Effects of Vegetation Composition and Land-use Variables on Bait Station Visitations by Black Bears

Darren A. Miller, *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

Harry A. Jacobson, *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

Bruce D. Leopold, *Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762*

Abstract: Bait stations have proven effective in monitoring black bear (*Ursus americanus*) population changes. However, little research has been conducted to investigate influences of habitat characteristics on bait station visitations. Vegetation (N = 20) and land-use (N = 3) variables were evaluated at bait stations visited (N = 27) and not visited (N = 25) by black bears on 2 islands in Arkansas. Overstory, midstory, and understory vegetation composition were assessed by nested circular plots centered on bait stations. Distance to nearest road and type and time since last timber harvest also were recorded for each site. Vegetative composition between visited and not visited bait stations did not differ (MRPP, P = 1.00) indicating that site-specific variables measured had no influence on probability of a bait station being visited.

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The American black bear (*Ursus americanus americanus*) and Louisiana black bear (*U. a. luteolus*) are listed as endangered in Mississippi (Miss. Mus. Nat. Sci. 1990). The Louisiana subspecies is listed as federally threatened (U.S. Dep. Int. 1991). Loss of bottomland hardwood forests in the Mississippi Alluvial Valley (MAV) is believed to be the primary threat to black bears in this region. The unknown status of remaining MAV bear populations makes it imperative that they are monitored.

Studies in the Southern Appalachian Region have used bait stations for monitoring black bear populations since 1980 (Carlock et al. 1983, Carlock 1986, Johnson 1992) and Miller (1993) investigated this technique within the MAV. However, the possible influence of site-specific habitat structure on visitation rates was not considered.

Teunissen Van Manen (1990) in North Carolina and Carlock (1986) in north Georgia investigated effects of several habitat variables on bait station visitation rates. Carlock (1986) found variation in visitation rate from forest type, road type, and microsite type (i.e., ridgetop, gap, etc.). However, his results were confounded by elevational effects. Teunissen Van Manen (1990) reported differences in visitation rates from distance to roads, distance to trails, and elevation. He stated that visitation rate differences by road type may have been influenced by other variables.

Smith (1985), on the White River National Wildlife Refuge (WRNWR) in Arkansas, determined that black bear movements were related to seasonal food availability. Clark et al. (1993) defined seasons based on major dietary shifts for a black bear population in the Ozark Mountains of Arkansas. Food availability related to different vegetation associations may cause disproportionate habitat use, thus affecting probability of black bears visiting particular bait stations. Therefore, we investigated influence of site-specific vegetation composition and land use characteristics on bait station visitation rates by black bears on Big Island and Montgomery Island, Arkansas.

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Methods

Study Area

The study area was Big and Montgomery Islands, Arkansas, and was chosen because of known bear presence. They were located 3 km west of Rosedale, Mississippi, in Desha County, Arkansas, and comprised 2,429 ha and 12,955 ha, respectively. Montgomery Island was bordered on the east, north, and south by the Mississippi River and on the west by the Old White River Chute. Big Island, on its eastern edge, was separated from Montgomery Island by the Old White River Chute, to the south and west by the Arkansas River, and to the north by the White River. Bears readily traverse these waterways (Smith 1985, T. White, Miss. State Univ., Dep. Wildl. and Fish., pers. commun.).

Dominant overstory species on Montgomery Island were green ash (*Fraxinus pennsylvanicus*), American elm (*Ulmus americanus*), and sugarberry (*Celtis laevigata*). Dominant overstory species on Big Island were pecan (*Carya illinoensis*), bald cypress (*Taxodium distichum*), oak (*Quercus* spp.), green ash, and sugarberry. Common understory species on both areas included persimmon (*Diospyros virginiana*), dogwood (*Cornus* spp.), sassafras (*Sassafras albidum*), and swamp privet (*Forestiera acuminata*). Montgomery Island was used for hunting with limited human activity during summer. Big Island, owned by Anderson-Tully Company, is used for timber production and leased to hunting clubs. Summer use is primarily restricted to logging activity.

Vegetation Classification

We divided overstory, midstory, and understory species into 2 groups: those species important to black bears and those species not important to black bears. Species were considered important if they were a recognized black bear food species. As demonstrated previously, summer movements of black bears within the MAV were dictated by food availability and was the impetus for our classification. Smith (1985) reported his results from WRNWR, which bordered our study area to the north. Classifications as a food species was based on available literature from this region (Black Bear Conserv. Comm. 1990, Weaver et al. 1990, Smith 1985). The only exception to this classification was for switchcane (*Arundinaria gigantea*). Although switchcane is eaten by black bears in this area, it is primarily an important cover species. Consequently, we classified switchcane as an "important" (i.e., food) species.

Bait Station Survey

Collection of data from sample plots coincided with research to evaluate bait station indices as a population monitoring technique for black bear in the MAV (Miller 1993). Bait stations were classified as visited or not visited following Miller (1993). All sample plots were evaluated once between the last 2 weeks of June and the first week of August. A station was classified as visited if at least 1 bear visit occurred from May-August 1993.

Vegetation Sampling

We centered sample plots ($N = 52$) at bait stations placed systematically at 0.8 km intervals along roads (Miller 1993). We quantified overstory, midstory, and understory species composition using a 0.04-ha circular plot in a nested plot design (Noble and Murphy 1976, White 1986). Presence or absence of bear food species was recorded without regard to number of occurrences within each plot.

We sampled understory vegetation ($\leq$1 m high) using a 0.0004-ha subplot within the 0.04-ha plot (Noble and Murphy 1976, White 1986). We estimated percent ground cover ocularly with the midpoint of each 10% bracket recorded (Noble and Murphy 1976). We also recorded total number of understory species within each plot.

We sampled midstory vegetation on a 0.004-ha subplot within the 0.04-ha plot (White 1986). We defined midstory vegetation as between 1.0 to 3.0 m high and/or $\leq$10 cm diameter at breast height (dbh) and classified by height (Mueller-Dombois and Ellenberg 1974:95). We recorded number and height of midstory species.

We sampled overstory vegetation, defined as $\geq$10 cm DBH, on 0.04-ha plots and classified by dbh (Mueller-Dombois and Ellenberg 1974:94). We estimated percentage canopy cover using a spherical densiometer. Additionally, we recorded number and basal area of overstory species.

We used the Shannon Index to estimate tree diversity at the overstory, midstory, and understory levels. We also recorded total number of species within each plot. We measured distance to nearest road (m) from plot center, time since last timber operation at each bait site and type of harvest (selection cut, selection cut followed by tree injection, group selection followed by tree injection, and group selection). These variables were included because they represent disturbances to natural habitat characteristics and therefore may influence plant species composition. Such disturbed areas may influence black bear movement patterns. Additionally, roads may influence visitation rates to bait stations (Carlock 1986, Teunissen Van Manen 1990).

Statistical Analysis

Twenty-three variables were quantified (Table 1). We classified 10 variables (number of overstory, midstory, and understory bear food and other species; height of midstory bear food and other species; and basal area of overstory bear food and other species) by whether they were bear food species.

We performed statistical analysis in 2 phases. A correlation matrix was developed and the least significant variable from variable pairs with $r > 0.4$ was excluded from further analyses to reduce multicollinearity (Brennan et al. 1986). Multicollinearity inflates R^2 values, thus giving models the appearance of accounting for more variability than in actuality. We used multivariate analysis with Multiple Response Permutation Procedure (MRPP) (Biondini et al. 1988, Reich et al. 1990, Potvin and Roff 1993) to test for differences between visited and not visited bait station vegetative and land-use characteristics based on remaining independent variables.

The test statistic in MRPP (Delta) is derived by comparing differences between intra-group Euclidean distances and inter-group Euclidean distances (Slauson et al. 1991). Individual P values are not computed for each variable. We also developed a logistic regression model to predict visitation as a function of independent variables. Logistic regression is a robust multivariate technique that is designed to analyze data with a binomial response variable (i.e., visited or not visited) (Press and Wilson 1978). This provided P values for each variable and used a more traditional analysis procedure to compare MRPP results with. Statistical tests were considered significant when $P \leq 0.05$.

Results

Of the 52 bait stations established on the study area, 27 bait stations were visited and 25 not visited. Fifteen species groups within vegetation plots were classified as food species (Table 2). Twenty-three variables were included for correlation analysis (Table 1). After least significant variables of correlated pairs were eliminated, 9 variables remained for analysis with MRPP and logistic re-

Table 1. Vegetation and land-use variables assessed for bait stations visited and not visited by black bears, Montgomery Island and Big Island, Arkansas, May to August 1993.

Variable[a]	Methodology
Canopy cover	Spherical densiometer
Ground cover	Ocular estimation
Total *N* Spp.	Tabulation
N Overstory Spp.	0.04-ha plots
N Overstory food spp.	0.04-ha plots
N Overstory other spp.	0.04-ha plots
Basal area overstory spp.	Tabulation
Basal area overstory food spp.	Tabulation
Basal area other overstory spp.	Tabulation
N Midstory spp.	0.004-ha plot
N Midstory food spp.	0.004-ha plot
N Midstory other spp.	0.004-ha plot
Height midstory food spp.	Ocular estimation
Height midstory other spp.	Ocular estimation
N Understory spp.	0.0004-ha plot
N Understory food spp.	0.0004-ha plot
N Understory other spp.	0.0004-ha plot
Overstory diversity	Shannon index
Midstory diversity	Shannon index
Understory diversity	Shannon index
Distance to nearest road	Quad map/tape measure
Type of timber harvest	Harvest records
Time since harvested	Harvest records

[a]Those species not important food species for black bears are denoted by "other."

gression (Table 3). No significant differences were detected (*Delta Observed* = 4.1, *Delta Expected* = 4.08, P = 1.00) with respect to response variation and central tendency between visited and not visited bait stations, Likewise, none of the variables were significant in the logistic regression analysis (Table 4).

Discussion

We concluded that site-specific vegetative structure and selected land-use variables had no effect on bait station visitations. This may result from bears having large home ranges and travelling long distances in 1 night enabling bears to traverse areas of unsuitable habitat to reach suitable habitat.

Habitat evaluation was not performed on the study area as a whole. It is possible that habitat on the study area was homogeneous, with respect to suitability for black bears, which would produce results commensurate with those obtained in this study. Timber management on Big Island is such that a wide array of interspersed seres were present. Montgomery Island had similarly aged forest stands throughout. However, many forest openings, fields (approx. 1–30 ha in size), and ecotones were present. The range of habitats present, as well as

Table 2. Black bear food species found in sample plots on Montgomery Island and Big Island, Arkansas, May to August 1993.

Species group	Common name
Quercus spp.	oaks
Carya spp.	pecan and hickories
Morus rubra	red mulberry
Cornus spp.	dogwood
Diospyros virginiana	persimmon
Vitis spp.	wild grape
Toxicodendron radicans	poison ivy
Phytolacca americana	pokeweed
Sambucus canadensis	elderberry
Smilax spp.	greenbriar
Poaceae	grasses
Ampelopsis spp.	peppervine
Rubus spp.	blackberries
Forestiera acuminata	swamp privet
Arundinaria gigantea	switchcane

Table 3. Mean and standard error for variables included in MRPP analysis of habitat effects on bait station visitation rates on Montgomery Island and Big Island, Arkansas, May–August 1993.

	Mean			Standard error		
Variable	V[a]	NV[b]	T[c]	V	NV	T
Canopy cover (%)	94.19	91.84	93.06	1.14	2.52	1.34
Ground cover (%)	36.67	45.40	40.87	5.07	6.72	4.17
N Overstory bear species	0.29	0.48	0.38	0.11	0.14	0.01
N Midstory species	0.78	1.12	0.94	0.15	0.16	0.11
Height midstory other species	4.63	3.80	4.23	1.29	0.92	0.80
N Understory bear species	1.59	1.64	1.62	0.20	0.21	0.14
Overstory diversity	0.37	0.31	0.34	0.07	0.07	0.05
Understory diversity	0.10	0.09	0.10	0.01	0.01	0.01
Type of timber harvest	2.03	1.64	1.85	0.39	0.39	0.27

[a]Visited bait stations.
[b]Not visited bait stations.
[c]Total visited and non-visited bait stations.

their spatial distribution, supports the assumption that habitat was not homogeneously suitable for black bears.

It is important to note that this research was conducted on areas that are islands for most of the year. Effects of this landscape physiognomy on black bear movements is currently under investigation (T. White, pers. commun., Miss. State Univ., Dep. Wildl. and Fish.). Because black bears living in this unique habitat may display different movement behavior than mainland populations, care should be taken when extrapolating these results beyond our study area.

Table 4. Pertinent statistical results of logistic regression of vegetation and land-use variables regressed on bait station visits by black bears, Montgomery Island and Big Island, Arkansas, May to August 1993.

Variable	df	*P*	*R*
Canopy cover	1	0.377	0.000
Ground cover	1	0.291	0.000
N Overstory food spp.	3	0.119	0.000
N Midstory spp.	3	0.359	0.000
Height midstory other spp.[a]	1	0.602	0.000
N Understory food spp.	4	0.998	0.000
Overstory diversity	1	0.525	0.000
Understory diversity	1	0.773	0.000
Type	4	0.393	0.000

[a]Species not used for food by black bears.

Researchers in other regions have found elevation to affect bait station visitations (Teunissen Van Manen 1990, Carlock 1986). However, Smith (1985) found no disproportionate use of habitats based on elevational diversity on WRNWR. This probably precludes elevation from affecting bait station visitations on our study area and, therefore, it was not included in analyses.

Hard mast trees were included in the analyses as bear food species. However, acorns are primarily consumed by bears in fall and winter (Smith 1985). Because mast does represent an important diet component and hard mast species are the natural climax overstory vegetation of our study area (Meanley 1956, Putnam et al. 1960), we felt that spatial patterns and vegetation relationships associated with a mast-producing overstory may significantly affect bear movements throughout the year. Our results suggest that overstory composition does not affect bait station visitations.

Analysis with logistic regression and MRPP produced similar results. However, the MRPP analysis may be more appropriate for several reasons. Multivariate assumptions are rarely met in ecological work (Brennan et al. 1986, Capen et al. 1986). MRPP is a distribution-free resampling procedure that allows multivariate statistical analyses without constraints of underlying distributional assumptions inherent to classical multivariate techniques (Slauson et al. 1990). MRPP yields significance levels similar to parametric tests when underlying parametric assumptions are met and it is more powerful than parametric tests when data are sampled from a non-normal distribution (Crowley 1992).

Several researchers have noted the importance of consistently placing scent and bait station lines in the same location every year and standardizing techniques (Carlock et al. 1983, Connor et al. 1983). This serves to reduce variability from environmental factors and allows comparisons among years for following population trends. Equally important is the assumption that each bait station has an equal probability of being visited. Results of this study indicate that black bear visits to bait stations on our study area were not influenced by the selected site-specific vegetation and land-use variables. This implies that bait station surveys in the MAV may not be biased by placement of bait stations in different vegetative associations, furthering evidence that bait station indices may be reliable technique for indexing black bear populations within the MAV.

Future research should be directed to determine effects of environmental variables on the probability of a black bear visiting a particular bait station, especially in areas with high habitat and environmental variability.

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