf courses, parks, recreational areas, (except areas associated with schools or other institutions) cemeteries, and entrapped agricultural and undeveloped land within urban areas.
Large-lot subdivision (forest)	Residential subdivisions with lot sizes of less than 20 acres but at least 5 acres, with a dominant land cover of deciduous, evergreen, or mixed forest.
Large-lot subdivision (agriculture)	Residential subdivisions with lot sizes of less than 20 acres but at least 5 acres, with a dominant land use being agriculture (e.g., cropland, pasture).
Water *	Rivers, waterways, reservoirs, and ponds.

Black bears that selected wetland habitats (bear #81 in 1993 and 1994; bear #267 in 1994) did not use residential areas even though these areas were available to them (Table 4). Bears with young cubs (bears #14 and #19 in 1994) that did not select wetland habitats selected residential areas during the spring/summer season; bear #262 also did not select wetland habitats the year she was monitored and selected residential areas during the spring/summer season.

Black bears selected habitat with relatively high stream densities (n = 8, z = 1.68), but distances of bear locations to streams were not different (P = 0.10) from random locations annually, during spring-summer, or fall (n = 8, z = 1.58, 1.58, and 1.05, respectively). Bears #14 and #19 selected habitat near streams the year they were traveling with cubs (#14 in 1994, z = 3.98; #19 in 1994, z = 3.78); bear #81 selected against habitat near streams both years monitored (#81 in 1993, z = 3.79; #81 in 1994, z = 2.57); and bear #262 selected habitat near streams the year she was monitored (1993, z = 1.68). Mean density of streams in annual home ranges of the 5 females was 0.75 km/km^2 (0.52 - 0.90 km/km^2).

Black bears in this study did not select or avoid (P = 0.10) habitat near Class 2, 3, 4, and 5 roads (class 2, 3, and 4: n = 8, z = 1.37, 0.84, 0.11, respectively; class 5: n = 6, z = 0.80). Class 1 roads (primary highways) were not analyzed statistically because they did not occur in 5 of the 8 annual bear home ranges (Fig. 1). Road densities (classes 2-5) around bear locations were not different (P = 0.10) from random locations overall (n = 8, z = 0.46). However, the 3 bears monitored for 2 years selected areas with lower road densities the year they were traveling with cubs (#14 in 1994, z = 2.13; #19 in 1994, z = 1.82; and #81 in 1993, z = 2.92); class 1 roads did not occur in annual home ranges of females with cubs. Mean road density in annual home ranges of bears (n = 8) was 1.14 km/km^2 for all road classes, 0.76 km/km^2 for improved roads (Classes 1-3), and 0.37 km/km^2 for unimproved roads and ORV

Table 2. Rank of annual and seasonal habitat selection by female black bears in western Maryland (n = 8) during 1993 and 1994 using Johnson's (1980) Rank Preference Index. Lowest mean difference in ranks indicates the most selected habitat (rank = 1). Different letters denote significant differences (P < 0.05) between selection indices. Example: Annually, mixed forest was selected more than deciduous, agriculture, brush/extractive, and residential habitats; mixed forest was not selected more or less than wetland and conifer habitats.

	Annual			Spring/Summer			Fall		
	Tbar *	Rank		Tbar *	Rank		Tbar *	Rank	
Residential	0.375	6	BCD	- 0.313	3	AB	- 0.375	1	A
Brush/Extractive	0.250	5	CD	0.125	5	BCD	0.688	7	B
Agriculture	0.875	7	D	0.750	7	D	0.0625	6	AB
Deciduous Forest	0.000	3	BC	0.000	4	BC	0.000	4	AB
Conifer Forest	0.000	4	ABCD	0.625	6	CD	0.000	5	AB
Mixed Forest	- 0.875	1	A	- 0.625	1	ABC	- 0.250	2	AB
Wetland	- 0.625	2	AB	- 0.563	2	A	- 0.125	3	A

* Mean difference in ranks.

Table 3. Percent of habitat used and available (in parentheses) annually (1993-1994) for 5 adult female black bears in western Maryland.

LULC	Bear #14 1993	Bear #14 1994	Bear #19 1993	Bear #19 1994	Bear #81 1993	Bear #81 1994	Bear #262 1993	Bear #267 1994
Residential	0.00 (0.21)	0.00 (0.21)	1.11 (1.93)	1.60 (1.2)	0.11 (0.78)	0.80 (1.61)	0.52 (0.70)	1.39 (2.40)
Brush/Extractive	9.95 (13.15)	8.10 (13.21)	17.49 (22.75)	14.59 (26.67)	9.03 (6.73)	6.44 (5.52)	8.55 (12.12)	0.80 (2.41)
Agriculture	8.6 (14.19)	5.84 (17.64)	3.03 (11.24)	6.71 (11.51)	3.71 (15.64)	12.35 (31.93)	14.25 (20.52)	4.76 (5.19)
Deciduous Forest	76.04 (63.26)	68.64 (61.31)	73.92 (60.65)	68.36 (57.92)	78.50 (72.45)	76.14 (60.29)	48.83 (46.39)	69.36 (71.50)
Conifer Forest	1.63 (4.28)	3.74 (3.33)	4.02 (1.82)	0.18 (1.51)	0.71 (2.49)	0.96 (2.49)	9.35 (3.10)	1.02 (1.25)
Mixed Forest	3.78 (4.82)	13.69 (4.21)	0.44 (1.61)	8.55 (1.24)	0.40 (0.22)	1.09 (0.54)	12.97 (9.21)	11.0 (11.25)
Wetland	0.00 (0.06)	0.00 (0.10)	0.00 (0.00)	0.00 (0.00)	7.45 (1.70)	2.22 (1.27)	5.52 (7.95)	11.65 (6.10)

Table 4. Seasonal habitat selection for 5 adult female black bears in western Maryland using Manly's (1972) alpha. Alpha values measure the probability of selecting an individual habitat type when all habitat types are equally available (Krebs 1989). Habitats with values greater than Manly's alpha are selected (denoted by *) and habitats with values lower, are avoided.

	Bear #81 1993 alpha values			Bear #81 1994 alpha values			Bear #262 1993 alpha values			Bear #267 1994 alpha values		
	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall
Residential	0.015	0.015	——	0.067	0.092	——	0.089	0.439 *	——	0.089	0.143	0.019
Brush/Extract.	0.144 *	0.097	0.309 *	0.156 *	0.136	0.229 *	0.085	0.067	0.143	0.051	0.076	0.000
Agriculture	0.026	0.017	0.000	0.052	0.078	0.113	0.084	0.095	0.055	0.141	0.035	0.721 *
Deciduous	0.117	0.108	0.106	0.169 *	0.121	0.184 *	0.127	0.070	0.318 *	0.149 *	0.123	0.071
Conifer	0.031	0.069	0.000	0.052	0.048	0.179 *	0.363 *	0.002	0.438 *	0.126	0.000	0.160 *
Mixed	0.196 *	0.227 *	——	0.270 *	0.444 *	0.000	0.169 *	0.212 *	0.046	0.150 *	0.204 *	0.030
Wetland	0.472 *	0.466 *	0.585 *	0.234 *	0.081	0.294 *	0.084	0.115	0.000	0.294 *	0.419 *	0.000
Manly's Alpha	0.143	0.143	0.200	0.143	0.143	0.167	0.143	0.143	0.167	0.143	0.143	0.143

	Bear #14 1993 alpha values			Bear #14 1994 alpha values			Bear #19 1993 alpha values			Bear #19 1994 alpha values		
	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall	Annual	Spring/Summer	Fall
Residential	0.000	——	0.000	0.000	0.833 *	——	0.108	0.028	0.406 *	0.125	0.522 *	0.228 *
Brush/Extract.	0.203 *	0.172	0.301 *	0.095	0.028	0.127	0.145	0.123	0.151	0.051	0.122	0.011
Agriculture	0.162 *	0.186	0.122	0.051	0.014	0.077	0.051	0.047	0.065	0.055	0.090	0.077
Deciduous	0.322 *	0.279 *	0.368 *	0.174 *	0.039	0.157	0.229 *	0.258 *	0.218 *	0.111	0.237 *	0.063
Conifer	0.102	0.100	0.210 *	0.174 *	0.038	0.122	0.416 *	0.452 *	0.003	0.011	0.030	0.000
Mixed	0.210 *	0.262 *	——	0.505 *	0.048	0.516 *	0.051	0.092	0.156	0.647 *	——	0.620 *
Wetland	0.000	——	——	0.000	0.000	——	——	——	——	——	——	——
Manly's Alpha	0.143	0.200	0.200	0.143	0.143	0.200	0.167	0.167	0.167	0.167	0.200	0.167

and hiking trails (Classes 4-5). Mean road density in annual home ranges for females traveling with cubs (n = 3) was 0.66 km/km^2 for improved roads (Classes 2-3) and 0.37 km/km^2 for unimproved roads and ORV and hiking trails (Classes 4-5).

DISCUSSION

Despite small sample sizes, our results established baseline data on Maryland's black bears from which additional hypotheses can be made and tested. In addition, our findings were similar to those documented for populations of bears in other states. Year-round, wetlands and mixed forest with high stream densities were selected by female bears in Maryland. These habitats provide bears important seasonal foods (i.e., soft and hard mast) (Costello 1992, Quigley 1982), water for consumption and thermoregulation in hot weather (Rogers and Allen 1987), and concealment cover while traveling (Elowe 1984). In addition, their structural components (e.g., dense understory and large dead and downed wood and slash piles) provide resting and winter den sites to bears (Elowe 1984, Kasbohm et al. 1996). Mixed hardwood forests and forested wetlands or riparian areas are used by black bears throughout their range in eastern forests [i.e., Massachusetts (Elowe 1984); New Hampshire (Meddleton and Litvaitis 1990); Virginia/North Carolina (Hellgren et al. 1991); Tennessee (Quigley 1982); New York (Costello and Sage 1994); Maine (Hugie 1982), and Pennsylvania (Kirkland and Serfass 1989].

Mixed forest was selected over deciduous forest, likely because of its conifer component, which afforded black bears additional escape, concealment, and thermal cover. For example, in Massachusetts, bears being chased by hounds preferred to escape by climbing mature conifer trees (white pine and eastern hemlock; Elowe 1984). In addition, in

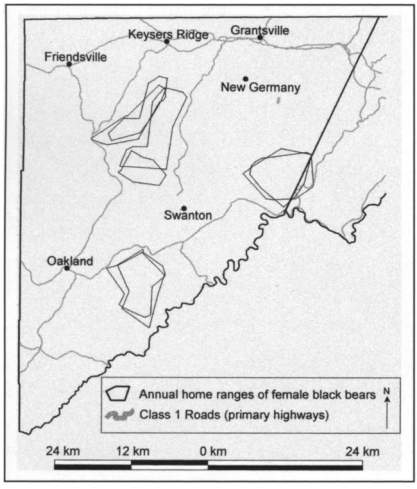

Figure 1. Eight annual home ranges (polygons) of female black bears in relation to class 1 roads (primary highways) in Garrett County, Maryland.

Minnesota, females with young cubs selected daybeds at the base of mature white pine trees where the cubs could easily climb the strong, furrowed bark of the trees to escape danger (Rogers and Lindquist 1992). Mature white pines with their large branches provided safety for entire families, and offered bears concealment cover and thermal cover when temperatures were warm (Rogers and Lindquist 1992).

Conifer stands were important to female black bears throughout the year. We observed study animals on several occasions using dense pole-size conifer stands. Bear #81 was located in a conifer stand on 27 June 1994 and observed on 20 July 1994 exiting a conifer stand and subsequently crossing a road. Bears #14 (on 1 October 1993, 26 May, 28 July, and 20 November 1994, and 21 January 1995) and #19 (on 9 June1993, and 17 June, 23 July, and 13 November 1994) were located in conifer stands. Bear #14 and her 2 cubs were located 3 different times in the same white pine stand. Adjacent food sources during the year included skunk cabbage (*Symplocarpus foetidus*), blueberry (*Vaccinium* spp.), raspberry (*Rubus* spp.), black cherry, crab apples (*Pyrus* spp.), acorns, and corn (*Zea mays*). In 1994, bear #14 and her 2 cubs denned in the stand. We hypothesize that bears are adapting to the current landscape in Maryland by selecting dense pole-size conifer stands for concealment and thermal cover. Maryland's forests are predominantly second-growth and are relatively young. Thus, the expansive rhododendron understory that historically provided bears cover in old-growth eastern deciduous forests is rare.

Black bears in Maryland may be increasing their use of riparian areas in mixed forest to compensate for a lack of, or to substitute, wetland habitats. Two bears that had little (#14) or no (#19) wetlands available to them increased their use of habitats near streams annually, the year they had cubs. We speculate that females selected dense riparian vegetation to conceal their cubs; bear #14 and her cubs were well-concealed in dense riparian vegetation within mature mixed forest 2 of the 6 times (29 June and 20 August 1994) that we observed her visually. In addition, bear #262 had wetlands available to her, but did not select this habitat type and instead selected habitat close to streams annually. We located this bear 22 km from her capture site in October 1992, and she may not have established a new home range when monitored in 1993. It is possible the bear was using lower-quality habitat due to intrasexual encounters in this protected population. Hirsch et al. (1999) observed occasional antagonistic encounters of female bears in Michigan. Bear #262 was located within about 320 m of another bear traveling with cubs (#81) on 23 June 1993 and did not remain in this bear's home range. Bear #262 also made at least 2 extensive movements outside her range in 1993, one during spring and another in late summer.

Black bears avoided habitats that were associated with the presence of humans. In fact, 5 of the LULC categories associated with the highest

human activity (commercial, industrial, institutional, large-lot subdivision-forest, and large-lot subdivision-agriculture) did not occur in the home ranges of any bears, perhaps indicating selection at the home-range level. Bears did select residential areas during the spring-summer seasons. When examined individually, however, 2 bears that used wetlands (#81 and #267) did not select residential areas. Wetlands provide some of the first foods available to bears in early spring such as skunk cabbage and grasses (Elowe 1984). Bears unable to exploit wetlands may seek foods in residential areas to supplement their diet. Moreover, hard mast abundance during the fall season may supply foods to bears emerging from their dens the following spring (Costello 1992). Mast crops in Garrett County were rated as "mast failures" in 1992 and "poor and spotty" in 1993 (Maryland Department of Natural Resources mast crop surveys 1992, 1993). It is possible that a combination of limited wetland use in conjunction with low fall hard-mast abundance resulted in individual animals selecting residential areas during the spring-summer seasons for foods. During a 4-year period (1990-1994), 36% of nuisance bear complaints (n = 103) reported by MDNR were attributed to bears upsetting garbage cans, damaging bird feeders and other general disturbances in residential areas (MDNR Nuisance Bear Reports 1990-1994); most complaints occurred during spring.

Black bears selected all habitats including residential and agricultural areas during fall. During this season female bears engage in hyperphagic behavior to gain weight before entering winter dens (Schooley et al. 1994). Female bears in this study likely exploited whatever food sources were available to them at this time.

Class 1 roads (primary highways) bordered home range boundaries and were avoided by female bears. In 2 years, we documented only 1 incident of bear #81 crossing beneath State Route 219 along a tributary of Deep Creek Lake, and 2 incidents of bear #19 crossing under State Route 36 likely through a culvert (see Webster 1994). Class 1 roads did not occur in the home ranges of 3 bears, although portions of home-range boundaries averaged 458 m from these roads. Moreover, year-round, female bears in this study traveled an average of 2.2 km/day (straight-line consecutive daily movement data, n = 276). Thus, the study animals could have crossed class 1 roads as frequently as they crossed other road classes if they had chosen to do so. Other studies have found that bears generally avoid 4-lane and interstate highways (Beringer et al. 1989, Fies et al. 1987, and Hellgren et al. 1991). High-speed highways may act as barriers to dispersal and population sinks (Hellgren and Maehr 1992, Paquet and Hackman 1995).

Class 2, 3, 4, and 5 roads did not impede bear movements and female black bears did not select habitat with low road densities. Carr and Pelton (1984) found that bears used habitat adjacent to, and readily crossed, logging roads and lightly-traveled paved roads (<100 vehicles per day).

Roadside margins create forest openings that are used as travel corridors by bears and promote growth of early successional vegetation on which black bears feed (Hellgren et al. 1991). The proximity of bear locations to trails and logging roads was noted by Brody (1984), Meddleton and Litvaitis (1990), and Quigley (1982). However, when analyzed individually, 3 females selected habitat at lower road densities when they traveled with cubs. Mean road densities of logging roads and ORV trails for these females was the same as the overall average; however, densities were lower for improved road classes. Perhaps females avoid more-traveled road classes when they have cubs. Young and Beecham (1980) reported female bears avoided roads in Idaho, however, they did not note reproductive status of the bears.

MANAGEMENT IMPLICATIONS

Black bears in Maryland used the landscape available to them to meet their needs. Bears that did not have access to wetlands increased their use of riparian areas in mixed forest habitats. Riparian areas in mixed forests are important to bears, but do not provide bears seasonal foods found in wetlands. Bears that select habitat with limited or no wetlands may be more likely to travel into residential areas to find food, increasing the potential for human-bear conflicts, especially during the spring season following years of low hard-mast abundance. In addition, female bears used pole-size conifer stands for concealment and thermal cover, perhaps as an adaptation to the absence of the historical old-growth forests with dense understory vegetation used by this species.

To conserve habitat for black bears, land managers could maintain mature mixed forest and wetland habitats. In areas where development will not permit the maintenance of mature forests, conifer stands could be planted for cover. Efforts also could focus on increasing cover in maturing deciduous forest (i.e., replanting or encouraging growth of rhododendron thickets, and native shrubs and conifer spp.,), which occupied the greatest area in home ranges of all females in this study. State forests, transmission lines, and reclaimed strip mines are lands in western Maryland that could be enriched to enhance habitat for black bears.

Road density has been factored into management plans for populations of large carnivores to minimize disturbance and habitat fragmentation. Gallatin National Forest in Montana initiated an open-road-density (ORD) standard of 0.31 km/km^2 to maintain a habitat for grizzly bears (*Ursus arctos*) and other big game (Paquet and Hackman 1995). Brody (1984) suggested that logging road densities >1.25 km/km^2 and open, improved roads at densities >0.5 km/km^2, may restrict bear movements. Data from our study indicate that 5 female bears can exist in habitat with a mean ORD of 1.14 km/km^2; females with young may require lower road densities. An ORD standard for bears in the eastern

United States should be determined, and guidelines for future road construction should include and adhere to ORD standards. Bears in unhunted populations in the eastern United States have been reported to avoid roads less than those of hunted populations (Hellgren and Maehr 1992). Bears in Maryland have been protected since 1954 and our results support this notion. However, hunted populations of bears may require lower road densities, and managers should be aware that bear behavior may change if bear hunting becomes legal in Maryland; habitat currently suitable for black bears due to their decreased fear of humans may become less suitable in the future.

Our study indicated that primary highways may be limiting female black bear movements in western Maryland. Long-term conservation strategies should focus on high-speed highways and the construction of wildlife underpasses to enable dispersal of yearlings, decrease mortality, and ultimately maintain genetic diversity of the species. The majority of vehicle collisions with bears in western Maryland occur on primary highways; most collisions are with male bears. Research in Florida has shown that bears will use underpasses if they are placed advantageously (Foster and Humphrey 1995), thereby decreasing the probability of bear-vehicle collisions.

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