# DIGESTIBILITY OF FOODS AND ANTHROPOGENIC FEEDING OF BLACK BEARS IN VIRGINIA

by

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Thesis submitted to the Faculty of

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

in

Fisheries and Wildlife Sciences

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10 August 2001

Blacksburg, VA

**Keywords:** black bears, digestibility, feeding, foods, nutrient composition, supplemental, *Ursus americanus*, Virginia

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## ABSTRACT

For years, bear hunters have provided an unknown amount of food to black bears (*Ursus americanus*) in Virginia, supplementing their natural food supply. Possible effects of feeding bears can be negative, such as food conditioning and habituation to people, or positive, such as enhanced or sustained reproductive rates, especially in years of mast crop failure. In July 1999, the Virginia Department of Game and Inland Fisheries (VDGIF) adopted a regulation recommendation that prohibited the feeding of wildlife on national forest and department-owned lands. We mailed a survey to all members of the Virginia Bear Hunters Association (VBHA, $n$ = 459) to determine the amount of food provided to bears by bear hunters in Virginia between 1 July 1998 and 30 June 1999. Survey response rate was 52%. One hundred thirteen of 238 (47.5%) survey respondents spent over $18,000 on supplemental food in one year, averaging $163/person. One hundred twenty-eight respondents reported cumulatively providing nearly 3 million kilograms of food to bears between 1 July 1998 and 30 June 1999. Whole-shelled corn, pastries, and grease accounted for 58% of the total food by weight; however, whole-shelled corn, pastries, and bread were the 3 most common foods offered. Feeding occurred in 25 counties in Virginia, primarily during July, August, and September. Rockingham County had the highest proportion of feeders (47%), followed by Giles (15%), Augusta (14%), Craig (9%) and Montgomery (9%) Counties. Accordingly, Rockingham County received the highest proportion of food (42%), followed by Craig (8%), Giles (7%), Montgomery (6%), and Tazewell (6%) Counties. The low survey response rate, coupled with the fact that 48% of sampled nonrespondents fed bears, suggests that the total amount of annual feeding in Virginia may exceed the total determined during this study. However, the possibility of an avidity bias, in which a higher response by the more avid feeders would erroneously inflate a total estimate extrapolated to include feeding by nonrespondents, cannot be eliminated.

Little work has been done pertaining to digestibilities of black bear foods, particularly

those in the eastern United States. We determined digestibilities for several important eastern black bear foods, including northern red oak (*Quercus rubra*), white oak (*Q. alba*), and chestnut oak acorns (*Q. prinus*), squawroot (*Conopholis americana*), high-protein dogfood, shelled corn, and doughnuts. All diets were evaluated for nutrient content as well as percent dry matter digestibility of crude protein, ether extract (a measure of fat), and gross energy. Diets we suspected were high in fiber were additionally evaluated for neutral detergent fiber or acid detergent fiber content and digestibility. Feeding trials were conducted with 1 male and 4 female captive bears during fall 1998, and 5 female captive bears during fall 1999, at the Center for Ursid Research, Blacksburg, Virginia. Acorns and squawroot were high in fiber (45-62%) and moderate to low in protein (5-7%). Fat content was high in doughnuts (24.7) and northern red oak acorns (12%), moderate in dogfood (8.2%) and white oak acorns (4.7%), and relatively low in shelled corn, chestnut oak acorns, and squawroot (1.3-3.5%). Crude protein was high in dogfood (29%) and moderate in all other diets (4.7-8.8%). Neutral detergent fiber content was high in squawroot and all acorn types (45-62.4%). Acid detergent fiber was high in squawroot (47%) and moderate in dogfood (9%). In 1998, crude protein digestibility was high in doughnuts (86%), moderate in shelled corn and white oak acorns (50-64%), and negligible in northern red oak acorns (-39%). Ether extract digestibility was high in doughnuts, red oak acorns, and white oak acorns (80-97%), and moderate in shelled corn (67%). Fiber digestibility was tested only on northern red oak and white oak acorns, and was moderate (62% and 68%, respectively). In 1999, crude protein digestibility was high in dogfood, dogfood mixed with squawroot, and doughnuts (75-85%); moderate in shelled corn, squawroot, and white oak acorns (43-58%); and low to negligible in chestnut oak and northern red oak acorns (-13-6%). Ether extract digestibility was moderate in shelled corn (64%) and squawroot (60%), and high in all other diets (79-97%). Neutral detergent fiber digestibility was moderately high in all acorn types (54-71%). Acid detergent fiber digestibility was moderate for dogfood (66%), and associative effects occurred between the fiber in squawroot and dogfood, resulting in negative fiber digestibility in squawroot determined by difference (-19%).

A luxury not always realized in wildlife management is the ability to investigate possible effects of management or policy changes prior to their employment. The amount of food provided to bears by bear hunters in Virginia may have been more substantial than previously believed, and likely provided bears with a high energy, stable food source that supplemented their natural food supply. We did not have the opportunity to study the effects of removing that food source on public lands prior to the regulation change; however, the opportunistic feeding strategy of bears, coupled with sufficient mast production at the time of the regulation change, likely softened any negative effects that may have occurred as a result of the removal of supplemental food as a regular food source for some bears.

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to the numerous people who directly or indirectly helped me complete this research. First, I would like to thank my major advisor Mike Vaughan, who hired me for my first wildlife technician position in 1994, despite my lack of experience, and later hired me as a graduate student on the Cooperative Alleghany Bear Study in 1997. I appreciate the guidance, support, and trust he willingly provides to all of his students, and the fact that his office door is always open. I'd also like to thank my committee members, Dr. Steve McMullin from the Department of Fisheries and Wildlife for his help with designing and implementing my survey, and Dr. Kenneth Webb, Jr. from the Department of Animal and Poultry Sciences for his help and support with my food trials research.

I would like to acknowledge the Virginia Department of Game and Inland Fisheries for its financial and personnel support of CABS research, with special thanks to Denny and Carole Martin, Dave Steffen, Jerry Blank, Larry Crane, Betsy Stinson, Marv Gautier, Al Bourgeois, Dave Kocka, Roger Houck, Joe Watson, and Nelson Lafon.

I appreciate the support of other funding agencies for this project, including Virginia Tech, the United States Geological Survey-Biological Resources Division, the National Fish and Wildlife Foundation, the United States Forest Service, and the Virginia Bear Hunters Association.

I owe big thanks to the officers of the Virginia Bear Hunters Association, including Jerry and Bonnie Snyder, Danny Thorn, Tony Hinkle, Cecil Boggs, Dick Collins, Greg Layman, John Ax, and Tony Wilt for reviewing and providing feedback on my supplemental feeding survey, and to all members of the VBHA for taking the time to complete and return the survey.

I wish to thank the numerous volunteers who helped collect acorns and squawroot for this study and/or helped feed the captive bears and collect droppings, including Ed Manchester, Andrew Reno, Brian Balmer, Anna Spellerberg, Ellen Adkins, Robin Trear, Bernadette Moore, Tiffany Beachy, Nancy Garren, Dan Garren, Daly Sheldon, Angela Burkhart, Kerry Signor, Sybille Klenzendorf, Kim Needham, Gyasi Quince, Darroch Whitaker, Brendan and Kim O'Neill, Lisa French, Cristina Faustino, Deb O'Neill, Daniel and Stephanie Lee, and Andrew Bridges. Big thanks go to Justin Crawford, Jenny Golding, Kimberly Miller, and Melissa Hooper for their support in the bear pens, and especially Colleen Olfenbuttel, without whom I would have buried myself under a pile of frozen doughnuts and poopballs. Thanks also to Steve

Manos for his prompt help in modifying the bear pens to suit my needs and for catching escaped bears.

Thanks go to Laura Vaughn Coffey and Judy in the Virginia Tech Forage Testing Lab for their help in analyzing my samples, and HUGE thanks to Don Shaw, for his friendship and energetic help in preparing and analyzing my samples, operating the bomb calorimeter, and helping determine weights of 5-gallon buckets of foods. I appreciate the help of other folks who supported and helped me in the lab, including Melony Massey, Lisa Wood, Kristin O'Connell, Gene Ball, Melanie Culver, and George Palmer.

A big thank-you goes to Larry Houghton for taking the time to teach me (forcing me to learn) a bunch of fancy formatting tricks on the computer, which saved a lot of time and prevented misery later. A very special thanks goes to Dan Garren for his help and support and patience, and for putting up with the bear study for 4 years. I'd also like to thank my mom and sisters, Tracy and Katie, for their support and encouragement throughout my education.

My deepest appreciation goes to the friendship and guidance of Mike Vaughan and former and current CABS students and technicians, including Jen Higgins, Adam Vashon, Cale Godfrey, Kris Higgins, Chris Ryan, Kim Needham, Sybille Klenzendorf, Colleen Olfenbuttel, Deb O'Neill and Mike St. Germaine, Andrew Bridges, Daniel Lee, and Gyasi Quince. Their untiring friendship and good humor have made my experience on the bear study most enjoyable, and they will be what I miss the most.

Finally, thanks to all of the bears we have handled during this study. Despite free drugs and doughnuts, their experience as study animals is probably not an enjoyable one, and I truly hope this research will benefit their lives and future management.

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# INTRODUCTION

The Cooperative Alleghany Bear Study (CABS) was initiated in 1994 to collect long-term data on Virginia's hunted black bear (*Ursus americanus*) population. The study has focused on age-specific reproduction and survival, dispersal of subadults, denning ecology, and the effects of using dogs to hunt bears. One vital aspect of black bear ecology that CABS had not investigated was nutritional ecology.

Nutritional condition of black bears purportedly affects their age at first reproduction (Bunnell and Tait 1981, Eiler et al. 1989), litter size (Jonkel and Cowan 1971, Rogers 1976, Bunnell and Tait 1981), inter-birth interval (Rogers 1976, Bunnell and Tait 1981), cub survival (Matson 1951, Rogers 1976, Eiler et al. 1989), growth rates (Cowan et al. 1957, Rogers 1976), home range sizes (Beeman and Pelton 1980, Garner 1986), and hunter harvest success (Beeman and Pelton 1980). In addition, low mast availability leading to poor nutritional condition of female bears may lengthen their normal reproductive cycles (Eiler 1981) while abundant and diverse food supplies may shorten the reproductive cycle (LeCount 1980). Plentiful food may enhance the physical condition of female bears and enable them to raise consecutive litters, as well as the chance of survival of cubs abandoned in late fall (LeCount 1983).

McCullough (1992) reported that age at first reproduction is the most influential parameter of population growth rates in K-selected species. Data from Virginia indicate that productivity rates are high compared with studies in other areas. The average age of primiparity of 6 radio collared females was 3.0 years in the southwest CABS study area (Ryan 1997), and 3.14 ($n$ = 7) years in the northwest study area in 1995-96 (Godfrey 1996) and 3.75 ($n$ = 4) in 1997-98 (Echols 2000). Other studies have reported substantially higher ages at first breeding. Average age of primiparity was 4 years for unexploited populations in Virginia (Carney 1985, Hellgren 1988), 4.6 years in the southern Appalachian Mountains (Eiler et al. 1989), 4-5 years in the Great Smoky Mountains National Park (GSMNP), Tennessee (Eiler 1981), 4 years in Washington (Lindzey and Meslow 1977), 4.6 to 5.1 years in Alaska (Schwartz and Franzmann 1991), 4 to 6 years in Maine depending on scaricity of beechnuts (*Fagus grandifolia*) (McLaughlin et al. 1994), and >6 years in Montana (Jonkel and Cowan 1971, Kasworm and Their 1994).

The high reproductive rates observed in western and southwestern Virginia, may be indicative of more abundant food resources. According to Jonkel and Cowan (1971), nutrition affects sexual maturity and ovulation rates in domestic animals, and may affect age of first successful breeding in bears. Food availability (McLaughlin et al. 1994) and size and condition of the bears contribute to geographical variation in age at first reproduction. Eiler (1981) attributed the high minimum age of breeding in Tennessee to extreme mast failure, and found that litters were smaller when preceded by a mast failure.

Inman (1997) reported that black bear reproduction in the GSMNP was correlated with hard mast production, and hypothesized that population dynamics are likely influenced by soft mast and other food sources as well. Suboptimal nutritional conditions may explain the small litter size, reduced frequency of litters, and the high age of first successful breeding for bears in Montana, where rising and falling reproductive rates coincided with similar huckleberry (*Vaccinium* spp.) fluctuations (Jonkel and Cowan 1971). Noyce and Coy (1990) found food availability, particularly of berries and nuts, to be linked to black bear reproduction. McLaughlin et al. (1994) reported that 95% of black bear litters in a study in Maine occurred in years following abundant beechnut crops. They postulated that food failures may cause synchronized reproduction in females in areas where bears depend on a small number of fall foods.

Bears are omnivorous, opportunistic feeders (Eiler 1981, Lunn and Stirling 1985, Joshi et al. 1994), and eat what is readily available and seasonally abundant (Beeman and Pelton 1980). According to Garner (1986), forbs, graminoids, squawroot (*Conopholis americana*), corn, and fruits of trees, shrubs, and vines constituted 90% volume of the black bear diet in Shenandoah National Park (SNP), Virginia, annually; animal matter from mammals, birds, and invertebrates comprised 8% of food consumed by bears. Scat and stomach analysis of bears in GSMNP showed black bear diets to consist of 81% plant matter (including fruits and nuts), 11% animal matter, 6% artificial food, and 2% debris (Beeman and Pelton 1980). Beeman and Pelton (1980) speculated that insects may provide bears with a critical source of protein, although the amount of protein a bear is able to utilize is unknown. Powell and Seaman (1990) suggested that weevils, which infested an average of 35% of acorns sampled in the Pisgah Bear Sanctuary, North Carolina, may provide an additional source of protein. However, weevil infestation renders part of the acorn unavailable to wildlife. Squawroot, blueberries (*Vaccinium* spp.), and huckleberries are important summer foods for bears in the southern Appalachians (Powell et al. 1997). Berries are also an important early fall food for bears in the southern Appalachians (Beeman and Pelton 1980). Powell and Seaman (1990) found that squawroot had a higher energy production than berries, and is potentially an important post-denning food in the spring. Squawroot is likely an important source of energy for bears (Eagle and Pelton 1983), and may be especially important to the high energy demands of lactating females. Garner (1986) reported that squawroot occurred most in black bear diets in the SNP through July and August, and composed 40% volume of the summer black bear diet.

The abundance and availability of preferred foods are also important management considerations. Productivity levels of important black bear foods differ greatly across the black bear's range (Powell and Seaman 1990). Availability of plants and habitats that produce spring and summer foods likely has significant impacts on bear recruitment and carrying capacity (Inman 1997). Beeman and Pelton (1980), however, postulated that due to the reliability and abundance of summer and early fall foods in the Great Smoky Mountains, food availability is probably not a limiting factor for bears. They found that long availability periods of huckleberries, blackberries, and blueberries were largely due to altitudinal variation. Elowe and Dodge (1989) found that female black bear diets in Massachusetts consisted of 1 or 2 major food items, which would shift depending on availability and elevation. Bears' ability to shift food sources may soften the effects of hard mast shortages (Eiler 1981). Similarly, a berry crop failure in the southern Appalachians may be counterbalanced by good production of fall nuts and soft mast, such as grapes (*Vitis* spp.) (Powell and Seaman 1990).

Data from 3 national forests in North Carolina show a correlation between tree diameter at breast height (dbh) and number of acorns produced by 5 oak species (Greenberg, USFS, unpublished data, 1997). Beck (1977) found that peak acorn production in the Pisgah Bear Sanctuary occurred every 4 years for white oak (*Quercus alba*) and every 5 years for red oak (*Q. rubra*). His estimate of average acorn production for all oak species was 58.1 ± 64.3 kg/ha. Squawroot and berries, though patchy in distribution, averaged 2.3 ± 0.05kg/ha and 2.6 ± 2.0kg/ha, respectively. Acorn production in Shenandoah National Park in 1988-89 was 118.4 +/- 33.4 kg/ha (Kasbohm 1994). Inman (1997) tested 19 important black bear foods in the northwest quadrant of GSMNP, and found that northern red oak produced 65.7% of the total caloric production, followed by squawroot (15.8%), and huckleberries (5.1%). He concluded that oaks are likely the most influential genera affecting bear ecology in the southern Appalachians.

Though wild fruit production can be difficult to measure due to temporal and spatial variability, clumped distribution of fruit-bearing species, and varying forest types (Noyce and

Coy 1990), Powell and Seaman (1990) suggested that documenting variance of food production (i.e., patchiness), over space and time, may be as important as determining production averages in understanding effects of food on aspects of bear biology such as reproduction and home range.

A measure of food abundance differs from availability in that it does not account for the amount eaten by competitors or wasted. Beeman and Pelton (1980) observed bears climbing trees to forage as well as to “prune” fruit-bearing branches whose fruit would otherwise have been unavailable. They suggested that the ability to forage arboreally may give bears an advantage over most mammals who depend on mast in the fall (with the exception of Sciurids). Likely food competitors with bears in western Virginia are the wild turkey (*Meleagris gallopavo*), white-tailed deer (*Odocoileus viginianus*), gray squirrel (*Sciurus carolinensis*), and mice (*Peromyscus* spp.) (Table 7). Although arboreal foraging increases food availability, it may require a larger energy expenditure than foraging on the ground.

Seasonal variation of black bear diets (Bacon and Burghardt 1983) as well as dramatic seasonal shifts in the diets of grizzly and brown bears have been documented (Bunnell and Hamilton 1983). Availability of food may not be solely responsible for seasonal shifts in diet. According to Bacon and Burghardt (1983), physiological and nutritional needs that change with season, age, sex, and reproductive status may cause dietary shifts in bears. Bunnell and Hamilton (1983) suggest that bears’ ability to extract energy and nutrients from consumed food may be cause for, or enable, bears to change their diets seasonally, though little work has been done to document this. Bears may maximize their net rate of energy intake, thus increasing their fitness, by selecting highly digestible forage (Bunnell and Hamilton 1983). This supports the optimal foraging theory (Schoener 1971).

In addition to natural foods, supplemental foods may play an important role in black bear populations in western Virginia. Though corn from cornfields or corn cribs occupied only 3% of the total volume of annual black bear diets in SNP (Garner 1986), it may be an important food source during low mast years. Panhandler females in GSMNP, who had access to high quality food sources from garbage and handouts from visitors, reached mature weights faster and became heavier than nonpanhandler females (Eiler 1971). Eiler (1971) postulated that because panhandlers reach mature weights earlier than nonpanhandlers, they likely become sexually mature at a younger age. Lunn and Stirling (1985) found no evidence that polar bears gained reproductive or survival advantages after using a dump to feed. However, after the closing of the dumps in Yellowstone National Park, mean Yellowstone grizzly bear litter sizes decreased from an average of 2.20 cubs (1959–1969) to 1.91 cubs (1973-1981) (Craighead et al. 1995:275).

Knowledge of the availability and nutritional value of important black bear foods, and whether current food availability is sufficient and sustainable, may provide insight for future forest management practices. Determining whether bears exhibit a preference for certain food items may be important in effectively managing forest resources for black bear habitat and ensuring the continued production of preferred food items as forests mature.

# CHAPTER 1: ANTHROPOGENIC FEEDING OF BLACK BEARS IN VIRGINIA

## JUSTIFICATION

For years, bear hunters have provided food to bears on public and private lands in the mountains of western and southwestern Virginia, supplementing their natural food supply. Hunters maintain feeding sites for bears to keep bears in the area in which they plan to hunt; to use as a release point for hunting dogs when training or hunting (Landers et al. 1979); to create a healthier bear population; to increase the number of cubs per litter; to help fatten male bears for harvest and to help female bears survive the den season; to observe and photograph or videotape bears; and for the social aspects of spending time with family or fellow hunt club members (VBHA members, pers. comm.). The amount of food provided to bears by bear hunters in Virginia is unknown (Ryan 1997), as are the potential effects of supplementary food on black bear reproduction and morphology.

The feeding that occurs in Virginia is different from baiting, which, from a hunting standpoint, usually implies an intent to kill an animal while it is using a bait site. Baiting, which has fallen under increasing public scrutiny, has always been illegal in Virginia and has been threatened or outlawed in several states. In 1983, 29 states had a black bear hunting season. Baiting was allowed in Colorado, Idaho, Michigan, Minnesota, New Hampshire, Oregon, Utah (bowhunters only), Wisconsin, and Wyoming (Meyer 1983). Ballot initiatives in Colorado (1992), Oregon (1994), Massachusetts (1996), and Washington (1996) banned baiting as a method to hunt bears (The Detroit News 11/7/96). Michigan and Idaho voted in 1996 to continue using baiting as a method to hunt bears.

Feeding sites that are close to roads may increase chances of unwanted bear encounters with humans, such as collisions with vehicles, or stealing foods at campsites. Habituation, though not always dependent upon food conditioning (McCullough 1982), is a possible consequence of feeding and can lead to encounters dangerous to humans as well as bears. Poorly managed garbage and food at national parks has sometimes resulted in higher levels of aggression in bears (Herrerro 1983). Conversely, feeding sites may prevent bears from seeking food, and causing damage to, agricultural or residential sites (Landers et al. 1979).

Bear hunters in Virginia provide an unknown quantity of supplemental food to bears year around within and around the CABS study areas (Ryan 1997). If this supplemental food source is comparable to those in the GSMNP (Eiler 1971), where bears reached mature weights, and possibly age at primaparity, faster, it may have similar effects on black bear morphology and reproduction in Virginia.

In February 1999, the VDGIF issued a regulation recommendation (4VAC 15-40-281) that would prohibit unauthorized feeding of bears, deer, or turkeys on national forest lands and department-owned lands. The VDGIF and the United States Forest Service (USFS) reasoned that the then-current level of feeding threatened the future management of the species (bear, deer, and turkey), as well as their safe and ethical enjoyment by hunters and non-hunters alike.

On 6-7 May 1999 the VDGIF held a board meeting to discuss wildlife regulation proposals. Members of the Virginia Bear Hunters Association (VBHA) present at the meeting suggested that rather than prohibiting the use of feeding sites, the VDGIF impose restrictions on feeding sites and police their use. According to VBHA members, supplemental feeding did not cause bears to cease their natural feeding activities; however, the hunters suggested curtailing the level of feeding in November, presumably to allow female bears with cubs to enter dens naturally instead of staying active for longer periods due to the availability of supplemental food. They added that research was underway with CABS to determine the impacts of supplemental feeding on bear reproduction, and suggested that the VDGIF wait until study results were available before prohibiting feeding activities. A VBHA member stated that hunters had not abused their right to feed wildlife during the harvest (i.e., by not killing over bait), and that Virginia's healthy bear population is attributable to wise management practices, hunters, and the public input process. The Forestry Ecology Group Leader from the George Washington/Jefferson National Forest protested that wildlife feeding on national forest lands resulted in littering, road access violations, and vandalism to forest road gates and locks. He requested that the VDGIF help address these problems by prohibiting wildlife feeding on public lands.

The regulation recommendation was passed and became effective 1 July 1999. If supplemental feeding has a positive impact on bear survival and reproduction, any changes in regulations regarding feeding may negatively impact black bear populations. Originally, we intended to examine the relationship between supplemental feeding and the high reproductive and survival rates we have recorded in the Virginia black bear populations by comparing reproduction and survival in areas where feeding occurred with areas where feeding did not take place. However, since feeding on public lands became illegal, we redesigned our study to ultimately look for differences in reproductive and survival rates of bears within the CABS study areas before and after the change in feeding laws.

**Objective and Hypothesis**

1. To estimate the amount and determine the distribution of food provided annually to black bears by bear hunters in western Virginia.

- $H_o$: Feeding is evenly distributed throughout western Virginia.

**STUDY AREA**

The Cooperative Alleghany Bear Study encompasses 2 study areas in western Virginia, in the Southern Appalachian Ridge and Valley Province. The southern study area encompasses 1,544 $km^2$ of the Blacksburg and Newcastle Ranger Districts of the GWJNF in Giles, Craig, and Montgomery Counties (Fig. 1; Ryan 1997). The GWJNF lands are primarily found along the ridges, with private land fragments of mainly agricultural land in the valleys (Higgins 1997). Elevation ranges from 492 m to 1,378 m. Predominant tree species in the southern study area include white oak (*Quercus alba*), chestnut oak (*Q. prinus*), northern red oak (*Q. rubra*), black oak (*Q. velutina*), and scarlet oak (*Q. coccinea*). Other common overstory species include pignut hickory (*Carya glabra*), bitternut hickory (*C. cordiformis*), red maple (*Acer rubrum*), pitch pine (*Pinus rigida*), eastern white pine (*P. strobus*), and table mountain pine (*P. pungens*) (Higgins 1997, Ryan 1997).

The northern study area encompasses 840 $km^2$ of the Dry River and Deerfield Ranger Districts of the George Washington and Jefferson National Forests (GWJNF) in western Rockingham and Augusta Counties (Fig. 1; Godfrey 1996). Elevation ranges from 488 m to 1,360 m, and annual rainfall averages 86 cm, and annual snowfall averages 71 cm (Godfrey 1996, Higgins 1997, Echols 2000). National forest lands in the northern study area are not as fragmented as those in the southern study area. Important tree species include eastern hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), yellow birch (*Betula allegheniensis*), chestnut oak, pitch pine, white oak, black oak, northern red oak, yellow poplar (*Liriodendron tulipifera*), and eastern white pine (Godfrey 1996, Higgins 1997).

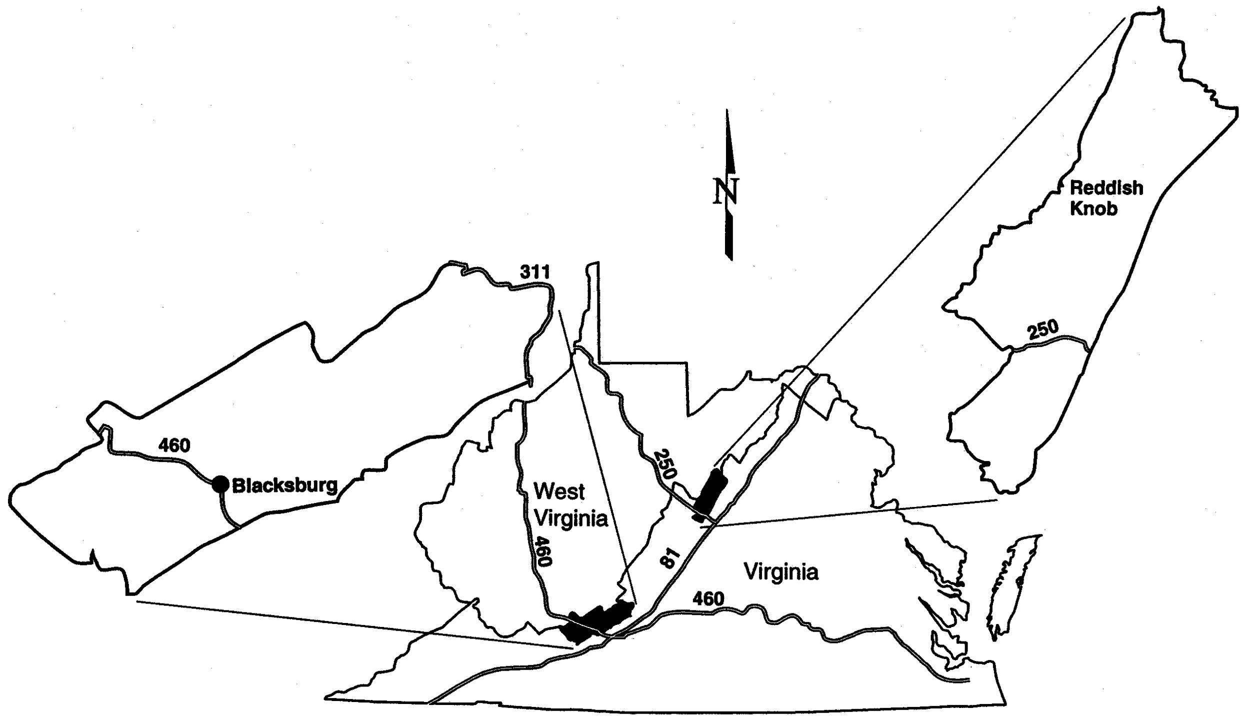


Figure 1. Northwest and southwest study areas of the Cooperative Alleghany Bear Study, Virginia.

## METHODS

### Feeding Survey

I sent a survey to all members of the VBHA (*n* = 486) requesting information on numerous aspects of feeding (Appendix 20). The survey was created with Survey Pro software (V. 2.0, Apian Software), and was designed to collect both quantitative and qualitative data relating to feeding bears. Questions were designed to determine the types of foods offered to bears, the frequency of feeding, the average amount of food placed at each feeding site, an estimate of the total number and general distribution of feeding sites in Virginia, opinions about the effects of feeding on bears as well as on public image, and response to the change in legislation which made it illegal to feed wildlife on public land beginning 1 July 1999. The VBHA was chosen as the target audience because, after discussion with its officers, we believed this group to include most people who fed bears in Virginia.

Early survey drafts were reviewed by 7 VDGIF employees, and 2 faculty members and 2 students in the Department of Fisheries and Wildlife Sciences, VPI & SU. We pre-tested the revised survey draft on the officers of the VBHA, and later met with them to discuss ways to improve the survey, clarify unclear questions, identify relevant overlooked topics, and facilitate its completion.

I administered the survey using a modified version of Dillman's (1978) total design method. Survey packets (cover letter, survey, and self-addressed, stamped return envelope) were mailed to all members of the VBHA on 28 October 1999 (Appendices 1, 20). A reminder postcard was mailed on 17 November 1999 to thank those who had already responded, and to ask those who had not yet responded to please complete and return their surveys (Appendix 2). A second survey packet with a revised cover letter (Appendix 3) was mailed on 8 December 1999 to all VBHA members who had not returned their surveys (*n* =297, 61.1%).

### Determination of Total Food Estimate

Survey respondents were asked to report which food items they fed and how often they fed those items. For the foods they fed frequently (at least twice per month or more often), they were asked to describe in pounds or 5-gallon buckets the average amount of food they provided each time they fed. Since many hunters used 5-gallon buckets to transport food to feeding stations, we believed that they would find it easier to answer in terms of number of buckets rather than in weight of the food. I converted bucket answer choices in the following way: less than 1 bucket = 0.5; 1–2 buckets = 1.5; 3–4 buckets = 3.5; 5-6 buckets = 5.5; 7-8 buckets = 7.5; and more than 8 buckets = 8.5. I weighed 3+ buckets (depending on variability) of each food type and averaged their weights to determine the mean weight in kilograms of 1 5-gallon bucket of each food type. I converted answer choices for amounts of food reported in pounds in the following way: less than 25 pounds = 12.5; 26–50 pounds = 38; 51–75 pounds = 63; 76–100 pounds = 88; and greater than 100 pounds = 100. Answers were divided by 2.2 to convert pounds into kilograms.

I converted answer choices on the survey for how often different food types were fed into days per month in the following way: everyday = 30; 2-3 days per week = 10; once per week = 4; and once every 2 weeks = 2. I did not ask respondents to report weights of foods that they fed less frequently than once every 2 weeks, therefore these were not included in the total food estimate.

For each respondent, the amount of food put out/site was multiplied by the days per month each food type was fed, the number of feeding sites stocked regularly, and the number of months per year feeding occurred. Food amounts for all respondents were added together to get the total annual food estimate. In addition, each food type was tallied separately, and the average amount of food per person and per county was determined.

**Opinions**

I used a Likert scale to determine how strongly VBHA members felt about several statements regarding feeding supplemental food to bears (Appendix 20, questions 24-45). Answer choices were scored as follows: strongly agree (SA) = 1, agree (A) = 2, neutral (N) = 3, disagree (D) = 4, and strongly disagree (SD) = 5. 'Strongly agree' and 'agree' were later collapsed into 1 category for analysis labeled 'agree'; 'strongly disagree' and 'disagree' were collapsed into 1 category labeled 'disagree'. Importance of feeding site characteristics was scored as follows: not at all important = 1, somewhat important = 2, and very important = 3 (Appendix 20, questions 46-60).

**Non-response Bias**

In April 2000 I randomly selected VBHA members who had not returned their surveys as a sample of nonrespondents to be compared with those who had returned their surveys to determine whether a non-response bias existed. I contacted 29 nonrespondents by telephone and asked them 14 selected questions from the original survey (Appendix 21). In addition, 2 VBHA members mailed in their completed questionnaires in late March and April 2000 after being provided with a third survey at a VBHA meeting on 25 March 2000. These I included with the nonrespondent follow-up survey responses. I used t-tests, Fisher's Exact Test, and chi-square analysis ($\alpha = 0.05$) to compare responses from the first and second survey mailings, and responses from the combined survey mailings and the follow-up telephone survey.

## RESULTS

### Response Rate

Twenty-seven of the original 486 survey packets were undeliverable and were returned-to-sender, reducing the effective sample size to 459. I received 179 (39.0%) surveys from the initial mailing and 59 surveys from the second mailing, totaling 238 (51.9%) completed responses.

### Hunter Effort and Success

Most (94.7%) respondents indicated they hunt bears; 5.3% do not. Respondents had hunted bears an average of 24.1 years (Fig. 2). Respondents spent an average of 5.5 more days hunting bears with dogs during the 1998 harvest season ($n = 210$) than during the training (chase only) season ($n = 207$; $t = 6.83$; $P < 0.001$). Respondents hunted with dogs an average of 40.7% of 29 available days during the training season ($n = 207$) and 48.1% of 36 available days during the harvest season ($n = 210$; $t = 2.93$; $P = 0.004$) (Table 1). Hunters who hunted at least one day hunted an average of 46.9% of available days during the training season ($n = 179$) and 51.1% during the harvest season ($n = 197$; $t = 1.79$; $P = 0.074$). Respondents averaged 12.7 bears chased and 8.3 bears treed during the harvest season, and 9.8 bears chased and 6.3 bears treed during the training season (Table 2). Catch (number of bears treed) per unit effort (day of hunting) was not significantly higher during the chase season (0.52; $n = 176$) than during the harvest season (0.49; $n = 192$; $P = 0.354$), and did not differ by number of days hunted for bear hound training ($F = 0.49$; $P = 0.783$) or harvest ($F = 0.48$; $P = 0.788$) seasons (Tables 2, 3). Hunters treed 60.3% of bears chased during the training season ($n = 174$ respondents), and 62.2% of bears chased during the harvest season ($n = 187$ respondents) ($P = 0.470$). Nine percent of respondents who hunted bears with dogs in 1998 ($n = 211$) harvested a bear that year.

Bear hunting effort without the use of hounds during the 1998 general firearms season and during the 1998 archery season was substantially less than with hounds among VBHA members (Table 1). Only 11.5% of 209 respondents hunted bears without dogs during the big game firearms season; they averaged 7.8 of 36 possible days hunting. Including respondents who reported hunting bears 0 days, the average number of days spent hunting bears without hounds during the big game firearms season was only 0.9. One respondent harvested a bear during this time. During the 1998 archery season, 4.9% of 104 respondents hunted bears for an average of 7.7 of 25 possible days. No respondents harvested a bear during the 1998 archery season (Table 1).

Table 1. Results of a survey of Virginia Bear Hunters Association members showing average bear hunter effort and success by hunting season in Virginia, 1998.

| Season | Total available days | All respondents | | Respondents who hunted >0 days | | | | | $n^a$ | $CPUE^b$ | Total bears harvested |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | Days hunted | n | Days hunted | Bears chased | Bears treed | Bears seen | | | |
| Bear hound training | 29 | 207 | 11.8 | 179 | 13.6 | 9.8 | 6.3 | N/A | 176 | 51.8 | N/A |
| General firearms (with hounds) | 36 | 210 | 17.3 | 197 | 18.4 | 12.7 | 8.3 | N/A | 192 | 48.6 | 19 |
| General firearms (no hounds) | 36 | 209 | 0.9 | 24 | 7.8 | N/A | N/A | 2.1 | 24 | 18.3 | 1 |
| Archery | 25 | 104 | 0.4 | 10 | 7.7 | N/A | N/A | 2.3 | 10 | 37.9 | 0 |

Note: also includes data from Greene and Madison counties, whose hunting season with dogs was 30 days rather than 36 days.

[a] Respondents who answered both questions applicable to determining catch per unit effort (CPUE)

[b] Catch (bears treed) per unit effort (day of hunting)

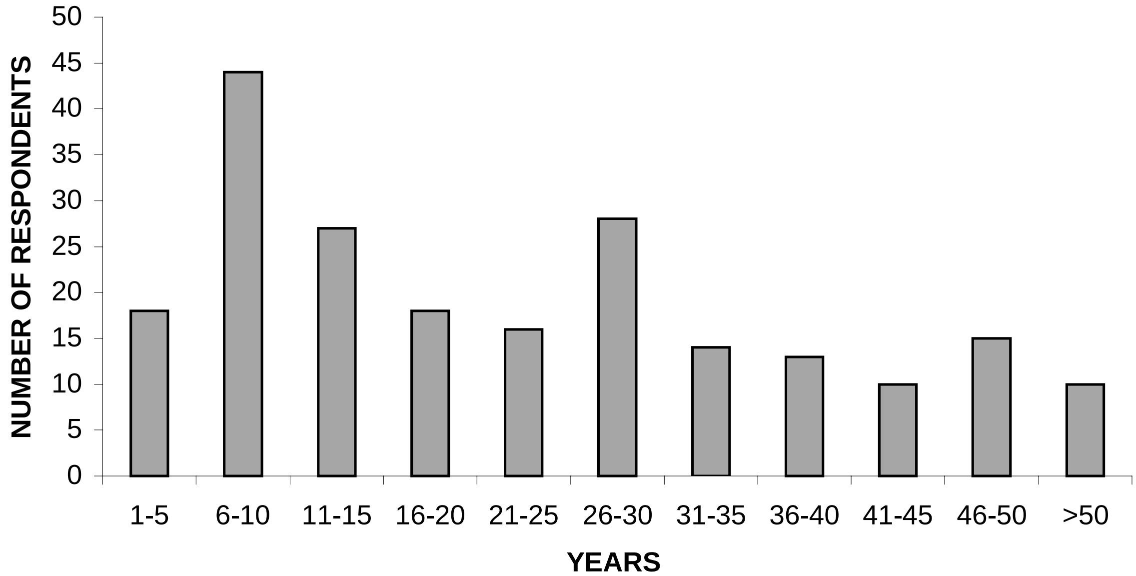


Figure 2.  Results of a survey of Virginia Bear Hunters Association members showing number of years survey respondents have hunted bears, Virginia, 1998 (Mean = 24.1).

Table 2. Catch per unit effort (CPUE) of bear hunters hunting with dogs during the bear hound training season, Virginia, 1998.

| Day categories | Training season hunters | Average number of bears treed training season | CPUE training season |
|---|---|---|---|
| 0 | 28 | 0 | N/A |
| 1-5 | 27 | 1.7 | 0.47 |
| 6-10 | 46 | 4.6 | 0.49 |
| 11-15 | 43 | 8 | 0.58 |
| 16-20 | 41 | 9.8 | 0.50 |
| 21-25 | 15 | 12.7 | 0.53 |
| >25 | 7 | 14.4 | 0.50 |

Table 3. Catch per unit effort (CPUE) of bear hunters hunting with dogs during the general firearms season, Virginia, 1998.

| Day categories | Hunting season hunters | Average number of bears treed hunting season | CPUE hunting season |
|---|---|---|---|
| 0 | 13 | 0 | N/A |
| 1-5 | 11 | 1.6 | 0.42 |
| 6-10 | 20 | 4 | 0.50 |
| 11-15 | 39 | 7.7 | 0.54 |
| 16-20 | 64 | 8.9 | 0.46 |
| 21-25 | 36 | 11.9 | 0.51 |
| >25 | 27 | 13.1 | 0.44 |

## Hunters' Opinions of Feeding Bears

Survey respondents predictably agreed with most positive statements and disagreed with most negative statements about feeding bears. Hunters felt most strongly that feeding helps bears in years of mast crop failure (1.38; Table 4). The vast majority of VBHA members felt that feeding benefits reproduction, survival, and opportunities for recreation. Likewise, >75% of respondents disagreed that feeding contributes to nuisance problems or makes bears dependent on artificial food. VBHA members were neutral about the effects of feeding bears on their public image, occurrence of littering, crop damage, and hunting success (Table 4).

## Importance of Feeding Site Characteristics

VBHA members did not consider any of the feeding site characteristics listed on the survey as very important (Appendix 20, questions 46-60). The most important feeding site characteristic was 'other' (2.59), which included characteristics supplied by the respondents in a fill-in-the-blank space (conveniently close to home, time investment, unpaved roads, away from major roads, good hunting areas, good habitat areas, evidence of sow and cub sign, rocks and cliffs), followed by 'far away from people traffic' (2.51). The least important feeding site characteristic listed in the survey was 'open tree canopy' (1.23; Table 5).

## Location of Feeding Sites

One hundred thirty-six (60.2%) respondents fed bears between 1 July 1998 and 30 June 1999. Half of respondents who fed bears fed on both public and private lands, while nearly equal numbers fed on public land only (25.8%) or on private land only (24.2%) (Fig. 3). Of the respondents who fed on both public and private land, 55.4% fed more on public land than on private land, and 44.6% fed more on private land than on public land (Fig. 4).

Table 4. Virginia Bear Hunters Association members' opinions on the effects of feeding bears in Virginia, 1999.

| Supplemental feeding of bears... | *n*[a] | Mean score[b] | A[c] | N | D[d] |
|---|---|---|---|---|---|
| ...helps bears in years of mast crop failure. | 160 | 1.38 | 94.4 | 1.9 | 3.7 |
| ...creates a healthier bear population. | 159 | 1.48 | 88.0 | 9.4 | 2.5 |
| ...results in more chases in training season. | 159 | 1.64 | 88.6 | 5.0 | 6.3 |
| ...increases reproduction. | 160 | 1.70 | 81.3 | 15.6 | 3.1 |
| ...increases survival. | 158 | 1.72 | 82.9 | 11.4 | 5.7 |
| ...increases population levels. | 160 | 1.76 | 82.5 | 12.5 | 5.0 |
| ...keeps bears in the area. | 159 | 1.77 | 86.8 | 8.2 | 5.0 |
| ...increases the chance of viewing bears. | 159 | 1.92 | 82.4 | 7.5 | 10.1 |
| ...results in bigger bears. | 157 | 1.97 | 73.3 | 19.7 | 7.0 |
| ...increases bowhunters' success. | 153 | 2.10 | 64.1 | 20.9 | 15.1 |
| ...reduces crop damage. | 159 | 2.12 | 71.1 | 20.8 | 8.1 |
| ...results in more chases in hunting season. | 156 | 2.17 | 68.2 | 14.6 | 17.2 |
| ...concentrates bears in certain areas. | 158 | 2.53 | 59.5 | 19.6 | 20.9 |
| ...gives bear hunters a good image to other hunters and non-hunters. | 159 | 2.81 | 33.4 | 42.1 | 24.5 |
| ...creates a negative public image. | 159 | 3.40 | 17.6 | 38.4 | 44.0 |
| ...makes bears less afraid of people. | 155 | 3.72 | 14.9 | 17.4 | 67.7 |
| ...results in littering. | 157 | 3.75 | 16.6 | 17.8 | 65.6 |
| ...increases chance of bear/vehicle collisions. | 159 | 3.86 | 13.2 | 13.2 | 73.6 |
| ...increases danger to campers. | 159 | 3.98 | 6.3 | 16.4 | 77.3 |
| ...creates nuisance bears. | 158 | 4.01 | 9.5 | 13.3 | 77.2 |
| ...makes bears dependent on artificial food. | 158 | 4.03 | 7.6 | 12.7 | 79.8 |
| ...causes disease problems for bears and/or other wildlife. | 160 | 4.19 | 1.8 | 17.5 | 80.7 |

[a] Number of respondents for each answer choice.
[b] Strongly agreed = 1; agreed = 2; neutral = 3; disagreed = 4; strongly disagreed = 5.
[c] Percentage of respondents who chose strongly agreed or agreed (A).
[d] Percentage of respondents who chose disagreed or strongly disagreed (D).

Table 5. Percent responses to importance of various feeding site characteristics to Virginia Bear Hunters Association members, Virginia 1999.

| Site characteristic | *n* | Mean importance score[a] | Not at all | Somewhat | Very |
|---|---|---|---|---|---|
| Other[b] | 13 | 2.59 | 15.4 | 7.7 | 76.9 |
| Far away from people traffic | 134 | 2.51 | 9.7 | 29.9 | 60.4 |
| Previous success at that site | 130 | 2.31 | 13.8 | 41.5 | 44.6 |
| Saw bear sign there | 133 | 2.17 | 23.3 | 36.8 | 39.8 |
| Distance from other feed stations | 126 | 2.13 | 20.6 | 46.0 | 33.3 |
| Thick underbrush | 127 | 2.11 | 26.8 | 35.4 | 37.8 |
| Tradition (someone fed there previously) | 122 | 1.92 | 32.8 | 42.6 | 24.6 |
| Easy access to vehicle | 137 | 1.83 | 29.9 | 56.9 | 13.1 |
| Saw a bear there | 127 | 1.82 | 46.5 | 25.2 | 28.3 |
| Ridgetop | 125 | 1.70 | 49.6 | 31.2 | 19.2 |
| Closed tree canopy | 108 | 1.70 | 51.9 | 25.9 | 22.2 |
| Hollow/drainage | 115 | 1.43 | 65.2 | 27.0 | 7.8 |
| Thin underbrush | 119 | 1.32 | 70.6 | 26.9 | 2.5 |
| Open tree canopy | 108 | 1.23 | 77.8 | 21.3 | 0.9 |

[a] 1 = not at all important; 2 = somewhat important; 3 = very important
[b] conveniently close to home, time investment, unpaved roads, away from major roads, good hunting areas, good habitat areas, evidence of sow and cub sign, rocks and cliffs

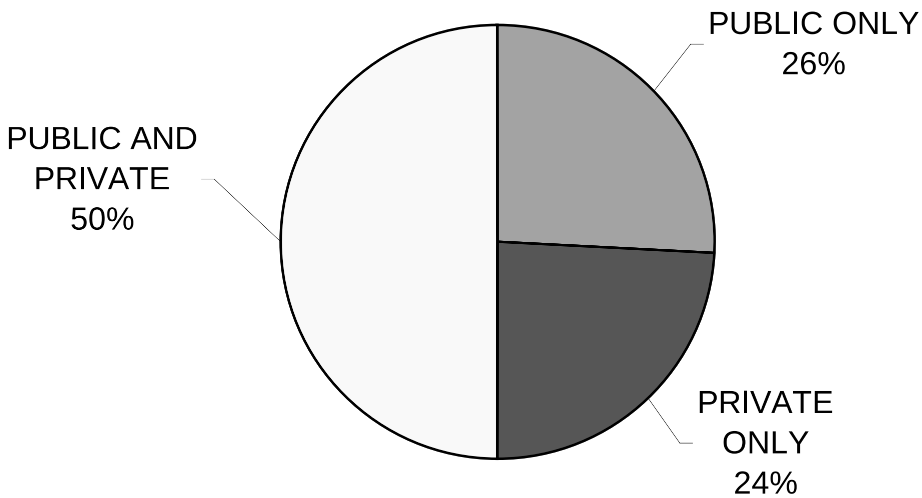


Figure 3. Distribution of black bear feeding effort on public and private lands in Virginia by Virginia Bear Hunters Association members between 1 July 1998 and 30 June 1999.

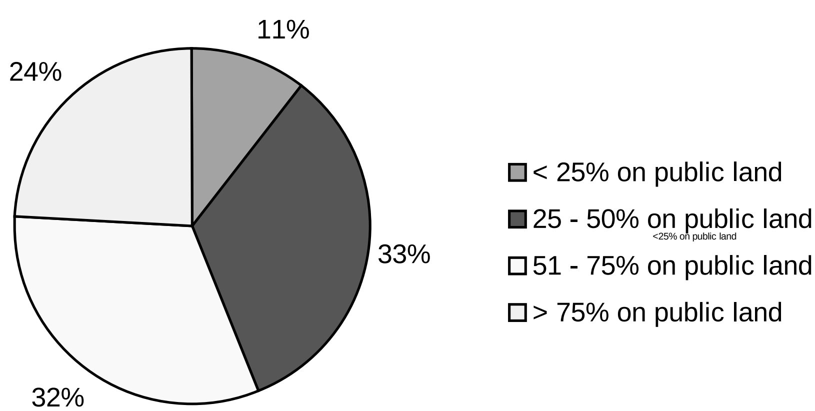


Figure 4. Percent of feeding on public land by Virginia Bear Hunters Association members who fed bears on both public and private lands in Virginia between 1 July 1998 and 30 June 1999

Table 6. Amount of supplemental food provided (kg) and number of hunters (*n*) who provided food to bears, 1 July 1998 and 30 June 1999, Virginia.

| | FOOD TYPE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Shelled corn** | **Pastries** | **Grease/ lard** | **Apples** | **Bread** | **Sweet feed corn** | **ham** | **Livestock feed** | **Cracked corn** | **Other** | **Meat scraps** | **Cob corn** | **Poultry feed** | **Animal carcasses** | **Total** |
| **As-fed weight** | 686,386 | 624,664 | 390,707 | 323,950 | 265,800 | 164,569 | 126,415 | 133,127 | 67,293 | 47,490+ | 46,021 | 42,275 | 23,035 | 662 | 2,942,394 |
| ***n*** | 70 | 102 | 62 | 31 | 73 | 28 | 7 | 16 | 9 | 28 | 15 | 8 | 3 | 4 | 128 |

**Feeding Expenditure**

One hundred thirteen (47.5%) of 238 respondents spent $18,378.00 on supplemental food for bears between 1 July 1998 and 30 June 1999; the average amount/person was $162.64 and the median was $100.00. This value includes 55 respondents who did not feed bears directly, but who donated money to a group, such as a hunt club, for the purpose of feeding bears. The largest amount of money spent by an individual on supplemental food in 1 year was $1,040.00. Two other individuals spent $1,000.00 each. Nine people indicated they fed bears but spent no money on food; the next smallest feeding expenditure reported was $5.00 ($n$ = 2). Most respondents spent $76.00 - $100.00 (Fig. 5).

**Feeding Sites**

Eighty-one of 130 respondents (62.3%) shared their feeding routes with a group of people; 49 (37.7%) did not ($\chi^2$ = 130.0; $P < 0.001$). Forty-one (51.3%) respondents shared their feeding routes only with other VBHA members. The remaining 39 respondents (48.8%) shared their routes with an average of 2.1 non-VBHA members. Eighty-eight respondents (63.8%) knew of at least 1 non-VBHA member who did not share their feeding routes, but fed bears.

The mean number of feeding sites stocked regularly by VBHA respondents ($n$ = 126) was 4.1. Number of sites/individual ranged from 0 ($n$ = 3) to 11 ($n$ = 3). The most common number of sites stocked regularly was 3 ($n$ = 27, 21.4%) (Fig. 6). Distances between feeding stations on public land were similar to distances between feeding stations on private land ($\chi^2$ = 8.75; $P$ = 0.068); the most frequent distribution of distance-between-feeding-site categories was '>1 mile apart' (Fig. 7). Rarely were distances between feeding sites <¼ mile apart on public land (5.4%).

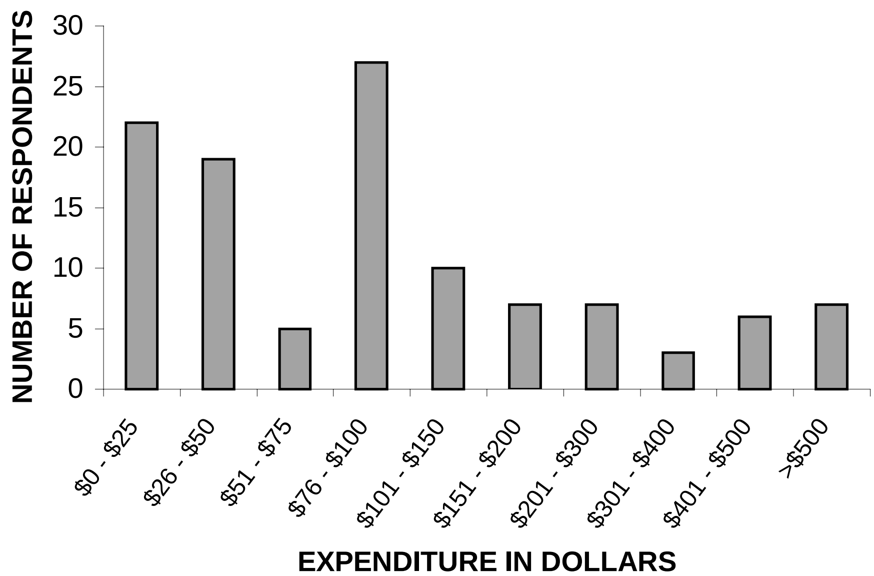


Figure 5. Feeding expenditures by survey respondents in Virginia who fed bears between 1 July 1998 and 30 June 1999 ($n$ = 113; mean = $162.64; median = $100.00).

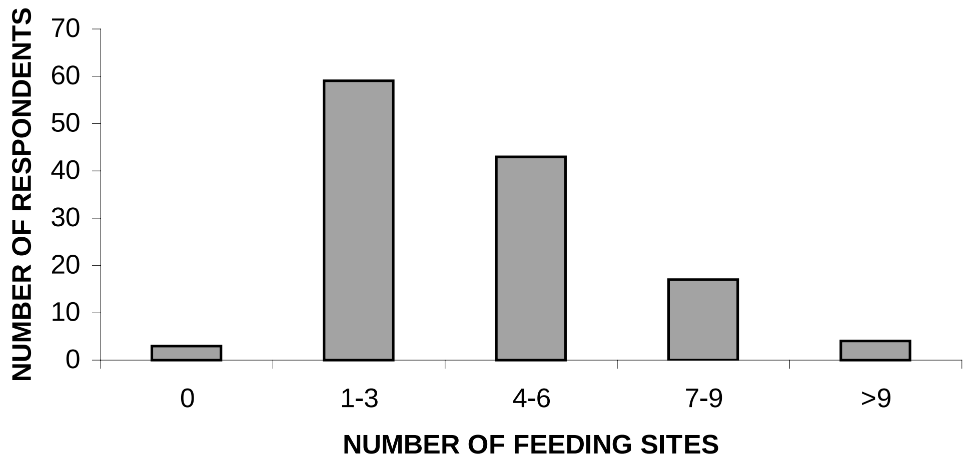


Figure 6. Number of black bear feeding sites/individual stocked regularly by Virginia Bear Hunters Association members between 1 July 1998 and 30 June 1999, Virginia. (Mean = 4.1)

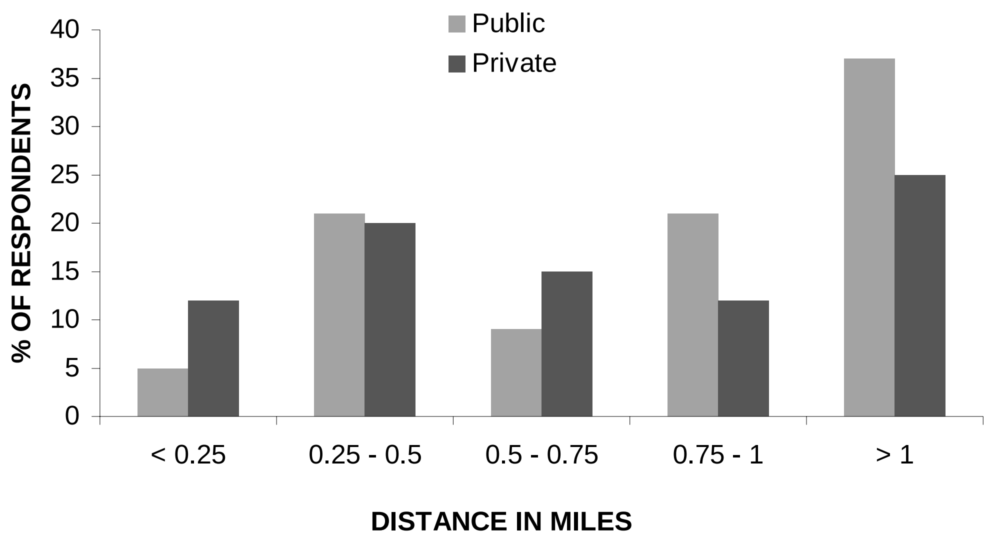


Figure 7. Average distances between black bear feeding sites on public and private lands in Virginia between 1 July 1998 and 30 June 1999.

**Temporal Distribution of Feeding**

Most feeding occurred in July (80.9%), August (90.8%), and September (89.3%) (Fig. 8). Only 35.1% of respondents fed bears in December, during the general firearms season when hunting with hounds is legal. Hunters that fed bears >3 months/year fed mostly during July (54.8%), August (71.8%), and September (66.9%) as well.

Thirty-eight of 133 (28.6%) respondents placed different types of food out at different times of year. The primary reason for feeding different food types at different times of year was availability of the food items (64.1%), followed by preference of the bears (43.6%), cost (20.5%), to help bears gain weight after winter (2.6%), and other reasons (2.6%), not all of which were stated.

**Restocking Feeding Sites**

The average maximum number of days/month feeding sites were stocked with at least 1 food type was 13; average visitation was 9 days/month to restock all food types ($n$ = 130). Based on a feeding schedule of 4 feeding sites regularly stocked 9 days/month, respondents provided an average of 53 kg of food per feeding site per day of feeding. The decision to restock a feeding site usually occurred when no old food was remaining (46.2%), however, 41.7% of 132 respondents restocked their feeding sites whenever they visited the site, regardless of how much food remained from previous visits (Fig. 9). One hundred twelve respondents (84.2%) reported that more than three-fourths of the food from the previous visit to that site was usually eaten by the time they returned to that site. Six percent of respondents stated that less than a quarter of the food from the previous visit was usually consumed by the time they returned to that feeding site (Fig. 10). Forty-seven (83.9%) of the 55 respondents who put food out at each visit to their feeding sites, regardless of how much food was remaining from the previous visit, stated that greater than three-fourths of the old food was usually consumed by the time they returned to their sites (Fig. 11).

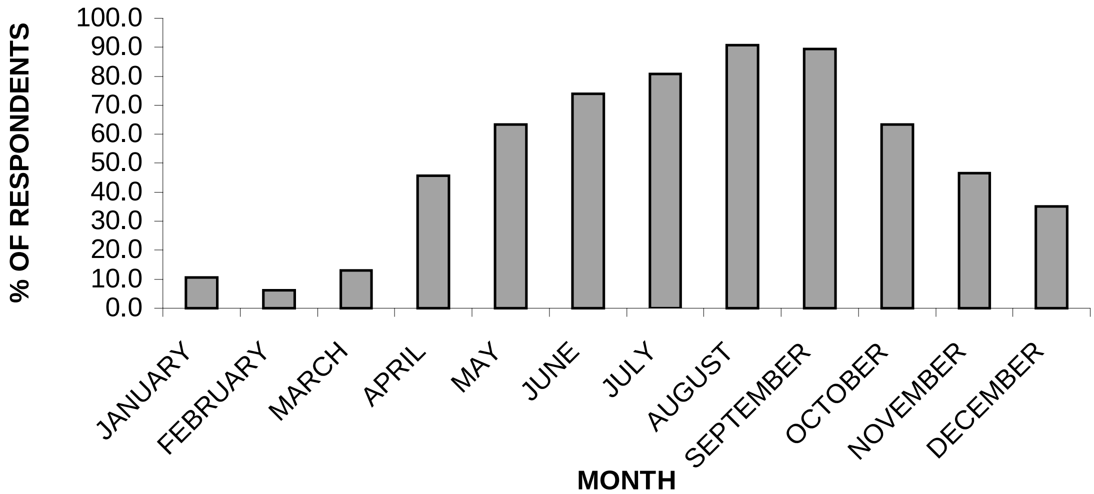


Figure 8. Annual pattern of feeding by Virginia Bear Hunters Association members who fed black bears in Virginia between 1 July 1998 and 30 June 1999.

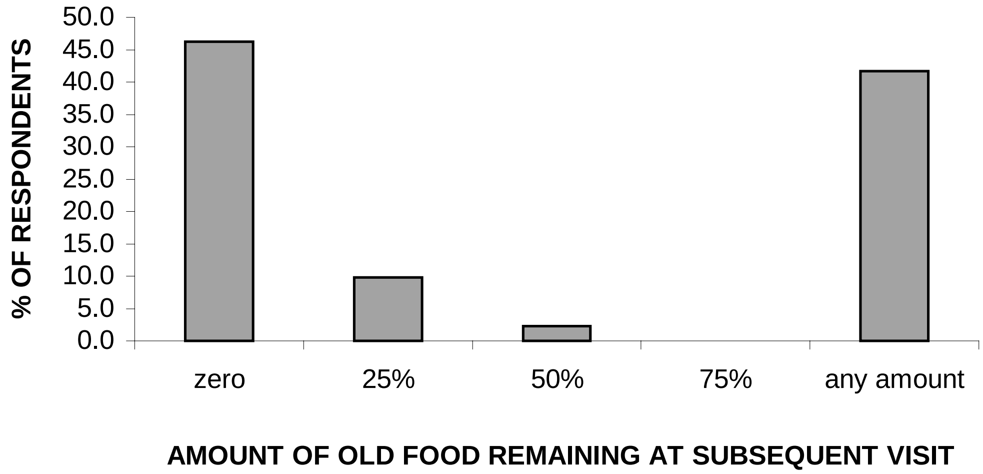


Figure 9. Amount of old food remaining when Virginia Bear Hunters Association members restocked black bear feeding sites in Virginia, 1 July 1998 to 30 June 1999 ($n$ = 132).

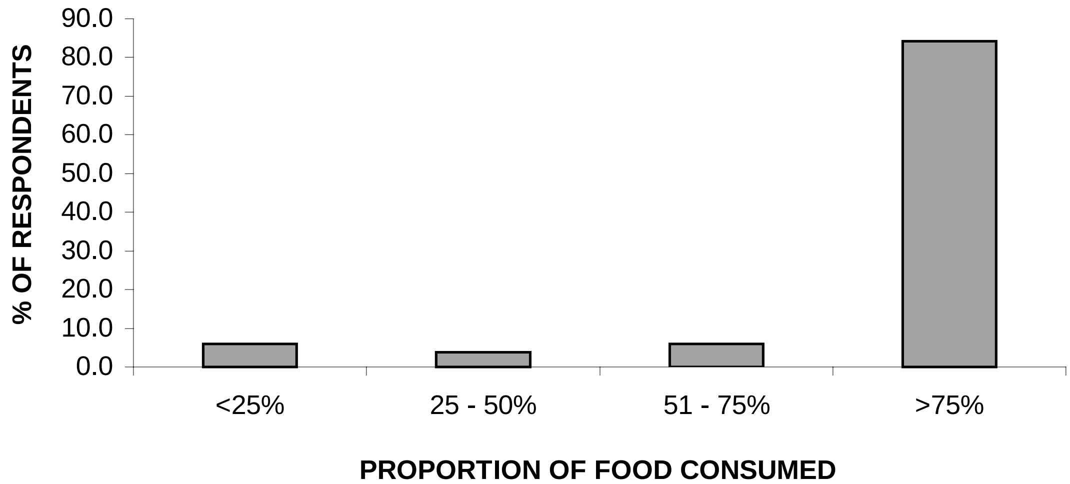


Figure 10. Proportion of food usually consumed at black bear feeding sites in Virginia by the time Virginia Bear Hunters Association members returned to restock, 1 July 1998 to 30 June 1999 (*n* = 133).

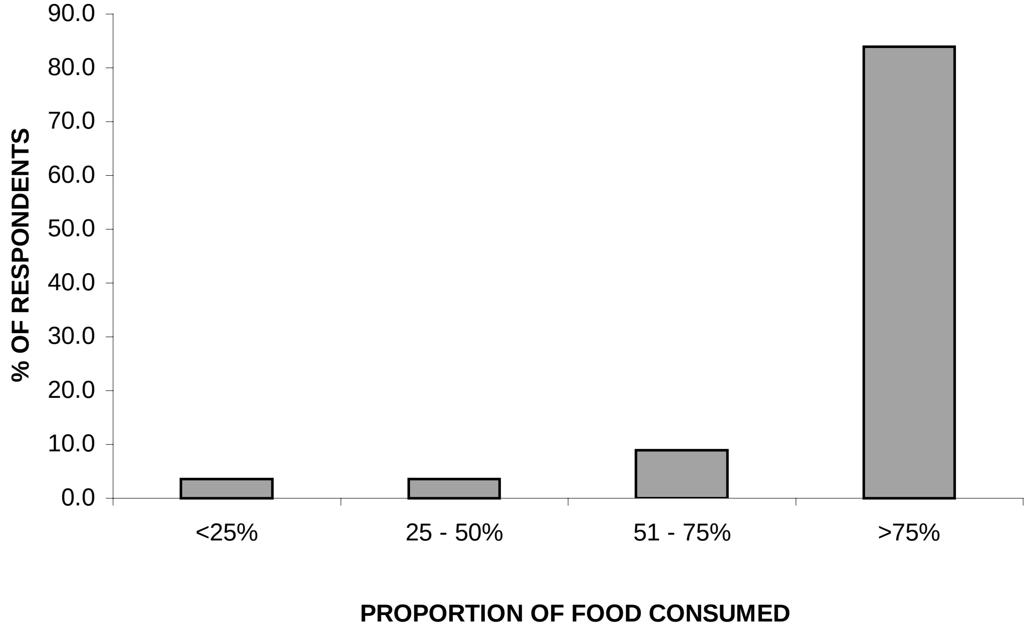


Figure 11. Proportion of food usually consumed at supplemental feeding sites in Virginia before subsequent visits to the site, for Virginia Bear Hunters Association members who restocked their sites at each visit, regardless of how much food was left, 1 July 1998-30 June 1999 (*n* = 56).

Sixty-one percent of 77 respondents believed that supplemental food was consumed at different rates throughout the year, whereas 14.3% did not believe that consumption rate varied; 24.7% were unsure. However, more people answered this question (*n* = 77) than the number who actually fed all 12 months of the year (*n* = 4).

**Amount of Food Provided**

One hundred twenty-eight hunters reported feeding 2,942,394 kg of food to bears between 1 July 1998 and 30 June 1999, averaging 22,987 kg/person; the median amount of food provided by an individual was 6,232 kg/year. Twelve respondents reported feeding over 50,000 kg of food each (2 only on private land, 2 only on public land, and 8 on both public and private land), including one outlier who reported feeding an unlikely 19.6% (577,579 kg) of the total. Excluding these 12, the mean amount of food provided by an individual was 10,437 kg/year, or 63 kg food/person/day. Shelled corn (23.3%), pastries (21.2%), and grease (13.3%) were the 3 most commonly fed foods by weight, and accounted for 57.8% of the total yearly amount of food provided (Table 6). However, bread, which accounted for only 9.0% of the total food weight, was fed by 7.8% more people than grease, which accounted for 13.3% of the total food weight. Dry weights, which would have made the weights of all food types comparable, were not determined. Twenty-eight respondents (21.9%) fed foods to bears that were not listed on the survey, including dog food, honey, peanut butter, molasses, syrup, baked chickens, caramel, sorghum, peaches and pears, cantaloupes, tomatoes, watermelons, and strawberry daquiri mix. Two respondents who frequently fed other food types not listed on the survey did not report what they were. The weights of the 'other' category for those who fed in 5-gallon buckets were not converted to pounds and are therefore not included in the total estimate.

**Distribution of Food by County**

Survey respondents fed bears in 25 of 95 counties in Virginia, mostly in the mountainous western and southwestern portions of the state. Forth-seven percent of all respondents (*n* = 121) who reported food amounts provided to bears between 1 July 1998 and 30 June 1999 and reported the counties in which they fed bears, fed in Rockingham County. Accordingly, nearly half of the total food by weight (41.7%) was distributed in Rockingham County. Following Rockingham County in proportion of respondents who fed bears by county were Giles (14.9%), Augusta (14.1%), Craig (9.1%), and Montgomery (9.1%) counties. Following Rockingham County in proportion of food distributed by county were Craig (8.3%), Giles (6.7%), Montgomery (6.2%), and Tazewell (5.5%) (Fig. 12). Pulaski County was the only county that received a higher percentage of food than it had feeders, due to 1 respondent who reported feeding a disproportionately large amount of food. Eight respondents reported feeding over 90,000 kg of food to bears in 1 year. Food from 8 respondents (not included in Fig. 12) who reported feeding bears, but did not specify in which counties they fed, totaled 9,144 kg.

**Evidence of Other Animals**

Most respondents (77.4% of 133) reported evidence that animals other than bears consumed food from their feeding sites. Fourteen species other than bears reportedly used black bear feeding sites; squirrels, raccoons, and ravens were the 3 animals most commonly reported to have used feeding sites (Table 7). Tracks (79.8%) and sightings (68.3%) were the 2 most common forms of evidence that animals other than bears had visited feeding sites (Table 8).

**Response to New Feeding Regulation**

Respondents were asked how the regulation (4 VAC 15-40-281), which made feeding wildlife on public lands illegal after 30 June 1999, would affect their feeding efforts on private land (Appendix 20, question 129). The majority (50.4%) of 141 respondents who answered this question reported they would continue feeding the same amount as before on private land, whereas 24.8% would cease feeding altogether, 22.7% would increase the amount of feeding on private land, and 2.1% would decrease the amount of feeding on private land (Table 9). These numbers included 18 people who did not feed bears between 1 July 1998 and 30 June 1999 and were therefore instructed not to answer this question, but did so anyway. Similar trends existed when these 18 respondents were left out of the analysis. I did not ask respondents about their future feeding activities on *public* land (this would have been incriminating, and results would likely have been biased), though several indicated in the comments section that they would ignore the new law and continue to feed on public land.

Table 7. Percent of Virginia Bear Hunters Association members who knew of animals other than bears that used black bear feeding sites in Virginia between 1 July 1998 and 30 June 1999 (*n* = 104 respondents).

| Animal | Percent |
|---|---|
| Raccoon | 90.4 |
| Squirrel | 52.9 |
| Raven | 42.3 |
| Deer | 34.6 |
| Fox | 29.8 |
| Turkey | 25.0 |
| Bobcat | 25.0 |
| Coyote | 22.1 |
| Possum | 3.8 |
| Crow | 2.9 |
| Mice | 1.9 |
| Skunk | 1.9 |
| Chipmunk | 1.0 |
| Songbirds | 1.0 |

Table 8. Percent of Virginia Bear Hunters Association Members who saw evidence of animals other than bears using black bear feeding sites in Virginia between 1 July 1998 and 30 June 1999 (*n* = 104 respondents).

| Evidence | Percent |
|---|---|
| Tracks | 79.8 |
| Sightings | 68.3 |
| Droppings | 49.0 |
| Claw marks | 9.6 |
| Other | 3.8 |

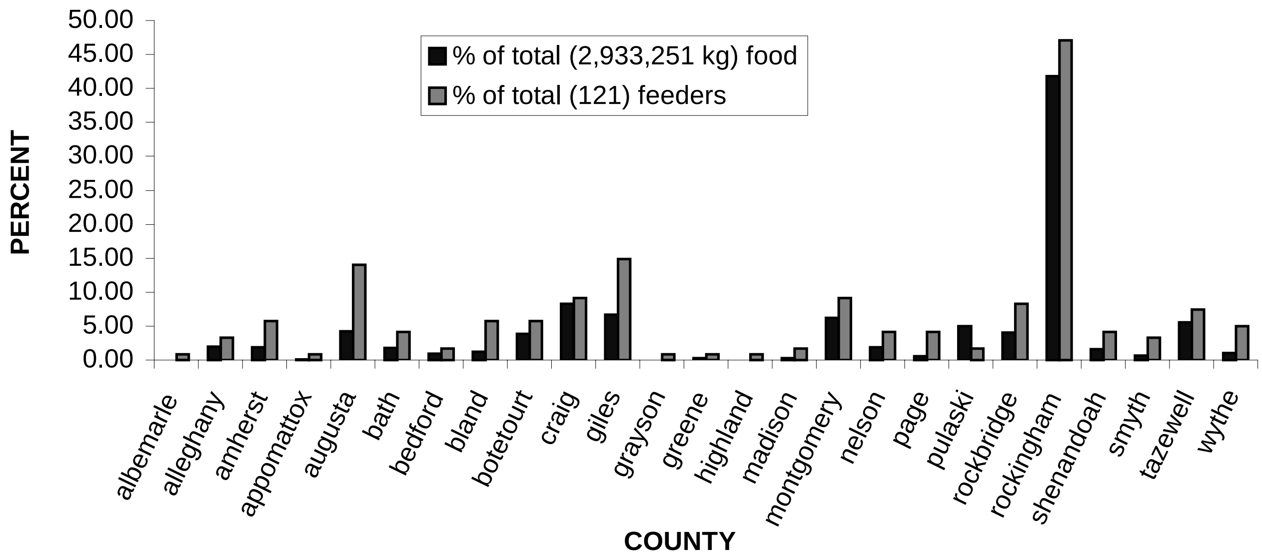


Figure 12. Percentages of respondents who fed bears and amount of food provided to bears per county in Virginia between 1 July 1998 and 30 June 1999.

Table 9. Response of Virginia bear hunters to feeding regulation 4 VAC 15-40-281 which made the feeding of bears, deer, and turkey illegal on public land, 1999.

| Response to law | Land type on which feeding occurred | | | | Percent feeding on public land of those who fed on both public and private lands | | | | | Did not feed[a] | totals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | unknown | Public only | Private only | Public and private | unknown | <25% | 26-50% | 51-75% | >75% | | |
| Cease feeding | 0 | 24 | 1 | 3 | 0 | 0 | 0 | 2 | 1 | 7 | **35** |
| Increase feeding on private land | 1 | 2 | 5 | 18 | 0 | 1 | 7 | 7 | 3 | 6 | **32** |
| Decrease feeding on private land | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 1 | **3** |
| No change on private land | 0 | 4[b] | 22 | 41 | 1 | 6 | 13 | 11 | 10 | 4 | **71** |
| No answer | 1[c] | 4 | 4 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | **11** |
| **Totals** | **2** | **34** | **32** | **66** | 1 | 7 | 22 | 21 | 15 | **18** | **152** |

[a] Respondents who did not feed bears between 1 July 1998 and 30 June 1999, but who reported how they would respond to the feeding law, despite a lack of instructions to do so.
[b] Respondents who did not feed on private land between 1 July 1998 and 30 June 1999, but said they would continue to feed the same amount as before on private land in response to the change in feeding laws.
[c] Respondent who fed bears but did not answer where feeding occurred or what his response to the law would be.

**Non-response Bias**

The number of days spent hunting bears with dogs during the 1998 bear hound training season did not differ between respondents from the first and second mailings ($t$ = 1.08, $P$ = 0.281), or between respondents and nonrespondents ($t$ = 0.87, $P$ = 0.392). Nor did the number of days spent hunting during the 1998 general firearms season differ between respondents from the first and second mailings ($t$ = 1.30, $P$ = 0.199) or respondents and nonrespondents ($t$ = 0.80, $P$ = 0.430). The number of days spent hunting bears without dogs during the 1998 general firearms season did not differ between respondents from the first and second mailings, however, mail respondents spent more days hunting bears without dogs (1.18 days) than nonrespondents (0.13 days; $t$ = 2.78, $P$ = 0.006). The proportion of respondents from the first mailing (65.7%) who fed bears between 1 July 1998 and 30 June 1999 was greater than the proportion of feeders from the second mailing (42.6%; $\chi^2$ = 9.16, $P$ = 0.003); however, the proportion of overall mail respondents (60.2%) who fed bears between 1 July 1998 and 30 June 1999 did not differ ($\chi^2$ = 1.564, $P$ = 0.211) from the proportion of nonrespondents (48.4%) who fed bears during that time. The proportion of respondents from the second mailing who fed bears (42.6%) did not differ from the proportion of nonrespondents who fed bears (48.4%; $\chi^2$ = 0.27, $P$ = 0.605). The type of land on which respondents from the first and second mailings fed bears did not differ ($\chi^2$ = 2.43, $P$ = 0.297). However, respondents (50.0%) were more likely to feed bears on both public and private land than nonrespondents (33.3%), and less likely to feed on private land only (24.2%) than nonrespondents (60.0%; Fisher's Exact Test $P$ = 0.020). The proportion of feeding on public land by those who fed on *both* public and private lands did not differ between respondents from the first and second mailings ($\chi^2$ = 7.42, $P$ = 0.060) or between respondents and nonrespondents (Fisher's Exact Test, $P$ = 0.358). The number of feeding sites stocked regularly by bear hunters did not differ between respondents from the first and second mailings ($t$ = -0.15, $P$ = 0.881) or between respondents and nonrespondents ($t$ = 1.67, $P$ = 0.098).

The amounts of food provided by respondents from the first (mean = 23,489 kg/person; $n$ = 106) and second (mean = 20,571 kg/person; $n$ = 22) mailings did not differ ($t$ = 0.32, $P$ = 0.753), nor did they differ between respondents from the first (10,151 kg; $n$

= 96) and second (11,808 kg; $n$ = 20) mailings when the 12 respondents who reported feeding >50,000 kg of food/year were excluded. Nonrespondents were not asked to recall weights of foods provided or frequency of feeding. The 3 most prominent food types provided by respondents and nonrespondents, respectively, who fed bears were pastries (79.7%, 60.0%), shelled corn (54.7%, 53.3%), and bread (57.0%, 33.3%), though this does not reflect the amounts provided. July, August, and September were the 3 months during which most feeding by respondents from the first and second mailings and nonrespondents occurred. Rockingham County had the highest percentage of feeding by respondents from the first (47.2%) and second (40.9%) mailings, as well as overall respondents (47.1%) and nonrespondents (33.3%).

Respondents from the first (80.0%) and second (61.9%) mailings ($\chi^2$ = 5.760, $P$ = 0.056), and overall respondents (76.4%) and nonrespondents (73.3%; Fisher's Exact Test $P$ = 0.167) classified the amount of feeding they did between 1 July 1998 and 30 June 1999 as typical of most years. Response to the prohibition of feeding on public lands did not differ between respondents from the first and second mailings ($\chi^2$ = 6.526, $P$ = 0.089) or between overall respondents and nonrespondents ($\chi^2$ = 5.104, $P$ = 0.164). Seventy-one (50.4%) of 141 mail respondents and 11 (73.3%) of 15 nonrespondents indicated they would continue providing the same amount of food to bears on private land as they provided prior to the change in feeding regulations. Respondents from the first and second mailings did not differ in their opinions on the legality of feeding ($\chi^2$ = 0.011, $P$ = 0.915); however, a higher proportion of respondents than nonrespondents felt it should be illegal to feed bears ($\chi^2$ = 11.153, $P$ = 0.004). The majority in both cases (81.2% and 67.7%, respectively) felt that feeding bears should be legal. The majority of respondents from the first (54.1%) and second (63.6%; $\chi^2$ = 0.671, $P$ = 0.413) mailings, as well as overall respondents (60.6%) and nonrespondents (61.3%; Fisher's Exact Test $P$ = 0.194), felt that feeding bears during the bear harvest season should be illegal.

## DISCUSSION

### Hunter Effort and Success

On average, 64.3 and 65.4% of chased bears were treed during the 1998 bear hound training season and general firearms season, respectively. These averages are substantially higher than Higgins (1997) reported in 1995 and 1996, when an average of 26.5% and 17.5%, respectively, of chases resulted in treed bears during the training seasons, and 30% and 38%, respectively, resulted in treed bears during the 1995 and 1996 general firearms seasons (averaged northern and southern CABS study areas for each year). These figures may show a true difference in treeing success between years; however, they were obtained using different methods and may not be directly comparable. Results from this study were obtained from numbers recalled by VBHA members of the previous year's bear hound training and firearms seasons, and may be subject to memory errors. The results from 1995 and 1996 were obtained from 3 different survey methods, including field surveys, mail surveys, and hunter diaries, and may be more accurate than the results of this study since there was no time lapse between the hunting season and survey distribution. The difference in treeing success between the 2 studies may also reflect a bias resulting from change in hunter behavior. As this study has progressed and more trust has developed between researchers and hunters, hunters may have become more comfortable reporting true success rates. Respondents in this study were asked to report their hunting success as individuals, but may have actually reported group results, given that they are more likely to hunt in a group than individually. Steinert et al (1994) suggested party hunting (working together to fill all licenses in a hunting group) or poor recall as reasons for discrepancies between hunter success rates reported at check stations versus postseason telephone interviews.

### Location of Feeding Sites and Response to Prohibition of Feeding on Public Land

Feeding sites were nearly evenly distributed on public and private lands. Twenty-six percent of respondents fed on public land only and 24% of respondents fed on private land only. Of the 50% of respondents who fed on public *and* private lands, 55.4% placed more than half of their food on public land; 44.6% placed more than half of their food on private land. Twenty-three percent of respondents reported they will cease all feeding activities as a result of the prohibition of feeding on public lands, however, nearly the same proportion (21.1%) predicted an increase in their feeding activities on private land. Large changes in yearly supply of supplemental food are therefore not likely if these 2 groups of respondents cancel each other out. In addition, many respondents commented that they would continue to feed on public lands, despite the new law; technicians on this study have confirmed this activity.

**Opinions of Feeding**

Respondents' overall feelings about feeding supplemental food were that it has a positive impact on the bear population. Respondents tended to agree with the positive statements about feeding (increased reproduction, survival, population levels, body size, and health), and disagree with negative statements (increased danger to campers, chance of bear/vehicle collisions, nuisance occurrences, littering, dependency on artificial food, and disease problems; Appendix 1, questions 24-45). Respondents remained neutral to statements about their public image. Occurrences that were viewed by the VDGIF and USFS as negative results of feeding, such as litter at feeding sites, were not perceived as a problem by the majority of survey respondents. Indeed, littering was probably a problem only in isolated areas, and some hunting groups conducted litter pickup in national forest areas where they hunted. The discrepancy between respondents' perception of feeding and that of VDGIF or USFS employees, may contribute to confusion about the reasons for the feeding law, and may explain future disagreements between the 2 groups.

**Accuracy of Total Food Estimate**

My estimate of the total amount of supplemental food provided to bears by bear hunters may have been affected by several factors. Many elements, such as a low response rate and the fact that not all bear feeders were surveyed, suggest that the estimate of total food is an underestimate; however, the small sample size may be subject to an avidity bias, in which only the more avid feeders (who presumably fed more than less avid feeders) responded to the survey (Fisher 1997, Dillman 1978:53). The average amount of food/person, subject to an avidity bias, would not be representative of nonrespondents. Unfortunately, to ensure the brevity of the telephone survey, we did not determine the amount of food or frequency of feeding by nonrespondents.

### ***Response Rate***

The response rate for my survey was 51.9%, which was lower than the response rate of 2 surveys completed by bear hunters who hunted in the same study areas in 1995-96 (73%; Higgins 1997), despite the fact that the targeted group was essentially the same. Higgins (1997) attributed her high response rate to hunters' interest in black bear management, and perhaps the working relationship established between CABS personnel and VBHA members. Possible reasons for the lower response rate in this study are the lengthy amount of time it may have taken to complete the survey (131 questions), a recall period that was too long and may have discouraged some respondents from completing the survey, that respondents felt overwhelmed by receiving another survey from CABS and were reluctant to fill it out, or the time of year that surveys were administered. Surveys should be concise and simple, and the information requested should apply to a recent time period to improve overall survey response rate and response rate for individual questions within the survey (Romberg 1999).

### ***Timing of Survey Mailings***

The timing of the first mailing was not ideal in that I was asking respondents to recall their feeding efforts 3-15 months prior. The long recall period may have caused higher nonresponse to the entire survey or to specific questions, and may have resulted in some people providing inaccurate answers (Romberg 1999). Long recall periods may result in overestimation of responses to questions. The timing of the second mailing (December 1999) was less than ideal due to the fact that respondents received it in the midst of their bear hound harvest season, arguably their busiest time of year. In addition, surveys should not be sent during the month of December because many people are busy with the holiday season (Dillman 1978).

### ***Food Tally***

Overall response rate for my survey was 51.9%, and of those, 60.2% fed bears. The amount of feeding done by telephone questionnaire nonrespondents who fed bears (48.4%) is not included in the total food estimate. Extrapolating the 48.4% of phone questionnaire nonrespondents who fed bears to all nonrespondents (n = 221) would add 107 feeders to the total food tally. Multiplying the median annual amount of food provided by an individual (6,232 kg) by 107 would add 666,824 kg of food to the total annual supplemental food estimate.

The existence of an outlier may have inflated the total food estimate. One respondent reported feeding 577,579 kg of food to bears, which amounted to 19.6% of the total food estimate, an unlikely, and probably impossible, amount for 1 person to have contributed.

Eighty-eight respondents (63.8%) knew of at least 1 non-VBHA member who did not share their feeding routes, but fed bears. Only VBHA members received surveys, so we may have missed a substantial number of non-VBHA constituents who fed bears; however, many respondents could have been referring to the same person. There was no good way to avoid this problem short of asking respondents to name names. Assuming that survey responses were accurate and representative of all bear feeders, the total estimate of food provided to bears in Virginia in 1 year was likely lower than in actuality.

### *Answer Choice Limitations*

Respondents were not asked to report amounts of *all* foods they provided to bears, just those they fed at least every 2 weeks, so the estimate is conservative in this regard. The answer choices on the survey for amounts of foods were given in ranges. For tallying purposes, when possible, I took the mean of the answer choice ranges. For example, if a respondent fed 26-50 pounds of a food item, I tallied it as 38 pounds. I tallied the answer choice '>100 lbs' as 100 pounds, so again this is conservative. Three to 4 buckets were tallied as 3.5 buckets, and so on. The largest answer choice for buckets (> 8 buckets) I tallied as 8.5 buckets.

I asked respondents how typical the amount of feeding they did between 1 July 1998 and 30 June 1999 was in comparison to other years. Most respondents (76.4%) reported it was typical of most years, whereas 11.0% said their feeding was less than most years, and 12.6% said it was more than most years. The fact that the numbers of people who fed less or more than usual are nearly equal suggests that this is not a concern with the accuracy of the total annual food estimate. However, it is impossible to know how much more or less feeding than usual was done.

VBHA members helped compile the list of food types listed on the survey from which respondents indicated which foods they fed to bears. Many of the food types listed on the survey were in accordance with those suggested by Meyer (1983) for baiting bears, including ham scraps, bacon grease, pastry, beef and pork scraps, and apples. Other foods suggested by Meyer (1983) were honey, sardines and other fish, candy, chicken, produce trimmings, and peanut butter. Some hunters who chose the ‘other’ category on my survey fed some of these foods to bears. I did not convert the ‘other’ food types of hunters who fed in buckets (*n* = 19) into kilograms, so these are not included in the total tally.

***Restocking Feeding Sites***

Forty-two percent of respondents claimed they supplied food to their feeding sites every time they visited the site (mean = 10 visits/month), regardless of how much food was left, so the amount of food provided was not necessarily consumed by wildlife. However, 84.2% of respondents who fed bears reported that at least 75% of the food from a previous visit had already been consumed by the time they returned to each site, and 83.9% of respondents who put food out at each visit, regardless of the amount of old food remaining, reported that >75% of the old food was usually gone. In most cases, the amount of food provided was equivalent to the amount of food consumed (by bears or other wildlife), and there was little evidence that food was wasted.

***Evidence of Other Animals***

One hundred three respondents (77.4% of 133) reported evidence that 14 species other than bears consumed food from their feeding sites, though the amount of scavenging was unknown. As many as 11 different nontarget species ate food from white-tailed deer feeders in Texas (Cooper and Ginnett 2000). Many of the bear hunters in the CABS study areas cover their feeding sites with heavy logs or boards weighted with rocks to prevent smaller animals from stealing the food. Meyer (1983) proposed hanging the food out of reach of small varmints, which also allows the scent to be carried further in the air, however, I am not aware of any hunters having used this method in our study areas. Ziegltrum (1994) suggested placing bear feeding containers 10 inches off the ground to deter rodents and prevent water contact with the food. Scavenging by other animals does not affect the overall estimate of annual supplemental food provided to bears, however, it does affect the amount available to bears. Animals other than bears may have left evidence of their presence at feeding sites, but this does not imply that they consumed food. In some circumstances, animals may have been attracted by the smell of food but unable to retrieve it. If scavenging is substantial, it could reduce the potential benefits of feeding bears, such as increased fitness and greater weight gain before denning.

### *Non-response Bias*

Non-response bias occurs when hunters fail to respond to the survey (Steinert et al. 1994), and results misrepresent the sampled population. A large non-response bias does not seem apparent in the data from the follow-up telephone survey of nonrespondents in this study. Non-response bias occurred in the type of land on which feeding occurred, in hunters' opinions on the legality of feeding bears, and in the amount of time spent hunting bears without dogs, most of which provided subjective reasons why many of the nonrespondents did not respond to the mail questionnaire. The smaller proportion of respondents who fed bears from the second survey mailing may indicate a smaller interest in feeding, and may be a reason for their later response. High levels of interest in the subject of a survey may not only be characteristic of early respondents, but also of all respondents (Fisher 1996); however, the proportion of respondents who fed bears did not differ from the proportion of sampled nonrespondents who fed bears. A higher percentage of nonrespondents fed only on private land (60.0%) as opposed to only 24.2% of respondents who fed only on private land. Nonrespondents may have had less interest in the mail questionnaire because the change in feeding regulations did not affect them as much as it affected respondents. Also, nonrespondents spent fewer days hunting bears without dogs than respondents, which may indicate less interest in hunting and feeding in general. A lower response may be expected from people who felt feeding bears should be illegal since they may be less interested in feeding; however, a higher proportion of respondents than nonrespondents felt it should be illegal to feed bears.

Non-response bias did not seem to occur in the amount of effort spent hunting bears with dogs, the number of feeding sites and type of food provided, the months feeding occurred, and response to the feeding regulation. However, not all questions in the mail survey were asked during the telephone survey, so the possibility of non-response bias occurring in other topics cannot be ruled out.

## Annual Feeding Pattern

The bear hound training season runs from the last weekend in August through September, thus it is not surprising that most feeding occurred during August and September. Increased bear activity at active feeding sites purportedly leaves more scent around feeding sites and enables dogs to detect bear trails more easily. Many bear hunters believed that feeding bears during the harvest season was illegal and therefore did not feed during December. Feeding rates dropped off during the winter months, especially following the general firearms season, however, some individuals fed throughout the winter. Den emergence in the CABS study area occurs mid to late April (Godfrey 1996). Feeding rates increased in April, as many hunters wanted to provide a food source to bears when natural food is less abundant.

## Opinions on Legality of Feeding

It is interesting to note that 13.7% of respondents who fed bears felt that feeding bears should be illegal, and that 16 (35.6%) of the 46 respondents who fed bears during December felt that if feeding on public lands were to become legal again, feeding during the harvest season should be illegal. The general consensus was that feeding bears during the harvest season would tempt “outlaw” hunters to illegally kill bears over bait, thereby stressing the population.

## Effect of Feeding on Reproduction

In the comments section at the end of the survey, bear hunters repeatedly stated that feeding helps bears survive the den season and helps sows with cubs (i.e., provides energy for lactation). Supporting their view, Alt (1989) reported that supplemental food supplied to bears by humans likely would have a positive effect on reproduction. Several studies have related nutritional condition to survival and reproduction (Brody and Pelton 1988, Eiler at al. 1989, Elowe and Dodge 1989, McLaughlin et al. 1994) and some have identified threshold weights below which females fail to produce cubs. For instance, juvenile females in Minnesota needed to weigh at least 41 kg by March in order to produce cubs the following year, and cubs and yearlings of females weighing less than 65 kg were less likely to reach threshold survival weights than those of heavier mothers (Noyce and Garshelis 1994). Herrero (1983) suggested that food from dumps in Jasper National Park may have positively impacted reproduction in black bears that fed at the dumps. Rogers (1976) found that bears that fed at dumps in Michigan had better reproductive success than bears that ate only natural food. Supplemental feeding can have long-term impacts on wild ungulate populations in Colorado if a minimum of 25% of the ungulate population is fed during severe winters ().

Pregnant bears that do not put on sufficient weight or that do not have access to high fat and carbohydrate diets prior to denning may fail to produce cubs (Elowe and Dodge 1989). Two captive female bears at the Virginia Tech Center for Ursid Research that remained active during the winter, despite no longer being fed, lost their cubs in 1998 (unpubl. data; Appendix 7). One bear gave birth to a live cub, but was not lactating and abandoned the cub. The other bear ate her cubs after giving birth. It is unknown whether the cubs were alive or dead at birth.

The number of respondents who said they would cease feeding (22.6% of 124 respondents) was nearly the same as the number who would begin or increase feeding on private land (20.2%), so the overall amount of feeding may have remained the same. Bears that used feeding sites on private land would not have been affected by the new regulation if they continued to use those sites. Likewise, bears that normally fed on public land, but shifted their feeding efforts to private, land would not have been affected by the regulation change. Eiler (1981) postulated that bears' abilities to shift food sources may soften the effects of hard mast failure. In some parts of the CABS study areas, such as Rockingham County, where private land is interspersed with public land, bears may not have had to change their feeding routines substantially to continue taking advantage of feeding sites.

A change in reproduction may only be detectable in years of mast crop failure (Landers et al. 1979). Many hunters maintain that bears will not use feeding sites, or will greatly reduce their rate of use, when acorns begin dropping from trees in late summer and early fall. Ziegltrum (1994) found that bears lost interest in supplemental feeding stations (which were successfully used as forest damage management tools in Washington) at the onset of the natural berry crop. Use of feeding sites may be compensatory rather than additive, and may only affect reproduction when acorns and other natural foods are scarce. Other studies have witnessed total reproductive failure following years of mast crop failure (Michael Pelton, Univ. Tennessee, pers. comm.).

During this study, acorn crops ranged from near failure to good (VDGIF mast survey, 1994-2000), while reproduction remained consistently good (Godfrey 1996, Ryan 1997, Needham 2000).

The entire CABS study area, which occupies the 5 counties in which most people fed bears, consists of 238,400 ha. The amount of supplemental food provided between 1 July 1998 and 30 June 1999 in the counties included in the CABS study area was 1,970,328 kg. Using estimates of acorn production in SNP in 1985 (McConnell 1988), acorn production for the CABS study area would be 110,856,000 kg during a qualitatively fair to good year. A less productive year in the CABS study area may yield between 23,840 kg (Hewitt et al. 1992) and 28,131,200 kg of acorns (Kasbohm 1994). Thus, supplemental food may provide a substantial amount of food to bears in years of mast shortage, but may only amount to 2% of the natural acorn mast crop during good or excellent mast years.

**Implications of Terminating Feeding**

In Yellowstone National Park, sudden elimination of dumps as a food source for grizzly bears resulted in greater nuisance occurrences in campgrounds rather than a quick adjustment to natural food sources (Craighead and Craighead 1971). Though feeding sites in Virginia do not concentrate bears in numbers as large as in Yellowstone, the abrupt removal of feeding sites on public land could have similar effects, especially in areas close to human habitation. Dumps provided bears with a predictable, concentrated, prolonged feeding source (Herrero 1983). In North Carolina, hunters maintained baiting sites for many years that were used year around by bears (Landers et al 1979). If bears became dependent on supplemental feeding sites in Virginia that were suddenly removed, they may be unsuccessful at finding sufficient natural foods, especially if they learned to feed on supplemental food as cubs. However, since bears are opportunistic feeders (Eiler 1981, Lunn and Stirling 1985), and most feeding sites in Virginia are not maintained year around, the chance of bears becoming dependent on them is unlikely. VBHA members maintained that supplemental feeding did not cause bears to cease their natural feeding activities (minutes from VDGIF board meeting 4-5 March 1999).

Feeding bears may increase their chance of becoming food-conditioned and habituated to people. Human scent undoubtedly remains at feeding sites after restocking by humans, and bears likely associate humans with the food they find at feeding sites. Bears that feed on garbage are more likely to have encounters with humans than bears that do not feed on garbage (Herrero 1985). Some believe that bears make other associations with odors, such as domestic animal carcasses, in supplemental food, and that these associations may cause bears to kill livestock (Huber and Reynolds 2001). Nutritional benefits to habituated bears feeding at dumps in national parks may be negated by increased mortality resulting from nuisance occurrences or human injury (Herrero 1983).

Supplemental feeding is used as a management technique in some circumstances. In Romania, supplemental food (no meat) is provided to bears as a management tool to limit bear conflicts with human use at specific sites (Huber and Reynolds 2001). Agricultural damage is reduced, and accurate counts are possible at feeding sites. A supplemental bear feeding program in Washington reduced damage to timber and reduced the use of lethal control methods for bears (Ziegltrum 1994). Supplemental food sites in Virginia during years of mast failure may reduce the incentive for bears to feed in, and subsequently cause damage to, agricultural or residential areas, as was suggested in North Carolina (Landers et al. 1979).

**Hunter Complaints, Concerns, and Suggestions for Compromise**

In February 1999, the VDGIF proposed a regulation that forbade the feeding of wildlife on public land. By then we had already met with a focus group primarily composed of VBHA officers to gather input to improve the survey design. In May 1999, the Commonwealth of Virginia approved the proposed regulation and set an effective date of July 1, 1999. The VDGIF then cancelled the survey because of the potential to further anger disgruntled bear feeders. However, during summer 1999 the VDGIF reconsidered, and permitted the survey.

The decision to prohibit feeding wildlife on public lands may have lasting negative effects in future interactions between the VBHA and the VDGIF and CABS. Many respondents expressed resentment and distrust towards CABS and the VDGIF, and believed that the new feeding regulation was imposed in order to provide CABS with before and after data regarding the effects of feeding on bears. A few respondents returned their surveys blank and refused to cooperate because they were angry about the feeding regulation. Others expressed their distrust and disappointment in the comments section at the end of the survey. It is not likely that results of this study will affect future feeding regulations, although many respondents expressed hope that they would regain feeding rights on public land.

Some respondents made suggestions for a compromise between bear hunters who wish to feed bears and the VDGIF. Many are willing to register feeding sites in their names and pay a yearly fee to "rent" that site. They would be held responsible for maintaining a litter-free site out of sight of any public roads. Others desired to regain feeding rights, but were willing to cease feeding during the bear hound harvest season, thus assuring that the presence of supplemental food would not prevent bears from denning when they normally would in the absence of supplemental food. Still others suggested that they be allowed to feed only during the hound training season. Many feed primarily for the purpose of training their dogs to track and tree bears.

**Management Implications and Recommendations for Further Study**

Supplemental feeding of wildlife has become a management technique in many areas in the United States and Europe (, Johnson and Dancak 1993, Ziegltrum 1994, Huber and Reynolds 2001), and is increasing in popularity in some places (Cooper and Ginnett 2000). Supplemental feeding can reduce damage caused by wildlife (, Ziegltrum 1994) and reduce mortality in winter (), and may increase body and antler size of white-tailed deer in areas of poor habitat (Johnson and Dancak 1993).

The opinions of wildlife managers and the public often differ on whether or not to use supplemental feeding as a management tool (). Managers are faced with public pressure to maintain hunting opportunities despite unpredictable winter weather conditions that can cause large population declines (Ouellet et al. 2001). In addition, the public often does not realize how well-adapted big game animals are to severe winter conditions, or that winter mortality is a natural regulator of population size (). Managers that are opposed to winter feeding programs express concern that feeding in any situation may set a precedent for feeding in every situation. In addition, feeding programs are expensive and may not be effective in reducing game losses (), partially due to the fact that the most appropriate supplemental food types for encouraging the recovery of starving animal populations are largely unknown (Ouellet et al. 2001).

Successful bear management requires understanding the relationship between black bear populations and nutritional processes, habitat composition, and silvicultural practices (Noyce and Coy 1990). To determine management procedures, biologists and managers must know the kinds of foods important to bears, in addition to their quantity, quality, and utilization (Beeman and Pelton 1980). The best way to evaluate the need for and success of supplemental feeding programs may be through cooperative research efforts among professional wildlife agencies, universities, and private landowners (Ziegltrum 1994).

Data collection and analysis prior to regulation changes is essential not only to justifying the changes biologically and understanding their ramifications, but also to maintaining good public relations with constituents. Studying the effects of supplemental food on black bear reproduction perhaps should have been accomplished prior to the change in feeding regulations, but should continue for several years to incorporate natural fluctuations in food supply. Parameters such as average litter size, percent of females breeding, denning weights of females and cubs, home range sizes, and bear densities should be monitored for changes, especially in years of mast crop failure, when supplemental food is more likely to affect black bear reproduction and movement. A program designed to teach hunters about the positive and negative aspects of feeding wildlife may be helpful in educating constituents about the decision to restrict bear feeding in Virginia.

# CHAPTER 2: DIGESTIBILITIES AND NUTRIENT COMPOSITION OF VARIOUS BLACK BEAR FOODS

## JUSTIFICATION

Many biologists have examined black bear scat to determine their food habits (Clark 1957, Beeman and Pelton 1980, Eiler 1981, Garner 1986, Raine and Kansas 1990), but few have determined the value of these foods to bears through digestibility studies (Bunnell and Hamilton 1983, Kasbohm 1994). Percent volume, perhaps the most common method for estimating food habits in scat analysis, is not necessarily proportional to the amount eaten due to differences in digestibility of various food items (Hewitt and Robbins 1996). Percent volume calculations are likely biased toward relatively indigestible foods (Hellgren et al. 1989). For example, animal matter, as opposed to green vegetation, is reduced greatly as it passes from the stomach through the digestive system, and tends to be underestimated in volumetric analysis of scats (Raine and Kansas 1990). Differential digestion rates of food items are the largest potential source of bias in any study of gut contents (Morrison et al. 1992).

Without knowing the nutritional value of individual food items or seasonal diets, use of food habits analyses is limiting (Eagle and Pelton 1983). Wainio and Forbes (1941) suggested that knowing the nutritive values of forest foods, especially those that build reserves to carry animals through the winter, is important in wildlife conservation. Feeding tests on wild feedstuffs are necessary before any definite conclusions can be drawn about their value (King 1944). Evaluation of the mast and browse foods is necessary in forest management to propagate the more desirable species (Wainio and Forbes 1941).

Hard and soft mast available during the fall differs nutritionally, with soft mast moderately high in protein and hard mast high in carbohydrates and sometimes fats (Eiler 1981). Not only do nutrient compositions among foods differ, but nutrient utilization by bears may differ at different times of year (Brody and Pelton 1988). According to Nelson et al. (1983), black bears and grizzly bears undergo 4 different biochemical and physiological stages annually, including hibernation, walking hibernation, normal activity, and hyperphagia, which result in seasonal differences in bears' abilities to utilize nutrients, assimilate fat, and metabolize urea. Brody and Pelton (1988) found that bears exhibited differences in energy and protein digestibilities when fed identical diets in the summer and fall, and suggested that the physiological changes in the fall resulting in an increase in fat and carbohydrate assimilation at the expense of protein assimilation allow for rapid weight gain prior to denning.

A food that causes the greater weight gain is said to be more digestible, as shown by its coefficient of digestibility (percentage consumed in a diet that does not appear in feces; Schneider and Flatt 1975). Usefulness of a food can be measured by the quantities of energy sources (carbohydrates, fats, and proteins) it contains, but the value of a food is dependent upon the amount of nutrients an animal can digest and use (Schneider and Flatt 1975).

Pritchard and Robbins (1990) tested the digestive and metabolic efficiencies of beef, blueberries (*Vaccinium corymbosum*), pinyon pine nuts (*Pinus edulis*), Columbian ground squirrels (*Spermophilus columbianus*), mule deer (*Odocoileus hemionus*), cutthroat trout (*Salmo clarkii*), and white clover (*Trifolium repens*) in captive brown bears (*Ursus arctos*) and black bears. In addition, they tested 4 mixed diets, including alfalfa-grain pellets; carrots and yams (*Daucus carota* and *Dioscorea* spp.); steelhead (*Salmo gairdnerii*), pine nuts, and fresh alfalfa (*Medicago sativa*); and beef, blueberries, and clover. McCarthy (1989) determined the digestibilities of sedge (*Carex lyngbyaei*), skunk cabbage (*Lysichitum americanum*), devil's club berries (*Oplopanax horridus*), and pink salmon (*Oncorhynchus gorbuscha*) in captive brown bears. Bunnell and Hamilton (1983) tested digestibilities of horsemeat with dog chow, blueberries, salmon, and beet pulp. These studies focused on the digestibilities and nutrient content of brown bear and/or western black bear foods. Most eastern bear foods have not been examined and relative digestibilities of individual food items are not known (Kasbohm 1994).

**Objective and Hypotheses**

1. To determine the nutrient composition and digestibilities of some foods important to black bears.

$H_o$: All food types have equal nutrient composition.

$H_o$: All food types have equal digestibility.

## METHODS

### Feeding Trials

Research was conducted at the Center for Ursid Research, VPI & SU, Blacksburg, Virginia, in a 590 $m^2$ covered barn. Walls consisted of oak slats stacked approximately 1.2 m high with chain-link fencing continuing to the roof. Bears were randomly assigned to 1 of 6 5.0 m diameter x 3.0 m high cylindrical, welded, steel cages with asphalt floors. Each cage had a 1.0 m x 1.3 m steel culvert extension in which the bear could be locked and separated from the main cage by lowering a metal trap door. The barn contained 15 stalls, 6 of which were used in this study. Each of the 6 stalls housed one cage, and stalls were separated by the same wooden slat/chain link combination as the outer walls. Bears were aware of each other and could see each other through the wooden slats or when standing.

Ten different bears were used in the feeding trials (5 per year). Both years began with 6 bears but decreased to 5 when 1 bear could not be locked in the culvert on a daily basis. Bears included in the 1998 food trials were M1, 60, 61, 62 (later excluded), 63, and 64. Bears included in the 1999 food trials were 65 (later excluded), 66, 67, 68, 69, and 70. All bears were adult females except M1, an adult male whom we used in the study for lack of acquiring a sixth female. All bears were captured by the VDGIF on nuisance complaints and, rather than being relocated immediately, were brought to the Virginia Tech Center for Ursid Research to be used as study animals until their spring release. All 1998 bears weighed between 125 and 172 pounds on 1 October (Appendix 5). The 1999 bears weighed between 152 and 242 on 15 October (Appendix 6).

Each feeding trial was conducted over a 10-day period, during which all bears were fed a constant daily dry matter intake of each test food at the same time every day. All uneaten food from the previous day was collected and weighed. We originally chose a dry matter intake of 1,000 g for all food types, however, we later modified this amount, depending on the diet, to prevent weight loss. Water and trace-mineralized salt were offered ad libitum. The first 5 days of each feeding trial composed the pretrial period, during which the bears acclimated to each new test diet, and their gastro-intestinal tracts were emptied of any pretest food. The second 5 days composed the fecal collection period. All feces were collected at the same time each day using a dustpan, a paint scraper, and a stiff brush. All feces for a given food type were composited for each bear for the 5-day collection period and kept frozen until prepared for analysis.

Foods tested in 1998 were shelled corn and doughnuts (the 2 most common foods offered to bears by bear hunters), northern red oak acorns (*Quercus rubra*), and white oak acorns (*Q. alba*) (common natural foods of bears). Acorns were fed with the shells intact. Corn and doughnuts were fed simultaneously 14 October – 4 November 1998 using the "switchback" design; 3 bears were fed one diet while the other 2 were fed the other diet. During the second trial period the food type was switched so that the bears who had previously eaten corn were fed doughnuts, and vice versa. Red and white oak acorns also were tested via the switchback design in trials 3 and 4 during 7 – 22 November 1998. The bears were randomly assigned to 1 of 2 groups that remained constant throughout all food trials for that year, and each group received a different diet during each trial period. Foods tested in 1999 included the same foods tested in 1998, as well as high protein dogfood, squawroot (*Conopholis americana*; entire plant), and chestnut oak acorns (*Q. prinus*; with shells). The switchback design, though preferable, was not adhered to for some 1999 food trials due to timing and availability of test foods. Dogfood and corn were tested simultaneously 16 September – 13 October; squawroot was tested 17 - 26 October; doughnuts were tested 28 October – 6 November; white oak acorns were tested 8 – 17 November; and northern red and chestnut oak acorns were tested simultaneously 30 November – 20 December. Digestion results for bears 66 and 67 for the northern red oak trial were inaccurate due to low food intake and were removed from the analysis.

Acorns used in the 1998 food trials were purchased from a private source in North Carolina. Acorns used in 1999 were collected in the mountains of western Virginia, as well as on the Virginia Tech campus. Additional red and chestnut oak acorns were purchased during 1999 from the same source used in 1998. Squawroot was collected from Craig and Giles Counties in western Virginia during summer 1999. Day-old pastries were donated by a grocery store bakery. Shelled corn and dogfood were purchased from feed supply stores. All food types except dogfood and shelled corn were kept frozen until ready for use.

**Captive Sampling**

Between each food trial, all bears were tranquilized, weighed, and had a blood sample taken as part of a study of reproductive physiology. During 1998, bears were sampled the day after the last day of each food trial, and were fed dogfood on each sampling date. The subsequent food trial began the day after sampling. In 1999, bears were sampled on the last day of each food trial after the fecal collection. The next trial's diet was fed on sampling days, and subsequent food trials began the day following sampling.

**Preparation of Samples for Analysis**

Food samples and composited fecal samples and orts (when applicable) for each bear and each diet were thawed, weighed, and homogenized, and 3 300 - 400 g subsamples of each were oven dried at 60$^{o}$ C. In cases where there were not enough orts to make 3 300 g subsamples, the total amount of orts was divided into 3 approximately equal subsamples. Oven-dried samples were weighed, then combined in a paper bag and left to air equilibrate for 14+ days. Air-equilibrated samples were ground through a 1 mm screen using a Wiley Mill, tabled (homogenized), and packed in sealed jars until analysis.

**Analyses**

All samples were analyzed for dry matter (DM), crude protein (CP), and ether extract (EE) (AOAC 1980). All acorns were analyzed for fiber content using neutral detergent analyses (NDF; Goering and Van Soest 1970 as modified with addition of amylase by Mertens 1985). Fiber content of squawroot and dogfood was determined using acid detergent analysis (ADF; Van Soest 1963). Gross energy (GE) was determined on all samples using a Parr 1271 adiabatic bomb calorimeter.

Digestibility for each test food was determined using the formula:

$$\text{Apparent Digestibility (\%)} = \frac{\text{Nutrient Intake} - \text{Nutrient in Feces}}{\text{Nutrient Intake}} \text{ (x 100).}$$

Squawroot was mixed with a basal diet of high protein dry dogfood and digestibility was calculated by difference using the formula:

$$S = \frac{100\,(T-A)}{s} + A$$

where:

S = digestibility of test ingredient

T = digestibility of test diet (basal diet + test ingredient)

A = digestibility of basal diet (dogfood)

s = percentage of test ingredient

Squawroot (stems and berries) composed 34% of the mixed diet on a dry matter basis, and was chopped into small pieces to homogenize with the dogfood. Apparent digested energy/g of food intake (DE/g) was calculated using the formula:

$$DE = \frac{\text{Intake Energy} - \text{Fecal Energy}}{\text{g Food Intake}}$$

Percent digestible energy was calculated by dividing the above equation by intake energy.

Analysis of variance and Tukey's Honest Significant Difference tests were used to test for differences between diet compositions and apparent digestibilities ($\alpha = 0.05$) (SAS v. 8.0). Apparent crude protein data were log-transformed. Statistical comparisons could be made only between diets fed simultaneously since timing of the food trial could not be eliminated as a possible source of variation between non-simultaneous trials.

**RESULTS**

**Apparent Digestibility Coefficients 1998**

Doughnuts had greater apparent digestibility than shelled corn for dry matter ($P < 0.001$), crude protein ($P = 0.002$), and ether extract ($P = 0.005$) (Table 10). White oak acorns had greater digestibility than northern red oak acorns for dry matter ($P = 0.001$), crude protein ($P = 0.001$), and ether extract ($P = 0.001$); neutral detergent fiber did not differ ($P = 0.120$) (Table 10). Apparent dry matter digestibility ranged from 55.9% in red oak acorns to 95.6% in doughnuts. Apparent crude protein digestibility ranged from –39.2% in northern red oak acorns to 86.4% in doughnuts. Apparent ether extract digestibility ranged from 66.8% in corn to 97.2% in doughnuts (Table 10, 13). Percent digestible energy was higher for doughnuts (95.6%) than shelled corn (77.0%; $P < 0.001$), and higher for white oak acorns (72.4%) than northern red oak acorns (61.0%; $P = 0.005$). Digestible energy/g food intake was higher for doughnuts (5.25 kcal/g) than for corn (4.01 kcal/g; $P < 0.001$), and higher for northern red oak acorns (5.37 kcal/g) than for white oak acorns (4.15 kcal/g; $P < 0.001$).

**Apparent Digestibility Coefficients 1999**

Dogfood had greater apparent digestibility than shelled corn for dry matter (*P* = 0.028), crude protein (*P* = 0.002), and ether extract (*P* = 0.003) (Table 11). Apparent digestibility did not differ between northern red oak acorns and chestnut oak acorns for dry matter (*P* = 0.331), crude protein (*P* = 0.211), ether extract (*P* = 0.167), or neutral detergent fiber (*P* = 0.278). Apparent dry matter digestibility ranged from 40.7% for squawroot to 94.6% for doughnuts. Apparent crude protein digestibility ranged from –13.0% in northern red oak acorns to 84.5% in doughnuts. Apparent ether extract digestibility ranged from 60.3% in squawroot to 96.8% in doughnuts (Table 11). Mean apparent acid detergent fiber digestibility for dogfood was 66.1% excluding bear 69, who was an outlier. Using the mean of 66.1% for dogfood in the by difference equation for determining mean apparent acid detergent fiber digestibility for squawroot gave a mean of –18.9%. Using the individual bears' acid detergent fiber apparent digestibility coefficients in the by difference equation for determining apparent acid detergent fiber digestibility of squawroot gave a mean of 13.1%. Percent digestible energy was higher for dogfood (84.0%) than shelled corn (68.4%; *P* = 0.007), and did not differ between northern red oak acorns (70.0%) and chestnut oak acorns (55.4%; *P* = 0.680; Table 11, 13). Digestible energy/g food intake was higher for dogfood (4.85 kcal/g) than for shelled corn (3.94 kcal/g), and higher for northern red oak acorns (5.16 kcal/g) than for chestnut oak acorns (4.13 kcal/g).

**Nutrient Composition 1998 and 1999**

Mean dry matter contents among all diets were different (*P* = 0.029), however, no 2 diet comparisons yielded significant differences (Tukey's Honest Significant Difference, $\alpha = 0.05$). Mean dry matter contents ranged from 92.8% for shelled corn to 96.0% for doughnuts (Table 12). Mean crude protein contents differed between diets (*P* < 0.001); crude protein in dogfood was greater than all other food types; crude protein in shelled corn was greater than all acorn types; crude protein in doughnuts was greater than northern red oak and chestnut oak acorns; crude protein in squawroot was greater than northern red oak acorns; and crude protein in white oak acorns was greater than northern red oak acorns (Tukey's Honest Significant Difference, $\alpha = 0.05$). Mean crude protein contents ranged from 4.7% in northern red oak acorns to 28.8% in dogfood (Table 12).

Ether extract values were different among all food types ($P < 0.001$) except shelled corn, squawroot, white oak acorns, and chestnut oak acorns (Tukey's Honest Significant Difference, $\alpha = 0.05$). Mean ether extract contents ranged from 1.3% in squawroot to 24.7% in doughnuts. Mean neutral detergent fiber contents were different among all diet comparisons ($P < 0.001$) except white oak acorns and chestnut oak acorns. Mean neutral detergent fiber contents ranged from 44.7% in chestnut oak acorns to 62.4% in squawroot (Table 12). Mean acid detergent fiber contents were 8.9% for dogfood and 47.1% for squawroot.

Table 10. Apparent digestibility [%] for dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), digestible energy (%DE), kcal digestible energy/g food intake (DE/g), and standard errors (SE) for shelled corn, doughnuts, northern red oak acorns (*Quercus rubra*), and white oak acorns (*Q. alba*) for black bears in Virginia, 1998.

| | YEAR 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | EXP 1 | | | | EXP 2 | | | | EXP 3 | |
| **ADCs** | **Shelled corn** | **SE** | **Doughnuts** | **SE** | ***Quercus rubra*** | **SE** | ***Q. alba*** | **SE** | **Shelled corn** | **SE** |
| DM | 77.9[a] | 1.56 | 95.6 | 0.43 | 55.9[b] | 1.56 | 70.6 | 1.00 | 68.8 | 1.67 |
| CP | 64.1[a] | 2.79 | 86.4 | 1.36 | -39.2[b] | 5.65 | 50.0 | 1.23 | 59.8 | 1.92 |
| EE | 66.8[a] | 5.32 | 97.2 | 0.41 | 80.0[b] | 1.90 | 96.4 | 1.22 | 61.0 | 4.05 |
| NDF | n/a | | n/a | | 62.2 | 1.86 | 68.5 | 1.53 | n/a | |
| DE/g | 4.01 | 0.03 | 5.25 | 0.02 | 5.37 | 0.08 | 4.15 | 0.03 | 3.92 | 0.01 |
| % DE | 77.0[a] | 1.81 | 95.6 | 0.49 | 61.0[b] | 1.83 | 72.4 | 1.10 | 67.3 | 1.76 |

[a] shelled corn differed from doughnuts ($P < 0.05$).
[b] *Quercus rubra* differed from *Q. alba* ($P < 0.05$).

Table 11. Apparent digestibility coefficients (ADCs) [%] for dry matter (DM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), kcal digestible energy/g food intake (DE/g), and percent digestible energy (%DE) for shelled corn, dogfood, squawroot/dogfood, squawroot (*Conopholis americana*), doughnuts, white oak acorns (*Quercus alba*), northern red oak acorns (*Q. rubra*), and chestnut oak acorns (*Q. prinus*) for black bears in Virginia, 1999.

| | YEAR 2 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EXP 4 | | | | EXP 5 | | | | EXP 6 | | EXP 7 | | EXP 8 | | | |
| ADCs | Shelled corn | SE | dogfood | SE | Squawroot/ dogfood | SE | squawroot | SE | doughnuts | SE | *Quercus alba* | SE | *Q. rubra* | SE | *Q. prinus* | SE |
| DM | 70.1[a] | 1.96 | 79.2 | 1.16 | 65.9 | 1.72 | 40.7 | 3.99 | 94.6 | 0.28 | 69.5 | 1.87 | 50.5 | 4.64 | 54.8 | 2.03 |
| CP | 57.5[a] | 2.41 | 81.9 | 1.85 | 74.7 | 1.41 | 61.1 | 3.91 | 84.5 | 0.76 | 43.1 | 1.56 | -13.0 | 13.45 | 6.0 | 1.79 |
| EE | 63.7[a] | 5.7 | 81.9 | 1.60 | 81.8 | 6.87 | 60.3 | 20.95 | 96.8 | 0.26 | 92.5 | 1.49 | 78.5 | 3.21 | 90.7 | 2.63 |
| NDF | N/A | | N/A | | N/A | | N/A | 4.69 | N/A | | 70.6 | 3.20 | 53.9 | 3.67 | 59.1 | 5.97 |
| ADF[b] | N/A | | 49.4 | 16.79 | 36.9 | 4.77 | 13.1 | 42.05 | N/A | | N/A | | N/A | | N/A | |
| ADF[c] | N/A | | 66.1 | 2.06 | 33.9 | | -18.9[d] | 13.89 | N/A | | N/A | | N/A | | N/A | |
| DE/g | 3.94[a] | 0.02 | 4.85 | 0.04 | 4.91 | 0.02 | | | 5.35 | 0.00 | 4.30 | 0.02 | 5.16 | 1.39 | 4.13 | 0.05 |
| % DE | 68.4 | 2.08 | 84.0 | 0.88 | 70.4 | 1.98 | | | 94.6 | 0.28 | 71.4 | 1.72 | 70.0[e] | 4.10 | 55.4 | 2.18 |

[a] Shelled corn differed from dogfood ($\alpha = 0.05$)
[b] Includes Bear 69, whose digestibility coefficient for ADF for dogfood was >100%.
[c] Bear 69 is excluded from this average because her ADC was an outlier.
[d] 66.1% digestibility for dogfood was used to determine digestibility of squawroot by difference, rather than the bears' individual ADF digestibility coefficients.
[e] Excludes bears 66 and 67 due to low intake. Including bears 66 and 67, %DE is 55.5 +/- 4.10.

**Gross Energy**

Mean gross energy contents (kcal/g) were different among all diet combinations (*P* < 0.001) except dogfood, squawroot, and northern red oak acorns; squawroot and chestnut oak acorns; and shelled corn, white oak acorns, and chestnut oak acorns. Mean gross energy contents ranged from 4.036 kcal/g for shelled corn to 5.291 kcal/g for doughnuts (Table 12).

**Digestible Energy 1998**

Bears consumed an average of 85.4% of the food offered them. Apparent digestible energy was 18.6% greater for doughnuts than for shelled corn (*P* < 0.001), and 11.4% greater for white oak acorns than for northern red oak acorns (*P* = 0.005). Apparent digestible energies ranged from 61.0% in red oak acorns to 95.6% in doughnuts (Table 10).

**Digestible Energy 1999**

Bears consumed an average of 76.5% of the food offered them for all 1999 food trials; excluding data from the northern red oak trial, which had substantially lower consumption than other diets, average consumption was 84.9%. Apparent digestible energy for dogfood was 15.6% greater than for shelled corn (*P* = 0.007); northern red oak acorns (70.0%) did not differ from chestnut oak acorns (55.4%; *P* = 0.680). Apparent digestible energies ranged from –20.3% in squawroot to 94.6% in doughnuts (Table 11).

Table 12. Nutrient composition [%] (dry matter = DM, crude protein = CP, ether extract = EE, neutral detergent fiber = NDF, acid detergent fiber = ADF) and gross energy [kcal/g] (GE) of black bear foods, Virginia, 1998 - 1999. Values within a column with the same letter did not differ at the $\alpha = 0.05$ level.

| **Food** | ***n*** | **DM** | **SE** | **CP** | **SE** | **EE** | **SE** | **NDF** | **SE** | **ADF** | **SE** | **GE** | **SE** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shelled corn | 5 | 92.8 | 0.61 | 8.8[b] | 0.27 | 3.5[d] | 0.23 | | | | | 4.036[d] | 0.01 |
| Dogfood | 3 | 95.2 | 0.33 | 28.8[a] | 2.31 | 8.2[c] | 1.08 | | | 8.9 | 0.63 | 4.580[b] | 0.04 |
| *Conopholis americana* | 1 | 94.3 | | 6.7[bcd] | | 1.3[d] | | 62.4[a] | | 47.1 | | 4.418[bc] | |
| Doughnuts | 3 | 96.0 | 0.87 | 7.6[bc] | 0.12 | 24.7[a] | 0.38 | | | | | 5.291[a] | 0.04 |
| *Quercus rubra* | 4 | 95.7 | 0.56 | 4.7[e] | 0.28 | 12.0[b] | 0.77 | 54.3[b] | 0.83 | | | 4.701[b] | 0.06 |
| *Q. alba* | 3 | 93.5 | 1.09 | 6.3[cd] | 0.11 | 4.7[d] | 0.76 | 45.7[c] | 0.87 | | | 4.100[d] | 0.06 |
| *Q. prinus* | 2 | 95.5 | 0.03 | 5.1[de] | 0.11 | 2.4[d] | 0.07 | 44.7[c] | 0.54 | | | 4.137[cd] | 0.03 |

## DISCUSSION

### Apparent Digestibilities

Apparent (gross) digestibility, as opposed to true (net) digestibility, does not correct for the endogenous metabolic products, such as fecal protein, lipids, or vitamins, which appear in the feces with the nondigested feed residues, and is always lower than true digestibility when a metabolic loss occurs (Robbins 1993:292). Negative apparent digestibility coefficients occur when metabolic and nondigested fecal losses exceed intake. Not accounting for urinary losses (the primary route of digested nitrogen loss; Robbins 1993:311) of protein in apparent digestion studies leads to an overestimate of protein utilization or quality. In addition, urinary contamination of the feces can lower apparent protein digestion. I do not know whether, or to what extent, this occurred in this study. We did not measure urinary loss since we were not determining nitrogen balance.

Some foods are less digestible than others due to the presence of certain chemical constituents that may prevent digestive enzymes from contacting the proper substrates (Schneider and Flatt 1975:251). Plant tannins, such as those found in acorns, can greatly reduce apparent protein digestibility (Robbins et al. 1987) in their ability to precipitate proteins (Hagerman 1989), but the reduction is much less in animals, such as black bears, that secrete tannin-binding salivary proteins (Robbins et al. 1991). Red oak acorns, which have been shown to have higher tannin content than white oak acorns (Chung-MacCoubrey, et. al 1997), were less digestible than white oak acorns in this study. Protein is also depleted during detoxification of secondary plant metabolites such as terpenes (Kimball et al. 1998).

The ratio between protein and the nonnitrogenous constituents of a food affects the apparent digestibility of protein (Schneider and Flatt 1975:251). Additionally, protein-rich feeds added to a low protein diet tend to stimulate microorganisms in the gastrointestinal tract and increase fiber digestibility (Schneider and Flatt 1975:252). Other studies found the percentage of protein to affect the digestibility of all nutrients (Schneider and Flatt 1975:252). In a study of protein digestion in moose, Schwartz et al. (1987) found that increased protein in the diet resulted in increased apparent digestion of crude protein, and concluded that apparent digestible protein is not an accurate way to determine the dietary contribution of protein to the animals since fecal nitrogen derives from many sources. Low protein diets usually have low protein digestibility, possibly due to decreased bacterial activity, and may even have negative apparent crude protein coefficients when the fecal protein (which includes metabolic nitrogen loss) exceeds nitrogen intake (Schneider and Flatt 1975:207).

The relationship of apparent crude protein digestibility between red and white oak acorns in this study (Table 9, Table 10) were similar to those of Chung-MacCoubrey et al. (1997), who found crude protein digestibility in gray squirrels to be greater for white oak acorns than for red oak acorns. Schneider et al. (1946, 1947; Schneider & Flatt 1975:207) showed the effects of varying crude protein levels in hay rations on apparent crude protein digestibility in sheep and cattle; zero digestibility occurred at about 4% crude protein and decreased exponentially as the percentage neared zero. Crude protein content of red oak acorns in this study was low enough (4.7%) to achieve a negative digestibility coefficient of –39.2% in 1998 and –13.0% in 1999.

Apparent acid detergent fiber digestibility for squawroot also had a negative coefficient in this study (–18.9%). An associative interaction between the squawroot and the basal diet of high protein dogfood diet appears to have occurred, though not in a manner consistent with Schneider and Flatt's (1975) postulate that protein-rich feeds increase fiber digestibilty. The acid detergent fiber in dogfood was highly digestible (66.1%) when fed alone, however, the digestibility of the mixed squawroot/dogfood diet was only 33.9%. Had the fiber in squawroot been zero percent digestible and no associative effects occurred, the acid detergent fiber digestibility coefficient should have been 43.6%.

Bears do not digest fiber efficiently, and the amount of fiber digested varies depending on digestion inhibitors, rate of passage (Robbins 1993:298, 295), and the nature and origin of the carbohydrate (Rerat 1978). Although some adaptations of bears reflect their dietary evolution from carnivory to mainly herbivory, grizzly bears do not digest course forage efficiently (Bunnell and Hamilton 1983). Bunnell and Hamilton (1983) tested the digestibilities of a basal diet of horsemeat and dog chow, blueberries and salmon, and beet pulp on captive grizzly bears and found that the diet containing the highest amount of fiber (beet pulp) had the lowest digestibility. Results from this study showed similar trends, with squawroot being the highest in fiber and the least digestible of the test foods. Type of gastrointestinal tract affects fiber digestibility too, as ruminants, who exhibit slower passage rates, typically digest fiber more efficiently than nonruminants, who possess less complex digestive systems (Robbins 1993). The simple stomach of bears, too acidic to support the microbial bacteria necessary for cellulose digestion, and lack of a cecum, make fiber digestion inefficient and limiting (Rogers 1976).

Increased intake can cause faster passage rates (Robbins 1993:332, Brody and Pelton 1988), and thus less efficient digestion. In addition, the possible laxative effect of fiber could cause more rapid passage, resulting in decreased digestion.

Nutritive composition can be a good indicator of a food's value, but does not always represent the amount available to an animal. Crude protein was slightly, but not significantly, higher in shelled corn than in doughnuts; however, apparent digestibility of crude protein for doughnuts was significantly higher than shelled corn. Fat content of red oak acorns was significantly higher than white oak acorns, but apparent digestibility of fat was higher for white oak acorns than for red oak acorns.

Several studies have determined nutrient content of black bear foods, including some tested in this study (Appendix 4). Despite some analytical differences between studies, results are fairly similar. Crude protein values varied the most among studies for squawroot (3.66%) and the least for white oak acorns (1.98%). Ether extract values varied the least for squawroot (0.04%) and the most for chestnut oak acorns (15.4%). Gross energy varied the most for red oak acorns (1.21 kcal/g) and the least for squawroot (0.38 kcal/g). Fiber values were less comparable because of varying methods of analysis. My results were consistent with Eiler's (1981) postulate that hard mast in the fall tends to be high in carbohydrates and fats, as shown in the acorn nutrient composition determined in this study. Squawroot, which was low in fat, high in fiber, and had moderate protein levels, did not follow the trend of summer diet nutrient levels found by Hellgren at al. (1989); however, analyses for fat and fiber were different. Squawroot in this study was picked in summer, when bears normally eat it (Beeman and Pelton 1980, Eagle and Pelton 1983, Garner 1986, Kasbohm et al. 1995), but not fed until fall. Thus, it may have undergone some changes while frozen prior to analysis.

**Are Some Foods Better Than Others?**

Determining which foods are better than others requires combining elements of palatability, availability, nutrient content, and digestibility. Bears consume 5,000 – 8,000 kcal/day in early spring and summer, and as much as 15,000 – 20,000 in fall (Nelson et al. 1983). Nutritional composition and requirements of black bear diets appeared similar in Great Dismal Swamp, Virginia-North Carolina and Great Smoky Mountains National Park, Tennessee-North Carolina. Spring black bear diets were typically herbaceous material high in protein and fiber; summer diets were high in fruits that were low or moderate in protein, moderate in acid detergent fiber, and high in carbohydrates; and fall diets were mainly hard mast that was low in acid detergent fiber and protein, but high in fats and carbohydrates (Eagle and Pelton 1983, Hellgren et al. 1989). Carbohydrates, fats, and proteins are all sources of energy in foods, but fat supplies more calories by weight, assuming equal digestibility (Schneider and Flatt 1975). According to my results, doughnuts were the most digestible food, and had the highest fat content and digestibility, and may therefore be considered by some to be the best bear food. Doughnuts likely are a localized, quick energy source for bears in Virginia due to feeding by bear hunters in the summer, and may aid in fat assimilation in the beginning of the hyperphagic period before denning. However, doughnuts are not a natural food for bears, and feeding an unnatural food high in sugar and fat may have deleterious effects, possibly health-related, but especially behavioral. White oak acorns were probably the most valuable to bears of the natural foods tested in this study, given their high fat and energy digestibilities, and their apparent desirability to bears (Bacon and Burghardt 1983). The fat content of red oak acorns (12%) was high enough that, despite it's lower digestibility (80.0%) than that of white oak acorns (96.4%), it still provided more available fat to bears. Most studies of bear food habits do not separate acorns by species (Beeman and Pelton 1980, Eagle and Pelton 1983, Garner 1986, Kasbohm 1994), so it is difficult to know whether a preference exists. Ruffed grouse (Servello and Kirkpatrick 1989), fox squirrels (Havera and Smith 1979), and gray squirrels (Chung-MacCoubrey 1993) had a higher dry matter intake of white oak acorns than red oak acorns, which may have reflected higher palatability and lower metabolizable energy of white oak acorns. The higher tannin content of red oak acorns may be a deterrent to animals, especially when fed alone with no other food to dilute or counteract the effects of the toxin (Chung-MacCoubrey 1993).

Bears' preferences for foods, as well as fruit biomass and nutritional value of the fruits, determine the relative importance of different foraging areas for bears (Noyce and Coy 1990). Morrison et al. (1992) discuss the use of preference, or electivity indices, which utilize a single index value to compare the frequency of food items in a diet with the availability of those items in the animal's environment.

Hewitt and Robbins (1996) developed correction factors (CF) during grizzly bear (*Ursus arctos*) digestion trials to relate the volume of residue in feces to the mass of dry matter ingested (CF = g dry matter ingested/ml residue in the feces). Correction factors can be applied by multiplying a diet item's percent volume in the feces by its corresponding correction factor, then dividing this product by the sum of all the products and multiplying it by 100 to obtain the diet item's percent dry matter contribution to the total diet. Correction factors are useful for estimating food habits of animals when scats containing recognizable food items are available and the amount of food eaten is unknown; however, associative effects can occur with different diet combinations, and may decrease accuracy of results.

Development and use of correction factors for eastern bear foods to determine the proportion of foods ingested, and use of electivity indices, or some other measure which relates availability and use, to relate amount of food eaten to availability, may provide an accurate assessment of which foods are truly important to bears, and may be a valuable tool in black bear management.

## Confounding Factors

### *Cage Set-up*

Feeding trials are typically conducted in small metabolism cages equipped with mesh floors with a fecal collection tray below (Pritchard and Robbins 1990, Chung-MacCoubrey et al. 1997). Bears used in this study were in large (5.0 m diameter) cages with an asphalt floor, which allowed them to move freely, but made fecal collection difficult. Since there were no trays below the cages separating bears from their feces, the possibility of bears stepping in their feces existed, especially while trying to coax the bears into the lockable culvert attached to the cage. This did not occur often, but made fecal collection difficult and possibly less accurate on some occasions. The rough asphalt cage floor surface probably caused some error in collection of softer feces since it was impossible to scrape up the entire amount. The doughnut feeding trial was probably the most affected, and may have had elevated digestibility coefficients as a result. The large cage size and rough floor surface also made ort collection difficult during the acorn feeding trials. Since fall scats of wild bears in Virginia typically contain pieces of acorn shells, we assumed that wild bears ate the entire acorn (minus the cap). In fact, the captive bears shelled the acorns and ingested relatively few shells. Most shells remained in the feeding troughs, however, some bears scattered acorn shells throughout their cages. The shells were relatively easy to see on the surface of the cage floor, but the roughness of the asphalt hindered collection.

### *Variability Among Animals*

I used 5 rather than 6 bears for the digestion trials due to difficulties locking the bears in their culverts; however, this number still fell within the number range recommended by Pond et al. (1995) (4 to 6) as sufficient to detect differences between diets since variability between animals is typically relatively low. Schneider and Flatt (1975:321) maintain that few animals are needed in digestion experiments; however, using animals of similar sex, size, weight, and condition will decrease the variation between sampling units. During 1999, bear 69 usually ate less than all of the other bears, and was the only bear to refuse food during the dogfood and corn experiments. Two bears ate so little food during trial 12 in 1999 that they had to be removed from the analysis.

Reproductive status may have been another source of variation among bears used in this study that could have affected behavior or digestion. Seven of the 9 female bears used in this study were pregnant (Appendix 7). Their reproductive status likely did not affect the food trial results since implantation occurs in late November or early December in Virginia (Hellgren et al. 1989), when most of the trials were finished. However, the last trial in 1999 did not end until 21 December, so the physiological state of some bears may have changed during this time. Feeding rates declined during the last trial in 1999, but appeared to be a factor of the food offered since intake was lower for red oak acorns than for chestnut oak acorns fed at the same time. Grindley et al. (1917) suggest that castrated males are the easiest animals to work with in digestion experiments because of the decreased chances of urine contaminating the excreta. I have not found in the literature any indication that male digestion would differ from female digestion except maybe during gestation or lactation, and these results do not suggest a difference between the male bear and the females used in 1998.

#### *Unplanned Sampling*

Normally, sampling of captive bears (e.g., blood and measurement collection), occurred on the days between feeding trials. Bear 66 was anesthetized on a separate occasion (4 and 6 October 1999) to have her broken lower jaw examined and repaired by a veterinarian. The procedure occurred on the first and third days of trial 7, when bear 66 was being fed dogfood. She ate less than half of her food for the first 5 days of the feeding trial, but then consumed everything she was fed during the fecal collection period. Rerat (1978) discusses some effects of antibiotic drugs on digestion, including reduction in the amount of metabolic fecal nitrogen (of microbial origin) excreted, as well as inhibition of formation of some amines produced by bacteria targeted by the antibiotic being used. It is unlikely that the 2:1 mixture of ketamine hydrochloride/xylazine hydrochloride had an effect on digestion, as it is a dissociative and muscle relaxant, and had likely passed through her system by the time fecal collection for that trial began.

### *Scavenging of Feces*

During both years, partial scavenging of feces occurred by rats (*Rattus norvegicus*) and occasionally songbirds during several feeding trials. Scavenging occurred most during the shelled corn trials. Unfortunately, the occurrence of scavenging was not recorded well. I recorded the number of fecal piles scavenged out of the total number of scats in that cage, but did not always record the number of scats in the non-scavenged cages, so it is impossible to quantify the scavenging accurately. Some feces of bears that were fed doughnuts were also scavenged, and whole acorns were sometimes scavenged from the food dishes. A significant amount of scavenging could cause overall dry matter digestibility to appear higher since total fecal output would be underestimated. In 1998, partial scavenging occurred in 64% (14 of 22, all corn diet) of the feces in cages where scavenging occurred during trial 1, and 53% (3 of 8 corn diet; 6 of 9 doughnut diet) of the feces in trial 2 in cages where scavenging occurred (15% of total feces from all cages). In 1999, 50% (15 of 30) of the feces in cages where scavenging occurred during the shelled corn trials were partially scavenged. Some minimal scavenging occurred during the 1999 doughnut feeding trial.

### *Switchback Design*

I did not adhere to the "switchback" experimental design during the second year due mainly to timing of availability of certain foods. This did not affect the outcome of the digestibility experiments, but prevented me from making valid statistical comparisons between some food items.

### *Mixed Diets*

We were unable to collect enough squawroot to feed only squawroot to 5 bears for 10 days, so we mixed the squawroot with a basal diet of dogfood and determined its digestibility by difference. We collected squawroot during summer 1999 and froze it until ready for use. I pretested feeding previously frozen squawroot stalks to a captive bear and determined that it would be palatable after having been frozen, and that the bears would eat the entire stalk, rather than just the berries, as Powell and Seaman (1990) had often observed.

Due to scheduling difficulties with other food trials, the dogfood trial used in the by-difference equation for squawroot digestibility was conducted prior to the squawroot trial rather than at the same time, as ideally should have happened. We assumed, then, in the by-difference equation, that the basal dogfood used in the mixed diet with squawroot had the same digestibility as that used in the preceding dogfood trial. Therefore, the accuracy of the results may be compromised, as variation in digestibility due to time cannot be eliminated as a possible source of error. However, Schneider and Flatt (1975:152) suggest that digestibility of basal diets used in by-difference equations are usually determined in a trial preceding the mixed-food trial.

I partially homogenized the squawroot-dogfood mixture by chopping the squawroot into small pieces prior to mixing it with the dogfood. Evidently, this was not enough homogenization, because the bears tended to pick the dogfood pieces out of the mixture and eat mainly those. The refusals consisted mainly of squawroot. Had I blended the 2 foods better, or perhaps added molasses to increase the palatability, squawroot intake may have been improved.

Determination of digestibility by difference assumes, sometimes erroneously, that the digestibility of each of the foods is the same when fed together as when fed alone, and is less accurate than determination of a food's digestibility when fed alone (Schneider and Flatt 1975:156). Although Pritchard and Robbins (1990) found associative effects between diet items during digestion in bears to be minimal, they did seem apparent in this study during the squawroot/dogfood trial, as mentioned above. Associative effects seem to be most evident in carbohydrates (Schneider and Flatt 1975:157), as evidenced by the acid detergent values for squawroot obtained in this study. Apparent fiber digestion was positive for dogfood and for dogfood mixed with squawroot; however, values for squawroot determined by difference were negative.

***Squawroot Ripeness***

The amounts of squawroot orts varied dramatically from day to day. We may have unknowingly collected batches of squawroot at different stages of ripeness or palatability, which could have affected daily intake rates. In addition, the squawroot was frozen prior to the food trial, which may have affected its palatability and digestibility. Frost can affect crops (drying and leaching), depending on their stage of maturity (Schneider and Flatt 1975); however, freezing squawroot soon after it was harvested probably would not have the same effect as frost. Nutritive and caloric values of seeds may change during maturation, and may vary between years, by geographic area, by habitat (Grodzinski and Sawicka-Kapusta 1970), or by exposure to different weather conditions (King 1944). Not only do the chemical compositions of plants change as a plant matures, but the crude fiber content increases and is less digestible than the fiber in younger plants (Schneider and Flatt 1975). Perhaps the days squawroot was collected and its maturation made a difference in its palatability.

***Time of Year***

A notable decline in food intake occurred during the northern red oak food trials in 1999, and may have been influenced by the onset of winter, when bears naturally cease feeding and begin hibernating. However, intake of chestnut oak acorns, which were fed at the same time as northern red oak acorns, did not obviously decline. Intake during the northern red oak acorn food trial in 1998 appeared to be much higher than in 1999 (Appendices 11, 19), but the 1998 trial occurred about 1 month earlier than in 1999. Northern red oak acorns have a relatively high tannin content (Wainio and Forbes 1941, Chung-MacCoubrey et al. 1997), which likely reduces their palatability. However, Wainio and Forbes (1941) found the tannin content of chestnut oak acorns to be higher than that of northern red oak acorns. Nitrogen-free extract, an indicator mainly of readily-available carbohydrate content, in chestnut oak acorns was higher than in northern red oak acorns (Wainio and Forbes 1941). Kimball et al. (1998) found that bears exhibited a chemically-mediated preference for forage low in terpenes and high in carbohydrates, and postulated that the preference for high carbohydrate concentration would prevail as long as the energetic benefits exceed the cost of terpene detoxification.

Another confounding factor related to time of year is whether my digestibility results are representative of nature, and whether bears' digestion changes during the year. I tried to feed the test foods at the same time of year bears would normally eat them in the wild; however, the squawroot trial took place at an abnormal time of year. Squawroot is typically a late spring/early summer food for bears (Garner 1986, Powell and Seaman 1990, Powell et al. 1997), and my food trial took place in October. This was unavoidable since we did not have any captive bears during the summer when squawroot is ripe, and since we would not have been able to collect enough fast enough to keep up with the feeding trial. The acorn trials took place during the fall and were fairly representative of nature. Doughnuts and shelled corn, which represent the 2 main unnatural foods provided to bears by hunters, were fed during September, one of the 3 months during which most supplemental feeding occurs.

Bears change physiologically to allow for rapid weight gain for denning (Brody and Pelton 1988) and may more than double their daily intake during hyperphagia in the fall (Nelson et al. 1983). Certain nutrients are digested more efficiently during certain times of year, according to physiological requirements of bears (Brody and Pelton 1988). Protein digestion was higher in August than November for captive bears in Tennessee, while the opposite was true for fat and carbohydrates (Brody and Pelton 1988). Evidence of seasonal changes in digestion in other animals seems to be related to changes in rumen physiology and bacterial levels (Mathiesen et al. 1987, Freudenberger et al. 1994). If similar seasonal, physiological trends occurred with the captive bears used in this study, it is possible that digestion results could be different if identical diets were fed at other times of year. In addition, if the bears' physiological states were changing during the fall, my digestibility results could be partially dependent on the order in which I fed the diets; however, it is impossible to tell since I did not continue to feed the same diets throughout the fall or have all diets represented during each food trial.

***Parasites and Infestation***

Visible parasites were seen in the feces of bear 69 on 1 October 1999. I supplied the Virginia Maryland Regional College of Veterinary Medicine with fecal samples from bears 66, 67, 68, 69, and 70 on 7 October 1999 for parasite analysis, but results were not available. The presence of parasites could increase the apparent digestibility of some nutrients by decreasing their proportion in the feces.

Rottenness (>50% of the acorn) and/or weevil infestation occurred in 14.7% of northern red oak acorns, 10.7% of white oak acorns, and 18% of chestnut oak acorns used in this study. These numbers do not appear as high as those in the Pisgah Bear Sanctuary, North Carolina, where 35% of sampled acorns were infested by weevils (Powell and Seaman 1990), or in the Tellico Wildlife Management Area, Tennessee, in which 40% of white oak acorns and 31% of northern red oak acorns were damaged by insects (Strickland 1972). More than half of the acorns used in this study were collected outside Virginia and may differ in rottenness or infestation from those in Virginia. Although weevils render part of the infested acorn unavailable to wildlife, they may provide an additional source of protein for bears (Powell and Seaman 1990).

## Recommendations for Future Digestibility Studies

The Center for Ursid Research is not an ideal facility for conducting digestion experiments. The asphalt floor prevented precise fecal collections important to such an undertaking. Ideally, cages such as metabolism crates, which allow excreta to be separated from the experimental animals, should be used to avoid disturbance by the study animals. The experimental facility should be clean and sealed from other animals that could scavenge the test foods or excreta. If squawroot were to be tested again in the future by difference, I would recommend testing different levels of squawroot in the basal diet to determine the degree to which associative effects occur. In addition, homogenization of the squawroot with the basal diet may be essential for adequate intake of the experimental diet. Increased palatability can be achieved by mixing less palatable foods with molasses, and feeding fresh rather than previously frozen foods.

## Summary

Despite the confounding factors that challenged the digestion trial procedures, I believe results are a good index of the ability of black bears to digest some common eastern black bear foods. Digestibility had not yet been determined for these foods for bears, and data from this study provide the groundwork and a means for comparison for future digestion studies of eastern foods for black bears and other wildlife. The white oak acorn, chestnut oak acorn, and 1998 northern red oak acorn trials may have provided the most accurate results due to high intake by bears and negligible, if any, scavenging by other animals. The shelled corn trials were the most affected by scavenging, and resulting digestibility coefficients may have been higher than in actuality. My results may provide ceiling values for the nutrient digestibility of shelled corn for black bears, but are likely not minimum values. Results from the shelled corn trial in April 1999, which are not directly comparable since the time of year is different, appear to be similar to the results of the other 2 shelled corn feeding trials, suggesting that scavenging may not have greatly affected results. However, bears are in different physiological states in spring and fall (Nelson et al. 1983) and perhaps should show differences in digestibility at different times of year (Brody and Pelton 1987). Protein digestion may be expected to be higher in the spring and summer than in the fall, when, according to Nelson et al. (1983), lean body growth ceases. If digestion in bears is truly different at different times of year, then similar crude protein digestion results in spring and fall suggest experimental error, possibly the result of scavenged feces. Results of doughnut digestibility were quite similar between 1998 and 1999, despite heavier scavenging during 1998; the effects of scavenging on the results were therefore likely minimal. The squawroot results revealed an interesting associative affect with fiber digestion in dogfood, and contradicted others' findings that high protein levels in a food increase the digestion of other nutrients. Rather, the high fiber content of the squawroot seemed to reduce fiber digestibility of dogfood. Northern red oak acorn results in 1999 were the most affected by bear behavior, as bears' intakes were probably too low to obtain accurate digestibility results.

A firm understanding of wildlife nutrition provides a basis for learning about the survival and productivity of wildlife populations, and is an important aspect of wildlife ecology and management (Robbins 1993:1). Many biologists have studied food habits of bears and other wildlife, usually through observation and scat analysis, but results are limited without knowledge of the values of different foods to wildlife. Values of foods should no longer be judged solely by their nutrient contents, but also by their digestibilities to wildlife. Nutritional requirements of animals are still largely unknown (Golley et al. 1965, Welch et al. 1997), but the need for understanding physiological and nutritive requirements of animals from an ecological perspective is great (Robbins 1993).

**Management Implications and Recommendations for Further Study**

Successful bear management requires understanding the relations between black bear populations and nutritional processes, habitat composition, and silvicultural practices (Noyce and Coy 1990). To determine management procedures, biologists and managers must know the kinds of foods important to bears, in addition to their quantity, quality, and utilization (Beeman and Pelton 1980).

Many studies suggest that human food sources can enhance reproduction in bears (Rogers 1976, Herrerro 1983, Alt 1989). Dumps and feeding sites provide an easy, predictable food source for bears with a high benefit to cost ratio (food acquisition with little energy expenditure) in most cases. Results from my feeding trials suggest that corn and doughnuts may be a food source high in fat and relatively high in protein, and highly digestible by bears. Survey results suggest that corn and doughnuts are the 2 foods most commonly offered to bears by bear hunters at feeding sites. Feeding occurred in 25 of Virginia's 95 counties, but probably impacted only local bear populations. Bears are capable of eating large quantities of food in a short time (Nelson et al. 1983), and will act aggressively near limited food sources (Herrerro 1983), hence, the first bear to arrive at a recently stocked feeding site probably will benefit the most. Most bear hunters stocked feeding sites in July, August, and September, preceding the hyperphagic stage of bear physiology when bears increase food intake in preparation for winter (see Chapter 1). Individual bears that use feeding sites that are stocked through December may benefit more from supplemental food than bears that use sites only stocked in summer. The benefits of allowing supplemental feeding by bear hunters (source of food high in energy and fat; high energy yield/feeding time; sustained reproduction after mast failures; constituent satisfaction) must be weighed with the consequences (chance of habituation to people; possibility of increased littering; artificial food source; alteration of natural bear behavior) to make a decision on whether to permit feeding.

Acorns provide an important food source for bears (Landers et al. 1979, Beeman and Pelton 1980, Eagle and Pelton 1983, Garner 1986) in nearly all localities where oak trees occur, and should be propagated by managers for future use by bears and other wildlife. White oak acorns may be one of the preferred and most digestibly useful species of acorn for bears in Virginia. However, due to frequent mast crop failures of oaks, other species of oaks and other hard and soft mast producers should be cultured as well (Kasbohm et al. 1995). Some oaks can take up to 35 years to produce acorns and may not peak until 40 - 60 years (Daniel et al. 1979), a fact which requires much forethought by forest and wildlife managers to ensure proper planning of silvicultural practices to provide a stable supply of mast for bears and other wildlife.

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# APPENDICES

Appendix 1. Cover letter mailed with Supplemental Feeding Survey to Virginia Bear Hunters Association members on 28 October 1999.

October 28, 1999

Dear Bear Hunter,

Since the initiation of the Cooperative Alleghany Bear Study (CABS) in 1994, we learned that bear hunters provided supplemental food to bears throughout the year in our study areas. The quantity and quality of supplemental food provided to bears was unknown, however, it is possible that bears benefited from using these food sources.

Recently, the Virginia Department of Game and Inland Fisheries (VDGIF) proposed a law that was passed by the Commonwealth of Virginia which made it illegal to feed wildlife on public lands beginning July 1, 1999.

Originally, we had intended to determine if a link existed between supplemental feeding and the high reproductive and survival rates we have recorded in Virginia black bear populations. However, now that feeding on public lands is illegal, we will change strategies and compare reproductive and survival rates of bears before and after the change in feeding laws to see if we detect differences.

To investigate this relationship we are distributing an anonymous survey to all members of the Virginia Bear Hunters Association. Our goals are (1) to obtain an estimate of the amount of supplemental food that was provided to bears annually, (2) to determine the effects supplemental food may have had on population size and distribution, age of first reproduction, adult body size, and litter size, and (3) to determine hunters' opinions of and responses to the new feeding laws.

The enclosed survey will take about 20 minutes to fill out. Your response to this survey will not be linked to your name in any way. Instead, each survey is coded using a numbering system that will enable us to check returned surveys off the list and prevent reminder notices and duplicate mailings from being sent to people who have already returned their surveys.

Bear hunter cooperation with CABS has been essential to black bear research in the George Washington-Jefferson National Forests. We ask for your continued support by taking time to fill out the enclosed survey and returning it promptly in the envelope provided. Thanks.

Sincerely,

Rachel Gray
Graduate Research Assistant,
Virginia Tech

Appendix 2. Supplemental Feeding Survey reminder card mailed to Virginia Bear Hunters Association members on 17 November 1999.

November 17, 1999

Dear VBHA member,

Last week you were sent a survey investigating aspects of supplemental feeding of bears. If you have already completed the survey and returned it to us, please disregard this card and know that your cooperation is appreciated. If you have not yet completed the survey, I ask you to take the time to fill it out and return it to us.

We hope to estimate the amount of food that was provided to bears on an annual basis prior to the recent change in laws regarding the feeding of wildlife in Virginia, and whether reproduction rates in bears will change as a result of the change in feeding laws. Our results are dependent upon a high survey response rate. If you do not currently feed bears or never fed bears in the past, it is still important that you return the survey.

If you did not receive a survey or have misplaced the one you had, please call me today (540-231-3776) and I will send you one. Thank you.

Sincerely,

Rachel M. Gray
Graduate Research Assistant,
Virginia Tech
Cooperative Alleghany Bear Study

Appendix 3. Cover letter sent with second mailing of Supplemental Feeding Survey to Virginia Bear Hunters Association nonrespondents on 8 December 1999.

December 8, 1999

Dear VBHA member,

About four weeks ago I sent a letter and survey to you regarding the supplemental feeding of bears in Virginia. We have not yet received your completed questionnaire.

We hope to obtain an accurate estimate of the amount of bear feeding that used to occur in Virginia prior to July 1, 1999 (when legislation made it illegal to feed bears on public land in Virginia), because we believe a link may have existed between supplemental feeding and the high reproductive rates we have recorded in Virginia black bear populations. Ultimately, we will compare reproductive rates of bears before and after the change in feeding laws. In order to find a correlation between supplemental feeding and reproduction, we need to know how much supplemental food was provided to bears both before and after the change in legislation.

I am writing to you to communicate the importance each survey has to this study. To get a quantitative estimate of all the feeding that occurred in Virginia before the change in feeding laws, we need as many returned surveys as possible. Surveys were sent to all members of the Virginia Bear Hunters Association because we believe that association included nearly all people who fed bears. So far we have received approximately 30% of the surveys sent out in our initial mailing. This number is not yet enough to accurately estimate the amount of bear feeding that occurred in Virginia prior to July 1, 1999. Whether we will be able to produce an accurate estimate depends on you and the others who have not yet responded. **It is important that we receive your response, even if you did not feed bears.**

In the event that your survey has been misplaced, another copy of the feeding survey is enclosed. I ask that you please take the time to fill it out and return it to me.

Your cooperation is greatly appreciated.

Sincerely,

Rachel Gray
Graduate Research Assistant,
Virginia Tech

Appendix 4. Nutrient composition [%] (CP = crude protein; EE = ether extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; NFE = nitrogen-free extract) and gross energy [kcal/g] (GE) of black bear food items from literature.

| Food item | CP | EE | crude fat | NDF | ADF | crude fiber | NFE | GE (kcal/g) | Ref. # |
|---|---|---|---|---|---|---|---|---|---|
| *Conopholis americana* | 5.14 | | | | | | | 4.662 | 5 |
| | 8.8 | 1.34 | | | | 16.53 | 69.1 | 4.8 | 11 |
| | 8 | | | | 22 | | | | 3 |
| | 6.7 | 1.3 | | 62.4 | 47.1 | | | 4.418 | 13 |
| *Quercus* (white oaks) | 5.9 | | 4.3 | | | 18.7 | | | 10 |
| *Quercus spp.* (with shell) | 7.0 | | | | | | | 4.95 | 9 |
| *Quercus spp.* (without shell) | 8.0 | | | | | | | 4.54 | 9* |
| *Quercus alba* | 7.2 | 8.8 | | | | | | 4.51 | 2* |
| | 7.3 | 8.8 | | | | | | 3.81 | 9* |
| | 6.73 | 5.67 | | | | 17.38 | 67.25 | | 7 |
| | 6.25 | 6.32 | | | | 2.47 | 82.32 | | 12* |
| | 5.32 | | | | | | | 4.054 | 5 |
| | | | | | | | | 4.461 | 6 |
| | | | | | | | | 3.907 | 1 |
| | 6.3 | 4.7 | | 45.7 | | | | 4.100 | 13 |
| *Q. rubra* | 5.22 | | | | | | | 4.541 | 5 |
| | 6.9 | 20.2 | | | | | | 5.29 | 2* |
| | 6.3 | 23.0 | | | | | | 4.08 | 9* |
| | 6.6 | 20.8 | | | | 3.1 | 67.1 | | 4 |
| | 6.56 | 20.81 | | | | 3.10 | 67.11 | | 12* |
| | | | | | | | | 4.919 | 6 |
| | | | | | | | | 5.199 | 8* |
| | 4.7 | 12.0 | | 54.3 | | | | 4.701 | 13 |
| *Q. prinus* | 4.63 | | | | | | | 4.188 | 5 |
| | 5.9 | 8.8 | | | | | | 3.31 | 9* |
| | 7.2 | 17.8 | | | | 15.6 | 58.4 | | 4 |
| | 6.94 | 5.05 | | | | 2.62 | 83.17 | | 12* |
| | | | | | | | | 4.072 | 1* |
| | 6 | | | | 4 | | | | 3* |
| | 5.1 | 2.4 | | 44.7 | | | | 4.137 | 13 |

*just meat of acorn

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13. Gray, R. M., this study

Appendix 5. Captive bear weights (kg), Center for Ursid Research, Virginia, 1998.

| Bear ID | 1 Oct | 12 Oct | 25 Oct | 6 Nov | 18 Nov | 30 Nov | 5 Dec | 14 Dec | 24 Dec | 2 April | 12 April |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M1 | 78.2 | 82.3 | 84.1 | 84.1 | 79.5 | 79.5 | N/A | 90.9 | 83.6 | 66.4 | 73.6 |
| 60 | 70.9 | 73.2 | 71.4 | 75.9 | 75.9 | N/A | 74.1 | 85.0 | 81.4 | 59.5 | 66.4 |
| 61 | 71.4 | 75.5 | 71.8 | 73.2 | 74.5 | 72.7 | N/A | 84.1 | 80.0 | 69.1 | 73.6 |
| 63 | 56.8 | 60.0 | 57.7 | 59.5 | 59.5 | 58.6 | N/A | 69.1 | 66.8 | 57.3 | 59.5 |
| 64 | 65.9 | 65.9 | 63.6 | 63.6 | 59.1 | N/A | 55.9 | 65.9 | 64.1 | 59.5 | 61.4 |

Appendix 6. Captive bear weights (kg), Center for Ursid Research, Virginia, 1999.

| Bear ID | 15 Oct | 27 Oct | 7 Nov | 18 Nov | 29 Nov | 10 Dec | 21 Dec |
|---|---|---|---|---|---|---|---|
| 66 | 110.0 | 113.2 | 113.6 | 113.6 | 123.2 | 120.5 | 114.1 |
| 67 | 109.1 | 111.4 | 114.1 | 115.9 | 122.7 | 119.1 | 115.9 |
| 68 | 102.7 | 98.2 | 107.7 | 110.0 | 119.5 | 116.4 | 115.9 |
| 69 | 69.1 | 72.7 | 75.0 | 75.0 | 71.8 | 75.0 | 75.0 |
| 70 | 107.3 | 109.5 | 113.6 | 113.6 | 130.0 | 122.7 | 123.2 |

Appendix 7. Weights (kg) and reproductive status and outcome of captive black bears, Center for Ursid Research, Virginia, 1998-1999.

| Bear ID | Weight in October[a] | Weight in December[b] | Reproductive status | Reproductive outcome |
|---|---|---|---|---|
| M1 | 82 | 84 | n/a | |
| 60 | 73 | 81 | Pregnant, 3 fetuses | 2 cubs 2/14/99 |
| 61 | 76 | 80 | Implanted late | Reabsorbed or lost fetuses |
| 62[c] | 77 | 89 | Not pregnant | |
| 63 | 60 | 67 | Pregnant, 2 fetuses | 1 cub born 2/5/99. Sow not lactating and abandoned cub. |
| 64 | 65.9 | 64 | Pregnant, 2 fetuses | Reabsorbed between 1/11/99 and 1/21/99 |
| 65[c] | 80 | 108 | Not pregnant | |
| 66 | 110 | 114 | Pregnant, 2 fetuses | 2 cubs 1/24/00 |
| 67 | 109 | 116 | Pregnant, 3 fetuses | 3 cubs born 1/9/00, one missing 1/20/00 |
| 68 | 103 | 116 | Pregnant, 3 fetuses | 3 cubs born 1/15/00; dead cub found 1/31/00 |
| 69 | 69 | 75 | Not pregnant | |
| 70 | 107 | 123 | Pregnant, 1 fetus | 3 cubs 2/5/00; 1 lost by 2/20/00 |

[a] Bears M1, 60-64 sampled on 12 October; Bears 65-70 sampled on 15 October and 21 December 1999.
[b] Bears M1, 60-64 sampled on 24 December 1998; Bears 65-70 sampled on 21 December 1999.
[c] Not included in food trial data. Fed a high protein dogfood throughout the study.

Appendix 8. Total food offered and refused and total feces (g DM) for Experiment 1 doughnuts, Center for Ursid Research, Virginia, 14 October – 4 November 1998.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| M1 | 5,201.28 | 0.0 | 100 | 150.73 |
| 60 | 5,187.72 | 0.0 | 100 | 226.27 |
| 61 | 5,173.71 | 0.0 | 100 | 265.69 |
| 63 | 5,183.28 | 0.0 | 100 | 276.24 |
| 64 | 5,218.01 | 0.0 | 100 | 219.47 |

Appendix 9. Total food offered and refused and total feces (g DM) for Experiment 1 shelled corn, Center for Ursid Research, Virginia, 14 October – 4 November 1998.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| M1 | 5,439.68 | 0.0 | 100.0 | 1,337.90 |
| 60 | 5,425.53 | 123.5 | 97.7 | 1,073.71 |
| 61 | 5,425.53 | 0.0 | 100.0 | 1,102.02 |
| 63 | 5,425.53 | 135.0 | 97.5 | 979.62 |
| 64 | 5,439.68 | 0.0 | 100.0 | 1,460.92 |

Appendix 10. Total food offered and refused and total feces (g DM) for Experiment 2 white oak acorn, Center for Ursid Research, Virginia, 11 November – 4 December 1998.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| M1 | 6,423 | 1,674.0 | 73.9 | 1,385.89 |
| 60 | 6,030 | 1,840.9 | 69.5 | 1,153.18 |
| 61 | 6,030 | 1,859.4 | 69.2 | 1,298.64 |
| 63 | 6,030 | 2,110.8 | 65.0 | 1,063.19 |
| 64 | 6,423 | 1,736.1 | 73.0 | 1,511.62 |

Appendix 8. Total food offered and refused and total feces (g DM) for Experiment 2 northern red oak acorn, Center for Ursid Research, Virginia, 11 November – 4 December 1998.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| M1 | 6,744 | 2,195.2 | 67.4 | 1,943.49 |
| 60 | 6,648 | 2,492.3 | 62.5 | 1,867.15 |
| 61 | 6,648 | 2,283.3 | 65.7 | 2,111.24 |
| 63 | 6,648 | 3,307.6 | 50.2 | 1,523.25 |
| 64 | 6,744 | 2,170.8 | 67.8 | 1,783.91 |

Appendix 12. Total food offered and refused and total feces (g DM) for Experiment 3 shelled corn, Center for Ursid Research, Virginia, 10 April 1999 – 19 April 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| M1 | 7,581.0 | 0.0 | 100.0 | 2,457.54 |
| 60 | 7,581.0 | 622.9 | 91.8 | 2,124.19 |
| 61 | 7,581.0 | 0.0 | 100.0 | 2,035.30 |
| 63 | 7,581.0 | 1,281.1 | 83.1 | 1,860.24 |
| 64 | 7,581.0 | 0.0 | 100.0 | 2,795.36 |

Appendix 13. Total food offered and refused and total feces (g DM) for Experiment 4 shelled corn, Center for Ursid Research, Virginia, 16 September 1999 – 13 October 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 9,673.34 | 0.0 | 100.0 | 2,923.29 |
| 67 | 9,673.34 | 0.0 | 100.0 | 2,571.84 |
| 68 | 9,673.34 | 0.0 | 100.0 | 3,602.11 |
| 69 | 9,606.08 | 844.8 | 91.2 | 2,522.87 |
| 70 | 9,606.08 | 0.0 | 100.0 | 2,556.32 |

Appendix 14. Total food offered and refused and total feces (g DM) for Experiment 4 dogfood, Center for Ursid Research, Virginia, 16 September 1999 – 13 October 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 9,500.97 | 0.0 | 100 | 2,380.87 |
| 67 | 9,500.97 | 0.0 | 100 | 1,949.18 |
| 68 | 9,500.97 | 0.0 | 100 | 2,006.67 |
| 69 | 9,503.01 | 5,366.4 | 43.5 | 772.17 |
| 70 | 9,503.01 | 0.0 | 100 | 1,785.13 |

Appendix 15. Total food offered and refused and total feces (g DM) for Experiment 5 squawroot/dogfood, Center for Ursid Research, Virginia, 17 October 1999 – 26 October 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 9,677.96 | 941.1 | 90.3 | 3,239.07 |
| 67 | 9,677.96 | 301.2 | 96.9 | 3,650.68 |
| 68 | 9,677.96 | 1,283.4 | 86.7 | 2,785.31 |
| 69 | 9,677.96 | 1,665.4 | 82.8 | 2,369.45 |
| 70 | 9,677.96 | 1,562.5 | 83.9 | 2,565.21 |

Appendix 16. Total food offered and refused and total feces (g DM) for Experiment 6 doughnuts, Center for Ursid Research, Virginia, 28 October 1999 – 6 November 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 6,990.36 | 0.0 | 100 | 366.63 |
| 67 | 6,998.43 | 0.0 | 100 | 430.11 |
| 68 | 7,175.24 | 0.0 | 100 | 361.86 |
| 69 | 7,203.60 | 0.0 | 100 | 432.88 |
| 70 | 7,229.22 | 0.0 | 100 | 340.26 |

Appendix 17. Total food offered and refused and total feces (g DM) for Experiment 7 white oak acorns, Center for Ursid Research, Virginia, 8 November 1999 – 17 November 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 11,816.40 | 3,479.7 | 70.6 | 2,887.36 |
| 67 | 11,816.40 | 3,125.0 | 73.6 | 2,883.16 |
| 68 | 11,816.40 | 3,029.4 | 74.4 | 2,794.07 |
| 69 | 11,816.40 | 5,689.4 | 51.9 | 1,474.30 |
| 70 | 11,816.40 | 3,029.0 | 74.4 | 2,547.62 |

Appendix 18. Total of food offered and refused and total feces (g DM) for Experiment 8 chestnut oak acorns, Center for Ursid Research, Virginia, 30 November 1999 – 20 December 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 10,601.71 | 3,637.4 | 65.7 | 3,542.37 |
| 67 | 10,599.06 | 4,130.0 | 61.0 | 2,539.72 |
| 68 | 10,600.12 | 3,150.2 | 70.3 | 3,139.29 |
| 69 | 11,102.56 | 3,891.9 | 64.9 | 3,408.06 |
| 70 | 11,102.00 | 3,776.8 | 66.0 | 3,393.87 |

Appendix 19. Total of food offered and refused and total feces (g DM) for Experiment 8 red oak acorns, Center for Ursid Research, Virginia, 30 November 1999 – 20 December 1999.

| Bear ID | offered | refused | % eaten | feces |
|---|---|---|---|---|
| 66 | 14,952.00 | 13,302.2 | 11.0 | 1,285.52 |
| 67 | 15,111.49 | 15,167.5 | 0 | 348.03 |
| 68 | 14,952.62 | 10,339.7 | 30.9 | 2,689.77 |
| 69 | 16,728.17 | 12,342.7 | 26.2 | 1,866.45 |
| 70 | 16,728.84 | 6,471.8 | 61.3 | 4,881.48 |

Appendix 20. Supplemental Feeding Survey distributed to Virginia Bear Hunters Association members, October 1999.


**BLACK BEAR**
**SUPPLEMENTAL FEEDING SURVEY**

---

Data will be used to determine the degree to which supplemental feeding occurred in Virginia prior to July 1, 1999, and whether it had an effect on Virginia's black bear population.

---

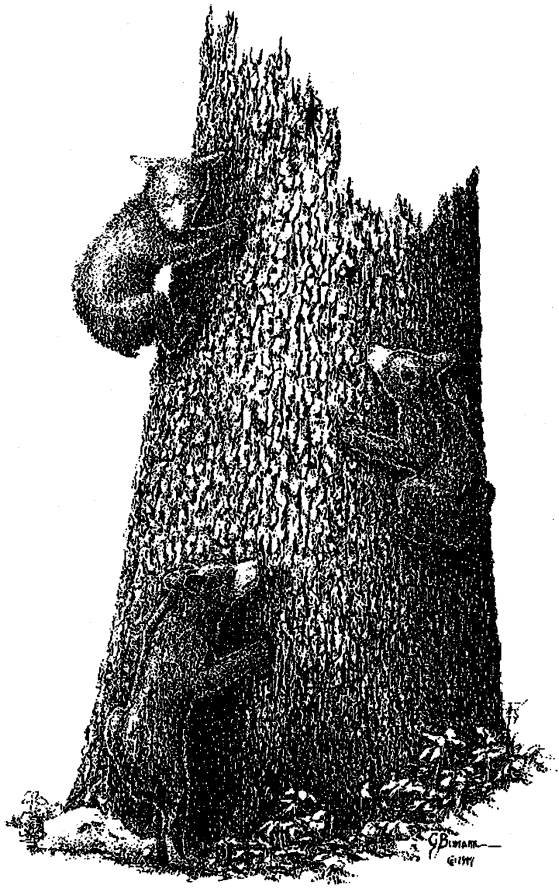
***This survey is anonymous. Your response to this survey will not be linked to your name.***

***Please choose the most appropriate response for each question and fill in the blank where appropriate. Choose only 1 response and then proceed to the following question unless otherwise indicated.***

***Answer questions as an <u>individual</u> person, rather than as part of a hunting party or hunt club.***

---

Appendix 20 continued.



❑ YES ❑ NO [IF NO, PLEASE GO TO (16).]

(2) How many years have you hunted bears? ........................ [ ]

*During the 1998 bear dog **training** season, ...*

(3) ... how many ***days*** did you hunt bears ***using dogs***? .......... [ ]

(4) ... how many ***bears*** did you ***chase***? ...................... [ ]

(5) ...how many ***bears*** did you ***tree***? ........................ [ ]

*During the 1998 bear dog hunting **harvest** season, ...*

(6) ... how many ***days*** did you hunt bears ***using dogs***? .......... [ ]

(7) ... how many ***bears*** did you ***chase***? ...................... [ ]

(8) ...how many ***bears*** did you ***tree***? ........................ [ ]

(9) ... did you harvest a bear? ............................. ❑ YES ❑ NO

*During the 1998 big game **firearms** season, ...*

(10) ... how many days did you ***gun*** hunt bears ***without dogs***? ..... [ ]

(11) ... how many ***bears*** did you ***see***? ........................ [ ]

(12) ... did you harvest a bear? ............................. ❑ YES ❑ NO

*During the 1998 **bowhunting** season, ...*

(13) ... how many days did you ***bowhunt*** bears? ................ [ ]

(14) ... how many ***bears*** did you ***see***? ........................ [ ]

(15) ... did you harvest a bear? ............................. ❑ YES ❑ NO

(16) During the period from July 1, 1998 to June 30, 1999, did you ever put food out for bears?

❑ YES ❑ NO [IF NO, PLEASE GO TO (19).]

(17) If you answered 'YES' to (16), please indicate ***where*** you put food out for bears.

❑ I FED ONLY ON PUBLIC LAND, SUCH AS NATIONAL FOREST. [SKIP TO (19).]
❑ I FED ONLY ON PRIVATE LAND. [SKIP TO (19).]
❑ I FED ON BOTH PUBLIC AND PRIVATE LANDS. [PLEASE GO TO (18).]

(18) What proportion of your overall feeding occurred on public land, such as National Forest?

❑ A) LESS THAN 25% ❑ C) 51 - 75%
❑ B) 25 - 50% ❑ D) GREATER THAN 75%

(19) Even if you did not feed bears directly during the period from July 1, 1998 to June 30, 1999, did you contribute money to a group, such as a hunt club, for the purpose of feeding bears?

❑ YES ❑ NO

(20) If you answered **YES** to (19) or (16), how much money did you spend on supplemental food for bears during the period from July 1, 1998 to June 30, 1999? (Direct expenditure **and/or** contribution to your hunt club.) .................................................. [$ ]

Page 2 -- Black Bear Supplemental Feeding Survey

*The remainder of this survey deals with aspects of feeding bears. If you did not put food out for bears between July 1, 1998 and June 30, 1999, please return your survey as is in the envelope provided. Please feel free to write any comments in the section provided on page 9. Thank you for taking the time to help with research on supplemental feeding of black bears.*

*If you did feed bears between July 1, 1998 and June 30, 1999, please continue to fill out the remainder of this survey before returning it in the envelope provided.*

(21) Did you usually share your feeding route with a group of people?

☐ NO [PLEASE GO TO (23).] ☐ YES [PLEASE GO TO (22).]

(22) This survey was sent to all members of the Virginia Bear Hunters Association (VBHA). We would like to know if this is a representative sample of all people who were involved with supplemental feeding of bears. How many of the people ***who assisted with your route*** are ***not*** members of the VBHA? . . . . ☐

(23) Did you know of anybody who was ***NOT*** a member of the VBHA and ***did NOT*** share your feeding route but ***did feed*** bears when it was legal?

☐ YES ☐ NO

***Please indicate how much you agree with the following statements.***

**Supplemental feeding of bears...**

| | | STRONGLY AGREE | AGREE | NEUTRAL | DISAGREE | STRONGLY DISAGREE |
|---|---|---|---|---|---|---|
| (24) | ... results in more chases during the dog training season. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (25) | ... results in more chases during the hunting season. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (26) | ...increases bowhunters' success. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (27) | ... creates nuisance bears. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (28) | ... creates a healthier bear population. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (29) | ... makes bears dependent on artificial food. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (30) | ...keeps bears in the area. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (31) | ... increases black bear reproduction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (32) | ...increases black bear survival. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (33) | ... gives bear hunters a good image to other hunters and non-hunters. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (34) | ... makes bears less afraid of people. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (35) | ... increases black bear population levels. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (36) | ... increases the chance of viewing bears. | ☐ | ☐ | ☐ | ☐ | ☐ |



**Supplemental feeding of bears...**

| | | STRONGLY AGREE | AGREE | NEUTRAL | DISAGREE | STRONGLY DISAGREE |
|---|---|---|---|---|---|---|
| (37) | ... increases danger to campers. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (38) | ... reduces crop damage. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (39) | ... increases chance of bear/vehicle collisions. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (40) | ...helps bears in years of mast crop failure (shortage of natural food). | ☐ | ☐ | ☐ | ☐ | ☐ |
| (41) | ... causes disease problems for bears and/or for other wildlife. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (42) | ... creates a negative public image. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (43) | ... results in bigger bears. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (44) | ... results in littering. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (45) | ... concentrates bears in certain areas. | ☐ | ☐ | ☐ | ☐ | ☐ |

***Please check the appropriate box to indicate how important each of the following characteristics was when choosing your feeding sites.***

| | | NOT AT ALL IMPORTANT | SOMEWHAT IMPORTANT | VERY IMPORTANT | DON'T KNOW |
|---|---|---|---|---|---|
| (46) | easy access to vehicle | ☐ | ☐ | ☐ | ☐ |
| (47) | distance from other feed stations | ☐ | ☐ | ☐ | ☐ |
| (48) | open tree canopy | ☐ | ☐ | ☐ | ☐ |
| (49) | closed tree canopy | ☐ | ☐ | ☐ | ☐ |
| (50) | thick underbrush | ☐ | ☐ | ☐ | ☐ |
| (51) | thin underbrush | ☐ | ☐ | ☐ | ☐ |
| (52) | ridgetop | ☐ | ☐ | ☐ | ☐ |
| (53) | hollow/drainage | ☐ | ☐ | ☐ | ☐ |
| (54) | previous success at that site | ☐ | ☐ | ☐ | ☐ |
| (55) | saw a bear there | ☐ | ☐ | ☐ | ☐ |
| (56) | saw bear sign there | ☐ | ☐ | ☐ | ☐ |
| (57) | far away from people traffic | ☐ | ☐ | ☐ | ☐ |
| (58) | tradition (I or others have fed there previously) | ☐ | ☐ | ☐ | ☐ |
| (59) | other ______________ | ☐ | ☐ | ☐ | ☐ |
| (60) | other ______________ | ☐ | ☐ | ☐ | ☐ |

(61) How many feeding sites did you, ***personally***, stock regularly? ....... ☐

What was the average distance between each of your feeding sites...

(62) ... on *public* land?

- ☐ Less than 1/4 mile
- ☐ Between 1/4 and 1/2 mile
- ☐ Between 1/2 and 3/4 mile
- ☐ Between 3/4 and 1 mile
- ☐ Greater than 1 mile
- ☐ I did not feed on public land

(63) ... on *private* land?

- ☐ Less than 1/4 mile
- ☐ Between 1/4 and 1/2 mile
- ☐ Between 1/2 and 3/4 mile
- ☐ Between 3/4 and 1 mile
- ☐ Greater than 1 mile
- ☐ I did not feed on private land

***Please indicate how often you used the following food items to feed bears by checking the most appropriate box.***

| | Every day | 2-3 days per week | Once per week | Once every 2 weeks | Once per month | Less than once per month | Never |
|---|---|---|---|---|---|---|---|
| (64) pastries ................ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (65) whole-shelled corn ....... | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (66) corn on the cob .......... | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (67) cracked corn ............ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (68) sweet feed corn (with molasses) ............... | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (69) livestock feed (such as Steerbuster) ............. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (70) country ham ........... | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (71) meatscraps ............. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (72) grease / lard ............. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (73) animal carcasses ......... | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (74) poultry feed ............ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (75) bread .................. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (76) apples ................. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (77) other _____________ . | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (78) other _____________ . | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |



***For the types of foods that you fed <u>frequently</u> (once every 2 weeks or more), please check the most appropriate <u>amount</u> you usually put out <u>each time you fed</u>. This is the average amount you put out at any given site on any given day. Note: If you measured in pounds, please answer the section below titled "<u>POUNDS</u>". If you measured in 5-gallon buckets, please answer the following section titled "<u>BUCKETS</u>" on Page 7.***

**<u>POUNDS</u>**

| | Less than 25 pounds | 26-50 pounds | 51-75 pounds | 76-100 pounds | More than 100 pounds |
|---|---|---|---|---|---|
| (79) pastries ................. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (80) whole-shelled corn ......... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (81) corn on the cob ........... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (82) cracked corn ............. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (83) sweet feed corn (with molasses) | ☐ | ☐ | ☐ | ☐ | ☐ |
| (84) livestock feed (such as Steerbuster) .............. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (85) country ham .............. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (86) meatscraps ................ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (87) grease / lard ............... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (88) animal carcasses .......... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (89) poultry feed .............. | ☐ | ☐ | ☐ | ☐ | ☐ |
| (90) bread .................... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (91) apples ................... | ☐ | ☐ | ☐ | ☐ | ☐ |
| (92) other _____________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (93) other .................... | ☐ | ☐ | ☐ | ☐ | ☐ |

**BUCKETS**

| | Less than 1 bucket | 1-2 buckets | 3-4 buckets | 5-6 buckets | 7-8 buckets | More than 8 buckets |
|---|---|---|---|---|---|---|
| (94) pastries | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (95) whole-shelled corn | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (96) corn on the cob | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (97) cracked corn | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (98) sweet feed corn (with molasses) | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (99) livestock feed (such as Steerbuster) | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (100) country ham | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (101) meatscraps | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (102) grease / lard | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (103) animal carcasses | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (104) poultry feed | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (105) bread | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (106) apples | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (107) other ________ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| (108) other ________ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

(109) What months did you feed bears? (Check all months that apply.)

❑ January ❑ April ❑ July ❑ October
❑ February ❑ May ❑ August ❑ November
❑ March ❑ June ❑ September ❑ December

(110) If you fed more than 3 months out of the year, please indicate ***which 3 months*** you did ***most*** of your feeding.

❑ January ❑ April ❑ July ❑ October
❑ February ❑ May ❑ August ❑ November
❑ March ❑ June ❑ September ❑ December

(111) Did you put different ***types*** of food out at different ***times*** of year?

❑ Yes
❑ No

(112) If you answered YES to (111), please indicate ***why*** you put different ***types*** of foods out at different ***times*** of year.

❑ Availability
❑ Preference of bears
❑ Cost
❑ Other (please describe.) ________

(113) At what point did you decide to restock a feeding site? (Please choose only 1 answer.)

❑ No old food remaining
❑ 1/4 old food remaining
❑ 1/2 old food remaining
❑ 3/4 old food remaining
❑ Whenever I visited the site, regardless of how much food was left



(114) How much of the food from your previous visit was ***usually*** eaten by the time you returned to each site?

❑ A) Less than 25% ❑ C) 51 - 75%
❑ B) 25 - 50% ❑ D) Greater than 75%

(115) If you fed all year long, was the food consumed more quickly at certain times of year?

❑ Yes ❑ Uncertain [Skip to (120).] ❑ No [Skip tp (120).]

***Please rank the seasons from 1 to 4, with 1 being the season during which food was consumed most quickly.***

(116) SPRING ____
(117) SUMMER ____
(118) FALL .. ____
(119) WINTER ____

(120) Was the food consumed more quickly during poor mast years (years when natural food, such as acorns, was scarce)?

❑ Yes ❑ Uncertain ❑ No

(121) Did you see evidence that animals other than bears ate the food you placed at your feeding sites?

❑ No [Please go to (124).] ❑ Yes [Please go to (122).]

(122) What animals other than bears used your feeding sites?

❑ Deer ❑ Fox
❑ Turkey ❑ Coyote
❑ Raccoon ❑ Raven
❑ Squirrel ❑ Other ________
❑ Bobcat ❑ Other ________

(123) What was the evidence that animals other than bears consumed the food at your feeding sites?

❑ Sightings ❑ Claw marks on trees
❑ Tracks ❑ Other ________
❑ Droppings ❑ Other ________

(124) Please list all counties in which you fed: ________

***Please indicate how your feeding practices between July 1, 1998 and June 30, 1999 compared to other years by completing the following statement:***

(125) The amount of feeding I did between July1, 1998 and June 30, 1999, as described in this survey, was...

❑ ... typical of most years ❑ ... less than most years
❑ ... more than most years

(126) Do you think it should be illegal to feed bears?

❑ Yes ❑ No

(127) If feeding bears were to become legal again, would you think feeding during the bear hunting season should be legal?

❑ Yes ❑ No

Appendix 20 continued.

(128) Why do you or don't you think it should be illegal to feed bears during the hunting season?

(129) What will your response be to the recent legislation passed by the Commonwealth of Virginia which made it illegal to feed wildlife on public lands beginning July 1, 1999?

- ❑ CEASE FEEDING ALTOGETHER
- ❑ INCREASE AMOUNT OF FEEDING ON PRIVATE LAND
- ❑ DECREASE AMOUNT OF FEEDING ON PRIVATE LAND
- ❑ CONTINUE FEEDING THE SAME AMOUNT AS BEFORE ON PRIVATE LAND

(130) Please use the following space to write any comments you may have about this survey or suggestions that will help improve it.

(131) Would you like a copy of the results of this survey to be sent to you? . . ❑ YES ❑ NO

Please return your completed survey in the envelope provided to:
**Rachel Gray**
**Dept. of Fisheries & Wildlife Sciences**
**Virginia Tech**
**Blacksburg, VA 24061-0321**

We appreciate your interest and participation in black bear supplemental feeding research.
Thank you for taking the time to fill out this survey.

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Appendix 21. Telephone questionnaire given to a sample of Virginia Bear Hunters Association members who did not respond to the Supplemental Feeding Survey, April 2000.

## Follow-up Survey for Black Bear Supplemental Feeding Survey Non-respondents

(1) During the 1998 bear dog training season, how many days did you hunt bears *using dogs*?

❑ 0 ❑ 1-7 ❑ 8-14 ❑ 15-21 ❑ 22-all

(2) During the 1998 bear dog harvest season, how many days did you hunt bears *using dogs*?

❑ 0 ❑ 1-7 ❑ 8-14 ❑ 15-21 ❑ 22-all

(3) During the 1998 big game firearms season, how many days did you hunt bears *without* dogs?

❑ 0 ❑ 1-7 ❑ 8-14 ❑ 15-21 ❑ 22-all

(4) During the period from July 1, 1998 to June 30, 1999, did you ever put food out for bears?

❑ Yes ❑ No (go to 13)

(5) Did you feed on public land, such as National Forest, only; private land only; or both public and private land?

❑ public only (go to 7) ❑ both public and private (go to 6)
❑ private only (go to 7)

(6) What percent of your feeding occurred on public land?

❑ less than 25% ❑ 25-50% ❑ 51-75% ❑ 76-100%

(7) How many feeding sites did you, personally, stock regularly?

❑ 0 ❑ 1-3 ❑ 4-6 ❑ 7-9 ❑ greater than 9

(8) What were the 3 most prominent foods you fed? ______________________

______________________

______________________

______________________

(9) During which 3 months did you do most of your feeding?

❑ January ❑ April ❑ July ❑ October
❑ February ❑ May ❑ August ❑ November
❑ March ❑ June ❑ September ❑ December

(10) In what counties did you feed? ______________________

______________________

______________________

(11) Was the amount of feeding you just described...

❑ typical of most years ❑ less than most years ❑ more than most years

(12) How have you responded to the Game Department's new law prohibiting the feeding of wildlife on public lands?

❑ cease feeding altogether
❑ increase amount of feeding on private land
❑ decrease amount of feeding on private land
❑ continue feeding the same amount as before on private land

(13) Do you think it should be illegal to feed bears?

❑ Yes ❑ No

(14) If feeding bears were to become legal again on public land, would you think feeding bears during the hunting season should be legal?

❑ Yes ❑ No

(15) Why didn't you return the mail survey? (only if they volunteered this information)

## VITA

Rachel Masterson Gray was born to Sterling Price and Virginia Cook Gray in Mountain View, California on September 8, 1972. She moved to northern Virginia with her family in 1985, where she attended middle school and high school in Fairfax County. In 1994, she graduated with a B.S. in Forestry and Wildlife from Virginia Polytechnic Institute and State University, where she was a member of the student chapter of The Wildlife Society and Xi Sigma Pi Forestry Honor Society. Following graduation, she worked as a technician on the Cooperative Alleghany Bear Study in Virginia for one year. She then worked in Yellowstone National Park researching coyote behavior, and in Juneau, Alaska, censusing and monitoring wildlife in riparian areas. In 1996, Rachel returned to Virginia to work on the Cooperative Alleghany Bear Study as a technician, and enrolled as a master's student at Virginia Polytechnic Institute and State University in fall 1997, studying food digestibility and anthropogenic feeding of bears. She began work on a study of desert bighorn sheep in Grand Canyon National Park, Arizona, in October 2000, before completing her master's degree in Fisheries and Wildlife in August 2001.