BLACK BEARS' USE OF ABANDONED HOMESITES IN SHENANDOAH NATIONAL PARK

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Abstract: From May 1982 to April 1985 we studied seasonal use of domestic fruits at 330 abandoned homesites by 24 adult female, 17 adult male, and 3 subadult male black bears (*Ursus americanus*) in central Shenandoah National Park, Virginia.

Distance-to-nearest-homesite measurements indicated that males were never closer ($P > 0.10$) to homesites than females or random points during any season and that females were closer ($P < 0.001$) to homesites than males and random points during summer. Only females were located < 100 m from homesites more ($P < 0.001$) than expected during summer and early fall. Food habit analysis of 857 scats indicated that bears consumed apples (*Malus* spp.) and sweet cherries (*Prunus avium*) at abandoned homesites mainly in summer, early fall, and late fall. Bears used homesites in late fall more than distance measures indicated. Domestic fruits were an important nutritional food for black bears in relation to total soft fruits eaten.

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The establishment of Shenandoah National Park (SNP) in 1935 "marked the first dedication of a large populated area of private land, all human-dominated with hardly an acre of virgin land to save, for restoration and preservation forever" (Lambert 1979). In the past 50 years, the black bear population in Shenandoah National Park, Va., has increased from a few individuals to one of the densest populations in North America (Carney 1985). This recovery has been due in part to protection from human exploitation and in part to the availability of good habitat and good nutrition. Abandoned homesites (homesteads inhabited until 1935) with associated fruit tree orchards abound in SNP and may be an important element in the overall nutritional status of the bear population. This research was designed to determine the influence of domestic fruit trees at abandoned homesites on the seasonal movements and diets of black bears in SNP. This work was part of a comprehensive study of black bear biology and habitat use on the SNP forests.

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STUDY AREA

The study area is the 307 km^2 Central District of SNP in the Blue Ridge Mountains of northern Virginia and surrounding environs (Fig. 1). The Central District of SNP is characterized by rugged terrain, steep slopes, and narrow valley bottoms; elevation ranges 274–1,234 m. The district is 3–21 km wide, 40 km long, and is oriented in a southwest-northeast direction. This narrow mountainous area lies entirely within the Blue Ridge physiographic province between the low-lying Piedmont province to the east and the Valley and Ridge province to the west (Gathright 1976).

Nearly 95% of SNP (777 km^2) is forested with approximately 100 tree species and more than 1,000 species of shrubs, forbs, and grasses (Mazzeo 1979). The study area is dominated by hardwood forests that include northern red oak (*Quercus rubra*) and chestnut oak (*Q. prinus*) as the predominant tree species, mixed with white oak (*Q. alba*) and hickory (*Carya spp.*) along ridges and slopes at all elevations. Cove hardwoods include yellow poplar (*Liriodendron tulipifera*), American basswood (*Tilia americana*), white ash (*Fraxinus americana*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), black birch (*Betula lenta*), and various oak species. Scattered evergreen species include eastern hemlock (*Tsuga canadensis*) and 5 species of pine (*Pinus* spp.), with red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) occurring on a few mountaintops at the highest elevations. Domesticated tree species such as apple, sweet cherry, peach (*P. persica*), American plum (*P. americana*), and pear (*Pyrus communis*) occur at abandoned homesites where small orchards were planted (Mazzeo 1979).

Second-growth timber (< 60 years old) predominates in much of the forest because of the influences of logging, agriculture, and livestock grazing exerted by early settlers and the chestnut blight fungus (*Endothia parasitica*) that killed most of the dominant American chestnut (*Castanea dentata*) at the turn of

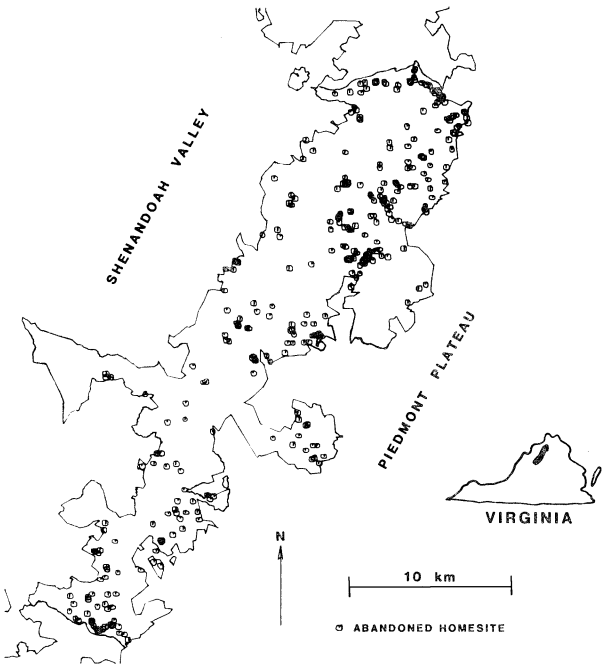

Fig. 1. Map of study area and abandoned homesites in the Central District of Shenandoah National Park.

the century (Mazzeo 1979). The expected climax forest in SNP under present conditions is oak/hickory (Braun 1950).

Precipitation averaged 15%–20% more and temperature 5.5 C cooler at higher elevations in the Park than in surrounding lowlands (Heatwole 1978). Temperatures in the upper elevations range from a mean of −2.3 C in January to 19.2 C in July. Average annual precipitation in the higher elevations is 125 cm of rain plus 122 cm of snow.

METHODS

We captured bears in Aldrich foot snares and culvert traps from spring 1982 through summer 1984 and immobilized them with intramuscular injections of ketamine hydrochloride and xylazine in a 2:1 mixture (dosage rate 6.6 mg/kg of body weight). Selected individuals were fitted with motion-sensitive radio transmitter collars (Telonics, Inc., Mesa, Ariz.: reference to this or any other product or trade name does not imply endorsement by the U.S. Government).

Homesite Use Analysis

Radio-marked bears were monitored during all seasons through April 1985 and located during daylight hours between 0600 and 2100. We attempted to locate each bear every 2–3 days from the ground and once a week from the air. Ground locations were determined using triangulation of radio fixes with directional hand-held H antennas. Aerial locations were made from fixed-wing aircraft with directional H antennas mounted under each wing.

Only aerial locations and close ground triangulations (< 100 m from investigator) were used for analysis because their accuracy had been tested (Lee et al. 1985). The computer program TELEM (Koeln 1980) was used to triangulate bear locations.

Locations of individual bears and old homesites were plotted on U.S. Geological Survey topographic maps (scale 1:24,000) using the Universal Transverse Mercator grid system. Bear locations were grouped by season and sex of bear. Seasons were based on changes in plant phenology and weather patterns: spring (20 Mar–15 Jun); summer (16 Jun–31 Aug); early fall (1 Sep–15 Oct); and late fall (16 Oct–20 Dec). We visited a random sample ($N = 40$) of abandoned homesites to assess map accuracy and determine the presence of domestic fruit trees.

We determined the distance-to-nearest-homesite for each bear location within the Central District (or outside the Central District but < 1,000 m from a Central District homesite) and for each of 1,000 random points. We included locations of bears within 1,000 m of a homesite even when outside the Central District because they may have been attracted to homesites near the Park boundary. Presence at homesites was investigated by comparing the frequency with which bears and random points were within 100 m or less of a homesite location. Locations of bears that had moved into the North and South Districts of SNP were not included in this analysis because bears may have been attracted to unidentified homesites in those areas.

We used the Wilcoxon rank sum test and chi-square test for statistical comparisons unless otherwise noted. Two-sided significance levels are reported.

Food Habits and Phenology Analysis

We analyzed scats ($N = 837$) collected May 1982–December 1984 to determine the amount of domestic tree fruits that black bears consumed. Scats (usually < 2 weeks old) were collected incidental to trapping, tracking, and habitat mapping procedures. Approximately 95% of the scats were collected within the Central District; the remaining 5% were collected in

other areas of SNP or outside the Park. Scats collected outside the Park in areas associated with commercial orchards were eliminated from the analysis. Scats were frozen within 24 hours and later thawed and washed using techniques described by Tisch (1961) and Mealey (1980).

We identified all food items in each scat and stomach and ocularly estimated the volume of each food item (Clark 1957, Tisch 1961) using 25% intervals. Quantification of domestic fruit was based on the amount of seeds, stems, fleshy pulp, and outer skin encountered in relation to other food items present in each scat or stomach. We specified the amount of domestic fruit consumed for each season and the entire year (Beeman and Pelton 1980). We expressed frequency of occurrence for each food item and assigned each food item an index value based on the percent volume in each scat or stomach: 0 = trace; 1 = 1%–25%; 2 = 26%–50%; 3 = 51%–75%; and 4 = 76%–100%.

Volume index percent =

$$\frac{\text{Index value for an individual food item}}{\text{Sum of index values for all food items}} \times 100$$

Both frequency of occurrence and volume index percentage were used to evaluate use of domestic fruits by black bears.

Phenological development for the most common domestic tree species found at abandoned homesites at different elevations was recorded in 1984 using the method of West and Wein (1971).

RESULTS

Homesite Characteristics

We identified 330 abandoned homesites within the study area (Fig. 1). Homesites contained partial ruins of log cabins, fences, or other log structures. Disturbed areas around homesites averaged 1–2 ha in size and included 2 or 3 fruit trees or small orchards (usually 5–15 trees) and evidence of past agriculture and grazing activity. Homesites were in forested areas at low-to-mid elevations ($\bar{x}$ = 635 m, range 269–1,127 m), on gentle slopes ($\bar{x}$ = 13, range 2°–36°), near streams and small rivers ($\bar{x}$ = 221 m, range 10–1,240 m) on all aspects. The most common domesticated tree species found around homesites were sweet cherry and apple; at least 1 of these was present at 90% (N = 36) of visited homesite areas (N = 40). Unlike the North and South Districts of SNP, where domestic fruit trees occasionally occur in large orchards not associated with homesite locations, these 2 tree species were found exclusively around abandoned homesites throughout the study area. Every mature sweet cherry and nearly all apple trees located displayed claw marks from past climbing activity by bears. Other fruit trees such as peach, pear, and plum were considered rare because they were located at only a few homesites (5%).

Movements

Bears were frequently seen during aerial tracking in spring (10.2% visuals) and late fall (26.3% visuals), when deciduous cover was reduced. The accuracy of aerial locations was also tested by locating bears at den sites and using reference transmitters placed in known locations periodically during the study. The tests indicated that aerial locations were in error by less than 100 m in any direction approximately 95% of the time. Garshelis (1978), Quigley (1982), and Garris (1983) used a 150 m distance to verify accuracy of acceptable bear locations. Close ground triangulations were considered highly accurate because of the investigator's proximity to the bear and verification by sightings.

Distance-to-nearest-homesite did not differ between years within seasons for either sex (N = 1,374, $P > 0.05$); thus we combined data for each season from 1982 to 1985. The number of bears of each sex radiotracked each season ranged 12–23. Bears were monitored for periods ranging from 2 weeks to 34 months.

Male Movements.—Distance-to-nearest-homesite for males did not differ among seasons (Kruskal-Wallis Test, X^2 = 5.34, df = 3, P = 0.148; Table 1). Males were not located within 200 m of any homesite during early and late fall but were occasionally located within 100 m of homesites in spring (2.3%) and summer (3.4%).

Distance-to-nearest-homesite for male bears was not different from random distances during spring (P = 0.585), summer (P = 0.473), or early fall (P = 0.352) but was greater than random ($\bar{x}$ = 820 m) in late fall ($\bar{x}$ = 920 m) (P = 0.012, Table 1). Random points fell within 100 m of homesites 1.5% of the time, comparable to the 0–3.4% of males within 100 m of homesites for all seasons.

Female Movements.—Distance-to-nearest-home-

Table 1. Seasonal distance-to-nearest-homsite (m) for black bears and random points in Shenandoah National Park, Va, 1982–85.

Season	Sex	*N*	Mean	Median	SD	Range
Spring	M	88	730[a]	590	470	60–2,230
	F	216	700	670	400	70–2,350
Summer	M	117	802	710	620	50–4,850
	F	397	640	560	430	30–2,180
Early fall	M	43	810	880	440	210–1,860
	F	213	750	680	530	10–3,380
Late fall	M	90	920	760	630	240–4,170
	F	210	790	730	400	90–2,090
Random		1,000	820	670	670	50–5,870

[a] All values rounded to the nearest ten.

site for females with cubs and solitary females was not different ($P > 0.10$) within seasons over all years combined. Analysis of female movements therefore included both types of females.

Distance-to-nearest-homesite for females differed seasonally (Kruskal-Wallis Test, $X^2 = 21.51$, df = 3, $P < 0.001$). Females were closer to homesites in the summer than during any other season (Rank LSD, $P < 0.041$), whereas females were farther from homesites in the late fall than during spring ($P = 0.025$), summer ($P < 0.001$), and early fall ($P = 0.076$) (Table 1). Spring and early fall distances were similar (Rank LSD, $P = 0.850$). In contrast, females were located at homesites more in the summer (6.5%) and early fall (6.1%) than during spring (1.4%) and late fall (1.0%) ($P < 0.01$ for each of 4 seasonal comparisons). The proportion of time females were located at homesites during summer and early fall was similar ($X^2 = 0.046$, df = 1, $P = 0.830$).

Distance-to-nearest-homesite for females was not different from random distances during spring ($P = 0.404$) and early fall ($P = 0.409$); was less than random distances during the summer ($P < 0.001$); and was greater than random distances (median = 670 m) during the late fall (median = 730 m) ($P = 0.061$, Table 1). However, females were located at homesites more frequently than random points during summer ($X^2 = 25.43$, df = 1, $P < 0.001$) and early fall ($X^2 = 16.50$, df = 1, $P < 0.001$).

Relative Homesite Use by Males and Females.—Overall, distance-to-nearest-homesite was similar for males and females during spring ($P = 0.977$), early fall ($P = 0.224$), and late fall ($P = 0.286$); females were closer to homesites than males during the summer months ($P = 0.003$). Females used homesites in the early and late fall but males did not. No difference was found between the proportion of time each sex was observed at homesites during summer (males 3.4%, females 6.5%; $X^2 = 1.611$, df = 1, $P = 0.204$) and spring (males 2.3%, females 1.4%).

Phenology and Food Habits

Scat data were pooled over years because the majority of scats were collected in 1983 and food habit analysis indicated that annual differences were minor in use of domestic fruits. However, plant phenology and availability of domestic fruits may have varied between years. During 1984, sweet cherry ripened from mid-June to mid-July and apple ripened from mid-August to late October (Fig. 2).

Bears consumed domestic tree fruits mainly from summer to late fall (Table 2). Sweet cherries were consumed almost exclusively during the summer, from mid-June to mid-July, when fruits were ripe. Apples, both ripe and unripe, were eaten during the summer, early fall, and late fall seasons. Late fall apple consumption was primarily from fallen fruit (Fig. 2). Trace amounts of peach and plum were eaten during the summer and early fall. Due to the higher digestibility of fleshy pulp in fruits in comparison to fruit seeds, stems, and outer skin, the actual volume of domestic fruits in the diet of black bears in SNP may have been underestimated.

Black bears in SNP frequently consumed substantial amounts of domestic fruits in comparison with total soft fruits eaten. Percent frequency of domestic fruits in scats containing any soft fruits was similar in summer (32%) and early fall (29%) but increased in late fall (50%). Of the soft fruits eaten during summer, early fall, and late fall, 16%, 11%, and 44%, respectively, were domestic fruit.

DISCUSSION

Even though home ranges for males were larger (Garner 1986) and included more homesites, females

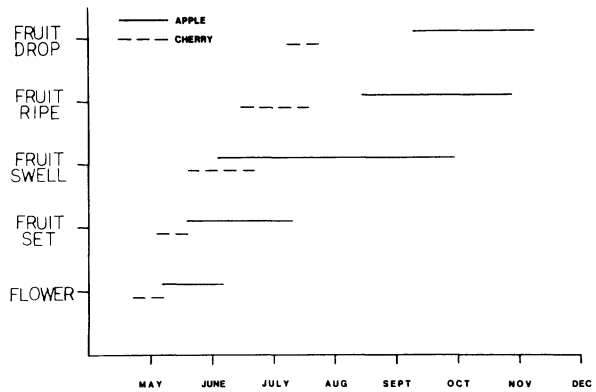

Fig. 2. Phenological changes in apple trees (N = 11, elevational range 326–1015 m) and sweet cherry trees (N = 7, elevational range 357–677 m) in Shenandoah National Park, Va., 1984. Based on method of West and Weln (1971).

most likely recognized the spatial distribution of homesites within their smaller ranges more than far ranging males and returned to these areas, which they had previously associated with domestic fruit. Herrstein (1971) showed that an animal's behavior is influenced by positive reinforcement, which prompts it to repeat the experience. This may partly explain why males were never closer to homesites than expected in any season, whereas females were closer to homesites than expected during summer. In addition, females were located at homesites more frequently than expected during summer and early fall. The greatest use of homesites would be expected during summer because sweet cherries and apples were available and the probability of finding a homesite with at least 1 of the 2 fruits was high. In the Great Smoky Mountains National Park (GSMNP), where apple trees occur at orchards and abandoned homesites scattered at lower elevations (Pelton, pers. commun.), bears ate apples during summer (Eagle 1979). In Pennsylvania, black bears consumed substantial amounts of wild-growing domestic apples during summer as well as in other seasons (Bennett et al. 1943). The unavailability of domestic fruits during spring likely explains why males, females, and random observations were similar in respect to abandoned homesites.

During mid-September, males and females moved away from their summer ranges to fall ranges in predominantly oak forests where they consumed large quantities of acorns in early fall (19% volume) and late fall (66% volume) (Garner 1986). Black bears in other Appalachian states also concentrate their activities in mast-producing areas during the fall, primarily for acorn consumption (Beeman 1975, Garshelis and Pelton 1981, Quigley 1982, Villarrubia 1982, Carr 1983, Waburton 1984). The effect of movements by bears into acorn-producing areas also reduced fall homesite use by bears in SNP (only 2 observations in late fall) because only 19% of all homesites were located in oak forests. In late fall, males and females were farther than expected from homesites because acorn-producing areas were farther from homesites than random points. Furthermore, the probability of finding an abandoned homesite with domestic fruits was less during early and late fall, because apple trees did not occur at each homesite and sweet cherry fruits were not available. The relative nearness of females to homesites in early fall, compared to late fall, likely reflects the continued use of homesites to eat apples in early September before females shifted to fall feeding areas. Garshelis and Pelton (1981) speculated that the abundance of wild black cherry (*Prunus serotina*) in a bear's summer range may delay movement to areas of oak abundance until cherries became scarce later in the fall.

Clearly, abandoned homesites in SNP were used

Table 2. Percentage frequency and volume index of domestic fruits identified in bear scats from Shenandoah National Park, Va, 1982–84.

	Spring (N = 174)		Summer (N = 229)		Early fall (N = 237)		Late fall (N = 197)	
	% freq.	Volume index	% freq.	Volume index	% freq.	Volume index	% freq.	Volume index
Sweet cherry	T[a]	T	10.43	4.60				
Apple	1.0	T	16.52	6.81	25.21	7.40	14.14	7.12
Peach			T	T	T	T		
Plum			T	T				

[a] All T symbols indicate values < 1%.

mainly by females during the summer (distance and frequency analysis), and also during early fall (frequency analysis). Males in SNP relied primarily on alternate foods of squawroot (*Conopholis americana*) and ants (Formicidae) in the summer and wild black cherries and acorns in the fall. Also, based on the amount of apples in scats during late fall, bears used homesites more than distance measures indicate. Other studies have shown that bears consume domestic fruits during the fall season (Bennett et al. 1943, Beeman and Pelton 1980, Hugie 1982, Graber and White 1983, Servheen 1983).

Many of the shrub and tree fruits eaten by black bears are low to moderate in protein content, moderate in crude fiber, and high in carbohydrates (Eagle and Pelton 1983). The pulp and skin of wild black cherry (considered nutritionally similar to sweet cherry) is poor in protein and fat, high in nitrogen-free extract, and low in tannins (Wainio and Forbs 1941). Servello (1985) listed apples as low in tannins and high in metabolizable energy. Both sweet cherry and apple are easily digested and provide a high-energy source of food for daily activity and body maintenance.

Ecological Implications

Fruit production at abandoned homesites throughout SNP will likely decline drastically during the next 20 years as forests intrude into abandoned homesite areas. Dead and dying apple trees are present in many homesite areas that have developed a thick forest canopy. Ecological implications for the black bear include a decreased source of important soft fruits during the summer, early fall, and late fall seasons. As a result, bears may use commercial orchards adjacent to SNP to a greater extent. Beeman and Pelton (1980) reported increased movements of bears out of GSMNP during years of food scarcity. Rogers (1977) observed that bears in Minnesota made excursions from their normal home ranges to areas where food was more abundant. Presently, 30–35 nuisance bears are trapped each year on private lands in the 8 counties surrounding SNP because they damage commercial orchards, corn fields, and beehive operations (J. Blank, Virginia State Trapper, pers. commun.). Reduced domestic fruit production at abandoned homesites may cause females to seek alternate food sources during the summer and early fall because they primarily use homesites for domestic fruit consumption during those periods. The ultimate effect of this forage shift on the bear population is unknown. Current Park Service policy prevents maintaining domestic fruit production at abandoned homesites and larger orchards in the Park.

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