Seasonal Movements, Habitat Selection, and Food Habits of Black

Bears (Ursus americanus) in Shenandoah National Park, Virginia

by

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(ABSTRACT)

The seasonal movements, food habits, and habitat selection of black bears (Ursus americanus) in Shenandoah National Park, Virginia were studied from May 1982 to April 1985. A total of 47 collared bears, including 25 adult females, 17 adult males, and 5 subadult males < 3.5 years old, was located 3973 times during the study.

Adult males had larger ($P < 0.001$) home ranges (100% $X = 195$ km², 95% $X = 116$ km²) than adult females (100% $X = 38$ km², 95% $X = 22$ km²). Subadult males had larger ($P < 0.10$) home ranges (100% $X = 542$ km², 95% $X = 289$ km²) than adult males and females. Extensive home range overlap occurred among each sex and age group. At least three subadult males dispersed from the Park during the study. Female bears with cubs were less mobile than solitary females during the spring. Fall cubs were large and did not restrict females' movements. Large fall home ranges for females were related to the scattered supply of acorns relative to the concentrated sources of soft mast used in the summer. Two females with cubs and 2 subadult males remained active during the winter months.

Adult and subadult males generally had less stable home ranges than adult females. Female bears displayed infidelity to given areas during the fall from year-to-year due to variation in the distribution of hard mast (acorns). Male bears made long excursions onto the Piedmont Plateau east of the Park mainly during the spring and early fall. Females were not exposed to as much human induced mortality as males because they were located within the Park 17% more frequently than males.

Males avoided fire roads ($P < 0.001$), light duty roads ($P < 0.001$), and primary roads ($P < 0.01$) year around. Female bears preferred fire roads during summer ($P < 0.001$) and early

fall ($P < 0.01$) and avoided heavier traveled roads such as light duty roads ($P < 0.001$) and primary roads ($P < 0.001$) year around. Both male and female bears preferred foot trails for travel ($P < 0.05$). Bears rarely came within 100 meters of campgrounds, picnic areas, and other human disturbance areas within the Park. Both sexes used low ($P < 0.10$) elevations during the summer and high ($P < 0.10$) elevations during early and late fall. Bears showed the greatest use of small rivers and streams during the driest months of summer. Geographic land forms of specific aspects, contours, and varying steepness were used differently by male and female bears.

Twelve stomachs and 854 scats were analyzed for food content. Forbs, graminoids, squawroot (*Conopholis americana*), corn, and the fruits of trees, shrubs, and vines composed 90 percent volume of the annual diet. Eight percent of the food consumed was animal matter from mammals, birds, and invertebrates.

During all seasons, females used yellow poplar (*Liriodendron tulipifera*) forests more ($P < 0.05$) than males while males used yellow poplar forests less ($P < 0.05$) than expected; males used black locust (*Robinia pseudoacacia*) \ black cherry (*Prunus serotina*) forests more ($P < 0.05$) than females and more ($P < 0.05$) than expected. Shifts in use of chestnut oak (*Quercus prinus*) \ northern red oak (*Q. rubra*) forests and northern red oak \ white oak (*Q. alba*) forests by both males and females in early and late fall was attributed to annual variation in oak mast production, preference for white oak acorns, foraging strategy, and the importance of mountain laurel (*Kalmia latifolia*) shrub cover in late fall.

Seasonal use of domestic fruits at 330 abandoned homesites was determined. Distance-to-nearest-homesite measurements indicated that males were never closer ($P > 0.10$) to homesites than females or random points during any season while females were closer ($P < 0.001$) to homesites than males and random points during summer. Only females were located at homesites ($\leq$ 100m) more ($P < 0.001$) than expected during summer and early fall. 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.

Acknowledgements

This study involved many organizations and people who shared an intense interest in studying black bears in Shenandoah National Park, Virginia. I would like to express my sincere appreciation to the following:

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Technicians Jim Stuart and Alison Teetor, and interns Jeff Waldon and Mike Patterson for assistance with data collection in the field.

We need another and a wiser and perhaps

a more mystical concept of animals, for the

animals shall not be measured by man.

They are not our brethren.

They are not our underlings.

They are other nations caught with ourselves

in a net of life and time; fellow prisoners

of the splendor and travail of earth.

Henry Beston

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Introduction

Black bears in Virginia are distributed in 3 ecologically distinct areas: 1) the mountains of western Virginia; 2) portions of the hilly Piedmont Plateau in the central section; and 3) the Dismal Swamp in the southeast. Presently, roughly half the bears reportedly killed each year in Virginia are hunted in the eight counties surrounding Shenandoah National Park (SNP), (VCGIF harvest records). The establishment of 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 1979:1). In the past 50 years, the black bear population in SNP has increased from a few individuals to one of the densest populations in North America at 1 bear per 0.96 to 1.49 km^2 (Carney 1985:34). Reasons for the population increase include protection from hunting and improvement in habitat quality (i.e., increased cover and higher quality bear food as a result of hardwood forest maturation) resulting in good nutrition. Construction of Skyline Drive and numerous lodges, campgrounds, trails, and picnic areas in the Park during the last 50 years has led to a concurrent increase in visitor use. By the mid-1960's, increased bear-human interactions in the Park, along with complaints of crop damage by bears from farmers on adjacent farmland prompted Park personnel to establish a black bear management policy.

The primary objective of the current SNP Bear Management Plan involves the management of a viable bear population with minimum bear-human conflicts (Haskell 1982). Past

research from SNP used in formulating current management policy included 1) identification of demographic characteristics of the bear population (Raybourne 1976, Dubrock 1980); 2) visitor perception of bear problems in SNP (Baptiste et al. 1979); and 3) use of computerized habitat systems for evaluating habitat suitability for bears in SNP (Williamson and Whelan 1980).

Bears and people in SNP are numerous and little is known about bear requirements in the Park. This study was initiated to help develop a more comprehensive management plan that would further alleviate any potential bear-human problems. The study was designed to 1) determine seasonal movement patterns and home ranges of black bears in SNP in relation to geographic features including human disturbance areas in the Park; 2) determine seasonal food habits and habitat requirements of black bears in the Park; and 3) 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 ecology and biology on the SNP forests. Instead of a standard thesis format, the results are reported in 3 papers with one introduction and study area description.

Study Area

The study area was the 307km² Central District of SNP in the Blue Ridge Mountains of northern Virginia (Figure 1). The Central District of SNP is characterized by rugged terrain, steep slopes and narrow valley bottoms; elevation ranges from 274m to 1234m. 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 1976:7).

Nearly 95 percent of SNP (777km²) is forested with approximately 100 tree species and more than 1000 species of shrubs, forbs, and grasses (Mazzeo 1979:4). The study area was dominated by hardwood forests that included northern red oak and chestnut oak as the predominant tree species, mixed with white oak and hickory (*Carya* spp.) along ridges and slopes at all elevations. Cove hardwoods included yellow poplar, 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 included 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*) occurred at abandoned

SHENANDOAH NATIONAL PARK
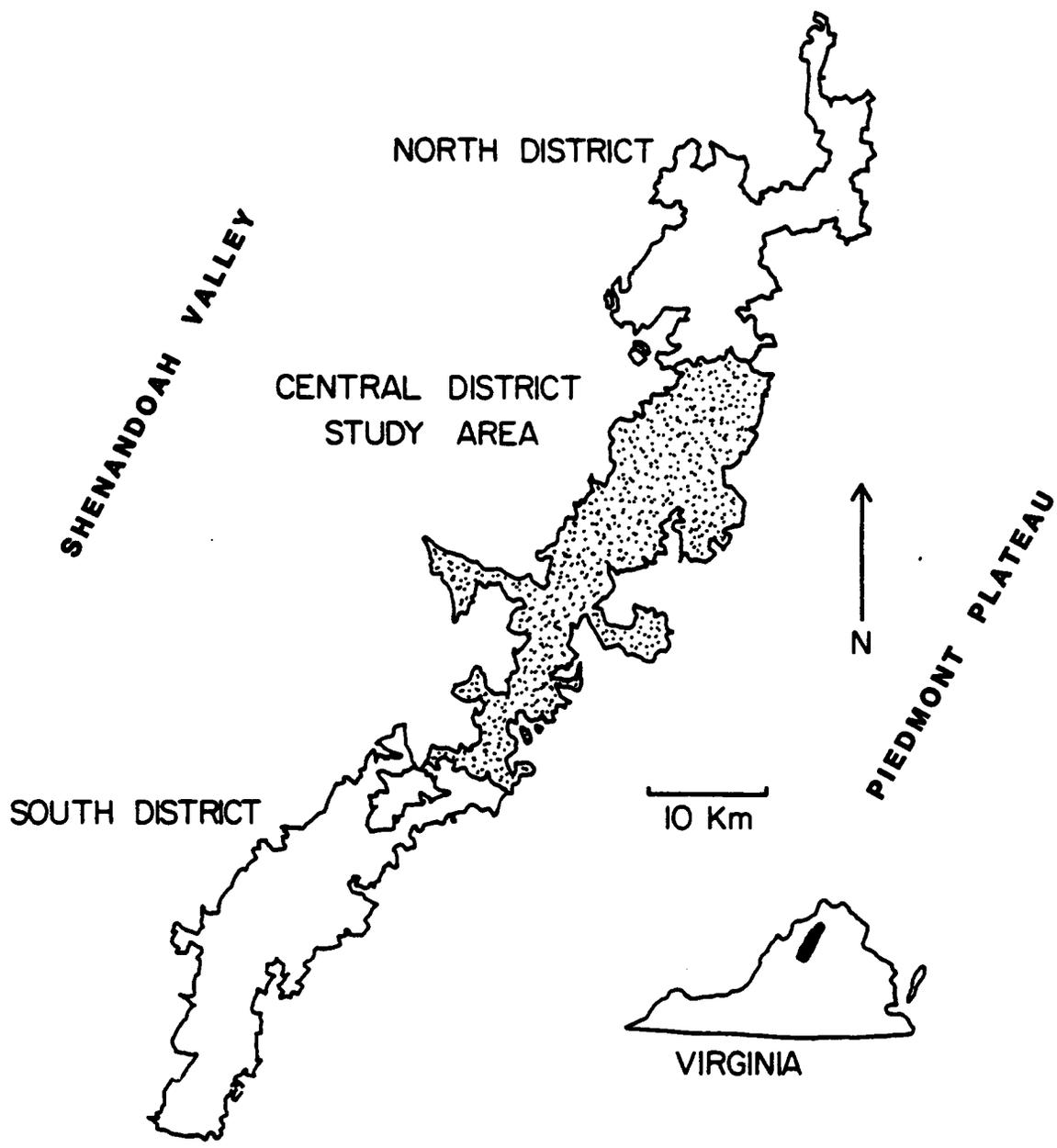
Figure 1. Study area in Shenandoah National Park, Virginia.

homesites where small orchards were planted (Mazzeo 1979:49-55). Understory shrubs included witch-hazel (*Hamamelis virginiana*) scattered at all elevations, spicebush (*Lindera benzoin*) along watercourses and in areas with moist soils, and mountain laurel on drier slopes and ridges. The remaining 5 percent of the study area was covered by utility corridors, scenic overlooks, meadows, burns, talus slopes, roads, and large rock formations.

Second growth timber (<60 yrs old) predominated in much of the forest due to 1) the influences of logging, agriculture, and livestock grazing before th Park was established; and 2) the foreign Chestnut blight fungus (*Endothia parasitica*) that killed most of the dominant American chestnut (*Castanea dentata*) at the turn of the century (Mazzeo 1979:4,5). The expected climax forest in SNP under present conditions is oak \ hickory (Braun 1950:445).

Precipitation and temperatures vary and generally average 15-20% greater and 5.5°C cooler respectively, 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.

Chapter 1: Seasonal Movements And Home Range Dynamics

Methods

Bears were captured in Aldrich foot snares and culvert traps from spring 1982 to summer 1984 and immobilized with intramuscular injections of ketamine hydrochloride and xylazine in a 2:1 mixture (dosage rate 6.6 mg per kg of body weight). Selected individuals were fitted with motion-sensitive radio transmitter collars (Telonics, Inc., Mesa, AZ 85203).

Radio-marked bears were monitored during all seasons through April, 1985 and located during daylight hours between 0600 and 2100. An attempt was made 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 taken with directional hand-held H antennas. Aerial locations were made from fixed-wing aircraft (Cessna 150,172) with directional H antennas mounted under each wing.

Only aerial telemetry and close ground triangulations ($\leq$ 100m from investigator) were used to determine the proportion of black bear locations within 100m of various geographic features inside and surrounding SNP (Table 1). Both types of locations also were used to determine seasonal trends in topographic land use related to elevation, slope, contour, and aspect. The accuracy of aerial locations was tested by 1) locating bears at den sites; and 2) periodically locating reference transmitters placed in known locations within the study area.

Table 1. Descriptions of geographic features electronically digitized and incorporated into a geographic data base for SNP, Va.

Feature	Descriptions[1]
Abandoned Roads	Abandoned dirt roads located on State lands outside the Park and on wilderness areas inside the Park. Currently gated or blocked off to prevent vehicular use. Roads initially built for fire control. Present in zones A and B.
Park Boundary	Irregular shaped boundary around Park totaled 723 kilometers in length. The boundary marked the separation between the Park and State/private landholdings. Dividing line between zones A and B.
Campgrounds	Four campgrounds open to recreational vehicle use covered 57 hectares inside the Park. Big Meadows and Lewis Mountain campgrounds occurred in the Central District. Park campgrounds only occurred in zone A.
Fire Roads	Dirt roads located in the Park and on surrounding State forests primarily used for fire control and backcountry patrol (law enforcement). Fire roads totaled 726 kilometers in zones A and B.
Foot Trails	Hikers presently use 897 kilometers of trails in the entire Park (zone A) and on State Forests (zone B) surrounding the Park.
Human Disturbance Areas	High human use areas found only in the Park (zone A) which included visitor centers, picnic areas, scenic overlooks, campgrounds, backcountry camping shelters and cabins, commercial lodges, and ranger stations. These human disturbance areas totaled 355 hectares in size throughout the Park.
Jeep Trails	Four-wheel drive backcountry roads scattered primarily on State Forests. Occasionally found in the Park where they are periodically used for law enforcement and search and rescue activities. Located in zones A and B.
Light Duty Roads	Gravel roads in zones A and B which totaled 643 kilometers in length.
Marsh	Small isolated wooded and non-wooded marshlands covered 76 hectares in zones A and B.
Picnic Areas	Seven picnic areas in the Park covered 45 hectares. The Pinnacles and South River picnic areas occurred in the Central District. Picnic areas only found in Zone A.
Ranger Stations	Eleven ranger stations are scattered throughout the Park (zone A) and covered 15 hectares. Two ranger stations occurred in the Central District.
Primary Roads	Paved roads which included primary and secondary highways located in zones A and B. Primary roads were 523 kilometers in length. The longest section of primary road was Skyline Drive which bisected the entire Park for 169 kilometers.
Small Rivers or Streams	Small rivers and intermittent streams located in zones A and B which totaled 2360 kilometers in length.
Urban Areas	Towns, residential areas (> 1 house per hectare), industrial areas, and unoccupied buildings (barns, etc) located in zone B covered 5060 hectares.
Utility Corridors	Railroad tracks, pipelines, powerlines, and telephone line corridors located in zones A and B totaled 160 kilometers in length.
Lake or Pond	Small fresh water impoundments scattered in zone B within and surrounding the study area.

[1] Refer to Figure 2 for description of zones A and B within and surrounding the study area.

Longer range triangulations (> 100m but usually between 0.50 km and 2 km from investigator) were not considered for precise distance or topographic analysis due to the inaccuracy associated with bearing error ($\pm$ 5-7°) over steep and rugged terrain and the inability to verify the presence of bears in the triangulation area (Lee et al. 1985).

Aerial locations and *all* ground triangulations were used to determine seasonal and annual home range sizes (km^2) of black bears in SNP. This combination of location types was used because ground triangulations usually fell along or within the perimeter of a home range defined using only aerial locations. Also, all triangulations used met azimuth criteria for locating bears which included angle and time between readings, signal strength and integrity, and distance from animal. Even though longer range triangulations were not used for more precise distance or topographic analysis, they were considered accurate enough to include in home range analysis involving area measurements.

Only aerial locations were used to determine the proportion of time bears were seasonally located within the Park (zone A), outside the Park but in close proximity ($\leq$ 2-3 km) to the Park boundary (zone B), or outside the Park and located greater than 2-3 km from the nearest Park boundary (zone C), (Figure 2).

All aerial and ground locations were plotted on USGS topographic maps (scale l:24,000) using the Universal Transverse Mercator (UTM) grid system. Program TELEM (Koeln 1980) triangulated ground fixes and calculated home ranges of bears using the 100% convex polygon (Mohr 1947) and 95% convex polygon (Michener 1979) methods. Areas of greatest use (core areas) within convex polygons were delineated by TELEM using a modified minimum area technique that connected the peripheral locations that were not more than 0.25 of the length of the major axis apart (Harvey and Barbour 1965). Modified minimum areas within convex polygons were compared seasonally and annually to describe the stability of home ranges.
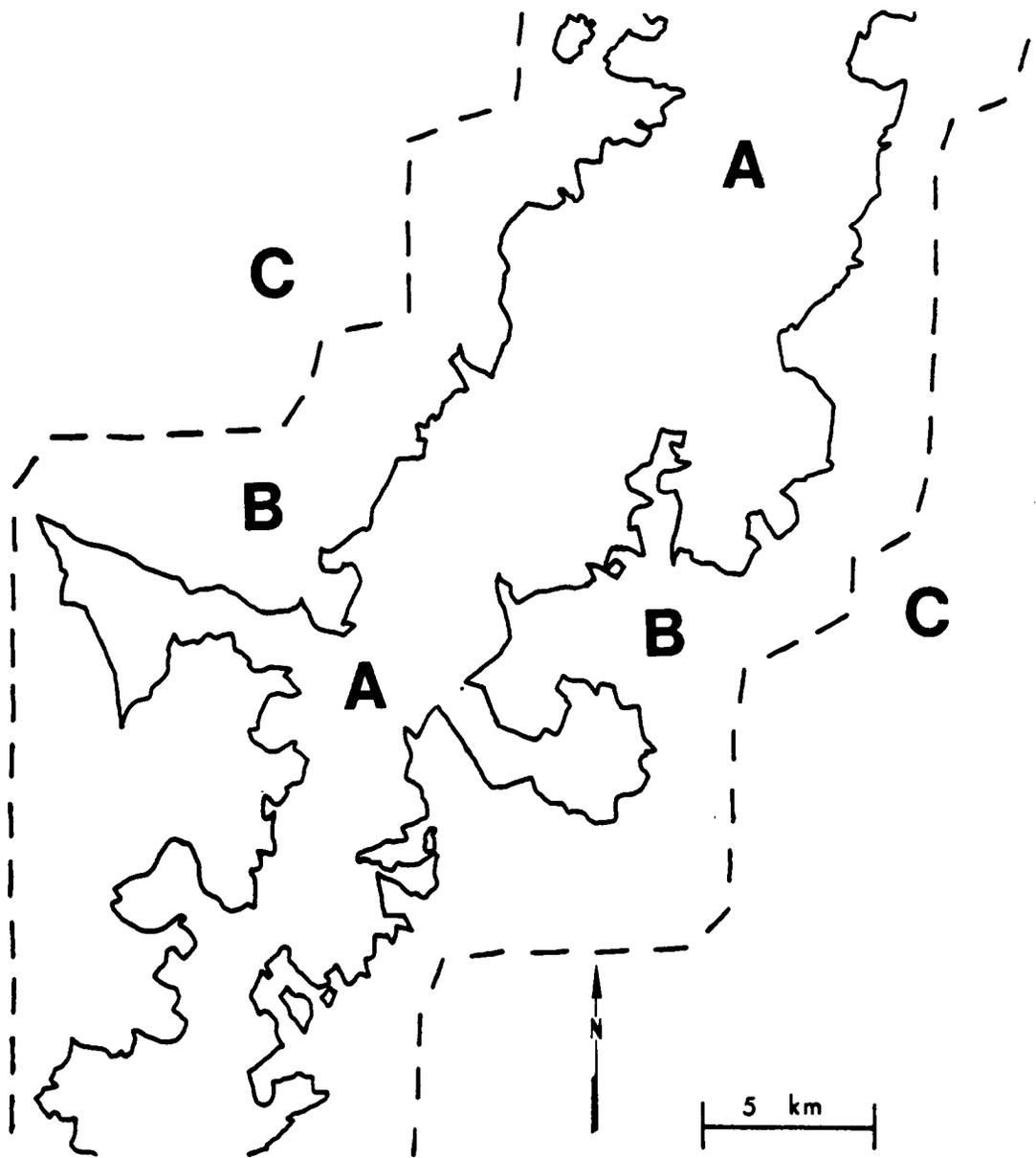
Figure 2. Zones A, B, and C within and surrounding the Central District of Shenandoah National Park, Virginia.

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); late fall (16 Oct - 20 Dec); and winter (21 Dec - 19 Mar).

Chi-square tests were used to determine if differences ($P < 0.05$) occurred between the proportion of time bears and 1751 random points were located within 100m of various geographic features (Table 1) and whether use of geographic features by males differed from females. A modification of the Bonferonni z statistic (Neu et al. 1974, Byers et al. 1984) was used to test for disproportionate use of 3 major land contours (slopes, ridgetops, valley bottoms) and 8 different aspects (45°, 90°, 135°, 180°, 225°, 270°, 315°, 360°) by sex. The non-parametric Kruskal-Wallis test, Rank LSD test (multiple comparisons), and Wilcoxon Rank Sum test (2 samples) were used to test for differences in home range areas, elevations, and slopes used by bears. Two-sided significance levels are reported.

Results and Discussion

A total of 47 collared bears, including 25 adult females, 17 adult males, and 5 subadult males < 3.5 years old, was located 3973 times during the study (Appendix A, 56% long ground triangulations, 38% aerial, and 6% close ground triangulation). Individual bears were radiotracked for periods ranging from 2 weeks to 34 months. The number of bears of each sex radiotracked each season, excluding winter, ranged from 12 to 23. From this sample, only females monitored $\geq$ 6 months and males monitored $\geq$ 9 months were used to calculate total home range size. As a result, annual home ranges of 24 adult females, 11 adult males, and 3 subadult males were determined using 3811 locations (2804 (73%) for females, 753 (20%) for adult males, 254 (7%) for subadult males). Seasonal and annual home ranges were calculated for those bears monitored an entire season or year.

Males were located from the ground every 5-6 days whereas females averaged 3-4 days between ground locations. Males and females averaged 7-8 days between aerial locations.

Based on these average time intervals between successive locations, I believe these observations were independent and unbiased (Dunn and Gipson 1977). Bears were frequently seen during aerial tracking in spring (10.2% visuals) and late fall (26.3% visuals) when deciduous cover was limited. Accuracy tests indicated that aerial locations were in error by less than 100m in any direction. Garshelis (1978:14-16), Quigley (1982:14-16), and Garris (1983:22) accepted an error of 150m. Close ground triangulations were considered highly accurate due to the close proximity of the investigator to the bear. The presence of bears in the close triangulated area was verified by sightings or strong signal reception. The large network of trails and service roads throughout the backcountry allowed investigators to get within 100m of a bear on many occasions without disturbance to the animal.

Total Home Range

Adult males in SNP had larger ($P<0.001$) total home ranges (100% $X=195$ km², 95% $X=116$ km²) than adult females (100% $X=38$ km², 95% $X=22$ km²), (Table 2, Figures 3,4). Black bear studies throughout North America indicate that males range farther than females (Table 3). Harestad and Bunnell (1979) reasoned that males of sexually dimorphic species utilize larger areas than females due to greater metabolic requirements. Amstrup and Beecham (1976:345) felt that males increased their reproductive success by being highly mobile and breeding with many females, while females most likely cover a minimum area large enough for "self maintenance and development of young".

Subadult males in SNP had larger ($P<0.10$) total home range areas (100% $X=542$ km², 95% $X=289$ km²) than adult males and adult females (Table 2). In Arizona, (Lecount 1980), and Pennsylvania (Eveland 1973), subadult males had the largest home range size of any sex or age class. Reynolds and Beecham (1980) noted that the size of subordinate males' home ranges may depend on whether they are residents or dispersers searching to establish a home range. Three subadult males in SNP had established ranges within the Park while a

Table 2. Home range size of adult males, subadult males, and adult females in Shenandoah National Park, Virginia, 1982-1985.

Sample	N	Number of Locations		Home Range Size[1](km^2) 100%		95%	
		per bear	Total	$\overline{X}$	Range	$\overline{X}$	Range
Adult Males	11	36 - 130	753	195	48-435	116	40-318
Sub-adult Males	3	58 - 130	254	542	251-807	289	146-538
Adult Females	21	48 - 273	2804	38	8-110	22	6-84

[1]Convex polygon methods (Mohr 1947, Michener 1979) used to calculate home range size for each bear. Adult females monitored $\geq$ 6 months and all males monitored $\geq$ 9 months.
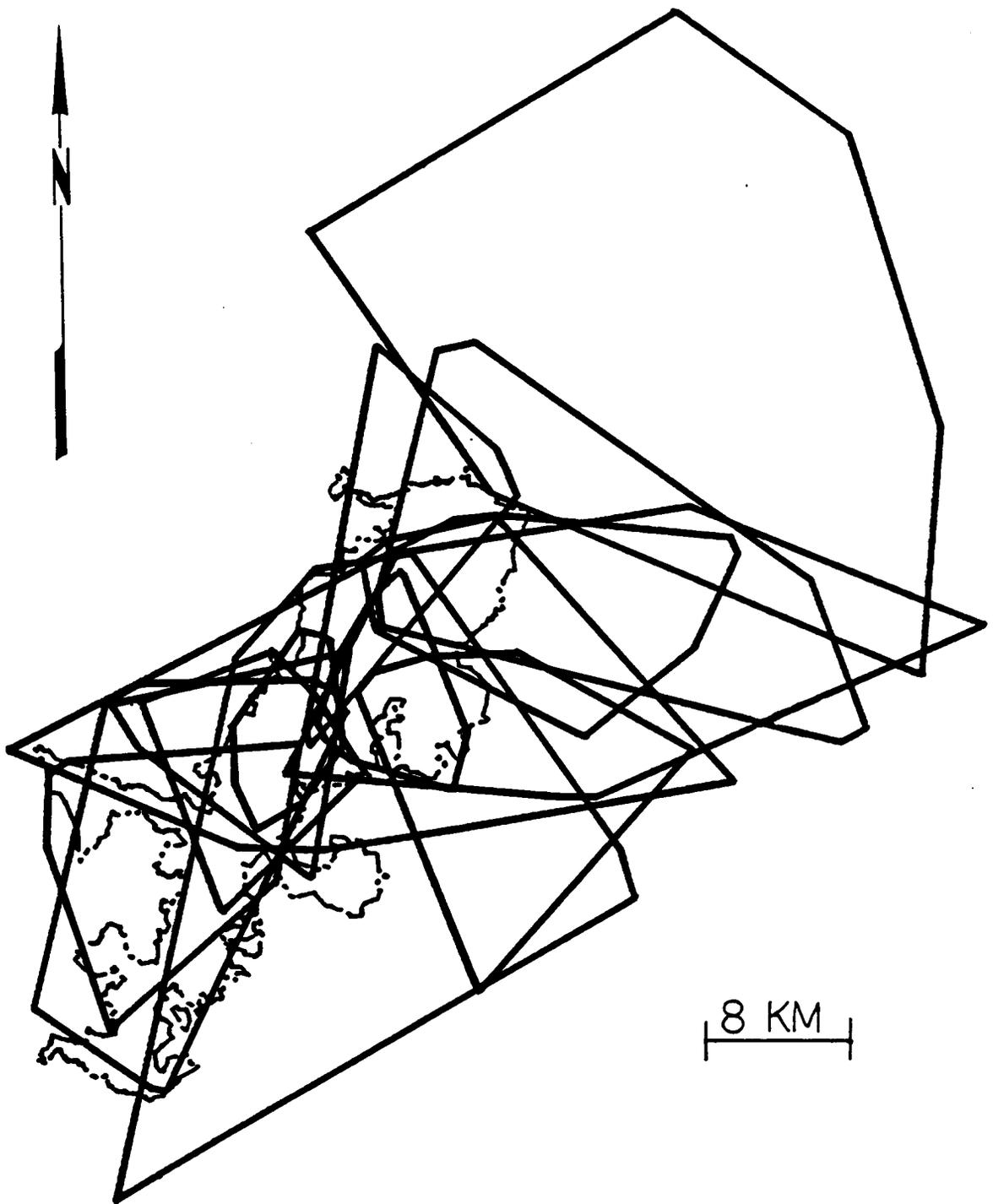
Figure 3. Home ranges of 14 male black bears monitored ≥ 9 months in Shenandoah National Park, Virginia, 1982-1985.

Figure 4. Home ranges of 21 adult female black bears monitored ≥ 6 months in Shenandoah National Park, Virginia, 1982-1985.

Table 3. Average home range sizes (km²) for black bears in North America.

Location	Source	Method	Male[1]	Female
Alberta	Young and Ruff (1982)	Telemetry--MA[2]	119	20
Arizona	Lecount (1980)	Telemetry--MA	29	18
Arkansas	Smith (1985)	Telemetry--CP[3]	128	11
California	Novick and Stewart (1982)	Telemetry--CP	36	25
Idaho	Amstrup and Beecham (1976)	Telemetry--CP	112	49
Idaho	Reynolds and Beecham (1980)	Telemetry--MA	60	12
Louisiana	Taylor (1971)	Telemetry--MA	111	20
Maine	Hugie (1982)	Telemetry--CP	1721	43
Massachusetts	Elowe (1984)	Telemetry--CP	318	28
Michigan	Erickson and Petrides (1964)	Trap-recapture	52	26
Montana	Jonkel and Cowan (1971)	Trap-recapture	31	5
North Carolina (mountains)	Brody (1984)	Telemetry--CP	32(SU) 69(FA)	9(SU) 17(FA)
North Carolina (coast)	Hamilton (1978)	Telemetry--MA	91	8
North Carolina (coast)	Hardy (1974)	Telemetry--MA	175	11
North Carolina (mountains)	Waburton (1984)	Telemetry--CP	61	17
Pennsylvania	Alt et al. (1976)	Telemetry--PE[4]	196	37
Pennsylvania	Alt et al. (1980)	Telemetry--PE	173	41
Tennessee	Beeman (1975)	Telemetry--CP	21	7
Tennessee	Carr (1983)	Telemetry--CP	119	22
Tennessee	Garris (1983)	Telemetry--CP	36	6
Tennessee	Garshelis (1978)	Telemetry--PE	192	22
Tennessee	Quigley (1982)	Telemetry--CP	60	15
Tennessee	Villarrubia (1982)	Telemetry--CP	42	15
Virginia	This study	Telemetry--CP	195	38
Washington (island)	Lindzey and Meslow (1977)	Telemetry--CP	5	2
Washington	Poelker and Hartwell (1973)	Telemetry--CP	52	5
West Virginia	Brown (1980)	Telemetry--PE	204	49

[1] Home range values rounded to nearest one.
[2] Minimum area.
[3] Convex polygon.
[4] Probability ellipse (95%).

fourth subadult dispersed onto the Piedmont Plateau east of SNP and established a home range approximately 30 km from where he was initially captured. A subadult male captured in SNP (ear tagged) was killed by hunters in the Massanutten Mountains 16 km west of the study area outside the Park across the Shenandoah Valley. A 1.5 year old male captured in fall 1982 (ear tagged) was later trapped by Maryland officials outside Baltimore, MD. in summer 1984, approximately 150 km from the initial capture location in SNP. Whether such characteristic dispersal behavior in subadult males is an annual occurrence of random exploration or a density-dependent form of population regulation has been disputed and discussed by several authors (Jonkel and Cowan 1971, Kemp 1976, Rogers 1976,1977, Reynolds and Beecham 1980). Adult males regulated subadult recruitment in Canada (Young and Ruff 1982). One expression of territoriality may be the dispersal behavior of subadult males in response to aggression by adult males (Hamilton 1978:65). Resident adult males in SNP most likely prevent the settlement of many transient subadults (Jonkel and Cowan 1971, Rogers 1976). Adult males reduce immigration of subadults and therefore reduce competition for food encountered by their offspring and competition for females (Rogers 1977).

Black bear home range size is greatly influenced by the quality and quantity of food available to them (Spencer 1955, Stickley 1961, Jonkel and Cowan 1971, Hatler 1972, Hardy 1974:102, Beeman 1975:74, Alt et al. 1976, Amstrup and Beecham 1976, Eubanks 1976:54, Lindzey and Meslow 1977, Reynolds and Beecham 1980, Garshelis and Pelton 1981, Hugie 1982:114, Garris 1983). Small home range size of female black bears in Alaska were found in high quality habitats when home ranges were compared to available habitats (Modafferi 1982). High quality habitat apparently allowed smaller home ranges on an island in southwest Washington (Lindzey and Meslow 1977). Highly diverse habitats with much dispersion support abundant food species and allow bears to readily shift food items when one particular food item is scarce (Carr 1983:28). Habitat diversity in SNP provided bears with a rich and abundant food supply (Chapter 2). Smaller home ranges of females in SNP likely reflected an intense use of high quality habitats in the Park.

Seasonal and Annual Home Range

Mean seasonal and annual home range size (Mohr 1947) was compared for adult males, solitary adult females, and females with cubs (Table 4). Low sample size prevented comparison for subadult males.

During all seasons and years of the study, adult males had larger ($P < 0.07$) home ranges than either solitary females or females with cubs (Table 4). Adult male home range size did not differ between seasons during 1983 ($P = 0.351$) or 1984 ($P = 0.778$) or within seasons between years during spring ($P = 0.256$), summer ($P = 0.637$), or fall ($P = 0.233$), (Table 4). I did not test whether use of larger areas was highly correlated with greater distances traveled per day due to sampling intervals greater than 24 hours. However, Alt et al. (1980) did find a high correlation between these two variables for black bears in Pennsylvania. Lindzey (1976) in Washington and Alt et al. (1980) in Pennsylvania reported greatest movements by adult males during the breeding season (summer), but Reynolds and Beecham (1980) in Idaho found no seasonal differences. Spring and fall ranges were artificially inflated because males moved from zone A through zone B into zone C but mainly used core areas in zones A and C (Figure 2, Table 5). As a result, convex polygon analysis did not detect differences in seasonal home range size for adult males despite large summer ranges and use of all areas within summer ranges.

Solitary females had larger ($P < 0.10$) home ranges than females with cubs during spring 1983 and 1984 (Table 4). Females with cubs had smaller ($P = 0.029$) home ranges than solitary females in summer 1983 but not during summer 1984 ($P = 0.464$). Adult females with and without cubs had similar sized home ranges during fall 1983 ($P = 0.119$) and 1984 ($P = 0.190$). In addition, annual home range size for solitary females and females with cubs was not different in 1983 ($P = 0.518$) or 1984 ($P = 0.143$), (Table 4). Female bears with cubs in SNP were less mobile than solitary females during the spring; whether this was the case in summer was unclear. However, fall cubs were large and not likely to restrict females' movements. Except

Table 4. Seasonal and annual home range size (km²) of solitary adult females, females with cubs, and adult male bears in SNP.

Sample[1]	N	Mean[2]	Median	SD	Range in Size
Spring 1983					
Solitary Females	6	8.52	4.33	10.58	3.76- 30.11
Females with cubs	3	1.95	2.70	1.40	0.33- 2.82
Adult Males	7	115.38	77.16	137.06	17.83-392.91
Spring 1984					
Solitary Females	10	3.98	3.89	2.02	1.54- 7.97
Females with cubs	9	2.52	1.63	2.23	0.42- 7.20
Adult Males	5	75.89	12.16	90.08	6.95-177.69
Summer 1983					
Solitary Females	16	11.43	8.89	7.07	3.94- 32.21
Females with cubs	3	3.89	4.25	1.91	1.83- 5.59
Adult Males	7	59.94	32.54	56.38	24.49-179.28
Summer 1984					
Solitary Females	10	10.74	6.95	14.89	1.79- 52.56
Females with cubs	7	8.39	8.07	3.25	5.25- 14.54
Adult Males	4	45.96	46.97	12.76	29.56- 60.33
Fall 1982					
Solitary Females	8	19.30	14.60	21.56	3.76- 70.22
Females with cubs	-	-----	-----	-----	-----------
Adult Males	4	57.28	56.61	18.16	39.61- 76.29
Fall 1983					
Solitary Females	18	10.18	6.71	6.86	3.43- 26.34
Females with cubs	3	14.78	13.97	1.50	13.86- 16.51
Adult Males	2	142.21	------	84.29	82.61-201.81
Fall 1984					
Solitary Females	9	20.35	15.80	14.89	5.07- 47.04
Females with cubs	4	8.01	9.03	3.60	2.94- 11.02
Adult Males	3	87.24	95.57	58.37	25.15-141.00
Annual 1983					
Solitary Females	6	22.64	19.17	9.25	11.81- 36.00
Females with cubs	3	17.16	17.94	1.57	15.36- 18.19
Adult Males	3	327.50	339.28	166.32	155.60-487.61
Annual 1984					
Solitary Females	9	31.70	18.31	25.51	7.94- 85.39
Females with cubs	4	12.65	12.97	4.84	6.51- 18.17
Adult Males	1	-----	-----	-----	366.80

[1]Only bears monitored during the entire specified season or year are included in samples.
[2]Convex polygon method (Mohr 1947) used to calculate seasonal and annual home range size.

Table 5. Seasonal distribution of male and female black bears in zones A, B, and C inside and surrounding the Central District.

Season	N	Percent of Locations		
		A[1]	B	C
Spring M	144	64%	12%	24%
F	189	90%	7%	3%
Summer M	172	58%	36%	6%
F	361	79%	19%	2%
Early Fall M	61	54%	25%	21%
F	176	84%	14%	2%
Late Fall M	95	88%	9%	3%
F	183	92%	8%	0%
Winter M	45	93%	7%	0%
F	73	95%	5%	0%
Total Season M	517	68%	20%	12%
F	982	85%	13%	2%

[1]All percentage values rounded to the nearest one. Refer to Figure 2 for zone descriptions.

for a short period immediately after den emergence, the presence of cubs did not restrict movements of female black bears in Idaho (Reynolds and Beecham 1980). However, Bray and Barnes (1967) and Eveland (1973) concluded that females with cubs were less mobile and used smaller areas than those without cubs. Alt et al. (1980) reported that adult female bears in Pennsylvania maintained larger home ranges while accompanied by offspring than without offspring. Solitary females in Tennessee had larger ranges than females with cubs which prompted Carr (1983:31) to speculate that the reproductive success of the breeding portion of the population would be enhanced by increased movements and larger ranges.

In 1983, spring and summer ranges of females with cubs were not different in size ($P = 0.383$) but were only 0.13 and 0.26 times as large as their fall range ($P < 0.08$), respectively (Table 4). During 1984, home range size of females with cubs was smallest in spring ($P < 0.02$) and averaged only 0.30 and 0.31 times the size of summer and fall ranges. In 1983, home range size of solitary females was smallest in spring ($P < 0.06$) and averaged 0.75 and 0.84 times the size of summer and fall ranges. In 1984, spring and summer ranges of solitary females were different in size ($P < 0.05$) and were only 0.20 and 0.53 times as large as their fall range ($P < 0.06$), respectively (Table 4). Large fall home ranges in SNP were likely related to the scattered supply of acorns relative to the concentrated sources of soft mast used in the summer (Chapter 2). Other variations in the amount of area used during spring and summer may be related to annual differences in food abundance and distribution. The patchy distribution of food items in Idaho greatly influenced day-to-day use of home ranges (Reynolds and Beecham 1980).

Two subadult male black bears and 2 females each with 3 yearlings remained active in the winter months during the study. During the winter of 1984-85, one female had a home range size of 3.38 km² (27 relocations, 100% convex polygon) whereas the other female's home range was 7.25 km² (18 relocations, 100% convex polygon). One subadult male was relocated only 5 times during the winter of 1982-83 and the other subadult male was relocated only 8 times during the winter of 1983-1984. Despite these low sample sizes for subadult male relocations, distances between successive relocations were as large as 10.8 kilometers over

a 3 month period. All winter-active bears in SNP made extensive use of evergreen mountain laurel thickets for escape and thermal cover during the winter months. Females with yearlings were the most active class of bears throughout the winter in Pennsylvania (Alt et al. 1976). Subadult males were trapped from January through March in coastal North Carolina (Hamilton 1978:68). Mild winter temperatures, lack of persistent snow cover, and diverse winter food items were factors contributing to the winter activity of black bears in the Great Dismal Swamp, Virginia (Hellgren and Vaughan 1986). Subadult males and adult females with yearlings in SNP may remain active during the winter to feed on available food items (Chapter 2) due to their low fat reserves brought on by the nutritional stress of body growth (subadults) and raising young (Hamilton and Marchinton 1980, Smith 1985, Hellgren and Vaughan 1986).

A small amount of 24 hour activity data was collected on selected black bears in SNP during the study. The limited nature of the data prevents drawing any conclusions. However, the data collected suggests that bears in SNP may have been most active and diurnal during the summer (breeding period) when soft mast was abundant and most nocturnal in the fall (predenning) to increase foraging when hard mast was abundant (Chapter 2). Garshelis and Pelton (1980) found this same activity pattern for black bears in the Great Smoky Mountains National Park (GSMNP), Tennessee. I also hypothesize that males became more nocturnal when making long excursions outside the Park in order to utilize the cover of night around human distubance areas (farms, residential areas, etc.).

Home Range Stability

Adult and subadult males generally had less stable home ranges (Figures 5-7) than adult females (Figures 8-12). Annual and within season between year comparisons of home range location for males showed numerous outliers and disjunct core areas (Figure 7). Seasonal comparisons within years for males also illustrated disjunct areas of intensive use (Figures 5,6).

1M

● SPRING 83
▲ SUMMER 83   5 KM

10M

● SPRING 83
▲ SUMMER83 ·   8.5 KM

21M

▲ SUMMER 84
● FALL 84   7 KM

33M

● SPRING 83
▲ SUMMER 83   5 KM

116M

● SPRING 84
▲ SUMMER 84   5 KM

N
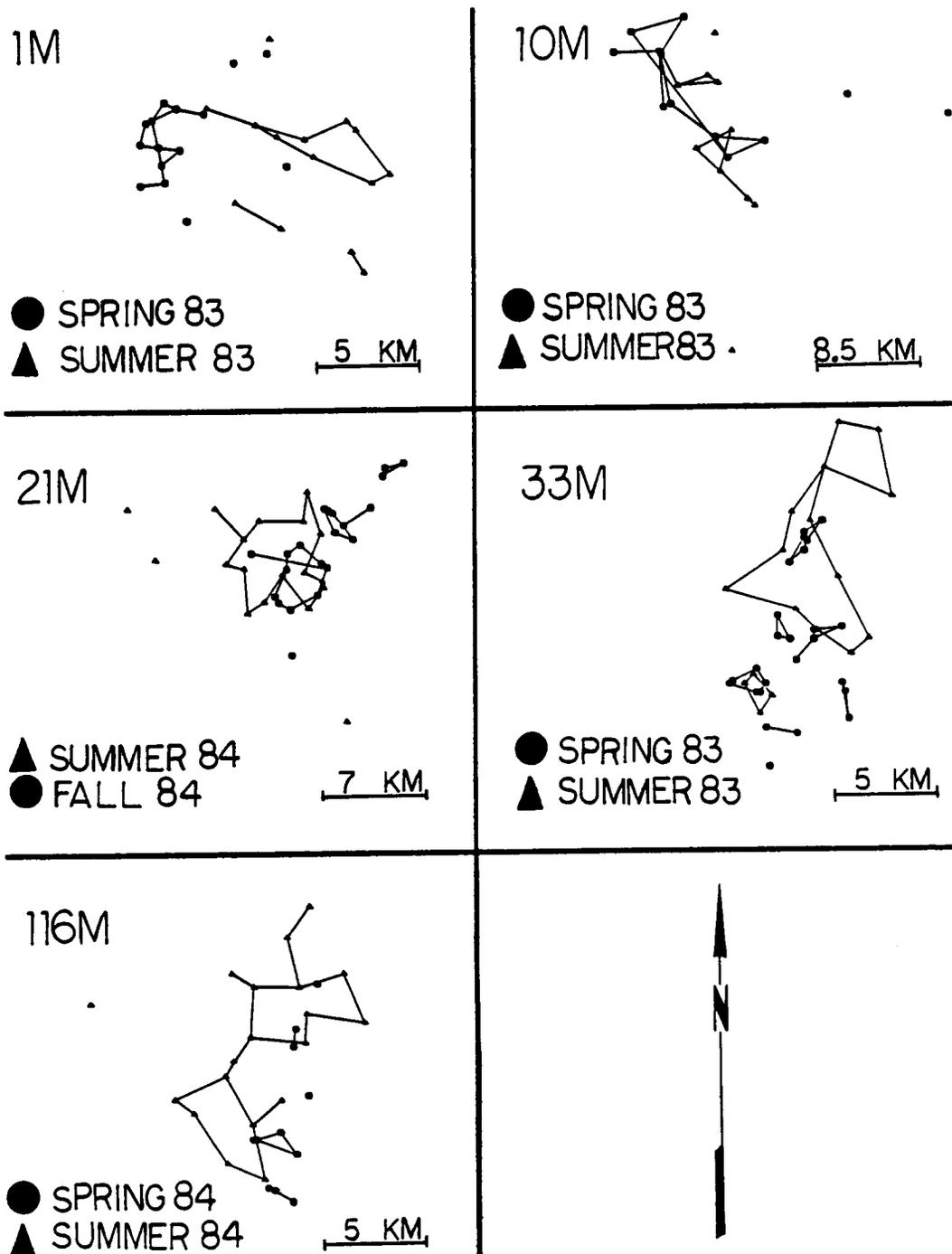
Figure 5. **Seasonal comparisons of modified minimum areas within the same year for adult male black bears in SNP, Virginia, 1983-1984: number of bear, scale in kilometers (KM), and season given in each frame.**
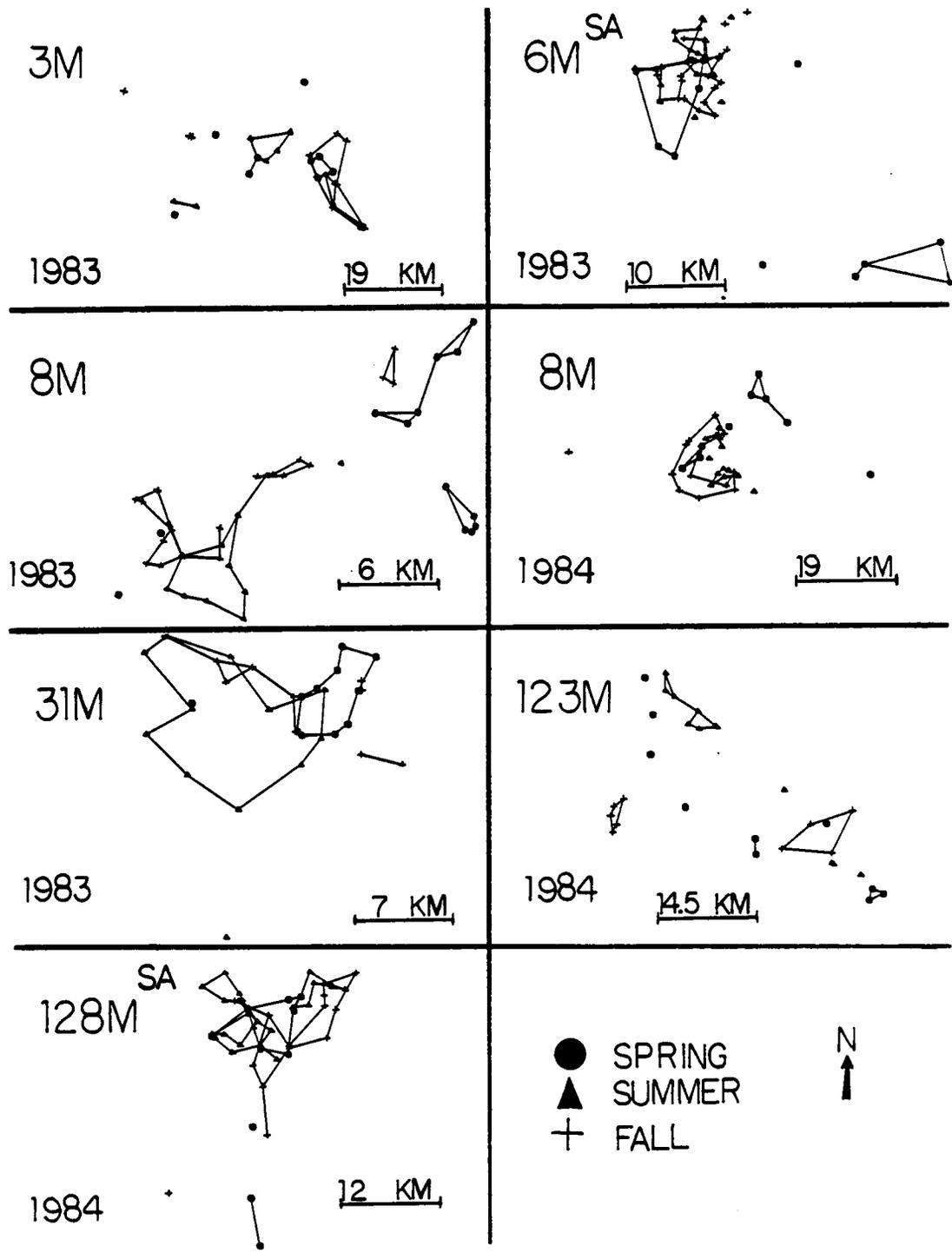
Figure 6. Seasonal comparisons of modified minimum areas within the same year for subadult (SA) and adult male black bears, 1983-1984: number of bear, scale in kilometers (KM), and year given in each frame.

8M

● FALL 82
▲ FALL 83
+FALL 84

|19 km|

8M

● 1983
▲ 1984

|18 km|

8M

●SUMMER 83
▲SUMMER 84

|7 km|

8M

●SPRING 83
▲SPRING 84

|11 km|

6M SA

X FALL 82
◆FALL 83

|12 km|

6M SA

N

X SPRING 83
◆SPRING 84

|10 km|
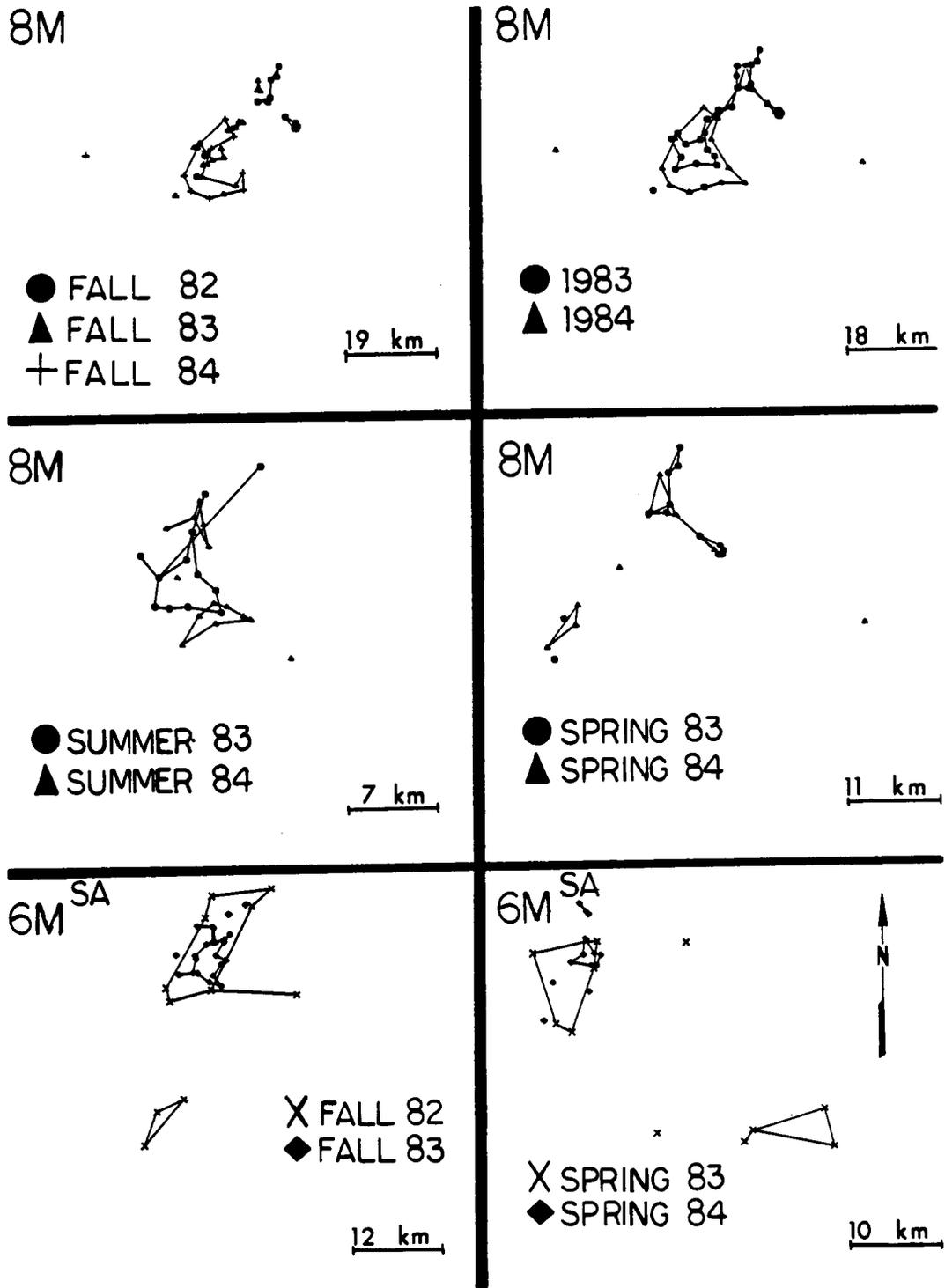
Figure 7. Seasonal and annual comparisons of modified minimum areas between years for subadult (SA) and adult male bears, 1982-1984: number of bear, scale in kilometers (KM), and season given in each frame.

Spring and summer home ranges of females were similarly positioned between years (Figures 9,10). Approximately the same home range areas were used each spring and summer regardless of the presence of cubs (Figures 9,10). During fall however, solitary adult females and females with cubs did not use the same area from year to year (Figure 11). This infidelity to a given area likely reflected the yearly variation in the distribution of hard mast (acorns), (Chapter 2). The lack of fidelity to annual ranges from year-to-year reflects the fall pattern of range use (Figures 11,12). Carr (1983:32) observed that fall range size for bears in Tennessee greatly contributed to the size of the annual range due to the bears response to acorn availability.

Core areas within home ranges of adult female and male black bears changed seasonally (Figures 5-6,8). Both sexes in SNP made excursions during the fall to areas of hard mast abundance. However, this summer-fall separation of core areas within home ranges was more prevalent for females than males (Figures 5-6,8). This shift in movement usually coincided with the maturation of acorns during the first two weeks in September. In GSMNP in Tennessee , Beeman (1975), Garshelis (1978), Quigley (1982), and Villarrubia (1982) documented shifts in range use in the fall in response to seasonally abundant hard mast.

Home Range Overlap

Extensive home range overlap occurred among adult males, subadult males, and adult females in SNP (Tables 6,7; Figures 3,4,13-16). Similar range overlap in other black bear populations across the U.S.A. (Spencer 1955, Sauer et al. 1969, Jonkel and Cowan 1971, Beeman 1975, Amstrup and Beecham 1976, Lindzey and Meslow 1977, Reynolds and Beecham 1980, Villarrubia 1982) suggests that they, at least periodically, display a high intraspecific
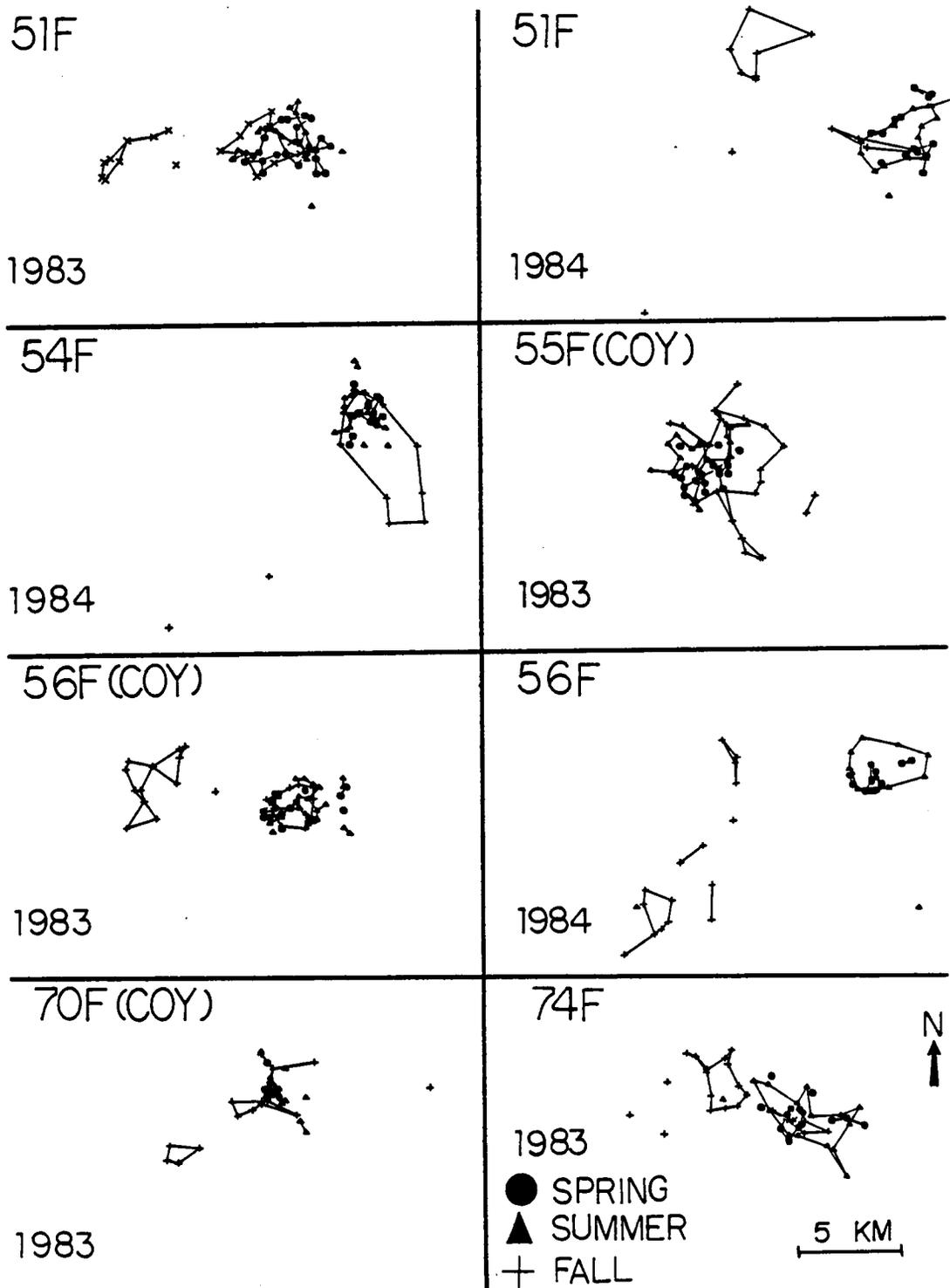
Figure 8. Seasonal comparisons of modified minimum areas within the same year for adult female black bears in SNP, Virginia, 1983-1984: number of bear and year given in each frame; scale equals 5 KM.

51F 54F

55F 56F

1983 (COY) 1983 (COY)

64F 66F

70F 74F

1984 (COY)
● SPRING 83
▲ SPRING 84

5 km

1983 (COY)
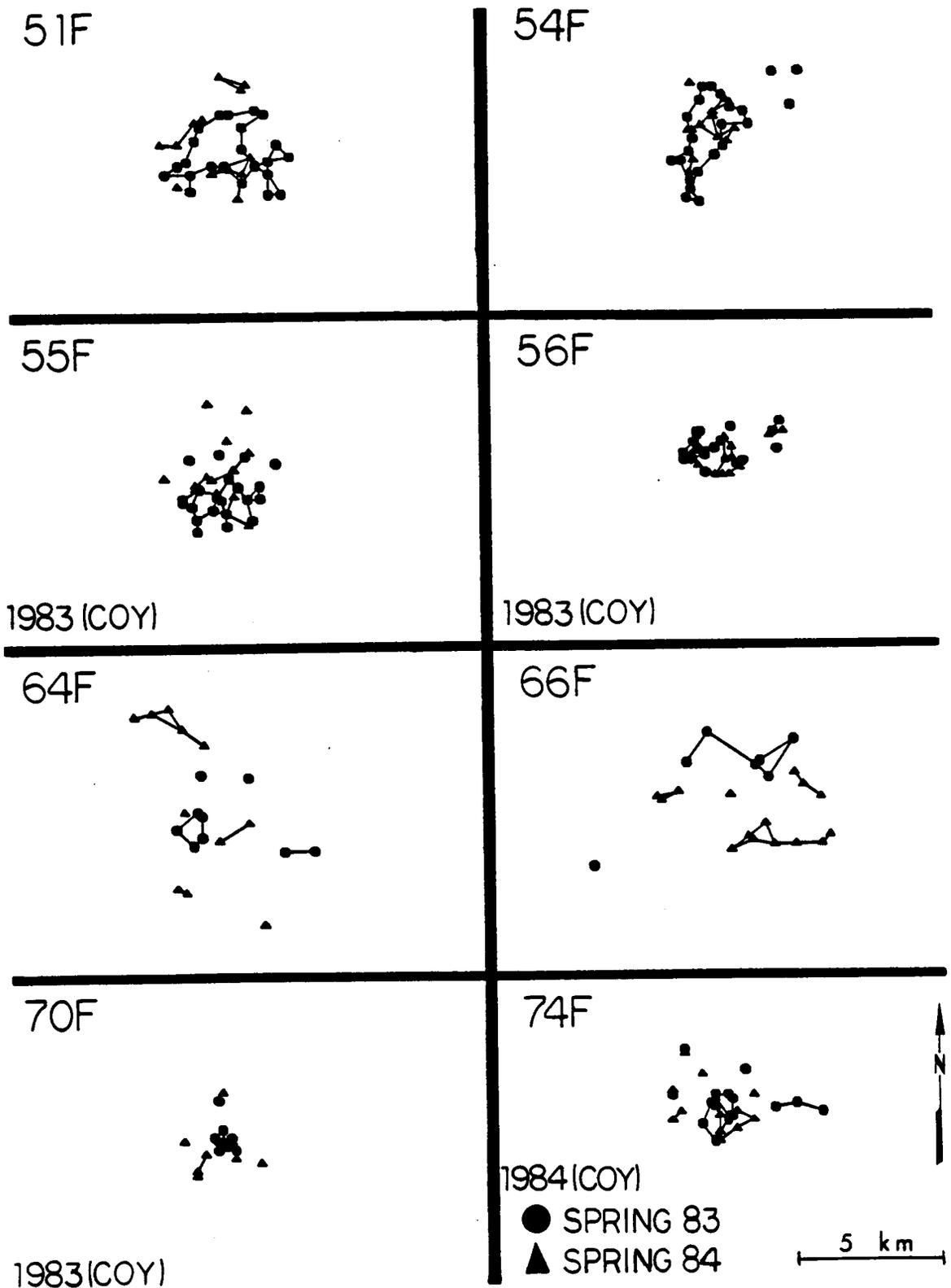
Figure 9. Spring comparisons of modified minimum areas between years for adult female black bears in SNP, Virginia, 1983-1984: number of bear and year when female had cubs given in each frame; scale equals 5 KM and COY designates cubs of the year.
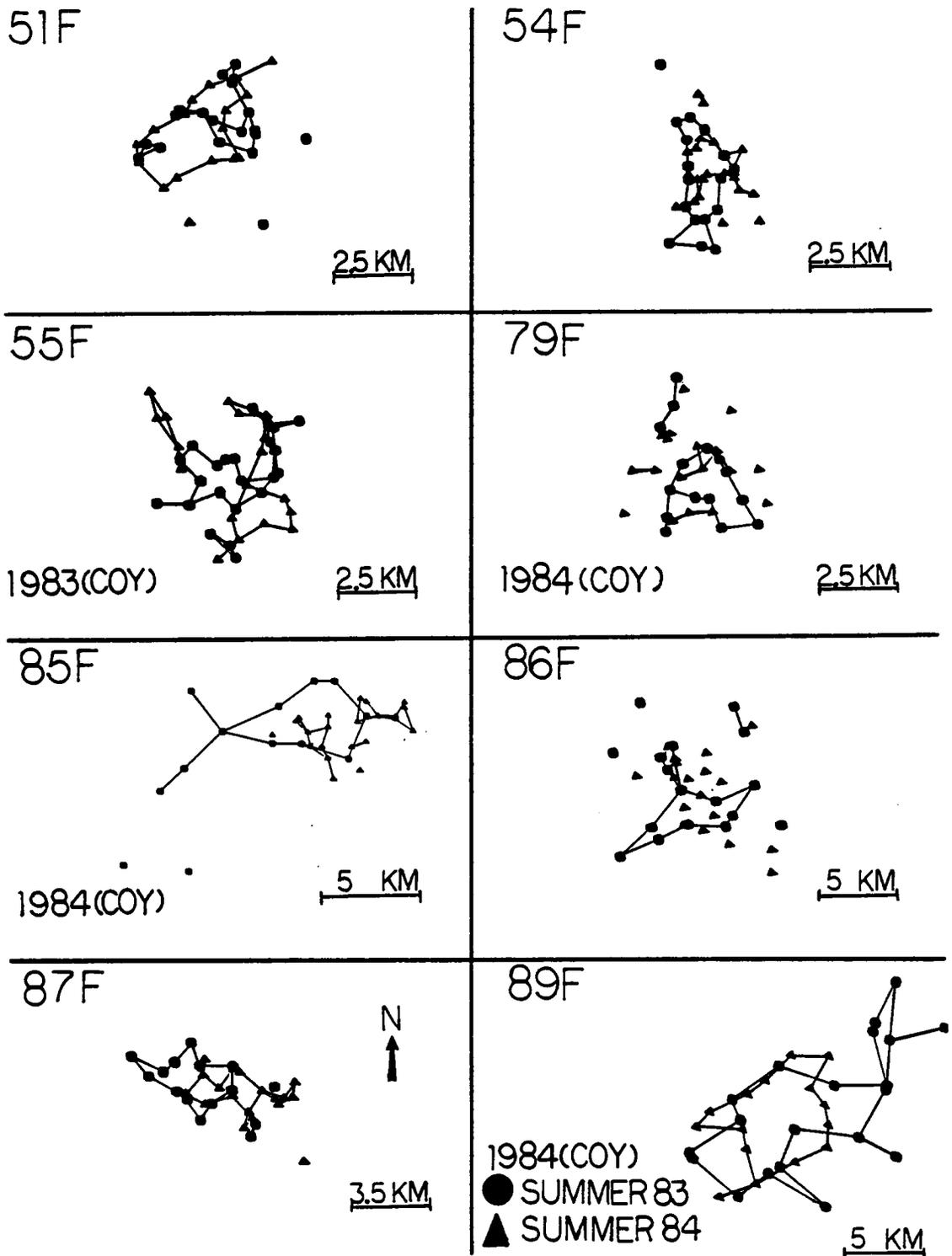
Figure 10. Summer comparisons of modified minimum areas between years for adult female black bears in SNP, Virginia, 1983-1984: number of bear, year when female had cubs, and scale in kilometers (KM) given in each frame; COY designates cubs of year.
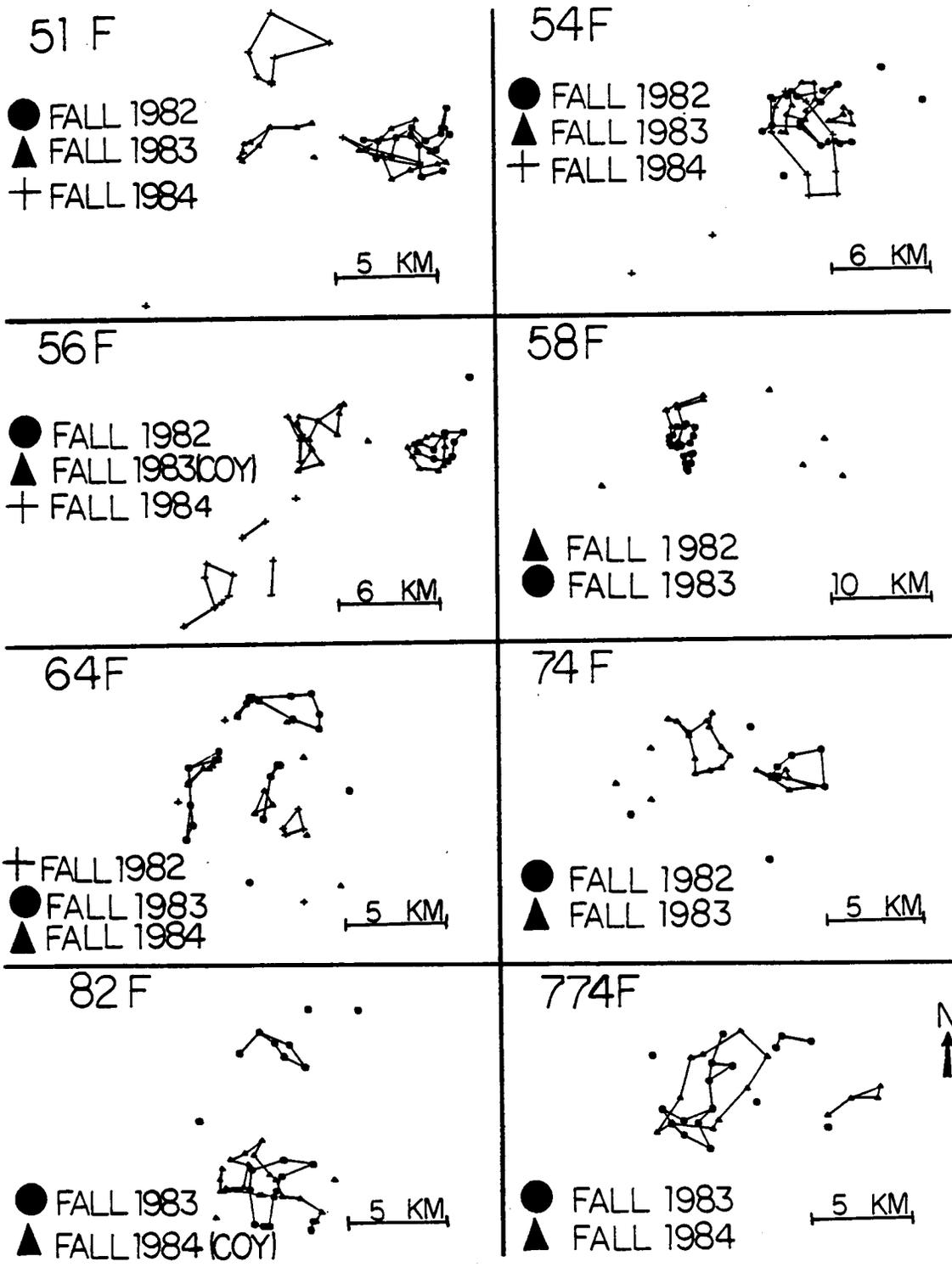
Figure 11. Fall comparisons of modified minimum areas between years for adult female black bears in SNP, Virginia, 1982-1984: number of bear, year when female had cubs, season, and scale (KM) given in each frame; COY designates cubs of year.

51F

54F

5 KM

6 KM

56F

64F

1983(COY)

6 KM

5 KM

66F

● ANNUAL 1983
▲ ANNUAL 1984

N

5 KM
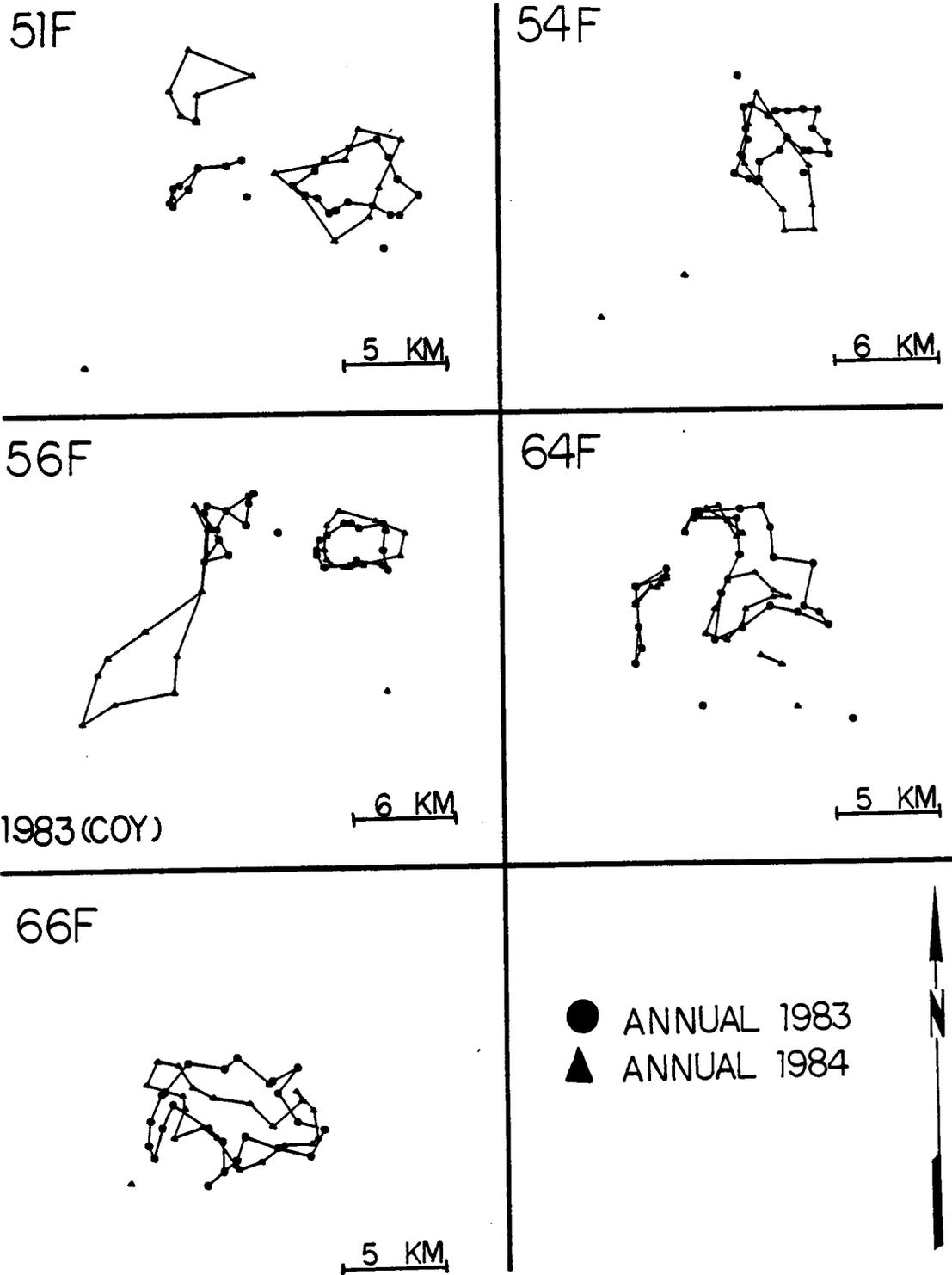
Figure 12. Annual comparisons of modified minimum areas for adult female black bears in Shenandoah National Park, Virginia, 1983-1984: number of bear, year when female had cubs, and scale (KM) given in each frame; COY designates cubs of year.

tolerance for one another. A lack of home range overlap may imply territoriality. Bears in SNP did not appear to be strongly territorial as were female black bears in Minnesota whose home ranges did not overlap (Rogers 1977).

Adult males in SNP overlapped the home ranges of several females during the breeding season (summer). Polygamy among bears accounts for home range overlap between sexes. Home range overlap among adult females, subadult females, and subadult males (predispersal) on the other hand may indicate the relatedness and kinship of bears. Spatial and temporal distribution of food may also, in part explain extensive home range overlap and high intraspecific tolerance among black bears (Reynolds and Beecham 1980). During fall 1983, when white oak acorns were abundant and concentrated (Chapter 2), two groups of 8 adult females, whose relatedness was unknown, exhibited the greatest amount of home range overlap observed during this study (Tables 6,7; Figures 13,15). Annual home ranges of adult females in 1983 were smaller and overlapped more than in 1984 when oak mast was less abundant and less concentrated causing bears to be more dispersed (Figure 16). The smallest annual composite range among bears in SNP occurred among four adult females (#51,#56,#66,#74) in 1983 and was 33.7 km² in size (Figure 16). Assuming this density persists throughout the Park yields a minimum estimate of 92 adult females in SNP. However, this estimate is low when compared to the population estimate of 1 bear per 0.96-1.49km² reported for the Central district of SNP (Carney 1985:33).

Despite extreme home range overlap observed in SNP, temporal and spatial separation most likely prevents close encounters among bears. Reynolds and Beecham (1980) reported that females concentrated their activities in only a portion of their range to minimize contact with other females. Villarrubia (1982:61) and Lindzey and Meslow (1977) reported that spatio-temporal exclusion occurred among bear populations. Strong mutual avoidance was noted among bears in GSMNP (Garshelis and Pelton 1981). Jonkel and Cowan (1971) reported

Table 6. Maximum seasonal overlap (%) of home ranges among 5 adult female black bears in SNP, Virginia, 1982-1984.

Season[1]	N[2]	Home Range Size[3] (km²)	Maximum Overlap with 1 Other Female	Maximum Overlap with 2 Other Females	Maximum Overlap with 3 Other Females	Maximum Overlap with 4 Other Females
Spring 1983						
Bear 51	33	4.18	39.47 %	64.11 %	---	---
Bear 56	20	2.70	61.11 %	---	---	---
Bear 66	8	4.47	---	---	---	---
Bear 74	27	3.95	26.08 %	---	---	---
Bear 92	---	---	---	---	---	---
Spring 1984						
Bear 51	14	3.97	25.44 %	48.11 %	---	---
Bear 56	16	1.63	61.96 %	40.25 %	---	---
Bear 66	17	4.77	22.22 %	44.53 %	---	---
Bear 74	15	2.56	41.41 %	---	---	---
Bear 92	14	1.63	---	---	---	---
Summer 1983						
Bear 51	23	6.89	44.70 %	76.92 %	76.92 %	---
Bear 56	21	4.25	72.47 %	72.47 %	---	---
Bear 66	26	7.36	47.01 %	47.01 %	---	---
Bear 74	27	7.82	44.25 %	69.57 %	69.57 %	---
Bear 92	---	---	---	---	---	---
Summer 1984						
Bear 51	28	4.89	92.02 %	100.00 %	100.00 %	---
Bear 56	23	5.55(95% range)	39.00 %	45.96 %	---	---
Bear 66	28	8.15	52.39 %	70.06 %	70.06 %	---
Bear 74	31	10.12	44.47 %	56.03 %	58.70 %	---
Bear 92	23	5.25	81.33 %	---	---	---
Fall 1982						
Bear 51	27	4.21	34.44 %	66.75 %	---	---
Bear 56	22	3.76	36.17 %	---	---	---
Bear 66	---	---	---	---	---	---
Bear 74	12	16.96	8.55 %	---	---	---
Bear 92	---	---	---	---	---	---
Fall 1983						
Bear 51	38	10.47	79.94 %	95.89 %	95.89 %	95.89 %
Bear 56	39	13.97	50.89 %	61.99 %	61.69 %	61.69 %
Bear 66	43	12.38	69.39 %	94.10 %	94.10 %	94.10 %
Bear 74	26	11.80	72.80 %	76.19 %	76.19 %	76.19 %
Bear 92	19	5.20	50.38 %	68.65 %	68.65 %	68.65 %
Fall 1984[4]						

[1] Data were not given for females who were not monitored during the entire specified season or did not display overlap with the specific number of females listed in each column. Under-lined bears indicate females with cubs.

[2] Number of locations for each female within each season.

[3] 100% convex polygon method (Mohr 1947) and 95% convex polygon method (Michener 1979) used to calculate seasonal home ranges.

[4] Large movements defined as excursions prevented accurate calculations of actual home range overlap with other females.

Table 7. Maximum seasonal overlap (%) of home ranges among 3 adult female black bears in SNP, Virginia, 1983-1984.

Season[1]	N[2]	Home Range Size[3](km²)	Maximum Overlap with 1 Other Female	Maximum Overlap with 2 Other Females
Summer 1983				
Bear 79	20	3.94	95.69 %	96.45 %
Bear 86	19	9.53	85.41 %	87.62 %
Bear 772	13	18.73	43.46 %	43.51 %
Fall 1983				
Bear 79	34	5.34	68.35 %	69.85 %
Bear 86	29	5.64	70.57 %	74.82 %
Bear 772	17	5.84	68.15 %	85.96 %
Spring 1984				
Bear 79	9	7.20	43.89 %	48.89 %
Bear 86	14	5.54	57.04 %	-------
Bear 772	13	5.17	6.96 %	-------
Summer 1984				
Bear 79	20	5.89	43.29 %	-------
Bear 86	20	5.55	45.95 %	63.60 %
Bear 772	21	7.08	13.84 %	-------

[1]Data were not given when overlap was not observed with the specific number of females listed in each column. Underlined bears indicate females with cubs.
[2]Number of locations for each female within each season.
[3]Convex polygon method (Mohr 1947) used to calculate seasonal home ranges.

CONVEX POLYGONS

CORE AREAS

SPRING 1983   2.5 KM

SUMMER 1983   2.5 KM

FALL 1983   2.5 KM

N

2.5 KM

2.5 KM

2.5 KM
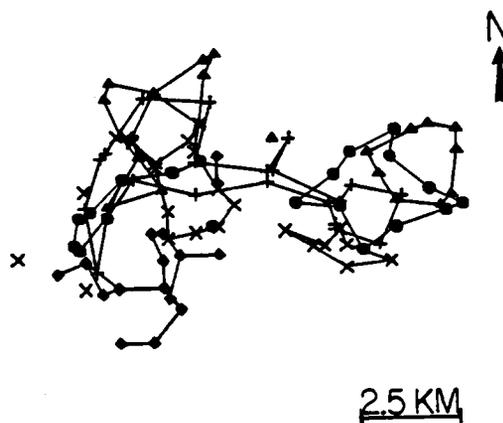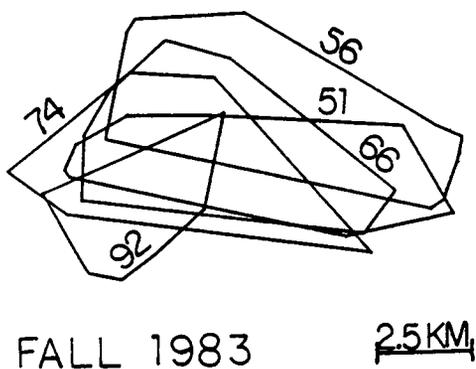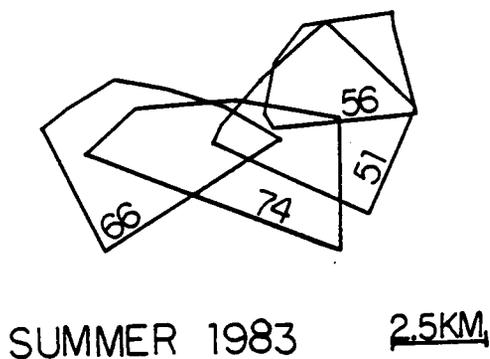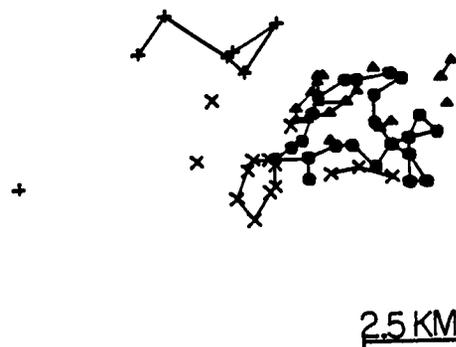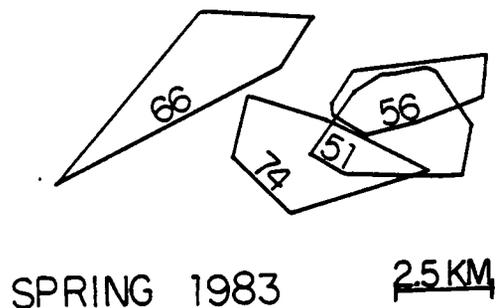
Figure 13. Seasonal overlap of convex polygon areas and modified minimum areas among adult female black bears in SNP, Virginia, 1983: ID numbers for bears, season, and scale in kilometers (KM) given for each frame association.

CONVEX POLYGONS

CORE AREAS
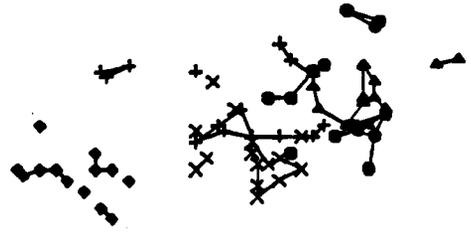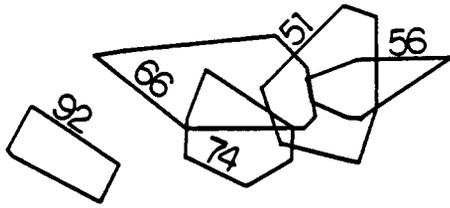
SPRING 1984   2.5 KM

2.5 KM
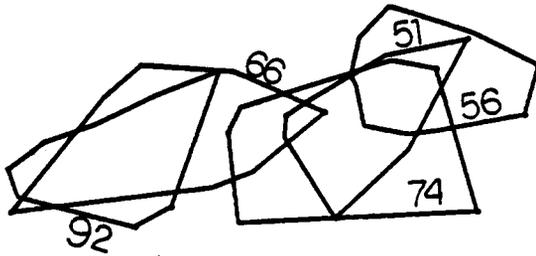
SUMMER 1984   2.5 KM

2.5 KM
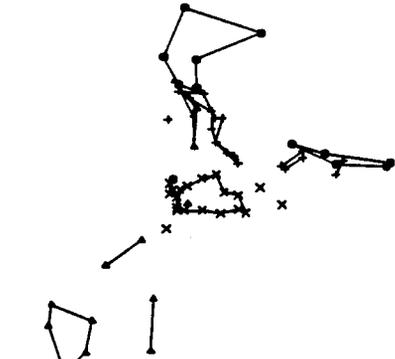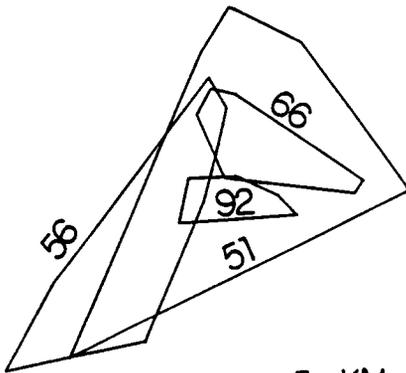
FALL 1984   5 KM

5 KM

Figure 14. Seasonal overlap of convex polygon areas and modified minimum areas among adult female black bears in SNP, Virginia, 1984: ID numbers for bears, season, and scale in kilometers (KM) given for each frame association.

CONVEX POLYGONS

CORE AREAS

SUMMER 1983

5 KM

5 KM

FALL 1983

2.5 KM

2.5 KM

SPRING 1984

5 KM

5 KM

SUMMER 1984

5 KM

N

5 KM
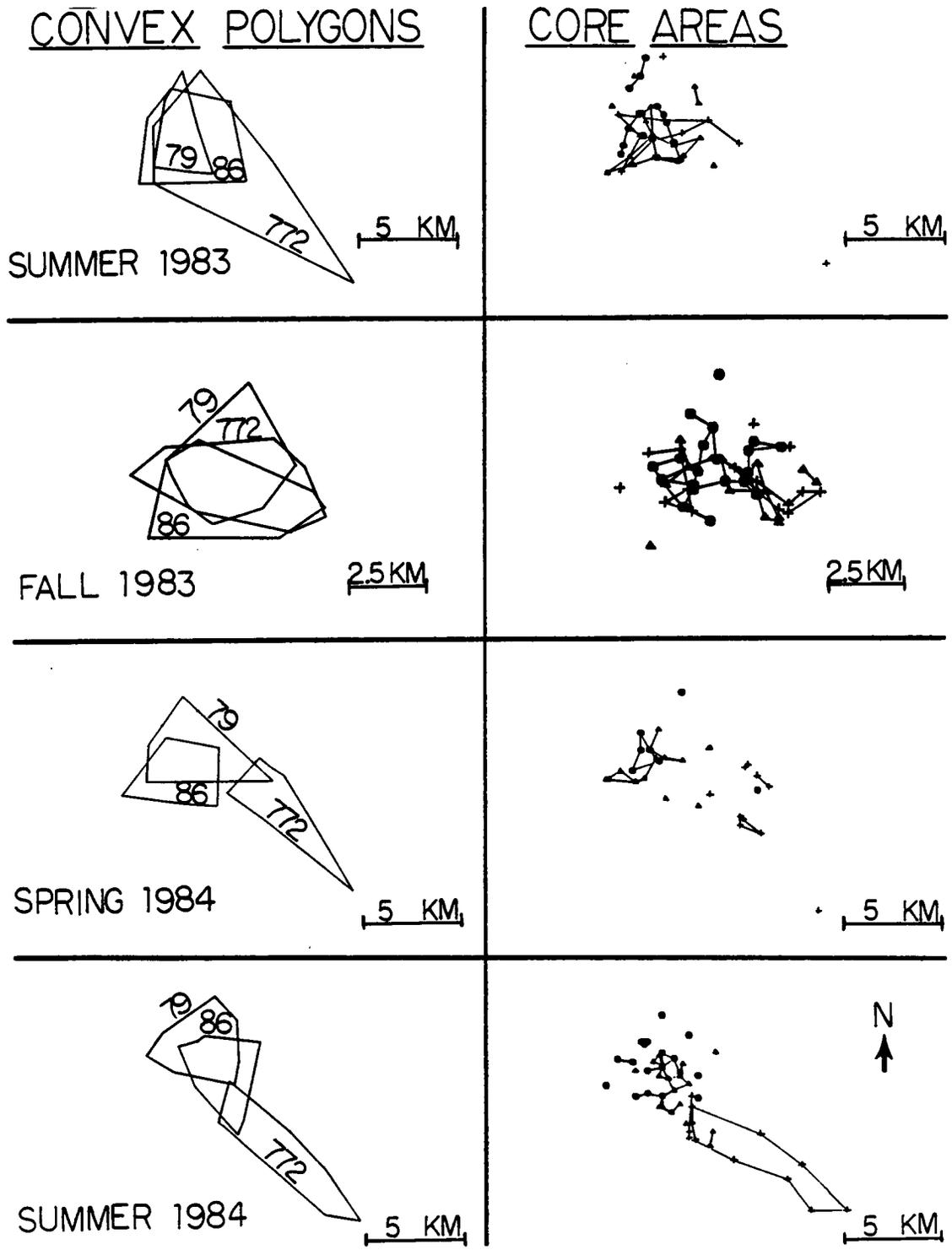
Figure 15. **Seasonal overlap of convex polygon areas and modified minimum areas among adult female black bears in SNP, 1983-1984:** ID numbers for bears, season, and scale in kilometers (KM) given for each frame association.
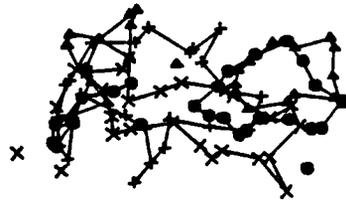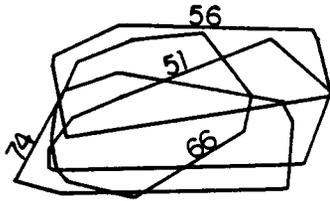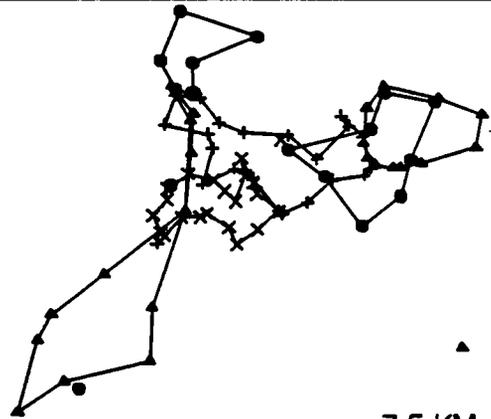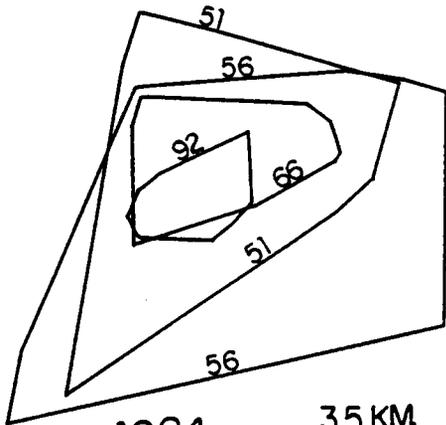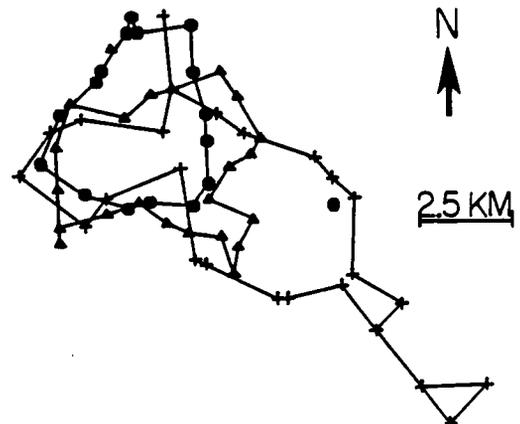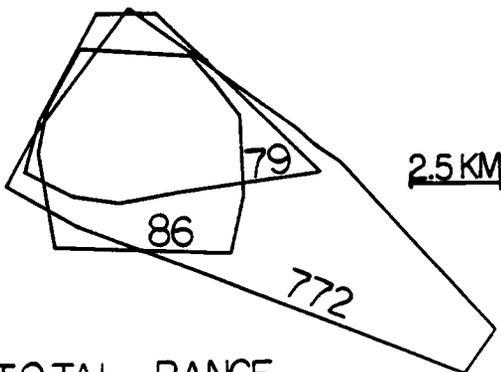
Figure 16. Annual and total overlap of convex polygon areas and modified minimum areas among adult female black bears in SNP, 1983-1984: ID numbers for bears, year, and scale in kilometers (KM) given for each frame association.

that although adult males and females travel together during the breeding season, 50m was the minimum distance they tolerated between one another during the rest of the year.

Seasonal Movements

Park vs Non-Park Areas

Seasonal comparisons were made between the proportion of time male and female bears were located within zones A,B, and C (Table 5, Figure 2). Bears located outside the study area mainly used zones B and C east of the Park on the Piedmont Plateau (Figures 2-4). Seven small rivers flowed from the study area onto the Piedmont Plateau and provided movement corridors with dense understory growth. The Piedmont Plateau was agricultural land intermixed with hilly forested tracts and sparsely populated townships. Bears had access to agricultural crops in zones B and C not available in the Park.

Males made long excursions to zone C in the spring and early fall (Table 5). Males remained either in the Park or in close proximity to the Park boundary 94% of the time during the breeding season. Because females rarely moved to zone C during any part of the year, the greatest opportunities to find breeding females occurred in zones A and B (Figure 2, Table 5). Radiocollared bears did not establish home ranges exclusive of the Park (zone A) with the exception of dispersing subadult males. Females were located outside the Park more in the summer (21% frequency) and early fall (16% frequency) than in spring (10% frequency) and late fall (8% frequency). All marked bears used the Park in late fall for acorn consumption (Chapter 2) and in winter for denning (Carney 1985). Based on the amount of time they were located outside the Park, both sexes seem to be at equal risk of being killed during the hunting season in late fall and early winter. However, females entered dens earlier than males in SNP (Carney 1985:55) and therefore increased their chances of survival through the hunting sea-

son. Annually, males were located outside the Park boundary 32% of the time and females 15%, thus males were more frequently at risk to human induced mortality (Table 5).

Geographic Features

I considered bears located within 100m of any specific geographic feature close enough to be influenced by it in some manner (only aerial locations and close ground triangulations were used because of their high degree of accuracy). Therefore, bears either preferred or avoided geographic features based on the proportion of time they were located ≤ 100m or > 100m from them when compared with random proportions (Tables 8,9). It is important to note that preference for or avoidance of geographic features may be due to other factors such as surrounding habitat characteristics.

Roads and Trails: Males avoided fire roads ($P<0.001$), light duty roads ($P<0.001$), and primary roads ($P<0.01$) year around. Males seldom used abandoned roads and jeep trails (Table 8). Female bears in SNP preferred fire roads during summer ($P<0.001$) and early fall ($P<0.01$) and avoided heavier traveled roads such as light duty roads ($P<0.001$) and primary roads ($P<0.001$) year around. Females did not use abandoned roads and seldom used jeep trails (Table 9). Fire roads in many sections of the Park and surrounding State Forest contained areas of soft mast production along their margins. Wild black cherries available along fire roads in the backcountry of SNP and on State Forests during late summer and early fall were used extensively by bears (Chapter 2). Females were most likely the heaviest users of wild black cherries along fire roads in SNP (Table 10). Perhaps the variation in use of tree fruits along fire road margins by males and females is due to differing abilities to climb trees. Heavier males may lose their ability to climb trees (J. Craighead, personal communication). It was rare to see an adult male in a tree feeding or resting during the study. Conversely,

Table 8. Percent of male black bears and 1751 random points that fell within 100 meters of various geographic features, 1982-1985.

Feature	Random points (N = 1751) Percent	Spring(N=119) Percent	P[1]	Summer(N=179) Percent	P	Early Fall(N=56) Percent	P	Late Fall(N=103) Percent	P	Total Season(N=459) Percent	P
Abandoned Road	0.57	1.68		0.00		0.00		0.97		0.65	
Park Boundary	10.97	9.24		10.06		6.90		8.74		9.15	
Campground[a]	----	0.00		0.00		0.00		0.00		0.00	
Fire Road	12.05	5.04	<0.05	7.82		3.45	<0.05	2.91	<0.01	5.45	<0.001
Foot Trail	12.85	21.85	<0.01	18.44	<0.05	34.48	<0.001	21.36	<0.05	22.00	<0.001
Human Disturbance Areas[a]	----	0.00		0.56		0.00		1.94		0.65	
Jeep Trail	2.86	0.00		1.68		3.45		0.00		1.09	<0.05
Light Duty Road	10.97	1.68	<0.01	8.94		1.72	<0.05	2.91	<0.01	4.79	<0.001
Marsh	0.11	0.00		0.00		0.00		0.00		0.00	
Picnic Area[a]	----	0.00		0.00		0.00		0.00		0.00	
Ranger Station[a]	----	0.00		0.00		0.00		0.97		0.22	
Primary Road	6.97	1.68	<0.05	3.91		5.17		2.91		3.27	<0.01
Small River or Stream	30.84	21.01	<0.05	28.49		24.14		16.50	<0.01	23.31	<0.01
Urban Area[a]	----	0.84		2.23		3.45		0.00		1.53	
Utility Corridor	1.71	0.84		1.12		3.45		0.00		1.09	
Lake or Pond[a]	----	0.00		0.56		1.72		0.00		0.44	

[1]Multiple comparisons at alpha = 0.05 implies possibility of 2 or 3 comparisons being significantly different by chance.
[a]Comparisons with random percent values not given since geographic feature only occurred inside Zone A or Zone B. Refer to Table 1 and Figure 2 for descriptions of geographic features and zones.

Table 9. Percent of female black bears and 1751 random points that fell within 100 meters of various geographic features, 1982-1985.

Feature	Random points (N = 1751) Percent	Spring (N=234) Percent	P	Summer (N=442) Percent	P	Early Fall (N=227) Percent	P	Late Fall (N=220) Percent	P	Total Season (N=1123) Percent	P
Abandoned Road	0.57	0.00		0.00		0.00		0.00		0.00	
Park Boundary	10.97	8.97		16.29	<0.01	7.93		5.45	<0.05	10.95	
Campground[a]	----	0.00		0.00		0.00		0.45		0.09	
Fire Road	12.05	14.10		18.10	<0.001	18.94	<0.01	12.27		16.30	<0.01
Foot Trail	12.85	26.07	<0.001	25.11	<0.001	25.11	<0.001	23.64	<0.001	25.02	<0.001
Human Disturbance Areas[a]	----	0.43		2.04		4.41		2.73		2.32	
Jeep Trail	2.86	1.28		0.45	<0.01	1.32		0.91		0.89	<0.001
Light Duty Road	10.97	0.85	<0.001	5.88	<0.01	1.76	<0.001	0.45	<0.001	2.94	<0.001
Marsh	0.11	0.00		0.00		0.00		0.00		0.00	
Picnic Area[a]	----	0.00		0.23		0.00		0.00		0.09	
Ranger Station[a]	----	0.00		0.00		0.00		0.00		0.00	
Primary Road	6.97	2.14	<0.01	2.26	<0.001	3.52	<0.05	5.00		3.03	<0.001
Small River or Stream	30.04	27.78		34.39		24.23	<0.05	23.64	<0.05	28.85	<0.05
Urban Area[a]	----	0.00		1.36		0.44		0.00		0.62	
Utility Corridor	1.71	0.00		1.13		0.00		0.00		0.45	<0.01
Lake or Pond[a]	----	0.00		0.00		0.00		0.00		0.00	

Multiple comparisons at alpha = 0.05 implies possibility of 2 or 3 comparisons being significantly different by chance.

[a] Comparisons with random percent values not given since geographic feature only occurred inside Zone A or Zone B. Refer to Table 1 and Figure 2 for descriptions of geographic features and zones.

Table 10. Comparison between the number of times male and female black bears were within 100 meters of various geographic features.

Feature	Spring		Summer		Early Fall		Late Fall		Total Season	
	P^1	Sex²	P	Sex	P	Sex	P	Sex	P	Sex
	–		–		–		–		–	
Park Boundary			<0.05	F						
Fire Road	<0.05	F	<0.01	F	<0.01	F	<0.01	F	<0.001	F
Human Disturbance Areas									<0.05	F
Small River or Stream									<0.05	F
Urban Area					<0.05	M				

¹Multiple comparisons at alpha = 0.05 implies possibility of 1 comparison being significantly different by chance.
²The sex located closer to geographic feature is given. Refer to Table 1 and Figure 2 for descriptions of geographic features and zones.

adult females were repeatedly seen climbing trees for tree fruits. Avoidance by bears of heavier traveled roads in and around SNP was likely due to human activity. Hamilton (1978) studied proximity of bears to roads and investigated human activity and concluded that avoidance of roads by black bears during the fall in coastal North Carolina was likely due to the human related disturbance of hunters and hunting dogs. Distances from bears to 5 different classes of roads in West Virginia indicated that males and females avoided heavier traveled roads (Brown 1980). In the southern Appalachians, Quigley (1982) and Villarrubia (1982) also reported that bears avoided roads. However, Carr (1983) found that bears in GSMNP regularly crossed roads and trails and utilized areas around them. He speculated that the determining factor of whether individuals will use roads and trails or adjacent areas is the spatial arrangement of bear home ranges in relation to them. Both male and female bears in SNP preferred foot trails for travel ($P < 0.05$), (Tables 8,9).

Streams and Small Rivers: Males used small rivers and streams less than expected in spring ($P < 0.05$) and summer ($P < 0.01$). Females were farther than expected from streams during early fall ($P < 0.05$) and late fall ($P < 0.05$). Both males and females showed the greatest use of small rivers and streams during the driest months of summer (Tables 8,9). Unsworth (1984:56) reported that black bears in Idaho selected areas within 100m of open water and speculated that it was an important habitat feature during the hot and dry summer months. Bedding and feeding sites of black bears in Arizona were predominately found within 0.25 miles of water (Mollohan 1982). SNP forests with lush forb understory were used as feeding sites by bears and were located along small rivers and streams (Chapter 2). Annually, females in SNP used small rivers and streams more ($P < 0.05$) than males.

Human Disturbance Areas: Males were never located within 100m of a campground or picnic area. Only 1 location was recorded within 100m of campgrounds and picnic areas during the study for females. Bears rarely came in close proximity to the different human disturbance areas within the Park (Tables 8,9). Bears have little opportunity to consume "human foods"

in SNP due to strict enforcement of rules concerning proper storage and handling of food in campgrounds. Also, the "bearproofing" of garbage cans around human disturbance areas in the early 1970's reduced the amount of garbage once available to bears. In fact, bears rarely consumed garbage in SNP during the study (Chapter 2). Regardless, females were located closer than males ($P < 0.05$) to human disturbance areas within the Park year around (Tables 8-10).

Topography: Elevation use by male bears varied seasonally ($P = 0.001$). The lowest ($P < 0.001$) elevational use by males occurred during the summer and the highest ($P < 0.10$) elevational use occurred during early and late fall. The same pattern was true for females (Figure 17). In mountainous terrain, seasonal shifts in elevation used in response to food availability have been reported from Alaska (Hatler 1967), Montana (Jonkel and Cowan 1971), Idaho (Amstrup and Beecham 1976, Reynolds and Beecham 1980), and Tennessee (Garshelis 1978). I hypothesize that soft mast was more abundant at low-to-mid elevations in summer (i.e. domestic fruits at abandoned homesites), (Chapter 2). Conversely, higher elevations in the Park contained the greatest distribution of oak forests and therefore a greater abundance of hard mast during both fall periods (Chapter 2).

The steepness of slopes used by male bears did not vary seasonally ($P = 0.386$), but females used steep slopes during spring and late fall ($P < 0.001$) and gentle slopes during early fall ($P < 0.001$), (Figure 18). Males used W aspects less ($P < 0.05$) than expected during spring and NW aspects less ($P < 0.05$) than expected in early fall. On an annual basis, females used NE aspects less ($P < 0.05$) than expected and S slopes greater ($P < 0.05$) than expected. Annually, male and female bears used ridgetops more ($P < 0.05$) than expected. The trails (human and wildlife) most frequently used by bears in the Park occurred on ridgetops. Ridges provided the most unobstructed pathways over steep and rocky terrain in much of the Park. The variety of topographic features combined with the ranges of temperature and precipitation produced a diversity of microhabitats used by bears in SNP for feeding and bedding.
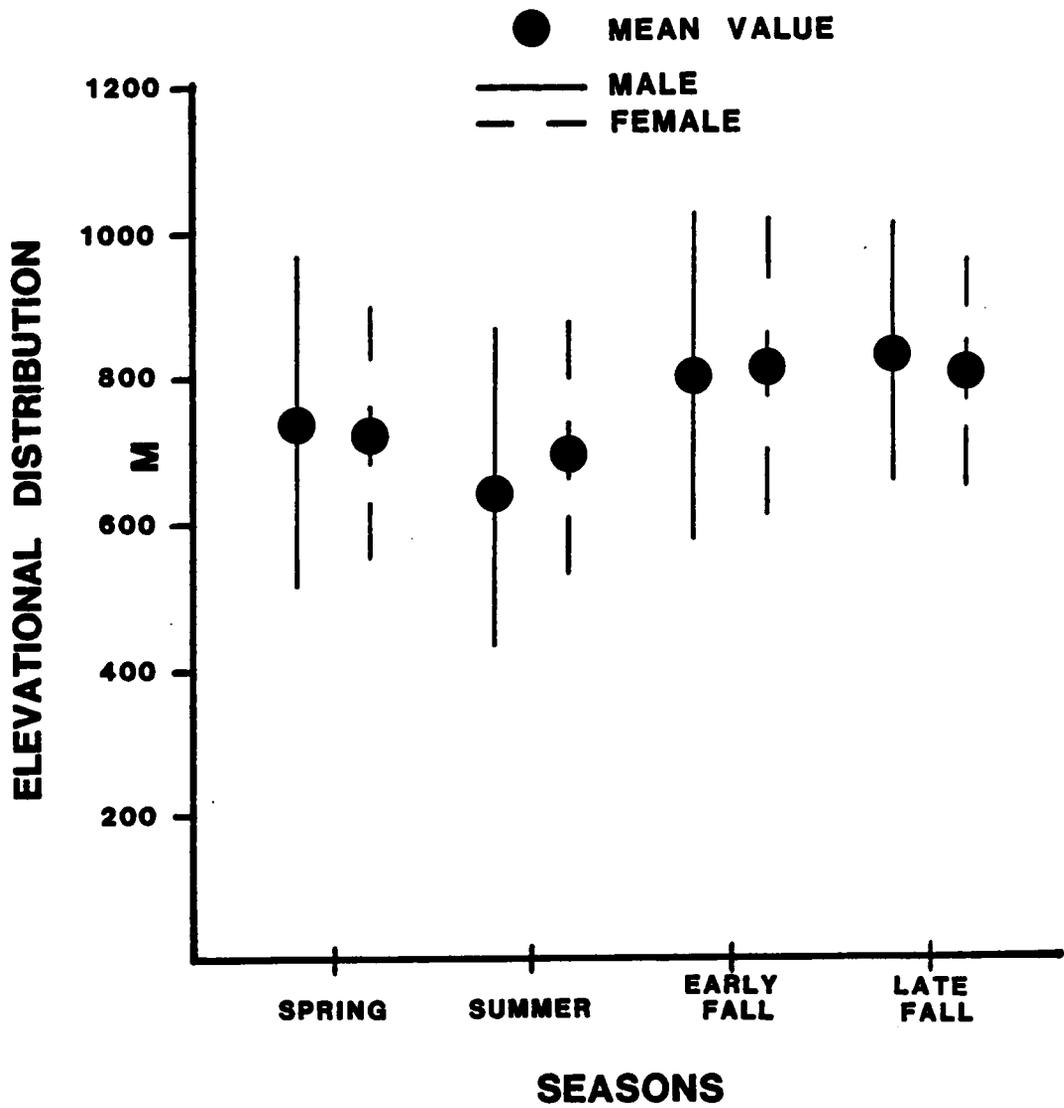
Figure 17. Seasonal distribution (± 1 SD) of elevations used by male and female black bears in SNP, Virginia, 1982-1985.
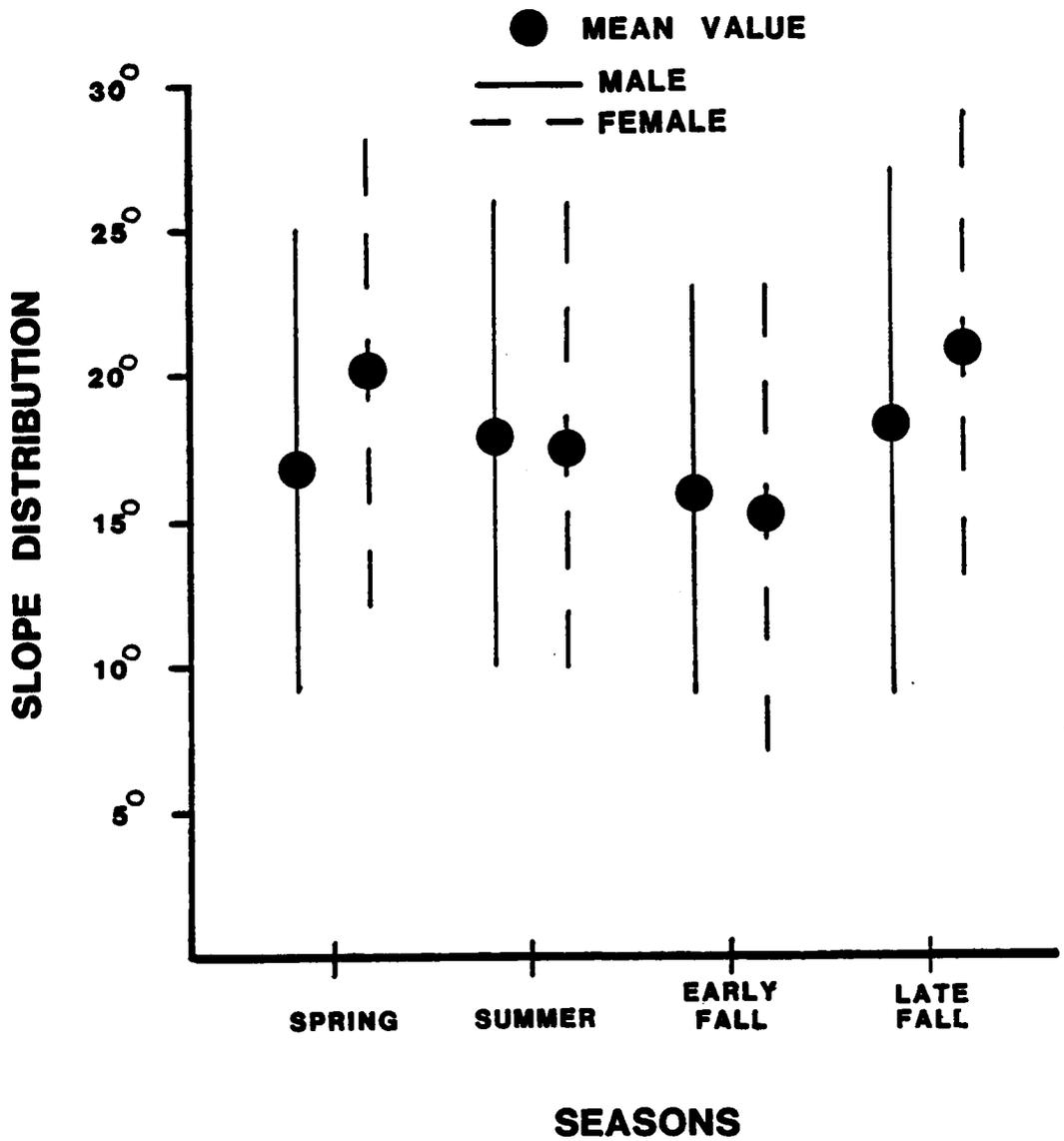
Figure 18. Seasonal distribution (± 1 SD) of slopes used by male and female black bears in SNP, Virginia, 1982-1985.

Visitor Use Implications

Visitors to SNP totaled nearly 2 million each year over the last 5 years (1981-1985), (D. Haskell, personal communication). During this time, numbers of people hiking and camping along trails in the backcountry averaged 51,413 annually. Despite this high level of human use in frontcountry and backcountry areas, and a dense bear population, bear incident reports (bear-human confrontations) have steadily declined from 67 in 1980 to 8 in 1985 (Figure 19). However, one area on which Park managers can concentrate their efforts to further decrease bear-human conflicts involves bears, people, and trails. Trails are the one area where bears and people still come in contact with one another in the Park. The data suggest that both male and female black bears prefer to use Park trails and adjacent areas while backcountry visitation continues at high levels. More education of the public concerning encounters with bears on backcountry trails is strongly recommended. Such education should be especially emphasized during the months of April, May, July, August, and October when backcountry use of trails by Park visitors is heaviest.
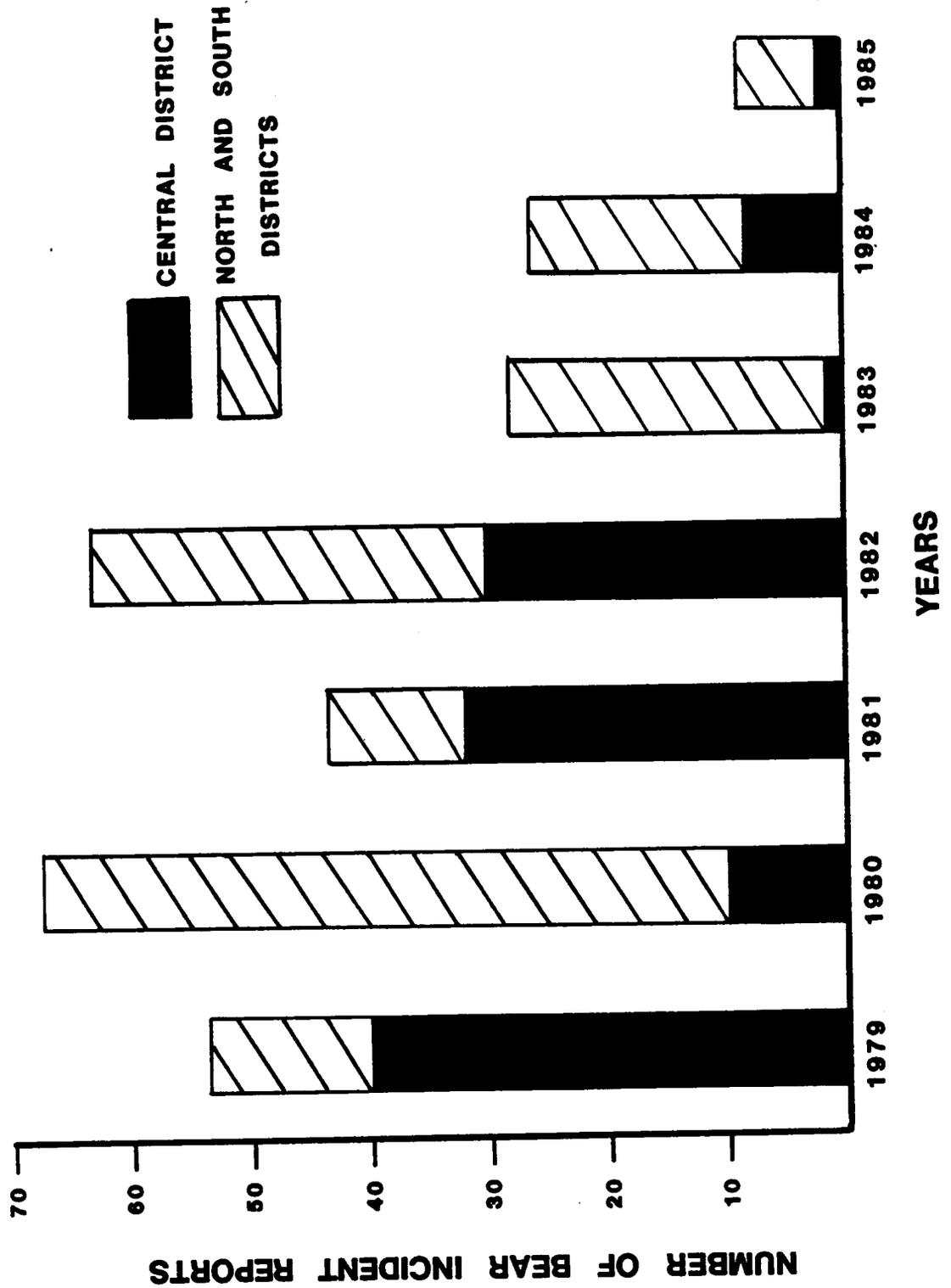
Figure 19. Frequency of bear incident reports for the 3 districts of Shenandoah National Park, Virginia, 1979-1985.

Chapter 2: Food Habits And Habitat Selection

Methods

Bears were captured in Aldrich foot snares and culvert traps during spring 1982 - summer 1984 and immobilized with intramuscular injections of ketamine hydrochloride and xylazine in a 2:1 mixture (dosage rate 6.6 mg per kg of body weight). Selected individuals were fitted with motion-sensitive radio transmitter collars (Telonics, Inc., Mesa, AZ 85203).

Radio-marked bears were monitored during all seasons through April, 1985 and located during daylight hours between 0600 and 2100. An attempt was made 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 taken with directional hand-held H antennas. Aerial locations were made from fixed-wing aircraft (Cessna 150,172) with directional H antennas mounted under each wing.

Only aerial locations and close ground triangulations ($\leq$ 100m from investigator) were used for analysis. The accuracy of aerial locations was tested by l) locating bears at den sites; and 2) periodically locating reference transmitters placed in known locations within the study area. Ground locations were plotted on USGS topographic maps (scale 1:24,000) using the Universal Transverse Mercator (UTM) grid system and then triangulated by program TELEM (Koeln 1980).

Longer range triangulations (> 100m but usually between 0.50 km and 2 km from investigator) were not considered for habitat use analysis due to the inaccuracy associated with bearing error (± 5-7°) over steep and rugged terrain and the inability to verify the presence of bears in the triangulation area (Lee et al. 1985).

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); late fall (16 Oct - 20 Dec); and winter (21 Dec - 19 Mar).

Habitats within the study area were partitioned into 7 major forest types identified from high altitude summer and winter color infrared (CIR) photography and statistically tested for accuracy using a discrete multivariate analysis technique (Congalton et al. 1983, Table 11). The presence of mountain laurel shrubs in the understory (>25% canopy coverage) was identified from winter CIR photography. A habitat map was constructed for the entire study area to determine availability of different forest types. Forested and agricultural lands outside the study area (Figure 20) were not included in the comparison between habitat use and availability.

Chi-square tests were used to determine if differences ($P < 0.05$) occurred between use and availability of habitats and whether use of habitat by males differed from females. A modification of the Bonferonni z statistic (Neu et al. 1974, Byers et al. 1984) was used to test for disproportionate use of habitat types.

Scats and stomachs collected from May 1982 to December 1984 were analyzed to determine food items consumed by black bears within and around the study area. Scats (usually <2 weeks old) were collected incidental to trapping, tracking, and habitat mapping procedures. Stomachs were collected from bears killed by hunters, poachers, and motor vehicles. Scats and stomachs were frozen within 24 hours and later thawed and washed through a series of sieves (mesh openings of 3.36mm, 2mm, 0.6mm, 0.25mm), (Tisch 1961:23-24, Mealey 1980).

Table 11. Descriptions and accuracy values for 7 major forest types within the Central District of Shenandoah National Park, Va.

Name[1]	Descriptions[2] and Accuracy
Chestnut oak//Red oak	Occurred primarily in a 50:50 mixture of chestnut oak and Northern red oak at all elevations mainly on slopes and ridges on mesic and xeric sites. Occasionally found in association with white oak, scarlet oak, black oak, yellow poplar, pitch pine, and hickory spp. Understory dominated by mountain laurel and deciduous shrubs and small trees. K = 0.63.[3]
Yellow Poplar	Found in pure stands or in association with various oak spp. which included primarily N. red oak and white oak. Occasionally found in association with Eastern hemlock, sugar maple, white ash, and yellow birch. Found primarily at low-to-mid elevations mainly on moist and mesic sites. Characteristic forest type along small rivers and intermittent streams. Forbs and deciduous shrubs and small trees predominated in understory. K = 0.82.
N. Red oak/White oak	Found in pure stands of N. red oak or in an association of N. red oak and white oak. Found primarily on mesic sites at mid-to-upper elevations mainly on slopes and ridges. Majority of white oak in study area occurred within this forest type. Deciduous shrubs and small trees dominated understory. K = 0.76.
Hardwood mixture	Mainly a mixture of N. red oak, white ash, and American basswood. Occasionally consisted of sugar maple or red maple stands found in association with American beech, yellow birch, Am. basswood, and various oak spp. Found at all elevations on slopes, ridges, and valley bottoms. More commonly associated with intermittent streams than small rivers when found in valley bottoms. Mostly moist and mesic sites dominated by forbs, deciduous shrubs, and small trees in the understory. K = 0.68.
Pine	Eastern white pine, pitch pine, and Virginia pine found in pure stands or in association with each other, red maple, E. hemlock, yellow poplar, or various oak spp. Mesic and xeric sites located primarily on slopes and ridges at all elevations. Deciduous shrubs and small trees predominated in understory. K= 0.79.
Locust/Cherry	Early successional forest type dominated by black locust. Black cherry, occasionally found in pure stands or in association with oak and maple spp., included within this forest type. Found at mid-to-upper elevations mainly on moist to mesic sites primarily along ridges and slopes. Forbs and deciduous shrubs and small trees predominated in understory. K = 0.77.
E. Hemlock	Found in pure stands on moist sites mainly on slopes and valley bottoms at low-to-mid elevations. Characteristic forest type along small rivers and intermittent streams where an association with yellow birch occurred. Open understory with sparse forb production. K = 0.72.

[1]Forest type names represent dominant tree species (> 60% canopy coverage) in overstory.
[2]Society of American Foresters (SAF 1980) and Virginia Commission of Game and Inland Fisheries cover type descriptions aided in identification of forest associations (> 20% canopy coverage in overstory needed to be an associated species). Pure stands are greater than 80% canopy coverage in overstory. Low elevations are < 610m; mid elevations 610m - 855m, and upper elevations > 855m.
[3]Fifteen strip transects totaling 58.5 km in length were placed randomly throughout study area and sampled at 200m intervals in order to compare encountered types with mapped types. Resulting accuracy values for each cover type using a K statistic described by Congalton et al. (1983) are given. One represents 100% accuracy.
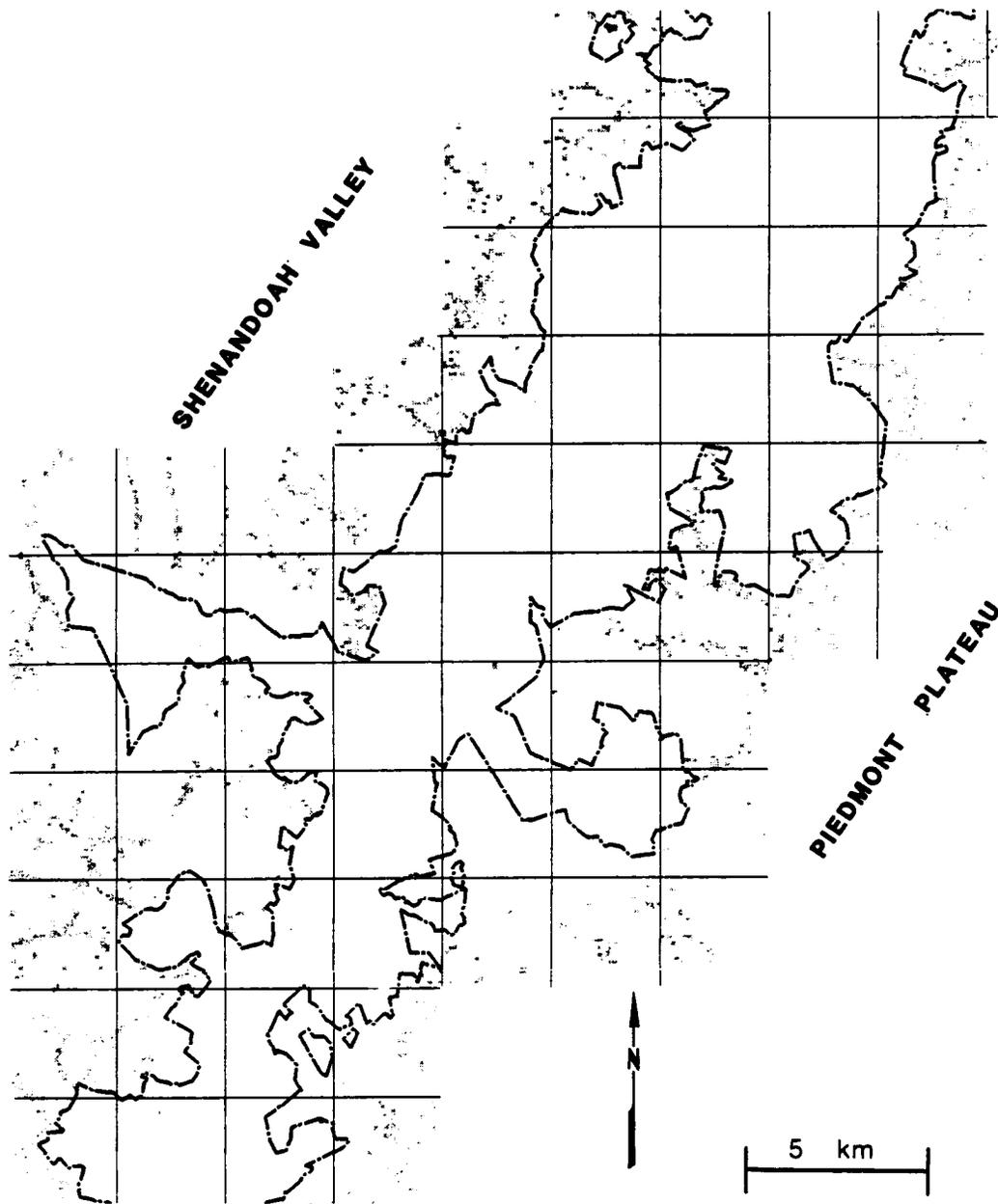
Figure 20. Urban and residential areas (shaded) in the agricultural lands surrounding the study area in Shenandoah National Park.

Macroscopic and microscopic examination was made until food items were identified in each scat and stomach. Percent volume of each food item was ocularly estimated (Clark 1957, Tisch 1961:24). Consumption of food items was specified for each season and the entire year (Beeman and Pelton 1980). Frequency of occurrence was expressed for each food item and each food item was assigned an index value based on the percent volume in each scat or stomach: 0=trace; 1=1-25 percent; 2=26-50 percent; 3=51-75 percent; and 4=76-100 percent.

Volume index percent =

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

Both frequency of occurrence and volume index percentage were used to evaluate the seasonal food habits of black bears.

Results and Discussion

Approximately 95 percent of the 854 scats were collected within the study area while the remaining 5 percent were collected in other areas of SNP or outside the Park. Scat and stomach ($N=12$) data were pooled over years because the majority of scats were collected in 1983 and food habit analysis indicated that annual differences in food preference were minor. However, plant phenology and availability of specific foods may have varied between years.

Seasonal Food Habits

Plant Foods

Tree fruits, forbs, and squawroot composed 81% of the annual diet (Table 12; Figures 21,22). Consumption of ripe tree fruits was associated with extensive tree climbing activity. The remaining plant food (9% volume) consisted of shrub and vine fruits, corn, and graminoids. Plant foods also dominated the annual diets of black bears in Pennsylvania (Bennett et al. 1943), Montana (Tisch 1961), Alaska (Hatler 1972), Washington (Poelker and Hartwell 1973), California (Piekielek and Burton 1975, Graber and White 1983), North Carolina (Landers et al. 1979), Tennessee (Beeman and Pelton 1980, Eagle and Pelton 1983), Maine (Hugie 1982), Florida (Maehr and Brady 1984), and Arkansas (Smith 1985).

Corn was a minor item in the annual diet (3% volume), but was available year around outside SNP either in cornfields or corn cribs and was eaten consistently from spring through late fall (Table 12; Figure 21). During early spring following den emergence, only males in our monitored sample fed on corn. In summer and early fall, both males and females used corn fields adjacent to the Park boundary whereas only males used corn fields farther away on the Piedmont Plateau. Males continued to use dried corn fields in the late fall. Repeated use of these food sources by certain individuals suggests a well established behavioral pattern in response to corn as reported by Landers et al. (1979) in North Carolina and Elowe (1984:41) in Massachusetts.

Spring: The spring diet was primarily leaves, stems, roots, and fruits of various forbs, including sweet cicely (*Osmorhiza* spp.), jack-in-the-pulpit (*Arisaema* spp.), mayapple (*Podophyllum peltatum*), and angelica (*Angelica atropurpurea*). Intensive use of sweet cicely in the spring (46% volume) has not been reported in the southeastern or mid-Atlantic States but is consistent with findings reported from Montana (Tisch 1961:59). Spring use of Jack-in-

Table 12. Frequency and volume index of food items identified in 854 scats and 12 stomachs of black bears in SNP, 1982-1984.

Food item	Spring (174 scats) Freq.[1]	Volume index	Summer (229 scats, 2 stomachs) Freq.	Volume index	Early Fall (237 scats, 1 stomach) Freq.	Volume index	Late Fall (197 scats, 9 stomachs) Freq.	Volume index	Winter (17 scats) Freq.	Volume index	Entire year Freq.	Volume index[6]
Gramineae	8	T[2]	5	T[2]	8	1	6	1	12	5	5	1
Forbs (s,l,r,f)[3]												
Phytolacca americana (f)			1		11	2	8	1			5	1
Rubus spp.[4] (f)			7	4	3	T					3	T
Osmorhiza spp.[5] (s,l)	63	46									12	T
Arisaema spp.[5] (s,l,r)	53	29									10	5
Podophyllum peltatum[5] (f)	53	7	25	10	12	4	4	2	6	1	10	1
Unidentified (s,l)	14	4	54	40	T						14	5
Squawroot (Conopholis americana)	1	1	2		28	19	79	46	76	58	29	22
Tree fruit												
Quercus spp.					6	1	17	9			6	2
Carya spp.	1	1	10	5	74	48	3	T			3	1
Prunus avium			12	5	25	7	15	7	29	18	24	15
Prunus serotina	1		17	7							16	6
Malus spp.					11	3	1					
Shrub fruit			8	4	1	T					5	2
Lindera benzoin			4	2			11	5			1	1
Gaylussacia spp.					6	2					5	2
Vine fruit			1	1								
Vitis spp.	5	1	4	T	14	1	6	T	47	1	8	1
Invertebrates												
Coleoptera					5	1	2	T			16	3
Hymenoptera	15	1	42	11	16	2	4	T			9	1
Formicidae			14	2								
Vespidae												
Mammals												
Odocoileus virginianus	4	1	3	2	3	1	6	1	41	13	5	1
Corn	3	3	2	1	4	3	6	5			4	3
Debris (wood, rocks, etc.)	7	T	33	3	21	1	20	1	47	1	22	1

[1] Percentage values are rounded to the nearest whole number.

[2] T indicates < 0.5 percent.

[3] s = stem, l = leaf, r = root, f = fruit.

[4] The major species of blackberries and raspberries within SNP are classified by Newcomb (1977) as flowering plants that are not shrubs or vines.

[5] From random sample of 49 (28%) spring scats. All spring scats were examined to determine the frequency (93%) and volume index (87%) of forbs in the spring diet.

[6] Trace quantities of 16 plant species (forbs, trees, shrubs, vines), 7 vertebrate species (mammals and birds), insects (2 families), crayfish (Cambarus bartonii), and artificial food (garbage) made up an additional 6 percent of the volume index.
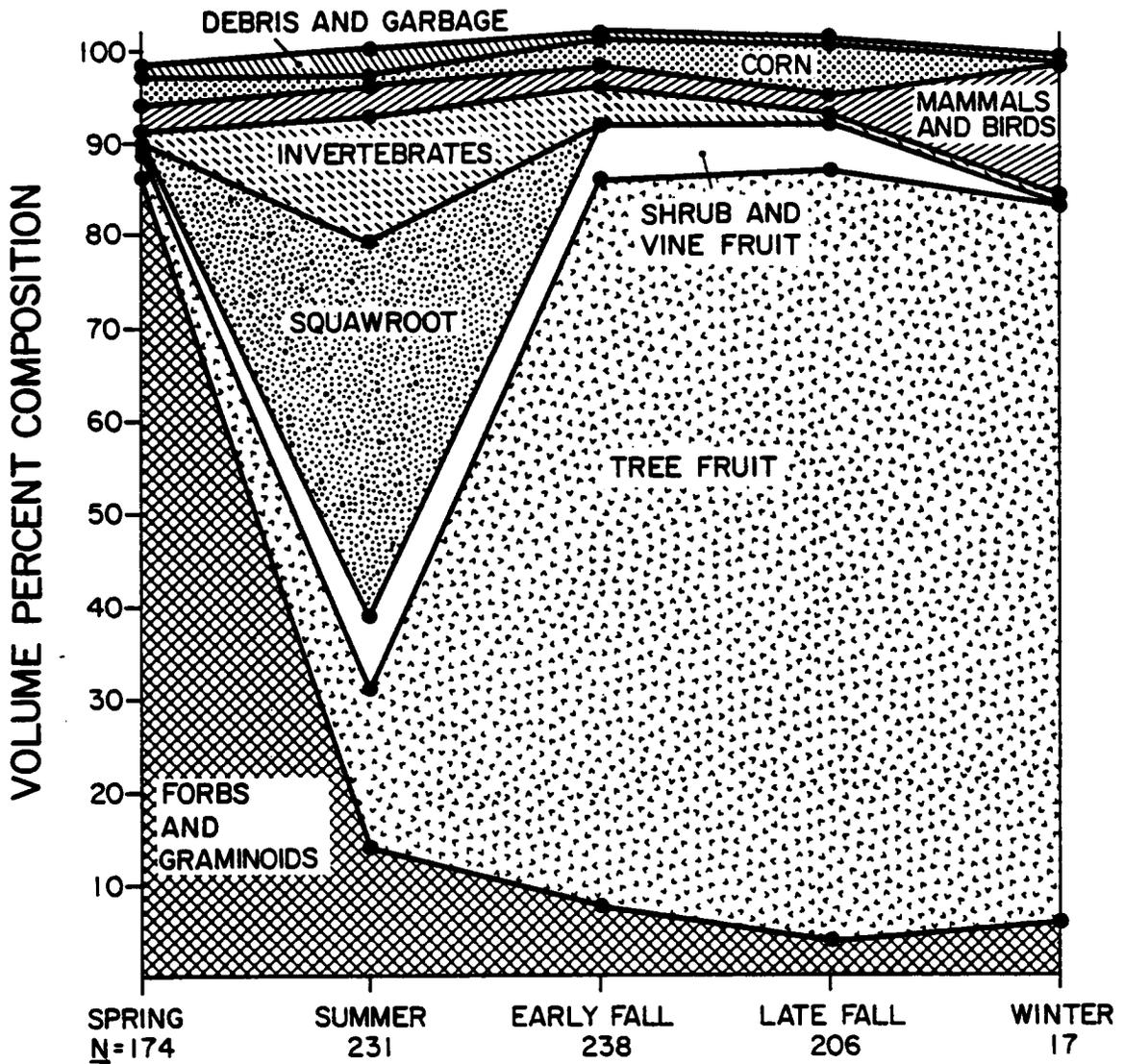
Figure 21. Seasonal food items eaten by black bears in Shenandoah National Park, Virginia and vicinity, 1982-1984: N = 854 scats and 12 stomachs.
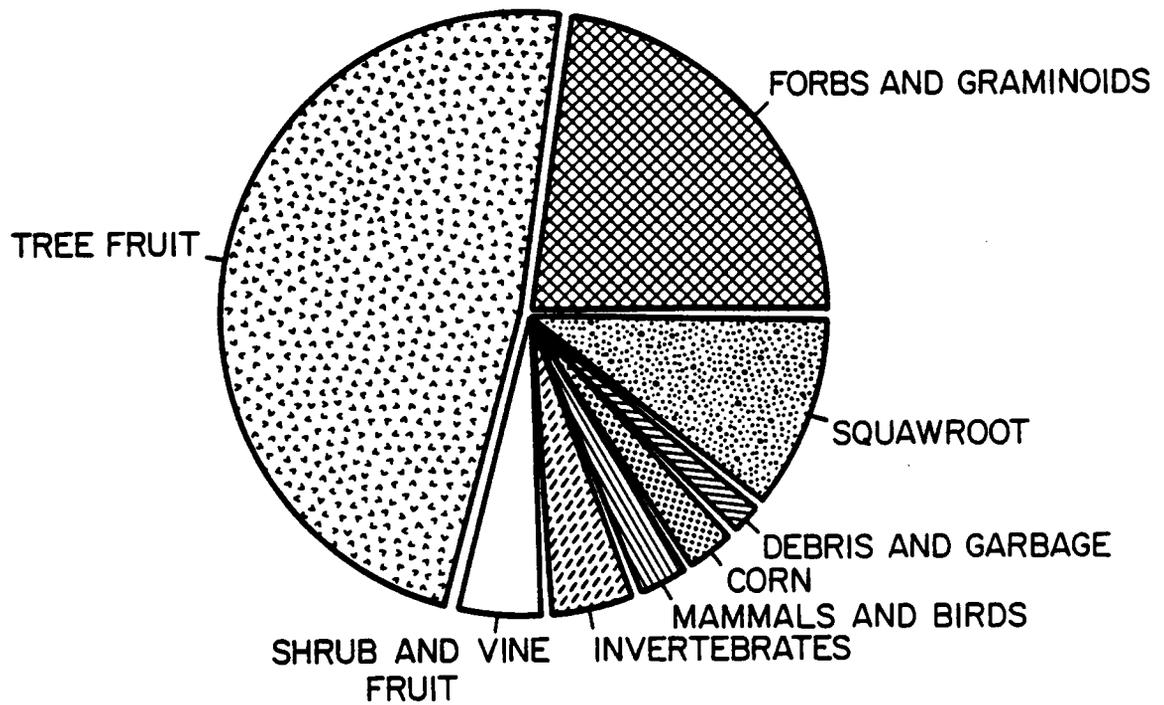
Figure 22. Annual food items eaten by black bears (by percentage volume) from spring through winter in SNP, Virginia, 1982-1984.

the-pulpit (29% volume) in SNP was greater than observed in Tennessee, North Carolina, and Georgia (1% volume) (Carlock et al. 1983:242,243). The only spring fruit used in significant amounts was mayapple (7% volume), which ripens in mid-to-late May. Bears seldom used sparsely scattered serviceberries (*Amelanchier* spp.) despite their ripening in early-to-mid June. Carlock et al. (1983:242,245) reported that serviceberries were the only spring fruits used in significant amounts (14% volume) by bears in the Smoky Mountains. Bears in Great Smoky Mountain National Park (GSMNP) preferred serviceberries in late spring when they were abundant (Eagle and Pelton 1983).

Forbs were eaten during all seasons but were most important during spring (Table 12). Eagle and Pelton (1983) reported that bears in GSMNP depend upon a largely undigestible, high fiber diet of herbaceous plant material during early spring. Poelker and Hartwell (1973:105) described early spring in Washington as a " negative foraging period " for black bears because they lost weight despite feeding. Bears also lost weight in response to nutritionally poor spring diets of herbaceous plant material in GSMNP (Beeman 1975:159) and Montana (Jonkel and Cowan 1971). This weight reduction represents the loss of fat reserves not used during denning (Eagle and Pelton 1983).

In the present study, an adult male was captured and weighed on 8 May and 26 June of 1983. He gained 25 kg over this 7 week period. Mayapples were the main spring fruits and sweet cherries were the main early summer fruits eaten by bears in SNP, and both likely provided a more readily digestible diet than herbaceous leaves and stems. Foods with high levels of cellulose are relatively undigestible to bears because their simple stomach is too acid to support the microbes needed for the digestion of cellulose (Rogers 1976). Ants (Formicidae), beetles (Coleoptera), and wasps and hornets (Vespidae) first eaten in late spring and early summer also provided a source of protein (Beck and Beck 1955, Southwood 1973:7, Redford and Dorea 1984). Bears gained weight during late spring in GSMNP (Beeman 1975:162) in response to a " higher nutritional plane " that lasted until denning (Eagle and Pelton 1983).

Summer: During summer, the diet shifted from primarily forbs to fruits and seeds of trees, shrubs, vines, and squawroot (Figure 21). Nevertheless, the stems and leaves of various forbs (10% volume) were eaten mainly in early summer and were a mixture of the same forb species identified in the spring sample (Table 12).

Fruits of squawroot, eaten mainly during July and August, composed 40 percent volume of the summer diet. Bears in the Smoky Mountains ate substantial amounts of squawroot in spring (5% - 10% volume) as well as summer (10% - 38% volume), (Beeman and Pelton 1980, Carlock et al. 1983:242, Eagle and Pelton 1983). Squawroot does not grow and thus is not available to bears north of Virginia (Radford et al. 1968:965).

Bears consumed tree fruits such as domestic apples (7% volume) and sweet cherries (5% volume) at abandoned homesites in SNP during the entire summer (Chapter 3). Wild black cherries (*Prunus serotina*, 5% volume) were present in the August diet.

Spicebush berries (4% volume), huckleberries (*Gaylussacia* spp., 2% volume), and blueberries (*Vaccinium* spp., 1% volume) accounted for most of the shrub fruits eaten by bears in SNP. Beeman and Pelton (1980) described greater consumption of huckleberries (11% volume) and blueberries (12% volume) by bears during the summer in GSMNP. However, in another GSMNP study, huckleberries (16% volume) were far more important than blueberries (5% volume) in the summer diet of bears (Eagle 1979:59,60). Landers et al. (1979) reported that huckleberry was the most important food item in July for bears in southeastern North Carolina.

Blackberries and raspberries (*Rubus* spp.), associated with disturbed sites along roadsides and utility corridors in SNP, made up an additional 4 percent of the summer diet. Blackberries (12%-24% volume) were used more heavily during the summer by bears in the Smoky Mountains (Beeman and Pelton 1980, Eagle and Pelton 1983). The most important soft mast item consumed annually by black bears in Maine was raspberry (Hugie 1982:91). However, many studies agree with these findings that blackberries and raspberries were relatively unimportant to black bears (Bennett et al. 1943, Spencer 1955, Harlow 1961, Tisch 1961, Poelker and Hartwell 1973, Landers et al. 1979).

Early Fall: The early fall diet was characterized by large amounts of soft and hard tree fruit (Figure 21). Wild black cherry (48% volume), the major food, was eaten primarily during September (Table 12). A similar pattern of intensive use of wild black cherries in the early fall was reported for black bears in the Smoky Mountains (Beeman and Pelton 1980, Eagle and Pelton 1983). In Pennsylvania (Bennett et al. 1943) and Maine (Hugie 1982), wild cherries were most prevalent in the summer diet of bears.

Acorns (19% volume) were first eaten by bears in SNP during the first 2 weeks of September and were most heavily used in early fall during the first 2 weeks of October. Apple (7% volume), spicebush (3% volume), huckleberry (1% volume), blueberry (trace), serviceberry (trace), and blackberry (trace) remained in the diet. Pokeberries (*Phytolacca americana*), (2% volume) and wild grapes (*Vitis* spp.), (2% volume) provided additional soft fruit during early fall.

Even though blueberries were not eaten to any extent by bears in SNP during summer and early fall, it is used in large amounts by bears in Alaska (Chatelain 1950, Hatler 1967), Florida (Maehr and Brady 1984), Maine (Spencer 1955, Hugie 1982), North Carolina (Hardy 1974, Landers et al. 1979), and Montana (Tisch 1961, Jonkel and Cowan 1971). In an earlier study, blueberry composed 17.4 percent of the total foods in stomachs of bears collected in Virginia and West Virginia during late fall (Cottam et al. 1939). Use of spicebush berries by SNP bears during summer (4% volume) and early fall (3% volume) in the present study is the only reported case of spicebush fruit consumption by bears in the Appalachian Mountain Region.

Late Fall: During the predenning period in late fall, hard mast such as acorns (66% volume) and hickory nuts (9% volume) formed the bulk of the diet (Table 12). Fruits of fallen apple (7% volume), grape (5% volume), and pokeweed (1% volume) also were eaten. The particular oak species eaten was difficult to discern due to the absence of acorn shells and caps in fecal material. Of the 3 major oak species within the study area, northern red oak and white oak acorns were commonly identified in scats and stomachs. Chestnut oak failed to produce

acorns during the study (Haskell 1984,unpublished SNP report). Acorns are an important item in the fall diet of black bears throughout most of their range (Cottam et al. 1939, Bennett et al. 1943, Piekielek and Burton 1975, Graber and White 1983, Willey 1978, Landers et al. 1979, Beeman and Pelton 1980, Eagle and Pelton 1983, Maehr and Brady 1984, Smith 1985).

Bears in GSMNP gained weight most rapidly during the fall when acorns were the main food item; they provided a low protein low fiber food, variable in fat content and high in carbohydrates (Eagle 1979:68). Bears in SNP were heavier during fall than any other season (Table 13). However, an adult male in GSMNP showed signs of starvation after losing 74 kg from summer 1984 to spring 1985 during a hard mast failure in fall 1984 (M. Pelton, personal communication). During years of scarce mast in the summer and fall in Montana (Jonkel and Cowan 1971) and Minnesota (Rogers 1976), females did not gain sufficient weight prior to denning to produce cubs. Females in GSMNP failed to produce cubs in winter 1985 after acorns and other hard mast failed to produce in fall 1984 (M. Pelton, personal communication). Nutritional factors related to mast failures were responsible in regulating the population of black bears in Minnesota through decreased reproduction and increased mortality on cubs and subadults (Rogers 1976).

Winter: A few winter-active bears in SNP (17 scats) continued to rely heavily on acorns (58% volume) and to a greater extent fallen apples (18% volume) to meet their foraging requirements (Chapter 1, Table 12). Bennett et al. (1943) considered acorns and apples sufficiently abundant and productive in Pennsylvania to provide food for bears during winter. Eagle (1979:66) suggested that the importance of acorns as a wildlife food may be due in part to their availability in winter. Increased consumption of dried graminoids in early winter was likely related to the formation of fecal plugs since several fecal plugs collected in early spring contained grasses and sedges.

Table 13. Mean seasonal weights (kg) of black bears captured in Shenandoah National Park, Virginia, 1982-1983.

Sample	Spring		Summer		Early Fall		Late Fall	
	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	N
Subadults	34.29	23	32.43	6	41.93	11	49.61	10
Adult Males	87.21	20	104.70	14	117.55	5	115.04	6
Adult Females	57.23	21	67.12	6	----------		68.03	1

Animal Foods

Invertebrates constituted 5 percent and mammals and birds 3 percent of the annual diet (Table 12; Figure 21,4). Eagle (1979:72) reported that animal matter served as a protein supplement to the plant foods that formed the bulk of the diet for black bears in GSMNP. Ants occurred in 42 percent and made up 11 percent volume of all scats and stomachs collected in SNP during summer. Yellow jackets, wasps, and hornets (Vespidae) occurred less frequently (14%) and in smaller amounts during summer (2% volume), but unlike ants, remained constant through early fall (2% volume). Beetles occurred in all seasons but contributed little to the diet (1% annual volume). Beeman and Pelton (1980) speculated that beetles were the most frequently eaten animal food in GSMNP because they were found as isolated individuals and were highly preferred and available. In SNP, colonial insects (Formicidae and Vespidae) occurred in the diet more frequently than beetles during all seasons (25% and 8% frequency, respectively). Trace amounts of honey bees (Apidae), bumble bees (Bombidae), and crayfish (*Cambarus bartonii*) made up the remainder of the invertebrates consumed. The use of insects (particularly ants) peeked in the summer diet due to their greater availability and activity during the warmest months. Because insect eggs and larvae are highly digestible (Graber and White 1983), they were likely underestimated in the diet.

Mammal and bird remains occurred in scats during all seasons. White-tailed deer (*Odocoileus virginianus*) composed only 2 percent of the diet during spring through late fall but increased to 13 percent volume during winter. The majority of deer eaten was assumed to be carrion from roadkilled or gunshot deer. For example, one bear drug a fresh roadkilled deer into the forest before consuming it. In addition, a winter active female with 3 yearlings killed and ate an adult deer in February, 1985. An eyewitness account of a fawn being chased, killed, and consumed by a black bear in SNP is consistent with other reports of such predation (King 1967, Ozoga and Verme 1982). In Idaho, black bears killed and consumed elk calves at calving grounds (Schlegal 1976).

Trace amounts of groundhog (*Marmota monax*), opposum (*Didelphis marsupialis*), rabbit (*Sylvilagus* spp.), raccoon (*Procyon lotor*), and weasel (*Mustela* spp.) occurred in the annual diet and may have been carrion. An adult female with a cub killed and partially consumed a beaver (*Castor canadensis*) shortly after den emergence in spring, 1984. Adult grouse (*Bonasa umbellus*) and unidentified egg fragments occurred as trace items from spring through early fall.

The frequent occurrence of black bear hair in the annual diet (10%) was most likely associated with grooming. The largest volume of bear hair was mixed with green, amorphous mucous in spring scats collected at den sites. This material was apparently gastro-intestinal contents packed in the lower intestine as bears groomed during dormancy (Smith 1985:95). Although no evidence of cannibalism was found, adult male bears may have consumed cubs in SNP (Carney 1985:35). In natural situations, reported victims of cannibalism have been either young bears (cubs and yearlings) or denning bears (Rogers 1983).

Garbage

Garbage was found in a few scats in spring and summer, but was considered an unimportant food item since it constituted only a trace amount in the annual diet. No bears were observed "panhandling" for food from Park visitors. Nevertheless, park visitors occasionally reported incidents of bears attempting to steal food. Since the closing of garbage dumps and the "bearproofing" of garbage cans in SNP in the early 1970's, bears have little opportunity to consume significant quantities of garbage while inside the Park. Beeman and Pelton (1980) concluded that although garbage composed a substantial percentage of the annual diet of black bears in GSMNP (6% volume), it was only eaten by a minority of the population.

Seasonal Habitat Use

Forty-four collared bears (24 adult females, 17 adult males, and 3 sub-adult males < 3.5 years old) were located 1311 times inside the study area (82% aerial, 18% close ground triangulation) to determine seasonal habitat use. This sample represented 80% of the total number of habitat use locations recorded; the remainder fell outside the study area. Individual bears were radiotracked for periods ranging from 2 weeks to 34 months. The number of bears of each sex radiotracked each season ranged from 12 to 23. Locations were grouped for analysis by sex and pooled over all years for each season.

Bears were located mainly from the air at one week intervals, thus I believe these observations were independent and unbiased (Dunn and Gipson 1977). Bears were frequently seen during aerial tracking in spring (10.2% visuals) and late fall (26.3% visuals) when deciduous cover was minimal. Accuracy tests indicated that aerial locations were in error by less than 100m in any direction. Garshelis (1978:14-16), Quigley (1982:14-16), and Garris (1983:22) accepted an error of 150m. Close ground triangulations were considered highly accurate due to the close proximity of the investigator to the bear based on strong signal reception. The presence of bears in the triangulated area was often verified by sightings. The large network of trails and service roads throughout the backcountry allowed investigators to get within 100m of a bear on many occasions without disturbance to the animal.

Bear home ranges covered the entire study area and some areas outside the Park (Chapter 1). While inside the Park, bears used primarily forested areas. Several studies conducted on the use of forest types by black bears in the eastern deciduous-coniferous forests of the Appalachian Mountain Region were not directly comparable to these findings because of differences in habitat and forest classifications (Beeman 1975, Lentz 1980, McLaughlin 1981, Hugie 1982, Quigley 1982, Villarrubia 1982, Carr 1893, Garris 1983, Brody 1984, Elowe 1984, Waburton 1984).

Spring

In spring, males used poplar forests proportionately less ($P < 0.05$) than their availability (Figure 23). Females used each of the 7 forest types in proportion to their availability during spring ($\chi^2 = 8.30$, 6 df, $P = 0.217$, Figure 24). However, females used poplar forests more ($P < 0.05$) than males whereas males used locust \ cherry forests more ($P < 0.05$) than females (Figure 25). Bears may have been attracted to poplar and locust \ cherry forests because of their lush understory of forbs compared to other forest types (Table 11).

Summer

Use of forest types by males and females during summer (breeding period) did not differ ($\chi^2 = 6.95$, 6 df, $P = 0.326$). Radio-monitored males were observed with radio-monitored females for several days during the breeding season. The movements of adult males to female ranges during the summer in Tennessee influenced adult male use of forest types (Garris 1983:67). Nevertheless, females in SNP used poplar forests more ($P < 0.05$) than their availability, but males did not (Figures 23,24). This may be due to continued use of forbs by females in early summer and close proximity of females to abandoned homesite orchards (51% of 330 abandoned homesites located within poplar forests) during the entire summer (Chapter 3). Males used forested habitats in proportion to their availability ($\chi^2 = 6.33$, 6 df, $P = 0.388$). Brody (1984:69) noted that equal summer use of forested stands by males in North Carolina may be an indication that some factor other than food, possibly breeding, influences summer behavior. Reliable water sources cannot be overlooked as an additional factor influencing the summer use of poplar forests by male and female bears in SNP. Poplar was the only forest type consistently found along small rivers that also provided dense understory cover (Table 11). Summer habitat selection also may have been affected by distribution of insects. Rogers
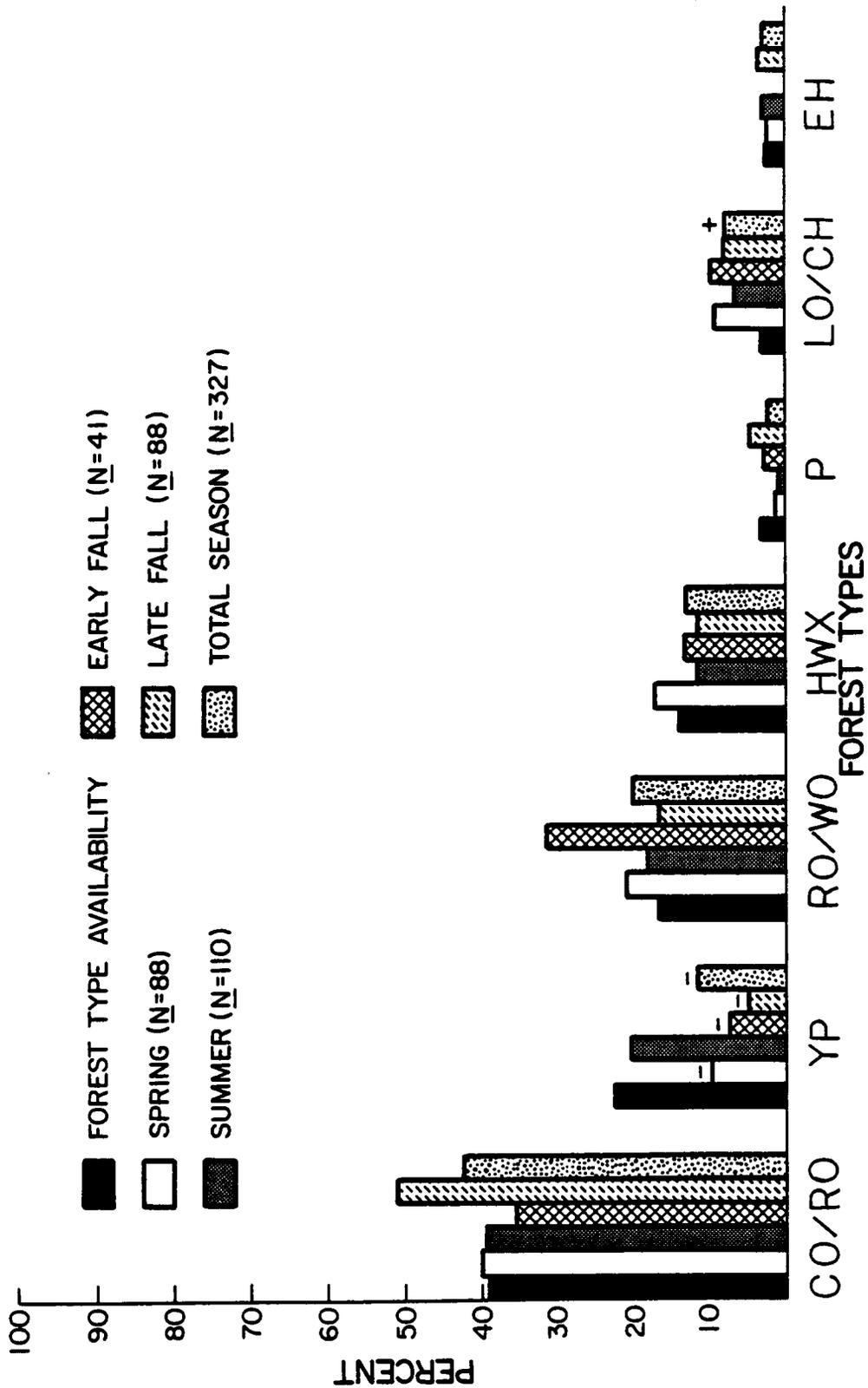
Figure 23. Seasonal forest use by male black bears and availability within the Central District of SNP, Virginia: a "+" indicates more (P < 0.05) use than expected and a "-" indicates less (P < 0.05) use than expected; N = male obs.
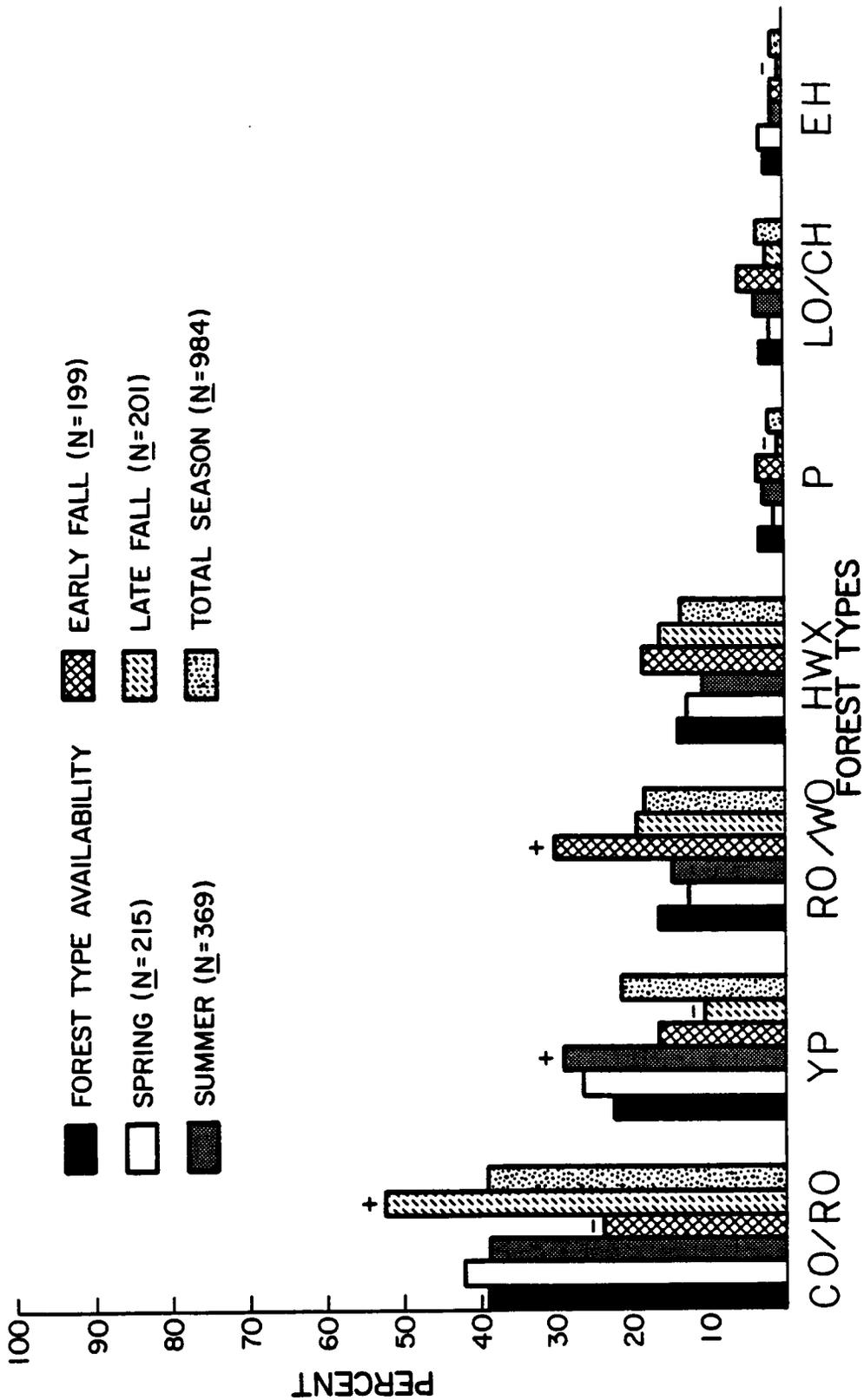
Figure 24. Seasonal forest use by female black bears and availability within the Central District of SNP, Virginia: a "+" indicates more (P < 0.05) use than expected and a "-" indicates less (P < 0.05) use than expected; N = female obs.
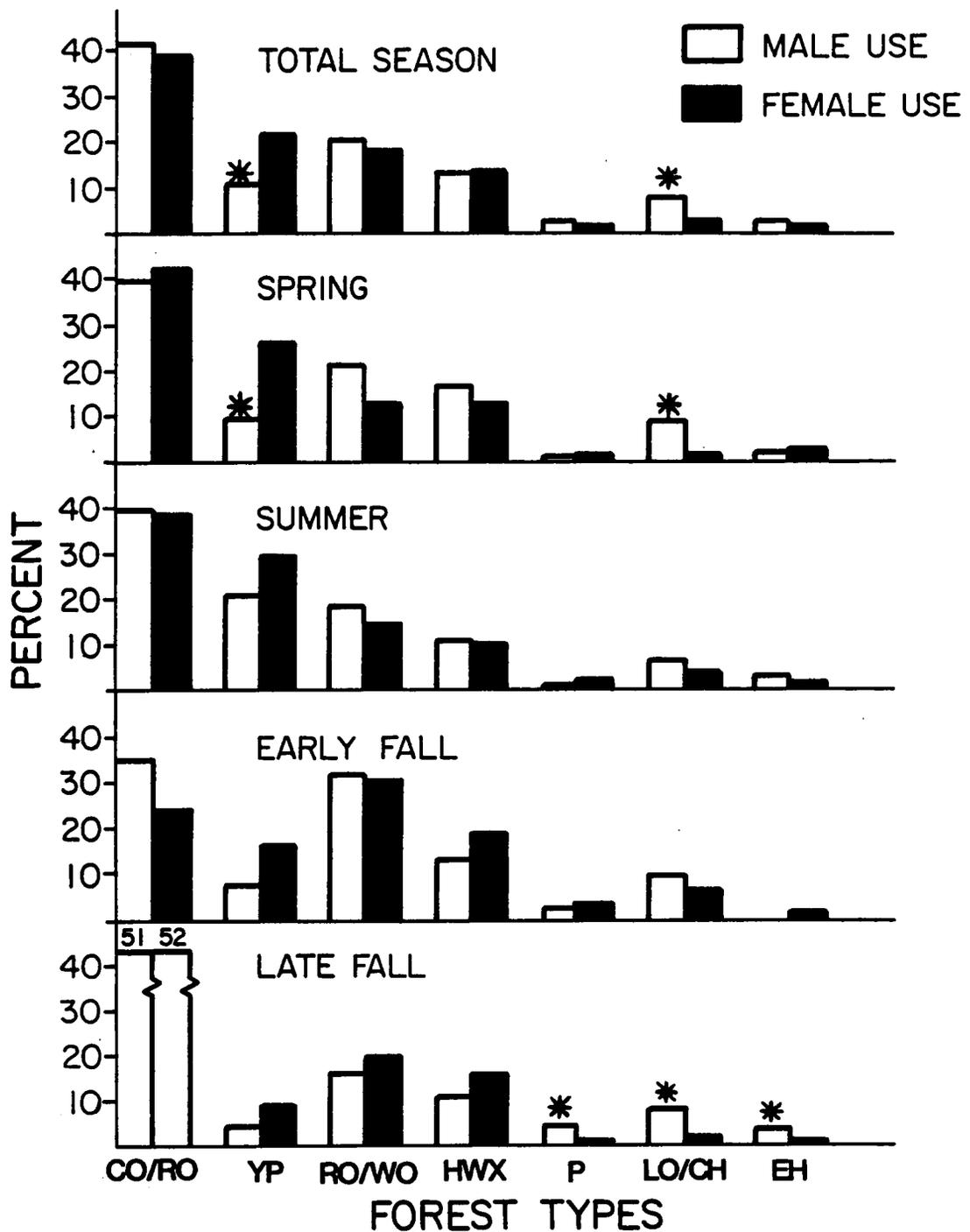
Figure 25. Seasonal comparisons between male and female forest type use within the Central District of SNP, Virginia: a "*" indicates a difference (P < 0.05) exists in use of a specified forest type.

(1976) reported that a female black bear in Minnesota spent the majority of her foraging time in mid-summer investigating sources of ants.

During summer, chestnut oak \ red oak was the most frequently used forest type (Figure 25). Squawroot, a parasitic plant that grows in clusters on oak tree roots (Radford et al. 1968:965), was found predominately within chestnut oak \ red oak forests.

Fall

Male and female bears in SNP increased their use of oak forests in early and late fall and decreased their use of other forest types (Figure 23,24). Lentz (1980:25), Garshelis and Pelton (1981), Quigley (1982:80), Villarrubia (1982:79,80), Carr (1983:62), Garris (1983:72,76), and Waburton (1984:51) have all documented that bears in the southern Appalachians prefer oak mast areas in fall. In SNP, females used poplar, pine, and eastern hemlock forests less ($P < 0.05$) than their availability in late fall. Males used poplar forests less ($P < 0.05$) than their availability during both fall periods and avoided eastern hemlock forests in early fall.

Habitat use by male and female bears was similar in early fall ($\chi^2 = 6.67$, 6 df, $P = 0.353$) but different in late fall ($\chi^2 = 72.09$, 6 df, $P < 0.001$). Males used locust \ cherry, eastern hemlock, and pine forests more ($P < 0.05$) than females during the late fall (Figure 25).

Use of locust \ cherry forests by males (9.8%) and females (6.0%) in early fall and by males in late fall (8.0%) was at least twice as great as its availability (3.1%). All bears used concentrated sources of wild black cherries and occasionally apples in locust \ cherry forests during both fall periods.

Females used chestnut oak \ red oak forests less ($P < 0.05$) than their availability and red oak \ white oak forests more ($P < 0.05$) than their availability in early fall. In late fall, chestnut oak \ red oak forests were used more ($P < 0.05$) than their availability while red oak \ white oak forests were used in proportion to availability. A similar pattern was observed for males but it was not as distinct, possibly due to smaller sample sizes (Figure 23). Both males and females seemed equally familiar with sources of fall foods (primarily acorns) within oak

forests. However, Quigley (1982:78) reported that young females have distinct advantages over young males in familiarity with fall food sources due to the overlap that female offspring have with their mothers and the dispersal behavior of young males into unexplored areas. But, Garshelis and Pelton (1981) found that dominant males excluded females and subordinate males from prime fall feeding areas that contained higher oak concentrations. I did not observe bears excluding other bears from feeding areas. In fact, females with and without cubs were observed in close proximity ($\leq$ 100m) to adult males during the fall in an area where abundant hard mast was concentrated. During fall, adult males were outside the Park 25 percent of the time and females were outside the Park 12 percent of the time, lessening the likelihood of aggressive encounters. Aggressive behavior may increase when bears refuse to share a food resource that is in short supply. Bears often tolerate one another in the confines of garbage dumps (Herrero 1983) and salmon streams (Egbert and Stokes 1976, Glenn and Miller 1980) where food is abundant, concentrated, and of high quality.

Between year use of chestnut oak \ red oak and red oak \ white oak forests during early and late fall was related to annual hard mast production (Figures 26,27). Chestnut oaks failed to produce acorns during the 3 year period (1982-1984); thus red oaks provided the majority of oak mast in chestnut oak \ red oak forests (Table 11, Figure 27). Both white and red oaks produced oak mast in the red oak \ white oak forests (Table 11, Figure 27). In 1982, when white oaks failed to produce and red oaks showed poor mast production, bears used chestnut oak \ red oak (20.70%) and red oak \ white oak (17.24%) forests similarly in early fall and differently in late fall (51.20% and 18.60%, respectively). A more dramatic shift occurred in 1983 when both white and red oaks showed good production. In 1983, bears used chestnut oak \ red oak forests less ($P < 0.05$) than their availability and red oak \ white oak forests more ($P < 0.05$) than their availability during early fall. In late fall, bears used chestnut oak \ red oak forests more ($P < 0.05$) than their availability and used red oak \ white oak forests in proportion to availability (Figure 26). In 1984, use of chestnut oak \ red oak and red oak \ white oak forests during both fall periods was nearly identical to that in 1983, but red oaks showed good mast yield and white oaks failed to produce (Figures 26,27).
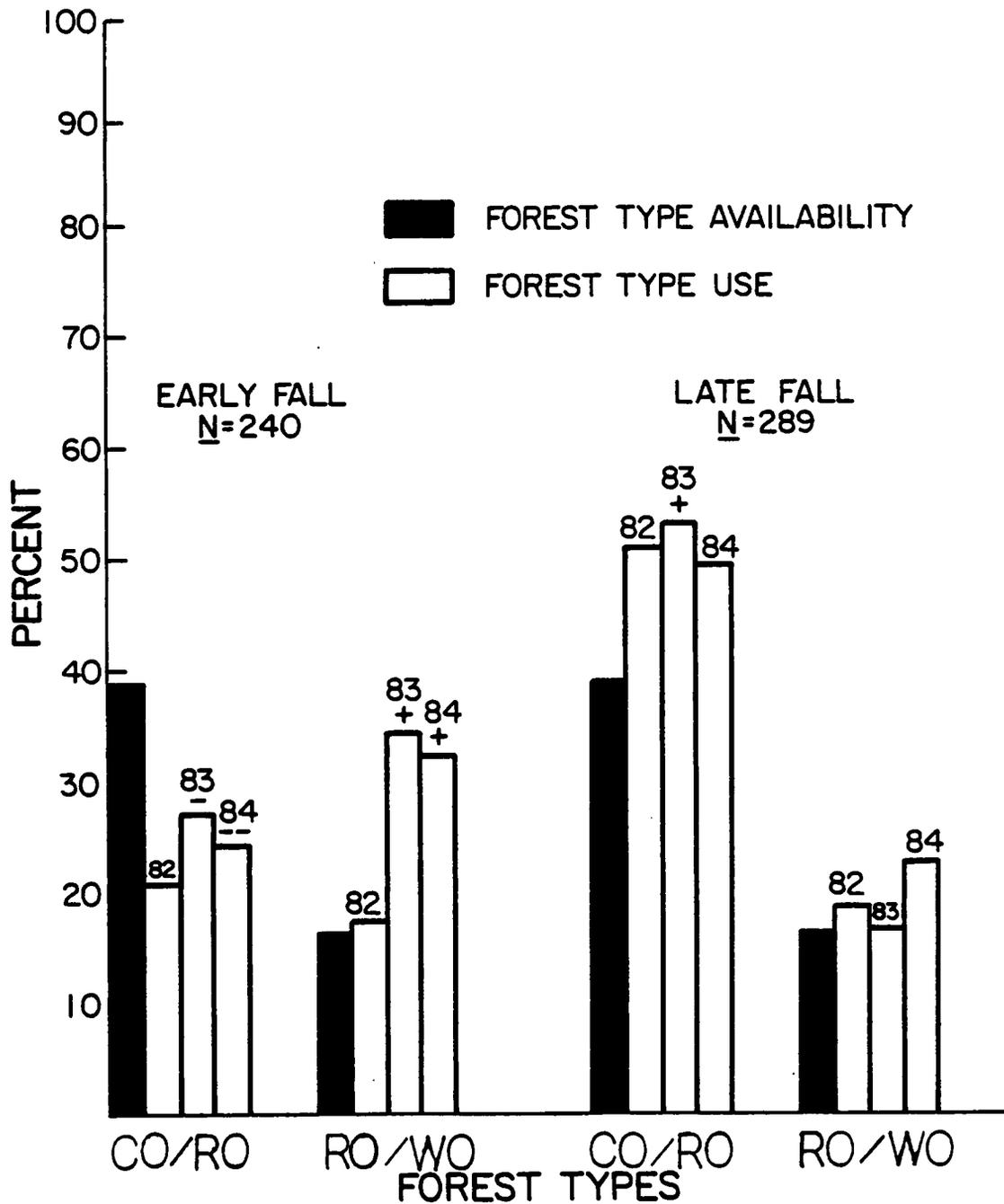
Figure 26. Yearly forest use (1982-1984) by black bears during fall and availability within the Central District of SNP, Virginia: a " + " indicates more (P < 0.05) use than expected, a "-" & "--" indicates less (P < 0.05), (P < 0.10) use than expected.
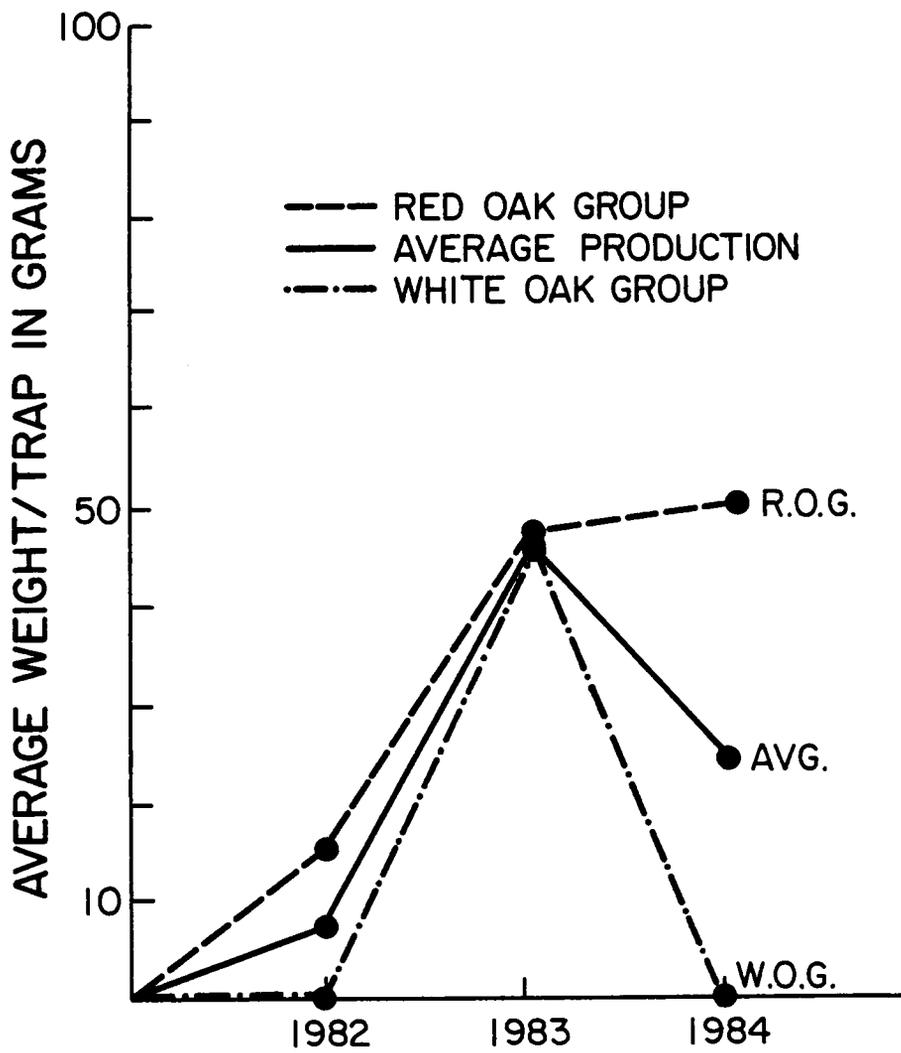
Figure 27. Yearly hard mast production from 1982-1984 for red oaks and white oaks within Shenandoah National Park, Virginia.

The age distribution of oaks within chestnut oak \ red oak and and red oak \ white oak forests was essentially the same (50-70 yrs) in SNP; thus the preference for either oak type was not related to stand age. Also, preference for oak types was not influenced by high use of wild black cherry during fall because cherry trees were scattered throughout the Park. Instead, shifts in chestnut oak \ red oak and red oak \ white oak forest use during both fall periods may be attributed to acorn preference and availability, foraging strategy, and cover.

Bears may have shifted to red oak \ white oak forests in early fall to feed on concentrated sources of red oak acorns and to use white oak acorns. Use of red oak \ white oak forests in early fall would increase foraging efficiency since the densest stands of pure red oak were found only within this forest type (Table 11). Bears could also use both sources of acorns (red and white) within red oak \ white oak forests. Bears in SNP likely prefer white oak acorns and indeed they were often observed in red oak \ white oak forests during September and October eating white oak acorns from tree branches. Bears may have been searching specifically for white oak acorns, regardless of their availability, when they used red oak \ white oak forests greater ($P < 0.05$) than expected and chestnut oak \ red oak forests less ($P < 0.10$) than expected in early fall 1983 and 1984 (Figure 26). This occurred despite good production of red oak acorns in both oak forest types during both years and a complete white oak mast failure in 1984 (Figure 27, Haskell 1984,unpublished SNP report). The preference for white oak acorns displayed by many wildlife species is thought to be caused by their lower tannin content and therefore higher palatability in comparison to other oak species (Wainio and Forbs 1941, Allen 1943:179, Baumgras 1944, Martin et al. 1951:308, Short and Epps 1976). Havera and Smith (1979) showed that fox squirrels (*Sciurus niger*) consumed more, gained more weight, and metabolized more energy on white oak acorns than any other diet examined, including red oak acorns. Carr (1983:57) reported that bears in GSMNP preferred oak forests in fall regardless of acorn availability. Conversely, a switch in the type of oak forests preferred by bears during fall periods corresponded to an observed change in oak mast availability in North Carolina (Brody 1984:66, Waburton 1984:51).

In 1982, overall acorn production was poor and bears did not increase their use of red oak \ white oak forests in early fall. Instead, they used both oak types to find other foods such as black cherries, apples, wild grapes, and hickory nuts. Garshelis and Pelton (1981) found evidence that abundant black cherries in a bears' summer range may delay movements to fall ranges. Bears in North Carolina (Waburton 1984:61) and GSMNP (Eiler 1981:73) fed on wild grapes to maintain themselves during a mast failure. Elowe (1984:42) reported that bears in Massachusetts stayed in cornfields until harvest time when hard mast was in short supply in fall.

Bears may have shifted to chestnut oak \ red oak forests in late fall due to the depletion of acorns in red oak \ white oak forests and because of the dense mountain laurel cover found in chestnut oak \ red oak stands (Table 11). In late fall, white and red oak acorns within the smaller red oak \ white oak forests (16.54% area) may have been depleted by bears, deer, fox squirrels, gray squirrels (*Sciurus carolinensis*), ruffed grouse, raccoons, and turkeys (*Meleagris gallopavo*) to such a degree that feeding on red oak acorns within the larger chestnut oak \ red oak forest type (38.53% area) became more energetically efficient. Escape and thermal cover in SNP after leaf drop was restricted to dense thickets of evergreen mountain laurel ($\geq$ 90% of evergreen shrub coverage in the study area was by mountain laurel). Thus, increased use of chestnut oak \ red oak forests for cover might be expected during late fall because 72 percent of the mountain laurel thickets occurred within this forest type; red oak \ white oak forests contained only 8 percent. Dense shrub layers have been used by bears as escape cover in other Appalachian Mountain areas (Villarrubia 1982:79, Waburton 1984:61) as well as in coastal regions (Landers et al. 1979). In SNP, males used dense mountain laurel understory greater ($P < 0.05$) than its availability in late fall; females used it in proportion to availability but used it more in late fall than during any other season (Figure 28).

In addition, males and females were in chestnut oak \ red oak forests 74% and 68% of the time respectively when using mountain laurel in late fall. During all 3 years, bears increased

their use of chestnut oak \ red oak forests from early-to-late fall to eat red oak acorns and utilize mountain laurel shrub cover regardless of overall acorn production (Figure 26). Lindzey and Meslow (1977) noted the importance of the juxtaposition of food and cover to bears in Washington.

Seasonal shifts in habitat use are related to the diversity, abundance, distribution, phenology, and quality of available food sources (Jonkel and Cowan 1971, Amstrup and Beecham 1976, Rogers 1976, Landers et al. 1979, Beeman and Pelton 1980). However, not all of the variation in habitat use can be attributed to habitat characteristics. Other factors such as human disturbance, social interactions, random exploration, and individual bear behavior may be important.

Summary and Conclusions

Black bears in SNP were largely herbivorous and used seasonally abundant foods. The major food items consumed were herbaceous leaves and stems in spring; squawroot, tree fruits (sweet cherry, black cherry, apple), insects, and various forbs in summer; and tree fruits (acorns, black cherries, apple, hickory nuts) in fall. Winter-active bears relied upon acorns, apples, and white-tailed deer. Bears in SNP consumed more tree fruits (48% volume) than any other food item annually. Implications from carrion consumption seen in this study are that bears are opportunistic and will readily eat meat when it is available. Based on nutritional studies of similar bear foods in North Carolina (Landers et al. 1979) and Tennessee (Eagle and Pelton 1983), spring foods (forbs, grasses) in SNP were low in nutritional value; summer and early fall foods were high in sugars and other carbohydrates (fruits and seeds) and provided a source of high quality protein (animal matter); and late fall foods were high in fats and available energy (acorns).
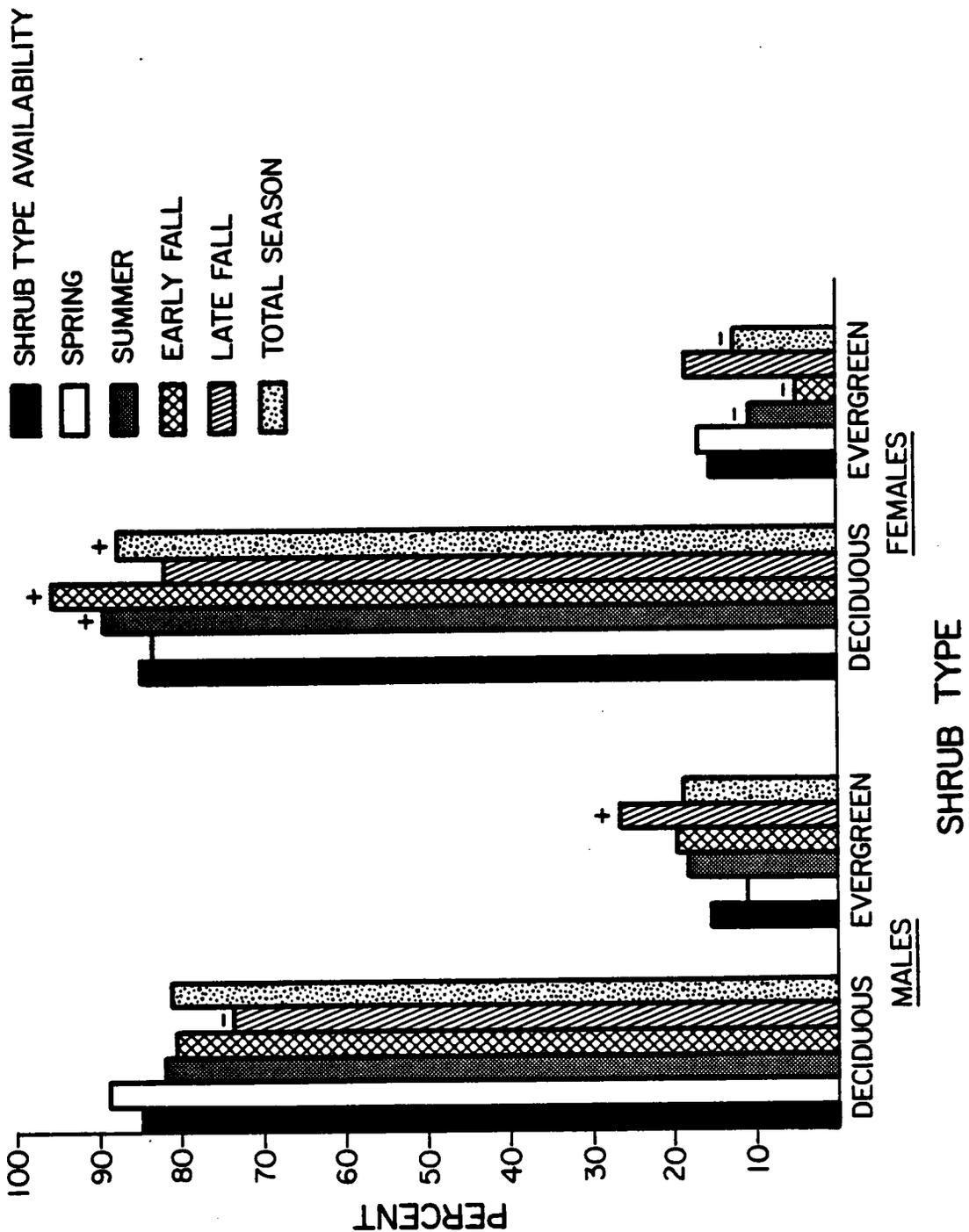
Figure 28. Seasonal shrub use by black bears and availability within the Central District of Shenandoah National Park, Virginia: a "+" indicates more (P < 0.05) use than expected and a "-" indicates less (P < 0.05) use than expected.

Females preferred poplar forests for consumption of forbs in spring and early summer and for utilization of domestic apples and sweet cherries at abandoned homesites throughout summer. Males preferred locust \ cherry forests for use of forbs in spring and for the consumption of wild black cherries and apples in fall. Significant shifts in use of chestnut oak \ red oak and red oak \ white oak forests by both males and females in early and late fall was attributed to availability of oak mast, preference for white oak acorns in early fall, foraging strategy, and the utilization of mountain laurel shrubs for escape and thermal cover in late fall.

Chestnut oak \ red oak forest was the most heavily used forest type during all seasons by both males and females; it provided forbs in spring, squawroot in summer, and acorns as well as mountain laurel shrub cover in fall. The importance of oak forests in SNP in providing year around foods is added evidence that oak types are critical habitats for bears in the southern Appalachians as suggested in other studies (Beeman 1975:93, Carr 1983:abstract, Garris 1983:72). The forests of SNP offer black bears a haven to utilize a diverse mixture of distinct forest types which provide a combination of quality habitats and foods.

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Chapter 3: Use Of Abandoned Homesites

Methods

Bears were captured in Aldrich foot snares and culvert traps from spring 1982 through summer 1984 and immobilized with intramuscular injections of ketamine hydrochloride and xylazine in a 2:1 mixture (dosage rate 6.6 mg per kg of body weight). Selected individuals were fitted with motion-sensitive radio transmitter collars (Telonics, Inc., Mesa, AZ 85203).

Homesite Use Analysis

Radio-marked bears were monitored during all seasons through April, 1985 and located during daylight hours between 0600 and 2100. An attempt was made 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 (Cessna 150,172) with directional H antennas mounted under each wing.

Only aerial locations and close ground triangulations ($\leq$ 100m from investigator) were used for analysis because their accuracy was tested and therefore known (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.G.S. 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). A random sample ($N = 40$) of abandoned homesites was visited to assess map accuracy and determine the presence of domestic fruit trees.

Distance-to-nearest-homesite was determined for each bear location within the Central District (or outside the Central District but < 1000m from a Central District homesite) and for each of 1000 random points. Locations of bears within 1000m of a homesite were included even when outside the Central District because they may have been influenced by homesites near the Park boundary. Presence at homesites was investigated by comparing the frequency with which bears and random points were within 100m 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 they may have been influenced by unidentified homesites in those areas.

The Wilcoxon Rank Sum Test and Chi Square Test were used for statistical comparisons unless otherwise noted. Two-sided significance levels are reported.

Food Habits and Phenology Analysis

Scats ($N = 837$) collected from May 1982 through December 1984 were analyzed 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 percent of the scats were collected within the Central District while the re-

maining 5 percent 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 (1961:23-24) and Mealey (1980).

Food items in each scat and stomach were identified. Volume of each food item was ocularly estimated (Clark 1957, Tisch 1961:24) using 25 percent 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. Consumption of domestic fruit was specified for each season and the entire year (Beeman and Pelton 1980). Frequency of occurrence was expressed for each food item and each food item was assigned an index value based on the percent volume in each scat or stomach: 0=trace; 1=1-25 percent; 2=26-50 percent; 3=51-75 percent; and 4=76-100 percent.

Volume index percent =

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

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

Identification of 330 abandoned homesites within the study area was made (Figure 29). Homesites contained partial ruins of log cabins, fences, or other log structures. Disturbed areas around homesites averaged 1-2 ha in size and included 2-3 fruit trees or small orchards (usually 5-15 trees) and evidence of past agriculture and grazing activity. Homesites were located in forested areas at low-to-mid elevations (X = 635m, range 269m - 1127m), on gentle slopes (X = 13°, range 2°- 36°), near streams and small rivers (X = 221m, range 10m - 1240m) on all aspects. The most common domesticated tree species found around homesites were sweet cherry and apple; at least one of these was present at 90 percent ($N=36$) 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 since 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 limited. The accuracy of aerial locations was also tested by 1) locating bears at den sites and 2) using reference transmitters placed in known locations periodically during the study. The tests indicated that aerial locations were in error by less than 100m in any direction approximately 95 percent of the time. Garshelis
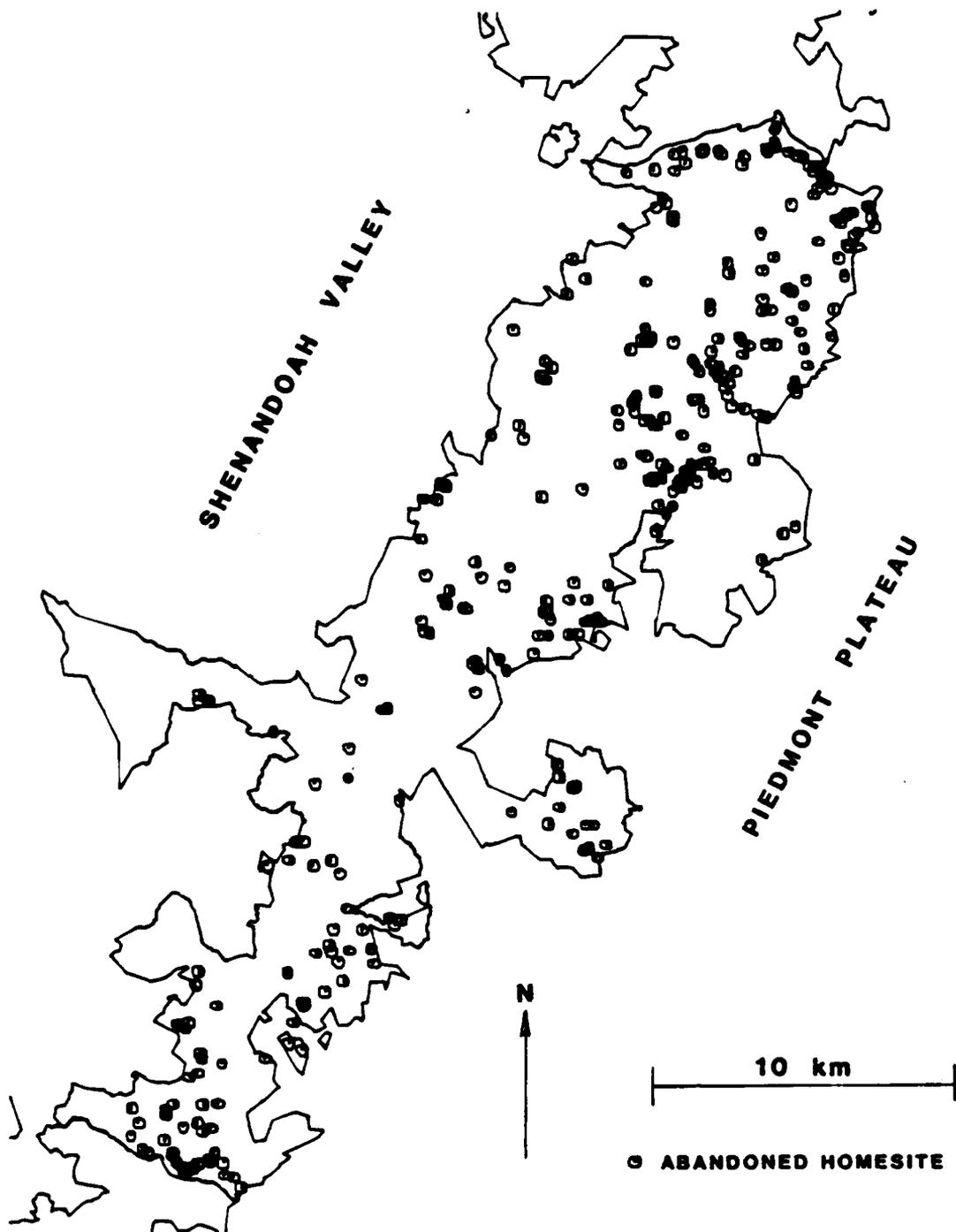
Figure 29. Map of abandoned homesites in the Central District of Shenandoah National Park, Virginia.

(1978:14-16), Quigley (1982:14-16), and Garris (1983:22) accepted an error of 150m. Close ground triangulations were considered highly accurate due to the close proximity of the investigator to the bear. The presence of bears in the triangulated area was often verified by sightings.

Distance-to-nearest-homesite did not differ between years within seasons for either sex ($N = 1374$, $P > 0.05$); thus data for 1982-1985 were combined for each season. The number of bears of each sex radiotracked each season ranged from 12 to 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, $\chi^2 = 5.34$, 3df, $P = 0.148$, Table 14). Males were not located within 200m of any homesite during early and late fall, but were located within 100m 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 (median = 670m) in late fall (median = 760m), ($P = 0.012$, Table 14). Random points fell within 100m of homesites 1.5% of the time, comparable to the 0% - 3.4% of males within 100m of homesites for all seasons.

Female Movements

Distance-to-nearest-homesite 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.

Table 14. Seasonal distance-to-nearest-homesite (m) for black bears and random points in SNP, Virginia, 1982-1985.

Season	Sex	N	Mean	Median	SD	Range
Spring	M	88	730	590	470	60 - 2230
	F	216	700	670	400	70 - 2350
Summer	M	117	820	710	620	50 - 4850
	F	397	640	560	430	30 - 2180
Early Fall	M	43	810	880	440	210 - 1860
	F	213	750	680	530	10 - 3380
Late Fall	M	90	920	760	630	240 - 4170
	F	210	790	730	400	90 - 2090
Random		1000	820	670	670	50 - 5870

All values rounded to the nearest ten.

Distance-to-nearest-homesite for females differed seasonally (Kruskal-Wallis Test, $\chi^2 = 21.51$, 3 df, $P < 0.001$). Females were closer to homesites in the summer than during any other season (Rank LSD, $P < 0.041$) while 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 14). 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 ($\chi^2 = 0.046$, 1df, $P = 0.830$).

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 = 670m) during the late fall (median = 730m), ($P = 0.061$, Table 14). However, females were located at homesites more frequently than random points during summer ($\chi^2 = 25.43$, 1df, $P < 0.001$) and early fall ($\chi^2 = 16.50$, 1df, $P < 0.001$).

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 while 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%, $\chi^2 = 1.611$, 1df, $P = 0.204$) 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 (Figure 30).

Bears consumed domestic tree fruits mainly from summer to late fall (Table 15). 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 (Figure 30). 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 under-estimated.

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%). Sixteen, 11, and 44% of the soft fruits eaten during summer, early fall, and late fall respectively was domestic fruit.

Discussion

Even though home ranges for males were larger (Chapter 1) and included more homesites, females most likely recognized the spatial distribution of homesites within their smaller ranges more than far ranging males and returned to these areas that they had asso-
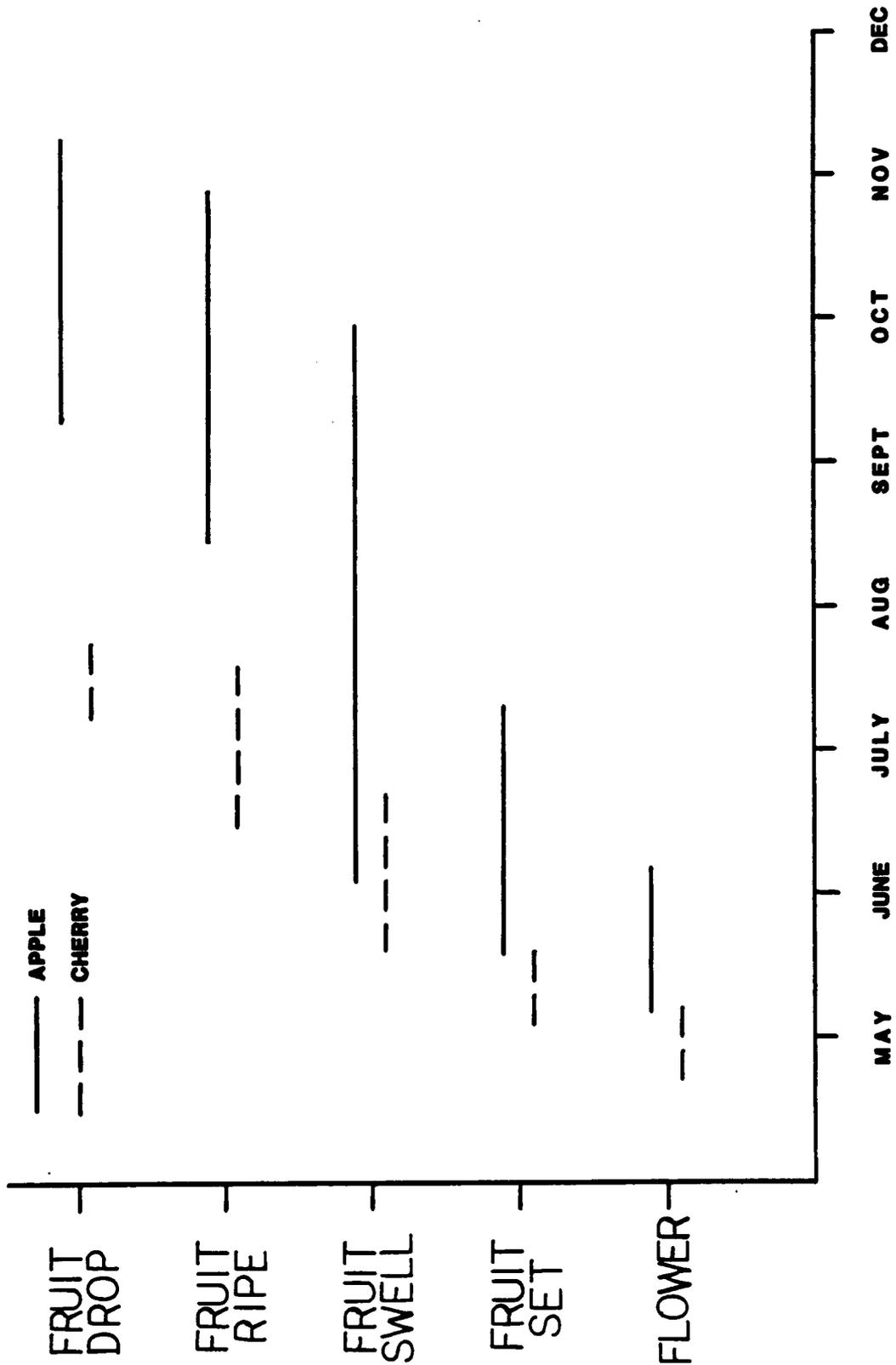
Figure 30. Phenological changes in apple trees and sweet cherry trees in Shenandoah National Park, Virginia, 1984: (n = 11 apple trees, elevational range 326m - 1015m; n = 7 sweet cherry trees, elevational range 357m - 677m).

Table 15. Percentage frequency and volume index of domestic fruits identified in bear scats from SNP, Virginia, 1982-1984.

	Spring (174 Scats)		Summer (229 Scats)		Early Fall (237 Scats)		Late Fall (197 Scats)	
	% Freq.	Volume index	% Freq.	Volume index	% Freq.	Volume index	% Freq.	Volume index
Sweet cherry	T[1]	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				

[1]T indicates < 1%.

ciated with domestic fruit in the past. 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 since both 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 where apple trees occur at orchards and abandoned homesites scattered at lower elevations (Pelton, personal communication), bears ate apples during summer (Eagle 1979:96,101). 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) (Chapters 1,2). Other studies have shown that black bears 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, and Waburton 1984). The effect of movements by bears into acorn-producing areas also reduced fall use of homesites by bears in SNP (only 2 observations at homesites in late fall) since 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 lessened 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 with respect to late fall likely reflects the continued use of homesites in early September before females shifted to fall feeding areas.

Garshelis and Pelton (1981) speculated that the abundance of black cherry in a bears' 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 mainly by females during the summer (distance and frequency analysis), and also during early fall (frequency analysis). 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 cherries (considered nutritionally similar to sweet cherries) is poor in protein and fat, high in nitrogen-free extract, and low in tannins (Wainio and Forbs 1941). Servello (1985:67) 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 show a drastic decline during the next twenty years as a result of forest intrusion 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 out of their home ranges to areas

where food was more abundant. Nuisance bears (30-35) are currently being trapped each year on private lands in the eight counties surrounding SNP due to damage in commercial orchards, corn fields, and beehive operations (J. Blank, Virginia State Trapper, personal communication). Reduction of domestic fruit production at abandoned homesites may cause females to seek alternate food sources during the summer and early fall because they use homesites for domestic fruit consumption mostly at those times. 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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Appendix A. Location Samples for Female Black Bears

ID Number	Age	Monitoring Period	Number of Locations
51	Adult	7/13/82 - 12/5/84	199
53	Adult	7/11/82 - 9/27/82	22
54	Adult	7/5/82 - 4/30/85	273
55	Adult	7/4/82 - 11/30/84	175
56	Adult	7/9/82 - 11/21/84	173
58	Adult	7/5/82 - 1/2/84	158
60	Adult	7/7/82 - 9/29/82	25
61	Adult	7/2/82 - 7/21/82	5
64	Adult	8/26/82 - 12/20/84	93
66	Adult	11/2/82 - 4/30/85	175
70	Adult	7/23/82 - 6/13/84	77
74	Adult	7/6/82 - 8/31/84	146
79	Adult	5/6/83 - 8/25/84	96
81	Adult	6/2/83 - 6/27/84	85
82	Adult	6/1/83 - 4/29/85	172
85	Adult	6/10/83 - 12/9/84	101
86	Adult	6/10/83 - 4/29/85	123
87	Adult	6/17/83 - 4/29/85	104
88	Adult	6/13/83 - 12/5/83	48
89	Adult	6/17/83 - 8/25/84	101
91	Adult	7/10/83 - 4/29/85	186
92	Adult	7/21/83 - 4/30/85	117
93	Adult	10/14/83 - 4/26/84	23
772	Adult	6/23/83 - 9/6/84	67
774	Adult	6/1/83 - 5/15/85	114
			Total = 2858

Appendix A. Location Samples for Female Black Bears

Appendix B. Location Samples For Male Black Bears

ID Number	Age	Monitoring Period	Number of Locations
1	Adult	7/18/82 - 9/21/83	74
2	Adult	8/23/82 - 10/24/82	6
3	Subadult	9/25/82 - 11/23/83	59
6	Subadult	7/23/82 - 6/29/84	130
7	Adult	7/2/82 - 6/23/83	36
8	Adult	7/7/82 - 1/16/85	130
10	Adult	8/23/82 - 10/14/83	50
15	Adult	7/10/82 - 7/27/82	6
17	Adult	7/4/82 - 8/18/82	4
21	Adult	6/10/84 - 4/30/85	95
27	Adult	10/24/82 - 12/18/82	7
31	Adult	11/6/82 - 11/7/83	80
33	Adult	11/6/82 - 9/3/83	77
39	Subadult	5/12/83 - 9/22/83	37
40	Adult	5/12/83 - 8/15/83	33
104	Subadult	12/21/83 - 12/29/83	5
116	Adult	10/14/83 - 9/11/84	74
118	Adult	10/15/83 - 11/23/83	9
120	Adult	10/16/83 - 7/13/84	36
123	Adult	10/24/83 - 11/24/84	55
124	Adult	10/19/83 - 7/16/84	46
128	Subadult	12/23/83 - 10/30/84	66
			Total = 1115

Appendix B. Location Samples For Male Black Bears

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