BLACK BEARS
OF UTAH'S EAST TAVAPUTS PLATEAU

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The following authors are faculty, graduate, and undergraduate students at Brigham Young University or UDWR personnel who created the data sets from which this report was generated.

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Others, who were not involved in the writing of this report but who, nevertheless, provided excellent field assistance (and in some cases reports or theses relevant to Utah black bear ecology and biology) are listed in the Product Summary section of this report.

Cover Art: The notion that bears had to be literally licked into shape by their mothers appeared in published literature by the 11th Century (see Nigel Rees, *The Cassell Dictionary of Word and Phrase Origins*, New York: Sterling, 1998). From this notion, Joshua D. Heward, a graduate student, produced the pencil sketch on the cover, which he titled, "Licked into Shape."

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ACKNOWLEDGMENTS

Who doesn't like bears? Fortunate for me that a host of graduate and undergraduate students are in that large pool of people who find large carnivores intellectually and psychologically irresistible. These students hardly need to be thanked for their contribution to this project since the excitement of trapping bears and visiting them in winter dens provided endorphin and adrenaline surges that are their own reward. In spite of this I thank them for their devotion to the project and their persistence in the face of temperatures; dust; and steep, dangerous, snowy hillsides that are hardly the dreams of wildlife biologists. Some of the long-term field assistants who are not listed as chapter authors in this report are Wade Paskett who remains connected to the project to this day, Dana Shurtleff, Heidi Johnson, Rick Lance, Robert Gardner, Maclane Heward, Krista Williams, Kenny Child, Matt Nelson, Cameron Black, Kyle Burtenshaw, David Harding, Katherine Viana, Barbara Viana, and others I have missed.

Dianna, my wife, accompanied us on field trips with the best homemade applesauce-chocolate chip and raisin-filled cookies anyone knows how to bake. I thank her for understanding that I never got tired of seeing summer-caught bears and winter cubs. I thank her for teaching me how to wash my loads of dirty field clothes. My children Lex, Deena, and Tim, and their spouses Lisa, Rick, and Brandie, and the grandchildren all visited the bear project. Some were long-term help, filling in for injured students. What a joy it has been to share my professional interests with them.

A former master's student, Janene Auger, has along with others, regularly returned from her PhD work at the University of Nevada, Reno to help with the winter den work. At Reno she continued trapping mammals and placing radio-collars around their necks. While her new study animals, kangaroo rats, held great fascination and academic interest for her, she still remained smitten with black bears and anxious to see this final report. Luckily I was able to support her as a post-doc to help me finish. Her skill with computers, attention to detail, organizational skills, and curation of the data has made her a valued assistant without which this report would have been much later than it was.

Borrowed equipment in the early stages of our research kept us going. Snowmobiles, trailers and ATVs from friends, especially Dr. DeVon Nelson of Mapleton, Utah, were much appreciated.

Brigham Young University's transportation services and shops were indispensable. Bear work is equipment-intensive and regular maintenance and emergency repairs were always done quickly to accommodate our needs. Don Kopp was expert at juggling schedules and anticipating our needs with trucks. Trent Whittle welded and fixed trailers on numerous occasions and permitted us to build our culvert traps in his kingdom. Cleon Bird is a trailer-wiring genius; Ron Durrence saw that tires were fixed with dispatch; Clay Chesnut kept things tuned up; Jerran Wolffinden and Lyle Smith tolerated the tons of mud we washed off equipment; and Brian Pulham fixed dents and paint. Lynette Webb was always gracious and tolerant of our requests for work that needed to be done—now! And Scott Sherwood was good to help keep these folks happy to serve us. The entire transportation crew was glad to see one female research assistant shipped off to Vladivostok, Russia on an LDS mission after she totaled two 4-wheel-drive trucks in less than 9 months.

My department and college here at BYU and the entire administrative network have been of immense value. Professional development funds and capital equipment requests were seldom, perhaps never, denied. This support was indispensable and included ATVs, snowmobiles, equipment trailers, and house trailers.

Numerous colleagues here at BYU have given advice and patiently listened to bear stories. Dr. Jerran T. Flinders has shared my enthusiasm for this project, loaned equipment now and then, and given critical professional advice and insights. Dr. Clayton M. White has sat quietly for story-telling episodes and enriched me with his own stories as we sat in the "lunchroom" sharing fresh garden salads and potatoes from the garden. H. Duane Smith loaned equipment and gave encouragement throughout the project.

I thank Ken Elowe, Jordan Pederson, Boyde

Blackwell, Bill Bates, Michael Wolfe, Craig McLaughlin, and Kevin Bunnell—mammal coordinators for the Utah Division of Wildlife Resources (UDWR)—for their encouragement. I also thank Steve Cranney and Walt Donaldson of the Vernal office of the UDWR for local support of our work on the Plateau. The UDWR was the primary sponsor of this research.

Numerous houndsmen and bear hunters reported ear-tagged and radio-collared females they had seen or treed. Several hunters reported finding tagged bears who had died of natural causes or from poaching. Some went the extra mile to retrieve ear-tags and collars from rotting bear carcasses, because they knew the data were valuable to us. Some hunters legally shot radio-collared females that they knew were study animals, but many declined to do so knowing the bears were important to our long-term research goals. A few hunters requested information about the size of the study area so they could avoid treeing or shooting study bears. I thank houndsmen and hunters for their cooperative efforts.

Figure 1. The Pine Springs Hilton.

We thank the Bureau of Land Management (BLM) for financial support in the early years of this study. Their cabin and its hot running water was a welcome respite after warm summer days and dusty roads. Steve Madsen, Bill Stroh, and Harry Barber of the BLM were always supportive and anxious to help. We especially thank Paul Buhler of the BLM for saving Wade Paskett and Marc Seid from certain death on a hill where oncoming travel was only visible at close quarters. (For his skills in avoiding these fellows, they agreed to water his raspberries with diligence—those back at South Camp.)

The large box traps designed by Tom Beck of the Colorado Division of Wildlife were a useful addition to our array of culvert traps.

The Pine Springs (Hilton) Cabin was home during the denning season (Fig. 1). Unknown UDWR personnel kept firewood readily available and this quaint cabin in good repair. And with its over-sized stove, we kept more than warm as we dried our wet clothes and boots after long days in winter weather.

Utah Division of Wildlife Resources fixed-wing pilots Val Judkins, Carl Downing, Steve Biggs, Rex Meyer, Clair Schaeffer, and Craig Hunt flew us to the Plateau to locate bears from the air. I thank them for bringing my students back in one piece and for never insisting that I go along. (There is not enough Dramamine in the known universe to get me in a small plane.)

One cattle rancher and his wife live year-round in the middle of the study area. They gave us access through their property during winter and summer, provided shelter from heavy summer rains and lightning storms, loaned us gasoline when our barrels ran dry, extracted us from mud-holes in spring, and accompanied us to the dens of their "pet" bear Spy to see her cubs. Phone calls to them gave us on-the-spot weather conditions. They also provided details of the effect of the drought of 2000 on calf production and survival—the best data we have on the poor range conditions that summer. Thanks Bert and Chris DeLambert for your help and friendship and for liking Allyson the Spy as long as you could.

The labor and equipment intensive nature of working with bears has meant that numerous individuals have had involvement with this project. Many have been rewarded as they worked to collect data and others have accompanied us as short-term guests to winter dens. Over 1100 guests have seen mother bears in dens accompanied by cubs or yearlings. They included office staff and biologists from various state and federal agencies, high school science students, environmental clubs from junior high schools, Boy Scouts of all ages, young women church groups, friends and families of research assistants, BYU faculty and students, as well as TV, radio, and newspaper media, free-lance writers, etc.

All of this activity has not come without costs in the form of accidents. A one-time city girl from Portland (Janene) failed to ride a bucking Honda ATV out of an arroyo and broke her radius in the process. Mississippi Rob got carried away strumming his make-believe guitar while "riding" an ATV and broke his radius when failing to make a turn. The contents of the bait bucket soaked his clothes and drove most of the employees out of the emergency room before my wife and I could get him cleaned up. On another occasion Rob slipped on an icy hillside and had to launch himself into a Douglas-fir to keep from falling 20–30ft over a cliff. Krista Williams, an undergraduate, somehow fell from an ATV and dislocated her knee-cap. An orthopedic surgeon, DeVon Nelson, instructed us over a cell phone on how to put it back in its normal position. We did and continued our work. Dr. John Frischknecht lost his ATV out of the back of his truck when he struck a large pot-hole. On another occasion he blew out the back window of the truck when he failed to secure his machine. Later that day my wife and another passenger rolled with him and his ATV down a sidehill with no injuries. And even later that day, a young lady from a church group broke her coccyx sliding down an icy hillside after visiting a den.

Not a single full-time research assistant avoided some sort of wreck. This is more understandable if one considers that over 50,000 miles were logged on ATVs during the course of this study and that all of those drivers were nearer 20 in age than 30.

Hal L. Black

PRODUCT SUMMARY OF BLACK BEAR RESEARCH IN UTAH

The black bear research effort in Utah from 1987 through 2004—supported financially by the Utah Division of Wildlife (UDWR), the Bureau of Land Management (BLM), the USDA Forest Service, the Uinta and Ouray Indian Tribe, Brigham Young University (BYU), and private individuals—has produced a plethora of written works in addition to the present report (see comprehensive list and thesis abstracts below). These are the products of 16 graduate students, several professional researchers (BYU, University of Utah, USDA Forest Service, and UDWR) and many undergraduates who have all benefitted in their training and experience through these funds. Topics cover Utah bear management issues such as food selection, home range characteristics, and reproductive success, as well as ecological, genetic, and physiological questions of general interest to scientists. Specifically, we have examined black bear population structure and determination of paternity, the role of bears in seed dispersal, occurrence of osteoporosis (important because bears do not lose bone mass during long periods of winter lethargy), use of dogs to study habitat utilization, track identification by shape, and den selection.

To date we have published 8 works including a proceedings of the Fifth Western Black Bear Workshop which was hosted in Provo, UT during February 1994, 4 peer-reviewed journal articles, 2 chapters in edited books, and a compilation of anecdotes from the project interwoven with natural history of bears. Three additional articles are currently in press: 1 in a peer-reviewed conference proceedings, 1 in a peer-reviewed techniques journal, and 1 in a student journal of technical writings. We consider at least 6 more of the theses publishable (Westwood 1996, Seid 1997, Tolman 1998, Smith 2000, Palochak 2004, Heward 2004) and anticipate those submissions at a future time. Several other papers that grew out of the project will be submitted as well (see Miscellaneous Unpublished Manuscripts). Additionally, 35 presentations were given at professional meetings in the form of oral papers or posters.

PUBLISHED WORKS

RICHARDSON, W. S. 1991. **New Records of Vascular Plants on the La Sal Mountains, Utah.** Great Basin Naturalist 51:293–295.

AUGER, J. AND H. L. BLACK (EDS.). 1995. **Proceedings of the Fifth Western Black Bear Workshop: Human–Black Bear Interactions.** 1994 February 22–25; Provo, UT. Brigham Young University Press. Vol. 5 in a series.

BLACK, H. L. 1997. **Non-Human Mortality, Injuries, and Possible Cannibalism in Utah Black Bears.** Pages 207–214 *in* Yates, T. L., W. L. Gannon, and D. E. Wilson (eds.) Life Among the Muses: Papers in Honor of James S. Findley. The Museum of Southwestern Biology, The University of New Mexico, Albuquerque.

TOLMAN, J. WITH C. WHITE. 1997. **Stories of the American Black Bear on the East Tavaputs Plateau.** Journal of the Dan O'Laurie Canyon Country Museum 29:13–15.

AUGER, J., S. E. MEYER, AND H. L. BLACK. 2002. **Are American Black Bears (*Ursus americanus*) Legitimate Seed Dispersers for Fleshy-fruited Shrubs?** American Midland Naturalist 147:352–357.

AUGER, J. AND J. G. SMITH. 2002. **Peraphyllum: Squaw-apple.** *In* Seeds of Woody Plants in the United States. 2nd revision. R. G. Nisley, editor. Forest Service, U. S. Department of Agriculture, Washington, D. C. **This chapter is currently available at http://www.wpsm.net/index.html. Publication in hard copy is pending.**

SINCLAIR, E. A., H. L. BLACK, AND K. A. CRANDALL. 2003. **Population Structure and Paternity in an American Black Bear (*Ursus americanus*) Population Using Microsatellite DNA.** Western North American Naturalist 63:489–497.

AUGER, J., G. L. OGBORN, C. L. PRITCHETT, AND H. L. BLACK. 2004. **Selection of Ants by the American Black Bear (*Ursus americanus*).** Western North American Naturalist 64:166–174.

IN PRESS

BLACK, H. L., J. AUGER, J. D. HEWARD, AND G. WALLACE. **Movements of Utah Black Bears: Implications for Management and Conservation**. Proceedings of the 8th Western Black Bear Workshop. Cecily Costello, editor. Final revision submitted 11 Nov 2004.

HARDING, L. E., AND H. L. BLACK. **Habitat Use, Behaviors, and Movements of Black Bears on the East Tavaputs Plateau, Utah.** Wildlife Society Bulletin. Submitted September 2004.

HEWARD, B. J. 2005. **Food Habits of Utah Bears: Three Studies and 1787 Scats Later.** IMPACT: Journal of Technical Communication (Vol. 6) *in* John M. Lannon, *Technical Communication*, Custom Edition for Brigham Young University (Fall 2005).

IN PREPARATION *(MANUSCRIPTS AVAILABLE)*

AUGER, J., AND H. L. BLACK. **Long-term Trapping of Utah Black Bears: Non-random Distribution of Captures and Conservation Implications.** Ursus.

AUGER, J., R. V. SMITH, A. T. YOUNG, M. C. BELK, AND H. L. BLACK. **A Shape Analysis of American Black Bear Tracks.** Wildlife Society Bulletin.

WESTWOOD, S. C., J. AUGER, K. N. BACHUS, AND H. L. BLACK. **Loss of Bone Mass with Aging in American Black Bears (*Ursus americanus*).** Journal of Mammalogy.

HEWARD, JOSHUA D. 2004. **Management of Black Bears in Utah: Harvest Strategies and Outcomes.** Ursus.

REPORTS

BLACK, H. L., AND H. D. SMITH. 1992. **Black bears of the Upper Hill Creek Drainage.** Report to the Uinta and Ouray Indian Tribe Biologist Karen Corts.

THESES

FROST, HERBERT C. 1990. **Population and Reproductive Characteristics of Black Bears on an Isolated Mountain in Southeastern Utah.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—From 1987 to 1989, 69 bears were captured 114 times on the La Sal Mountains in southeastern Utah. Sex ratio of initial captures was 1.3 M:1.0 F. Adult males ($\geq$ 4 years, n = 6) were rare while sub-adult males (< 4 years, n = 28) were common. Females were represented in all age groups. Litter size ($\bar{x}$ = 2.0), age of first reproduction (4–5 years), interbirth interval ($\bar{x}$ = 2.27 years), and natality (0.88) were comparable to other western populations. Cub mortality was insignificant (1 of 18). Estimates of annual survival rates taken from capture data were 0.52 for males and 0.72 for females. Survival estimates from harvest data were 0.53 and 0.74 for males and females, respectively. Man-caused mortality comprised 96% of all known deaths. Our estimate of density was 0.13 bear/km^2, or 167 bears for the 1296 km^2 study area. A population model was constructed to simulate extreme harvest of male bears and a unique event, such as a mast crop failure, when no cubs were produced for one year. Extreme harvest of male bears did not affect the overall population density, but the male to female sex ratio deviated from 1:1. No cub production for 1 year resulted in a greater amplitude of the population curve.

OGBORN, GARY L. 1990. **Ants (Formicidae) in the Diet of American Black Bears (*Ursus americanus*) in Southeastern Utah.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Black bear (*Ursus americanus*) preference for ants was examined by comparing the genera of ants in 99 scats with ants collected from study plots. In addition, ants were analyzed for nutritional value. Black bears preferred *Formica*, consumed *Lasius* and *Camponotus* in proportion to their relative abundance, and avoided *Tapinoma* and *Myrmica*. Relative abundance, presence or absence of a functional sting, individual size, colony size, and nest type probably affected the preference for ant genera in black bear diet. Energy values of ants ranged from 3.67 to 5.60 kcals per gram dry weight. Bears may select for ant brood because they are more digestible and lack defense mechanisms. Ants are a predictable and nutritional source of food for black bears.

RICHARDSON, W. SCOTT. 1991. **Habitat Selection and Feeding Ecology of Black Bears in Southeastern Utah**. M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Habitat selection and feeding ecology of black bears was investigated on the La Sal Mountains in southeastern Utah from 1988 to 1989. Factors influencing both macro- and microhabitat selection were determined. Macrohabitat selection differed significantly ($P \leq 0.01$) among season, between sexes, and among age classes of bears. Microhabitat selection differed significantly ($P \leq 0.01$) only among seasons. Macrohabitat use was influenced by food sources, while microhabitat use was influenced by horizontal and vertical cover. Investigation of feeding ecology revealed that green vegetation was the most important food in spring and mast species were most important in summer and fall. Ants provided a supplement to diets in spring and summer. Black bear predation on mammals appeared to occur on a regular basis with mule deer (*Odocoileus hemionus*) the most common mammal utilized. Bears may enhance food species through seed dispersal and removal of top growth.

AUGER, JANENE. 1994. **Viability and Germination of Seeds from Seven Fleshy-Fruited Shrubs after Passage through the American Black Bear (*Ursus americanus*).** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Seeds of seven fleshy-fruits in the diets of American black bears (*Ursus americanus*) were extracted from fresh fruit and scats from free-ranging and captive bears. Effects of digestion by black bears on viability, germinability, and germination rate were measured. Filled control seeds were highly viable (> 74%). Excepting serviceberry (*Amelanchier alnifolia*), where viability fell 14% for seeds passed through captive bears, digestion had no significant effect on initial viability ($P < 0.05$). Once imbibed, however, rosaceous seeds passed through captive bears were highly susceptible to fungal attack. Germination of controls was significantly different from that of at least one bear ingestion treatment for four species. For Oregon grape (*Mahonia repens*) and skunkbush sumac (*Rhus trilobata*), digestion by wild black bears enhanced germination; but for snowberry (*Symphoricarpos oreophilus*), control seeds germinated better. All viable serviceberry and squawapple (*Peraphyllum ramosissimum*) germinated after sufficient chill, but rates were different between ingestion treatments. Chokecherry (*Prunus virginiana*) germinated too poorly to obtain reliable comparisons, and blue elderberry (*Sambucus cerulea*) did not germinate under any ingestion treatment or chill regime. The biological significance of these effects depends on several variables including defecation sites, scat composition, secondary dispersal, and weather. Appendices present (1) preliminary results illustrating rodent predation on seeds in scats and (2) scanning electron micrographs comparing control and digested seeds.

JOHNSON, HEIDI K. 1994. **An Analysis of Multiple Paternity in the American Black Bear Using RAPD DNA Fingerprinting**. M. S. Thesis. Brigham Young University, Provo, UT. 21 p.

Abstract.—I examined the possibility of multiple paternity in eight black bear litters from eastern Utah. The Randomly Amplified Polymorphic DNA (RAPD) Polymerase Chain Reaction was employed to generate fingerprints for individuals in eight families and 20 potential fathers. Band sharing coefficients were calculated. The population had a high overall average similarity (0.786), which is not unexpected when using RAPD markers. This made assigning specific paternity inconclusive. Instead, I looked at relatedness between cub pairs, and for some, similarity fell below the average known first degree relative value of 0.869. In all families with three cubs, two cubs were more closely related than either were to the other cub. Relatedness within these families was lower than the within family relatedness suggesting that all three had multiple fathers. Relatedness in families of two cubs was not as conclusive but at least two of these families had lower than average cub similarity. A phylogenetic tree was constructed using the computer program PAUP. Families split up on the tree indicated multiple paternity especially if the split correlated with my conclusions based on band sharing. RAPDs produce dominant bands and therefore, heterozygotes are not detectible. Paternity evaluations would be more straightforward if techniques that do allow heterozygote detection and\or amplify more polymorphic regions of DNA are employed.

YOUNG, APRIL T. 1995. **Black Bear Behavior and Population Structure as Revealed by Road Track Surveys**. M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Track surveys of American black bears (*Ursus americanus*) were conducted along with regular trapping activities during the summers of 1993 and 1994 in the Book Cliffs of east-central Utah. From June to early August, two 16 km transects along the Divide Road were regularly monitored for bear tracks. Fifty-one surveys over the two summers yielded 258 track sets (132 on the east transect, 126 on the west). Mean number of tracks/km was significantly higher in 1994 ($P < 0.05$). Correlation analysis of capture success vs. tracking success resulted in a significant positive relationship ($P < 0.05$). For both years, bears used the Divide Road as a travel route approximately 20% of the time that they encountered it. Tracks of females with cubs appear to be under-represented. When compared to front pad widths of captured bears, measurements of front track widths underestimated actual pad size ($P < 0.05$). No significant differences in front track widths existed between survey year and transect ($P > 0.05$). Both sexes appeared to be represented in surveys; tracks with widths >12.0 cm most likely belonged to males. Linear regression analyses indicated that front pad width was correlated with weight, total body length, and age. Using six measurements from front and rear pads, discriminant function analysis separated captured bears into age classes (22.6% error) and categorized tracks into a similar age class distribution ($P > 0.05$). Track locations were not uniformly distributed along the road ($P < 0.05$).

WESTWOOD, SCOT. 1996. **Loss of Bone Mass with Aging and Femoral Sexual Dimorphism in the American Black Bear (*Ursus americanus*)**. M. S. Thesis. Brigham Young University, Provo, UT. 50 p.

Abstract.—Bone volume fraction measurements which estimate bone mass were performed on core samples taken from the femoral neck of American black bears, *Ursus americanus*. They were performed using backscatter electron imaging to determine if bears lose bone mass as they age. There was a significant decrease in bone mass as the animals aged ($P = 0.003$). This study also showed that this loss in bone mass was more prominent in females than in males, although this discrepancy could be partially due to low numbers of old males. These patterns were present for both regressions done on known age animals and for estimated ages. Radiographs were taken using a cabinet radiograph to measure the width of cortical bone at mid- and quarter shaft. No significant correlation was found between the thickness of cortical bone and age, sex or area fraction. In the process of measuring the bone for coring, we found sexual dimorphism in the length of the bones, the narrowest point of the femoral neck, and the distance between the medial and lateral epicondyles. These differences all proved to be statistically significant. A SAS program using a discriminant analysis was able to successfully classify 87% of the females and 95% of the males into their appropriate sex categories.

HARTVIGSEN, DANIELLE M. 1996. **Black Bear Denning Characteristics in Two Utah Populations.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—American black bear (*Ursus americanus*) den characteristics from the La Sal and the Book Cliffs study areas in Utah were compared and analyzed for differences in den selection for the following factors: elevation, den type, den entrance size, den chamber size, and depth of nesting material. Elevations of dens were also compared to the elevations of randomly selected points, but were not found to differ ($P > 0.05$). However, the dens in the two areas were found to significantly differ in elevation, in chamber length and in depth of nesting material ($P < 0.05$), but not for other dimensions or den type. The differences appear to be due to availability of respective resources. Bears in these study areas preferred rock type dens. The distance from dens to the nearest secondary or tertiary road was also compared to randomly selected points in the Book Cliffs study area. No difference in distance was found between the dens and the random points.

TENNEY, LORI A. 1996. **Home Range in Two Utah Black Bear Populations**. M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Home range sizes among black bears in two Utah populations were estimated using radio telemetry. Data were collected during the years of 1987 through 1995. Female bears with cubs usually maintain smaller home ranges than they do when solitary. Male black bears in the La Sal Mountains utilize a home range over four times as large as that of La Sal females. In addition to gender, home range size fluctuates among adult females, with the Book Cliffs bears having significantly larger ranges (Z = -2.33, df = 32, $P = 0.019$). This may be a result of vegetation differences. GIS was used to analyze overlap and vegetation cover-types. Spatial overlap occurs extensively between males and females, and also among genders. Adult female bears in the Book Cliffs appear to non-randomly select Oak and Ponderosa Pine/Mountain Shrub cover-types over other types when adding to their home ranges.

SEID, MARC. 1997. **Ant Colonies Under Rocks as a Food Source for Black Bears (*Ursus americanus*)**. M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Ants play an important role in the diet of the American black bear as evident by the large quantities of adult ants found in their scat. However, ant brood (eggs, larvae, pupae) are rarely evident in scat. In east-central Utah ant colonies located under rocks were sampled to determine the ratio of adults to brood for rock turning bears. Four thousand, six hundred sixty-six rocks were turned with 522 ant colonies found (11.2%). Brood to adult ratios were as high as 600:1 ($\bar{x}$ = 2:1). Thus, scat analysis probably underestimates the importance of brood in the diet of black bears. Discriminant function analysis was able to predict the presence or absence of ants under rocks 68% of the time. Large rocks (over 2500 cm^2 in surface area) were more likely to house ant colonies than small ones. Fourteen genera were found to nest under rocks. The most common were *Formica, Myrmica, Tapinoma* and *Camponotus*. Bears may select *Formica* and *Camponotus* for their large size and high brood to adult ratio.

TOLMAN, JULIE. 1998. **A Comparison of Reproductive and Habitat Characteristics of Two Utah Black Bear Populations.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—The connection between habitat quality and black bear (*Ursus americanus*) reproductive characteristics has been demonstrated in the literature (Bunnel and Tait 1981, Rogers 1987, Eiler et al. 1989, Elowe and Dodge 1989). To evaluate this relationship reproductive characteristics of 2 Utah black bear populations were analyzed. Cub mortality in the East Tavaputs Plateau population was the highest reported for black bear studies at 56.4%. The Plateau had a lower reproductive rate than the La Sal Mountain population. I tested the hypothesis that different reproductive characteristics were due to differences in fall habitat quality using density and size of mast producing species as quality indicators. These indicators could not explain differences between populations. Cub sex ratio on the Plateau was significantly male biased ($P = 0.042$). The results of high mortality and sex bias natality have significant implications for management of the these populations.

HARDING, LARISA E. 2000. **Differential Habitat Use, Behavior, and Movements of Black Bears on the East Tavaputs Plateau, Utah.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Most black bear (*Ursus americanus*) habitat data is collected with conventional tracking tools, such as aerial or ground telemetry. Often these measures have large margins of error and bear behaviors go unobserved. To document diel behavior and localized habitat use, I employed a novel technique and used trained hounds on leash to follow fresh bear tracks during May–July, 1995–1997. Analysis of 69 transects suggests that these transects act as a population sampling method. Bears utilize all habitats, but disproportionately use sagebrush steppe as a foraging substrate for ants. Small bears differentially move through more dense oak communities and large individuals frequent more exposed sagebrush areas. Bears also traveled in linear directional patterns, suggesting memory or knowledge from prior experience within an area. Behavioral observations are under-represented in the literature, even though they allow biologists to document what bears actually do in different habitats. This information is important to bear management, but may be particularly critical for management of bear populations in marginal habitats, as indicated by low reproductive performance, such as on the East Tavaputs Plateau, UT.

BUNNELL, STEPHEN T. 2000. **Spring and Summer Diet and Feeding Behavior of Black Bears on the East Tavaputs Plateau, Utah.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—The diet and feeding behavior of black bears (*Ursus americanus*) on the East Tavaputs Plateau is described. Diet description is based on the analysis of 405 scats collected from May-August 1991–1997. Observations of feeding behavior were obtained by following bear tracks with hounds. Correction factors are used to relate the volume of fecal residue to the amount of material ingested. Application of correction factors greatly increased the perceived use of mammals and greatly decreased the perceived use of grass and other green vegetation. Remains of mammals dominated the diet June–August. All observations of predation were by adult black bears. Use of western sweet cicely (*Osmorhiza occidentalis*) by bears on the ETP may be an example of zoopharmacognosy. Black bears forage on ant colonies under rocks in May and then switch to colonies in thatch mounds in June and July. All black bears in the population use ants, and bears exhibit no preference based on the size of thatch mounds.

SMITH, ROBERT V. 2000. **Live-Trapping Success and Associated Biases for East Tavaputs Plateau Black Bears.** M. S. Thesis. Brigham Young University, Provo, UT. 95 p.

Abstract.—Black bears (*Ursus americanus*) were captured during the summer months 1991–1997 on the East Tavaputs Plateau in Utah. A survival analysis was used to predict time to recapture based on characteristics of the bear and of the trapping technique. Number of people present and sex of the bear were significant predictors of recapture time for one data set analyzed while age of the bear predicted recapture time for all data sets analyzed ($P = 0.05$). Trapping in continuous vs. discontinuous sessions also affected capture success. However, month, year, number of times a bear was jabbed with sedative, and trap type did not significantly affect capture results. Bias associated with trap response and heterogeneity was identified in the data and explained as the result of learned behavior, movement patterns of black bears, and trapping methodology. The population was also determined to be open and heavily hunted.

PALOCHAK, ANDREA. 2004. **Cementum Annuli Patterns in Utah Black Bears: Accuracy and Precision of Cementum Annuli for Aging and Reproduction, and Tracking Trends in Annuli Patterns.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—The cementum annuli patterns of premolars have been widely used to determine the age of dead and living black bears (*Ursus americanus*). Narrowed sequences of these annuli have also been used to estimate reproductive occurrences in female black bears. However, some have questioned the reliability of cementum annuli. Beck (1991) reports that it is inaccurate for aging, and Coy and Garshelis (1992) caution that reconstructing reproductive success needs to be calibrated by study area, as not all populations show reliable indicators, and as drought or a lack of food can also cause narrowing. In Utah, we studied patterns in reproduction, compared observed cub production with cementum annuli read for reproductively caused narrowing, determined the accuracy of aging and identification of reproduction by these methods, and appraised cementum annuli indicators of reproduction for long-term patterns. Our results from the patterns in observed reproduction show cub production occurs much less frequently than that of an idealized population where females reproduce every 2 years. Results of the age determination by cementum annuli of Utah bears show the method is accurate within one year (91.7%), but the relationship of cementum annuli narrowing with the observed reproductive data is poor in Utah, and it is not a reliable measure of reproduction. Most of the errors in identifying reproduction by the specific narrowing of light-staining cementum annuli were caused by under-reporting: 29 light-staining annuli (26.4%) were formed during periods of nursing, but were not narrowed as caused by lactation and were not identified by this method. Narrowing reported as a reproductive event, when it was not caused by prolonged lactation, was infrequent (3.6%). Our results show narrowing of light-staining cementum annuli is affected primarily by age, inhibiting identification of reproduction.

HEWARD, JOSHUA D. 2004. **Management of Black Bears in Utah: Harvest Strategies and Outcomes.** M. S. Thesis. Brigham Young University, Provo, UT.

Abstract.—Black bear (*Ursus americanus*) managers in Utah rely heavily on harvest statistics to make management decisions; however, harvest statistics have previously not been rigorously analyzed especially in regard to regional variations in key parameters such as kill type and age. Harvest data for the last 15 years were compiled and analyzed with respect to sex, age, kill type, season, kill location, and method of take. Spring hunting, which was abandoned in 1993, results in a significantly lower female harvest and is desirable to ensure that harvest objectives for females are consistently met. Mean age of bears varied according to region with regions in the southern and eastern portions of the state having significantly higher ages. Mean age also increased slightly over time. Statewide the mean age of 5.6 exceeded the minimum harvest objective of 5 outlined by the 2000 Bear Management Plan. The Wasatch and Central Mountains failed to meet harvest objectives for age. In Utah, 60% of documented bear mortalities are attributed to hunters and 36% are associated with depredation and nuisance activity. The number of bears killed for depredation has significantly increased over time and has been largely confined to the Wasatch, Uintah, and Central Mountains, which harbor 80% of the sheep in bear habitat. Population models based on harvest data, density estimates from telemetry-based studies, and increases in depredation and nuisance activity indicate that the state's bear population is increasing. Maintaining a conservative harvest and an emphasis on gathering accurate and complete data on each bear killed in the state will allow managers to effectively evaluate and alter strategies for bear management. Additionally, cementum-annuli aging should continue for all bears since visual inspections for age estimation have proven unreliable in the past. Future management decisions would benefit from more elaborate modeling which includes population information from telemetry-based studies and food surveys along with the traditional harvest data.

MISCELLANEOUS UNPUBLISHED MANUSCRIPTS

HARDING, L. E., J. F. BARNES, J. C. REYNOLDS, H. L. BLACK, AND J. T. FLINDERS. **Trophic Relationships of the Mountain Lion (*Felis concolor*) with Various Scavengers: a Survey of Observations from Professional Biologists and Houndsmen.**

Abstract.—Professional biologists, houndsmen, and others completed surveys concerning the sympatric interactions of mountain lions (*Felis concolor*) and other predator-scavenger fauna. We compared the responses of professional biologists to those of houndsmen and other groups of people. Results showed few significant differences between responses of each group. However, we found that houndsmen observed anti-scavenger behavior that biologists infrequently observed.

BELL, A. R., J. AUGER, L. A. WOOLSTENHULME, C. FRANDSEN, AND H. L. BLACK. **Relationship of Utah Black Bear Distribution with Montane Hard and Soft Mast Availability.**

Abstract.—Successful reproduction in breeding age female black bears (*Ursus americanus*) is largely a function of late summer and fall availability of hard and soft mast species of plants. We investigated the correlation of mast species richness and black bear distribution in Utah. The distributions of 42 hard and soft mast species important to bears were determined for 30 Utah mountain ranges within real or potential bear habitat. Bear food plants were available in many areas, though species richness was significantly higher in eastern mountain ranges as well as in ranges where bears were present. Cluster analysis showed that ranges supporting bears were more similar to each other in composition of bear food plants than to ranges not supporting bear populations.

HEWARD, B. J., J. AUGER, C. FRANDSEN, H. L. BLACK. **Den Site Selection of Breeding Age Female Black Bears in Relation to Home Range.**

Abstract.—Many black bear (*Ursus americanus*) studies in the western United States have considered the characteristics of dens that bears may prefer (Beecham 1994, Costello et al. 2001, Mack 1998). We tested the hypothesis that den sites of individual females were not randomly allocated within their respective home ranges. We gathered radio telemetry data on 19 bears. A home range was calculated for each bear using minimum convex polygon and fixed kernel estimators and location data gathered from trapping and summer radio-telemetry. Den locations of each bear through a series of years were then analyzed using the same home range estimators to establish a den range. Den ranges were found to be significantly smaller than the home range for most bears and therefore den site choice was not random. While it is not completely understood why bears choose to den within a limited area, we suggest that in many cases philopatry may be an underlying determinant.

PAPER AND POSTER PRESENTATIONS AT PROFESSIONAL MEETINGS

1988 **The La Sal Mountain Bear Population: A Progress Report.** Central Mountains and Great Plains Section, The Wildlife Society, Annual Meeting. Ephraim, UT. August.

1989 **Observations on a Semi-isolated Black Bear Population in Southeastern Utah.** [Poster.] Eighth International Conference on Bear Research and Management. Victoria, British Columbia. February. (H. L. Black with S. Richardson, H. Frost, and J. Pederson).

1989 **Home Range Comparison of Breeding and Non-breeding Female Black Bears.** Utah Chapter, The Wildlife Society, Annual Meeting. Provo, UT. March. (H. L. Black with H. Frost and S. Richardson).

1989 **Seasonal Movements of a Semi-isolated Black Bear Population in Response to Ephemeral Food Resources.** Utah Chapter, The Wildlife Society, Annual Meeting. Provo, UT. March. (H. L. Black with S. Richardson, G. Ogborn and H. Frost).

1989 **Ants in the Diet of Black Bears, *Ursus americanus*.** Utah Chapter, The Wildlife Society, Annual Meeting. Provo, UT. March. (With S. Richardson and H. Frost).

1990 **Population Characteristics of Black Bears on an Isolated Mountain in Southeastern Utah.** [Poster.] American Society of Mammalogists, Annual Meeting. Frostburg, MD. July. (With H. Frost and S. Richardson).

1992 Auger, J., W. Paskett, H. L. Black, and H. D. Smith. **Black Bear Field Studies: To Trap or to Snare, That is the Question.** [Poster.] American Society of Mammalogists, Annual Meeting, Salt Lake City, UT. June. Also displayed at the Ninth International Bear Conference, Missoula, MT in February 1993.

1993 **The Role of Black Bears in Seed Dispersal.** Utah Chapter, The Wildlife Society, Annual Meeting. St. George, UT. February.

1993 Auger, J., S. E. Meyer, H. L. Black, and H. D. Smith. **Black Bears and Seed Dispersal: Preliminary Evaluation of Bears as Legitimate Seed Dispersers.** American Society of Mammalogists, Annual Meeting, Bellingham, WA. June.

1993 Auger, J., S. E. Meyer, H. L. Black, and H. D. Smith. **Black Bears and Seed Dispersal: Preliminary Observations and Hypotheses.** [Poster.] International Union of Game Biologists XXI Congress, Halifax, Nova Scotia, Canada. August. Also displayed at the Fifth Western Black Bear Workshop, Provo, UT in February 1994.

1993 Auger, J., S. E. Meyer, and H. L. Black. **Viability and Germinability of Seeds from Black Bear Scats Collected in the Book Cliffs, Utah: Implications for Seed Dispersal.** Second Biennial Conference of Research on the Colorado Plateau. Flagstaff, AZ. October.

1994 Auger, J., S. E. Meyer, and H. L. Black. **Viability and Germinability of Seeds from Seven Fleshy-fruited Shrubs after Passage Through the Black Bear.** [Poster and Published Abstract.] Fifth Western Black Bear Workshop. Provo, UT. February. Also displayed at the Tenth International Conference on Bear Research and Management, Fairbanks, AK in July 1995.

1994 **An Analysis of Multiple Paternity in the American Black Bear Using RAPD DNA Finger Printing.** [Poster and Published Abstract.] Fifth Western Black Bear Workshop. Provo, UT. February. (H. L. Black with H. K. Johnson, D. S. Rogers, and S. Woodward).

1994 **Preliminary Road Track Surveys of Black Bears in Utah.** [Poster and Published Abstract.] Fifth Western Black Bear Workshop. Provo, UT. February. (H. L. Black with A. T. Young, W. P. Paskett, K. V. Young, M. A. Seid, and H. D. Smith).

1995 **Road Track Surveys of Black Bears in Utah.** [Poster and Published Abstract.] Abstracts, Tenth International Conference on Bear Research and Management. Fairbanks, AK. July.

1996 **Lion–Black Bear Interactions: A Survey for Participants.** [Presentation, Survey, and Published Abstract.] Fifth Mountain Lion Workshop, Southern California Chapter of The Wildlife Society and California Department of Fish and Game. February. (H. L. Black with J. T. Flinders).

1997 Seid, M. A., and H. L. Black. **The Role of Ants in the Diet of the American Black Bear: Colonies under Rocks.** Sixth Western Black Bear Workshop. Ocean Shores, WA. May.

1997 Smith, R. V., M. C. Belk, and H. L. Black. **How Well Can Track Shape Be Described in Black Bears?** Sixth Western Black Bear Workshop. Ocean Shores, WA. May.

1997 Tolman, J., and H. L. Black. **Reproductive Characteristics of an East-central Utah Population of Black Bears.** Sixth Western Black Bear Workshop. Ocean Shores, WA. May.

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1998 Bunnell, S. T., and H. L. Black. **Spring and Early Summer Food Habits of Black Bears on the East Tavaputs Plateau, Utah.** Eleventh International Conference on Bear Research and Management. Gatlinburg, TN. April.

1999 Smith, R. V., and H. L. Black. **Success and Biases of Live Trapping Black Bears in Utah.** Utah Chapter, The Wildlife Society, Annual Meeting. March.

1999 Black, H. L., S. Bunnell, L. Harding, and R.V. Smith. **Black Bear Habitat Use: Ground-truthing with Dogs.** Utah Chapter, The Wildlife Society, Annual Meeting. March.

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2001 Black, H. L., and J. Heward. **Barren Bears: The Summer from Hell in the Book Cliffs.** Utah Chapter, The Wildlife Society, Annual Meeting. St. George, UT.

2003 Black, H. L., J. Heward, and A. Palochak. **Utah Black Bears: Dispersal, Homing, and Long Distance Movements for Food.** Eighth Western Black Bear Workshop. Pray, Montana. 15–17 April.

2003 Heward, J. D., and H. L. Black. **Trends in Utah's black bear harvest.** Eighth Western Black Bear Workshop. Pray, Montana. 15–17 April.

2004 Shawcroft, T., B. J. Heward, J. Auger, and H. L. Black. **Bear Den Necessities: Individual Bear Den Ranges as a Function of Home Range.** Utah Chapter, The Wildlife Society, Annual Meeting. Provo, UT. 4–6 February.

2004 Bell, A. R., J. Auger, L. A. Woolstenhulme, and H. L. Black. **Black Bear Distribution in Utah as a Reflection of Hard and Soft Mast Availability.** Utah Chapter, The Wildlife Society, Annual Meeting. Provo, UT. 4–6 February.

2004 Auger, J., J. D. Heward, B. J. Heward, C. Frandsen, A. Johnson, and H. L. Black. **Long-term Trapping of Utah Black Bears: Non-random Distribution of Captures and Conservation Implications.** [Poster.] Fifteenth International Conference on Bear Research and Management. San Diego, CA. 9–13 February.

2004 Heward, B. J., J. D. Heward, J. Auger, and H. L. Black. F**ood Habits of Utah Bears: Three Studies and 1787 Scats Later.** [Poster.] Fifteenth International Conference on Bear Research and Management. San Diego, CA. 9–13 February.

2004 Palochak, A., J. D. Heward, and H. L. Black. **Cementum Annuli Patterns in Utah Black Bears: Accuracy and Precision of Cementum Annuli for Aging and Reproduction, and Tracking Trends in Annuli Patterns.** [Poster.] Fifteenth International Conference on Bear Research and Management. San Diego, CA. 9–13 February.

2004 Heward, J. D., B. J. Heward, H. L Black, and C. R. McLaughlin. **Trends in Utah's Bear Harvest.** [Poster.] Fifteenth International Conference on Bear Research and Management. San Diego, CA. 9–13 February.

INTRODUCTION

In 1985 the Utah Division of Wildlife Resources (UDWR) began a study of black bears (*Ursus americanus*) in central Utah largely centered in the drainages of Hobble Creek and Diamond Fork along the Wasatch Front (Bates 1991). A short-term study was also conducted in the La Sal Mountains of southeastern Utah between 1987 and 1991 (Richardson 1991, Frost 1990, Ogborn 1990). In 1991 the UDWR, under the direction of Mammal Coordinator Dr. Jordan Pederson, proposed that a long-term study be conducted in a black bear hunting unit that was distant from urban settings and in a large expanse of contiguous habitat. Additionally this new study site was to be in a hunting unit with a history of high hunter success. The most remote hunting unit that fit these criteria was the East Tavaputs Plateau (Plateau), 70–80 miles (112–128 km) from the towns of Roosevelt and Vernal in Utah and Grand Junction in Colorado. The Plateau continues into Colorado on the east and is bordered to the west by Desolation Canyon through which the Green River flows.

The Plateau, while remote from urban areas, is none-the-less frequented by sportsmen hunting deer, elk, mountain lions, and black bears. Additionally, cattle operations use the high-elevation summer ranges and low-elevation winter ranges to the north and south of the Plateau. Natural gas fields and the numerous secondary roads that provide access to well-heads are almost daily traveled by personnel from various companies. Thus, anthropogenic activities on the Plateau are common but unlike those seen in the Wasatch Front study site located near the highly populated Utah Valley and the La Sal study site adjacent to Moab, Utah.

Accordingly the Plateau was selected as the most remote, large area of contiguous bear habitat free of extensive human activity. Here we initiated a long-term study designed to determine population characteristics of black bears with special emphasis on the productivity of breeding-age females.

It was unofficially agreed that long-term support could best be maintained if annual budgets were modest and if graduate students eager to carve out portions of the study for Master's theses could be recruited. This strategy is not without pitfalls because we would have many short-term student research assistants (18 in our case) helping to keep track of long-term data sets (Pelton and van Manen 1996)

This report includes newly written summary chapters, revised student theses, and ancillary papers relevant to the primary research objectives, bear ecology, and bear behavior.

OBJECTIVES

We considered the costs of various research objectives and chose to concentrate on those that would, given a long-term study (i.e., > 10 years), contribute the most to our understanding of Utah's black bears and management concerns.

Major objectives were to

- characterize the reproductive performance of adult female bears
- explore the use of track surveys as a technique for monitoring bear activity
- analyze scats to obtain an indication of important food resources
- review the management practices and outcomes of Utah's black bear harvest
- provide a minimum density estimate for females
- determine the spatial distribution of bears using trapping records and suggest how this might relate to areas of high quality habitat
- describe physical aspects of bears relevant to management and hunting practices
- analyze movement patterns of marked bears as they relate to homing, dispersal, and mast production
- consider how introduction of large carnivores (wolves and grizzly bears) might impact black bear populations
- explore the role of female parental investment as a function of age.

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PELTON, M. R., AND F. T. VAN MANEN. 1996. Benefits and pitfalls of long-term research: a case study of black bears in Great Smoky Mountains National Park. Wildlife Society Bulletin 24:443–450.

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STUDY AREA

East Tavaputs Plateau.—A vivid and detailed description of vegetation associations, geology and physiography of the East Tavaputs Plateau is given by Ranck (1961). The Plateau extends from the Green River in Utah eastward into Colorado. To the north the it reaches the White River and to the south the Roan Cliffs and at lower elevations the Book Cliffs. Various streams drain northward and westward into the Green River or White River. Major streams (intermittent in dry years) are Hill Creek, Willow Creek and the smaller Meadow Creek in the western regions of the Plateau and Main Canyon, Sweetwater, and Bitter Creek. Major streams draining to the south through the Roan and Book Cliffs, again intermittent in dry years, are Westwater, Middle Canyon, East Canyon, San Arroyo Canyon, and Bitter Creek (south).

Snow packs are gone by early June and this is reflected in low to non-existent stream flow at lower elevations throughout much of the Plateau. But at higher elevations, wildlife find small streams, springs, and stockponds adequate to sustain life.

The elevation and topography combined make it difficult to recognize discrete vegetation zones typically found throughout western mountains, but patches and mosaics of dominant vegetation types are easily recognized. Dominant and conspicuous species in these patches are aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), Gambel's oak (*Quercus gambelii*), two-needle pinyon (*Pinus edulis*), juniper (*Juniperus scopulorum* and *J. osteosperma*), serviceberry (*Amelanchier alnifolia*), snowberry (*Symphoricarpos oreophilus*), squawapple (*Peraphyllum ramosissimum*), chokecherry (*Prunus virginiana*) and big sagebrush (*Artemisia tridentata*) (Tolman 1998). The composition of mast producing species on the Plateau is not dissimilar to the neighboring high elevation La Sal Mountains to the south. However, the paucity of riparian habitats with year-round stream flow probably explains the low species diversity compared for example to the high-elevation La Sal Mountains (Tolman 1998).

The Plateau is divided by numerous canyons to the extent that on the ground it hardly seems plateau-like at all. From its northern borders at approximately 1400 m (4600 ft) it gently raises to an elevation of about 2750 m (9000 ft). These higher elevations have for years provided summer grazing for livestock mainly cattle, and the lower elevations to the south and north are used as winter range. From the lower elevation to the crest of the Plateaus extensive natural gas and oil exploration and active wells of the same has resulted in the creation of a network of roads on ridgetops and in canyon bottoms that allow good vehicle access especially in the central portion of the Plateau. We chose a well-roaded area at higher elevation as our study area because the use of large live traps necessitated transportation by small trucks and by trailers pulled by 4 x 4 ATVs.

A rectangle of 9 × 18 miles (14.5 × 29 km) encompassed all the trapping locations within the study area (Chapter 2). The trapping area was bordered on the west by Hay Canyon and on the east by Bitter Creek (north), and the Divide road roughly bisected the north–south width.

In this report reference will be made to two other investigations of bears in Utah, and we provide a brief description of these study sites below.

Hobble Creek.—The Hobble Creek and Diamond Fork drainages on the Wasatch Front east of Springville, Utah are montane areas encompassing approximately 129,650 ha (500 mi^2). The elevation ranges from 1398–3065 m (4585–10,055 ft), and precipitation ranges from 38.8 to more than 52 cm (15.3–20.5 in) annually. Common vegetation includes aspen (*Populus tremuloides*), white fir (*Abies concolor*), Engelmann spruce (*Picea engelmannii*), and Douglas fir (*Pseudotsuga menziesii*) in higher elevations, and Gambel's oak (*Quercus gambelii*), big sagebrush (*Artemisia tridentata*), and big-toothed maple (*Acer grandidentatum*) in mid to lower elevations (Bates 1991). Low intensity black bear trapping was conducted in this area from 1985–1991.

La Sal Mountains.—The La Sal Mountains are located 25 km southeast of Moab, UT, and bears were researched there from 1987–1991. The study area was approximately 1,296 km^2 and was composed of three groups of peaks, rolling foothills, and a series of plateaus dissected by canyons ranging from 1,690 to 3,914 m in elevation. Mean annual temperatures measured at the La Sal Mountain-Upper station at an elevation of 3,002 m ranged from -1 to 15 °C. Timber, mining and livestock operations are present and sport hunting for deer, elk and black bears has a long history (Frost 1990, Richardson 1991). Annual precipitation ranges widely from 25 to 77 cm, depending on the altitude.

Common vegetation includes Engelmann spruce, subalpine fir (*Abies lasiocarpa*), Colorado blue spruce (*Picea pungens*), white fir (*Abies concolor*), and aspen in higher altitudes, and pinyon (*Pinus edulis*), juniper (*Juniperus osteosperma*), Gambel's oak, and ponderosa pine (*Pinus ponderosa*) in lower elevations (Richardson 1991).

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LONG-TERM TRAPPING OF BLACK BEARS ON THE EAST TAVAPUTS PLATEAU

HAL L. BLACK, JANENE AUGER, AND ROBERT V. SMITH

Part of this long-term study of black bears on the East Tavaputs Plateau (Plateau) included live-trapping during 10 of the 12 years of fieldwork. The summer field season (Jun–Aug) consisted largely of live-trapping with 2 primary objectives: (1) to radio-collar reproductive-age females and (2) to ear-tag all other bears caught. As with most efforts to trap animals we wondered what our capture results might mean. For example, would all age classes be evenly represented? Would size, age, and sex dictate capture rates? Would trap-shy and happy individuals bias our results? Might social status or season affect capture success or lack of it? And could habitat quality and seasonal variation in natural foods compromise capture likelihood?

Here we describe trapping methods and present data on trap success and efficiency, sex ratios, age structure, various morphometric measurements, and persistence of marked animals in the trapping sample. We also summarize limitations and biases inherent in interpreting the results of our long-term trapping (Smith 2000).

METHODS

Starting in 1991 and ending in 2002, bears were live-trapped in a section of Plateau measuring about 9 x 18 miles (Fig. 1 in Chapter 2). This rectangle encompassed all but 3 of 137 trap sites and was oriented in a SW–NE plane with the western edge near Hay Canyon and the north-eastern boundary at Bitter Creek. Trapping was not conducted in the summers of 1998 and 2000.

Barrel traps were used almost exclusively with the exception of a few Aldrich spring-activated snares used in 1991 and 14 box traps, borrowed from Colorado Division of Wildlife and used in conjunction with barrel traps in 1996, 2001, and 2002. Most trapping was done beginning in early June and terminating in mid-August. Initially we trapped in May but catching few animals we abandoned the effort. We used Honda 4 X 4s pulling small custom-built trap-trailers to position traps (Fig. 1a). Traps were placed near water (streams, springs, and stockponds) whenever possible and checked daily between 9:00 A.M. and 1:00 P.M. We trapped the entire study area each year. The location of trap sites is given in Figure 2 and reflects the distribution of roads and trails. Beef carrion "aged" in 55 gal drums was used as an

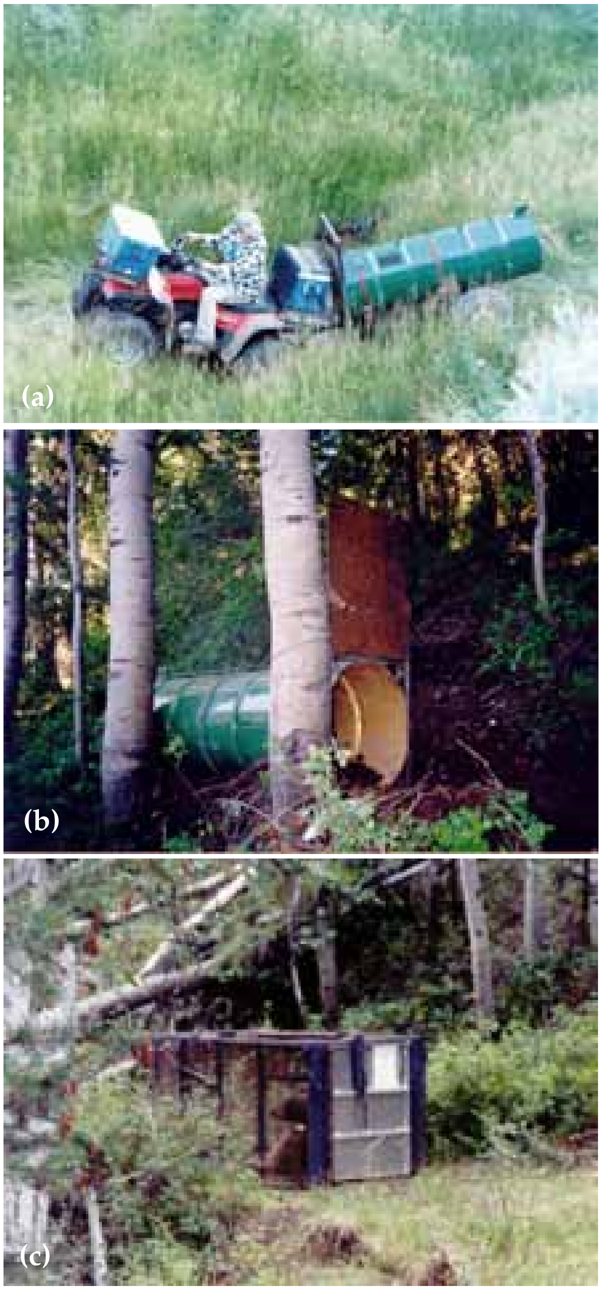

Figure 1. (a) Transportation of traps with an ATV and a custom built trailer, (b) barrel-style trap wired to a tree, (c) box-trap built by the Colorado Division of Wildlife.

attractant. Several shovels of soil were spread in the bottom of trap to absorb urine and fecal material and to facilitate cleaning of traps. The trigger in the barrel traps was loaded with a small handful of bacon or gumballs and Twizzlers enclosed in a woven bag which was then smeared with peanut butter. Traps were secured to a tree by heavy wire; the larger Colorado box traps (Fig. 1b), weighing about 500 lbs, required no anchorage. Barrel traps were in the shade of the anchor tree (Fig. 1c). Leafy limbs were as required placed on top of traps for additional shading. Warning signs were placed near traps that were close to roads or trails to alert people to the possibility of danger and that bear trapping was in progress.

Bears were sedated with ketamine hydrochloride and xylazine hydrochloride at a dosage of 2 cc ketamine and 1 cc xylazine per 100 lbs of body weight. We used jab-sticks to administer the drug through holes in the sides or the end of the traps. After immobilization bears were placed in the shade, eye drops were administered, and eyes covered with cloth to prevent them from dehydrating and to keep insects and debris out. Numbered All-Flex ear tags were placed in each ear and most adult females were fitted with radio-collars (Telonics, AZ). Cubs caught were not ear-tagged until seen in dens as yearlings. A premolar was removed from all non-cub bears for aging by cementum annuli (Willey 1974; Matson's Laboratory, Milltown, MT). Several physical measurements were taken and bears were weighed after the methods of LeCount (1986). Any unusual features or scars were noted. In the first two years of the study, blood was drawn from the femoral vein and/or a 3 mm ear plug taken to provide cells for genetic analysis (Sinclair et al. 2003). Bears were left unattended to recover from drugs, lying on their abdomens with their eyes covered by a soft cloth.

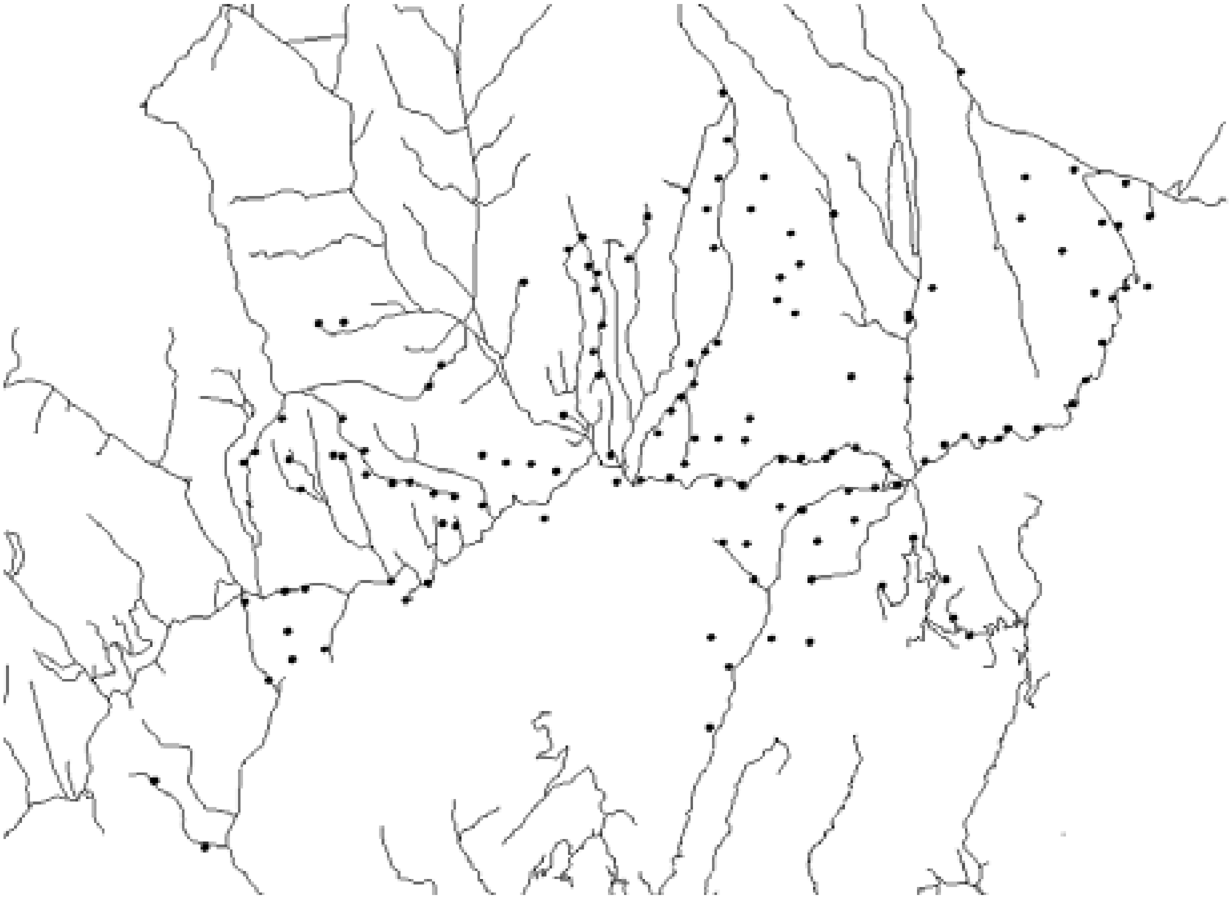

Figure 2. Dots indicate the location of trapping sites on the East Tavaputs Plateau, UT. Lines are roads or trails.

Table 1. Trap nights, captures, and capture success for 10 years of trapping with barrel and box traps on the East Tavaputs Plateau. (Totals differ from those in Chapter 2 because 7 captures and 152 trap nights were outside the cell grid.)

Year	Trap Nights	Captures	Trap-nights/ capture
1991	1146	34	33.7
1992	905	21	43.1
1993	1113	45	24.7
1994	1088	51	21.3
1995	1059	20	53.0
1996	769	41	18.8
1997	913	12	76.1
1999	1158	31	37.4
2001	1142	56	20.4
2002	1685	53	31.8
Total	10,978	364	30.1

Minimum numbers known alive were calculated from all available data: trapping records, hunting returns, den visits, sightings, and telemetry data. The enumeration depended on several assumptions and rules. We assumed that young females do not disperse off the study area and that those caught as adults were born in the study area. We also assumed that males caught in traps as 1 year olds were born in the study site. We counted only cubs that survived to be yearlings as present in their first year; however if a sub-adult or adult was killed, it was counted as present in that year. It is useful to note that MKNA values are strong *correlates* of population size (Slade and Blair 2000), but are underestimates at the beginning of any study when new individuals are still available to be marked. (Pocock et al. 2004). Future hunting returns may change the results slightly because a return is positive evidence that an animal was on the study site between the last capture and the kill date.

RESULTS AND DISCUSSION

Trapping Results

Captures, Effort, and Trapability.—Trapping effort was relatively constant from year to year with the exception of a low of 769 trap-nights in 1997 and a high of 1685 in 2002 (Table 1). The few captures in 1997 may simply reflect the reduced effort and more dispersed trapping locations. In 2002 the effort was greater and the density of traps throughout the study site higher.

Three hundred sixty-four bears were trapped (179 individuals). Recaptures slightly exceeded initial captures. Mean trap nights per capture was 30.4 (Table 1). Capture rates in years following no trapping (1999 and 2001) showed no increase in

Table 2. Three hundred sixty-four by sex and capture/recapture. The heading *R* stands for recapture where *n* means that a bear has never been handled in a trap before (may have been tagged in a den) and *y* indicates that a bear had been previously handled in a trapping situation.

		Year										
Sex	R	1991	1992	1993	1994	1995	1996	1997	1999	2001	2002	Total
F	n	14	7	4	7	1	3	2	9	12	4	63
	y	2	4	13	13	12	11	1	1	18	20	95
F Total		16	11	17	20	13	14	3	10	30	24	158
M	n	12	6	18	12	3	13	6	17	13	16	116
	y	6	4	10	19	4	14	3	4	13	13	90
M Total		18	10	28	31	7	27	9	21	26	29	206

Table 3. Minimum number known alive (MNKA) for females in various age classes on the East Tavaputs Plateau, Utah. Only cubs that survived through their first year were counted. These results were finalized on 25 Oct 2004. Future hunting returns may alter the results presented here.

Year	Cubs (Surviving)	1–3 Years	4 Years	> 4 Years	Total
1991	3	8	4	13	28
1992	4	7	3	16	30
1993	5	9	2	18	34
1994	5	11	2	18	36
1995	4	11	3	20	38
1996	3	12	2	21	38
1997	11	8	4	21	44
1998	4	16	2	21	43
1999	5	15	3	21	44
2000	3	15	2	22	42
2001	2	10	7	21	40
2002	0	5	3	25	33

captures over previous years of sequential trapping. Captures of new males exceeded new females in all but the first 2 years of the study. There was a pronounced bias of males in 1993 when 18 of 22 new captures were males. Males constituted 65% of all initial captures (Table 2).

Overall trapping efficiency on the Plateau of 30.1 trap-nights per capture was low compared to results in other areas of the United States (Table 3 in Smith, 2000). Trapping in Idaho was extremely effective at 6–8 nights per capture (Beecham and Rohlman 1994). Only in Alaska was efficiency lower than on the Plateau (132.9 trap-nights/capture; Schwartz and Franzmann 1991). A short-term, 4-year study in southeastern Utah (La Sal Mountains) using snares had a considerably higher capture rate (21.8 trap nights per capture, Frost 1990).

In spite of annual hunting (Chapter 4) marked animals remained fairly constant between years (Table 3 and Table 4). Sub-adult females (< 4 years old) were regularly trapped and the pool of breeding age females (≥ 4 years) ranged from 13–25 individuals (Table 3). In 2002 we saw the maximum number of adult females. These may have come from the 1997 cub cohort which was unusually large because it followed a year of poor production and missed reproductive opportunities (birth synchrony induced by environmental conditions). Numbers of marked sub-adult and adult males were likewise somewhat constant in the study area (Table 4). Trapped males (63%) were more likely to have the fate of *no data* than trapped females (47%) and we surmised that those numbers reflect the more transitory nature of males. The turnover of males is not apparent in the minimum number known alive table because new males were marked each year in effect replacing those with unknown fates (Table 4). To further illustrate, we only know three cases where male bears were seen as cubs or yearlings and then again as adults (> 4 years old) on the study site.

We present age structure by sex for all initial captures during the 10 years of trapping (Fig. 3). This distribution of age classes is typical of hunted populations with a high proportion of sub-adults relative to adults (for a review see Beecham and Rohlman 1994). Ten thousand nine hundred seventy-eight trap nights produced only 13 individuals older than 10 (4 females, 9 males). Adults (≥4 years old) represent 48% of the total captures of individuals (N = 179). This percentage

Table 4. Minimum number known alive (MNKA) for males in various age classes on the East Tavaputs Plateau, Utah. Only cubs that survived through their first year were counted. These results were finalized on 25 Oct 2004. Future hunting returns may alter the results presented here.

Year	Cubs (Surviving)	1–3 Years	4 Years	> 4 Years	Total
1991	1	2	5	5	13
1992	4	3	3	11	21
1993	6	13	1	14	34
1994	5	16	3	11	35
1995	6	12	2	10	30
1996	0	17	2	11	30
1997	5	9	4	11	29
1998	2	7	2	11	22
1999	1	10	3	16	30 + 1 unk. age
2000	1	6	1	16	24
2001	1	9	6	15	31
2002	0	4	1	22	27 + 2 unk. age

is identical to that of a heavily hunted area in Idaho (Beecham and Rohlman 1994).

In the western portion of the Plateau the Ute Tribe owns land (Hillcreek Extension) of which 500 mi^2 are above 6000 ft. We trapped this *unhunted* black bear population in 1992 using techniques identical to those used on the Plateau study area to the east. Eight hundred eleven trap nights produced 53 capture of 34 different bears. Trap success was twice that on the Plateau (1 bear per 15 trap nights). We determined the age of 32 bears on the Hillcreek Extension. The youngest of the 15 females caught was 4 years old (i.e., no sub-adults females were caught) and the oldest 18. Mean age of females was 7.4 years and mean age of males was 6.1 years. The proportion of adults to sub-adults was highly skewed; only 12.5% of the 32 bears were younger than 4. By contrast 48% of initial captures on the Plateau study site were 1–3 years old.

The 811 trap nights over one summer of trapping on the Hillcreek Extension yielded 5 bears 10 years and older (3 females, 2 males) while 10,978 trap nights over 10 years of trapping on the *hunted* Plateau study site yielded only 13 initial captures 10 and older.

Others have demonstrated the value of unhunted populations as a source of bears to neighboring hunted populations (Powell et al. 1996, Beringer et al. 1998). We suggest that the Indian unhunted population has "seeded" not only Plateau hunted lands to the east but also the West Tavaputs Plateau west beyond the Green River with dispersing bears. The Green River is not a barrier to bear movements (Black and Auger 2003, Chapter 7).

Smith (2000) performed several analyses on the trapping data from 1991–1997 including a modified survival analysis which predicts the time to recapture (of a bear) based on a suite of variables measured at the time of initial capture including month, year, age, sex, number of drug injections, and number of people present. In the model, mortality of marked bears was accounted for. The objectives were (1) to evaluate the assumption of equal catchability which is important to many population models, (2) to generate recommendations about how to increase capture efficiency and decrease costs of live-trapping black bears in the state of Utah, and (3) to qualify the interpretation of sex and age structure data obtained from live-trapping data.

The results are summarized as follows:

(a)

(b)

Figure 3. (a) Age structure of initial captures on the East Tavaputs Plateau from 1991–2002. (b) Age structure of a non-hunted population in 1992 on Ute Indian lands adjacent to the Green River on the west and State and Federal lands on the east.

- Bears were not equally catchable and heterogeneity existed in the capture data from the Plateau. The population was open as evidenced by the capture rate of unmarked bears over time within a season.
- Age was the most prominent variable affecting time to recapture. Older bears had higher times to recapture even after the model adjusted for mortality.

- Males also had greater times to recapture than females which can be primarily attributed to the transience of subadult males in the study area. Another contributing factor may be that older males displace females and sub-adult males into areas with a greater chance of human contact (i. e., near roads where we would have placed traps) (Mattson 1990).
- A higher number of people present at a trap corresponded to an increase in recapture time.
- Number of drug injections and date of capture were not significant predictors of time to recapture.
- Bear trapping in Utah should be done in episodes during June, July or August (no difference in capture rate between these months). Bait should be left in open traps during breaks between episodes. This action allows bears to experience the trap without being captured which may postpone their learning to avoid capture.
- Traps should be moved regularly because trap response becomes evident after 20 consecutive nights.
- Four summers of trapping were enough to capture most adult females on the Plateau study site. This conclusion of Smith (2000) was also borne out by the calculations of minimum number known alive (MNKA) for adult females (Table 3) which stabilized at 20–21 after 4 years.

The analysis of trapping data is generally compromised by the heterogeneous behavior of individuals towards trapping directly and the probability of encountering a trap. In the case of solitary black bears, for example, a female not sexually active until 4–5 years old would in theory have no reason to approach a trap that had previously captured a bear and contained its scent because of the risk another bear could be to her. If this is the case, capture rates for sub-adult females should be low relative to older, larger bears (Smith 2000). Adult females with cubs should likewise avoid areas of bear concentrations or traps smelling of bears (Jonkel and Cowan 1971, Garshelis and Pelton 1981, Maddrey 1995, Rogers 1987).

Bear Density Estimate.—No one knows how many black bears are found within the state but a conservative estimate for the Plateau is now possible.

The first *eight* years of trapping black bears on the Plateau in an area circumscribed by a parallelogram roughly 9 × 18 miles resulted in the capture of 129 different bears. The trapping effort (1991–97, 1999) was relatively constant ranging from a low of 769 trap nights per year to a high of 1,158 and a mean of 1,018. The first four years of trapping included 4,252 trap-nights and the last four years 3,899. Four years into the study (1994), a total of 20 adult breeding age females, ≥ 4 years of age, were known to be resident in the area (Table 3). The four trapping episodes in the years 1995–1999 yielded only three more *newly-caught* breeding-age females, leaving us to conclude that most of the trappable adult females had been caught by the fourth year of the study (1994). We combined the total males and females known to be alive in 1994 (36 ♀, 35 ♂) to estimate minimum population density.

Most of the females were radio-collared and monitored periodically for varying lengths of time (month to years). Locations of collared females were obtained from fixed-wing aircraft, visits to den sites, and from ground triangulations. While relatively few locations were made annually (intensive radio-tracking was not a research priority owing to budgetary constraints), the accumulation of locations over years up to 1994 and beyond have shown these bears to have predictable home ranges.

All radio-locations of the adult females and the trap locations of females under the age of 4 are contained within an area 20 x 20 miles (400 mi^2). The 35 males also known alive in 1994 were trapped within the home ranges of the 20 adult females. The 36 females occurred at a density of one bear per 11.1 mi^2 and the males at one bear per 11.4 mi^2. The combined density estimate, therefore, is one bear per 5.6 mi^2.

The 400 mi^2 used in these calculations represents about 20% of the 1,973 mi^2 on the East Tavaputs Plateau over 6000 ft in elevation between the Colorado–Utah state line in the east and the Green River in the west. Using the combined density estimate (1 bear/5.6 mi^2), there are a minimum of 352 bears on the Plateau. The Ute Indian Trust Lands in the western extreme of the Plateau probably have higher bear densities than those calculated here because of little to no hunting

Figure 4. Severe injury to a male involving the upper lip and nostril. Not shown is a 7-inch laceration on the lower back that was filled with maggots. This bear was treed by houndsmen about a year after this photo was taken and was judged to be in excellent condition.

pressure prior to 1994.

These estimates, while perhaps the best available for Utah bears, are simplistic and compromised by not having collared sub-adults, yearlings, and adult males.

In the SSA study area of New Mexico which has similar plant composition, elevation, precipitation, and rainfall patterns to our study area, female density was higher (1 per 6.3 mi^2) and male density was the same as ours (1 per 11.4 mi^2) (Costello et al. 2001).

We are somewhat comfortable with these density estimates for the Plateau, but caution that they are minimum numbers of bears known alive at a point in time. Given that drought can severely impact cub production, we suggest that extrapolation of these density estimates to other populations in the state is unwise and not justified. Most bears in the state have access to high-elevation plant foods and water resources not found on the Plateau (Tolman 1998). These high-elevation habitats might provide refuge to females and cubs, mitigating the impacts of drought. For example, Frost (1990) showed that bear density on the high-elevation La Sal Mountains (1 bear per 3.0 mi^2) was twice that of the Plateau.

Natural Injuries.—Scars were regularly seen on the face and occasionally on the bodies of both males and females. Injuries were well-documented during our work on the Hillcreek Extension in 1992, and 13 of 34 (38%) of those bears had minor flesh wounds received prior to trapping. When we saw open wounds we treated them with antibiotic ointments and powders. The most severe natural injury was to a 19-year-old, 300 lb male we caught in June 1999 (during the breeding season) that had portions of his upper lip and nostril missing (Fig. 4), and a 7-inch deep laceration across his lower back that was filled with hundreds of maggots. After washing the wound with alcohol, we applied ointment and a mud pack to keep out flies. We assume this old, mature individual received these wounds while contesting with another male for access to a female. A houndsman from Vernal, UT, Brad Evans, treed this bear during the bear hunt in September saying he appeared to be in good shape but "too ugly to kill." In May 2000 this bear was treed by another houndsman. It was undoubtedly the same bear because he had the right colored eartags, a scarred upper lip and nostril and a dark strip of hair across the lower back where the wound had healed. When treed he was approximately 25 miles to the west of where we caught him the previous year. This is a good example of the

Table 5. Fates of marked black bears on the East Tavaputs Plateau, UT (1991–2004).

Fate	♂	♀	Unknown
Alive and collared	–	7	
Cub Loss	32	19	1
Depredation	3	4	
Hunter	41	19	
Natural	1	2	
Research	1	1	
Vehicle	1	–	
No Data	94	48	2
Poached	–	3	
Total	173	103	3

recuperative powers of bears. Other examples of recovery from severe injury are found in Black (1997). It would seem that in long-lived animals with low reproductive rates immunological adaptations would be rather robust. An interesting research effort in this regard would be to document the abundance and distribution of gut associated lymphoid tissue called Peyer's patches (Sherwood 2001) in the digestive tract of black bears and compare it to mountain lions (*Puma concolor*). These two species are on opposite extremes of the fresh meat to rotten meat food continuum. (Mountain lions would be the fresh meat eating model and black bears the rotten meat one.) The prediction is that a pathogen-laden rotten meat diet should demand a more aggressive immune response (more Peyer's patches in this case) than a fresh meat diet. Digestive tract specimens for this proposed research could easily be obtained from lion and bear hunters.

Mortality.—Including cubs we handled 279 bears (173 males, 103 females, and 3 of unknown sex). We know the cause of death for 47 males (27%) and 31 females (30%) (Table 5). There were two research related deaths. One was a sub-adult female and the other a young adult male. Both appeared to have had adverse reactions to the drugs. Though we seldom remained near bears until they revived from sedation, we have no evidence that any were ever killed or attacked as they slept.

Natural mortality was documented 3 times. An 18-year-old male with only one functional canine protruding above its gum-line (Black 1997) died in March at the base of a tree adjacent to his last den. (It would have been its first sepulcher if it had died during winter lethargy.) A 5-year-old female with a first litter of 2 cubs died in August 2000 perhaps of nutritional stress (Chapter 10). Another old female was found dead in March 2004. The few remaining scattered bones, skull and radio-collar suggested she died and was scavenged in the fall 2003.

A bowhunter found an adult female in September 2004 that had been shot through the rib-cage with a high powered rifle. A second slug was found embedded in the radio transmitter. Two other radio-collared females were found dead. Both appeared to have died in September when big game hunts were in progress. Circumstances suggested they were illegally killed.

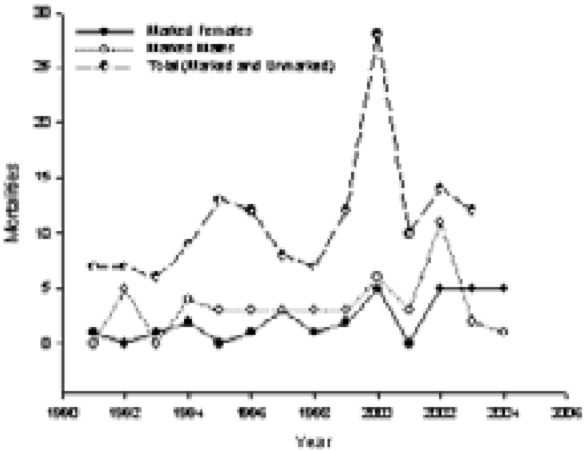

Figure 5. Mortalities from all causes of black bears on the East Tavaputs Plateau from 1991–2004. The spike in 2000 was in part due to 5 bears leaving the Plateau to feed in watermelon fields near the city of Green River, Utah.

Three radio collared adult females were killed by personnel from the U. S. Department of Agriculture, Wildlife Services Section. All were pursued from calf carcasses, treed by hounds and shot. Another sub-adult female was killed in a cornfield near Fruita, Colorado (Bear 9 in Chapter 7). A young male was killed by a houndsman who encountered him outside his camp-trailer; another young male was killed by a ranch-hand; and a mature male was killed in a depredation situation (sheep) in Colorado. Hunters legally killed 19 marked females and 41 marked males. We do not know the fates of 46 ear-tagged females and 93 ear-tagged males.

The distribution of mortality through time is rather constant with the exception of 2000 when record high numbers of marked bears were killed (Fig. 5). The year 2000 was extremely dry (Chapter 3 and Chapter 7) and 2000–2002 represent 3 consecutive years of poor cub production and presumably poor fall mast production. In neighboring New Mexico there was also extensive failure of mast production in 2000 (Costello et al. 2001). These authors demonstrated that bear movements were more extensive in years of mast failure and apparently independent of the increase in movements normally associated with fall foraging activity (Costello et al. 2001). Increased

Figure 6. Front pad of an adult female black bear taken in early March showing hair growth that occurred after the onset of denning. (Photo by Jim Crook)

activity associated with poor food production may increase hunter success as bears become more vulnerable as they search over larger areas for food (Noyce and Garshelis 1997).

Physical Characteristics

Out of tradition, many black bear studies routinely take various morphometric measurements that are used to describe the population under study. Some measurements have intrinsic intellectual and even heuristic value. Others are more utilitarian and useful for management purposes. Here we report those which we believe will be useful to both managers and hunters or otherwise inherently interesting.

"It has not escaped our notice" (Watson and Crick 1953) that with numerous individuals taking measurements there was undoubtedly considerable inter-researcher variation in spite of the fact that in no year was there ever a completely new field crew. Experienced personnel always trained new-comers to the project (see Eason et al. 1996 for an evaluation of this problem.)

Color and Pelt Condition.—Black bears in our study area were judged to be black 12.2% of the time. The remainder were numerous shades of brown, from dark chocolate that would appear black in poor light or at a distance to late summer bears that appeared to be bleached blonde. Because summer trapping ended by mid-August, we made few observations of pelt condition. We assume our bears were near prime condition by September as reported for Colorado bears at about the same latitude (Beck 1991). Bears caught in June were often shedding with dark new hair visible under shedding, lighter-colored hair. Bears seen in dens were with rare exceptions judged to have pelts in excellent condition. Hair growth on the feet apparently continues to some extent in denned bears because long guard-hairs were often seen growing around and under toes and palm pads—hair that would have been worn away with ambulatory activity (Fig. 6). This caused us to question whether pelts might be most prime in late winter if prime means maximum hair length. Hunters on occasion told us that May-killed bears often have excellent pelage. Therefore, spring-killed bears (April–May) should yield specimens with quality pelts. In the lower latitudes of New Mexico this might not be the case (Costello et al. 2001)

If for some reason a hunter in Utah wants to shoot a black bear that is actually black, he is likely to find 12 of that color for every 100 bears that he sees. If it is early morning, late evening or an overcast day, a bear at some distance on a hillside, high in a tree or in deep shade may appear black but is most likely just dark brown. In Colorado, 26% of the bears are black (Beck 1991). In New Mexico one study population contained about 17% black (both sexes) and another population had 42% black females and 36% black males (Costello et al. 2001). Throughout most of the mountainous western United States most black bears are brown in color. In the eastern United States most are black (Pelton 2000). Explanations for variable color and regional differences remain unclear (Beck 1991).

Front Pad Widths.—Male and female front pad widths as a function of age are shown in Fig. 7. At about 4 years of age both sexes seem to have reached adult widths. All female pad widths were less than 4.5 inches (11.4 cm). Male widths were consistently above 4.5 inches (11.4 cm) after age 4. We have shown elsewhere that pad measurements can differentiate age groups with an error of 22.6 percent (Chapter 5). Most of the error resulted from considerable overlap in pad widths of subadults.

Chest Girth.—Chest girth is on the surface a fairly straight-forward measurement, but like so

Figure 7. Widths of front pads of male and female black bears captured on the East Tavaputs Plateau, UT from June–August in the years 1991–2002. Multiple measures from an individual within a year were averaged. Repeated measures between years were treated as independent. Symmetrical standard error bars are shown.

many measurements taken on bears it is subject to rather extreme variation in precision owing to human error (Pelton and van Manen 1996, Eason et al. 1996).

Chest girth dimorphism like weight manifests itself in young 2–4 year-old individuals. Chest girth can clearly be used to measure growth related with age, but care must be taken to minimize variation between researchers (Eason et al. 1996). When taken from a live sedated animal, the measurement requires that phases in the breathing cycle be accounted for, and it is obviously not a measurement that can be taken by managers or researchers from a skin. Shallow respiration may give chest measurements different from those obtained from an intact carcass. Furthermore, season of the year must be considered. An example from Noyce and Garshelis (1998) is instructive. They showed that yearlings measured in a den in March may have chest girths greater than those measured for the same bear in early summer. One might conclude that the animal had lost weight when in fact they had increased in weight due to skeletal and even muscular growth but had lost "girth fat" in the process. Our data do not permit a good understanding of the girth to weight relationship especially for a management use, because we have few weights from early summer- and fall-caught bears.

Weights.—Dimorphism in weight appears to begin at about age 2 and becomes asymptotic at around age 5 for females and 7–8 for males (Fig. 8). Weights were from bears caught in June, July and August. These weights would not include gut contents if bears had been in traps over 13 hours (retention rates, depending on food eaten, ranges from 7–13 hours) (Pritchard and Robbins 1990).

If patterns of weight gains in Utah bears are similar to those calculated in Minnesota (Noyce and Garshelis 1998), then weights of young males represent increasing skeletal growth even as fat levels are decreasing. Weights of 4–5 year-old males and males 6 and older probably represent some recovery of weight lost during the breeding season. Like males, young females will have by June or July increased 30–50 lbs over March den weights. Gains of 30–40% over March weights could be expected in 1–2 year-old females. Three to five-year-old non-lactating females in Minnesota did not change significantly from late winter (March) to early summer but 6+ year-old females gained an average of 7.3 kg, while lactating females had no discernable patterns (Noyce and Garshelis 1998). The absence of collared males did not permit an evaluation like the one done in Minnesota and small sample size plus few captures of females in May preclude further analysis.

Figure 8. Weights of male and female black bears captured on the East Tavaputs Plateau, UT from June–August in the years 1991–2002. Multiple measures from an individual within a year were averaged. Repeated measures between years were treated as independent. Symmetrical standard error bars are shown.

MANAGEMENT IMPLICATIONS

While recaptures of bears slightly exceeded initial captures, they were not evenly distributed among age classes (Smith 2000). Old males and females were hardest to recapture. An extreme example was a female who after initial capture in 1992 was not caught again until 2001. We trapped throughout her home range every year and she was seen in her winter dens in 12 consecutive years. This example and numerous others suggest that trapping should not be the method of choice if catching an individual previously caught is the objective. If the home range of the target bear is known then hounds could be used to tree the bear. Reasons for recapture might include removal of a dysfunctional radio collar or application of a new one.

Over the course of this study our sample size of reproductive females could have been nearly double if they had been off-limits to hunting. Bears are long-lived animals and are suitable models for many interesting ecological questions. Unfortunately, the repeated human-caused mortalities of collared females severely constrained the statistical utility of these data especially in the contexts of population modeling and estimation of variation in reproductive fitness (Chapter 3, Palochak 2004). Additionally, premature deaths of collared animals represent a significant loss to the UDWR because the greatest monetary investment is in the initial capture and collaring, not in the routine monitoring. Any future work involving live trapping and monitoring of bears would yield adequate sample size much faster if hunting were not permitted during the study.

Because most bear carcasses are not retrieved by Utah hunters (only skulls and skins are required to be checked by UDWR personnel), data on weights and fat levels as indicators of general health and reproductive potential are generally unavailable. A recent paper by Noyce et al. (2002) offers hope that field evaluation can be easily done to provide an indication of physical condition and reproductive state. Management may want to consider enlisting hunters in the gathering of data on the condition of breeding females, the bears that ultimately determine hunting opportunity.

Front pad widths alone are very useful in identifying mature males with high confidence, but the overlap of front pad widths from subadult males and adult females precludes discrimination of other age classes (Chapter 5); however, another preliminary analysis of a combination of three pad measurements (width, length, and total length) suggests that sexes *can* be reliably discriminated from tracks (unpublished data, see Manuscripts in Preparation, p. viii)—a useful management tool. Hunters, houndsmen, recreationists, and wildlife biologists often encounter bear tracks in various substrates (dusty roads and at the edges of springs and creeks). An air of excitement often accompanies these occasions, but unfortunately a ruler usually does not. A stick could be used to "measure" track widths and then later at camp or in the office, real track dimensions could be determined to add validity to the tales that inevitably follow from track observations.

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PATTERNS IN CAPTURE DISTRIBUTION OF BLACK BEARS ON THE EAST TAVAPUTS PLATEAU DETERMINED BY RANDOMIZATION ANALYSIS

JANENE AUGER AND HAL L. BLACK

Abstract.—Black bears (*Ursus americanus*) were trapped and marked 10 of 12 years during a study on the East Tavaputs Plateau of eastern Utah. Location of traps and trapping effort varied slightly from year to year; however, the same major and minor drainages along a network of secondary roads were trapped each summer (1991–1997, 1999, and 2001–2003). Here we report the distribution of all initial and subsequent captures of 179 unique bears within the 14.5 x 29 km study area. We divided the study site into 18 cells of equal shape and area and compared the observed distribution of all captures to a random distribution generated by computer simulation, thereby accounting for differential trapping effort between cells. There was a non-random distribution of captures with some cells yielding significantly higher numbers of unique individuals. Poorly developed roads, dead-end roads, water, mature conifer stands, and food resources probably combined to create high-quality habitat patches attractive to bears of both sexes and age groups. One of these high-quality habitats was recently opened to natural gas exploration. We report the failure of the results of this long-term study to impact land managers in the State of Utah and Bureau of Land Management to forego exploration in what may be one of the highest quality bear habitats in the state of Utah.

The areas encompassed by the East Tavaputs Plateau (Plateau) black bear study site are either federal lands managed by the BLM under multiple-use philosophy, Utah State Trust Lands managed for revenue generation, or small private holdings used for cattle ranching. Overlaid on these patterns of human interests is the utilization distribution of bears which is revealed, at least coarsely, by trapping results. An understanding of the these patterns seems imperative for effective management especially when interests such as oil or mineral extraction must be simultaneously considered.

As trapping progressed through the 12 years of the study, we observed that some regions of the trapping area seemed consistently more heavily utilized by bears than others, resulting in higher capture totals—both in unique (first-time) bears and in recaptures. One place which seemed particularly trafficked was a cluster of 3 canyons in the west-central portion of the study site (Horse Canyon, Main Canyon and Trail Canyon). But rigorous analysis of the trapping data presented challenges to traditional statistical methods because the specific locations of traps and the trapping effort varied somewhat between summers even though geographic coverage of the trapping between years was constant. Randomization procedures are effective tools in such cases (Manly 1997) and allowed us to determine if our observations were convincingly real in a statistical sense. Herein is our analysis and a discussion of the management implications.

METHODS

Bears were live-trapped on the Plateau in 10 of 12 years (1991–1997, 1999, and 2001–2002). Location of traps and trapping effort within the 14.5 x 29 km (9 x 18 mi) study area varied slightly from year to year; however, the same major and minor drainages along a network of secondary roads were trapped each summer. We divided the study area into 18 equally-sized square cells (See layout and numbering in Fig. 1). Cells were 4.8 km (3 mi) on a side and included all but 3 of the 137 trapping stations used in the years 1991 to 2002. Horse, Main and Trail Canyons were contained in cells 3, 8 and 9 and were of special interest. Trap nights per cell and total captures per cell were tallied (Table 1). Both captures of new bears and recaptures of previously marked bears were counted with the reasoning that recaptures provide information on space usage of bears whose home ranges straddle our artificial cell configuration.

Essentially, the randomization procedure—carried out by the Medusa Random Sample Generator (Gonzales 2004)—randomly assigned the observed number of captures over all years to the cells while accounting for the

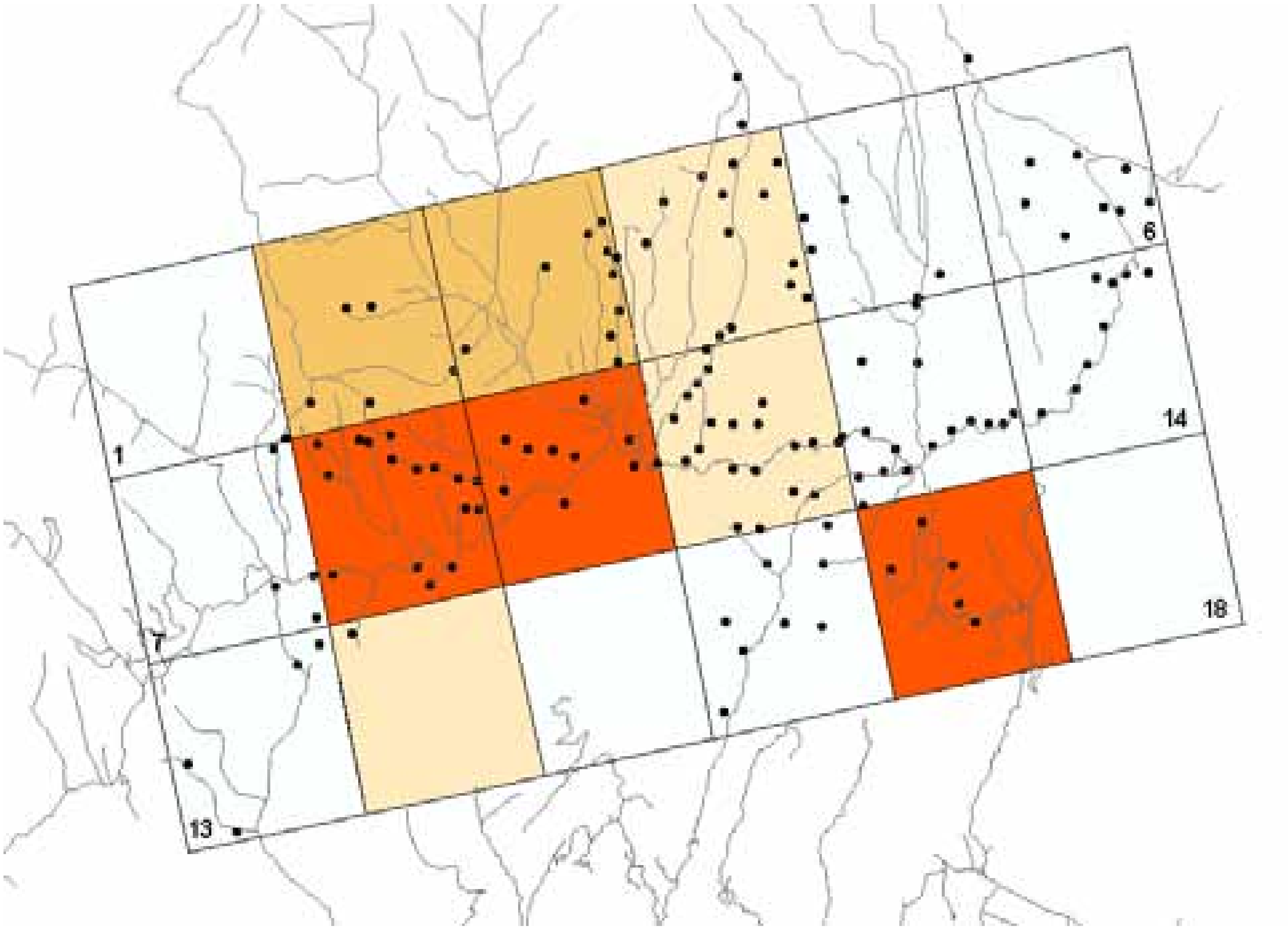

Figure 1. Numbered cell layout of the ETP study site with roads and trap locations shown. Dark orange cells = high captures and cream cells = low captures. See text on page 21 for further details.

differential trapping effort in each cell, i.e., we drew the 357 captures out of a "hat" containing the correct number of trap nights for each cell summed over years for a total of 10,826 trap nights in the "hat" (Table 1). Distribution of trapping effort among cells was not even because physical access to some cells was too difficult. Sampling was done without replacement and 999 iterations were performed. For each iteration the number of captures per cell was tallied. The simulated distribution of captures within each cell approximated a normal curve. We estimated an approximate p-value for each cell by using the rank of the observed value within the simulated values. If the observed value was equal to one or more cases of the simulated value then we always used the *most conservative rank* as the approximate p-value (e.g., if the observed value was ranked 45th out of 1000, but there were 15 randomly simulated values equal to the observed value and occupying the ranks of 46–60, then we used 0.060 as the approximate *P*-value rather than 0.045). If the observed value fell within the tails ($\alpha = 0.10$) of the distribution then we concluded that it was a rare and significant event (concept illustrated in Fig. 2). We used a conservative method of estimating the *P*-value in order to decrease the chance of a statistical type I error (calling a test result significant when it is not), but we used a less-stringent alpha value because a basic principle of wildlife conservation is that management action should begin at a low threshold, before a problem becomes a crisis. Two cells (13 and 18) were excluded because they contained no trap locations. The three cells on the

Table 1. Total trap nights and captures for each cell on the East Tavaputs Plateau, UT study site.

Cell	Trap Nights	Total Captures (Observed)
1	15	0
2	362	16
3	832	33
4	1157	29
5	246	11
6	376	13
7	100	3
8	1740	68
9	1039	48
10	1519	31
11	1567	46
12	589	20

western edge of the study area (1, 7, and 13) were included in the randomization procedure, but excluded from interpretation because the range of simulation values for captures was < 10 which means that the observed value could share rank with > 100 simulation values. This creates problems for obvious statistical reasons and precludes any biological meaning.

RESULTS

The analysis was based on 357 captures of 179 individual bears captured in a total of 10,826 trap nights. The general non-agreement of the observed captures within cells with the simulated distributions provides evidence that bear distribution on the Plateau was non-random (Fig. 3). If captures had been random, the observed number of captures would consistently lie in the middle of the simulated ranges (Fig. 3).

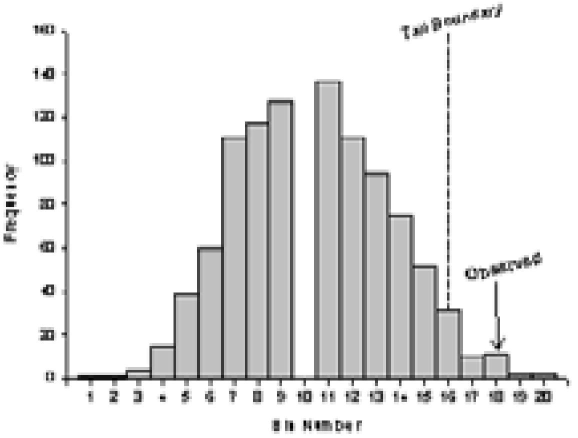

Figure 2. Illustration of how significance was determined for each cell. The x-axis represents the range of the total captures divided into 20 equal bins and N = 1000 (1 observation and 999 simulations). The observation is shown as well as the approximate demarcation of the 10% upper tail.

Observed capture counts in cells 8, 9, and 17 were significantly high (Fig. 1, red-orange). All 3 observed values ranked within the first 62 out of 1000 simulations (est. p-value ≤ 0.062 for these cells). Rank of cell 9 was 10 out of 1000 and the ranks of cells 8 and 17 were 62 and 58 respectively. Captures in cells 2 and 3 (Fig. 1, light orange) also trended towards significance (est. p = 0.138 for both cells). Captures in cells 4, 10, and 14 were remarkably low (Fig. 1, beige). The estimated *P*-values for cells 4 and 14 were 0.070 and 0.022 respectively. The observed value for cell 10 ranked lowest out of 1000 ($P \leq 0.001$) with *no simulated values equaling the observed value*. The remaining 5 cells (Fig. 1, non-colored) caught bears at a rate not different from the random expectation.

DISCUSSION

What may account for the occurrence of bear-rich and -poor areas on the Plateau study site? Canyons and ridges in the bear-rich areas are accessed in many cases by dead-end roads, roads in poor condition that receive little to no yearly maintenance and are often over-grown with vegetation, and, in one cell, roads on private land where access to the public is denied. Man-made small stock ponds, springs piped into holding tanks (troughs), and small streams providing permanent water are characteristics of all bear-rich cells. Escape cover in the form of large conifer stands are common in productive cells and hard and soft mast is present. With the exception of one year-round ranch

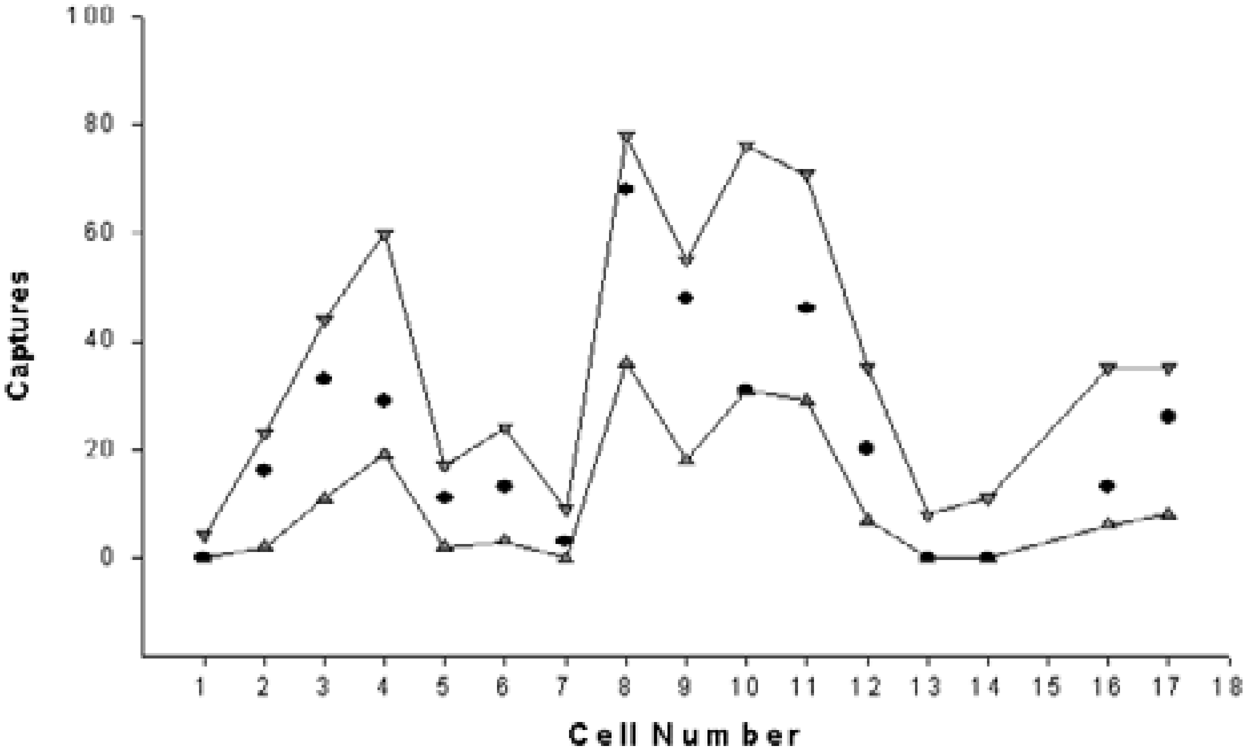

Figure 3. Comparison between the observed distribution of captures (●) and the maximum (▾) and minimum (▴) captures from randomly simulated data.

operation, no permanent human habitations are found in rich cells and there are no developed recreational campsites. Collectively and even perhaps individually these characteristics may combine to create excellent bear habitat and hence the trapping patterns we observed. We are not saying that bear densities are necessarily high in these locations, but that some discrete places are ecological magnets for bears and are frequented for the ecological resources they contain as well as the needed escape terrain from human activities such as pursuit by dogs in the spring pursuit seasons or the fall bear season. We suggest that within these high-profile cells bears have refuges or sanctuary. Undoubtedly, trapping throughout the Plateau would reveal other areas with similar importance to black bears. We are not saying here that poorer trapping areas are not extensively used by black bears. In fact, work by (Young 1995) and Harding and Black (in press) demonstrated that bears traverse the whole of the Plateau but that a non-random distribution probably reflects differential utilization of the Plateau's important resources.

MANAGEMENT IMPLICATIONS

While the East Tavaputs Plateau already includes many secondary roads and producing gas wells, the improvement of existing roads and construction of new ones for extraction activities will increase traffic and human access for the long-term and displace bears, at least while active extraction is on-going. A case history of Horse Canyon illustrates this concept. Our original forays into Horse Canyon and its tributaries revealed unsullied springs and prominent patches of currant (*Ribes* spp.), dogwood (*Cornus* spp.), serviceberry (*Amelanchier* spp.), and chokecherry (*Prunus virginianus*) which are important fall food resources for bears (Fig. 4a). Large Douglas fir trees were plentiful as escape cover. An existing dead-end road was accessible only to 4 x 4 vehicles with high clearance and we met few people during trapping activities. Trapping efforts were generally productive except in two

Figure 4. (a) Trap location in Little Berry Canyon on the East Tavaputs Plateau, Utah. (b) Improved road in Horse Canyon to permit passage of semi-tractors and drilling rig. Prior to construction this road was passable only by high-clearance, 4-WD vehicles.

instances. In 1995, what turned out to be an illegal logging operation kept us from trapping bears in Horse Canyon during the summer. Resumption of trapping in 1996 yielded no bears for two consecutive years (1996–1997). Also, in the summer of 2002 when a well was being drilled 400–500 m away on the ridgetop above a tributary of Horse Canyon called Little Berry Canyon, not a single bear was captured in that tributary. The vacancy cannot be attributed convincingly to any other cause besides human activity. Yet, despite the accumulation of unsuccessful trap nights during those years of human disturbance (resource extraction), traps in Horse Canyon still caught significantly more bears than expected over the years of the long-term study. This means that the estimated *P*-value of 0.062 for cell 8 is conservative and the statistical results are probably underestimating the biological importance of this area.

In the summer and fall of 2002, extensive exploratory 3-D seismic surveying encompassing 104 km^2 (40 mi^2) in bear-rich habitat was conducted, and, in total, 1,985 shot holes were drilled and detonated in the middle of the study area (USDI/BLM 2002) (Fig. 5). In 2003 the road into Horse Canyon was widened and graded to allow the erection of a drilling platform at the mouth of Little Berry Canyon (Fig. 4b, Fig. 6a, 6b) and the tributary is now adjacent to a second well site. Unfortunately, trapping activities were suspended after 2002 and current fine-scale movements of females within the area are also unknown.

Bears appear to be displaced by resource extraction activities, but will this have a negative impact on individual bears and the population at large? Bears are not a social species outside of the breeding season and the period of dependency of cubs. Their capacity to live to old age is by dint of individual learning and experience and we suppose old successful bears know where things are such as dependable water sources, berry and acorn patches, and deer fawning and elk calving sites. Surely as patches of good habitat are inundated by anthropogenic activities bears will be forced to utilize less-preferred habitat or compressed into smaller high-quality patches where intraspecific aggression or exclusion by conspecifics could occur. Interestingly this might affect the breeding pool of females the most for they provide indirect safety for their cubs by avoiding other adults, especially males. The Plateau has been shown to be poor habitat at best for bears in years of food shortage (Chapter 3); continued exploration and the increase in human

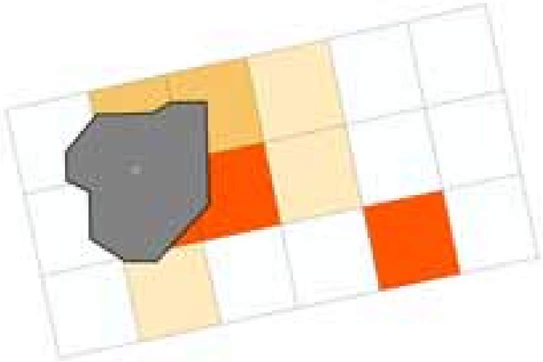

Figure 5. Area of seismic surveying on the East Tavaputs Plateau, UT.

Figure 6. (a) Natural gas drill site in Horse Canyon at the mouth of Little Berry Canyon, summer 2003. (b) Catchment basin at drill site. Little Berry Canyon is in the background.

activity and access cannot be a positive note for black bears unless mitigating processes can be implemented. The improvement of water resources available to bears and other wildlife, closure of roads no longer needed, and re-vegetation of closed roads and drill sites should be advocated. Placement of new roads or improvement of existing ones in areas of quality habitat might be reconsidered in light of information presented here. Managers may want to identify habitat quality throughout the Plateau to help mitigate future exploration efforts.

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REPRODUCTION OF BLACK BEARS ON THE EAST TAVAPUTS PLATEAU

HAL L. BLACK, JANENE AUGER, JOSHUA D. HEWARD, AND JULIE TOLMAN THOMPSON

Eiler et al. (1989) described the black bear (*Ursus americanus*) as having "one of the lowest reproductive rates of any North American land mammal." This designation comes from relatively late reproductive maturity, small litters, and long birth intervals. Data on black bear reproduction is of particular importance to their management given the correlation between cub production and the availability of adequate food (Jonkel and Cowan 1971, Rogers 1987, Elowe and Dodge 1989, Miller 1994, McLaughlin et al. 1994, Costello et al. 2003). Reproductive traits that have been commonly reported include age at primiparity, litter size, cub sex ratio, natality rate, litter intervals and cub survival. Here we characterize reproductive success in a sample of breeding-aged females on the East Tavaputs Plateau (Plateau) from 1991–2004. Our primary objective was to describe population and individual reproductive success and consider it in relation to variation in productivity of bear food plants.

METHODS

Visits to radio-collared females in dens and a few fortuitous summer captures of marked females allowed us to count and weigh cubs, and determine their sex. Cubs not denned with their mothers as yearlings were assumed dead. Sample sizes of collared females varied annually owing to hunter-caused mortalities, collar failures, collar removal, and inaccessibility of den sites. Females and yearlings were sedated as described in Chapter 1.

Litter size and sex composition were determined by direct observation. Compositions of 8 litters were inferred from the data on surviving yearlings (i.e., cubs were not directly observed, but yearlings were). In these cases only minimum cub numbers could be determined (i.e., some cubs in the litter may not have survived).

RESULTS

We visited 39 different females in their dens a total of 138 times. Fifty-eight cub litters were observed and 35 yearling litters.

Litter Size and Cub Mortality.—Fourteen cub litters consisted of singlets, 32 were twins, 11 were triplets, and there was one litter of quadruplets (Table 1). Cub survival was determined from 95 cubs from 47 litters where we knew number of cubs *and* survival to 1 year of age in each litter (requiring den visits to the female in two consecutive years). Of 55 males, only 22 (40%) survived to 1 year of age and, of 37 females, 17 (46%) survived. There were 3 cubs of unknown sex who did not survive. Overall cub mortality was 59%. There were 20 cases of whole-litter failures, 15 complete-litter successes, and 12 partial successes.

Litter Interval.—There were 27 cases from 15 females where we observed litter interval directly. Mean interval was 2.0 years (SD = 0.81) and the range was 1 to 4 years (Fig. 1). The distribution of litter intervals shows that while the mode was 2 years, 41% of litter intervals were not 2 years.

Sex Ratios and Weights.—Sex ratio of cubs was 67 males to 43 females (1.56:1) which is significantly different from the expected ratio of 1:1 ($\chi^2 = 5.24$, df = 1, $P < 0.05$). Sex ratio of yearlings found in 35 dens was 25 males to 24 females (1.04:1). Mean weight of cubs in natal dens was 3.8 lb and sexes were not significantly different (Pooled variance 2-sample *t*-test, $t = -0.009$, df= 93, $P = 0.993$). Year had a significant effect on mean cub weight ($F_{10,84} = 3.531$, $P = 0.001$). A planned comparison of the cub weight means of 1996, 2000, 2001, and 2002 (the winters following drought years) with the remaining years showed significantly lower natal weights for drought years ($F_{1,84} = 19.360$, $P = 0.000$).

Mean yearling weight for males was not different from that of females (Pooled variance 2-sample t-test, t = -1.210, df = 25, $P = 0.238$). Mean male weight was 45.3 lb (SD = 15.2, N = 12) and mean female weight was 39.1 lb (SD = 11.3, N = 15).

Survival and Recruitment of Females.—Twenty yearlings were caught or identified from the hunter harvest at age 2 or greater (Table 2). Eleven of these were females. Three females were alive at 2 years of age, 1 at 3, 2 at 4, 2 at 5 and one each at 7 and 12.

Two 2-year-olds died in their second year and one five and seven year old died.

The fate of the other 2 year old and 3 year old is unknown. This leaves a total of 5 females that were recruited into the breeding pool and still alive in 2003. Of course the 5 and 7 year olds that died were of breeding age. The fate of the other 13 female yearlings is unknown.

Individual Reproductive Histories.—We observed 39 collared females in this study. There were 66 known pregnancies, most of which were observed directly while a few were inferred from visits to dens where females had yearlings. One hundred twenty-six cubs were born to 32 females. Fifty-one of these were seen in their dens as yearlings. And 20 of these yearlings survived to age 2 and beyond. The fates of the other 31 are unknown (Table 2).

Individual variation in reproductive success, measured by number of cubs surviving to the age of one, is rather dramatic; but made most difficult to interpret by the variable lengths of time bears were observed and the variation in environmental conditions over the time frame of the study. Theoretically one could calculate the number of surviving yearlings per pregnancy for each female or some other standardized parameter of comparison, but 15 of the 39 females were observed through only 1 reproductive event. This introduces bias caused by sampling error. Yet some individuals may be qualitatively called good or poor reproducers, and some lineages seem especially productive (Table 2). Exemplary reproducers are Maggie and her offspring. In two pregnancies she produced 4 cubs, all of which survived to yearlings. One of these (Willow) had 4 pregnancies and 3 surviving yearlings. One of those survivors (Karren) in one pregnancy had a female cub whose status is currently unknown.

Typical females are for example, Heidi, currently 19 years old, who had 8 pregnancies that produced 15 cubs, 4 of which were alive as yearlings. Jane in two pregnancies produced 6 cubs (two litters of triplets). The first litter did not survive, but the second litter (2 males, 1 female) all

Table 1. Data on litter size for 58 litters observed on the East Tavaputs Plateau, UT from 1992–2004.

	Litter Size Frequency				
Year	Single	Twins	Triplets	Quadruplets	Mean Litter Size
1992	0	2	1	0	2.33
1993	2	3	2	0	2.0
1994	3	3	1	0	1.71
1995	2	4	1	0	1.86
1996	0	0	1	0	
1997	2	7	1	0	1.90
1998	0	5	0	0	2.0
1999	1	1	1	1	2.50
2000	1	2	0	0	1.67
2001	0	0	1	0	
2002	1	0	0	0	
2003	1	2	1	0	2.0
2004	2	1	2	0	2.0
All years	15	30	12	1	1.98

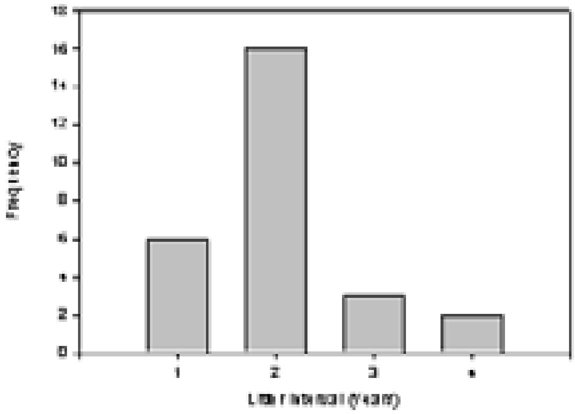

Figure 1. Litter intervals for East Tavaputs Plateau black bears derived from 27 cases.

survived to age one. And Hillary in 3 pregnancies produced 6 cubs. Four survived to yearlings and one male lived to be 9 before being killed by a hunter.

Two old females, Xina, 16 years old and observed for 13 consecutive years, and Bucky, 19 years old and observed for a total of 10 years (not consecutively), have had little reproductive success (Table 2). Xina has given birth to 14 cubs. Only one male survived its first year and was killed as a 4 year old. Xina missed 6 reproductive opportunities (i.e., observed in her den without offspring). Bucky only produced 2 cubs over 6 breeding opportunities and none survived. Beck (1991) and Kolenosky (1990) also report highly variable reproductive success in mature female bears.

DISCUSSION

Reproductive parameters (litter size, litter interval, sex ratios, age of primiparity, for example) of this population of bears are similar to neighboring states—Colorado, Idaho, and New Mexico (Beck 1991, Beecham and Rohlman 1994, Costello et al. 2001), but mortality of cubs is among the highest we are aware of. Why might this be? We have only one example of a bear abandoning her cubs after we left her den. In this case both cubs died. She was a first-time mother at 4 years of age. While we didn't measure productivity of masting plants in our study area there is the strong suggestion that food shortages were responsible for little reproductive success during some years. In this study, poor plant productivity may be exacerbated by relatively low annual precipitation. The early disappearance of snow pack as a consequence of physiography and elevation on the Plateau may also have a negative impact on productivity of masting species.

The females in this study failed to reproduce anywhere near their natural history theoretical maximum of cubs every two years (Table 2) (Palochak 2004). There were 66 occasions in which females with previously known successful reproduction or theoretical (4 years of age or older) capacity to produce cubs did and forty-six occasions where cubs were expected but were not born. (Table 2). One female failed to reproduce on 6 occasions and another on 5. Combined they comprised nearly 24% of the missed opportunities. Twenty-four (67%) of the 39 females missed at least one reproductive bout. Many failures to reproduce occurred during the drought years of 1995, 2000–2 when the proportion with cubs was 7%, 0%, 8%, and 27% respectively (Fig. 2, Table 3)

Had the females produced cubs at their maximum theoretical potential for bears in western states, the performances of females listed in Table 2 would have been dramatically different. The 66 observed and the 46 failed opportunities for pregnancy (N = 112) would have produced 224 cubs not 126. One hundred twenty-six cubs would have survived to yearlings. Of course this would never happen in the real world, but serves to indicate that any management practices which assume all adult females produce and nurture cubs is flawed. Beck (1991) similarly showed that differential reproduction by females was the theme in Colorado were even regular cub production doesn't mean production of yearlings, and that some mothers are better than others at rearing cubs to estrangement or family break-up in early summer.

Given that annual variability in the production of soft and hard mast species is correlated with reproductive success of female bears it is unfortunate that we did not establish transects on which plant productivity was regularly monitored. We do however have circumstantial evidence for low plant production. For example prior to the summer of 1995, the percentage of females with cubs or yearlings in attendance was 83%, 91%, and 100% for 1992, 1993, and 1994 respectively. In 1995,

Table 2. Reproductive outcomes of 39 breeding age female black bears on the East Tavaputs Plateau, UT. Missed opportunities are those occasions where cubs were expected based on age or previous reproductive history, but were not produced. The *known survival* column contains bears caught or bears killed at age two or older. When a second number is given under *Cubs Produced*, it indicates that cub fates were unknown.

Bear	Observed Pregnancies	Missed Reproduction	Cubs Produced	Surviving to Yearling	Known Survival (2 yr and beyond)
Heidi	8	1	13, 2	4	Unknown
Leti	1	0	3	2	♀$_{2\text{ y}}$ X
Lisa	2	0	2, 2	2	♀$_{4\text{ y}}$
Maggie	2	0	4	4	♀$_{12\text{ y}}$, ♀$_{3\text{ y}}$, ♂$_{2\text{ y}}$
Friday	3	0	3, 1	1	Unknown
Jane	2	1	6	3	♂$_{4\text{ y}}$ X, ♂$_{6\text{ y}}$X
Fine	4	0	4, 3	4	♂$_{2\text{ y}}$
Xina	5	6	14	1	♂$_{4\text{ y}}$X
Belle	2	2	4	1	Unknown
Raquel	3	0	5	2	Unknown
Bathsheba	2	0	3	3	♀$_{2\text{ y}}$ X, ♀$_{7\text{ y}}$ X
Bucky	1	5	1	0	0
Hillary	3	1	6	4	♂$_{9\text{ y}}$, ♀$_{5\text{ y}}$
Willow	4	1	4, 1	3	♀$_{7\text{ y}}$
Allyson	2	1	5	3	Unknown
Erica	2	3	4	3	♂$_{2\text{ y}}$, X
Nenie	2	0	1, 1	0	0
Penelope	3	1	5	3	♂$_{4\text{ y}}$ X, ♀$_{4\text{ y}}$
S.Skunkbac	1	3	2	0	0
Cashew	1	0	2	0	0
Tatiana	1	1	2	0	0
Chica	1	1	2	1	Unknown
Colleen	1	1	1	0	0
Soula[a]	1	3	3	0	0
Cherylee	1	0	2	2	Unknown
Ma'am	1	1	2	2	♂$_{7\text{ y}}$ X
Angel	1	0	2	2	♀$_{2\text{ y}}$, ♀$_{5\text{ y}}$ X
Mariah	2	0	1, 3	1	Unknown
Lafayette	1	0	0, 2		
Osa Loca	1	0	0, 2		
Makell	1	1	0, 2		
Karren	1	2	0, 1		
Lemon	0	1			
Candy	0	3			
Annie	0	2			
Holyfield	0	2			
Sage	0	1			
Twilight	0	2			

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[a] Soula was poached in Aug 2004. Triplet cubs were seen 3 wk later by a hunter, but never thereafter.

Figure 2. Percent of females on the East Tavaputs Plateau, UT with cubs (solid), with yearlings (forward hatched), and without offspring (back hatched). See Table 3 for sample sizes.

a dry, hot summer with little visual evidence of mast production, the percentage of females with young in the den measured in March of 1996 was only 47%. Similarly the summers of 2000–2002 were dry with little evidence of mast production suitable for black bears and the percent of females with no offspring in the den (again cubs or yearlings) was 75%, 75% and 66%. In the fall of 2003 a pinyon crop apparently ensured reproduction because only 22% of females were without young (Fig. 2, Table 3). Another indication of the severity of the drought of 2000 was the unprecedented early entrance of two breeding age females into dens in late September (Chapter 4). They were apparently cutting their losses by shifting their physiology to the energy conserving mode of winter lethargy (Nelson 1973, Lindsey and Meslow 1976, Johnson and Pelton 1980b, Floyd and Nelson 1990, Beecham and Rohlman 1994).

Another indirect example of the effect of drought and poor food production is the observation of long-time Plateau rancher, Bert DeLambert, that fall calf weights were at an all-time 20 year low in 2000 (Chapter 6). He also reported to us that 2001 and 2002 were sub-par years with calf weights better than 2000 but still lower than long-term averages. He told us that 2003 weights were normal. Further evidence for the drought in 2000 was the first recorded fall movements of an adult female off the study area to agricultural lands on the desert floor where it was killed (Chapter 7). Another lactating female apparently died of natural causes (perhaps nutritional stress) late in the summer of 2000.

Table 3. Summary of the breeding conditions of female bears on the East Tavaputs Plateau, Utah for the years 1992–2004. Only bears who were visited in the dens are included in any given year.

Year	♀s Visited in Den	Proportion w/ cubs	Proportion w/ yearlings	Proportion w/ no offspring
1992	6	0.50 (3)	0.33 (2)	0.17 (1)
1993	11	0.64 (7)	0.27 (3)	0.09 (1)
1994	9	0.78 (7)	0.22 (2)	0
1995	12	0.58 (7)	0.25 (3)	0.17 (2)
1996	15	0.07 (1)	0.40 (6)	0.53 (8)
1997	16	0.63 (10)	0.06 (1)	0.31 (5)
1998	15	0.33 (5)	0.53 (8)	0.14 (2)
1999	8	0.50 (4)	0.38 (3)	0.12 (1)
2000	6	0.50 (3)	0.17 (1)	0.33 (2)
2001	4	0	0.25 (1)	0.75 (3)
2002	12	0.08 (1)	0.17 (2)	0.75 (9)
2003	15	0.27 (4)	0.07 (1)	0.66 (10)
2004	9	0.56 (5)	0.22 (2)	0.22 (2)

We agree with Beck (1991) that reproductive failure as a consequence of fall food shortages (or other reasons) probably has little long-term effect on bear population. He had one such year in 10 years of study. We had 1 poor year in the first 9 then 3 consecutive poor years (2000–2002) followed by good reproduction in 2003. Jonkel and Cowan (1971) also reported 3 consecutive years of poor cub production. Again we agree with Beck (1991) that 2–3 in succession demands action be taken to reduce man-caused mortality several years beyond the period of poor cub production. Should weather patterns (e.g., warmer summers and/or reduced precipitation) lower primary productivity, bear populations in the Plateau might decline.

One certainty is that any sample of reproductive performance over a 2–3 year period will not provide a realistic picture of the productivity of females (Fig. 2, Table 3). This should be intuitively obvious since black bears are on the slow end of the slow to fast breeding continuum; they are large animals that live to old age, breed every two years at best, have considerable pre- and post- weaning parental investment, and low reproductive potential. Therefore their ability to forego cub production when nutritional and energetically risky is adaptive and leaves them to breed another day.

While the cost of directly observing annual cub production and survival by den visitation would be desirable, annual monitoring of 12–15 important food plants may provide an index to cub production. (Costello et al. 2001, Noyce and Garshelis 1997). A cautionary note however seems in order. In 2000 the pattern throughout much of the West was sever drought. On the Abajo/Elk Ridge hunting unit of southeastern Utah drought was similarly severe but there were no reported increases in bear nuisance problems and hunting success was normal. We observed a bear hunt with dogs over 2–3 days in September 2000 and during that time he saw numerous scats containing large quantities of manzanita berries. These berries were in late September still conspicuous on plants suggesting a good crop. Could this single crop breed successful bear reproduction as pinyon may have done on the Plateau in the fall of 2003? Might a single food plant species guarantee reproductive success here in the West as has been observed in the eastern U. S.? Costello et al. (2001) provided evidence for the importance of oak production in this regard. They further found that in New Mexico models predicting mast conditions using abiotic variables were not adequate for management objectives.

MANAGEMENT IMPLICATIONS

Is there an over-riding management objective dictated by our observations on the East Tavaputs Plateau? We suggest there is: long-term persistence demands that female bears need to be protected. Reproductive parameters reported here suggest only one primary and obvious conclusion: conserve female bears. In addition to a natural history that in its totality argues for a species with a low reproductive rate (Eiler et al. 1989) black bears in hunted and managed populations suffer mortality from a host of anthropogenic activities. Hunters knowingly kill ear-tagged and collared adult females (albeit legally) and trappers from the U. S. Department of Agriculture (Wildlife Services) do not discriminate between males and females in their depredation activities. Hunters cannot or do not distinguish between males and females regardless of hunting method (hounds, bow and arrow or spot and stalk (Chapter 4). In some hunter of large ungulates, animosity towards predators exists (deer and elk) in Utah, and some encourage aggressive harvest quotas for bears and lions (pers. obs.). This attitude is not unique to Utah (Miller 1989). Poachers in the Plateau study area have killed females with cubs at their heels.

The fortuitous timeliness of this report with the recent sustained poor production of cubs requires us to encourage a reduction in harvest permits over the next 2–3 years to (1) permit retention of females in the population and (2) allow for the recruitment that might be on the rebound starting with good cub production and yearling survival seen in 2003. Long-term it seems to us that any increase in harvest permits should only be done if harvest is by regions within the Plateau (see below). Bear harvest should, given the dynamic nature of food production, be monitored closely and perhaps always be conservative.

Management cannot significantly change the genetically predisposed and nutritionally tempered breeding potential of Plateau black bears. But this population could be augmented if female harvest is reduced and/or spread over the entirety of the Plateau. A resumption of the spring bear hunt would help accomplish this (Chapter 4). Also, our impression is that hunters and those engaged in pursuit concentrate their activities to a large extent in the general region of our study area and we suppose for the same reason we choose it in the first place—good road access for both small trucks and ATVs. We recommend that the harvest on the Plateau be divided into 4 regions using the Seep Ridge Road as a boundary between east and west. The Seep Ridge Road could be extrapolated to the south of the Divide through Middle Canyon. The Divide Road would provide the boundary between north and south.

The conservation of females might include a management plan that identifies females by marking a female segment of the population with conspicuous eartags. This protected breeding pool would be off-limits to hunters, a sanctuary of reproducing females. Periodic trapping—perhaps every 5 years—could maintain this pool. Given that man-caused mortality is the primary limiting factor to survival of females, trapping periods greater than 5 years may be all that is required. However, retention rates of tags would need to be evaluated. Five older female bears have retained both right and left eartags for 10, 11, or 12 years. Four other bears retained one tag for a range of 8–11 years. Beck (1991) had considerably less success with the oldest retention time of 4 years. Trapping and marking females might be even a more relevant management tool in the small disjunct meta-populations on the La Sal Mountains (Frost 1990) and Abajo Mountains of southeastern Utah (Chapter 7).

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MANAGEMENT OF BLACK BEARS IN UTAH: HARVEST STRATEGIES AND OUTCOMES

JOSHUA D. HEWARD AND HAL L. BLACK

Abstract.—Black bear (*Ursus americanus*) managers in Utah rely heavily on harvest statistics to make management decisions; however, harvest statistics have previously not been rigorously analyzed especially in regard to regional variations in key parameters such as kill type and age. Harvest data for the last 15 years were compiled and analyzed in respect to sex, age, kill type, season, kill location and method of take. Spring hunting, which was abandoned in 1993, resulted in a significantly lower female harvest. Mean age of bears varied according to region with regions in the southern and eastern portions of the state having significantly older ages. Mean age also increased slightly over time. Statewide the mean age of 5.6 years exceeded the minimum harvest objective of 5 years as outlined by the 2000 bear management plan. The Wasatch and Central Mountains regions failed to meet harvest objectives for age. In Utah, 60% of documented bear mortalities in this time period were attributed to hunters and 36% were associated with depredation and nuisance activity. The number of bears killed for depredation has significantly increased over time and has been largely confined to the Wasatch, Uintah and Central Mountains, which contain 80% of the domestic sheep grazing allotments in bear habitat. Population models based on harvest data, density estimates from telemetry-based studies and increases in depredation and nuisance activity indicate that the state's bear population has increased. Maintaining a conservative harvest and an emphasis on gathering accurate and complete data on each bear killed in the state will allow managers to effectively evaluate and alter strategies for bear management. Spring hunting seasons may be desirable in the future to ensure that harvest objectives for females are consistently met. Additionally, cementum-annuli aging should continue for all bears since visual inspections for age estimation have proven unreliable in the past. Future management decisions would benefit from more elaborate modeling which includes population information from telemetry-based studies and food surveys along with the traditional harvest data.

Black bears (*Ursus americanus*) are harvested as a game animal throughout most of their range. Harvests provide a source of revenue for management agencies and recreational opportunities for hunters. Managers rely heavily on harvest data (e.g., sex and age composition of killed animals) to make decisions concerning harvest levels, seasons and methods (Garshelis 1990). Use of harvest data varies from simple comparisons of harvest parameters with long term averages or objectives to the application of more sophisticated models that estimate underlying populations and harvest rates (Bunnell and Tait 1980, Paloheimo and Fraser 1981, Fraser et al. 1982). A few agencies attempt to combine harvest data and information from other sources to develop elaborate models as a basis for management decisions (McLaughlin 1998, Costello et al. 2001). Harvest data do not necessarily reflect changes in underlying populations and must be evaluated cautiously to avoid making management mistakes (Garshelis 1990, Miller 1990). There have been numerous attempts to monitor populations independent of, or supplementary to, harvest data: mark-recapture studies (Garshelis 1990, Garshelis and Visser 1997), bait-station visitations (Beecham and Rohlman 1994, Powell et al. 1996), food surveys (Noyce and Garshelis 1997), DNA fingerprinting from hair snares (Boersen et al. 2003), track surveys (Young 1995) and other sign or sightings (Akenson et al. 2001, Martorello et al. 2001), nuisance activity, and road kill rates (Garshelis 1990). Often these alternative methods are cost prohibitive over large geographic areas so that results must be extrapolated from small study sites, whereas harvest data are readily obtainable across large areas. Despite inherent biases and problems associated with managing based on harvest data, most populations are considered to be stable or increasing (Garshelis 1990).

Black bears were given protected wildlife species status in Utah in 1967 (BBDG 2000) and there have been varying degrees of effort since that time to regulate and monitor the harvest. In 1967 and 1968 harvest numbers were calculated based on observations of conservation officers in the field.

Beginning in 1969 permits were required to hunt bears and harvest estimates were based on hunter questionnaires from 1969–1980 (Burruss 1981). Since 1981 there has been an actual enumeration of the harvest with successful hunters being required to check animals in with Utah Division of Wildlife Resources (UDWR) personnel within 48 hours (Fitzgerald 1982). A tooth (1st upper premolar) has been collected from bears checked by UDWR since 1989 (Pedersen and Newman 1989) and has been sectioned and aged according to Willey (1974). The UDWR moved to a limited entry bear hunt in 1990, where permits were designated for specific management units (Pederson and McDonald 1991). The boundaries of units have been in flux since the instigation of the permit system to enhance hunter opportunity and regulate hunting pressure. Prior to 1993 bear hunting occurred in both spring and fall with the majority of permits issued in the spring (98 vs. 44). Spring seasons typically lasted from April 15 through the first weekend in June and fall seasons ran for the month of September and the month of November. October was closed to bear hunting to minimize conflicts with other big game hunters. In 1993 the spring hunt was discontinued due to public concern over the potential "orphaning" of cubs and all hunting pressure was relegated to the fall. In March 1999, the State Wildlife Board commissioned the Black Bear Discussion Group (BBDG), an ad hoc committee representing all major interest groups, to address concerns with the rising percent of females in the harvest and the increasing number of bears killed for livestock depredation (Bates and Henry 1999). In 2001, at the recommendation of the BBDG, a five-year experimental spring hunt was initiated on select units to measure the impact of hunt season on female harvest and depredations on livestock. It is anticipated that spring hunting will be reevaluated at the conclusion of the experiment.

Currently there are three methods of take in Utah: hound hunting, baiting and stalking. Hound hunting typically is initiated from a vehicle with strike dogs that pick up bear scent and bay. Once alerted, the houndsmen set the dogs out after the bear, which is treed or brought to bay at the conclusion of a successful chase. Baiting is only open to hunters using archery tackle and involves a hunter using a single registered bait station as an attractant for bears; baits often include pastries, meat or other aromatic foods and oils. Stalking consists of spotting bears from a distance or locating tracks and then approaching the animal to within shooting range. Hunters report kills to UDWR and aspects of the kill are recorded such as location, date, hunting method, sex, estimated age, body measurements and hunting effort. In addition bears are killed each year in depredation and nuisance situations. More than 95% of the depredation is on domestic sheep with the remainder on cattle, goats and turkeys (BBDG 2000).

The black bear management plan developed by the BBDG calls for a thorough analysis of past harvest records to provide a more complete picture of bear management than is contained in the UDWR annual harvest reports. Accordingly, we analyzed Utah's harvest over the last 15 years with the following objectives: (1) determine the influence of method of take (hounds, bait or stalk), region and timing of the hunt on the harvest sex ratio; (2) determine the relationship of harvest sex ratio and hunting season in Colorado where the spring hunt was also abandoned in 1993; (4) look for changes in the harvest age structure over time, space and method of take; (5) determine the value of age-class data contained in pre-1989 harvest reports in potential comparisons with recent harvest records where cementum annuli aging occurred; (6) use Paloheimo and Fraser's (1981) population model to determine population trend over the last 15 years and compare it to other estimates made by the UDWR; (7) quantify the apparent increase in depredation harvest over time; and (8) identify significant differences in sex and age structure of depredation and sport harvested bears.

METHODS

Shifting unit boundaries and incomplete individual harvest records made it impossible to analyze the data according to current unit boundaries. In order to account for this, units were lumped into nine geographical regions: the Wasatch Mountains (units 2–4; and 17a, b and c), Uintah Mountains (6; 7; 8a and b; and 9a, b and c), Central Mountains (16a, b and c; and 25a and b), Range creek (11a and b), Book Cliffs (10), La Sal Mountains (13a and b), Southern Mountains (28 and 29), Boulder Mountains (25c) and Abajo Mountains

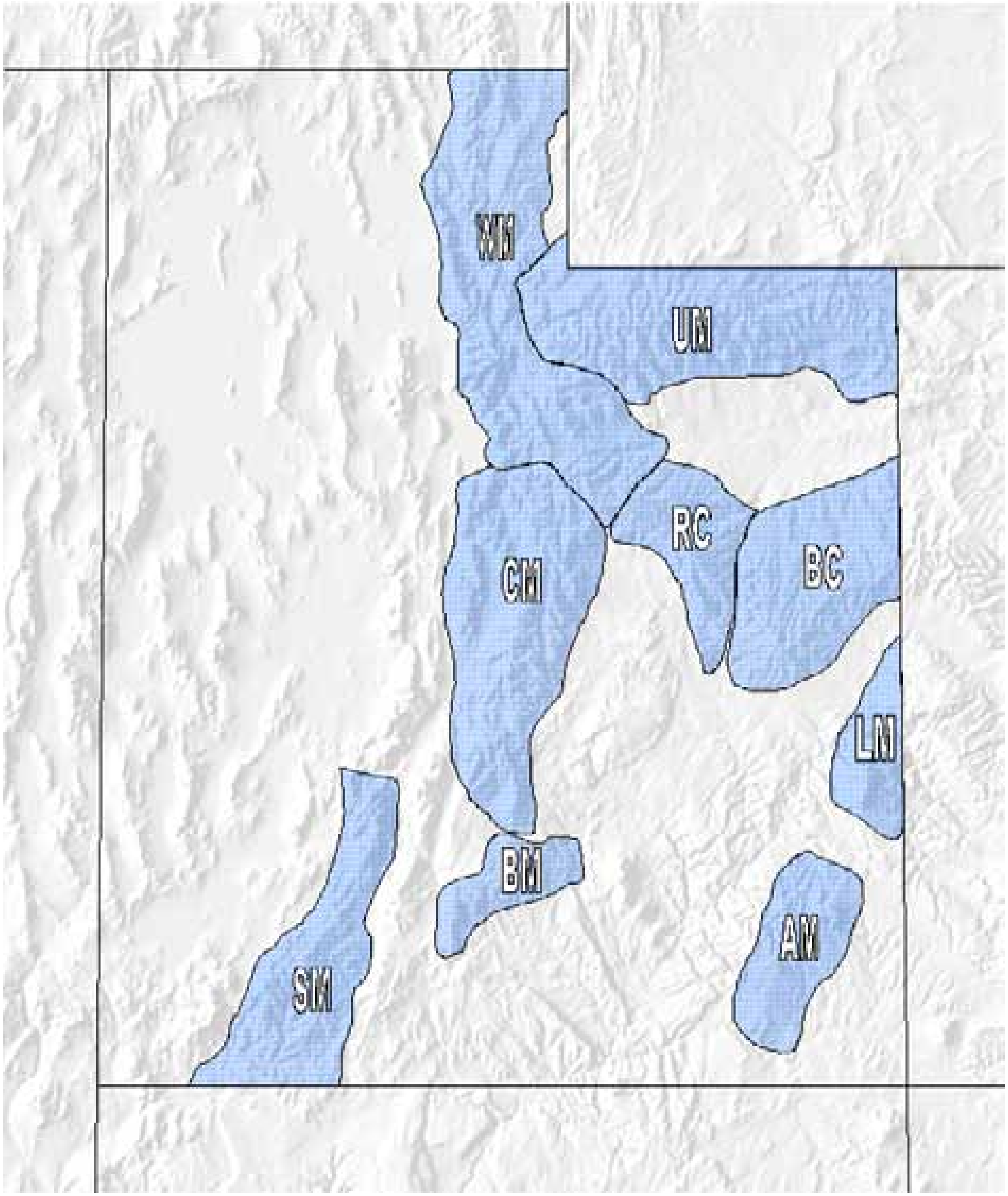

Figure 1. This map shows the regions used for data analysis. Region boundaries were chosen to account for shifts in hunt unit boundaries over time with an attempt to maintain geographic relevance.

(14) (Fig. 1). Using the regions rather than the hunt units also allowed for larger sample sizes in data analysis.

We compiled sex, age, location, type of kill (sport, depredation or other) and, for sport-harvested bears, method of take (hounds, bait or stalk) from individual harvest records from 1989–2003. Individual records prior to 1989 were unavailable and annual harvest reports lacked age information since teeth were not collected until 1989. Annual reports from 1981–1988 summarize location and type of kill data and grouped bears according to sex and age-class (adult or subadult) based on the estimation of the UDWR employee checking the animal. Sex composition of spring and fall harvests were compiled from Colorado's 1984–2001 annual harvest reports.

We used binary logistic regression (proc LOGISTIC, SAS 2003) to analyze the sex in relation to method of take, region and hunt season. Colorado's harvest was also analyzed with logistic regression in respect to harvest sex ratio and hunt season for the nine years preceding and following the abandonment of the spring hunt. ANOVA (proc GLM) was used to determine the relationship of age with year, region, sex and method of take.

In order to understand the usefulness of data contained in harvest reports pre-1989, the accuracy of the age class estimate at the time a bear was "checked in" was compared with the actual age based on the extracted tooth. Bears aged 1–4 years were considered subadults and counted as misclassified when labeled adults. Adult bears aged 5–10 years were counted when misclassified as subadults.

Sex, age and hunter effort data were used to estimate harvest rates after a model by Paloheimo and Fraser (1981). The male to female ratio in the harvest is relatively high for young bears, but females become more common in older age classes. The model uses the rate of decline with age in the male: female ratio to estimate the population's harvest rate (Roseberry and Woolf 1991). Ages 1–16 were used in the analysis with age class 16 including all ages older than 16. The model requires non-zero values for the sex-age classes so 0.001 was used to replace any zero values. Data were pooled in three-year increments to increase sample size (Harris and Metzgar 1987) and the sum of the harvest effort for the three years was used to calculate population size. Hunting effort was in terms of thousands of permits sold. Hunter days would have been a preferred measure of effort but data were not available for several harvest years. The harvest rates computed by the model were obtained by using a nonlinear least squares procedure in SAS (proc NLIN) and population estimates were obtained by dividing the total harvest by the estimated harvest rate.

The probability of depredation harvests over time and the relationship of kill type with sex and age-structure were evaluated with logistic regression. A confidence level of 95% was used to evaluate the statistical significance of all tests.

RESULTS

There were a record 687 tags sold in the 1989 harvest season probably in anticipation of the limited entry hunt which began the following year. Since 1990 there have been 2584 permits issued with an annual mean of 185 permits. Since 1989 hunters harvested 860 individuals yielding a long term success rate of 29%. An additional 515 bears were killed in depredation and nuisance situations, and there have been 61 other documented mortalities (e.g. road kills) for a total of 1436. The distribution of sport and depredation harvest is not even across the state (Table 1). Most sport-harvested bears are taken with the use of hounds, 78%; followed by bait, 14%; and stalking, 8%. The harvest data are summarized in the appendix.

Sex Ratio.—The sex of harvested bears was not significantly correlated with either region (Wald Chi^2 = 4.4977, P = 0.8097) or method of take (Wald Chi^2 = 0.6141, P = 0.7356). However, there was a significantly greater proportion of females harvested during the fall (0.40, 95% CI = 0.36–0.44) than spring (0.25, 95% CI = 0.20–0.31, Wald Chi^2 = 17.5066, P < 0.0001). In Colorado the same pattern occurred with a greater proportion of females in the fall harvests (0.40, 95% CI = 0.39–0.41) than in the spring (0.34, 95% CI = 0.32–0.35, Wald Chi^2 = 38.1455, P < 0.0001).

Age-structure.—Mean age did not change significantly between years ($F_{12,566}$ = 1.28, P = 0.2285) or method ($F_{2,577}$ = 2.65, P = 0.0712). Mean age of bears did, however, differ among the nine regions ($F_{8,1070}$ = 7.58, P < 0.0001). Wasatch, Uintah,

Table 1. These data allow comparisons of regions by percentages of total harvest parameters for bears (see Fig. 1 for key to abbreviations). The percent of total sheep found in bear habitat is also included for each region.

Region	% Total Permits	% Total Sport	% Total Depredation	% Total Mortality	% Total Sheep
WM	14.5%	6.6%	27.4%	14.5%	34.3%
UM	10.7%	9.8%	20.4%	13.8%	15.6%
CM	25.2%	14.5%	23.1%	18.4%	32.3%
RC	9.3%	10.5%	5.4%	8.4%	3.9%
BC	11.5%	18.3%	3.9%	13.0%	2.7%
LM	9.8%	17.1%	3.9%	11.7%	0.6%
SM	3.7%	1.5%	4.5%	2.6%	8.6%
BM	3.6%	4.8%	4.5%	4.5%	1.1%
AM	11.0%	16.4%	3.5%	11.4%	0.8%

Central Mountains and Range Creek regions had lower mean ages (4.8, 5.2, 4.4, and 5.0) than the Book Cliffs, Boulder and Abajo Mountains regions (6.6, 7.3, and 7.0), while the La Sal and Southern Mountains regions (6.0 and 5.4) fell in-between the two groups (Fig. 2). Males were significantly younger than females (5.1 vs. 6.8, $F_{1,1070} = 47.84$, $P < 0.0001$) and age has been increasing by an average of 0.07 years annually (SE = 0.028, $F_{1,1070} = 6.13$, $P = 0.0135$). The degrees of freedom in the error term varied due to incomplete harvest records. Interactions between the variables were tested and none of them were significant. Variables were eliminated from the full model in a stepwise procedure.

The accuracy data for the age classification are summarized in Table 2. Almost 40% of the known-age bears were misclassified.

Table 2. These data show the frequency that bears were misclassified with respect to age classification. Bears aged 1–4 were considered to be subadults and were counted if they were classified as adults. Adult bears (ages 5–10) were counted when classified as subadults.

		Number Misclassified				
Age	N	Female	Male	Unknown	Total Misclassified	% Misclassified
1	88	4	21	1	26	29.5
2	186	21	88	0	109	58.6
3	160	28	92	1	121	75.6
4	119	25	75	0	100	84.0
5	99	3	0	0	3	3.0
6	97	4	2	0	6	6.2
7	68	3	1	0	4	5.9
8	78	1	5	0	6	7.7
9	47	0	1	0	1	2.1
10	23	1	1	0	2	8.7
TOTAL	965				378	39.2

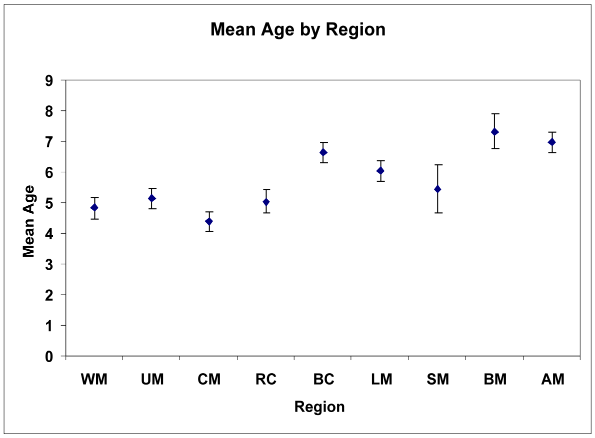

Figure 2. Shown here is the mean age of bears by region (see Fig. 1 for key to abbreviations). Wasatch, Uintah, Central Mountains and Range Creek are statistically lower than the Book Cliffs, Boulder and Abajo Mountains. The La Sal and Southern Mountains lie in between the two groups.

Misclassifications were made almost exclusively with the subadults (94%). The percent misclassified could be considered inflated if 4 year-olds are considered adults in which case the total percent misclassified would be reduced to 32%.

P&F Model.—The harvest rates estimated with this model reveal a decreasing trend over the last 15 years. Estimated harvest rates were highest in 1989–1991 and lowest in 1995–1997: 0.146 (SE = 0.033), 1989–1991; 0.103 (SE = 0.028), 1992–1994; 0.125 (SE = 0.011), 1995–1997; 0.070 (SE = 0.041), 1998–2000; 0.114 (SE = 0.037), 2001–2003. Because there is an actual enumeration of harvested bears in the state it was possible to use the estimated harvest rates to plot changes in population size (Fig. 3).

Depredation.—The depredation harvest consisted of significantly more males 0.71 (95% CI = 0.67–0.75) than the sport harvest 0.65 (95% CI = 0.62–0.68, Wald Chi^2 = 6.0598, P = 0.0138). The age of depredation harvested bears did not differ significantly from sport ($F_{2,1048}$ = 3.24, P = 0.0720). The logistic regression model for depredation showed a significant positive correlation with year (odds ratio = 1.07, 95% CI 1.04–1.09, Wald Chi^2 = 22.6536, P < 0.0001). We recognize that years are typically highly correlated. Logistic regression was used in this case to quantify the increase in depredation harvest over time and is justified because depredating bears are usually killed at the time of the offense. The number of bears killed in depredation and nuisance situations has continued to climb over the last 15 years (Fig. 4). The depredation harvest is predominantly confined to the Wasatch, Uintah and Central Mountains. These regions have the highest numbers of sheep with over 80% of the total sheep in bear habitat (Table 1). There is a strong positive correlation between the number of sheep in a region and the number of bears killed for depredating (r^2 = 0.91, P < 0.001).

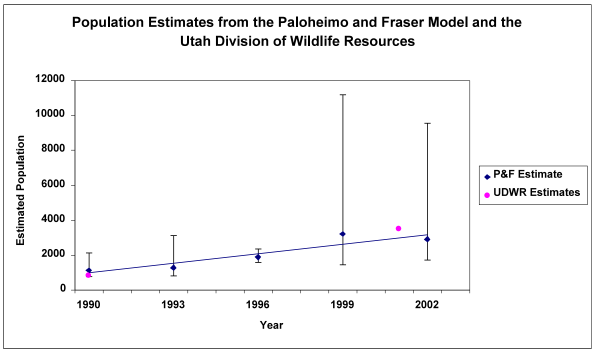

Figure 3. An increasing population trend for black bears is evident in estimates from two different sources. Population estimates from the Paloheimo and Fraser (1981) model include error bars that were calculated from the standard errors of the estimated harvest rates produced by the model. The population levels from this model are likely overestimated because of violations in assumptions (Harris and Metzgar 1987). The recent UDWR population estimate is based on an extrapolation from a minimum known bear density derived from a telemetry-based study in the Book Cliffs. The 1990 UDWR estimate is of unknown origin.

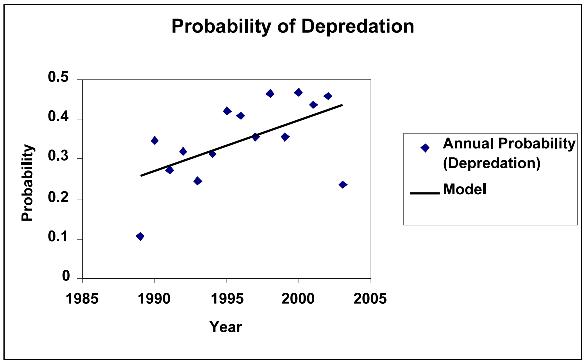

Figure 4. The plotted data project the annual probability that any given harvested bear will be a depredation kill.

DISCUSSION

Sex Ratio.—The sex ratio of harvested bears showed no significant relationship with either region or method of take. The lack of difference in harvest between regions indicates that there is no single region of special concern. The lack of significance in method of take was surprising and contrary to results found in New Hampshire where males were more commonly taken with hounds or bait than by stalking (Litvatis and Kane 1994) and in Oregon where baiting resulted in higher proportion of males than hound hunting and stalking (Kohlmann et al. 1999). In Utah the hunters were selecting males at the same rate with all three methods. It is doubtful however that stalking allows a hunter to determine sex as well as hounding or baiting, which both allow close-up views of individual animals. Likely there is not enough motivation for hunters to select males over females. Alternatively, the similarity in methods could be attributed to the unpopularity of stalking in Utah where it accounts for only 8% of the harvest.

The timing of the hunt was the only factor correlated with the harvest sex ratio. Spring hunting resulted in a significantly lower female harvest. Colorado has also seen a rise in the proportion of females harvested since they abandoned spring hunting. Current objectives as outlined in the bear management plan include a goal to keep female harvest levels below 40% of the total harvest (BBDG 2000). Six of the eight years that spring hunting was eliminated failed to meet the objective. None of the seven years with spring hunts failed to do so. Adult female survival is the most important factor in maintaining populations (Knight and Eberhardt 1984, Taylor et al. 1987) and males can be harvested at a much higher rate than females (Schwartz and Franzmann 1992). Assuming past trends would continue, Utah could minimize female harvest by moving to a spring only hunt and abandoning the fall hunt completely. It is illegal to harvest females accompanied with cubs in Utah and early in the spring is when the highest number of females will be protected by the presence of cubs or yearlings.

The initial reason for abandoning the spring hunt was pressure from anti-hunting groups claiming that cubs would be "orphaned" if their mother was killed. Nearly 60% of all cubs born in Utah die before they reach age one (Tolman 1998). Hristienko et al. (2004) documented the causes of cub mortality and found that less than 2% of it was attributable to orphaning. It is unlikely that orphaning of cubs caused by spring harvests would ever be a major source of mortality and it would have little impact on the overall population (Knight and Eberhardt 1984). In other jurisdictions, management techniques have also been influenced by public initiative (Kohlmann et al. 1999). In Utah, the attempt to save cubs, from being orphaned, by abandoning the spring hunt probably negatively impacted the population growth rate by increasing the proportion of females in the harvest. Increased emphasis on public education could help laymen to better understand how management decisions need to be based on sound biological and ecological principles (Elowe 1990).

Age-structure.—Method of take apparently is unrelated to the age of bears killed in Utah, contrary to harvests in Oregon (Kohlmann et al. 1999) and New Hampshire (Litvatis and Kane 1994). Mean ages did vary by region with the four regions in the northwestern portion of the state being lower than the three regions in the south and east. Mean ages for the La Sal and Southern Mountains were in the middle of the two groups. Harvest objectives for the state are to maintain a mean age of 5 years or older (BBDG 2000). The idea is that a mean age less than 5 years could indicate an over-harvest although that is not always the case (Garshelis 1990, Miller 1990). The Wasatch and Central Mountains failed to meet the harvest goal with respect to age in the last 15 years and the Uintah Mountains and Range Creek only just made it indicating that these regions may be experiencing some over harvest. An alternative explanation for the relatively young age of bears killed in these regions is the relatively high proportion of protein in their diets (Bates 1991, Bunnell 2000) possibly leading to larger body sizes of young animals which would make them more appealing to hunters. Overall mean age has been increasing over the past 15 years at an average rate of 0.07 years. That increase could be interpreted as evidence in support of an increasing population or at the very least as grounds for not claiming over harvest based on age structure.

The high degree of inaccuracy of age

classifications made by UDWR employees at the time an animal was checked, indicates that reported age-classifications prior to 1989, when teeth were collected, are unreliable and should not be used in analysis or modeling. It also stresses the importance of continuing to collect teeth from all harvested bears. One explanation for this high inaccuracy could be that in the last 15 years bears were checked by 181 individuals, many of which probably received little or no training on age estimation. If age-classifications are to be used in the future without cementum-annuli aging, then employees must be trained to recognize the wear patterns on teeth associated with aging allowing them to accurately determine age-classes. LeCount (1986) provided a photographic key that would be helpful as a guide in that respect. Limiting the authority to check bears to trained and readily available staff (i.e. conservation officers or clerical staff) may prove useful in improving accuracy of age classifications.

P&F Model.—Harris and Metzgar (1987) explored the impact of violating assumptions of the Paloheimo and Fraser model. The likely violations of Utah's harvest and their impacts according to Harris and Metzgar are listed below. Utah populations violated the initial sex-ratio assumption (Tolman 1998), where males outnumber females potentially leading to an underestimation of harvest rate. The model assumes sex-specific vulnerability remains constant with age, but older females are more likely to be protected by the presence of cubs or yearlings and older larger males are sought by hunters. Modeling revealed that this situation tends to underestimate harvest rate, especially when the true harvest rate is low. This effect may be somewhat offset by Utah's frequent drought-induced mast failures making it less likely that an older female would be protected by accompanying cubs. Simulations also showed changes in hunting effort caused lags of 10–15 years before estimated harvest rates equaled true harvest rates, although trends were apparent immediately. Utah has had changes in hunting effort most notably between the 1989 and 1990 harvest seasons, current estimates of harvest rate may only now be converging on actual rates as a result. Hunter surveys may lead to a more accurate measure of hunter effort than the number of permits issued used in this analysis (Inman and Vaughan 2002). The last assumption evaluated by Harris and Metzgar (1987) is that natural mortality rates are the same for both sexes. More males are harvested than females so more females must be dying of natural causes, but data relating to natural mortality rates are not available. If male mortality is higher, then the model overestimates harvest rates; if female mortality is higher, it underestimates.

According to the estimates from the Paloheimo and Fraser model, harvest rate (the proportion of the total population killed annually) has been on a declining trend since 1989. Under optimal conditions maximum sustainable harvest rates have been estimated at 14.2% (Miller 1990). In Utah, cub production and survival are below optimum (Tolman 1998); yet, estimated harvest rates have reached the maximum sustainable level in the past. Increasing the number of permits issued could create a situation where harvests exceed sustainable levels resulting in a population decline.

The population estimates, derived from the model's estimated harvest rates, reveal an increasing population trend. Based on the effect of the assumption violations as determined by Harris and Metzgar (1987), the population level estimated by the model is likely an overestimate. While the actual population values should not be interpreted as an accurate measure of reality, the population trends outlined by model estimates have been shown to follow closely actual population changes (Roseberry and Woolf 1991) and estimates derived in other ways (Garshelis 1990).

In 1990 the statewide population estimate from UDWR was 800 black bears and the population was evaluated as being stable (Garshelis 1990). In 2000 the BBDG estimated the population to be as high as 3540. No method was reported for the earlier estimate; however, determining the minimum density on a small study site on the East Tavaputs Plateau and applying that density to statewide estimates of available bear habitat derived the more recent estimate. It is not possible to compare the two estimates directly since they were made using different techniques. The population estimates from the Paloheimo and Fraser model are similar to the UDWR and BBDG estimates (Fig. 3).

Depredation.—Both depredation and sport harvests were biased towards males, but the male harvest for depredation was significantly larger.

The age of bears killed in nuisance and depredation situations did not significantly differ from those killed by hunters; although, they were slightly younger (5.66 vs. 6.22). The number of bears killed in depredation and nuisance situations has continued to climb over the last 15 years (Fig. 4) with the majority of the harvest occurring in the Wasatch, Uintah, and Central Mountains. As mentioned previously 95% of the depredation is on domestic sheep and not surprisingly those regions have the highest number of sheep with over 80% of the total sheep in bear habitat. In spite of declining numbers of sheep, the number of bears killed for depredation has risen, which may be interpreted as an indication of an increasing bear population. Several agencies outside of Utah use trends in depredation and nuisance activity as an indication of population status (Garshelis 1990). Other circumstances could also readily explain the rise in depredation such as a decrease in natural foods. The Wasatch, Uintah, and Central Mountains regions are also adjacent to the large metropolitan areas of the state along the Wasatch Front and have been the location of many of the past bear-human conflicts, which will likely increase as the human population continues to grow. It is possible that moving to a spring only hunt will transfer some of the depredation harvest to hunters by killing individuals that would end up depredating later in the summer. Hunters could potentially provide a source of compensatory mortality that would result in a smaller depredation harvest. It may be necessary to increase the number of permits issued in these areas to achieve the desired effect. This idea is currently being evaluated by the 5-year experimental spring hunt.

MANAGEMENT IMPLICATIONS

These data suggest the harvest has been conservative enough in recent years to allow population increases in most areas. Evidence in support of an increasing population includes an increase in mean age of bears over the last 15 years, a continually high hunter success, the population trend outlined by the Paloheimo and Fraser model, and an increase in depredation and nuisance activity. This evidence is by no means conclusive and should be interpreted cautiously as alternative explanations do exist and other factors such as environmental changes and unmeasured alterations in hunting effort and technique can alter harvest outcome. Given the state's small annual harvest, it is imperative that accurate and complete information be collected from each bear killed. Personnel collecting data should be thoroughly trained in a detailed, written protocol. Also, the number of personnel involved should be minimized to improve data integrity (Eason et al. 1996, Pelton and van Manen 1996). Utah should maintain a conservative strategy for managing bears because of the potential impact of frequent droughts on reproduction and survival, and the long-term impact of over harvest (Miller 1990). Caution should be exercised before implementing management strategies that would increase the number of bears harvested, as current estimated harvest rates are near maximum sustainable levels. Additional long-term telemetry studies are desirable to better interpret Utah's apparently low reproduction and high cub mortality (Tolman 1998) and to collect data useful in population modeling. The correlation between a spring hunting season and a low female harvest indicates that moving to a spring only hunt would be an effective way to minimize female harvest. Depredation is a real concern with the number of bears killed in recent years nearly equal to those taken by hunters. It is too early to know if the experimental spring hunt will significantly reduce depredation, but perhaps it will take a substantial increase in the number of permits issued in the Wasatch, Uintah, and Central Mountains to transfer a significant portion of bear mortality from depredation to sport hunters. If the additional mortality is additive rather than compensatory these regions may not be able to withstand increased hunting pressure as indicated by the relatively low mean age of harvested animals. Kane and Litvaitis (1992) emphasized the need to use multiple indices when modeling populations or measuring the response of a population to changes in management techniques. The development and application of a model incorporating food surveys (Noyce and Garshelis 1997), harvest data and data gathered from telemetry-based mark recapture studies will allow managers to better understand and respond to changes in Utah's bear population.

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A REMOTE TECHNIQUE FOR MONITORING BLACK BEAR POPULATIONS: ROAD TRACK SURVEYS

APRIL T. YOUNG, KEVIN V. YOUNG, AND HAL L. BLACK

Abstract.—Track surveys of American black bears (*Ursus americanus*) were conducted along with regular trapping activities during the summers of 1993 and 1994 on the East Tavaputs Plateau of east-central Utah. From June to early August, two 16 km transects along the Divide Road were regularly monitored for bear tracks. Fifty-one surveys over the two summers yielded 258 track sets (132 on the east transect, 126 on the west). Mean number of tracks/km was significantly higher in 1994 (t = -2.04, df = 49, P = 0.0463). Correlation analysis of capture success vs. tracking success resulted in a significant positive relationship (r^2 = 0.687, n = 9, P = 0.041). For both years, bears used the Divide Road as a travel route approximately 20% of the time that they encountered it. Tracks of females with cubs appear to be under-represented. When compared to front pad widths of captured bears, measurements of front track widths underestimated actual pad size (t = 2.67, df = 183, P = 0.008). No significant differences in front track widths existed between survey year and transect. Both sexes appeared to be represented in surveys; tracks with widths >12.0 cm most likely belonged to males. Linear regression analyses indicated that front pad width was correlated with weight, total body length, and age. Using six measurements from front and rear pads, discriminant function analysis separated captured bears into age classes (22.6% error) and categorized tracks into a similar age class distribution (χ^2 = 6.36, df = 3, P = 0.095). Track locations were not uniformly distributed along the road (χ^2 = 59.2, df = 31, P = 0.0017).

Assessment of black bear populations is important to management agencies in understanding impacts of recreation, hunting, ranching, resource extraction (mining, gas, and oil), and other human activities. Standard data collection methods include trapping, tagging, and radio-collaring black bears during the summer months (LeCount 1986). However, such methods pose potential risks to bears (Johnson and Pelton 1980, Beck 1991) in addition to being expensive and time-consuming to the researchers.

Employing an alternate strategy, some biologists have attempted to evaluate bear tracks on roads as an indicator of trends in abundance (Wooding and Hardisky 1987, Shea 1991, Brandenburg 1992, Warburton 1992). Unlike similar studies involving mountain lions (*Felis concolor*) (Van Dyke et al. 1986, Van Sickle and Lindzey 1992), none of these studies validated track survey results with capture data and/or bait station visitations. Results of bear track surveys in Florida's Ocala National Forest indicated that track counts would detect only large population changes, and suggestions were offered to increase the sensitivity of the method (Wooding and Hardisky 1987). A second study in Florida obtained yearly index values from bear track surveys, and a downward trend in track abundance was attributed to increased human activities and development in the area (Shea 1991). Analysis of track counts from five study areas in eastern North Carolina suggested that significant decreases in track numbers could be easily detected (Warburton 1992). Additionally, different cohorts of bears (adult males, females with cubs or yearlings, and yearlings) were identifiable from tracks found on roads during a 5-day survey conducted in Hofmann Forest, North Carolina (Brandenburg 1992).

The purposes of our study were to evaluate track surveys along a major dirt road as a population trend indicator for bears on the East Tavaputs Plateau and determine what additional information can be obtained from bear track measurements. Specific objectives included (1) testing if relative population trends in road track survey results are reflected in trap capture success, (2) determining if track size can be used to identify sex, body size, weight, and/or age class of a bear, and (3) characterizing the spatial distribution of tracks on a road. If a consistent relationship exists between the proportion of tracks counted on the road and the proportion of bears trapped, then fluctuations in this population will be reflected in track surveys. In addition, if tracks also accurately predict sex, size, and/or age class of bears, then track surveys would be useful as a management technique in describing population structure.

METHODS

Sampling Methods.—Track surveys of two 16-km transects (one on the west portion of the trapping area, and one on the east) were conducted along with regular trapping activities from June to early August during four sampling periods in 1993 and five periods in 1994. The evening prior to a track survey, a drag consisting of 3–6 tires was towed behind a truck at a speed of 25–30 km/h (Fig. 1a). Both sides of one of the transects were dragged to remove any existing animal or vehicle tracks and create a dust layer to facilitate track detection, especially along the shoulders of the road.

Figure 1. Methods of road track surveying: (a) truck towing a drag designed to prepare the road surface prior to a tracking survey, (b) observer facing into the morning sun and looking for tracks.

At sunrise the following morning, two observers rode side by side on 4-wheelers at a speed of <15 km/h simultaneously scanning the road for tracks (Fig. 1b). To aid track detection, they wore polarized sunglasses and drove into the sun. A few places on each transect consisted of solid rock or gravel substrate which made track detection difficult. Additionally, the activities of cattle, mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*) probably obliterated some tracks.

When a track set was found, plexiglass was placed over the best front track and a tracing was made onto a transparency. Rear tracks were also traced during the summer of 1993. Track lengths, widths, and total lengths were later measured from these tracings. Distance that the bear traveled on the road was noted for each track set. Locations of tracks were recorded during the summer of 1994 using a Magellan Global Positioning System (GPS).

We also collected morphometric data from captured bears from 1991–1994. Bears were captured in barrel traps and immobilized with a weight-specific dosage of a Ketamine/Xylazine mixture (LeCount 1986). They were weighed and sexed, and measurements of body length as well as length, width, and total length of left front and rear pads were taken. Additionally, a premolar was extracted for cementum annuli age assessment (Matson's Laboratory, Milltown, MT).

Statistical Methods.—Statistical analyses were performed using SAS (1990). A 2-sample *t*-test was used to compare the overall tracking success of 1993 with that of 1994. Tracking success was defined as the number of track sets per km of road surveyed. Overall capture success between years was also compared using a 2-sample *t*-test. Capture success was defined by the number of bears caught per trap night—a trap night being one trap set for one night. Correlation analysis was used to evaluate the relationship between capture success vs. tracking success for 4 sampling periods in 1993 and 5 periods in 1994.

A 2-sample *t*-test was used to test for differences between front pad widths of captured bears vs. front track widths measured from transect surveys. Measurements of front track widths from surveys were tested with a 2-way analysis of variance (ANOVA) using year (1993 or 1994) and transect (east or west) as fixed main effects. The interaction term (year*transect) was also included in the model.

To determine what information could be obtained from a bear track, we performed a series of analyses using pad measurements from *captured* bears. A 2-sample *t*-test was used to compare front pad widths of all males and females. Regression analyses were used to predict weight, body length, and age from the front pad width of captured bears. We treated front pad width as the independent variable (x) so that predictions of weight, body length, and age could be made from *front track* widths measured in road surveys if the relationships proved significant. We transformed the front pad width (independent variable) to its negative inverse ($-1/x$) to obtain a linear relationship for body size vs. front pad width, and we log transformed the dependent variable (age) for age vs. front pad width.

Discriminant function analysis was used to (1) achieve optimal separation of age groups based on pad measurements and (2) develop linear combinations of pad measurements from known bears to predict age class of unknown tracks (Manly 1986). Measurements of front and rear pad lengths, widths, and total lengths from captured bears with known ages were categorized into four age groups: cub (0 years), yearling (1 year), sub-adult (2-3 years), and adult (4+ years) (Beck 1991). We used measurements of front and rear track lengths, widths, and total lengths taken from the 1993 road surveys as test variables to observe how they separated by age group.

To compensate for possible differences between the actual size of pads and their tracks, which could cause misclassifications of tracks in the preceding model, we added a correction factor to track measurements and repeated the test variable step of the discriminant function analysis using the *corrected* track measurements. We then compared age group classification of pad measurements to age group classification of track measurements using a chi-square goodness of fit test. We repeated this test using age group classifications of the *corrected* track measurements.

Track locations obtained in 1994 by global positioning were plotted on digitized USGS quadrangle maps. Transects were divided into sections of 1.0 km, and the number of track locations recorded was counted for each section. A chi-square goodness of fit test was used to determine if tracks were uniformly distributed along the road.

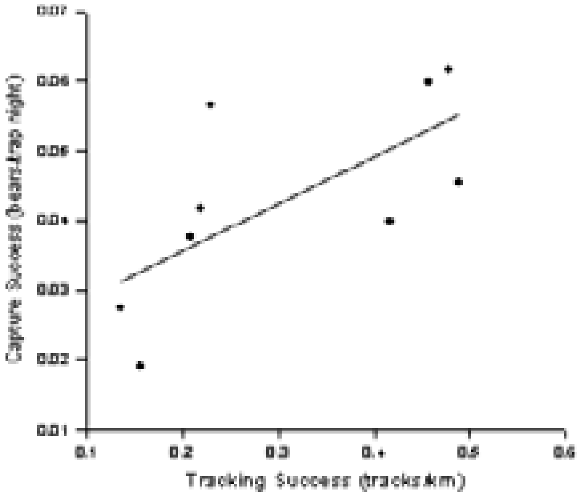

Figure 2. Capture success vs. tracking success for four sampling periods in 1993 and five sampling periods in 1994. Capture success was measured as the number of bears caught per trap night. Tracking success was measured as the number of tracks found per kilometer sampled.

RESULTS

Track Numbers and Dynamics.—Twenty-four track surveys (12 on each transect) were conducted in 1993, with 52 track sets found on the east transect and 45 found on the west. Tracks were not found in 3 surveys (12.5%). In 1994, we conducted 27 track surveys (14 on the east, 13 on the west) finding a total of 80 track sets on the east and 81 on the west. No tracks were found in 2 surveys (7.4%). Overall tracking success was significantly higher in 1994 (t = -2.04, df = 49, P = 0.0463); however, no significant difference existed between years for overall capture success (t = -1.156, df = 7, P = 0.2855). Correlation analysis of capture success and tracking success for 1993 and 1994 resulted in a significant positive relationship ($r^2 = 0.687$, n = 9, P = 0.041; Fig. 2).

Bears crossed the road approximately 65% of the time that they entered the transect, and they traveled along the road (distances >20 m) approximately 20% of the time (Fig. 3). For the remaining cases we

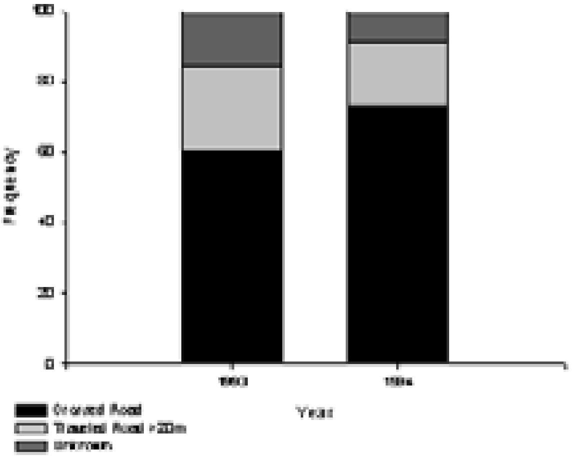

Figure 3. Bear use of the Divide Road for the summers of 1993 and 1994. Dark gray bars represent the frequency of tracks that crossed the road, light gray bars represent the frequency of tracks that traveled along the road (distances >20 m), and open bars represent unknown use.

could not clearly distinguish the bears' activities on the road. Tracks of females with cubs were observed only 4 times. More than one set of tracks (excluding females with young) occurred together 16 times. These were mainly observed in June during the breeding season. Bears crossed the road six times either going to or coming from a known large mammal carcass.

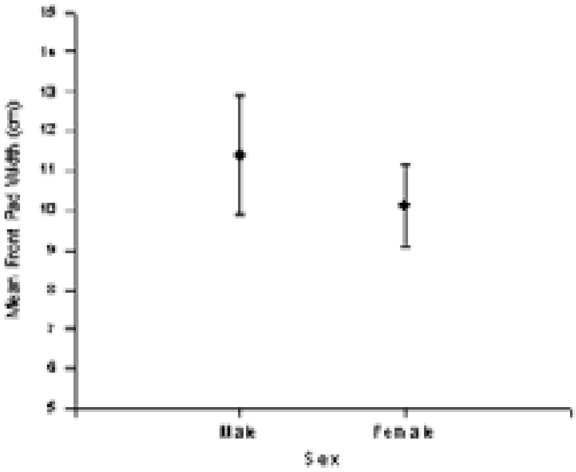

Figure 4. Graph depicting male and female front pad width means (cm). Vertical bars indicate standard deviations.

Track Quality & Front Track/Pad Widths.—Complete measurements of tracks were made when possible. Typically all toes were not completely visible, thus measurements of total lengths were most often lacking.

Front track widths measured from tracings ranged in size from 5.7–13.3 cm with a mean width of 10.5 cm. Front pad widths measured from captured bears ranged from 6.4–15.2 cm with a mean width of 10.9 cm (Table 1). These means were statistically different (t = 2.67, df = 183, P = 0.008).

Mean front track widths measured from tracings were not significantly different between survey years or transects (F = 0.16, df = 225, P = 0.9218). Thus, data collected from both years and both transects were grouped together for subsequent analyses. The mean front pad width of males was significantly larger than that of females (t = -5.53, df = 109, P = 0.0001) (Fig. 4).

Table 1. Mean, standard deviation, and range of front pad widths for captured black bears (C) and tracks observed in road surveys (T).

	n	Mean (cm)	SD	Range (cm)
C	111	10.9	1.50	6.3 – 15.2
T	226	10.5	1.21	5.7 – 13.3

Regression Analyses.—The regression analysis of weight vs. front pad width was significant (β_0 = -107.96, β_1 = 15.95, t [slope] = 16.28, df [error] = 95, P = 0.0001; Fig. 5a). The coefficient of correlation (r^2 = 0.74) suggested a strong relationship between the two variables. Similarly, regression analysis of body length vs. front pad width (transformed) proved significant (β_0 = -278.10, β_1 = 1348.93, t [slope] = 19.75, df [error] = 108, P = 0.0001) with a strong relationship (r^2 = 0.78) between foot size and body length (Fig. 5b). A positive linear relationship between age (transformed) vs. front pad width existed (β_0 = -0.727, β_1 = 0.116, t [slope] = 6.033, df [error] = 102, P = 0.0001) with r^2 = 0.26 (Fig. 5c).

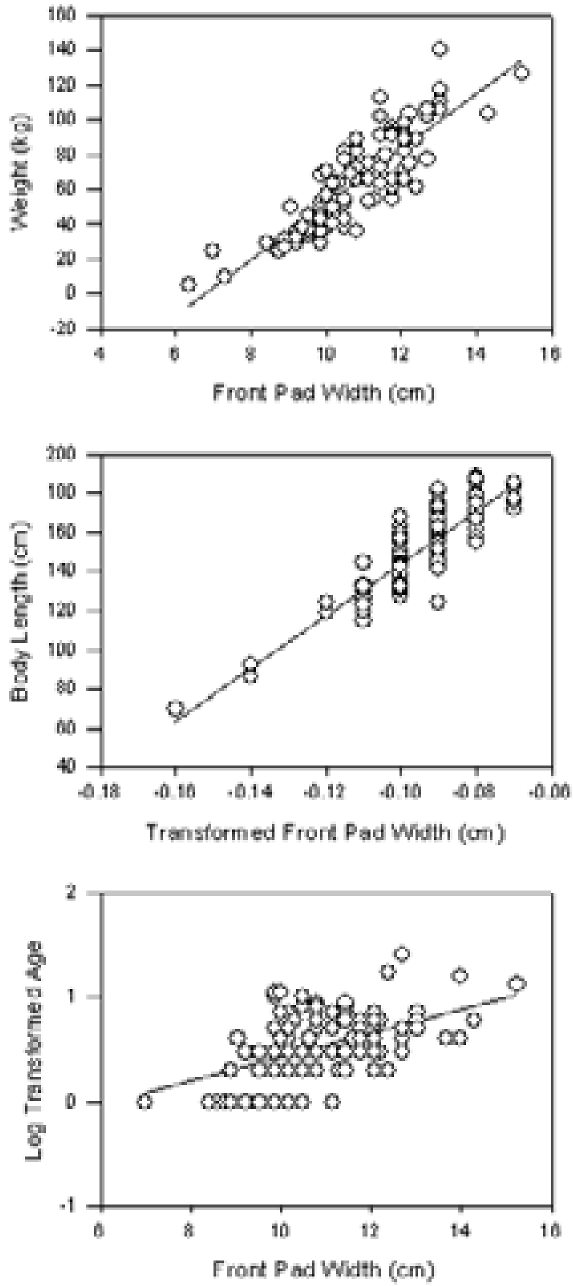

Figure 5. Significant relationships of front pad width with three variables: (a) body weight (kg) vs. front pad width (cm) with regression line ($r^2 = 0.74$), (b) body length (cm) vs. transformed front pad width (cm) with regression line (front pad width transformed to -1/x, $r^2 = 0.78$), (c) log-transformed age (years) vs. front pad width (cm) with regression line ($r^2 = 0.26$).

Discriminant Function Analysis.—Eighty-two percent of the variability in front pad width between age groups was explained by the eigenvalue for canonical axis 1 in the discriminant function analysis ($\lambda_1 = 0.792$). This was significant according to the likelihood ratio for canonical axis 1 ($F_{18,274} = 4.621$, $P = 0.0001$) (Table 2). The eigenvalues for canonical axes 2 and 3 were insignificant and together accounted for only 0.177 of the variability among age classes (Table 2). The age group means on canonical axis 1 indicated that the smallest pad sizes occur in the youngest bears and the largest sizes occur in the oldest bears (Fig. 6).

Table 2. Test for overall differences between means of the age groups of captured bears using discriminant function analysis.

	λ	Approx. *F*	df
Canonical Axis 1	0.792 [a]	4.621	18, 274
Canonical Axis 2	0.117	1.678	10, 196
Canonical Axis 3	0.055	1.356	4, 99

[a] $P = 0.0001$

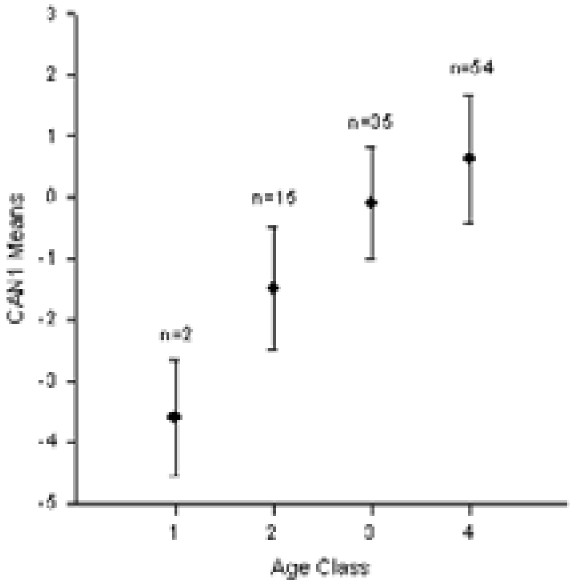

Figure 6. Age class means for canonical axis 1 from the discriminant function analysis using front and rear pad measurements from captured bears. Vertical bars indicate standard deviations.

Figure 7. Track numbers per kilometer of road for the 32 kilometers (east and west transects together) surveyed during the summer of 1994.

Figure 8. Male, female, and track front pad width distribution.

Using discriminant function analysis, we classified captured bears into age groups according to pad measurements. Individual bears belonging to age group 1 were correctly assigned 100% of the time, while those belonging to age group 2 were correctly assigned 86.7% of the time. Discriminant function analysis correctly identified bears 60.0% and 63.0% of the time for age groups 3 and 4, respectively. Total error rate for age group classification was 22.6% (Table 3).

Using front and rear track lengths, widths, and total lengths measured from 59 track sets, discriminant function analysis categorized 1) tracks belonging to unknown-age bears and 2) *corrected* tracks into age groups presented in Table 3. We determined the correction factor for track size (based upon a subsample of tracks made by known bears) as follows:

$$C = T + xT$$

where C denotes the corrected track measurement, T represents the original track measurement, and x = (average pad measurement – average track measurement) ÷ average track measurement. Chi-square analysis of age group classification between pad vs. track measurements was not significant ($\chi^2 = 6.36$, df = 3, $P = 0.095$). Chi-square analysis of age group classification between pad vs. *corrected* track measurements was also not significant ($\chi^2 = 3.976$, df = 3, $P = 0.2641$).

Spatial Distributions of Tracks.—Tracks were not randomly distributed along survey transects. The chi-square analysis testing a uniform distribution of tracks on the road was significantly different ($\chi^2 = 59.2$, df = 31, $P = 0.0017$). Tracks were present in all but one section (1.0 km) of road, and the highest frequency among sections was 12 tracks/km (Fig. 7).

DISCUSSION

The mean number of tracks/km significantly increased from 0.25 in 1993 to 0.37 in 1994. Because these index values are based upon only 2 years of data, we are unable to report conclusions about how tracking may correlate with population trends; however, we suggest that relative trends could be observed over a period of several years through comparisons of index values.

The significant positive correlation between capture success and tracking success indicates that track surveys are valid as a technique for monitoring black bear population trends in our study area. We expect that trapping and tracking will become less positively correlated as the study continues since trapping success declines as bears in the study area become "trap-wise." For example, of 34 incidents where tracks were observed near traps on the Divide Road, only 2 traps (5.9%) caught bears and 4 other traps (11.8%) were disturbed (e.g. bait was moved). Because there is less behavioral bias affecting

Table 3. Number of known-age bears and unknown tracks separated into age groups based on pad measurements[a] using discriminant function analysis. Parenthetical values indicate proportions of totals.

	Cub	Yrlg	Sub-Adult	Adult	Total	Error
Cub	2 (100%)	0	0	0	2	0.0%
Yearling	0	13 (86.7%)	2 (13.3%)	0	1	13.3%
Sub-Adult	1 (2.9%)	5 (14.3%)	21 (60.0%)	8 (22.9%)	35	40.0%
Adult	0	6 (11.1%)	14 (25.9%)	34 (63.0%)	54	37.0%
Total	3 (2.8%)	24 (22.6%)	37 (35.0%)	42 (39.6%)	106	22.6%
Tracks	3 (5.1%)	19 (32.2%)	13 (22.0%)	24 (40.7%)	59	—
Corrected Tracks	3 (5.1%)	17 (28.8%)	13 (22.0%)	26 (44.1%)	59	—

[a] Measurements included front and rear pad lengths, widths, and total lengths.

tracking success, changes in track counts may actually be more reflective of population dynamics than changes in trapping success.

Previous studies have yielded conflicting results on the effects of roads on bear behavior. Female black bears in northern Idaho were reported to avoid roads (Young and Beecham 1986); however, foraging females in west-central Idaho did not (Unsworth et al. 1989). In central Utah, females with cubs were not found near roads during the spring (Bates 1991). Conversely, a study in southeastern Utah found no significant difference among seasons, sexes, or age classes of bears in their average distance to nearest road (Richardson 1991). Major roads negatively affect bear behavior. Analysis of frequency of road crossings by radio-collared bears in North Carolina indicated that bears avoided paved roads with higher traffic volumes (Brody and Pelton 1989). A follow-up study in the same area confirmed that road density and traffic volume influenced frequency of road-crossings by bears (Beringer et al. 1990).

In general, our observations coincide with findings in Michigan (Manville 1983), northern Idaho (Young and Beecham 1986), and North Carolina (Brody 1984, Siebert 1989) where bears used roads as travel routes. However, tracks of females with cubs appear under-represented in our surveys. We agree with Bates (1991), who suggested that the limited mobility of cubs kept females from encountering roads in spring. Also, females with cubs may simply be more wary than other bears as witnessed by their avoidance of traps (pers. obs.).

Average front pad width of males was significantly larger than average front pad width of females (Fig. 4). Applying this to track measurements, we conclude that tracks >12.0 cm will usually belong to males (Fig. 8). Smaller tracks could belong to either sex, but preliminary analysis of this dataset suggests that sexes may be discriminated by using front pad width, length, and total length (including toes; manuscript in preparation). Discrimination between individual cougars has been achieved based on pad allometry (Smallwood and Fitzhugh 1993), but it is unknown if the technique could be applied successfully to bears.

Significant positive relationships existed between weight and front pad width as well as between body length and front pad width. Thus, we could predict weight and/or total length of bears based on front track width measures from road surveys, but the degree of certainty is limited (low r^2 values). Weight fluctuates during the trapping season, with a general pattern of weight gain later in summer as bears accumulate fat in preparation for hibernation. Body length does not increase as dramatically and thus would be a better measure to consider. Even though age correlated with front pad width, the low r^2 value suggests that ages could not be predicted accurately based upon this regression.

Discriminant function analysis more distinctly categorized bears into age groups using measurements from both front and rear pads. Cubs and yearlings separated with low error rates, but overlap existed between separations of sub-adult and adult bears (Table 3). Growth rates of bears decrease with age (Alt 1980); thus, size difference is greater between pads of cubs and yearlings than between pads of sub-adults and adults.

We expected that tracks would be distributed among age classes in the same proportion as known-age bears, because track surveys and trapping were conducted in the same study area. Chi-square analysis demonstrated that measurements of pads from actual bears and measurements of tracks from survey tracings showed a statistically similar age group distribution. Thus, measurements from road track surveys accurately indicated age structure for this population, although there was some error in the discrimination between subadults and adults. Multiplication of track measurements by the correction factor resulted in better discrimination. Unfortunately, our sample size of known bear tracks was small ($n = 2$); a larger sample size would permit calculation of a more robust correction factor and a reduction in the number of misclassifications between age groups.

Track locations were clustered along both transects. Possible explanations for this nonuniform distribution include 1) favorable crossing sites based upon topographical features (e.g., saddle areas) and/or habitat quality, 2) temporary food sources (e.g., cougar kills, baited traps), 3) intersection of home ranges with road, and 4) movements of males in association with females.

MANAGEMENT IMPLICATIONS

Since bear tracks are easily and frequently seen on secondary dirt roads, track surveys conducted over several years during the breeding season (when bear movement is presumably greatest) could provide management agencies with a useful tool for monitoring relative abundance, size diversity, age class, and even sex ratio of the population. This method would be less expensive to researchers and less hazardous to bears than trapping or snaring.

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HABITAT USE, BEHAVIORS, AND MOVEMENTS OF BLACK BEARS ON THE EAST TAVAPUTS PLATEAU, UTAH

LARISA E. HARDING AND HAL L. BLACK

Abstract.—Traditionally, American black bear (*Ursus americanus*) habitat data have been collected with conventional tracking tools, such as aerial or ground telemetry. Often, these measures have large margins of error and bear behaviors go unobserved. To document behavior and habitat use, we used trained hounds on leash to follow fresh bear tracks and establish transects (n = 80) of bear activity. Bears disproportionately used sagebrush steppe as a foraging substrate for ants. Small bears differentially utilized oak communities more and large individuals frequented open sagebrush areas more; both groups primarily traveled in these open-canopy communities and under-used other habitats with closed canopies. Behavioral observations documented here are under-represented in the literature, though they allow biologists to determine what behaviors bears actually perform in different habitats.

Effective management of wildlife habitat depends in part on our ability to understand and predict wildlife-habitat relationships (van Manen and Pelton 1997). Habitat quality affects reproduction (Eagle and Pelton 1983, Rogers 1987, Tolman 1998) and survival in the American black bear (*Ursus americanus*), but knowledge of the extent to which a bear samples its environment on a local scale is limited (Craighead 1998). Although many habitat studies have been done in North America (Lindzey and Meslow 1977, Novick and Stewart 1982, Eagle and Pelton 1983, Beecham and Rohlman 1994, Boileau et al. 1994), they were largely limited to montane or mesic forested regions and analyses focused on large-scale habitat measures, such as land cover or habitat classes (van Manen and Pelton 1997). Efforts to document habitat use and movement of black bears with conventional tools, such as aerial telemetry, global positioning system (GPS) collars, field sightings, and triangulation from the ground have been effective on a macro-scale (Maehr and Brady 1984, Schwartz et al. 1987, Mykytka and Pelton 1990). Nevertheless distance errors may range from 100 to 3,100 m with these techniques (Keating et al. 1991, Obbard et al. 1998). Therefore, these methods often do not allow ground verification of the bear's location or determination of what particular environmental variables influence a bear's use of a certain habitat. Observations using conventional techniques show the coarse-grained patterns found in bear behavior but fail to produce insight into the fine-grained ways that bears likely use locally abundant, high-quality food sources or view escape cover (Obbard et al. 1998, Harding 2000). This localized behavior within specific habitats would be particularly important for management of bears in areas with low population densities.

Because conventional techniques could not provide information on micro-habitat use and associated bear behavior, we used a novel method that allowed us to collect data on these variables. We reasoned that if trained hounds held on leash closely followed the paths of bears, we could create transects across the bear's landscape. Because bears frequently leave evidence of their activities in the form of hair, scratch marks on trees, tracks, scat, bed sites, turned rocks, and disturbed ant nests, we continuously confirmed visually that the hounds followed the bear's course. This would also allow us to collect data on foraging and other behaviors from sign left along the bear's trail. We wanted also to examine the ways a bear might use lateral cover instead of or in concert with vertical cover for protection as it foraged.

Efforts to examine localized behavior and feeding habits led others to follow habituated black bears (Rogers and Wilker 1990, DeBruyn 1992), but these studies were limited to few bears and did not provide broad population samples. Though we did not directly observe the animals, we assumed if we followed individuals of different track sizes, our methods would provide a population sample.

Due to the abundance of black bear tracks we observed over the study area, we surmised that following tracks would allow us to document bear movements through various habitats and observe evidences of behaviors performed within each ecotype. Specifically, we wished to see where bear activity occurred and how bears used habitats in this area relative to the abundance of habitats. We also wanted to see if bears of varying sizes utilized the same habitats in differential proportions.

Here we present methods used and data gleaned by establishing bear transects. We conclude with suggestions for future research in bear biology.

METHODS

Dogs.—We borrowed trained hound dogs experienced in the pursuit of bears. They were mixed breed but primarily blue-tick or black-and-tan. We used five males and one female over the course of our study. Their ages ranged from 3-13 years.

We usually employed one mature experienced dog and one younger hound per transect. Their owner provided information on techniques for motivating the dogs to their task, such as offering encouragement by saying 'find the bear', 'good dog', and patting and praising the dogs intermittently. The hounds worked well in his absence and were relatively obedient.

Finding tracks

During the springs and early summers of 1995–1997, our search for tracks was focused along the Divide Road that bisects the study area from east to west. Trapping efforts from 1991–1999 have been concentrated along this same road, and we expected to see congruence between the live-captured population and that of the track transects because they were presumably the same population.

We located tracks primarily on roads. To prepare a fresh tracking surface, we dragged several roads with tires chained together and pulled behind a pickup truck in the evening and returned the following morning to locate any new tracks. Dragging obliterated existing tracks of vehicles, deer, elk, and cattle and created a loose soil film that made track detection easier. Tracks were commonly spotted from the vehicle as we drove slowly (12–15 km/hour). We also initiated a few transects from tracks found near water, by approaching a radio-collared bear, or from tracks located after a dog(s) struck bear scent while riding in the back of the truck. Tracking was most effective during the morning hours, yet on cool, overcast days tracking sometimes extended into the late afternoon.

When we located a track we took a leashed hound and tested the track. If the dog barked and showed interest or displayed general enthusiasm for pursuit, we followed the track. In our early efforts, we used a 12-year-old, experienced, and "retired" dog. Though unfit for full-fledged bear pursuits, this dog worked well for our tracking.

Establishing transects.—Once we found a fresh trail, we used a hip-chain to dispense a 15-pound cotton string along the path the dogs and the bear took. We reduced drift of the line by periodically wrapping it around vegetation, branches, or other convenient landmarks to maintain the accuracy of the transect. This was especially important when bear tracks crossed ravines where long expanses of unattached string could be caught by wind and blown off course.

The dogs' eagerness to pursue the bear's scent and our frequent observations of tracks, turned rocks, and scat gave us positive confirmation that we followed the bear's path. We made no attempt to record data as the initial "out bound" transect was established; we moved quickly, so that the dogs could actively pursue the scent and not be constrained by a slower pace.

The ideal tracking team consisted of two dogs on leash accompanied by handlers, with a third researcher trailing close behind to lay down the string-line. When a third researcher was unavailable, two individuals with leashed dogs were also effective. The dogs alternated the lead as one or the other was in better "touch" with the scent of the bear. Our impression was that there was an element of competition between the dogs that resulted in their close adherence to the bear's path. We pursued the bear's path until the dogs lost the scent or their interest in pursuit; we then terminated the transect.

Initially we only backtracked bears since forward tracking might put us in close proximity to the bear and alter its normal activity. Nevertheless, if dogs failed at backtracking we would track forward. If we found evidence that we were altering a bear's activity (such as visual contact, change in stride length, or a noisy departure by the bear), we terminated our transect.

On occasion the dogs encountered tracks from other bears, and the dogs would split at the intersection and we had to reestablish them on the desired track set. Track size usually allowed us to discriminate between tracks of different individuals and thus keep the dogs focused on the target bear. When we were unable to distinguish between tracks of individual bears, we terminated our transect.

Data Collection.—At the end of the outbound transect, we detached string from the hip chain dispenser and started a return line. The hip-chain counter allowed us to measure distances through major vegetation types. To avoid destroying evidence of bear behaviors we walked 2–3 m apart as we recorded data from the transect. Two researchers collected data, and a third, when present, returned the dogs to the field vehicle.

In back-tracking and forward-tracking a bear, we recorded the front pad width (FPW) because it appeared to be the most relevant form of measurement for estimating animal size or age class because it was readily apparent and also often the only evidence of a bear drinking at water sources. To measure FPW on a transect, we compared several tracks and measured the one subjectively thought to provide the best resolution.

This sampling method provided us with quantitative data on habitat use through documentation of disturbed ant mounds and turned rocks or logs, as well as the spatial aspects of various behaviors such as defecation and feeding, and behavioral states such as resting, walking, or running (as indicated by changes in stride length). We also recorded behaviors reported in Table 1. These behaviors were described in written detail and documented on the inbound return transects that encompassed the original transect and one meter to either side.

During the summers of 1996 and 1997, we measured horizontal obscurity cover within each habitat (Skovlin 1982), which estimates the degree of obstruction to the bear's line of sight. We used a 1-m^2 cover board separated into 36 equal squares. At each subjectively defined ecotone along a given transect, we measured the distance from the bear path to the board when one end of the board rested on the groung and 90% of the squares were obscured by vegetation in that habitat. These measurements were taken in four directions: to the front, rear, left, and right of the observer standing on the same path taken by the bear and indirectly measure the amount of lateral cover available to a bear moving through an area.

We plotted transects by hand onto 1:24,000 USGS topography maps using visual confirmation of topographic or geologic features along transects, though this could now be plotted directly using GPS technology. Upon return to the lab, we digitized our transects from the USGS topography maps. This allowed us to combine bear transects with the topographic, elevation, and road coverages from the geographic information database for the state (UT; SGID).

Tracks and Front Pad Width.—We used regression analysis on a data set of known bears trapped in the study area to examine the linear relationships between mass and body length with FPW. We also used the Student's t-test to determine whether FPW measurements of trapped bears of known mass differed from those of the unidentified transect bears to ensure that our method could sample the population. We acknowledge that tracks left by bears are slightly larger than actual pad measurements (< 4.0% on the Plateau; Young 1995), yet the difference is so slight that we felt it was unnecessary to make any corrections from the FPW measured in tracks.

Using the known-bear data, we calculated the average FPW of an adult bear of known age on the Plateau so that we could divide unknown transect bears into two size categories that would indirectly reflect age classes (i.e., adult, juvenile). Given the difficulty in assigning unknown bears to specific age classes, we classified transect bears in two size classes based on mean FPW of known-age bears. For purposes of this study, large bears (i.e., likely adults) were those individuals with a FPW greater than 10.2 cm, and small bears (i.e., likely juveniles or small adult females) had a FPW less than or equal to 10.2 cm.

Habitat Use and Directional Movements.—To obtain a general idea of bear movements through habitats, we collapsed vegetation coverages measured on a 1-ha scale in Utah GAP analysis (United States Department of Interior 1997) to build five broad habitat types from dominant plant species. These habitats included Pinyon-Juniper, Douglas fir, Aspen, Oak-Mountain Brush, and Sagebrush-Grass. Coarse GAP data also provided us with the approximate area (ha) of each habitat type, and we calculated the percentage of total area covered by each across the study area.

We counted habitat transitions on transects and the linear distance that bears moved within habitats. We defined bear use of habitats as the distance bears traveled through any one habitat type (Powell 1994). We used Chi-square to test for differences in overall bear habitat use versus habitat availability, and to look for differences by the two size classes in the percent use and patterns of usage of each habitat. Using ANOVA (PROC GLM, SAS Institute Inc. 1987), we tested for the effects of bear size on habitat use and the interactions between these elements. Horizontal obscurity measures, which indirectly quantify lateral cover, for 1996 and 1997 were grouped by habitat type and tested for significance due to habitat type, orientation of the bear moving directionally along a transect, and the interactions of both using ANOVA (PROC GLM, SAS Institute Inc. 1987).

RESULTS

Transects and Tracks.—We followed bear tracks in the spring and early summers (May–July) of 1995–1997 and established a total of 80 transects: 23 in 1995, 23 in 1996, and 34 in 1997. Though we do not know how many bears these transects represent, differences in front pad widths on known bears clearly allow separation of small and large individuals but considerable overlap (Fig. 1) occurs between adult females and juvenile bears (Young 1995). Front pad widths (Fig. 2) from the population of captured bears did not differ significantly from those of unidentified transect bears (t = 1.86, P = 0.065, df = 261, SD = 1.51). Front pad widths of known adult males were larger than FPW of known adult females (Fig. 3; t = 8.00, P < 0.001, df = 93, SD = 1.03; mean male = 12.23 cm, mean female = 10.54 cm), but FPW of known adult females were not different from FPW of known juveniles (t = -0.80, P = 0.428, df = 153, SD = 1.43). All known bears with FPW greater than 12.50 cm were males (N = 27); a total of four transect bears

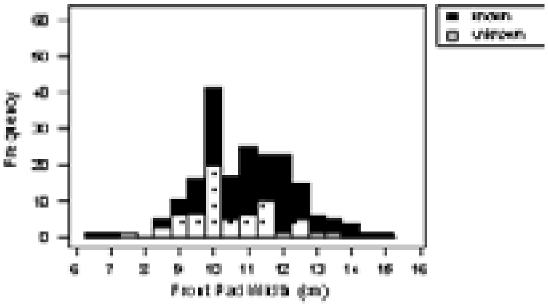

Figure 2. Distribution of trapped bears (known) and transect bears (unknown) on the East Tavaputs Plateau, Utah. Trapped bear data from 1991–1999; transect data from 1995–1997.

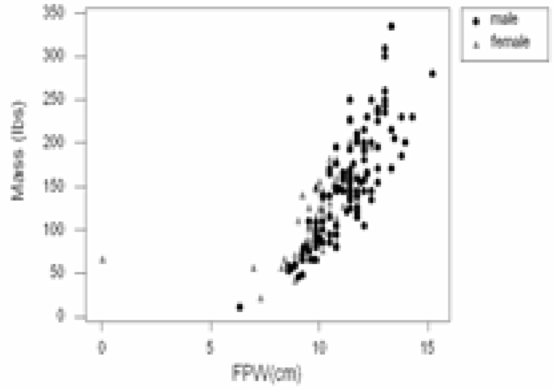

Figure 1. Plot of relationship between front pad width (FPW, in cm) and weight (lbs) of known ETP bears (1991–1999).

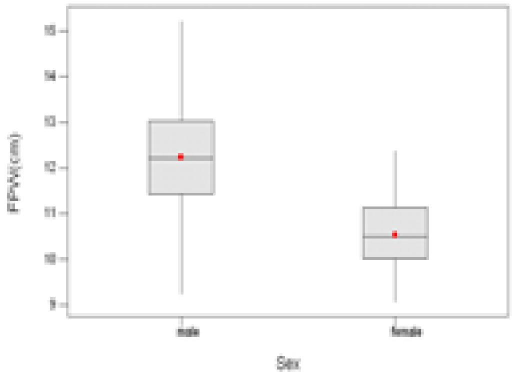

Figure 3. FPW (cm) of known adult male and female bears (4 yrs or more in age); dot indicates mean FPW.

Table 1. Examples of evidences of behaviors from black bears in spring-early summer detected along 80 transects on the East Tavaputs Plateau, Utah 1995–1997.

Behavior	n events observed	on n transects
Track intersections	7	6
Bed site	16	15
Visit old/potential dens	5	5
Flipped rocks/logs/ cow pies	93/16/23	18/11/5
Walk/cross road	85	35
Walk top of gas pipes	4	3
Claw marking	3	3
Cross riparian zone	41	19
Scat deposits	165	49
Digging for tubers	95	2
Kill or carcass observed	7	5
Walk game trail	18	13
Ant mounds observed:		
Camponotus nests (observed/disturbed)	50/8	16/4
Formica nests (observed/disturbed)	271/151	51/36

had FPW larger than 12.50 cm. On two occasions, we also followed a female with offspring; they were included in the small bear transect analyses. Though we seldom documented gender of the transect bears using FPW, if desired, researchers could potentially collect scat and perform DNA analyses to determine the sex of any bear followed. Regression analysis of bears of known mass and size captured on our study site demonstrated a moderate relationship between FPW and mass and body length ($r^2 = 0.58$, n = 183, $P < 0.001$; and $r^2 = 0.60$, n = 194, $P < 0.001$, respectively).

We realize that tracks on some transects could be made by the same individual on successive days. To address the probability of sampling the same bear repeatedly in a given season, we looked at tracks of the same size in close proximity on successive days and found that, at most, three transects may have been made by the same individuals on consecutive transects in 1995, five in 1996, and nine in 1997. If these were excluded to satisfy requirements of independence for our statistical analysis, this would leave 63 transects representing what we consider to be 63 individual bears. Given that we are comparing habitat use between small and large individuals and reporting the evidences of behaviors in the respective habitats, we do not consider the rather trivial violation of independence caused by the inclusion of all 80 transects to outweigh the value of lost observations that elimination of those few transects would require.

In total, we observed evidence of 737 behaviors (Table 1) in various habitats as we followed 80 sets of black bear tracks. Transects varied in length from 69 m to 6,211 m (mean = 1,149 m). Short transects undoubtedly represent a small segment of the daily activity of the bear, while longer transects could be a reflection or record of most of the day's activity. Transects ranged from 1,920 m to 2,573 m in elevation. Our work yielded a total of 92.1 km of bear transects through 297 habitat transitions (mean = 3.7 transitions/transect).

Habitat Use and Movements.—Along with behavioral data, these transects allowed us to document bear movements through dominant habitats on the Plateau. For example, in 1995, bears traversed 7,600 m in sagebrush, 5,000 m in oak brush, 4,100 m in Douglas fir, 2,000 m in mountain brush, and another 2,000 m in aspen habitats. That bears on the Plateau frequent open sagebrush habitats so often was not expected and differed from other western studies (Unsworth et al. 1989, Beecham and Rohlman 1994).

Comparing estimates of the area of available habitats to the actual distances that bears traveled within those habitats, we found a difference between overall habitat availability and use ($\chi^2 = 77.65$, $P < 0.001$, df = 4). Due to possible problems of non-independence among transects, we were unable to test statistically for bear habitat preferences. Yet when we tested for differences among the size classes and the way they used the

Table 2. Habitat types, area (ha), and percent available of total area, and percent use by large and small bears on the East Tavaputs Plateau, Utah. (+/- indicate use above or below expected values).

			Bear Use (%, +/-)	
Habitat	Area	Available (%)	Large	Small
Conifer	1646.87	2.17	15.11 (+)	21.50 (+)
Aspen	123.84	0.16	2.56 (+)	5.46 (+)
Sagebrush - Grass	4542.21	5.99	46.30 (+)	24.71 (+)
Pinyon - Juniper	42191.28	55.66	5.34 (-)	6.05 (-)
Oak - Mountain Brush	27292.59	36.01	30.69 (-)	42.28 (+)

different habitats, size did have significant overall effects on habitat use (F = 3.91, P = 0.0493, df = 1) and bears in the two size classes traversed the habitats differently (F = 19.13, P < 0.0001, df = 4). Our data suggest that both size groups of bears on the Plateau primarily used areas lacking a heavy canopy cover, but where spring and early summer food sources, in the form of ants and grass, were abundant in sagebrush and oak habitats. Chi-square analysis revealed that there was a significant interaction between a bear's size and the pattern observed in habitat use (χ^2 = 7.84, P = 0.0495, df = 3). Approximately 24% of all small-bear transects used oak habitats exclusively, while 10% were found exclusively in sage, and 19% used a combination of oak and sage habitats. Among large-bear transects, only 5% visited oak exclusively, while 13% foraged only in sage habitats, and 40% primarily utilized a combination of oak and sage habitats when traveling and feeding. Given that we found 95.4% of all disturbed Formica thatch mounds in sage and oak habitats, we would expect those habitats to be most heavily used during the sampling period. Correspondingly, relative to habitat availability (Table 2), bears appeared to under use the pinyon-juniper, conifer, and aspen ecotypes with denser canopies and relatively open understories.

Though bears appear to frequent the forested areas less often, these areas served other important purposes. We observed sixteen bed sites, all at the bases of large trees. Nine of the sites were in Douglas fir habitat, and we observed three additional beds near the bases of large, solitary Douglas firs in other ecotypes. Of these twelve beds, large bears used nine and small bears occupied the other three resting areas. In addition to bed sites observed in Douglas fir habitats, we documented two small bears feeding on aggregations of tubers from individual plants of western sweet cicely (*Osmorhiza occidentalis*) under Douglas fir trees (Table 1).

The horizontal obscurity measurements showed both the habitat type and directional orientation of the observer along a bear's trail to be highly significant to the distance we could see the cover board (F = 5.70, P < 0.001, df = 23 for model). Horizontal obscurity was greatest in oak-mountain brush and lowest in conifer (mean line of sight = 7.43 m and 13.67 m respectively).

IMPLICATIONS AND MANAGEMENT CONSIDERATIONS

Tracks.—Given the obvious wealth of information on bear behaviors to be gleaned by following bears and reading tracks, we were excited to see how easily we encountered bear tracks regularly on the roads and also near water or along game trails. The width of a bear's front pad, to some extent, indicates the mass and approximate age class (via body length) of the bear (Piekielek and Burton 1975, Beck 1991). FPW allowed us to discriminate some size and one gender class for select segments of the population (i.e., large males). While still providing valuable behavioral data, segmented samples proved too small to produce significant statistical data. Because FPW can be measured from tracks, managers may however be able to broadly characterize populations without the additional financial and equipment investments involved in trapping and handling bears, thus making tracks useful tools for management.

Habitat Use and Bear Movements.—Bears appeared to use areas with dense horizontal cover. In sagebrush-grass habitats and other areas of low overhead canopy, horizontal obscurity was high. This suggests that even in areas lacking vertical cover, bears benefit from thick vegetation that provides horizontal cover. On the Plateau, bears use habitats characteristically high in horizontal cover. Because visual obscurity was less to the front and rear orientations on our transects (i.e., the direction of the bear's travel) we suspect that bears subsequently move along the clearest routes within those habitats (i.e., established game trails, ephemeral stream drainages, roads).

Bear use of sagebrush-grass areas in this study differs from other studies in the western states where bears monitored by telemetry in the daylight hours apparently under-used these areas (Unsworth et al. 1989, Beecham and Rohlman 1994). Our techniques allowed us to document evidence of crepuscular and nocturnal behaviors and feeding events in these habitats. This provides additional and perhaps critical insight into traditional habitat studies where telemetry has not permitted documentation of bear use in certain habitats during the evening and nighttime hours.

Grass and ants are important foods in sagebrush-grass habitats and oak-mountain brush areas during the spring and summer (Bunnell 2000). The abundance of ants is possibly due to the relative paucity of canopy layers in these habitats where ants build above-ground thatch mound nests and nests under large, flat rocks that act as heat sinks (Seid 1997). In turn, this may enable them to produce earlier broods than those in more densely covered habitats (Seid 1997), thus providing nutrition for bears in a time of relative food scarcity. Bears on the Plateau fed heavily on ants of the genus Formica and new grass during May and June, with a foraging peak in July (Bunnell 2000). Thus, we propose that sagebrush-grass habitats should be considered important spring and summer landscapes, as they afford open areas where ants provide a predictable food source for bears.

Oak habitats are the most vegetatively dense communities on the Plateau (Tolman 1998). That smaller bears are found more often in oak-mountain brush suggests that while seeking foraging opportunities, they exploit the protective cover of oak understories. Young bears may be forced to use dense vegetation for feeding and escape cover instead of concentrating on the more productive open areas that are regularly exploited by larger, mature bears. This strategy may lower the probability of agonistic encounters and reduce competition (Jonkel 1967, Beecham 1980, Dusi et al. 1987, Rudis and Tansey 1995, Kovach and Powell 2003).

Bears used conifer habitats primarily for bed sites. Bed sites located at the bases of large trees allude to the importance of these trees and the innate tendency of black bears to select them. This suggests that timber-harvest practices should be sensitive to bear needs, especially in areas where removal of mature trees was or is substantial or where large trees are relatively rare owing to slow maturation.

Bunnell (2000) showed that bears searched for tubers in Douglas fir understory and chewed the cambial layer of Douglas firs. Though we rarely observed trees where bears had exposed the cambium, as is common in the Pacific Northwest, we did find that bears ate tubers in the understory. Other studies showed that bears use mixed-conifer forests for sleep, travel, or escape cover in the spring and summer months (Kellyhouse 1980, Beecham 1983). Additionally, Kellyhouse (1980) noted that bear sign was frequently encountered near forest ecotones with other habitats and that all bed sites were within 30 m of some potential food source.

In addition to the initial point on roads where we found tracks and started transects, our transects frequently crossed roads or riparian areas (Table 1, initial start points not included), indicating that bears do cross and often walk on open, exposed road areas. Roads may serve as an attractive corridor for travel through dense vegetation (Hellgren et al. 1991) or as possible home range boundaries (Mace and Waller 1997). Only female bears with offspring seem to be under-represented on roads in our study. Perhaps maternal females avoid roads and the potential dangers associated with human activity or other bears (Hellgren et al. 1991, Clark et al. 1993, Mace et al. 1999). It may be that female movements are so constrained by the lack of cub mobility (Lindzey and Meslow 1977, Garshelis and Pelton 1981, Hirsch et al. 1999) that encounters with roads are reduced in frequency over those seen for females without cubs in the spring to early summer months.

The direction an animal takes may also be motivated partially by the efforts to optimize energy expenditures (Wilmshurst et al. 1999). Solitary black bears may predictably adopt straighter paths when population densities are low because individuals searching for food or mates who do not walk straight paths are less efficient because they retrace steps and search the same areas (Adler and Gordon 1992). Given the low density of bears on the Plateau (1 bear / 5.6 mi^2 ; Chapter 1), interactions between individuals are quite possibly rare. Thus, bears should travel straighter routes so as to maximize mating opportunities. Daily movements might also be more linear if a bear traverses its home range as it forages. Given that the average home range of adult females on the Plateau is 20.8 km^2 (H. L. Black, unpublished data), it would be possible that a transect could run in a linear trajectory for 4.6 km before crossing a bear's home range boundaries. At that point the bear would most likely be deflected so that it remained within its territory.

These data represent many opportunities for future research in bear biology. One direction the data suggests is that habitat value be quantified seasonally as well as generally; otherwise habitats that play critical roles in particular seasons, such as sagebrush-grass areas on the Plateau, are discounted in their significance. Though our findings may be specific to the bears on the Plateau, it is plausible that similar behaviors occur in other sagebrush-dominated landscapes across the western United States, and therefore, these habitats are likely to be just as critical to bear survival elsewhere.

Efforts to quantify habitat use with conventional methods like telemetry and GPS may lead to considerable error and ambiguity where topography and habitats are spatially and vegetatively heterogeneous. Although telemetry is appropriate for determining macro-scale movements, and GPS readings provide more precise locations, neither one can document what a bear actually does on the ground within a habitat. Use of the technique presented here allows for documentation of behaviors, feeding, and movements on a finer scale, thus allowing for estimates of micro-habitat use, as well as documenting nocturnal behaviors, which are often unavailable through other methods.

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MOVEMENTS OF UTAH BLACK BEARS: IMPLICATIONS FOR MANAGEMENT AND CONSERVATION

HAL L. BLACK, JANENE AUGER, JOSHUA D. HEWARD, AND GUY WALLACE

Abstract.—In Utah, black bears occur in large and small habitat patches. Recovery of ear-tags from research and nuisance bears revealed large movements within and between patches by dispersing males. Homing movements both within habitat patches and over extensive semi-arid habitats are documented. Both sub-adult and adult females are shown to have left montane summer range to forage in agricultural areas in valley bottoms, perhaps in response to food shortages. These various movements collectively suggest that large expanses of habitat unfit for residency are crossed. Rates of movements are hypothesized to be relatively rapid and direct in non-bear habitat and less so in contiguous habitat where escape cover (trees), water, and food resources are present. Some montane areas of the state with low population densities may be enhanced by augmenting female numbers since the likelihood of dispersal by females is low. Dispersing males provide gene flow between these metapopulations.

In Utah, black bears (*Ursus americanus*) occur in large and contiguous expanses of habitat along the Wasatch Range, on the East and West Tavaputs Plateaus, and the Uinta Mountains. They are also found on several smaller isolated and semi-isolated montane islands including the La Sal, Abajo/Elk Ridge, Boulder, and Henry Mountains (Fig. 1). Other montane regions of the state appear to have adequate habitat, but either lack bear populations (Raft River, Deep Creek, and Navajo Mountain Ranges) or support populations at low densities (Bear River, Pavant, Tusher, Pine Valley, Paunsaugunt Ranges) (UDWR 2000). Here we report dispersal movements of black bears, homing movements of relocated bears, and movements apparently motivated by food shortages within and between mountain ranges. Collectively these movements demonstrate the capacity of black bears to travel rather long distances often through expanses of non-bear habitat. Additionally, we explore the implications of these movements for population structure, management, and conservation.

METHODS

In the 18 years between 1985 and 2003, there have been 3 field studies of black bears in Utah. The first spanned the years 1985–1992 and was centered in the Hobble and Diamond Creek drainages along the Wasatch Front (Bates 1991). The second was a short-term study (1987–1991) in the La Sal Mountains (Frost 1990, Richardson 1991, Auger et al. 2004), and the third was a 12-year study (1991–2003) on the East Tavaputs Plateau (Plateau) near the border with Colorado. These three study sites were all in high elevation montane habitats (2190 m–3900 m) containing continuously flowing streams. The Wasatch Front study site is along the eastern edge of the Great Basin and is adjacent to the heavily populated Utah County (Provo and Orem being the largest cities). Continuous montane bear habitat is found to the north, south, and east (Fig. 1). The La Sal Mountains are relatively isolated with desert shrub and/or juniper woodland found to the east, west, north and south. The East Tavaputs Plateau site is one of the remotest areas in Utah and is separated from the West Tavaputs Plateau by the Green River in Desolation Canyon. Low elevation desert shrub is found to the north and south of the West and East Tavaputs Plateaus.

Bears in all study areas were ear-tagged at their initial capture site or as yearlings in winter dens. Recovery of ear-tagged bears from beyond the trapping boundaries of the study areas by hunters and wildlife biologists provides most of the data. Additionally, we kept records of radio-collared bears removed from nuisance situations on the eastern slope of the Abajo Mountains and relocated to the western slopes, 41–65 km from the capture sites. These records provided insight into homing behavior in a sample of adult and sub-adult males and females. To determine distance moved by each bear, we measured a straight-line between the release site and the recovery site from digital topographic maps. Bears were aged using cementum annuli (Matson's Laboratory in Milltown, MT). Bears ≥4 years-old were considered adults.

RESULTS

Owing to the absence of any published observations of movements of Utah bears, we report 22 individual accounts (19 ♂, 3 ♀) of movements along with figures that illustrate them. These emphasize in some cases extensive movements through both hospitable and inhospitable habitats to arrive at food resources, new areas for settlement, or former home ranges.

Bears 1–14 were individuals marked on the 3 study areas—10 bears from the East Tavaputs Plateau (Fig. 2), 3 bears from the La Sal Mountains (Fig. 3) and 1 from the Wasatch Front (Fig. 3)—that subsequently moved and were killed elsewhere. Bears 15–17 were nuisance bears relocated to the East Tavaputs Plateau that homed (Fig. 3).

Bears 18–22 were unmarked individuals whose origins were unknown, but have relevance because they were killed or seen in non-bear habitat (Fig. 3). The 4 bears encountered near I-70 (bears 19–22) were traversing salt desert shrub habitats at least 24–40 km from the closest montane habitat.

Table 2 contains examples of 8 additional bears (bears 23–30) homing after being removed from

Table 1. Natural movements of black bears from the study areas on the East Tavaputs Plateau, La Sal Mountains, and Wasatch Mountains in Utah.

Bear	Sex	Age at Death	Distance Moved (km)	Movement through non-bear habitat	Mortality	Date of Death
1	M	5	116	N	Hunter	29 May 2003
2	M	cub	60	Y	Unknown	30 Aug 1992
3	M	13	274	N	Vehicle	Sep 2000
4	M	7	96	N	Depredation	28 Jul 2000
5	M	3	112	N	Hunter	20 Sep 1997
6	M	4	113	N	Hunter	1 Sep 1998
7	F	7	86	Y	Depredation	16 Sep 2000
8	M	4	155	N	Hunter	Sep 2002
9	F	6	48	Y	Hunter	18 Sep 2004
10	F	2	48	Y	Depredation	20 Sep 2002
11	M	3	37	Y	Hunter	Spr 1991
12	M	3	60	Y	Hunter	13 May 1991
13	M	6	87	Y	Hunter	5 Sep 1996
14	M	3	68	N	Hunter	13 May 1989
15	F	Adult	113	Y	Unknown	Fall 1997–8
16	M	1	126	N	Depredation	1 Jul 1994
17	M	Subadult	103	Y	Vehicle	Jun 1994

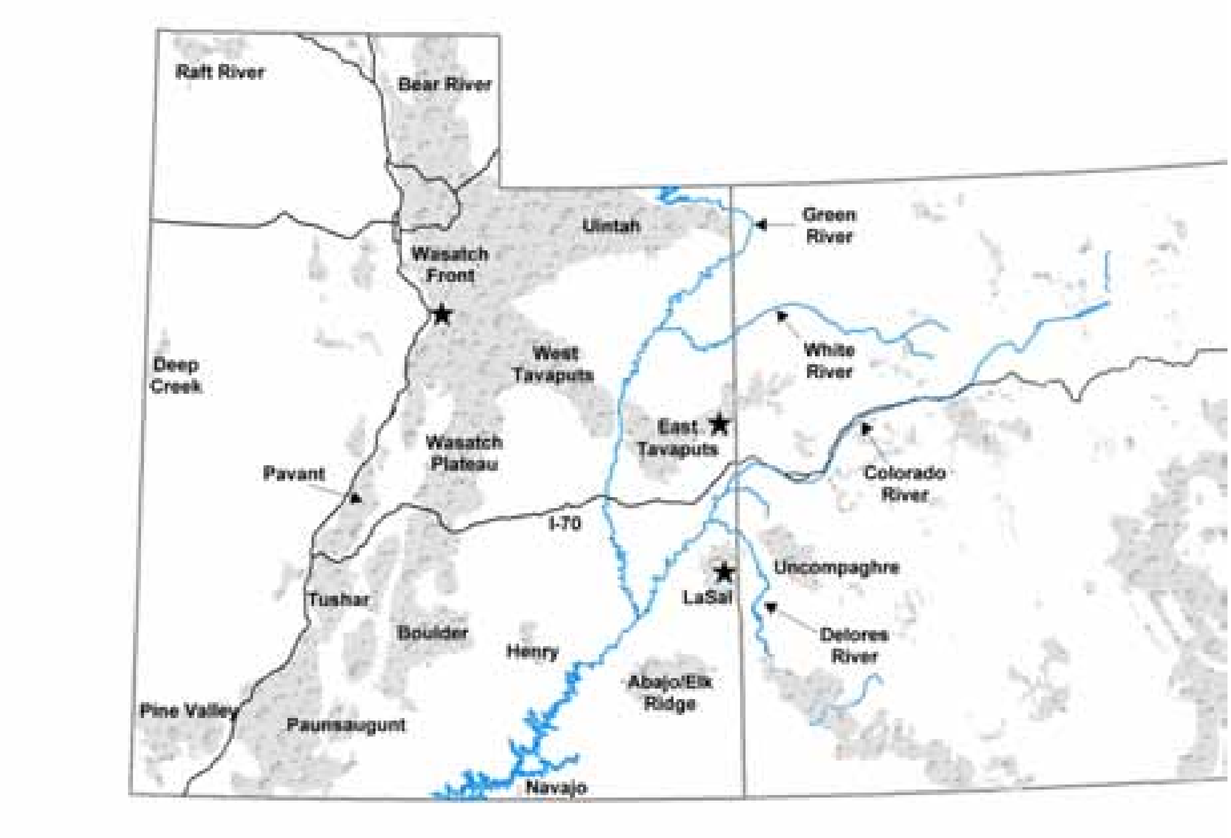

Figure 1. Bear habitat and geographic features of Utah and western Colorado. Shaded areas in Utah represent real (currently occupied) and potential (unoccupied area at elevations above 1700 m) bear habitat. Shaded areas in Colorado represent bear population concentrations. Bears are hunted throughout much of the montane areas of Utah with the exception of the Raft River, Deep Creek and Navajo Mountains where no bears occur, and in the Henry Mountains where observations of bears and their signs are rare. Stars indicate study areas where bears were ear-tagged during research activities.

nuisance situations. Mean distance of return was 52.4 km ± 9.6 (SD). All of these returns could have been made through contiguous bear habitat. Mean elapsed time between relocation and return was 24.3 days ± 12.0 (SD, excluding one outlier who returned in 333 days).

Individual Accounts

Bear 1. This male bear was caught as a 3.5 year-old in Jul 2001 on the East Tavaputs Plateau and killed 2 years later (May 2003) in Range Creek on the West Tavaputs Plateau, 116 km from his last capture site. He crossed the Green River when moving between the plateaus.

Bear 2. A 4.5 kg male cub was caught on the East Tavaputs Plateau on 9 Aug 1992 along with its 8.2 kg female sibling. He was ear-tagged and released, then subsequently captured by Colorado Division of Wildlife personnel 3 weeks later on 30 Aug 1992 in a peach orchard 6.4 km west of Fruita, CO. Twenty-one days after capture he had traveled 60 km. He may have moved down one of the drainages out of the East Tavaputs Plateau, then through arid valley floor for 24–32 km before reaching the orchard.

Bear 3. Male bear 3, first caught on the East Tavaputs Plateau at age 6 in 1993, was struck by an automobile on I-70 near Frisco, Colorado in Sep 2000 at age 13. He was presumably a resident on the Plateau study area where first caught. This movement of 274 km was the longest recorded for a Utah bear. He crossed the Colorado River when dispersing.

Table 2. Radio-collared nuisance bears relocated from the Abajo Mountains who homed to their initial capture areas.

Bear	Sex	Age	Date Relocated	Date Returned	Time Elapsed (days)	Distance Traveled (km)
23	F	SA	10 Oct 2001	24 Oct 2001	14	47
24	F	A	1 Sep 2001	25 Sep 2001	25	57
25	M	SA	15 Aug 2001	20 Sep 2001	37	59
26	F	A	27 Aug 2001	1 Nov 2001	36	65
27	F	SA	25 Jul 2002	2 Aug 2002	9	57
28	M	A	25 Jul 2002	7 Aug 2002	14	57
29	M	A	30 Sep 2002	24 Oct 2002	35	36
30	M	SA	13 Sep 2002	15 Aug 2003	333	41

Bears 4 and 5. These male siblings were marked on the Plateau in 1995 as yearlings. Bear 4 was killed at age 7 in a nuisance situation in Meeker, Colorado and bear 5 was killed at age 3 in Range Creek on the West Tavaputs Plateau. The distance between these siblings at death was 209 km. Both could have dispersed through continuous bear habitat to the sites where they were killed. Bear 5 crossed the Green River.

Bear 6. This male was ear-tagged on the Plateau in 1995 as a yearling. He was killed on 1 Sep 1998, 113 km from his natal area across the Green River on Anthro Mountain (West Tavaputs Plateau). He could have traveled through continuous bear habitat.

Bear 7. This 7 year-old female caught in 1996 at age 3 was killed in a nuisance situation near Palisade, CO in September 2000, 86 km from her capture site on the Plateau.

Bear 8. This male bear was marked on the Plateau in 1999 as a yearling. He was trapped in his natal area as a 3 year-old in Jun 2001, but killed in Sep 2002 near Scofield Reservoir on the Wasatch Plateau, 155 km away and across the Green River.

Bear 9. This 6 year-old female radio-collared in 2002 was shot in Sep 2004 about 15 km north of Fruita, Colorado where she had been feeding in a cornfield. She was last seen in the den with her cub in March 2004 in San Arroyo Canyon on the East Tavaputs Plateau about 48 km from where killed.

Bear 10. This 2.5 year-old female was captured 13 June 2002. She weighed 31.8 kg and was so thin that we could delineate the individual large bones of her lower appendages. She was 48 km southeast from her capture site when shot as she ran from a cornfield near Fruita, CO in September 2002.

Bear 11. This male yearling was tagged in Apr 1989 in the La Sal Mountains. He was seen in his den or trapped in the study area on 5 additional occasions through Dec 1990. He was killed in Colorado in the spring of 1991, 37 km from his last known location in Utah. He crossed the Dolores River into Colorado.

Bear 12. A yearling male was tagged on the southern end of the La Sal Mountains in May 1989. He was killed two years later in May 1991 on the southern margin of the Uncompahgre Plateau in Colorado, a distance of 60 km from his last known location in Utah. Like Bear 11, he also crossed the Dolores River when dispersing.

Bear 13. A yearling male was trapped in summer 1996 in a nuisance situation on the south side of the La Sal Mountains and relocated 32 km to the north end of the mountain range. He was legally shot 5 years later in Sep 2001 on the northeastern side of the Abajo Mountains, a distance of 87 km from the release site. The low-elevation habitat through which he traveled included sagebrush valleys and juniper woodland.

Bear 14. This young male dispersed as a yearling from his natal area in the Wasatch Front study area to Tabby Mountain (Uintah Mountains),

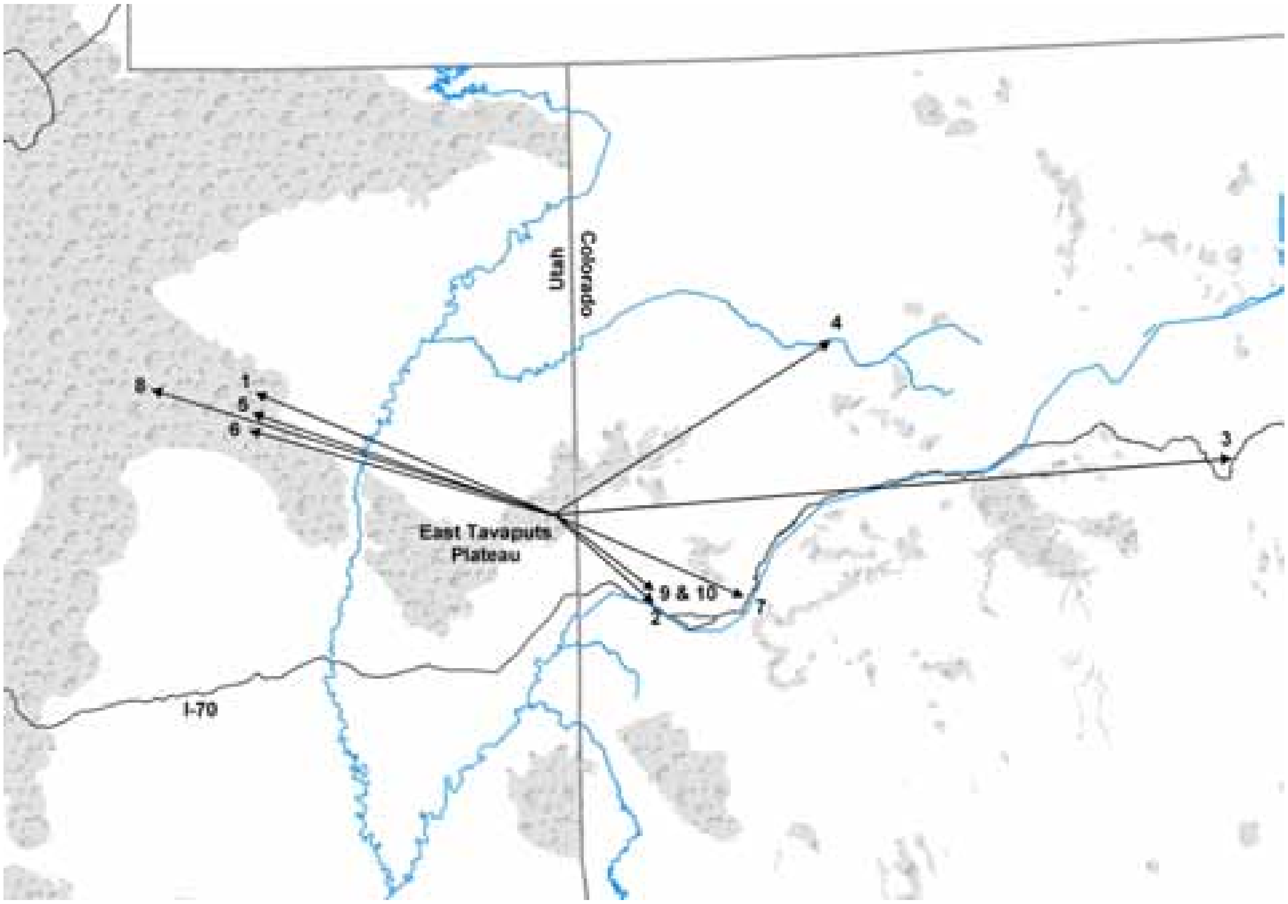

Figure 2. Natural movements of 10 bears away from the East Tavaputs Plateau study area. Bear numbers correspond to Table 1. Movements are represented as straight-lines, because precise routes of travel are not known.

a distance of 68 km. He was killed by a hunter in May 1989 as a 3 year-old.

Bear 15. An adult female was trapped in Sep 1995 in the rural community of Myton, UT. Cub tracks were seen where she was trapped, but the cub was not captured. She was released on the East Tavaputs Plateau in Railroad Canyon. Within 21 days she returned to her original capture site, a distance of 113 km. In returning she crossed the Green River, and perhaps the White River, and traversed 40–48 km of non-bear habitat.

Bear 16. In Apr 1993, two orphaned cubs, were captured on the Wasatch Front near Provo, UT in April 1993. In late fall they were placed in an artificial den on the East Tavaputs Plateau and remained there until released in March 1994. Four months later in Jul 1994 the yearling male was shot by a cabin owner in Nine-Mile Canyon on the West Tavaputs Plateau across the Green River and 126 km from his artificial den site.

Bear 17. This male bear was relocated to the East Tavaputs Plateau after being captured 6 June 1994. About 4 weeks after release he was struck by a car on U.S. Route 191, 48 km SE of Price, UT. Habitat at the kill site was juniper woodland and low-growing desert shrub at an elevation of 1402 m. The closest montane habitat was approximately 16 km to the east. When killed, he had traveled 103 km in a westerly direction and across the Green River from his release site.

Bear 18. In 1996 a long-time resident of Callao, UT saw a bear running west about 16–19 km from the foothills of the Deep Creeks on the Utah–Nevada border (Fig. 3). To our knowledge this is the first report of a black bear on this isolated mountain range. The closest bear population in any

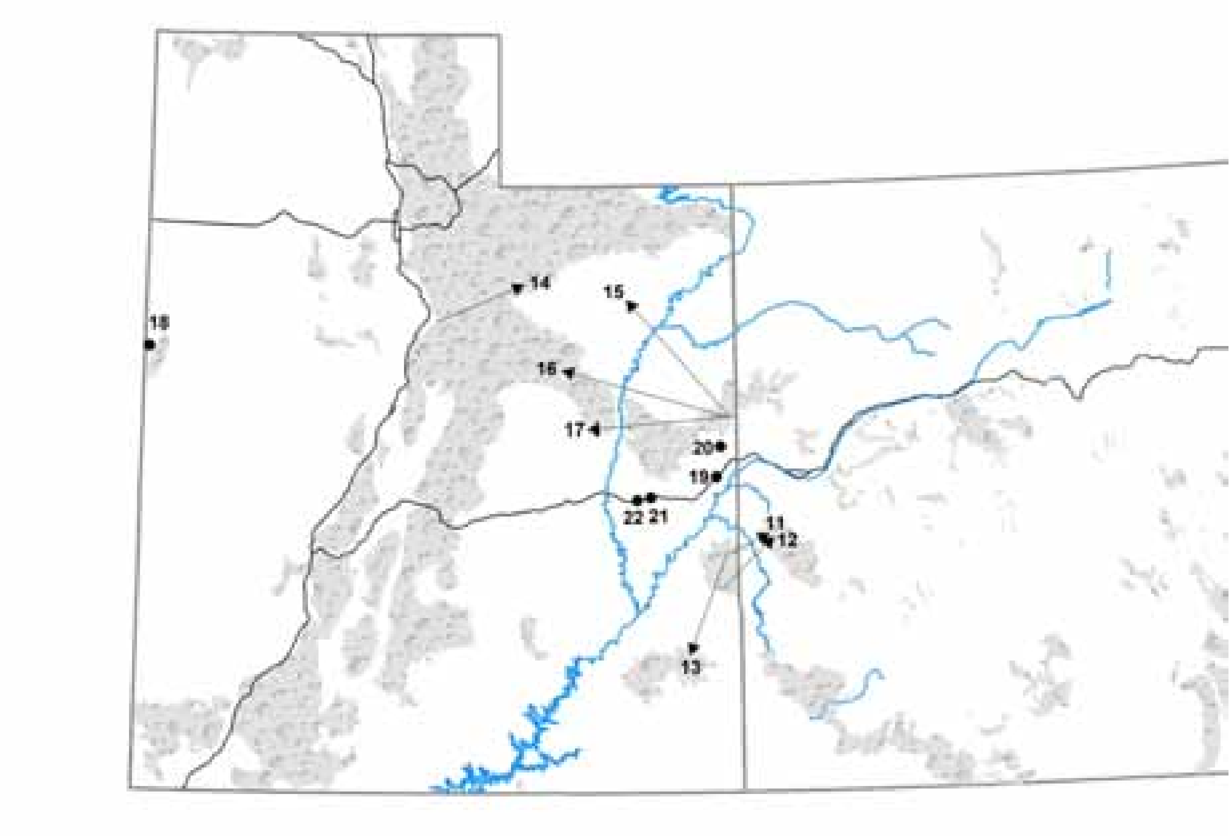

Figure 3. Natural movements of bears away from the La Sal Mountains (bears 11–13) and the Wasatch Front (bear 14), movements of 3 nuisance bears relocated to the East Tavaputs Plateau study area (bears 15–17), and point locations of bears seen or killed in non-bear habitat (bears 18–22).

direction is on the Wasatch Front, a minimum distance of 193 km. If this was a relocated nuisance bear or an unsanctioned introduction, there is no record.

Bear 19. On 8 Oct 1999 a bear of unknown sex was struck on I-70 at milepost 220 in Grand Co., UT. Direction of movement was not reported.

Bear 20. In early Aug 2000, while traveling a secondary road south of the Plateau at 9:00 am, we saw a medium-sized bear heading in a southeasterly direction in the open, arid saltbush valley floor between the East Tavaputs Plateau and the Uncompahgre Plateau in Colorado. The elevation was 1615 m. It was a drought summer and a hot morning. This bear, presumably a male, was apparently dispersing from the East Tavaputs Plateau to the montane habitat of the Uncompahgre some 81 km from the foothills. A major 4-lane interstate, I-70, runs between the two areas. This bear was not following a creek bed and there was nothing resembling the cover or food plants of bear habitat for many kilometers in any direction.

Bear 21. On 27 October 2000 at 1:20 pm a "large" bear of unknown sex was seen crossing I-70 about 1.6 km west of Crescent Junction. It was heading north towards the East Tavaputs Plateau.

Bear 22. An unmarked bear of unknown sex was struck by a large truck on I-70 at milepost 170 on 29 August 2002. Direction of movement was not reported.

DISCUSSION

Collectively these movements suggest that, whether motivated by food shortages, homing instinct, or dispersal, bears can move over the rather heterogenous landscapes found in Utah, in some cases traveling through many kilometers of habitat unsuitable for permanent residence. The distances covered may seem rather impressive to us only because our bipedal life form and lifestyles constrain us—a species of similar size. For example, we saw bear 20, for whatever the motivation, traveling through a desert shrub landscape with no visible riparian areas. It was traveling toward montane habitat 81 km to the south of its position when seen.

The years 1999–2002 were years of severe drought in much of the west, and the East Tavaputs Plateau was particularly dry (USGS 2003). Bert DeLambert, a resident rancher there, told us that in fall of 2000 calf weights averaged 18 kg less than usual and were by far the lowest in his 20-year history on the Plateau. Average calf weights would have been even lower but he didn't sell 40–50 calves that were small. Range conditions were unlike anything he had seen in the previous 20 years. Bear scats collected in late summer and early fall of 2000 contained little of the mast remains typically seen, e.g., acorns (*Quercus gambelli*), chokecherry (*Prunus virginiana*) or serviceberry (*Amelanchier alnifolia*), but did contain juniper seeds in the highest frequency and volume that we had observed (Bunnell 2000). Furthermore, we found a radio-collared lactating female who had apparently died of starvation in August 2000. She had been accompanied by twins throughout the summer and was the only adult female we know of to die of natural causes during this study. Also, in 2000 we documented the first movement of a marked adult female (bear 7) from her summer range to agriculture areas on the valley floor where she was found feeding.

Further evidence that the proximal explanation for the movements of bears 7, 9 and 10 was food shortages on the Plateau is the fact that until the year 2000 we had no records of bears from the Plateau study area in the lowland agricultural areas of Fruita, Colorado (with the exception of Bear 2, which was an orphaned cub). Prior to 2000, we had tagged 76 male bears and 45 females ≥1 year-old in the study area who could have been candidates for movement to agricultural areas.

Subsequent to 2000, bears 9 and 10 marked on the East Tavaputs Plateau were killed while feeding in lowland agricultural sites near where bear 7 was killed in 2000. Perhaps the drought will establish a tradition among a segment of the population to migrate to dependable food sources in the agricultural areas near Fuita and Grand Junction, Colorado. Van Graham of the Colorado Fish and Game, who reported the Colorado mortalities of our marked bears, has told us of other unmarked bears presumably from both the Colorado and Utah portions of the Plateau that were seen, killed or captured in early fall in the same agricultural areas as those described above. Fall excursions to food resources have been documented in Colorado (Beck 1991) and in other studies (Garshelis and Pelton 1981, Hellgren and Vaughan 1990, Maehr 1997, Rogers 1987a, Samson and Huot 1998).

In the town of Green River, Utah a large melon industry along the Green River annually attracts bears in the fall from the East Tavaputs Plateau and perhaps the West Tavaputs Plateau, again suggesting a tradition of migration from higher elevations to the desert valley floor to feed prior to winter lethargy.

The homing movement of bear 15 clearly demonstrates again the ability of bears to leave montane habitat, descend into low elevation desert and home a considerable distance to where it was initially captured. The benefits of returning home may outweigh the apparent risks associated with travel through habitat containing few food resources, water, or escape cover. Massopust and Anderson (1984) showed that the adaptive advantage to homing black bears is reflected in greater longevity relative to non-homing individuals.

Bear 23 (Table 2) impaired by a compound fracture of her foreleg showed strong motivation to return to her initial capture site. Bears 24–30 also demonstrated motivation to return home but passed through suitable contiguous bear habitat in the process (Table 2). Return times and distances traveled were relatively short and similar to northern Wisconson bears (Massopust and Anderson 1984). Also, Ingram (1995) found that all bears translocated out of nuisance situations in Sequoia–Kings Canyon National Park returned to the capture sites.

Bears listed as dispersers moved an average of 100 km (SD = 55) from their capture site to where they died (Table 1). These bears moved distances similar to those in Massachusetts where 8 yearlings all moved more than 60 km and the mean dispersal distance was 112.5 km (Elowe 1987). Eight yearlings in Minnesota dispersed 13–219 km with a mean distance of 61 km (Rogers 1987a). In New

Mexico, male bears under 3 years-old dispersed 25–60 km (Costello et al. 2001). Schwartz and Franzman (1992) reported much shorter dispersal distances for 15 subadult males, ages 1–3, on the Kenai Peninsula, AK where mean distance moved was 12.3 km with a range of 4.5–30 km. In that study only 1 of the15 lived to adulthood. The other 14 may have dispersed farther from their natal sites had they not been killed.

Our data do not permit us to calculate the rate at which bears travel. Movements within bear habitat might be a "fits and starts" program where individuals move directionally or not, having their movements dictated by both endogenous and exogenous stimuli, prior to their establishing a home range (Rogers 1987a). But, bears dispersing through 50–60 km or more of non-bear habitat, one largely devoid of water and food and lacking trees as escape cover may be motivated to cross these areas rapidly and non-randomly. In this connection, we were impressed as we watched bear 20 as it loped away from us with a smooth gait reminiscent of a wolverine (*Gulo gulo*), a gait which could carry it over many kilometers of desert floor in hours rather than days. Stratman et al. (2001) documented extensive movements of an 11 year-old adult male bear who on one occasion moved 123 km in 10 hours.

Young male bears dispersing through non-bear habitat, such as that between the several disjunct populations in Utah and elsewhere throughout the west, may effectively bridge these populations and effect gene exchange. For example, dispersal between the East Tavaputs Plateau and the Uncompaghre Plateau (Colorado), between the East Tavaputs Plateau and La Sal, between the La Sal and Abajo Mountains, or between the La Sal and Uncompaghre, are examples of where direct dispersal may occur regularly (i.e., more often than we observe, Fig. 1). The number of examples of dispersal given here may seem small, but we were working with a modest sample of marked bears (93 marked male potential dispersers ages 1–4 on the East Tavaputs Plateau, slightly less than half that on the La Sals, and only 5–6 subadult males on the Wasatch Front). Undoubtedly, reciprocal dispersal of male bears moving in directions opposite our observations would have been detected had there been marked individuals to recover. If true, then these semi-isolated montane island populations would not be expected to be genetically distinct, nor would we expect bears in contiguous habitat to show genetic diversification. Sinclair et al. (2003) suggests, based on microsatellite DNA evidence, that the East Tavaputs Plateau study population was part of a larger population extending east into Colorado and west to the Wasatch range.

Some of the dispersal movements through kilometers of non-bear habitat (bears 2, 7, 9, 10, 11, 12, 13, 15, 17, 18, 19, 20, 21, and 22) suggest that these individuals traveled extensively in the absence of anything resembling a connective corridor (Table 1). Here the corridor may simply be substrate in which to travel and the capacity to see a distant mountain in profile or otherwise navigate directionally. If distance vision of black bears is as good as that of humans, then they could easily see the Uncompaghre and the La Sal from the higher elevations on the East Tavaputs Plateau and the Abajo Mountains from the La Sal. When movement between disjunct populations does not occur in habitat corridors, management efforts to reduce human/vehicle mortality on highways such as I-70 is compromised. Non-corridor dispersal does not concentrate bears in a predictable manner and thus allow for underpasses, green bridges, or warning signs to help reduce mortality.

We have little insight into activities of bears prior to being killed or last observed. So questions regarding the amount and direction of wandering cannot be addressed. Considerable wandering and even 180 degree changes in direction before settling on a home range does occur (Rogers 1987a, 1987b). Obviously, with regular monitoring, radio-collared individuals can provide a fine-scale picture of the dynamics of dispersal; however, simple recovery of ear-tagged individuals as detailed here has shown that movements between disjunct populations occur, that in some cases corridors in the traditional sense may not be used (or perhaps not recognized), and that bears can traverse rather extensive non-bear or marginal habitat in the process of dispersing. Managers and researchers should take confidence in the value of tagging all bears they handle knowing that ear-tags can persist for years and are a safe and inexpensive device for identifying individuals.

We have no records of females dispersing from the Plateau and settling in a new home-range (assuming that the "agricultural bears," of course, had simply migrated to fall resources and would have returned to their former ranges). We concur with Onorato and Hellgren (2001) that there is apparently a low probability of females dispersing to disjunct populations even if the source population is large.

Apparently adequate black bear habitat occurs on the Pavant, Tushar and Paunsaugunt ranges in Utah but they have low population densities of bears (Heward, 2004). These ranges are somewhat isolated from the larger more contiguous patches of bear habitat to the east (Figure 1). The agricultural and open rangelands between these mountain ranges could easily be crossed by dispersing males, but are probably crossed infrequently by females because they do not normally disperse over long distances. Augmentation of bear populations in Utah as called for by the Utah Black Bear Management Plan (UDWR 2000) would only be possible by the translocation of females. If successful, these populations would grow; and we could gain insight into growth rates, conservation genetics, metapopulation theory and even female/female offspring social organization (Onorato and Hellgren 2001).

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FOOD HABITS OF UTAH BEARS: THREE STUDIES AND 1787 SCATS LATER

BRADY J. HEWARD, JOSHUA D. HEWARD, JANENE AUGER, HAL L. BLACK

Abstract.—Since 1985 three studies on the American black bear (*Ursus americanus*) have been conducted in Utah: a short-term study in the Wasatch Mountains, a short-term study in the La Sal Mountains, and a 12-year study on the East Tavaputs Plateau. As part of each of these studies, black bear scat was collected where encountered (trails, roads, and traps). A total of 1787 scats were examined. Dietary trends followed a basic patterns in all study areas, with variation dictated by abundance of food. Early spring scats contained largely grasses and forbs followed by ants. Ants became increasingly more important through late spring and early summer. Soft mast appeared in scats in late summer and early fall, with serviceberry and chokecherry being the most frequently consumed. Pine nuts were a major fall food item in some years, and appeared in a few spring scats following a pine nut year. Acorns were a common fall food item in some years. Meat remained important throughout the summer especially in the Wasatch study area. On a population level, a positive correlation exists between the animal matter consumed and the mean weight of bears. Years of drought and late spring freezes had adverse effects on soft and hard mast production. During these years of limited food supplies, an increase in juniper berry consumption occurred over years of heavy mast production, when juniper berries were rarely observed in scat.

The American black bear (*Ursus americanus*) is widely distributed throughout much of North America; and, in various states and provinces, its ecology, behavior, and relationship to humans have been studied extensively. Most studies have included analyses of food habits for their intrinsic value and because of the relationship between food availability and population dynamics (Rogers 1976, Elowe and Dodge 1989, McDonald and Fuller 1994, McLaughlin et al. 1994, McDonald and Fuller 2001, Costello et al 2003). Habitat for bears in Utah is generally more xeric than in other states (Ashcroft et al. 1992), and both hard and soft mast plant species have years where drought or late freezes cause partial or complete crop failures (pers. obs.). Therefore, understanding the diet of Utah bears and how alternative food sources are utilized within and between years is important to sound management.

Three studies of Utah's black bears over the past 20 years (Hobble Creek, La Sal Mountains, and East Tavaputs Plateau) each had a food habits component (Bates 1991, Richardson 1991, Bunnell 2000). Here we summarize and compare the results of these studies and include a small dataset collected on the Plateau in the years 2000–2002 when drought conditions were particularly severe in Utah (USGS 2003).

METHODS

On all study sites, bear scats were collected opportunistically during trapping and radio-tracking activities, and occasionally, concerted searches were conducted. Scats were initially placed in brown paper bags and date and location were recorded. Analyses varied by study site and are described in detail below; but in general terms, presence or absence of items in broad categories such as green vegetation, animal matter and so forth was visually determined for each scat. Then % volume of items in each category was visually estimated. Lastly, 3 variables were calculated for each category over the respective study area: % frequency (total presences in scats/total number of scats), mean % volume for each food category (sum of % volume over all scats/total number of scats), and importance value (mean % volume multiplied by % frequency).

Hobble Creek (Bates 1991).—Scats were collected from 1985 to 1989. Each was oven-dried, manually fragmented until homogenous, washed in a nylon sack until the water exiting the sample was clear, dried, and then spread in a pan. The presence or absence of recognizable items in 6 categories was visually determined: green vegetation (including both grasses and dicots), ants, other insects, fruits and flowers (including both hard and soft mast species), animal matter, and other material (generally debris). Content categories were then assigned to the following % volume categories: trace (<1%), 1%–5%, 6%–25%, 26%–50%, 51%–75%, and 76%–100%.

La Sal Mountains (Richardson 1991).— Scats were collected between May and November in 1988 and 1989. Seasons were defined as spring (Apr 1–Jun 30), summer (Jul 1–Aug 31) and fall (Sep 1–Nov 15) (Tisch 1961, Hatler 1972). All scats were oven-dried at 40 °C for 24 hr and stored at 22 °C (ambient room temperature). For analysis scats were manually fragmented in a pan and visually examined for content and % volume. Categories were the same as in the Hobble Creek study.

East Tavaputs Plateau, 1991–1997 (Bunnell 2000).—Scats were collected during the years 1991–1997 and, following air-drying, were stored at 22 °C. For analysis, scats were manually homogenized and spread at a uniform depth into a tray (61 × 91 cm). Each tray was divided into sextants, and one small-sized dot was randomly placed within each sextant. The item nearest the dot was identified and the number of times an item occurred nearest to a dot was used in the calculation of importance value. Presence or absence of other food items was also recorded. Relative food item volumes were estimated in increments of 5%. Items occurring in less than 5% volume were given an arbitrary value of 3%. Food items were classified into the following 8 groups: mammal, ant, insect, hard mast, soft mast, grass, other green vegetation, and other materials (debris). Mammalian remains (i.e., hair, bones, and hooves) from 100 randomly selected scats were identified to show trends in mammalian consumption.

Correction factors to account for differential digestibility of various diet items were applied to the Plateau dataset to determine grams ingested per milliliter of fecal material (rGI) (Bunnell 2000). These factors were obtained from Hewitt and Robbins (1996) who fed captive grizzly bears (*Ursus arctos*) various food items to derive the relationship between grams ingested and volume excreted. A high correction factor means that the food is more digestible. Meat had the highest correction factor (3.0) followed by hard mast (1.5), soft mast (0.93), and grass and dicot (0.26, Hewitt and Robbins 1996). Bunnell (2000) established a correction factor for ants (1.74). These values suggest that traditional percent volume values may be misleading as well as relative importance values which are calculated using percent volumes. Relative importance values most likely overestimate the importance of green vegetation and underestimate the importance of meat, ants, and hard mast in bear diets (Hewitt and Robbins 1996; see Bunnell 2000 for detailed discussion).

The use of broad percent volume categories in the La Sal and Hobble Creek studies precluded calculation of rGI for those datasets. Our comparisons of food habits by determining a percent of items consumed should not be influenced by the lack of correction factors. It was not our purpose to determine the grams ingested of specific materials, but the patterns of what bears were consuming.

East Tavaputs Plateau 2000–2002.—In the year 2000, a severe drought and a late freeze significantly reduced production of hard and soft mast. Flowers were frozen and surviving fruits failed to mature (pers. obs.). We reasoned that the effect on black bear diet during this year and 2 subsequent years of improving conditions would be reflected in frequency of food items in scat. We performed on-site analysis. Scats were spread over the ground and only items occurring at ≥ 10% volume were identified and classed into 8 content categories as defined previously for the ETP. Hard and soft mast were identified to species.

Comparison Methods.—We analyzed the raw data of the La Sal and Plateau study areas to determine trends in food item consumption; we were unable to obtain the raw data for the Hobble Creek study, but used the % volume results as a basis for comparison. We eliminated all items that were assigned to either the "trace" or 1–5% volume categories in the La Sal data to make them comparable to data from the East Tavaputs Plateau (2000–2002). The data collected between 1991 and 1997 on the East Tavaputs Plateau were also adjusted by eliminating all values that were under 10% of non-debris volume (i.e., we eliminated all items that occurred as less than 10% of the identifiable material). This eliminated items that may have been consumed incidentally or were carried over in the digestive tract from previous feeding bouts. We then determined the % of each item consumed for the revised datasets from the Plateau and La Sal Mountains. This was done by

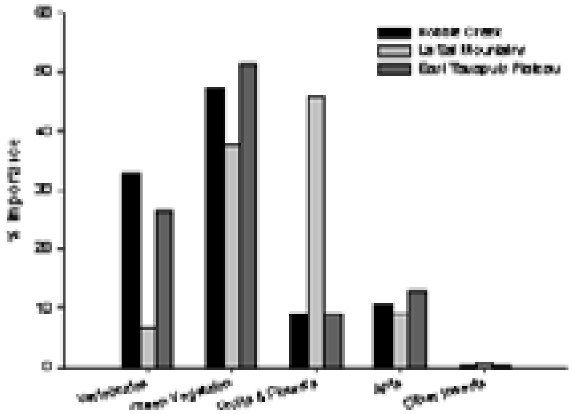

Figure 1. Diets of Utah black bears compared using importance values for the Hobble Creek, La Sal Mountains and East Tavaputs Plateau study areas.

dividing the frequency of occurrence by the total number of items consumed in the scats. Separate values were calculated for early spring (dates before June1), June 1–15, June 16–30, July 1–15, July 16–31, August 1–15, August 16–31, and late fall (dates after August 31).

RESULTS

A total of 1787 scats were analyzed: 179 from Hobble Creek, 859 from the La Sal Mountains, 405 from the Plateau from 1991–1997, and 344 from the Plateau from 2000–2002. The results of each study are included here, as well as the results of the comparison methods.

Hobble Creek (Bates 1991).—The overall importance values of each of the items were green vegetation 47.2%, ants 10.6%, other insects 0.3%, fruits and flowers 9.0% and meat 32.9% (Fig. 1).

Green vegetation (primarily grasses) made up the highest percent volume of scat in the spring but gradually decreased in the fall to become a small portion of the scats (Fig. 2). Dandelion (*Taraxacum officinale*), Utah angelica (*Angelica wheeleri*), and other dicots were also consumed.

Ants were consumed throughout the year. They made up 8.1% of scat volume in the spring, 17.2 % during the summer, and 4.7% during the fall. Overall, ants made up 10.1% of scat volume. Other insects were rarely found in bear scats in the Hobble Creek area (< 1%).

Fruits became increasingly important in late summer and early fall. Chokecherry (*Prunus virginiana*) and serviceberry (*Amelanchier alnifolia*) were the two most frequently consumed fruits. Acorns (*Quercus gambelli*) were the primary hard mast species in the Hobble Creek area, but they were never seen in large quantities on Gambel's oak in the area or in scats. Fruits and flowers accounted for 13.1% volume of the scats.

Meat was very important in the diet of Hobble Creek bears. In spring, 20.7% of scat volume was made up by meat remnants. Decreased meat consumption occurred during the summer months. In the fall, scats consisted of 50.1% meat by volume. Analysis of hair in scats revealed that the primary sources of meat for bears were porcupines (*Erethizon dorsatum*) and mule deer (*Odocoileus hemionus*).

La Sal Mountains (Richardson 1991).—The overall importance values were green vegetation 37.8%, ants 9.1%, insects 0.6%, fruits and flowers 45.8% and meat 6.7% (Fig. 1).

Green vegetation occurred in 87.4% of spring scats collected. Consumption of green vegetation, including grasses and forbs, decreased significantly into summer and again into fall.

Ants occurred in increasing frequency from spring to summer and decreased sharply in the fall. The most commonly consumed ants were from the genera *Formica*, *Tapinoma*, *Camponotus*, *Lasius* and *Myrmica* (Auger et al. 2004). Other insects were consumed in low but relatively constant amounts throughout the year. Common insects consumed by black bears, other than ants, were wasps (*Vespula*

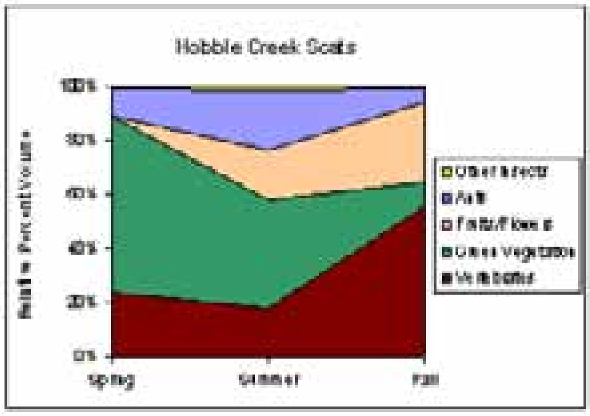

Figure 2. Food habit trends in Hobble Creek from spring to fall based on percent volume data.

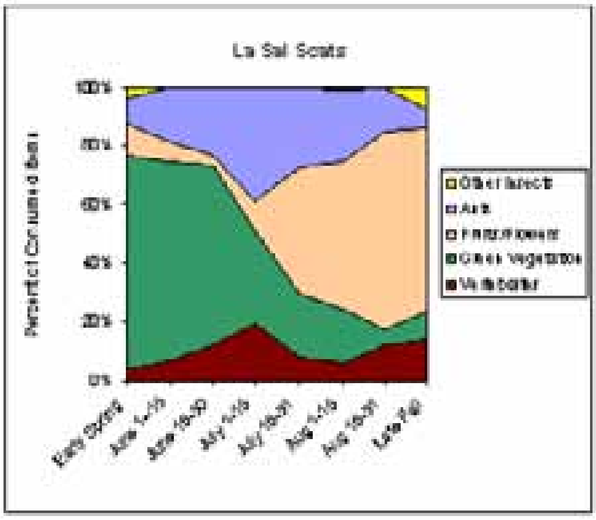

Figure 3. Food habit trends throughout the year in the La Sal Mountains based on percent of consumed items.

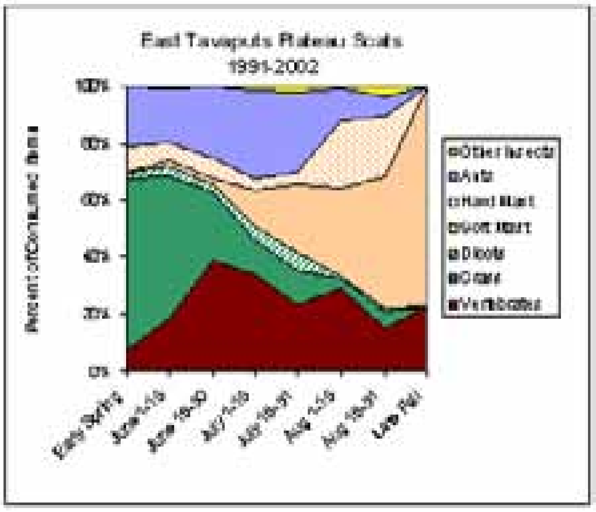

Figure 4. Food habit trends throughout the year in the East Tavaputs Plateau study based on percent consumed items.

spp.).

Consumption of fruits and flowers was largely limited to summer and fall. Aspen buds were the first flower to be consumed by bears and were found in 33.5% of spring scats. During summer and fall, chokecherry and serviceberry were the most commonly consumed fruits, found in 31.2% of summer scats. Two hard mast food items, pinenuts and acorns, were significant in fall when available occurring in 83.0% of fall scats.

Meat was most important in the La Sal study area during summer and late fall; mule deer being the primary food source. Domestic animals were consumed in low amounts. Cattle remains were generally accompanied by maggots, indicating that bears were scavenging carcasses.

East Tavaputs Plateau (Bunnell 2000).—The relative importance values of food types on the Plateau were green vegetation 51.1%, ants 12.9%, insects 0.3%, fruits and flowers 9.2% and meat 26.5% (Fig. 1).

Green vegetation, including grasses and dicots, occurred frequently in spring and summer scats. Green vegetation became decreasingly important throughout the year.

Ants were the second highest occurring food item in scats from the Plateau. Consumption of ants increased from spring to summer and then greatly decreased into late fall. They were commonly taken from under overturned rocks and dug-up thatch mounds (Chapter 9). The most common genus of ants consumed was *Formica*. Other insects were consumed in small quantities and in low frequencies.

Fruits and flowers became increasingly significant as they became available. Bear scats contained 10 genera of soft mast (*Prunus, Ribes, Juniperus, Mahonia, Amelanchier, Rhus, Peraphyllum, Populus, Cornus,* and *Symphoricarpos*) and 2 species of hard mast (*Pinus* and *Quercus*) in bear scats.

Meat was important throughout the year. Mule deer and elk (*Cervus elaphus*) made up 80% of the rGI of meat. The remaining grams ingested were divided equally among rodents, domestic livestock (bovids) and ursids. Little predation on domestic livestock occurred on the Plateau.

Diet corrected for differential digestibility and expressed as relative grams ingested (rGI) was notably different than the relative importance values indicated. Meat (58.2%) and ants (20.5%) became more important while green vegetation (7.4%), fruits and flowers (11.8%), and insects (1.8%) became less important.

Comparisons Between Studies.—The La Sal and Plateau areas show similar patterns of increase and decrease in specific food categories consumed (Fig. 3 and Fig. 4). Both areas show peak green vegetation consumption in early spring through the first weeks in June. In June green vegetation drops

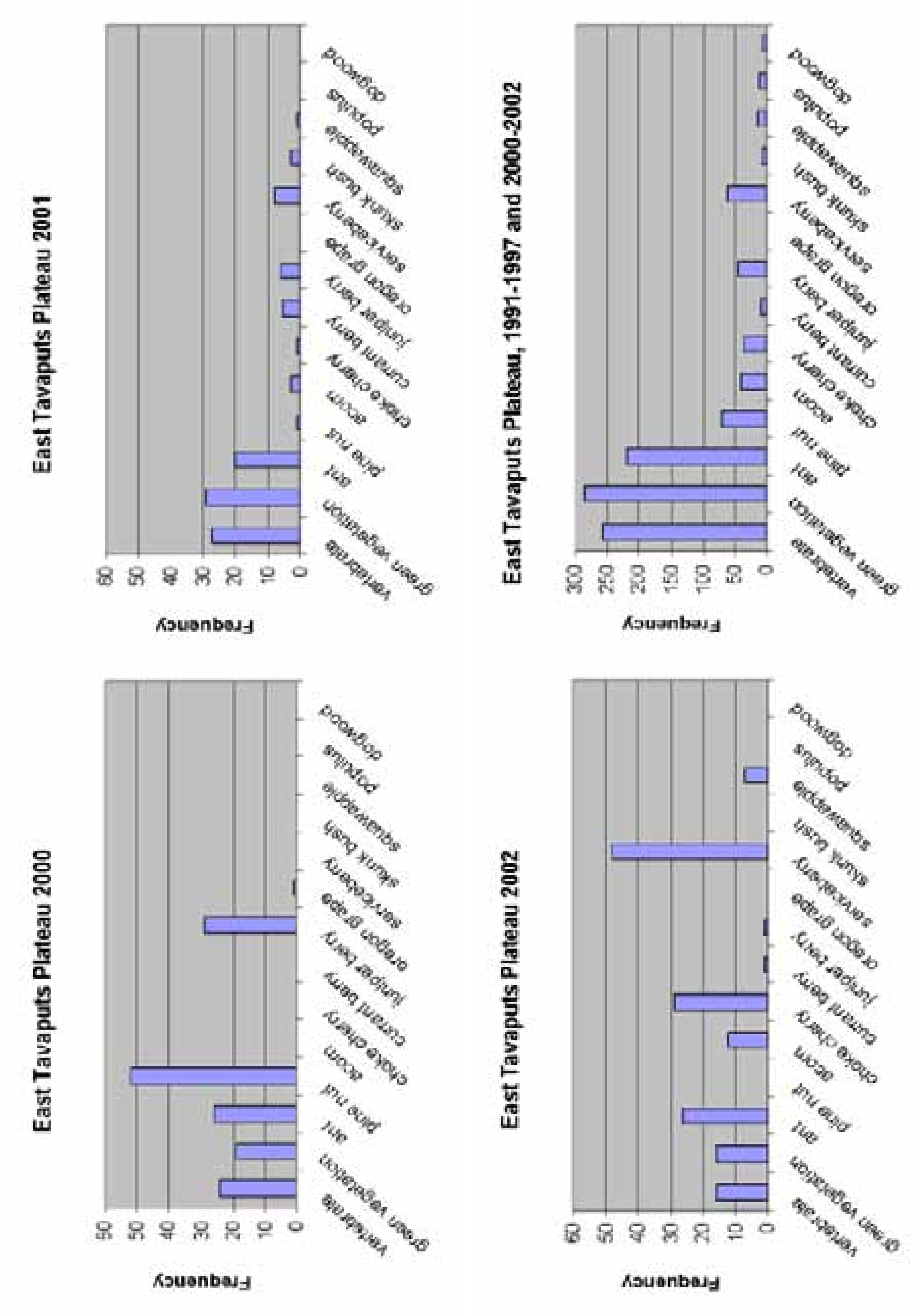

Figure 5. Freq

significantly, and fruits and flowers begin and flowers begin to be consumed. Both continue to be consumed in increasing amounts throughout the summer into the fall in both study areas. Ants are consumed throughout the year in both areas, but became less important in fall. Peak ant consumption occurs during the first few weeks of June in the La Sal Mountains and during the first weeks in July on the Plateau. Meat consumption peaks during the first weeks of July in the La Sal Mountains and during the last weeks of June on the Plateau. In both areas, meat consumption decreases into late summer and increases slightly in the fall.

The trends in consumption of green vegetation, ants, and fruits and flowers in Hobble Creek, as dictated by the relative percent volume in the scats, were similar to the other areas (Fig. 2, Fig. 3, and Fig. 4). However, the consumption pattern of meat in the Hobble Creek study area differed notably from the other two areas; meat was consumed in lowest frequency in summer but increased significantly into fall. The consumption of other insects in all areas was minimal.

Because of the multiple years of data collection on the Plateau, we compared the differences in food consumption between years (Fig. 5). Differences in the items consumed and percentages of items consumed occurred. Some years were marked by the near absence of fruits and flowers, while in other years, they represented the most significant food source. The year 2000 was dominated by extremely dry conditions and a late, severe freeze. This year was used as a model for food deficient years due to weather patterns.

The primary foods observed in scat in 2000 were pine nuts (n = 52), juniper berries (n = 29), ants (n = 26), vertebrates or meat (n = 24), and green vegetation (n = 19) (Fig. 5a). There was one occurrence of Oregon grape (*Mahonia repens*). This order of food item consumption is notably different from the totals of all years. Frequency of consumption on the Plateau over all years was dominated by green vegetation (n = 285), vertebrates or meat (n = 257), ants (n = 220), pine nuts (n = 70), serviceberry (n = 61), juniper (n = 45), acorn (n = 41), and chokecherry (n = 35) (Fig. 5d). The composition of scats in 2001 was similar to the that for all years (Fig. 5b). Scats found in 2002 were serviceberry (n = 48), chokecherry (n = 29), ants (n = 26), green vegetation (n = 16), vertebrates or meat (n = 16), acorn (n = 12), and squawapple (*Peraphyllum ramosissimum,* n = 7) (Fig. 5c).

Miscellaneous Observations.—Here we present interesting observations that provide further insight into foraging strategies of black bears. Once on the La Sal Mountains when retrieving a radio collar we found that the 2.5-year-old female had been killed, at least scavenged, by another bear. Over 30 bear scats were in the immediate vicinity of the carcass and a bear bed was nearby at the base of a large *Pinus ponderosa* (Black 1997).

Visiting the den of an adult female on the Plateau we found that she had scavenged a yearling cow elk, or perhaps commandeered it. The elk had puncture wounds and hemorrhaging in the ventral part of its neck that appeared to have been the result of a mountain lion attack. Regardless, she had dragged the carcass over 70 m to the den site where it was consumed by her and her 3 cubs except for the skin, skull and a few large bones, several of which were in the den proper.

Also on the Plateau, a 27-year-old male was found in his den with a medium-sized skull and antlers of a 4-point mule deer. Portions of the vertebral column and leg bones were in the den as well. We reasoned that the deer may have been scavenged or perhaps it had been wounded in the fall rifle hunt making it vulnerable to predation. This old bear did not have any canines capable of piercing flesh or delivering a swift, killing bite.

Two different bears, as indicated by the front pad widths, converged at the site of a sweet cecily (*Osmorhiza occidentalis*) patch where numerous individual plants were excavated and the roots eaten (Chapter 6) This plant belongs to the family Umbelliferae known to have medicinal value (Balick and Cox 1996). DeBruyn (1999) observed bears in Michigan eating the leaves of this plant in spring.

It is not without a little emotion when one finds cub claws in a bear scat. Of course, we cannot definitively say whether this was an example of infanticide, scavenging, or cannibalism. We did watch one day as a female abruptly followed its cub up a tree then turned head down at a large (presumably) male who didn't attempt to further pursue them. Without the female there, this cub would have probably ended up in scat also.

It seems that when bears find an abundant food resource that they just camp out in it (DeBruyn

1999). How else can one explain over 60,000 Oregon grape seeds in a scat pile (Auger et al. 2002) or 2.2 kg of ants in a young bear's stomach (Chapter 9), or a single scat containing slightly over 1500 juniper seeds?

In 2002, a fairly extensive summer range fire occurred in the Steer Ridge region of the Plateau. Long-time ranchers Bert and Christine DeLambert reported that bears "devoured" the burnt carcasses of domestic range cattle, elk and deer within days of the burn. One would have to conclude that the motivation for food was high as bears moved from unburned forest patches to feed in the barren openness of the burn. In contrast, bears in Idaho have been reported to avoid clear cuts when traveling and foraging (Beecham and Rohlman 1994).

DISCUSSION

Black bears rely on food resources which are variable within and between years due to extremes in weather typical at Utah latitudes (e.g., late spring freezes and high/low precipitation) and masting cycles of resource-accumulating plants such as oaks or pinyon pines. Opportunistic feeding behavior is especially reflected in the Plateau analysis.

Winter lethargy generally occurs between October and April, but during the remainder of the year, breeding in June and the search for food determines their behavior (DeBruyn 1999). We found in all three study areas that as bears left their dens, one of the first items they began to eat was green vegetation. In spring, more than 50% of the items consumed by bears were grasses and other green vegetation, including dicots. The consumption of green vegetation decreased in summer months. This is likely due to the drying of grasses and the availability of new food sources such as soft mast. Bears consumed relatively little green vegetation in the fall.

Bears ate ants throughout the year in all areas. Peak ant consumption correlated with the decrease in green vegetation consumption and the scarcity of fruits and flowers. On the Plateau ants were consumed more often in the early spring than in the other two areas, possibly due to drier conditions not favoring the grasses and lower altitudes causing the ants to be available sooner. Chapter 9 of this report and Auger et al. (2004) discuss bear foraging habits on ant colonies in detail. Bears commonly eat ants by finding colonies under rocks or by digging through thatch mounds. An analysis of a bear stomach revealed a brood (larval ants) to worker (adult) ratio of 7:1. Brood are completely digested by bears and never appear in scats (Bunnell 2000). This suggests that ants may play a much larger role in bear diet than suggested by scat analysis. Ant brood are relatively high in protein and fat content, and a stomach-full of ants with brood could provide over a third of a bear's daily caloric requirement (Auger et al. 2004). Bears consumed relatively few insects besides ants in all areas. Other insects consumed consisted of wasps, beetles and orthopterans.

Both the La Sal and East Tavaputs Plateau data show a peak in meat consumption at the end of June and the first part of July. We expected to find peaks at these times, which correlated to the parturition of deer fawns and elk calves. In contrast Hobble Creek showed a decrease in meat consumption during the summer months and an increase to >50% scat volume in the fall. An analysis of the meat consumed by Hobble Creek bears showed a high portion of porcupine and other rodents (Bates 1991).

Utah bears appear to be dependent on the consumption of soft and hard mast for reproduction. Our review of reproductive data shows that years of poor mast production correlate with low reproductive success (Chapter 3). Hard mast, consisting of acorns and pine nuts, is consumed in large quantities when available. Pine nuts follow a cycle of 2–5 years (Richardson 1991).

When available, bears consume large quantities of fleshy fruits such as serviceberry and chokecherry. Other fruits are not so readily consumed. Juniper berry crops are consistently produced in Utah, but are seemingly used as a food item of last resort in our study areas. However, researchers in New Mexico recently showed that juniper berries made up an important part of the diet of bears in that state (Costello et al. 2001). Snowberries (*Symphoricarpos oreophilus*) are also an abundant understory plant throughout bear habitat in Utah; nevertheless, we found little evidence that bears eat them.

Low productivity of common bear food plants as seen in 2000 cause notable changes in bear feeding habits. Figure 5a may be misleading in the amount of pine nuts consumed by bears. A fall crop of pine nuts were produced in 1999 and we are inclined to think the pine nut scats of 2000 were primarily, if not exclusively, scats that over-wintered. Juniper berries were the primary soft mast consumed in 2000; one scat containing Oregon grape seeds represented the only other soft mast found. The year 2000 accounted for more than half of the total frequency of juniper in scats (29/45) observed over ten years of scat collection. Juniper ingestion may serve as an indicator of poor conditions for black bear feeding on the Plateau study area.

MANAGEMENT IMPLICATIONS

Outside of the breeding season when large males do not eat much, black bears seem devoted to the business of growing and preparing fat stores for winter. From birth they are born to eat. And for the most part they seem to eat things that are immobile like grass, roots, ant brood, berries, ants, deer fawns and elk calves, and carrion.

This review of food habits of Utah's bears further demonstrates the opportunistic feeding strategies of this large omnivore. What is added to the knowledge of food habits of black bears? Could sweet cicely have medicinal value? Are seeds regionally important? Social insects (ants) may be a seasonal staple. Reproduction in 2000 was compromised and we documented a case of apparent starvation of an adult lactating female (Chapter 10). We also observed movements off the Plateau in search of food in lowland agricultural settings. The Plateau in spite of high diversity of bear foods (Tolman 1998) appeared inadequate in 2000 to sustain reproduction. We suspect that the fall hunting seasons for deer and elk (bow, muzzle-loader, and rifle) provide offal, wounded, and unretrieved dead cervids for pre-denning bears. This may be especially important for bears when soft and hard mast is rare. If environmental conditions reduce the local distribution and productivity of bear food plants on the Plateau, bear populations will undoubtedly decline.

Water resources for cattle in the form of man-made reservoirs and metal troughs are in use throughout most of the Plateau. They are filled during summer with water from small springs and stream which in some cases have to be physically altered to permit effective pumping into water-tracks. One cannot see trucks pumping, hauling and emptying water daily and not question what effects this might have on water tables and riparian plant productivity. Water consumption by companies drilling for oil and gas require large amounts of water and here again the meager water sources of the Plateau may be taxed. Disturbance from exploration activities may also exclude bears from high quality feeding sites (Chapter 2).

Are there any conditions under which supplemental feeding would be a management strategy for free ranging bears on the Plateau? Bear baiting is supplemental feeding. In Virginia feeding of bears by hunters is believed to have substantially enhanced bear productivity and population density (Gray et al. 2004)

These findings show the basic patterns of food consumption of bears in Utah. They also show the changes in bear diet that might occur between years. Management agencies should be aware of the adverse consequences that weather may have on bear feeding habits and reproductive success. Years of difficult dietary conditions should be followed by a decrease in permits issued.

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ANT COLONIES UNDER ROCKS AS A FOOD SOURCE FOR BLACK BEARS (*URSUS AMERICANUS*)

MARC A. SEID AND HAL L. BLACK

Abstract.—Ants play an important role in the diet of the American black bear (*Ursus americanus*) as evidenced by the large quantities of adult ants found in their scat. However, ant brood (eggs, larvae, pupae) are rarely detected in scat. On the East Tavaputs Plateau in Utah ant colonies located under rocks were sampled to determine the ratio of adults to brood. Four thousand, six hundred sixty-six rocks were turned with 522 ant colonies found (11.2%). Brood to adult ratios were as high as 600:1 ($\bar{x}$ = 2:1). Thus, scat analysis probably underestimates the importance of brood in the diet of black bears who turn rocks looking for ants and other prey. Discriminant function analysis was able to predict the presence or absence of ants under rocks 68% of the time. Large rocks (over 2500 cm2 in surface area) were more likely to house ant colonies than smaller ones. Fourteen genera were found to nest under rocks. The most common were *Formica*, *Myrmica*, *Tapinoma* and *Camponotus*. Bears may select *Formica* and *Camponotus* for their large size and high brood to adult ratio.

Relatively few studies have attempted to identify rock properties selected by animals for protection and/or nest sites. Huey et al. (1989) showed how the thermal properties of rocks affect selection of retreat sites by garter snakes. Schlisinger and Shine (1994) demonstrated the effect of rock collectors on rock selection by saxicolous lizards. Hadley (1970) investigated rock selection by arthropods. Several researchers have studied rock ecology on ant nests (Billick 2001, Fernandez-Escudero and Tinaut 1999, Ignacio et al. 1993, Larmuth 1978, Dean and Turner 1991, Cloudsley-Thompson 1956, Steiner 1928, Tinaut et al. 1999). The undersides of rocks are regularly used by ants as colony sites (Seeley and Heinrich 1981, Hölldobler and Wilson 1990, Tinaut et al. 1999, Wilson 1971). The thermodynamic and physical properties (heat absorption, heat retention, moisture retention, moisture collection, physical barrier) of rocks create an ideal micro-habitat for nests (Cloudsley-Thompson 1956, Dean and Turner 1991, Ignacio at el. 1993, Steiner 1928). Thus the uppermost chambers of many nests are often found under rocks (Steiner 1928). Also, rocks provide protection against most vertebrate predators (Dean and Turner 1991), and along with their thermodynamic advantages, ants will often tend brood under them.

An examination of bear scat often yields thousands of intact adult ants, while brood (eggs, larvae, and pupae) are rarely evident or detected only with difficulty. Most studies of bears foraging on ants have relied heavily on scat analysis and undoubtedly underestimate the number of brood eaten (Boileau et al. 1994, Hatler 1972, Auger et al. 2004). Although many studies have addressed the importance of ants in the diet of bears (Bigelow 1922, Boileau et al. 1994, Garshelis and Pelton 1980, Hellgren et al. 1989, Johnson 1996, Mattson 2001, Noyce et al. 1997, Raine and Kansas 1989, Swenson et al. 1999), only a few have addressed ant brood as a significant food source (Bigelow 1922, Auger et al. 2004). Auger et al. (2004) and Bigelow (1922) reported large numbers of brood in the diet of bears. Auger et al. (2004) obtained a sample containing a conservative estimate of 3 brood to 1 adult, while Bigelow (1922) reported "quarts" of ant brood found in the stomachs of bears. Further evidence of the importance of brood was obtained from the stomach of a bear shot on the East Tavaputs Plateau (Plateau) in 1992. The stomach contents weighed 2.1 kg and contained 62,540 individual ants (7,840 adult, 54,700 brood) with a brood-to-adult ratio of 7:1.

Ant nests found in logs, stumps, soil and under rocks represent a concentrated food source that black bears are well adapted to exploit given their size, strength, mobility, and olfactory and visual capabilities. Bears are one of the few large carnivorous mammals that routinely eat ants and may be the only large mammal that turns rocks as a foraging strategy. It seems reasonable to assume that turning rocks might, on average, require less energy than excavation of logs, stumps, or soil. Additionally, the nutritional reward of eating ants and ant brood under rocks may also be higher, because brood are often aggregated on the rock surface where there is little non-food debris (rather than inside thatch mounds or under bark or litter), brood have no defensive mechanisms, and their nutritional value and digestibility are greater than adults. Therefore, it seems relevant to our understanding of the feeding ecology of black bears to determine the availability of ant brood found under rocks.

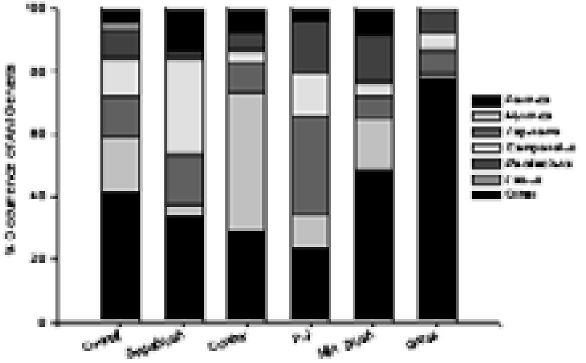

Figure 1. Ant composition in 5 habitats. *Formica* is at the bottoms of the bars and *Other* at the tops.

METHODS

Samples were collected at four different times during June and July 1994 (Jun 5–9, Jun 18–23, Jul 8–12, and Jul 24–28). Six habitat types were sampled during each collection period. New areas within each habitat type were selected for each sampling period. Each habitat was sampled using belt transects 100 m by 2 m. Two transects were sampled in each habitat, one from 9:00 am–12:00 pm. and the other from 5:00–8:00 pm. Midday samples were not taken because bears are less active then and most ants carry brood deep into the nest to avoid high temperatures (M. Seid, unpublished data). Date, air temperature, ground temperature, cloud conditions, precipitation, wind, elevation, slope, and exposure were noted for each transect. All rocks whose centers were within the transect and whose dorsal surface areas were over 25 cm2 were turned. Rocks too large to be turned were recorded. Rocks were classified into 9 categories by the combination of surface area (3 levels: A is 25 cm^2 to 625 cm^2; B is 626 cm^2 to 2,500 cm^2; and C is >2,500 cm^2) and thickness (3 levels: 1 is 0.0 cm to 6.0 cm, 2 is >6.1 cm to 12 cm and 3 is >12 cm). For every rock depth in soil and shading were noted, and adult ants and brood (if present) were collected with small battery-powered, hand-held vacuum cleaners. Samples were stored individually in zip-lock freezer bags and frozen before sorting.

For each sample total weight, ant weight, debris weight, and other animals present were recorded. Ants were separated into adult workers (majors, minors), alates (female and males) and brood (eggs, larva, cocoons). Each group was counted and weighed separately. After sorting, ants were stored in 95% ethanol and later identified to genus (Allred 1982).

Discriminant function analysis (Manly 1994) was used to determine the possible factors involved in rock selection by ants. Fifteen variables were used to describe each rock in the analysis; rock classification, depth of rock in soil, shade on rock, habitat, period sampled, time of day (mornings or evenings), light meter reading, air temperature,

Table 1. Number of rocks in each classification type and habitat on the East Tavaputs Plateau, UT, June–July 1994.

Habitat	A1	A2	A3	B1	B2	B3	C1	C2	C3	Total
Sagebrush	425	89	13	72	106	47	8	11	31	802
Conifer	444	72	7	137	134	35	6	16	14	865
Pinyon/Juniper	735	72	15	170	198	77	11	26	42	1344
Mtn. Brush	470	74	14	105	111	28	6	10	9	837
Grass	443	83	4	85	124	42	6	12	18	817
Total	2518	390	53	569	673	239	37	75	112	4666

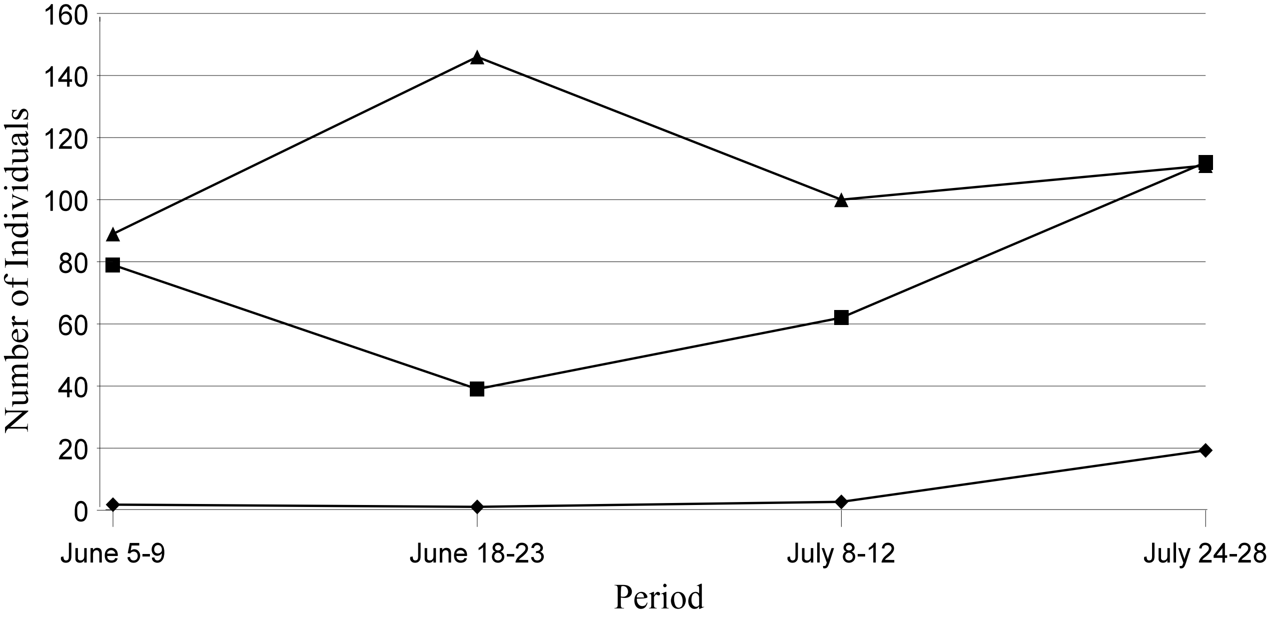

Figure 2. Mean number of workers (▲), brood (■), and alates (◆) collected under rocks during sampling periods on the East Tavaputs Plateau, UT, June–July 1994.

ground temperature, elevation, exposure, slope, current weather condition, wind speed, and most recent rain.

RESULTS

Four thousand, six hundred and sixty-six rocks were turned and assigned a rock classification. Ant nests were found under 522 (11.2%) rocks and brood was found under 198 (6.4%) of the rocks. Of the 522 nests found, only 434 samples were collected because some nests only had one or a few ants present, and these were able to escape collection.

Fourteen genera (*Formica*, *Camponotus*, *Paratrechina*, *Lasius*, *Aphaenogaster*, *Tapinoma*, *Myrmica*, *Leptothorax*, *Pheidole*, *Messor*, *Solenopsis*, *Polyergus*, *Tetramorium*, *Acanthomyops*) representing three subfamilies (*Formicinae*, *Myrmicinae*, *Dolichoderinae*) were collected. The most abundant were *Formica*, *Myrmica*, *Tapinoma*, and *Camponotus* (Fig. 1). *Formica* was most abundant in sagebrush, mountain brush, and grass habitats; *Myrmica* was most common in conifer; and *Tapinoma* was abundant in pinyon-juniper (Fig. 1).

Small rocks designated A1 were the most common, while C1 rocks, having the largest surface area associated with the thinnest thickness class, were the least common (Table 1). B2 rocks were the second-most commonly sampled, followed by B1 rocks. Juniper habitats had the largest number of rocks while aspen habitats had the least (Table 1). Because aspen habitats in the study areas are

Table 2. Mean count of rocks by habitat on te East Tavaputs Plateau, UT, June–July 1994.

Habitat	Mean count of rocks (SD)
Sagebrush	200.5 (94.9)
Conifer	216.3 (109.9)
Pinyon/Juniper	336.3 (223.8)
Mountain Brush	209.3 (91.8)
Grass	204.3 (127.1)
Mean	235.1

Table 3. Mean number of workers and brood by genus and ratios of brood to workers on the East Tavaputs Plateau, UT, June–July 1994.

Genus	Count of nests	Mean count of workers (SD)	Mean count of brood (SD)	Brood per
Tapinoma	48	116.8 (118.9)	298.1 (416.2)	2.6
Camponotus	49	25.2 (21.2)	51.7 (53.5)	2.1
Formica	160	73.6 (103.6)	108.1 (283.5)	1.5
Paratrechina	35	100.0 (175.1)	73.8 (115.3)	0.7
Lasius	9	73.4 (71.2)	233.7 (553.4)	3.0
Leptothorax	4	41.3 (25.1)	86.8 (107.4)	2.1
Solenopsis	4	167.0 (167.2)	456.5 (391.1)	2.7
Myrmica	70	56.9 (103.9)	70.5 (78.1)	1.2

distributed in relatively small stands with heavy ground cover and deep soil, rocks were difficult to find there. This habitat was not further analyzed. Aspen stands, however, do contain numerous ant colonies (Auger et al. 2004). A mean of 235 rocks was found per area sampled , with a high mean of 336.25 (S.D. = 223.76) rocks for juniper habitats and a low mean of 200.5 (S.D. = 94.86) rocks for sagebrush areas. No significant differences for number of rocks were found between habitats (F = 0.699, P = 0.643) (Table 2).

Brood numbers peaked in mid-June and leveled off in July (Fig. 2). Worker numbers were lowest in mid-June and peaked as brood numbers fell. The brood to adult ratio under rocks averaged only 1.5:1; however, this is because we sampled during the ants' summer reproductive season. The brood to adult ratio went from a low average of 1:1 to a high of 3.6:1. Brood to adult ratios were as high as 600:1. By late July worker numbers became stable and alates had increased tenfold from the beginning of June.

Lasius had the largest average brood to adult ratio of 3.03:1, while *Paratrechina* had the lowest, 0.74:1 (Table 3). Although *Paratrechina* had the lowest brood to adult ratio, more alates were found in their nests than in any other genus. Formica had the greatest number of brood with 17,181 individuals. Camponotus was the largest ant.

One hundred and forty nests were found under A1 rocks (Fig. 3) and the fewest nests were found under A3 type. Although the greatest number of nests were found under A1 rocks, only 5.6% of A1 rocks had nests. The highest percentage of nests were found under C1 rocks (35%), although only 13 nests were located under this size category (Fig. 4). As the rock's surface area increased a higher percentage of the rocks had ant nests under them. Surface area C-rocks had 25.9%, surface-area B-rocks had 17.1% and surface-area A-rocks had 7.1%. Ants on average selected larger rocks for nests (Kruskal-Wallis, chi-square = 187.8, df = 1, $P < 0.001$).

Although sagebrush habitats contained the fewest rocks, they had the greatest number of nests, followed by mountain brush, grass, pinyon/juniper, and conifer, respectively (Fig. 5). Sagebrush habitats had an average of 37.8 (S.D. 6.65) ant nests per transect, while a low of nine ant nests per transects was found in conifer areas. For percentage of nests per number of rocks, again sagebrush had the highest percentage with 18.8% of the rocks having nests, while pinyon/juniper had the smallest percentage, 6.7% (Table 4).

Table 4. Mean number of nests per habitat and percentage of nests to number of rocks in each habitat.

Habitat	Mean count of nests (SD)	% Ant nests per rocks
Sagebrush	37.8 (6.7)	18.8
Conifer	19.8 (6.4)	9.1
Pinyon/Juniper	22.5 (6.7)	6.7
Mountain brush	29.3 (4.5)	13.4
Grass	24.0 (12.2)	11.8

Table 5. Predictions made by discriminant function analysis of rocks with nest to rocks without nests. Predictions made by discriminant function analysis of rocks with brood to rocks without brood.

			Prediction	
Analysis	Category	Observed	Correctly classified	Incorrectly classified
Discriminant Function 1	Rocks w/o nests	4144	2900 (70%)	1244 (30%)
	Rocks w/ nests	522	347 (66%)	175 (34%)
	Totals	4666	3247 (70%)	1419 (30%)
Discriminant Function 2	Rocks w/o brood	4368	2977 (68%)	1391 (32%)
	Rocks w/ brood	298	207 (69%)	91 (31%)
	Totals	4666	3184 (68%)	1482 (32%)

The discriminant function analysis yielded a 31.77% error rate for distinguishing rocks without nests to rocks with nests (Table 5). A similar error rate of 31.29% was found when comparing rocks without to rocks with brood (Table 5).

DISCUSSION

Selection of Rocks.—In this study, large rocks were selected over smaller ones as nest sites by ants. Nesting under larger rocks may be a thermal/predation trade-off for ants. Large rocks provide increased protection from predators and a diversity of thermal gradients. Rocks provide protection from daily temperature extremes, they enhance humidity, and provide greater warmth in cold weather. However, rock size can greatly influence how these properties are distributed (Dean and Turner 1991, Seeley and Heinrich 1981) and large rocks with a larger thermal capacity will reduce thermal fluctuations in the soil beneath them, but they do not heat up as quickly as small rocks at low temperatures (Dean and Turner 1991, Ignacio et al. 1993). Thus, small rocks may have a thermal advantage at high elevations (Ignacio et al. 1993). Although large rocks take longer to heat up, which may be disadvantageous for brood development at high elevations, they provide protection from predators (Dean and Turner 1991). However, large rocks have greater heat sink capacities and may dampen the extreme temperatures of the day (Dean and Turner 1991, Seeley and Heinrich 1981). Therefore, ants which nest under large rocks could tend brood under large rocks during midday and thus protect brood from predation. Although the percentage of nests increases from A-class to C-class rocks, the proportion of C-class rocks with nests having brood declines (Fig. 4). Since our intent was to sample at times when bears were most likely to be active, that is morning and evening hours (Beecham and Rohlman 1994), we may have missed the time when brood was tended under larger rocks.

Still bears do move large rocks when foraging for ants, but rather than turning them, they usually displace them to one side or partially lift and drop them (pers. obs.). Thus, colonies under large rocks tend be only partly exposed to foraging bears and the unexposed sections under large rocks offer a refuge. Ants nesting under large rocks may only be vulnerable to large adult bears. Dean and Turner (1991) found that ants preferred nesting under large rocks where aardvark predation was heavy. Ignacio et al. (1993) found that ants preferred small rocks, presumably for their thermal advantages. In Igancio's (1993) study site, however, there were no large myrmecophagous mammals. Therefore the selection of large rocks in our study area may indeed be a predation/thermal trade-off for the maturation of brood.

Habitat Selection by Ants.—Although different habitats had roughly the same number and classification of rocks each had a different assemblage of ant genera. Conifer had the fewest

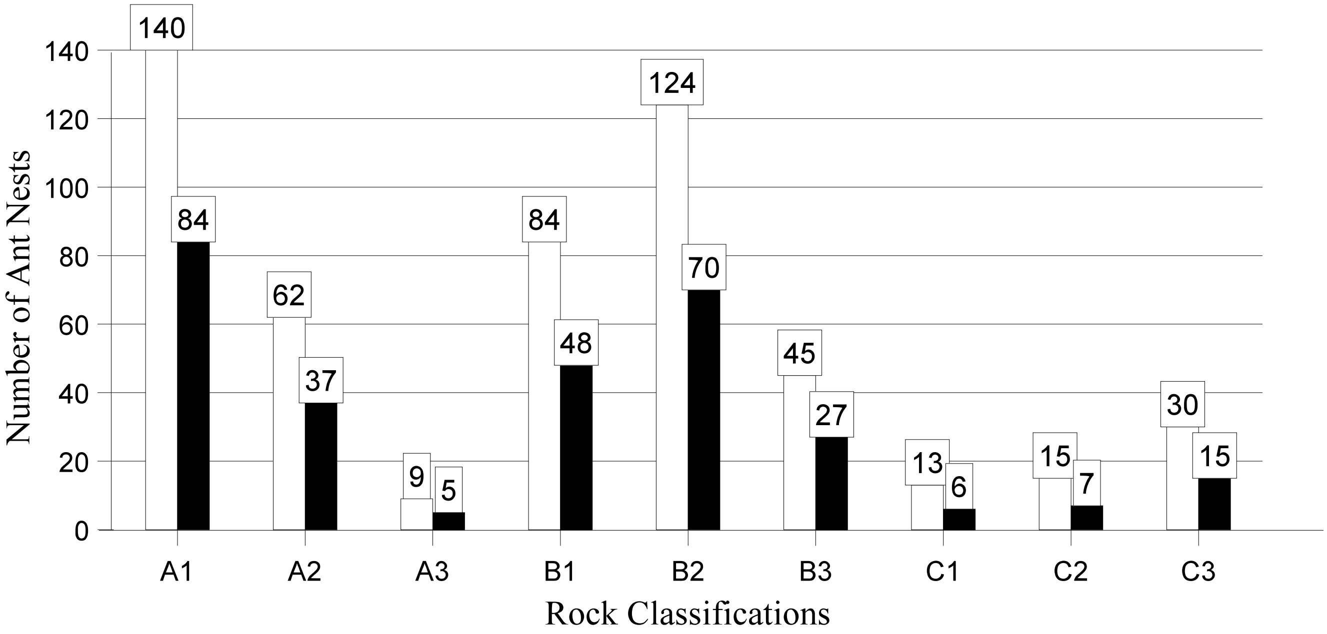

Figure 3. Number of nests found under each rock classification type on the East Tavaputs Plateau, UT, June–July 1994. White bars represent number of ant nests. Grey bars represent number of ant nests with brood.

ant nests and of the nests found, *Myrmica* occurred most frequently. The relatively closed canopy of conifer stands probably reduces the thermal advantages and physical protection rocks offer. *Myrmica* may produce brood at lower temperatures than other genera.

Pinyon/juniper habitats had the second lowest number of nests. *Tapinoma* nests were most frequent followed closely by *Formica*. The open canopy of pinyon/juniper woodland is associated with xeric soil and high ground temperatures, therefore ant numbers may be reduced. Grass habitats had slightly more nests under rocks than pinyon/juniper. *Formica* was by far the most abundant ant in grass habitats (Fig. 1).

Mountain brush habitats had the second highest abundance of nests and also had *Formica* as the dominant genus. Perhaps the diversity of plants and micro-habitats created by the varying sizes of brush plants contributed to this larger number. Mountain brush habitats also have a mixture of open and closed canopies. Therefore rocks receive a mix of shade and sun throughout the day which may increase thermal diversity for brood development.

Sagebrush areas had more ant nests than any other habitat with *Formica* and *Camponotus* most abundant. Both genera are common in bear scat (Auger et al. 2004, Onoyama 1988). Like mountain brush, sagebrush habitats might offer thermal advantages by giving rocks sun mixed with shade throughout the day. Seventy-eight percent of all the *Camponotus* nests were observed in this habitat. *Camponotus* have secondarily lost the ability to produce phenylacetic acid, a compound used to retard fungal and bacterial growth (Hölldobler and Wilson 1990). Sagebrush areas tend to be dry and might limit fungal and bacterial growth or perhaps sagebrush itself has chemicals that inhibit fungal and bacterial growth, thus making these areas favorable for Camponotus. *Formica* was the most abundant genus observed in this study and it has been identified as an important genus in the diet of bears (Auger et al. 2004). Sagebrush, mountain brush and grass habitats all contain *Formica* in abundance and are undoubtedly important habitats for bears.

Discriminant Function Analysis.—Although our analysis had an error rate of over 31% for both

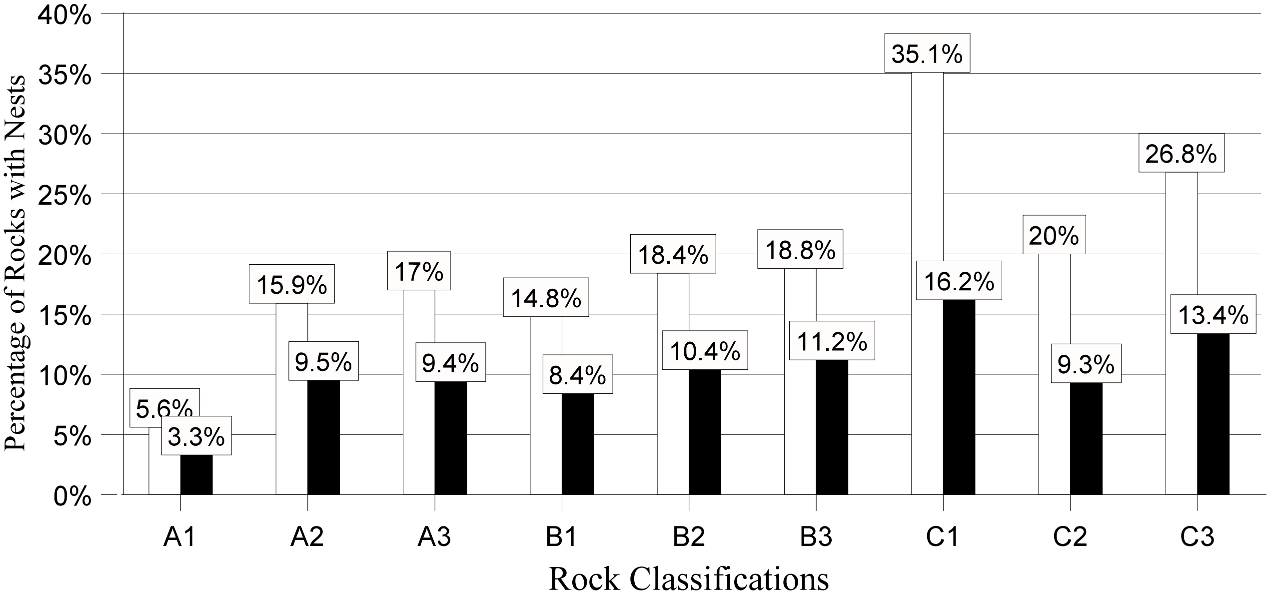

Figure 4. Percentage of nests found under each rock classification type according to the number of rocks sampled in East Tavaputs Plateau, UT, June–July 1994. White bars represent percent of ant nests. Grey bars represent percent of ant nests with brood.

ant nests and ant nests with brood, it significantly improved the location rate of ant nests over randomly selecting rocks. It misclassified 175 rocks that had ants under them as rocks without ants, while misclassifying 1244 rocks without ants under them as rocks with ants. If a bear discriminated among rocks using the variables included in this analysis, it would find ants under 22% of the rocks turned (total number of rocks the analysis predicted having nests (1,591) divided by the actual number of rocks with nests (347). That success rate is nearly double the location rate we observed in our sampling (11.2%). Of 4,666 total rocks sampled, our analysis would have eliminated 2,900 rocks. Likewise we found similar results for ant nests with brood. The analysis misclassified 1,282 rocks without ants with brood, as rocks having ants with brood and 99 rocks with ants and brood as not having either. Again the analysis doubled our location rate to 13.4% (we observed 6.4% of the ant nests to have brood in our random sample of rocks). With the help of olfaction, sight, and experience, bears could match, if not improve on, the success rate obtained with our analysis.

The reason for misclassifying 1,244 rocks as having ant nests, when observation demonstrated ant nests were absent can be explained as follows: first, intraspecific and interspecific competition may have dictated that rocks suitable for ant nests be avoided or abandoned. Thurber et al. (1993) found that mortality of *Paraponera clavata* nests was due to close proximity to other nests of this species. Thus, historical events could effect nest location. Since the environment can support only a certain number of ants, many suitable rocks would remain unoccupied. Competition from other organisms seeking similar microclimate conditions could also have prevented colonization of 'good' rocks by ants (Hadley 1970, Huey et al. 1989, Nobel et al. 1992, Schlisinger and Shine 1994).

Our analysis misclassified 175 rocks as not harboring ants when they actually did. This might be explained by the relatively rough measurements used in our description of rocks. Rock aspect, slope position, and elevation were given common values for rather large areas that may have been somewhat heterogeneous. Also, intraspecific and interspecific variation in selection for micro-habitats could have caused increased variability in the type of rocks selected. When dealing with 14 genera (numerous species), it is likely that the variation for selection of micro-habitats are diverse enough between species

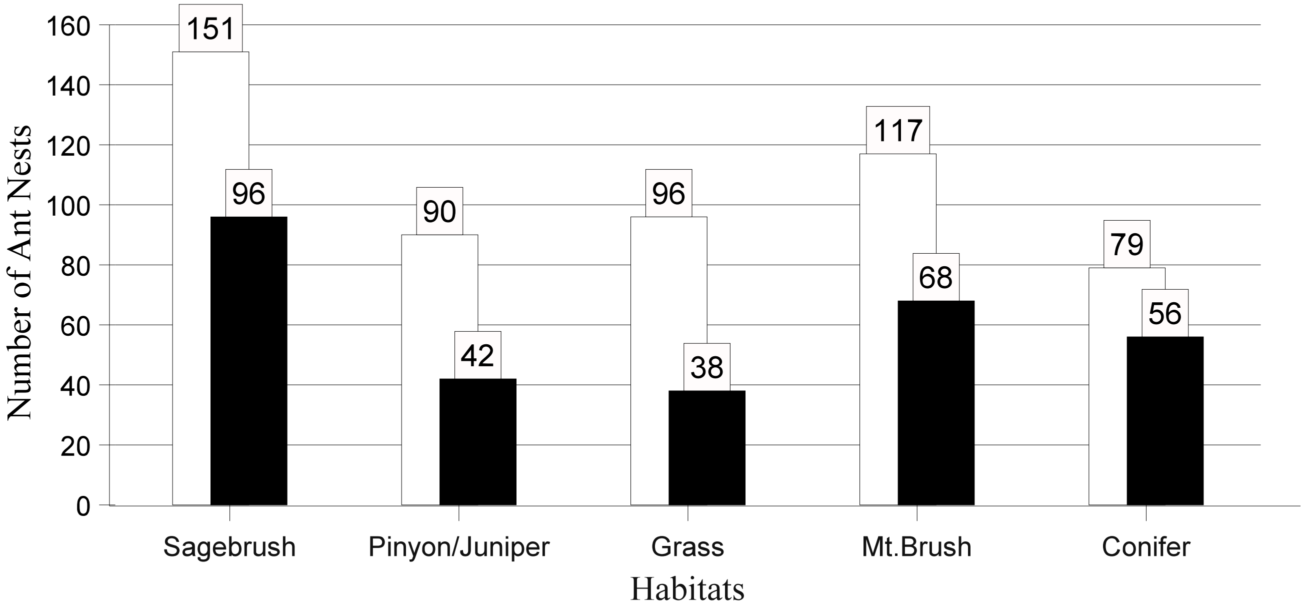

Figure 5. Number of nests found in each habitat beneath rocks on the East Tavaputs Plateau, UT, June–July 1994. White bars represent number of ant nests. Grey bars represent ant nests with brood.

to cause differences in rock selection. Another possibility is that some of the rocks which had ants under them, misclassified as not having them, were colonized because ants were forced to nest under rocks that were less than ideal. Variations in the life stages and size of a colony could affect microclimate conditions required and rocks selected.

Predation and Rock Selection by Ants.—Some have observed that ants in the subfamily Formicinae are fed upon by bears more frequently than other ants (Auger et al. 2004, Noyce et al. 1997). Although Formicinae lack a functional stinger, this alone is an unlikely explanation for bears' preference for this subfamily, because bears are known to readily attack Apidae (bee) and Vespidae (wasp) nests (Bigelow 1922, Jeanne 1982). Redford (1987) has also found that many vertebrate predators are not completely deterred by ant stings and many genera of Myrmicinae also have functional stingers (Buschinger and Maschwitz 1984, Kugler 1979).

Our data suggest that bears select Formicinae when foraging under rocks, possibly because of brood numbers. Brood is more digestible than adults and may be selected because of their lower percentage of ash and absence of defensive structures (Auger et al. 2004, Redford and Dorea 1984, Redford 1987). Therefore consumption of large of number of broods, which are often not identifiable in scat analysis, may be under-represented in many studies. In this study some of the greatest brood to adult ratios were found in formicine genera, *Lasius*, *Formica* and *Camponotus*. Although 2 genera that are not formicines, *Tapinoma* and *Solenopsis*, also had large brood to adult ratios, their small size may select against their use as a food store for large predators. Likewise, *Formica* and *Camponotus* are relatively large; thus, large brood may be selected for not only because they are more conspicuous, but also due to the larger energetic payoff. Also the sheer abundance of *Formica* nests that average over 100 pupae and/or larvae per nest may make it a favored food source.

On the lower end of the brood to adult ratio were Myrmicine ants, *Myrmica* with ratios of 1.2:1. Myrmicines tend to have more heavily armored exoskeletons often adorned with spines and hooks (Wheeler, 1910). These defenses may make them less attractive to vertebrate predators who might prefer the less armored formicines with high brood to adult ratios (Buschinger and Maschwitz 1984, Hunt 1983).

Are Bears Ant Specialists?—Stirling and Derocher (1989) and Auger et al. (2004) both suggest that black bears may be facultatively myrmecophagous. When bears are feeding on ants in early to midsummer, grasses have lost much of their nutritional value, and hard and soft mass is still unavailable. It may be that bears in our study area are have an 'ant season' similar to that suggested by Raine and Kansas (1989). Redford (1987) found that the abundance and diversity of social insects seems to dictate the number of predators that feed and specialize on them. Because ants in temperate regions are seasonally abundant and diverse, seasonal specialist are likely to evolve. Likewise, because black bears are not sympatric with other terrestrial myrmecophagous specialists (Stirling and Derocher 1990), they appear to fill this myrmecophagous niche. Furthermore, brood and alate abundance in tropical regions are known to dictate the frequency and duration in which specialists feed (Redford 1987) on colonies, thus it is not surprising that in temperate regions, the importance of ants in the diet of black bears coincides with brood and alate abundance.

CONCLUSIONS

Although discriminant function analysis still had an error rate of over 31%, it predicted which rocks would harbor ant nests with greater success than would result from randomly turning rocks. It is likely that bears use many of the same variables we measured and with the help of olfaction, sight, and experience, at least match, and probably exceed our analytical attempt at selecting "ant" rocks.

Black bears are known to use their front paws to manipulate objects and are adept at turning rocks (Bacon 1976). The underside of rocks provides a unique foraging substrate for bears, since they are one of the few large mammals that turn rocks as a foraging technique. The peak brood production seems to correlate well with the peak of ants in scat in our study with about 70%–80% of the bear scats collected during brood season containing ants. By feeding on ants when brood is abundant, bears take advantage of high brood numbers and low worker numbers.

Turning rocks is likely an efficient way for bears to obtain a significant meal. The stomach of the bear shot on the Plateau which had the brood to adult ratio of 7:1 was obtained from a relatively young male bear (age = 2.5 years). We found no evidence of digestion in the upper small intestine and suspect that this bear, who was shot at 8:00 pm in early July, took no more than one to two hours to fill his stomach. Auger et al. (2004) estimated that the meal represented 695 calories or 37% of the bear's daily requirement. Whether he collected ants under rocks, from logs, in thatch mounds, or in soil nests is not known, but rocks would be a likely source given the brood to adult ratio. Regardless of the foraging site(s), this sample clearly shows how quickly a bear can obtain a meal of ants.

Although rocks provide significant advantages and protect ants against physical and biological hazards, they are limited in their capacity to protect ants from bears. Turning rocks for ants increases the bear's harvest of brood. Black bears partially fill an underexploited myrmecophagous niche in North America. Myrmecophagy may have made black bears more successful by allowing them to fill their diet requirements during seasons when other food is scarce.

MANAGEMENT IMPLICATIONS

If black bears don't climb trees, they don't do anything at all. Evolution has shaped the claws (strongly curved) and stout forearms to permit rapid climbing of trees (Stirling and Derocher 1989, Herrero 2002). Arboreal behavior permits access to foods and escape from predators. But in North America, the variety of ants black bears eat are largely terrestrial, and, at least in some regions, ant diversity and colony density is not necessarily associated with forested habitats (Auger et al. 2004). Foraging under rocks is a strategy commonly employed and some forest types have low densities of rocks suitable for ant colonies (Auger et al. 2004, Noyce et al. 1997). In this study area it was initially a surprise to find that open grassland and shrub habitats provided substantial foraging substrate for bears (Chapter 6). Habitat manipulation that reduces tree canopy cover permitting great light penetration that allows heating of rocks (incubation sites for ants) might enhance foraging efficiency of bears. Manipulations that alter brushy habitats (heavy duty harrowing or prescribed burns) probably destroy numerous ant colonies especially above-ground thatch nests of the genus *Formica*. On the Plateau, black bears seem to rely rather heavily on food resources not related to trees, with the exception of the erratic production of pine nuts by pinyon (*Pinus* spp.). The spotty distribution and small stands of aspen are probably relatively unimportant and the Douglas-fir communities do not harbor a high diversity of ant taxa or colonies (Auger et al. 2004). Therefore, habitat alterations that reduce ant productivity need to be addressed as a potential impact on bear populations. A suite of foraging adaptations in addition to those for climbing trees suggest the importance of ants in bear diets—namely forelimbs for ripping log stumps and trees and excavating ground nests of social insects, dynamic long tongues, and acute sense of smell.

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MATERNAL INVESTMENT IN RELATION TO AGE IN UTAH BLACK BEARS

JOSHUA D. HEWARD AND HAL L. BLACK

Williams (1966) proposed a model where costs of reproduction varied with residual reproductive value (RRV), which is defined as the total reproductive value minus the immediate reproductive consequences. The basic idea is that the fewer reproductive opportunities an individual has remaining, the greater the costs it should be willing to incur for reproduction. The balance of diminishing returns for reproductive effort should shift towards greater effort with increased age. Conversely, young animals should spend less effort (risk less) if future reproduction is possible. There have been proposed models that build on Williams's hypothesis and take into account various confounding variables (Gadgil and Bossert 1970, Schaffer 1974, Pianka and Parker 1975, Curio 1988). An inverse relationship between reproductive effort and decreased parental survival has been documented for various taxa (Boyd et al. 1995, Jacobsen et al. 1995, Thomas et al. 2000). Parental effort has been shown to have a positive relationship with offspring survival (Sinervo and DeNardo 1996). The trade-off between current reproductive effort and future health and reproductive opportunities has also been documented (Schwarzkopf 1993, Sand 1998, Ruusila et al. 2000, Weimerskirch et al. 2000). The prediction from Williams's model (1966) that parental effort should increase with age has been substantiated in some cases (Tinkle and Hadley 1973, Tinkle and Hadley 1975, Pianka and Parker 1975, Pugesk 1981, Pugesk and Diem 1983) and may result in increased reproductive success with age (Luiselli et al. 1996). However, it should be noted that not all species follow the predicted pattern (Tinkle and Hadley 1975, Wheelwright 1991, Clutton-Brock 1991, Ratcliffe and Furniss 1999) and that alternative hypotheses for variants exist (Fagen 1972, Begon and Parker 1986, Mongomerie and Weatherhead 1988).

Requirements for testing Williams's hypothesis include a species with seasonal reproduction, measurable reproductive effort, mortality rates, and changes in fecundity (Williams 1966). These requirements are met by black bears (*Ursus americanus*), for which data already exists on mortality rates and fecundity (Chapter 1, Chapter 3). In addition, there is observable variation in the behavioral response of females with cubs to perceived threats and that response has been reported to increase over time (Pelton 2000). We used behavioral observations of mothers acquired while monitoring cub survival to determine whether or not female black bears modify their behavior with respect to age in the presence of a perceived threat. In Utah it is illegal to kill female bears if they are accompanied by cubs. Given that cub mortality on the Plateau is 59% (Chapter 3), the timing of cub mortality could have a direct impact on the number of female bears harvested. We attempted to approximate the timing of cub mortality in the year 2000 through direct observations of radio-collared females approached on foot. This approach was chosen over other methods of monitoring cub survival with all their attendant problems (LeCount 1987, Elowe and Dodge 1989, Echols et al. 2004).

METHODS

Dens of female bears were visited during January and March of 2000 to determine presence or absence of cubs and in the summer they were located weekly from a fixed wing aircraft. Weekly ground approaches using radio-telemetry were made to visually inspect females with cubs. A single individual (occasionally two), dressed in camouflage, quietly approached bears in full camouflage to determine the presence or absence of cubs and record the response of the bears to humans. Scats and behavioral observations of foraging strategies were collected opportunistically.

Bear responses to human intrusions were classified into four categories: (1) intrusion unnoticed (the bears were apparently unaware of the stalker), (2) female and cubs fled (the female and cubs ran/walked away from the stalker but their presence was confirmed by tracks or visual sighting), (3) female only fled (leaving cubs in a tree), and (4) female remained with cubs (the cubs were in a tree and the female was either on the ground near the tree or treed with the cubs). The responses were then ranked and given a score of 0, 1, 2, or 3 respectively (Williams 1966). Ranks represent the degree of reproductive effort for the observed behavior (3 being the most effort or highest potential risk to the female). The bears were then given a mean score based on the number of observations made for each rank or level divided by the total number of observations (an adjusted total was used to eliminate the confounding effect of unnoticed intrusions). The bears were then ordered according to mean score (Curio 1988) and the resulting order was compared to the known ages.

RESULTS

Three females with cubs were stalked throughout the summer: Heidi (Bear 21) with two cubs, Hillary (Bear 101) with one cub, and Cashew (Bear 203) with two cubs. Four females without cubs were also stalked on at least one occasion: Xina (Bear 38), Erica (Bear 103), Candy (Bear 195), and Delphi (Bear 207). We made 61 attempts to closely approach females and 36 (59%) were successful. Chases were deemed successful if there was a visual confirmation of the bears or if tracks encountered revealed their presence (and the presence or absence of cubs). Of the successful chases, 27 were of females with cubs (the remainder were of solitary females). The mean pursuit time was 3.87 hr (range = 1 min–12.2 hr.).

Cashew was successfully chased 7 times and her calculated mean score was 1.2. Heidi was successfully chased 8 times and her calculated mean score was 1.6. Hillary was chased 12 times and received a mean score of 2.8 (see Table 1). The age order of the bears predicted by the mean scores is Cashew < Heidi < Hillary. This matches the order of previously known ages 6 (Cashew) < 17(Heidi) < 23 (Hillary).

Cashew died between 28 July and 3 August and her carcass was found under a small Douglas fir. It was examined visually for signs of predation and with a metal detector but no metal was found (arrow point or bullet). Cashew had lost one of her cubs between 22 July and 27 July prior to her death. The second cub was observed in the vicinity of her carcass on 4 August and it appeared to have fed on the carcass between 4 August and 10 August. Heidi lost her two cubs sometime between 4 August and 10 August. Hillary was the only female to successfully raise a cub during 2000. In the course of stalking females in the fall, 3 were located in dens. Erica entered a den before 29 September, Candy before 30 September, and Hillary between 29 September and 14 October.

DISCUSSION

Caution should be exercised in making inferences and drawing conclusions from this data but we think it has at the least heuristic value and suggests a need for more research. Bears were not selected at random (we used those we had) and sample size is small. In spite of these limitations the bears show increased effort (risk) with age as predicted by Williams's hypothesis. It is possible that the results are only an artifact of individual variation among bears. But despite its shortcomings this study can serve as impetus for a larger scale

Table 1. The table provides a summary of the behavioral responses of the 3 females. In addition, the mean scores for each bear are given.

Bear #	Age	# of cubs	Intrusion unnoticed	Level 1 Female & cubs fled	Level 2 Female only fled	Level 3 Female remained with cubs	Total # of chases	Mean score
21	17	2	3	3	1	1	8 (*5)	1.6
101	23	1	1	1	0	10	12 (*11)	2.8
203	6	2	1	5	1	0	7 (*6)	1.2

*Adjusted totals after eliminating the unnoticed intrusions. These values were used in computing the mean scores.

study incorporating additional field observations with analysis of data harvested from other published and unpublished research.

Cashew's death was the only natural mortality of an adult female that we documented over the course of 13 years of field work on the Plateau. We hypothesize that her death was due to nutritional stress (Chapter 3). Cub mortality documented here occurred late in the summer, not in spring or early summer as reported in other studies (LeCount 1987, Elowe and Dodge 1989, Costello et al. 2001). Females that lose cubs this late in the summer probably do not have an opportunity to breed. If the females with cubs monitored during 2000 had been encountered by hunters during a spring hunting season, all three of them potentially would have been protected from harvest because cubs would be nearby. If they had been encountered during a fall hunt season (and if Cashew had not died), then only Hillary would have had cubs in attendance. With this example, spring hunting is likely to be the best management strategy to reduce female harvest (Chapter 4).

Smith et al. (1994) indicated that the timing of den entrance is likely an interaction of several factors. A primary one is the availability of food resources. Drought contributed to poor bear food conditions on the Plateau in 2000 (Chapter 3). We found here that den entrance times were earlier than the mean entrance times of 23 population samples reviewed by Smith et al. (1994) and earlier than female entrance times on the Plateau in 1991 and 1992 (pers. obs. from fall telemetry data). Snowfall had not yet occurred and normal fall temperatures make it unlikely that either of those factors contributed to early den entrance.

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LOSS OF SELECTION FOR SECURE DEN SITES AS A RESULT OF PREDATOR EXTIRPATION: AN HYPOTHESIS WITH MANAGEMENT IMPLICATIONS

JOSHUA D. HEWARD AND HAL L. BLACK

Abstract.—Black bears (*Ursus americanus*) den in a wide variety of den types. Den types are largely dependent on the habitat and the available den sites. Occasionally black bears are preyed upon by grizzly bears (*Ursus arctos*) and wolves (*Canis lupus*). These predators of black bears have been extirpated from much of the black bear range. In areas where they are still present there is a strong selection for secure den types with small entrances. In areas in which the predators have been extirpated, there is a relaxed selection on den security and mean den entrances are larger. Critical habitat for bear dens must be conserved and caution is advised for reintroductions of wolves into areas where selection for den security is relaxed.

Winter lethargy is a critical part of the life history of black bears (*Ursus americanus*). Winter lethargy and denning removes the need to forage during periods of scarce resources and often harsh climatic conditions (Hayes & Pelton 1994). While in the den, altricial cubs are born and early development and maternal care takes place for 2–3 months prior to emergence; therefore, selection of adequate den sites is critical for the reproductive success of black bears (Oli et. al. 1997).

A large amount of variation exists among den types and locations. Dens have been found in elevated and basal tree cavities (Johnson & Pelton 1981, Kolenosky & Strathearn 1986, Schwartz et. al. 1986, Hellgren & Vaughan 1989, Beecham 1990, Goodrich & Berger 1994, Hayes & Pelton 1994, Kasbohm et. al. 1996, Oli et. al. 1997), in hollow logs or stumps (Johnson & Pelton 1981, Kolenosky & Strathearn 1986, Hellgren & Vaughan 1989, Beecham 1990, Goodrich & Berger 1994), under brush piles or fallen logs and snags (Johnson & Pelton 1981, Manville 1986, Goodrich & Berger 1994, Hayes & Pelton 1994), in excavated cavities in the ground or (associated with) a rock or tree roots (Johnson & Pelton 1981, Kolenosky & Strathearn 1986, Manville 1986, Schwartz et. al. 1986, Hellgren & Vaughan 1989, Beecham 1990, Goodrich & Berger 1994, Hayes & Pelton 1994, Oli et. al. 1997), in natural caverns or rockpiles (LeCount 1983, Kolenosky & Strathearn 1986, Schwartz et. al. 1986, Goodrich & Berger 1994, Hayes & Pelton 1994, Doan-Crider & Hellgren 1996), on the ground in open nests (Manville 1986, Hellgren & Vaughan 1989, Hayes & Pelton 1994, Oli et. al. 1997), or in man-made debris (Kolenosky & Strathearn 1986). Some bears, in the southern parts of their range, do not den at all and remain active throughout the winter (Doan-Crider & Hellgren 1996).

Construction and use of certain types of dens (i.e. tree dens), has been shown to decrease the amount of energy required for thermoregulation (Johnson & Pelton 1981); although, evidence does not support an inverse relationship between thermoregulatory energy requirements and cub survival (McDonald and Fuller 1989). In addition, dens can provide security from predators and other disturbances (Smith & Follmann 1993).

Black bears are not at the top trophic level throughout much of their range and are preyed upon by wolves (Canis lupus) (Rogers & Mech 1981, Horejsi et. al. 1984, Paquet & Carbyn 1986), grizzly bears (*Ursus arctos*) (Murie 1981, Ross et. al. 1988, Smith & Follmann 1993), and other black bears (Alt & Gruttadauria 1984, Tietje et. al. 1986, Black 1997). Some predation on black bears occurs while they are in dens.

It is assumed that the presence of these predators over most of the black bears' range has favored the selection of secure dens with relatively small, single entrances allowing bears to defend themselves and their cubs. In the last century wolves and grizzly bears have been eliminated from much of their historic range by human activities (Churcher 1999, Mech 1999). They were continually pushed back to the northern parts of their range. Only recently have they been allowed to return, and in some cases reintroduced, into areas of their former range. It is hypothesized that the removal of these predators has eliminated the selective force driving bears to use secure den sites. The den entrance is the most logical place of defense. Generally the smaller the entrance the easier it could be defended. In areas where predators of black bears have been removed there should exist a relaxed selection for small den entrances relative to areas where predators are sympatric with black bears.

METHODS

Accounts of predation on denned black bears were reviewed with specific reference (when available) to the den types involved. Data concerning den types were gathered and reviewed. Measurements were taken from dens of radio-collared females on the Plateau. Reports of den entrance sizes were gathered from areas with wolves and grizzlies and compared to the data from the Plateau and other areas where these predators have been extirpated. A *t*-test was used to determine the significance of the differences in mean entrance areas in Alaska and the Plateau.

RESULTS

Black Bear Cannibalism.—In Alberta, two cases of cannibalism and one attempt were reported by Tietje et al. (1986). One adult female was killed in a newly occupied den by a suspected large male black bear. On a second occasion an adult (4-year-old) male killed and consumed a yearling male in its den. A third encounter involved an attempt at cannibalism of a 5-year-old male by a larger transient male that had been feeding at a nearby garbage dump. The original earthen den had been torn apart and the 5 year-old moved to a new den where it was later examined and superficial wounds were found on its head, shoulders and front right leg. The first and third cases were reported to be the result of unrelated transient bears moving through the area and finding already denned bears. The second case happened while the adult bear was on its way to a den site. The authors offered very little information about the den characteristics of these bears.

Alt and Gruttadauria (1984) reported a case of predation in Pennsylvania on a denned female bear and cubs by another bear. No further details were given. Black (1997) reported a case of possible predation on an adult female (or a 5–6 year old male) by another larger male bear. The den was one that had been used by at least three different bears. Despite the risks of cannibalism, there have been documented cases of den co-occupancy other than females with cubs or yearlings (Goodrich & Stiver 1989).

Predation by Grizzlies.—Smith and Follmann (1993) reported an adult female black bear that was killed in its den by a grizzly bear. The den was an earthen den and apparently the entrance was surrounded by stout tree roots allowing the bear to defend herself. The grizzly bear dug a second entrance causing the female to flee, she was pursued and killed a short distance from the den.

Murie (1981) recounted the story of a trapper who had found a black bear that had been killed by a grizzly bear while digging its den. Ross et al. (1988) indicated that entering the den before the first persistent snow fall can be advantageous to black bears. Their speculation is based on an observation of a female grizzly bear and two yearlings following the tracks of a female black bear accompanied by yearlings to a den. The earthen den was partially excavated and the two black bear yearlings were killed. Apparently the mother escaped.

Predation by Wolves.—In February 1977 a radio-collared 16 year old female black bear and cubs were killed by nine wolves. The den was a shallow depression under five logs that allowed the wolves to approach the bear from both sides and chase her out of the nest. The bear fought her way (22 m) to a large aspen. She escaped up into the tree and later returned to the den where she died or was killed (Rogers & Mech 1981).

Horejsi et al. (1983) spotted wolves feeding on a female bear carcass while conducting moose surveys from a helicopter. The bear and her two cubs were denned under a clump of willows at ground level, and with only 15 cm of snow were visible to the wolves. The events leading to her death were revealed by tracks in the snow. The female was chased 400 m away from the den where she was killed. There was no evidence that she attempted to climb a tree; however, the two cubs escaped into a tree and were observed there partially covered by snow the next day. Two days after the occurrence the cubs were spotted on the ground near the base of the tree they had escaped into, and the wolves were not found in the area.

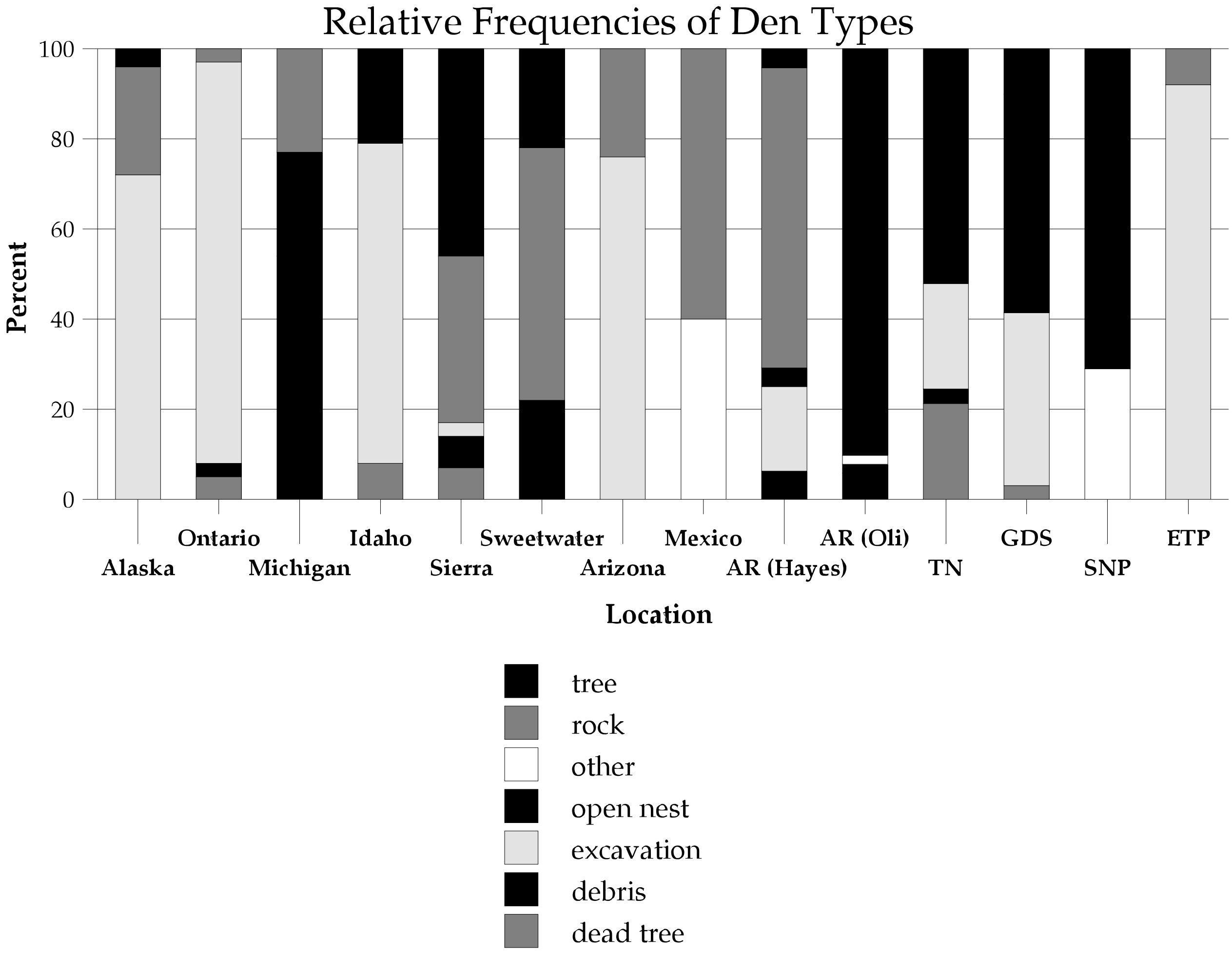

Figure 1. Frequency of den types for 14 areas. Various den types were consolidated into one of the 7 categories above.

Three denning black bears were killed by wolves in southwestern Manitoba in February 1984 (Paquet and Carbyn 1986). The first was a two year old bear that had a shallow depression nest partially covered by a leaning tree. The wolf pack that was responsible for the kill consisted of ten members, but the number involved in the kill was unknown. The second bear was an 11 year old with a shallow (1.5 m deep) earthen den between two stumps and some dead falls. The two wolves that killed the bear had tried to dig it out of the den when the bear emerged and was immediately attacked and killed 12 m from the entrance. The bear had a bullet wound below the left orbit through the palate and out the angular process, but it is unclear when the wound occurred or how debilitated the bear was as a result of it. The third case was related by a trapper who found five wolves near a bear carcass 45 m from the bear's den. The den was shallow and the wolves had dug three holes into it before the bear emerged and was subsequently killed.

Den Types.—The various den types and their relative frequencies at each location are summarized below. A statistical analysis of preference in den types is not possible because of the lack of data on the availability of den types (Fig. 1).

Schwartz et al. (1986) studied three different populations of black bears in Alaska. They found 72% of the dens were excavated, 24% were in natural caves or rock piles and 4% were located in trees.

Kolenosky and Strathearn (1986) found 89% of the 98 dens measured in Ontario were excavations (41% were under trees, 23% under fallen logs, and 36% were entirely earthen). Dens located in hollow logs, in rock cavities, and under man-made debris were each 3%. The remaining 2% of the dens were located in hollow trees.

Michigan bears were found in a high percentage of open unprotected surface nests (23%, n = 31). Fifty-four percent of the dens were depressions or chambers under fallen trees, brush or root masses (at least one of these was open on two sides), and 23% were in underground cavities (Manville 1986).

Beecham (1980) found that 71% of dens in Idaho were excavated ground dens, 21% were located in the base of hollow trees and 8% were in hollow logs. Three of the 66 dens had two separate entrances.

Goodrich and Berger (1994) did a comparative study of two bear populations in the Sierra and Sweetwater Mountains of Nevada and California. It was found that in the Sierras 53% of dens were located in trees with most of these (69%) at the base of hollow trees and the others were in either elevated tree dens or hollow stumps and logs. Rock dens constituted the majority of the remaining den types (37%). Two bears denned in piles of logs and brush and one in an excavated earthen den. In the Sweetwaters they found that rock dens were the most common (56%) and the rest were tree dens and nests on the ground (22% each).

In central Arizona it was found that all bear dens studied were located in rocks. Seventy-six percent of these dens were excavated and the remainder were in natural cavities (LeCount 1983). In Mexico only pregnant females and 40% of the females with yearlings denned at all. All other bears monitored during the study remained active throughout the winter. All of the dens were located in hillside boulder piles, rock ledges, or in narrow natural caves (Doan-Crider & Hellgren 1996).

Hayes and Pelton (1994) found bears in Arkansas using mostly rock cavities (66.6%). Other dens were located in excavations (18.75% and two-thirds of these were associated with trees), brush piles (6.25%), open nests (4.2%), and tree cavities (4.2%). In a second study in Arkansas

Table 1. Mean den entrance measurements for Alaska (Schwartz et. al. 1986) and the Plateau.

		Entrance height (cm)		Entrance width (cm)		Entrance area (m^2)	
Location	n	x̄	SD	x̄	SD	x̄	SD
Alaska Total		46		55		0.24	
Kenai Peninsula							
excavated	91	43	10	54	14	0.23	0.11
natural	2	37	6	41	7	0.15	0.05
Susitna River							
excavated	40	45	22	57	20	0.22	0.13
natural	27	54	19	46	17	0.24	0.11
Prince William Sound							
natural	9	60	45	86	81	0.47	0.36
tree	5	46	11	48	16	0.23	0.11
Plateau Total		55	32	103	78	0.55	0.53
excavated							
(rock)	46	55	34	100	63	0.54	0.50
(earthen)	3	54	32	59	14	0.35	0.30
natural	4	49	12	166	197	0.82	1.02

90.2% of dens were located in elevated tree dens, 5.9% under fallen trees, one den was a nest at the base of a cottonwood tree (*Populus deltoides*), and one den was located in an old beaver lodge (Oli et. al. 1997).

In Tennessee 49% of the dens were located in trees high above the ground (11.2 m). Of the remaining dens 22% were cavities under tree roots, 17% were in stumps, 3% were at the base of snags and 3% were under fallen logs (Johnson & Pelton 1981).

Characteristics of dens in the Great Dismal Swamp (GDS) of Virginia and North Carolina were reported by Hellgren and Vaughan (1989). Forty-eight percent of dens were located in ground nests, 38% were in excavated earthen dens under roots or next to logs or stumps, 10% were located in tree dens (only half of these were elevated and the others were at the base of the trees), and 3% were in a stump.

In Shenandoah National Park (SNP), 71% of dens studied were located in tree cavities. Of the pregnant females in the study, 84% were found using tree dens (Kasbohm et. al. 1996).

In the Plateau (ETP in Figure 1) 86% of the dens (n = 53) were located in excavations under rocks. Eight percent of the dens were located in natural rock cavities and the remaining 6% had excavated earthen dens.

Mean Areas of Den Entrances.—There is a highly significant difference between the den entrance areas in Alaska 0.24 m^2 (Schwartz et. al. 1986) and Utah 0.55 m^2 (TS = 4.02, df = 225, $P <$ 0.000) (Table 1). Statistical comparisons of entrance areas from other locations were not possible because the respective variances were not reported. In Ontario, similar results to those found in Alaska (Schwartz et. al. 1986) were reported by Kolenosky and Strathearn (1986). Twenty-seven dens were measured in their study with a mean height 40 cm, mean width 45 cm, and mean area 0.19 m^2. The mean entrance areas have also been reported for south-central Alaska (Miller 1989), for the GDS in North Carolina and Virginia (Hellgren & Vaughan 1989), and for ground dens in Tennessee (Johnson & Pelton 1981). The mean entrance areas were found to be 0.22 m^2, 0.18 m^2, 0.35 m^2, respectively.

DISCUSSION

From the reported instances of predation on denned black bears, it is apparent that susceptible bears are those that have open dens or dens with two entrances (Rogers and Mech 1981, Paquet & Carbyn 1986). The dens with only a single entrance are defendable against predators unless it is possible for the predator to dig a new entrance (Smith and Follmann 1993). The tendency of young bears to abandon dens may increase survival by avoiding conflicts with other bears or predators (Kolenosky and Strathearn 1986). While predation on denned bears is relatively uncommon, the fact that it does occur provides evidence that it is a selective force in constructing and/or selecting secure dens.

There is considerable variation in den types across the black bears' range (Fig. 1). There also seems to be no consistent pattern for the den types selected by bears; although, some evidence indicates that selection of den types is directly correlated with availability (Goodrich and Berger 1994, Hayes and Pelton 1994, Schwartz et al. 1986). Not all den types are equally secure. Open dens are obviously not secure and can usually be approached from several sides. An excavated den can offer protection but the entrances can also be widened or new entrances excavated. Natural cavities are relatively secure and are only accessible by the entrance. In Alaska, natural cavities were reused more frequently than other den types (Schwartz et al. 1986) indicating a preference for natural cavities. Elevated tree dens offer protection from wolves and grizzly bears. In SNP pregnant females used elevated tree dens at a high rate (84%) indicating the importance of this type of den for reproduction (Kasbohm et. al. 1996).

Alt and Gruttadauria (1984) suggested that the infrequent reuse of dens could be a strategy to avoid predators and the risk of disease transmission. A habitat with abundant den sites may be important in the conservation of black bears. If a bear is disturbed in its den in an area with abundant den site possibilities, then the bear could change dens after a disturbance with minimal stress and energy expenditure.

The Plateau has many sandstone cliffs, outcrops, and boulders. Bears in the Plateau are most often found in excavated dens under these formations. There are relatively few or no large trees available for elevated tree dens in the Plateau, but this is compensated for by potential excavation den sites would seem to be unlimited in number.

Not only is the type of den important, but also its location. Dens must be not only secure from predators, but also free from human disturbance. Beecham (1980) and Graber (1989) reported several den abandonments as a result of visiting the dens. A study in the Sierra Nevada and Sweetwater Mountains of Nevada and California showed that bears were likely to abandon dens and cubs when disturbed by humans (Goodrich and Berger 1994). All but one of the bears in this study remained active after den abandonment for the remainder of the denning season. In Arizona it was noted that of the bears that were disturbed in their dens, 36% moved to a new den (LeCount 1983). Contrary to Goodrich's data Doan-Crider and Hellgren (1996) reported no den abandonment in Mexico after human disturbance. Protecting den areas from human disturbance may be a critical aspect of preserving and maintaining bear populations (Goodrich and Berger 1994).

Hartvigsen (1996) found no statistical difference in the distance of dens to roads compared to random points in the Plateau. The significance of this data is questionable because of the minimal use of the roads in the Plateau, especially during the winter months. The only significant use of roads during the winter comes from the periodic gas well checkers and sporadic mountain lion (Puma concolor) hunters. Unlike the study of Goodrich and Berger (1994), winter recreation in the Plateau is low owing to its distance from large urban areas. Another factor affecting the insignificant finding of the distance of dens in relation to the nearest road is the varied topography. The Plateau is riddled with canyons that are steep and deep and any distance measured on a map does not always provide an accurate distance on the ground. A den may be only 1 km from a road, but separated by a canyon or a ridge top making the effectual distance is much farther.

Although human disturbance of denning bears may currently be minimal, future development and use of the Plateau should be closely monitored and curtailed when necessary due to the potential detrimental impacts on bear denning and successful rearing of young.

The hypothesis that den entrances will be larger in areas where predators have been extirpated is supported by the data from the Plateau. Dens in Tennessee also had larger entrances than those in Alaska. The hypothesis is further supported by the similarity in den entrance size in studies from Alaska (Schwartz et. al. 1986), south-central Alaska (Miller 1989) and in Ontario (Kolenosky & Strathearn 1986). The mean entrance area reported for the GDS (Hellgren & Vaughan 1989) was reported as being more similar to those of Alaska (Schwartz et. al. 1986) despite the lack of grizzlies and wolves in that area. It is not possible to show a cause-and-effect relationship between den selection and predator extirpation with an observational study such as this one. Alternative explanations for the observed pattern may include variation in den type availability and climatic conditions (e.g., temperature and snowfall).

MANAGEMENT IMPLICATIONS

Black bear management plans need to focus on critical habitat. Beringer et al. (1998) discussed the effect of small sanctuaries on the survival rates of black bears in North Carolina. He showed that the presence of small sanctuaries with limited activities affecting bear behavior could serve as a source population for surrounding areas where sport harvest occurs or is desired. It is critical that managers include adequate habitat for secure dens in their normal food and cover based management strategies. Johnson and Pelton (1981) suggest that den sites in the far north are not under as much pressure to offer protection from the elements and predators, because the deep snow levels provide insulation and concealment. This information becomes even more critical as wolves are being reintroduced into areas of their historic range. If bear dens in areas of reintroduction are not secure, then there could be an increased rate of mortality for the bears due to direct killing by wolves. There could also be an increased abandonment of cubs as a result of disturbance. Any incidents of predation or attempts should be closely monitored and management actions should compensate (i.e., hunting should be restricted).

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APPENDIX I: EAST TAVAPUTS PLATEAU BLACK BEARS

This appendix contains the complete record of summer captures, den visits, and recorded mortalities of marked bears on the East Tavaputs Plateau, Utah. The period covered is June 1991 through October 2004. Each bear was given a unique identification number and name which correspond to the original datasheets and all other databases maintained by Hal L. Black at Brigham Young University. Records are sorted by bear number and then by date.

Mother–offspring relationships (when known) are given as well as sex (Male, Female, Unknown) and age (in years). Ages were determined by cementum annuli analysis (Matson's Laboratory, Milltown, MT) or by direct observation in cases of cubs and yearlings in dens.

Type of record refers to the whether the observation was a trapping event (T), a denning event (D), a natal den (ND), a sighting (S), or a mortality (X).

The column titled *Fate* gives the last-known status of the bear or cause of mortality. Most designations are self-explanatory. Cubs not in dens with their mothers as yearlings were assumed dead and given the designation of *Cub Loss*. *Collared* means that the bear carried an active collar as of October 2004. *Pending* means that the information will be available in spring 2005 when dens are visited.

Coordinates are UTM eastings and northings for NAD 27, Zone 12 (Utah). These were known for all traps and most den sites. Mortality records usually did not include precise locations.

Ear tag numbers are given so that future kills of marked bears may be identified. Ear tags were manufactured by Allflex USA Inc. (DFW Airport, Texas) and were of various colors (w = white, y = yellow, b = blue, o = orange, g = green) and two shapes (round unless indicated by *sq* which means square). Thirty-three additional bears were marked on the Ouray and Ute Indian Reservation in 1992 and 1993 (Black and Smith 1992). In that study females received round orange tags with numbers ranging from 0001–0032 and males received round blue tags with numbers ranging from 0001–0050.

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ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
1	WP		M	.	14-Jun-91	T	Hunter	651246	4367847	0250w	0249w
1	WP		M	.	18-Jun-91	T	Hunter	650146	4375281	0250w	0249w
1	WP		M	.	18-May-92	X	Hunter	.	.	0250w	0249w
2	Nenie		F	3	27-Jun-91	T	Hunter	654162	4366584	0233y	0234y
2	Nenie		F	3	13-Jul-91	T	Hunter	658162	4365660	0233y	0234y
2	Nenie		F	5	12-Jun-93	T	Hunter	662939	4369661	0233y	0234y
2	Nenie		F	5	14-Jul-93	T	Hunter	663313	4370404	0233y	0234y
2	Nenie		F	6	11-Mar-94	D	Hunter	659806	4366580	0233y	0234y
2	Nenie		F	7	22-Jul-96	T	Hunter	662939	4369661	0233y	0234y
2	Nenie		F	8	5-Mar-97	D	Hunter	663167	4368761	0233y	0234y
2	Nenie		F	8	1-Sep-97	X	Hunter	.	.	0233y	0234y
3	Lafayette		F	4	28-Jun-91	T	No Data	658507	4367965	0241y	0242y
3	Lafayette		F	6	27-Mar-93	D	No Data	660012	4365944	0241y	0242y
3	Lafayette		F	6	18-Jul-93	T	No Data	659676	4368707	0241y	0242y
4	Leti		F	6	29-Jun-91	T	Hunter	646666	4367838	0244y	0243y
4	Leti		F	6	1-Jul-91	T	Hunter	654754	4368049	0244y	0243y
4	Leti		F	7	15-Mar-92	D	Hunter	655982	4363875	0244y	0243y
4	Leti		F	7	23-Jul-92	T	Hunter	656421	4368361	0244y	0243y
4	Leti		F	8	6-Mar-93	D	Hunter	655747	4357545	0244y	0243y
4	Leti		F	8	29-Jun-93	T	Hunter	653359	4364396	0244y	.
4	Leti		F	8	10-Sep-93	X	Hunter	.	.	0244y	.
5	Tick		F	3	30-Jun-91	T	No Data	655744	4375365	0249y	0248y
6	BigO		M	7	1-Jul-91	T	Hunter	646666	4367838	0248w	0247w
6	BigO		M	7	25-Jul-91	T	Hunter	652248	4371479	0248w	0247w
6	BigO		M	8	17-May-92	X	Hunter	.	.	0248w	0247w
7	Lisa		F	12	2-Jul-91	T	Hunter	662939	4369661	0231y	0232y
7	Lisa		F	13	29-Mar-92	D	Hunter	660628	4373993	0231y	0232y
7	Lisa		F	14	9-Mar-93	D	Hunter	662747	4370140	0231y	0232y
7	Lisa		F	15	3-Mar-94	D	Hunter	654781	4369286	0231y	0232y
7	Lisa		F	18	3-Sep-97	X	Hunter	.	.	0231y	0232y
8	Darth		M	4	10-Jul-91	T	Hunter	655239	4365547	0246w	0245w
8	Darth		M	4	12-Jul-91	T	Hunter	645895	4367881	0246w	0245w
8	Darth		M	8	4-Sep-95	X	Hunter	.	.	0246w	0245w
9	Dana		M	4	15-Jul-91	T	No Data	646666	4367838	0243w	0244w
9	Dana		M	5	9-Jul-92	T	No Data	648656	4373589	0243w	0244w
10	Bathsheba		F	4	16-Jul-91	T	No Data	659122	4364390	0228y	0229y
10	Bathsheba		F	6	27-Jun-93	T	No Data	658507	4367965	0228y	0229y
10	Bathsheba		F	6	17-Jul-93	T	No Data	659676	4368707	0228y	0229y
10	Bathsheba		F	8	6-Jan-95	D	No Data	660365	4363900	0228y	0229y
10	Bathsheba		F	8	25-Feb-95	D	No Data	660365	4363900	0228y	0229y
10	Bathsheba		F	9	3-Jan-96	D	No Data	660132	4363171	0228y	0229y
10	Bathsheba		F	9	18-Jul-96	T	No Data	659122	4364390	0228y	0229y
10	Bathsheba		F	10	15-Mar-97	D	No Data	.	.	0228y	0229y
10	Bathsheba		F	11	3-Jan-98	D	No Data	.	.	0228y	0229y
11	MarkEaton		M	4	18-Jul-91	T	No Data	659676	4368707	0241w	0242w
11	MarkEaton		M	6	12-Jun-93	T	No Data	659676	4368707	0241w	0242w
12	MicahLamar		M	6	18-Jul-91	T	No Data	645895	4367881	0238w	0239w

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
12	MicahLamar		M	7	27-Jun-92	T	No Data	647638	4369325	0238w	0239w
12	MicahLamar		M	16	14-Jul-01	T	No Data	651949	4375476	0414y	0415y
13	Maggie		F	4	25-Jul-91	T	Hunter	648499	4371248	0250y	0226y
13	Maggie		F	5	13-Mar-92	D	Hunter	640546	4373109	0250y	0226y
13	Maggie		F	5	13-Jun-92	T	Hunter	645895	4367881	0250y	0226y
13	Maggie		F	6	7-Mar-93	D	Hunter	646783	4373713	0250y	0226y
13	Maggie		F	7	26-Feb-94	D	Hunter	645416	4373090	0250y	0226y
13	Maggie		F	10	29-Sep-97	X	Hunter	.	.	0250y	0226y
14	OsaLoca		F	5	28-Jul-91	T	Natural	662939	4369661	0245y	0246y
14	OsaLoca		F	7	11-Mar-93	D	Natural	664880	4371680	0245y	0246y
14	OsaLoca		F	8	5-Jun-94	T	Natural	663609	4373011	0245y	0246y
14	OsaLoca		F	16	9-Jun-02	T	Natural	664308	4374988	0245y	74g sq
14	OsaLoca		F	18	26-Mar-04	X	Natural	667471	4379463	0245y	74g sq
15	Mike		M	4	29-Jul-91	T	Hunter	646666	4367838	0232w	0237w
15	Mike		M	7	29-Aug-94	X	Hunter	.	.	0232w	0237w
16	Pew		M	4	29-Jul-91	T	Hunter	645895	4367881	0229w	0228w
16	Pew		M	10	22-Sep-97	X	Hunter	.	.	0229w	0228w
17	WillieWonka		M	6	30-Jul-91	T	Hunter	665265	4375273	0226w	0227w
17	WillieWonka		M	7	20-May-92	X	Hunter	.	.	0226w	0227w
18	Lesterine		M	3	1-Aug-91	T	Hunter	642472	4367288	0236w	0240w
18	Lesterine		M	3	12-Aug-91	T	Hunter	640685	4368124	0236w	0240w
18	Lesterine		M	8	7-Jul-96	T	Hunter	646666	4367838	0236w	0240w
18	Lesterine		M	13	1-Jul-01	T	Hunter	646666	4367838	0424y	0413y
18	Lesterine		M	13	12-Aug-01	T	Hunter	654162	4366584	0424y	0413y
18	Lesterine		M	14	.	X	Hunter	.	.	0424y	0413y
19	Paddington		M	3	12-Aug-91	T	Hunter	645895	4367881	0230w	0231w
19	Paddington		M	3	13-Aug-91	T	Hunter	646666	4367838	0230w	0231w
19	Paddington		M	3	15-Aug-91	T	Hunter	640685	4368124	0230w	0231w
19	Paddington		M	4	20-May-92	X	Hunter	.	.	0230w	0231w
20	Juanita		F	4	13-Aug-91	T	Hunter	662939	4369661	0219y	0220y
20	Juanita		F	4	5-Sep-91	X	Hunter	.	.	0219y	0220y
21	Heidi		F	6	14-Aug-91	T	Collared	643537	4364325	0221y	0222y
21	Heidi		F	7	21-Mar-92	D	Collared	642510	4355842	0221y	0222y
21	Heidi		F	8	10-Mar-93	D	Collared	641639	4362843	0221y	0222y
21	Heidi		F	8	10-Jun-93	T	Collared	642472	4367288	0221y	0222y
21	Heidi		F	9	12-Mar-94	D	Collared	641440	4356411	0221y	0222y
21	Heidi		F	10	26-Feb-95	D	Collared	644701	4355211	0221y	0222y
21	Heidi		F	11	3-Jan-96	D	Collared	646396	4358282	0221y	0222y
21	Heidi		F	11	7-Mar-96	D	Collared	641316	4360429	0221y	0222y
21	Heidi		F	11	14-Jul-96	T	Collared	642892	4363786	0221y	0222y
21	Heidi		F	12	4-Jan-97	D	Collared	644288	4353678	0221y	0222y
21	Heidi		F	13	8-Mar-98	D	Collared	644008	4354297	0221y	0222y
21	Heidi		F	14	25-Jan-99	D	Collared	642448	4361204	0221y	0222y
21	Heidi		F	15	11-Mar-00	D	Collared	641044	4357747	0221y	0222y
21	Heidi		F	16	18-Jun-01	T	Collared	642892	4363786	0444y	0445y
21	Heidi		F	17	4-Mar-02	D	Collared	642148	4353907	0444y	0445y
21	Heidi		F	18	3-Jan-03	D	Collared	640527	4354841	0444y	0445y
21	Heidi		F	18	2-Mar-03	D	Collared	644343	4354572	0444y	0445y

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
21	Heidi		F	19	4-Mar-04	D	Collared	641648	4362734	0444y	0445y
22	Gramps		M	17	16-Aug-91	T	Natural	660695	4368614	0234w	0233w
22	Gramps		M	18	8-Mar-92	D	Natural	.	.	.	0233w
22	Gramps		M	18	.	X	Natural	.	.	.	0233w
23	Jane		F	8	21-Aug-91	T	Hunter	641686	4367559	0224y	0225y
23	Jane		F	9	6-Mar-92	D	Hunter	641613	4377427	0224y	0225y
23	Jane		F	10	8-Mar-93	D	Hunter	644745	4386206	0225y	0224y
23	Jane		F	11	28-Feb-94	D	Hunter	639488	4383536	0224y	0225y
23	Jane		F	12	25-Feb-95	D	Hunter	648090	4383538	0224y	0225y
23	Jane		F	19	1-Sep-02	X	Hunter	.	.	0224y	0225y
24	Fine		F	5	27-Aug-91	T	No Data	640685	4368124	0223y	0247y
24	Fine		F	7	10-Mar-93	D	No Data	631072	4379945	0223y	0247y
24	Fine		F	7	30-Jun-93	T	No Data	641686	4367559	0223y	0247y
24	Fine		F	8	13-Mar-94	D	No Data	632896	4372309	0223y	0247y
24	Fine		F	9	27-Jun-95	T	No Data	639849	4364108	0223y	0247y
24	Fine		F	10	3-Mar-96	D	No Data	633404	4372452	0223y	0247y
24	Fine		F	10	22-Jul-96	T	No Data	640957	4368067	0223y	0247y
24	Fine		F	11	3-Mar-97	D	No Data	639210	4369569	0223y	0247y
24	Fine		F	11	6-Mar-97	D	No Data	639210	4369569	0223y	0247y
24	Fine		F	12	4-Jan-98	D	No Data	639446	4368623	0223y	0247y
24	Fine		F	13	27-Feb-99	D	No Data	638248	4367755	0223y	0247y
25	Ma'am		F	11	13-Sep-91	T	No Data	645895	4367881	0212y	0203y
25	Ma'am		F	13	6-Mar-93	D	No Data	624446	4358088	0212y	0203y
25	Ma'am		F	15	6-Jan-96	D	No Data	629252	4352504	0212y	0203y
26	Friday		F	6	13-Sep-91	T	Poach	646666	4367838	0206y	0204y
26	Friday		F	7	20-Mar-92	D	Poach	636454	4357022	0206y	0204y
26	Friday		F	8	12-Mar-93	D	Poach	635058	4358007	0206y	0144y
26	Friday		F	10	28-Feb-95	D	Poach	637383	4358000	0206y	0144y
26	Friday		F	11	2-Mar-96	X	Poach	.	.	0206y	0144y
27	Willow	Maggie	F	1	13-Mar-92	D	No Data	640546	4373109	0230y	0220y
27	Willow	Maggie	F	2	8-Jun-93	T	No Data	648556	4373082	0319g	0220y
27	Willow	Maggie	F	3	9-Jul-94	T	No Data	648378	4373796	0319g	0220y
27	Willow	Maggie	F	4	26-Feb-95	D	No Data	650288	4374366	0319g	0220y
27	Willow	Maggie	F	5	4-Jan-96	D	No Data	649533	4372896	0319g	0220y
27	Willow	Maggie	F	6	3-Mar-97	D	No Data	649641	4372638	0319g	0220y
27	Willow	Maggie	F	7	4-Jan-98	D	No Data	649689	4375127	0319g	0220y
27	Willow	Maggie	F	8	26-Feb-99	D	No Data	648426	4371107	0319g	0220y
27	Willow	Maggie	F	10	10-Aug-01	T	No Data	648706	4370505	0319g	0220y
27	Willow	Maggie	F	10	28-Dec-01	D	No Data	649816	4374873	0319g	0220y
27	Willow	Maggie	F	12	8-Mar-03	D	No Data	649662	4373899	0319g	0220y
28	Randall	Leti	M	0	15-Mar-92	ND	No Data	655982	4363875	no tag	no tag
28	Randall	Leti	M	0	9-Aug-92	T	No Data	653359	4364396	0205w	0235w
28	Randall	Leti	M	0	30-Aug-92	S	No Data	.	.	0205w	0235w
29	Shea	Leti	M	0	15-Mar-92	ND	No Data	655982	4363875	no tag	no tag
29	Shea	Leti	M	0	26-Jul-92	T	No Data	659122	4364390	no tag	no tag
29	Shea	Leti	M	1	6-Mar-93	D	No Data	655747	4357545	no tag	no tag
30	Semicircle	Leti	F	0	15-Mar-92	ND	Hunter	655982	4363875	no tag	no tag
30	Semicircle	Leti	F	0	26-Jul-92	T	Hunter	659122	4364390	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
30	Semicircle	Leti	F	0	9-Aug-92	T	Hunter	653359	4364396	0235y	0240y
30	Semicircle	Leti	F	1	6-Mar-93	D	Hunter	655747	4357545	0235y	0240y
30	Semicircle	Leti	F	1	11-Jun-93	T	Hunter	658162	4365660	0235y	0240y
30	Semicircle	Leti	F	1	27-Jun-93	T	Hunter	653880	4362619	0235y	no tag
30	Semicircle	Leti	F	1	14-Jul-93	T	Hunter	655239	4365547	0235y	0314g
30	Semicircle	Leti	F	2	6-Jun-94	T	Hunter	658162	4365660	0235y	0314g
30	Semicircle	Leti	F	2	26-Jun-94	T	Hunter	658162	4365660	0235y	0314g
30	Semicircle	Leti	F	2	11-Jul-94	T	Hunter	658162	4365660	0235y	0314g
30	Semicircle	Leti	F	2	25-Sep-94	X	Hunter	.	.	0235y	0314g
31	Kent	Heidi	M	0	21-Mar-92	ND	No Data	642510	4355842	no tag	no tag
31	Kent	Heidi	M	1	10-Mar-93	D	No Data	641639	4362843	0209w	0206w
31	Kent	Heidi	M	1	1-Aug-93	T	No Data	639849	4364108	0209w	0206w
32	John	Heidi	M	0	21-Mar-92	ND	No Data	642510	4355842	no tag	no tag
32	John	Heidi	M	1	10-Mar-93	D	No Data	641639	4362843	0213w	0212w
32	John	Heidi	M	1	30-Jun-93	T	No Data	643537	4364325	0213w	0212w
32	John	Heidi	M	1	18-Jul-93	T	No Data	640685	4368124	0213w	0212w
33	Yuki	Lisa	F	0	29-Mar-92	ND	No Data	660628	4373993	no tag	no tag
33	Yuki	Lisa	F	1	9-Mar-93	D	No Data	662747	4370140	0133	0132
34	LemonDrop	Lisa	F	0	29-Mar-92	ND	No Data	660628	4373993	no tag	no tag
34	LemonDrop	Lisa	F	1	9-Mar-93	D	No Data	662747	4370140	0202y	0210y
34	LemonDrop	Lisa	F	2	12-Jun-94	T	No Data	663823	4371517	0202y	0210y
34	LemonDrop	Lisa	F	3	5-Jun-95	T	No Data	661004	4368917	0202y	0210y
34	LemonDrop	Lisa	F	4	3-Mar-96	D	No Data	661012	4372216	0202y	0210y
35	Achilles		M	4	11-Jun-92	T	Hunter	651246	4367847	0202w	0204w
35	Achilles		M	5	9-Jul-93	T	Hunter	660695	4368614	0202w	0204w
35	Achilles		M	8	22-Jul-96	T	Hunter	653075	4368576	0357w	0381w
35	Achilles		M	8	3-Sep-96	X	Hunter	.	.	0357w	0381w
36	CT		M	2	20-Jun-92	T	No Data	643729	4366988	0203w	0224w
36	CT		M	2	25-Jul-92	T	No Data	640685	4368124	0203w	0224w
36	CT		M	3	26-Jun-93	T	No Data	643601	4370210	0203w	0224w
36	CT		M	4	5-Jun-94	T	No Data	640685	4368124	0203w	0224w
37	Millie		F	7	20-Jun-92	T	No Data	641686	4367559	0215y	0213y
38	Xina		F	4	23-Jun-92	T	Collared	651949	4375476	0211y	0201y
38	Xina		F	5	8-Mar-93	D	Collared	649197	4384361	0214y	0236y
38	Xina		F	6	26-Feb-94	D	Collared	649832	4382017	0214y	0236y
38	Xina		F	7	5-Jan-95	D	Collared	650119	4382431	0214y	0236y
38	Xina		F	8	2-Mar-96	D	Collared	653418	4385641	0214y	0236y
38	Xina		F	9	1-Mar-97	D	Collared	655250	4384225	0214y	0236y
38	Xina		F	10	7-Mar-98	D	Collared	655869	4388872	0214y	0236y
38	Xina		F	11	26-Feb-99	D	Collared	656706	4382021	0214y	0236y
38	Xina		F	11	20-Nov-99	D	Collared	.	.	0214y	0236y
38	Xina		F	12	3-Mar-00	D	Collared	657044	4383896	0214y	0236y
38	Xina		F	13	10-Mar-01	D	Collared	654597	4380104	0214y	0236y
38	Xina		F	13	27-Jul-01	T	Collared	652431	4379010	0214y	0236y
38	Xina		F	14	3-Mar-02	D	Collared	656786	4382912	0214y	0236y
38	Xina		F	15	1-Mar-03	D	Collared	656168	4388791	0214y	0236y
38	Xina		F	16	3-Jan-04	D	Collared	656353	4380188	0214y	0236y
38	Xina		F	16	7-Mar-04	D	Collared	655898	4381302	0214y	0236y

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
39	Bucky		F	7	24-Jun-92	T	Collared	651591	4368622	0217y	0208y
39	Bucky		F	9	29-Jun-94	T	Collared	656206	4367040	0217y	0317g
39	Bucky		F	10	27-Feb-95	D	Collared	651865	4362113	0217y	0317g
39	Bucky		F	11	4-Jan-96	D	Collared	650687	4360579	0217y	0317g
39	Bucky		F	11	4-Mar-96	D	Collared	.	.	0217y	0317g
39	Bucky		F	12	15-Mar-97	D	Collared	650081	4361001	0217y	0317g
39	Bucky		F	13	14-Mar-98	D	Collared	651766	4362379	0217y	0317g
39	Bucky		F	17	20-Jul-02	T	Collared	651246	4367847	0320w sq	0317g
39	Bucky		F	18	Mar-03	D	Collared	650929	4359296	0320w sq	0317g
39	Bucky		F	19	12-Mar-04	D	Collared	651125	4362810	0320w sq	0317g
40	Allyson		F	3	25-Jun-92	T	Depredation	640964	4369239	0209y	0207y
40	Allyson		F	3	23-Jul-92	T	Depredation	641686	4367559	0209y	0207y
40	Allyson		F	4	29-Jun-93	T	Depredation	640685	4368124	0209y	0207y
40	Allyson		F	7	22-Jul-96	T	Depredation	643601	4370210	0209y	0207y
40	Allyson		F	8	4-Mar-97	D	Depredation	640402	4369323	0209y	0207y
40	Allyson		F	9	30-Jan-98	D	Depredation	640938	4369224	0209y	0207y
40	Allyson		F	9	6-Mar-98	D	Depredation	640342	4368936	0209y	0207y
40	Allyson		F	12	17-Jun-01	T	Depredation	641686	4367559	0209y	0207y
40	Allyson		F	12	11-Jul-01	T	Depredation	640685	4368124	0209y	0207y
40	Allyson		F	12	27-Dec-01	D	Depredation	641430	4369497	0209y	0207y
40	Allyson		F	14	1-Mar-03	D	Depredation	640209	4369113	0209y	no tag
40	Allyson		F	14	.	X	Depredation	.	.	0209y	no tag
41	Cherylee		F	3	11-Jul-92	T	No Data	646666	4367838	0227y	0216y
41	Cherylee		F	6	6-Jan-95	D	No Data	648259	4365445	0227y	0216y
42	RangerRick		M	3	12-Jul-92	T	Hunter	654798	4366467	0218w	0217w
42	RangerRick		M	4	12-Jun-93	T	Hunter	663313	4370404	0218w	0217w
42	RangerRick		M	5	22-Jul-94	T	Hunter	658507	4367965	0360w	0363w
42	RangerRick		M	5	2-Sep-94	X	Hunter	.	.	0360w	0363w
43	Mahal		M	2	27-Jul-92	T	No Data	654798	4366467	0207w	0208w
43	Mahal		M	2	6-Aug-92	T	No Data	654162	4366584	0207w	0208w
44	S.Skunkback		F	1	28-Jul-92	T	Hunter	654475	4374799	0237y	0150y
44	S.Skunkback		F	2	10-Jul-93	T	Hunter	652248	4371479	0237y	0313g
44	S.Skunkback		F	3	8-Jun-94	T	Hunter	655239	4365547	0237y	0313g
44	S.Skunkback		F	4	27-Jun-95	T	Hunter	658162	4365660	0237y	0313g
44	S.Skunkback		F	5	5-Mar-96	D	Hunter	654466	4357750	0237y	0313g
44	S.Skunkback		F	6	16-Mar-97	D	Hunter	654203	4356828	0237y	0313g
44	S.Skunkback		F	7	9-Mar-98	D	Hunter	658708	4359809	0237y	0313g
44	S.Skunkback		F	8	2-Jan-99	D	Hunter	.	.	0237y	0313g
44	S.Skunkback		F	11	17-Sep-02	X	Hunter	.	.	0237y	0313g
47	Newah	Maggie	M	0	7-Mar-93	ND	No Data	646783	4373713	no tag	no tag
47	Newah	Maggie	M	1	26-Feb-94	D	No Data	645416	4373090	0345w	0374w
47	Newah	Maggie	M	1	14-Jul-94	T	No Data	648556	4373082	0345w	0374w
47	Newah	Maggie	M	1	9-Aug-94	T	No Data	652248	4371479	0345w	0374w
47	Newah	Maggie	M	2	12-Jun-95	T	No Data	659676	4368707	0345w	0374w
48	Caderdoo	Maggie	M	0	7-Mar-93	ND	No Data	646783	4373713	no tag	no tag
48	Caderdoo	Maggie	M	1	26-Feb-94	D	No Data	645416	4373090	0332w	0375w
48	Caderdoo	Maggie	M	1	24-Jun-94	T	No Data	643601	4370210	0332w	0375w
49	Whiner	Maggie	F	0	7-Mar-93	ND	No Data	646783	4373713	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
49	Whiner	Maggie	F	1	26-Feb-94	D	No Data	645416	4373090	0310g	0302g
49	Whiner	Maggie	F	1	27-Jun-94	T	No Data	648556	4373082	0310g	0302g
49	Whiner	Maggie	F	1	10-Jul-94	T	No Data	643601	4370210	0310g	0302g
49	Whiner	Maggie	F	1	27-Jul-94	T	No Data	643601	4370210	0310g	0302g
49	Whiner	Maggie	F	1	11-Aug-94	T	No Data	648556	4373082	0310g	0302g
49	Whiner	Maggie	F	2	6-Jun-95	T	No Data	645895	4367881	0333g	0302g
49	Whiner	Maggie	F	2	8-Jun-95	T	No Data	643960	4370850	0333g	0302g
49	Whiner	Maggie	F	2	13-Jun-95	T	No Data	643601	4370210	0333g	0302g
49	Whiner	Maggie	F	3	10-Jul-96	T	No Data	643960	4370850	0333g	0302g
50	Steve	Xina	M	0	8-Mar-93	ND	Cub Loss	649197	4384361	no tag	no tag
51	Kawasaki	Xina	F	0	8-Mar-93	ND	Cub Loss	649197	4384361	no tag	no tag
52	Rufio	Jane	M	0	8-Mar-93	ND	Cub Loss	644745	4386206	no tag	no tag
53	Pun'kin	Jane	F	0	8-Mar-93	ND	Cub Loss	644745	4386206	no tag	no tag
54	Lucy	Jane	F	0	8-Mar-93	ND	Cub Loss	644745	4386206	no tag	no tag
55	Wilt	Fine	M	0	10-Mar-93	ND	No Data	631072	4379945	no tag	no tag
55	Wilt	Fine	M	0	30-Jun-93	S	No Data	.	.	no tag	no tag
55	Wilt	Fine	M	1	13-Mar-94	D	No Data	632896	4372309	0333w	0334w
55	Wilt	Fine	M	2	14-Jun-95	T	No Data	643601	4370210	0333w	0395w
55	Wilt	Fine	M	2	16-Jun-95	T	No Data	642472	4367288	0333w	0395w
56	FayeP.	Osa Loca	F	0	11-Mar-93	ND	No Data	664880	4371680	no tag	no tag
57	DonnaB.	Osa Loca	F	0	11-Mar-93	ND	No Data	664880	4371680	no tag	no tag
58	Preacher	Friday	M	0	12-Mar-93	ND	No Data	635058	4358007	no tag	no tag
59	Kooch	Lafayette	M	0	27-Mar-93	ND	No Data	660012	4365944	no tag	no tag
60	Midnight	Lafayette	F	0	27-Mar-93	ND	No Data	660012	4365944	no tag	no tag
61	Flex		M	3	9-Jun-93	T	No Data	641686	4367559	0349w	0350w
61	Flex		M	3	3-Aug-93	T	No Data	654159	4373439	0349w	0350w
61	Flex		M	11	28-Jun-01	T	No Data	652248	4371479	0418y	0436y
62	S.A.M.		M	2	23-Jun-93	T	Hunter	652144	4374343	0302w	0301w
62	S.A.M.		M	2	3-Aug-93	T	Hunter	652248	4371479	0302w	0301w
62	S.A.M.		M	3	5-Jun-94	T	Hunter	648378	4373796	0339w	0301w
62	S.A.M.		M	4	23-Sep-95	X	Hunter	.	.	0339w	0301w
63	D.Clod		M	6	23-Jun-93	T	Hunter	643537	4364325	0304w	0303w
63	D.Clod		M	6	13-Jul-93	T	Hunter	656280	4370491	0304w	0303w
63	D.Clod		M	8	10-Sep-95	X	Hunter	.	.	0304w	0303w
64	Matt		M	3	23-Jun-93	T	No Data	663844	4375102	0306w	0308w
64	Matt		M	4	27-Jun-94	T	No Data	663844	4375102	0306w	0308w
65	J.R.		M	6	24-Jun-93	T	No Data	661532	4376458	0305w	0307w
65	J.R.		M	6	25-Jun-93	T	No Data	663823	4371517	0305w	0307w
66	Mr.Moaner		M	1	26-Jun-93	T	No Data	659122	4364390	0310w	0309w
67	Raquel		F	9	26-Jun-93	T	Hunter	656280	4370491	0316g	0312g
67	Raquel		F	10	2-Mar-94	D	Hunter	652958	4374912	0316g	0350g
67	Raquel		F	10	12-Jun-94	T	Hunter	654601	4372390	0316g	0350g
67	Raquel		F	11	6-Jan-95	D	Hunter	654497	4373989	0316g	0350g
67	Raquel		F	11	15-Jun-95	T	Hunter	652248	4371479	0354g	0350g
67	Raquel		F	12	5-Jan-96	D	Hunter	653656	4372185	0354g	0350g
67	Raquel		F	12	12-Jul-96	T	Hunter	654601	4372390	0354g	0350g
67	Raquel		F	13	3-Mar-97	D	Hunter	652862	4371798	0354g	0350g
67	Raquel		F	14	3-Jan-98	D	Hunter	652966	4374316	0354g	0350g

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
67	Raquel		F	14	1-Sep-98	X	Hunter	.	.	0354g	0350g
68	Bonnie		F	5	28-Jun-93	T	Hunter	663609	4373011	0326g	0337g
68	Bonnie		F	6	23-Sep-94	X	Hunter	.	.	0326g	0337g
69	Clyde		M	3	28-Jun-93	T	No Data	663844	4375102	0321w	0322w
70	Rocky		M	6	29-Jun-93	T	No Data	652144	4374343	0317w	0318w
71	Penta-Wu		M	2	29-Jun-93	T	No Data	643601	4370210	0319w	0320w
71	Penta-Wu		M	3	8-Jul-94	T	No Data	645895	4367881	0319w	0320w
72	Delbert		M	3	29-Jun-93	T	No Data	643729	4366988	0338w	0348w
73	DirtyHarry		M	2	1-Jul-93	T	Hunter	653075	4368576	0340w	0341w
73	DirtyHarry		M	4	10-Jun-95	T	Hunter	654475	4374799	0340w	0341w
73	DirtyHarry		M	11	2-Sep-02	X	Hunter	.	.	0340w	0341w
74	Shaque		M	7	12-Jul-93	T	No Data	652990	4367222	0314w	0316w
75	George		M	2	15-Jul-93	T	Hunter	651591	4368622	0313w	0315w
75	George		M	2	19-Jul-93	T	Hunter	654754	4368049	0313w	0315w
75	George		M	3	11-Jun-94	T	Hunter	656206	4367040	0313w	0315w
75	George		M	3	8-Sep-94	X	Hunter	.	.	0313w	0315w
76	Belle		F	3	16-Jul-93	T	Depredation	646666	4367838	0315g	0318g
76	Belle		F	4	27-Feb-94	D	Depredation	629046	4386452	0315g	0345g
76	Belle		F	4	14-Jul-94	T	Depredation	643601	4370210	0315g	0345g
76	Belle		F	5	3-Mar-95	D	Depredation	626868	4386967	0315g	0345g
76	Belle		F	6	5-Mar-96	D	Depredation	630743	4378432	0315g	0345g
76	Belle		F	7	4-Mar-97	D	Depredation	627122	4374705	0375g	0345g
76	Belle		F	8	5-Jan-98	D	Depredation	628706	4378995	0375g	0345g
76	Belle		F	9	12-Jun-99	X	Depredation	.	.	0375g	0345g
77	Goliath		M	13	16-Jul-93	T	No Data	642472	4367288	0369w	0368w
78	Jean-Marc		M	6	18-Jul-93	T	Hunter	642472	4367288	0367w	0366w
78	Jean-Marc		M	13	1-Sep-00	X	Hunter	.	.	0367w	0366w
79	R.K.		M	6	1-Aug-93	T	Vehicle	656280	4370491	0323w	0312w
79	R.K.		M	13	13-Sep-00	X	Vehicle	.	.	0323w	0312w
80	Baloo	Xina	M	0	26-Feb-94	ND	Hunter	649832	4382017	no tag	no tag
80	Baloo	Xina	M	1	5-Jan-95	D	Hunter	650119	4382431	0336w	0327w
80	Baloo	Xina	M	4	1-Sep-98	X	Hunter	.	.	0336w	0327w
81	Brock	Xina	M	0	26-Feb-94	ND	Cub Loss	649832	4382017	no tag	no tag
82	Wendis	Jane	F	0	28-Feb-94	ND	No Data	639488	4383536	no tag	no tag
82	Wendis	Jane	F	1	25-Feb-95	D	No Data	648090	4383538	0348g	0344g
83	Escape	Jane	M	0	28-Feb-94	ND	Hunter	639488	4383536	no tag	no tag
83	Escape	Jane	M	1	25-Feb-95	D	Hunter	648090	4383538	0343w	0325w
83	Escape	Jane	M	3	20-Sep-97	X	Hunter	.	.	0343w	0325w
84	Speedy	Jane	M	0	28-Feb-94	ND	Depredation	639488	4383536	no tag	no tag
84	Speedy	Jane	M	1	25-Feb-95	D	Depredation	648090	4383538	0328w	0337w
84	Speedy	Jane	M	6	28-Jul-00	X	Depredation	.	.	0328w	0337w
85	Derek	Belle	M	0	27-Feb-94	ND	Cub Loss	629046	4386452	no tag	no tag
86	Frosty	Belle	M	0	27-Feb-94	ND	Cub Loss	629046	4386452	no tag	no tag
87	Buffy	Raquel	F	0	2-Mar-94	ND	Cub Loss	652958	4374912	no tag	no tag
88	Ryan	Lisa	M	0	3-Mar-94	ND	No Data	654781	4369286	no tag	no tag
89	Lacey	Lisa	F	0	3-Mar-94	ND	No Data	654781	4369286	no tag	no tag
90	Wanbli	Nenie	M	0	11-Mar-94	ND	No Data	659806	4366580	no tag	no tag
91	Sjaastad	Heidi	M	0	12-Mar-94	ND	Cub Loss	641440	4356411	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
92	Kenny		M	1	5-Jun-94	T	Hunter	655239	4365547	0326w	0329w
92	Kenny		M	1	13-Jun-94	T	Hunter	652990	4367222	0326w	0329w
92	Kenny		M	1	22-Jun-94	T	Hunter	661532	4376458	0326w	0329w
92	Kenny		M	1	11-Jul-94	T	Hunter	656421	4368361	0326w	0329w
92	Kenny		M	3	23-Jul-96	T	Hunter	656280	4370491	0326w	0329w
92	Kenny		M	3	22-Sep-96	X	Hunter	.	.	0326w	0329w
93	Hershey		M	2	6-Jun-94	T	Depredation	645895	4367881	0331w	0330w
93	Hershey		M	2	23-Jun-94	T	Depredation	646666	4367838	0331w	0330w
93	Hershey		M	2	27-Jun-94	T	Depredation	645895	4367881	0331w	0330w
93	Hershey		M	2	19-Jul-94	X	Depredation	.	.	0331w	0330w
94	Taylor		M	3	8-Jun-94	T	No Data	659676	4368707	0344w	0324w
94	Taylor		M	3	10-Jun-94	T	No Data	660695	4368614	0344w	0324w
94	Taylor		M	3	29-Jul-94	T	No Data	658507	4367965	0344w	0324w
95	Joel		M	.	9-Jun-94	T	No Data	643537	4364325	0210w	0215w
95	Joel		M	.	24-Jun-94	T	No Data	643729	4366988	0210w	0215w
95	Joel		M	.	7-Jul-94	T	No Data	641686	4367559	0210w	0215w
95	Joel		M	.	30-Jul-94	T	No Data	642472	4367288	0210w	0215w
96	Angel		F	4	10-Jun-94	T	Poach	665193	4373168	0304g	0305g
96	Angel		F	6	14-Jul-96	T	Poach	656280	4370491	0304g	0305g
96	Angel		F	8	14-Mar-98	D	Poach	654611	4367351	0304g	0305g
96	Angel		F	14	22-Sep-04	X	Poach	.	.	0304g	no tag
97	Bare		M	2	22-Jun-94	T	No Data	658507	4367965	0346w	0372w
97	Bare		M	2	26-Jun-94	T	No Data	655239	4365547	0346w	0372w
98	Hakeem		M	2	24-Jun-94	T	No Data	652248	4371479	0355w	0359w
99	Joseph		M	1	27-Jun-94	T	No Data	642472	4367288	0354w	0347w
99	Joseph		M	3	26-Jul-96	T	No Data	643960	4370850	0354w	0347w
100	Hyrum		M	1	27-Jun-94	T	Hunter	658507	4367965	0201w	0225w
100	Hyrum		M	1	22-Jul-94	T	Hunter	659676	4368707	0201w	0225w
100	Hyrum		M	2	17-Jun-95	T	Hunter	658162	4365660	0225w	0201w
100	Hyrum		M	5	30-Sep-98	X	Hunter	.	.	0225w	0201w
101	Hillary		F	17	28-Jun-94	T	Depredation	648378	4373796	0303g	0306g
101	Hillary		F	18	1-Mar-95	D	Depredation	649812	4381278	0303g	0306g
101	Hillary		F	18	17-Jun-95	T	Depredation	648556	4373082	0303g	0306g
101	Hillary		F	19	4-Jan-96	D	Depredation	647828	4375834	0303g	0306g
101	Hillary		F	19	25-Jul-96	T	Depredation	652144	4374343	0303g	0306g
101	Hillary		F	20	2-Mar-97	D	Depredation	647398	4375681	0303g	0306g
101	Hillary		F	21	7-Mar-98	D	Depredation	647006	4374943	0303g	0306g
101	Hillary		F	22	3-Jan-99	D	Depredation	647944	4374508	0303g	0306g
101	Hillary		F	23	4-Mar-00	D	Depredation	644410	4375460	0303g	0306g
101	Hillary		F	23	19-Mar-00	D	Depredation	644410	4375460	56g	66g
101	Hillary		F	23	8-Apr-00	D	Depredation	644410	4375460	56g	66g
101	Hillary		F	23	19-Apr-00	D	Depredation	644410	4375460	56g	66g
101	Hillary		F	23	29-Apr-00	D	Depredation	644410	4375460	56g	66g
101	Hillary		F	24	4-Jan-01	D	Depredation	646844	4375273	56g	66g
101	Hillary		F	26	21-Jun-03	X	Depredation	.	.	56g	66g
103	Erica		F	11	27-Jul-94	T	No Data	639849	4364108	0322g	0323g
103	Erica		F	11	6-Aug-94	T	No Data	642472	4367288	0322g	0323g
103	Erica		F	12	5-Jan-95	D	No Data	638627	4361146	0322g	0323g

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
103	Erica		F	12	28-Feb-95	D	No Data	.	.	0322g	0323g
103	Erica		F	12	15-Jun-95	T	No Data	642892	4363786	0322g	0323g
103	Erica		F	13	3-Mar-96	D	No Data	637681	4360456	0322g	0323g
103	Erica		F	14	5-Mar-97	D	No Data	635275	4359336	0322g	0323g
103	Erica		F	15	30-Jan-98	D	No Data	636716	4358578	0322g	0323g
103	Erica		F	16	13-Mar-99	D	No Data	641167	4362749	0322g	0323g
103	Erica		F	16	21-Nov-99	D	No Data	640255	4358519	0322g	0323g
103	Erica		F	17	11-Mar-00	D	No Data	641778	4361473	0322g	0323g
103	Erica		F	18	31-Mar-01	D	No Data	637651	4362057	0322g	0323g
104	Tatiana		F	1	27-Jul-94	T	Hunter	655239	4365547	0321g	0308g
104	Tatiana		F	2	23-Jun-95	T	Hunter	654754	4368049	0321g	0308g
104	Tatiana		F	8	10-Aug-01	T	Hunter	654162	4366584	64g sq	0308g
104	Tatiana		F	9	1-Mar-02	D	Hunter	653992	4365275	64g sq	0308g
104	Tatiana		F	10	4-Mar-03	D	Hunter	654302	4367157	64g sq	0308g
104	Tatiana		F	10	28-Aug-03	X	Hunter	.	.	64g sq	0308g
105	UncleNewt		M	26	29-Jul-94	T	No Data	654601	4372390	0362w	0342w
105	UncleNewt		M	28	6-Mar-96	D	No Data	.	.	0362w	0342w
106	Chris		M	2	30-Jul-94	T	No Data	643537	4364325	0353w	0351w
106	Chris		M	9	19-Jun-01	T	No Data	648499	4371248	0401y	0411y
107	Penelope		F	1	8-Aug-94	T	Hunter	652144	4374343	0331g	0347g
107	Penelope		F	2	12-Jun-95	T	Hunter	652144	4374343	0331g	0347g
107	Penelope		F	3	2-Mar-96	D	Hunter	650096	4376757	0331g	0347g
107	Penelope		F	4	2-Mar-97	D	Hunter	651540	4377995	0331g	0347g
107	Penelope		F	4	18-Jun-97	T	Hunter	654475	4374799	0331g	0347g
107	Penelope		F	5	3-Jan-98	D	Hunter	653036	4376218	0331g	0347g
107	Penelope		F	5	6-Mar-98	D	Hunter	.	.	0331g	0347g
107	Penelope		F	6	3-Jan-99	D	Hunter	650090	4378715	0331g	0347g
107	Penelope		F	9	6-Jul-02	T	Hunter	651949	4375476	0331g	0347g
107	Penelope		F	10	28-Feb-03	D	Hunter	649454	4385321	0331g	0347g
107	Penelope		F	11	2-Jan-04	D	Hunter	651749	4381011	0331g	0347g
107	Penelope		F	11	5-Mar-04	D	Hunter	651417	4381517	0331g	0347g
107	Penelope		F	11	29-Aug-04	X	Hunter	.	.	0331g	0347g
108	Morris	Cherylee	M	1	6-Jan-95	D	No Data	648259	4365445	0325w	0311w
109	PIN	Cherylee	F	1	6-Jan-95	D	No Data	648259	4365445	0335g	0349g
110	Reno	Raquel	M	0	6-Jan-95	ND	Hunter	654497	4373989	no tag	no tag
110	Reno	Raquel	M	1	5-Jan-96	D	Hunter	653656	4372185	0388w	0380w
110	Reno	Raquel	M	1	6-Jul-96	T	Hunter	654601	4372390	0388w	0380w
110	Reno	Raquel	M	1	9-Jul-96	T	Hunter	654475	4374799	0388w	0380w
110	Reno	Raquel	M	1	17-Jul-96	T	Hunter	654475	4374799	0388w	0380w
110	Reno	Raquel	M	1	29-Sep-96	X	Hunter	.	.	0388w	0380w
111	Angie	Raquel	F	0	6-Jan-95	ND	Cub Loss	654497	4373989	no tag	no tag
112	Laurs	Willow	M	0	26-Feb-95	ND	No Data	650288	4374366	no tag	no tag
112	Laurs	Willow	M	1	4-Jan-96	D	No Data	649533	4372896	0383w	0378w
113	Andy	Willow	M	0	26-Feb-95	ND	Cub Loss	650288	4374366	no tag	no tag
114	David	Bathsheba	M	0	25-Feb-95	ND	No Data	660365	4363900	no tag	no tag
114	David	Bathsheba	M	1	3-Jan-96	D	No Data	660132	4363171	0142w	0393w
114	David	Bathsheba	M	1	24-Jul-96	T	No Data	659676	4368707	0142w	0393w
115	Jeremy	Heidi	M	0	26-Feb-95	ND	Cub Loss	644701	4355211	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
116	Brooks	Heidi	M	0	26-Feb-95	ND	Cub Loss	644701	4355211	no tag	no tag
117	Leslie	Bucky	F	0	27-Feb-95	ND	Cub Loss	651865	4362113	no tag	no tag
118	Nick	Friday	M	0	28-Feb-95	ND	Cub Loss	637383	4358000	no tag	no tag
119	Mick	Friday	M	0	28-Feb-95	ND	Cub Loss	637383	4358000	no tag	no tag
120	Socks	Hillary	F	0	1-Mar-95	ND	Cub Loss	649812	4381278	no tag	no tag
121	Chelsea	Hillary	F	0	1-Mar-95	ND	Cub Loss	649812	4381278	no tag	no tag
122	Bill	Hillary	M	0	1-Mar-95	ND	Hunter	649812	4381278	no tag	no tag
122	Bill	Hillary	M	1	4-Jan-96	D	Hunter	647828	4375834	0136w	0386w
122	Bill	Hillary	M	9	.	X	Hunter	607957	4381258	0136w	0386w
123	PJ		M	1	13-Jun-95	T	No Data	655705	4368211	0397w	0143w
124	Soula		F	3	13-Jun-95	T	Poach	643960	4370850	0320g	0311g
124	Soula		F	3	24-Jun-95	T	Poach	640260	4372071	0320g	0311g
124	Soula		F	4	4-Mar-96	D	Poach	633109	4379740	0320g	0311g
124	Soula		F	5	1-Mar-97	D	Poach	638899	4370994	0320g	0311g
124	Soula		F	10	24-Jul-02	T	Poach	647638	4369325	0320g	0311g
124	Soula		F	11	8-Mar-03	D	Poach	639273	4375505	0320g	0311g
124	Soula		F	12	6-Mar-04	D	Poach	641553	4371120	0320g	0311g
124	Soula		F	12	27-Mar-04	D	Poach	641553	4371120	0320g	0311g
124	Soula		F	12	26-Aug-04	X	Poach	623762	4387586	0320g	0311g
125	Russ		M	2	25-Jun-95	T	No Data	658162	4365660	0400w	0399w
126	Zeus	Ma'am	M	1	6-Jan-96	D	Hunter	629252	4352504	0384w	0376w
126	Zeus	Ma'am	M	7	27-Sep-02	X	Hunter	.	.	0384w	0376w
127	Orion	Ma'am	M	1	6-Jan-96	D	No Data	629252	4352504	0379w	0382w
128	Maria	Fine	F	1	3-Mar-96	D	No Data	633404	4372452	0328g	0324g
129	Rob	Heidi	M	0	7-Mar-96	ND	Cub Loss	641316	4360429	no tag	no tag
130	Jen	Heidi	F	0	7-Mar-96	ND	Cub Loss	641316	4360429	no tag	no tag
131	Julie	Heidi	F	0	7-Mar-96	ND	No Data	641316	4360429	no tag	no tag
131	Julie	Heidi	F	1	4-Jan-97	D	No Data	644288	4353678	0370	0371
132	Cameron		M	3	7-Jul-96	T	No Data	658507	4367965	0211w	0385w
133	Daisy		F	3	7-Jul-96	T	Hunter	659122	4364390	0344g	0307g
133	Daisy		F	3	15-Jul-96	T	Hunter	659122	4364390	0344g	0307g
133	Daisy		F	3	23-Jul-96	T	Hunter	658162	4365660	0344g	0307g
133	Daisy		F	7	16-Sep-00	X	Hunter	.	.	0344g	0307g
134	Orson		M	2	7-Jul-96	T	No Data	643601	4370210	0392w	0377w
134	Orson		M	2	14-Jul-96	T	No Data	648378	4373796	0392w	0377w
134	Orson		M	2	15-Jul-96	T	No Data	648556	4373082	0392w	0377w
135	Kathryn		F	3	7-Jul-96	T	No Data	648378	4373796	0352g	0353g
135	Kathryn		F	9	7-Aug-02	T	No Data	648499	4371248	0352g	0353g
136	BoyWonder		M	3	8-Jul-96	T	No Data	643960	4370850	0394w	0389w
136	BoyWonder		M	8	13-Jul-01	T	No Data	648499	4371248	0404y	0405y
137	Carmax		M	2	8-Jul-96	T	Hunter	645895	4367881	0222w	0223w
137	Carmax		M	2	11-Jul-96	T	Hunter	646666	4367838	0222w	0223w
137	Carmax		M	2	21-Jul-96	T	Hunter	646666	4367838	0222w	0223w
137	Carmax		M	2	25-Jul-96	T	Hunter	645895	4367881	0222w	0223w
137	Carmax		M	3	5-Sep-97	X	Hunter	.	.	0222w	0223w
138	Grn.Lantern		M	2	11-Jul-96	T	No Data	659676	4368707	0144w	0145w
138	Grn.Lantern		M	3	22-Jun-97	T	No Data	654475	4374799	0144w	0145w
139	Duke		M	3	11-Jul-96	T	Hunter	658507	4367965	0398w	0390w

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
139	Duke		M	5	12-Sep-98	X	Hunter	.	.	0398w	0390w
140	Jackson		M	2	12-Jul-96	T	No Data	652248	4371479	0391w	0396w
140	Jackson		M	5	5-Jul-99	T	No Data	649232	4367345	0391w	0396w
141	Dwight		M	5	14-Jul-96	T	No Data	655705	4368211	0135w	0134w
141	Dwight		M	5	20-Jul-96	T	No Data	651246	4367847	0135w	0134w
141	Dwight		M	6	22-Jun-97	T	No Data	655239	4365547	0135w	0137w
142	Clay-Grizz		M	13	16-Jul-96	T	No Data	654601	4372390	0128w	0129w
142	Clay-Grizz		M	13	21-Jul-96	T	No Data	643601	4370210	0128w	0129w
143	Dante		M	4	16-Jul-96	T	No Data	645895	4367881	0127w	0126w
144	Chf.W.heart		M	2	17-Jul-96	T	Hunter	642892	4363786	0138w	0139w
144	Chf.W.heart		M	2	22-Jul-96	T	Hunter	646666	4367838	0138w	0139w
144	Chf.W.heart		M	5	1-Jul-99	T	Hunter	647388	4367645	0138w	0139w
144	Chf.W.heart		M	7	29-Sep-01	X	Hunter	.	.	0138w	0139w
145	Makell		F	5	25-Jul-96	T	Hunter	642892	4363786	0346g	0336g
145	Makell		F	6	4-Jan-97	D	Hunter	647526	4358026	0346g	0336g
145	Makell		F	6	16-Mar-97	D	Hunter	647526	4358026	0346g	0336g
145	Makell		F	7	7-Mar-98	D	Hunter	644702	4355211	0346g	0336g
145	Makell		F	8	10-Sep-00	X	Hunter	.	.	0346g	0336g
146	cub1	Xina	M	0	1-Mar-97	ND	Cub Loss	655250	4384225	no tag	no tag
147	cub2	Xina	M	0	1-Mar-97	ND	Cub Loss	655250	4384225	no tag	no tag
148	cub3	Xina	M	0	1-Mar-97	ND	Cub Loss	655250	4384225	no tag	no tag
149	Misha	Penelope	F	0	2-Mar-97	ND	Cub Loss	651540	4377995	no tag	no tag
150	Al	Penelope	M	0	2-Mar-97	ND	Cub Loss	651540	4377995	no tag	no tag
151	Karren	Willow	F	0	3-Mar-97	ND	No Data	649641	4372638	no tag	no tag
151	Karren	Willow	F	1	4-Jan-98	D	No Data	649689	4375127	0390g	0391g
151	Karren	Willow	F	4	12-Aug-01	T	No Data	654080	4372789	no tag	0391g
151	Karren	Willow	F	5	21-Mar-02	D	No Data	653242	4374627	no tag	0391g
151	Karren	Willow	F	6	28-Feb-03	D	No Data	652320	4374237	0308w sq	0391g
151	Karren	Willow	F	7	7-Mar-04	D	No Data	652974	4375564	0308w sq	0391g
152	Damon	Raquel	M	0	3-Mar-97	ND	No Data	652862	4371798	0039b	0045b
152	Damon	Raquel	M	1	3-Jan-98	D	No Data	652966	4374316	0039b	0045b
153	Otis	Raquel	M	0	3-Mar-97	ND	Cub Loss	652862	4371798	no tag	no tag
154	cub4	Belle	M	0	4-Mar-97	ND	Cub Loss	627122	4374705	no tag	no tag
155	Kendra	Belle	F	0	4-Mar-97	ND	No Data	627122	4374705	no tag	no tag
155	Kendra	Belle	F	1	5-Jan-98	D	No Data	628706	4378995	0046b	0044b
156	Spiderman	Allyson	M	0	4-Mar-97	ND	No Data	640402	4369323	no tag	no tag
156	Spiderman	Allyson	M	1	6-Mar-98	D	No Data	640342	4368936	0035b	0041b
157	Hideout	Allyson	M	0	4-Mar-97	ND	No Data	640402	4369323	no tag	no tag
157	Hideout	Allyson	M	1	6-Mar-98	D	No Data	640342	4368936	no tag	no tag
158	cub5	Erica	M	0	5-Mar-97	ND	Cub Loss	635275	4359336	no tag	no tag
159	Enticer	Erica	M	0	5-Mar-97	ND	No Data	635275	4359336	no tag	no tag
159	Enticer	Erica	M	1	30-Jan-98	D	No Data	636716	4358578	0047o	0043b
160	cub6	Nenie	M	0	5-Mar-97	ND	Cub Loss	663167	4368761	no tag	no tag
161	Megan	Fine	F	0	6-Mar-97	ND	No Data	639210	4369569	no tag	no tag
161	Megan	Fine	F	1	4-Jan-98	D	No Data	639446	4368623	0343g	0396g
162	Brent	Fine	M	0	6-Mar-97	ND	No Data	639210	4369569	no tag	no tag
162	Brent	Fine	M	1	4-Jan-98	D	No Data	639446	4368623	0356w	0107w
163	Mariah	Bathsheba	F	0	15-Mar-97	ND	Collared	.	.	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
163	Mariah	Bathsheba	F	1	3-Jan-98	D	Collared	.	.	0397o	0400o
163	Mariah	Bathsheba	F	2	9-Jun-99	T	Collared	659070	4368414	0397g	0400g
163	Mariah	Bathsheba	F	5	24-Jun-02	T	Collared	662939	4369661	0397g	0400g
163	Mariah	Bathsheba	F	6	4-Jan-03	D	Collared	663423	4368622	0397g	0400g
163	Mariah	Bathsheba	F	6	3-Mar-03	D	Collared	.	.	0397g	0400g
163	Mariah	Bathsheba	F	7	13-Mar-04	D	Collared	662924	4368771	0397g	0400g
164	Jeanette	Bathsheba	F	0	15-Mar-97	ND	Research	.	.	no tag	no tag
164	Jeanette	Bathsheba	F	1	3-Jan-98	D	Research	.	.	0360g	0356g
164	Jeanette	Bathsheba	F	2	15-Jun-99	T	Research	657220	4364232	0360g	0363g
164	Jeanette	Bathsheba	F	2	15-Jun-99	X	Research	.	.	0360g	0363g
165	Brad		M	3	6-Jun-97	T	No Data	643960	4370850	0358w	0352w
166	Sparky		M	4	6-Jun-97	T	No Data	642892	4363786	0119w	0387w
167	Karl		M	.	6-Jun-97	T	No Data	658162	4365660	0339g	0332g
168	Skippy		M	3	7-Jun-97	T	No Data	643537	4364325	0375g	0374g
169	Stockton		M	2	8-Jun-97	T	No Data	658162	4365660	0325g	0301g
169	Stockton		M	2	26-Jun-97	T	No Data	659122	4364390	0325g	0301g
170	Lazarus		M	4	13-Jun-97	T	No Data	658162	4365660	0036o	0035o
170	Lazarus		M	8	30-Jul-01	T	No Data	657000	4367158	0036o	57g sq
170	Lazarus		M	9	3-Jul-02	T	No Data	653212	4369253	0036o	57g sq
171	Eva		F	3	16-Jun-97	T	No Data	659122	4364390	0329g	0338g
172	Chica		F	3	16-Jun-97	T	Collared	656280	4370491	0373g	0372g
172	Chica		F	7	30-Jul-01	T	Collared	658507	4367965	0373g	0372g
172	Chica		F	8	1-Mar-02	D	Collared	659768	4370601	0373g	0372g
172	Chica		F	9	3-Mar-03	D	Collared	658341	4369588	0373g	0372g
172	Chica		F	10	12-Mar-04	D	Collared	659348	4372055	0373g	0372g
173	Risa	Angel	F	1	14-Mar-98	D	Hunter	654611	4367351	0288g	0309g
173	Risa	Angel	F	5	23-Aug-03	X	Hunter	.	.	0288g	0309g
174	Jenna	Angel	F	1	14-Mar-98	D	No Data	654611	4367351	0389g	0342g
174	Jenna	Angel	F	2	30-Jun-99	T	No Data	652300	4367261	0389g	0383g
175	Aspen	Penelope	F	0	6-Mar-98	ND	No Data	.	.	no tag	no tag
175	Aspen	Penelope	F	1	3-Jan-99	D	No Data	650090	4378715	0357g	0387g
175	Aspen	Penelope	F	1	27-Jun-99	T	No Data	654475	4374799	0357g	0387g
175	Aspen	Penelope	F	3	29-Jul-01	T	No Data	652567	4377585	0357g	0387g
175	Aspen	Penelope	F	4	11-Jun-02	T	No Data	654475	4374799	0357g	0387g
176	Oaks	Penelope	M	0	6-Mar-98	ND	Hunter	.	.	no tag	no tag
176	Oaks	Penelope	M	1	3-Jan-99	D	Hunter	650090	4378715	0399g	0392g
176	Oaks	Penelope	M	3	30-Jun-01	T	Hunter	651331	4376055	0399g	0392g
176	Oaks	Penelope	M	4	24-Sep-02	X	Hunter	.	.	0399g	0392g
177	Annie	Hillary	F	0	7-Mar-98	ND	No Data	647006	4374943	no tag	no tag
177	Annie	Hillary	F	1	3-Jan-99	D	No Data	647944	4374508	0378g	0376g
177	Annie	Hillary	F	3	13-Jun-01	T	No Data	645201	4368138	0378g	0376g
177	Annie	Hillary	F	3	13-Jul-01	T	No Data	643601	4370210	0378g	0376g
177	Annie	Hillary	F	4	2-Aug-02	T	No Data	646666	4367838	0378g	0376g
177	Annie	Hillary	F	4	.	D	No Data	648642	4377338	0378g	0376g
177	Annie	Hillary	F	5	.	D	No Data	646838	4375292	0378g	0376g
178	Cati	Hillary	F	0	7-Mar-98	ND	No Data	647006	4374943	no tag	no tag
178	Cati	Hillary	F	1	3-Jan-99	D	No Data	647944	4374508	0379g	0380g
179	cub8	Makell	M	0	7-Mar-98	ND	No Data	644702	4355211	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
180	cub7	Makell	F	0	7-Mar-98	ND	No Data	644702	4355211	no tag	no tag
181	cub9	Heidi	F	0	8-Mar-98	ND	Cub Loss	644008	4354297	no tag	no tag
182	Nod	Heidi	M	0	8-Mar-98	ND	No Data	644008	4354297	no tag	no tag
182	Nod	Heidi	M	1	25-Jan-99	D	No Data	642448	4361204	0364g	0044o
182	Nod	Heidi	M	1	4-Jul-99	T	No Data	644394	4366009	0364g	0044o
182	Nod	Heidi	M	1	5-Jul-99	T	No Data	643537	4364325	0364g	0044o
182	Nod	Heidi	M	1	10-Jul-99	T	No Data	642892	4363786	0364g	0044o
183	cub10	S.Skunkback	F	0	9-Mar-98	ND	Cub Loss	658708	4359809	no tag	no tag
184	cub11	S.Skunkback	F	0	9-Mar-98	ND	Cub Loss	658708	4359809	no tag	no tag
185	cub12	Willow	M	0	26-Feb-99	ND	No Data	648426	4371107	no tag	no tag
186	cub13	Xina	F	0	26-Feb-99	ND	Cub Loss	656706	4382021	no tag	no tag
187	cub14	Xina	F	0	26-Feb-99	ND	Cub Loss	656706	4382021	no tag	no tag
188	cub15	Xina	F	0	26-Feb-99	ND	Cub Loss	656706	4382021	no tag	no tag
189	cub16	Xina	M	0	26-Feb-99	ND	Cub Loss	656706	4382021	no tag	no tag
190	cub17	Fine	M	0	27-Feb-99	ND	No Data	638248	4367755	no tag	no tag
191	cub18	Fine	M	0	27-Feb-99	ND	No Data	638248	4367755	no tag	no tag
192	cub19	Fine	M	0	27-Feb-99	ND	No Data	638248	4367755	no tag	no tag
193	McClane	Erica	M	0	13-Mar-99	ND	Hunter	641167	4362749	no tag	no tag
193	McClane	Erica	M	1	11-Mar-00	D	Hunter	641778	4361473	0438y	0441y
193	McClane	Erica	M	2	1-Jun-01	T	Hunter	642892	4363786	0438y	0441y
193	McClane	Erica	M	2	28-Sep-01	X	Hunter	.	.	0438y	0441y
194	McKenzie	Erica	F	0	13-Mar-99	ND	No Data	641167	4362749	no tag	no tag
194	McKenzie	Erica	F	1	11-Mar-00	D	No Data	641778	4361473	0437y	0442y
195	Candy		F	5	3-Jun-99	T	No Data	662975	4376705	0030o	0037o
195	Candy		F	6	5-Mar-00	D	No Data	662647	4376719	0423y	0037o
195	Candy		F	7	9-Mar-01	D	No Data	664049	4375658	0443y	0037o
195	Candy		F	8	2-Mar-02	D	No Data	663462	4374765	0443y	0037o
195	Candy		F	8	19-Jun-02	T	No Data	661375	4375216	0443y	0037o
196	Helmet		M	5	5-Jun-99	T	Hunter	662975	4376705	0024b	0037b
196	Helmet		M	6	4-Sep-00	X	Hunter	.	.	0024b	0037b
197	Mona		F	2	8-Jun-99	T	Hunter	662939	4369661	0393g	0394g
197	Mona		F	5	3-Sep-02	X	Hunter	.	.	0393g	0394g
198	Cleft		M	19	9-Jun-99	T	No Data	664308	4374988	116o	121o
198	Cleft		M	19	17-Sep-99	S	No Data	.	.	116o	121o
199	Remus		M	2	13-Jun-99	T	Hunter	662939	4369661	0148y	0145y
199	Remus		M	5	28-Sep-02	X	Hunter	.	.	0148y	0145y
200	Foreman		M	2	15-Jun-99	T	Hunter	656356	4366162	0033o	0048o
200	Foreman		M	2	3-Sep-99	X	Hunter	.	.	0033o	0048o
201	Mohawk		M	2	15-Jun-99	T	Hunter	663313	4370404	0239y	0238y
201	Mohawk		M	2	17-Sep-99	X	Hunter	.	.	0239y	0238y
202	Woodstock		M	2	15-Jun-99	T	No Data	661873	4368917	0146y	0147y
203	Cashew		F	4	21-Jun-99	T	Natural	663313	4370404	0395g	0398g
203	Cashew		F	5	4-Mar-00	D	Natural	662994	4369100	0395g	0448g
203	Cashew		F	5	1-Aug-00	X	Natural	.	.	0395g	0448g
204	MochaWapiti		M	2	25-Jun-99	T	Hunter	661873	4368917	120o	0366g
204	MochaWapiti		M	3	5-Sep-00	X	Hunter	.	.	120o	0366g
205	Nivarre		M	2	28-Jun-99	T	Depredation	651246	4367847	0361g	0365w
205	Nivarre		M	4	12-Jun-01	X	Depredation	.	.	0361g	0365w

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
206	Hegotaway		M	.	2-Jul-99	T	No Data	643729	4366988	no tag	no tag
207	Delphi		F	3	2-Jul-99	T	Hunter	652990	4367222	0369g	0367g
207	Delphi		F	6	19-Aug-02	T	Hunter	651246	4367847	0369g	0367g
207	Delphi		F	6	24-Aug-02	X	Hunter	.	.	0369g	0367g
208	Twilight		F	3	2-Jul-99	T	No Data	651246	4367847	0358g	0330g
208	Twilight		F	3	29-Jul-99	T	No Data	649232	4367345	0358g	0330g
208	Twilight		F	5	16-Jun-01	T	No Data	646666	4367838	0358g	0330g
208	Twilight		F	5	30-Jul-01	T	No Data	646666	4367838	0358g	0330g
208	Twilight		F	6	28-Feb-02	D	No Data	648264	4365952	0358g	0330g
208	Twilight		F	7	9-Mar-03	D	No Data	648534	4366877	0358g	0330g
209	Caesar		M	5	3-Jul-99	T	Hunter	640685	4368124	0039o	0040o
209	Caesar		M	6	27-Aug-00	X	Hunter	.	.	0039o	0040o
210	Fugitive		M	4	10-Jul-99	T	Hunter	638027	4363743	0426y	0427y
210	Fugitive		M	7	18-Jul-02	T	Hunter	659070	4368414	0426y	0427y
210	Fugitive		M	8	24-Aug-03	X	Hunter	.	.	0426y	0427y
211	Geronimo		M	2	25-Jul-99	T	No Data	645201	4368138	0428y	0429y
211	Geronimo		M	4	27-Jun-01	T	No Data	640685	4368124	0420y	0421y
212	Diablo		M	3	27-Jul-99	T	Hunter	648499	4371248	0430y	0431y
212	Diablo		M	6	2-Sep-02	X	Hunter	.	.	0430y	0431y
213	Obelix		M	5	28-Jul-99	T	No Data	643729	4366988	0449y	0450y
214	Eben		M	2	29-Jul-99	T	No Data	654475	4374799	0432y	0433y
214	Eben		M	5	7-Jul-02	T	No Data	658027	4370441	0432y	0433y
215	Finale		M	2	1-Aug-99	T	Hunter	651246	4367847	0434y	0435y
215	Finale		M	2	27-Aug-99	X	Hunter	.	.	0434y	0435y
216	cub20	Cashew	M	0	4-Mar-00	ND	Cub Loss	662994	4369100	no tag	no tag
217	cub21	Cashew	M	0	4-Mar-00	ND	Cub Loss	662994	4369100	no tag	no tag
218	S.Willy	Hillary	M	0	4-Mar-00	ND	No Data	644410	4375460	no tag	no tag
218	S.Willy	Hillary	M	0	19-Mar-00	ND	No Data	644410	4375460	no tag	no tag
218	S.Willy	Hillary	M	0	8-Apr-00	ND	No Data	644410	4375460	no tag	no tag
218	S.Willy	Hillary	M	0	19-Apr-00	ND	No Data	644410	4375460	no tag	no tag
218	S.Willy	Hillary	M	1	4-Jan-01	D	No Data	646844	4375273	0439y	0446y
219	cub22	Heidi	F	0	11-Mar-00	ND	Cub Loss	641044	4357747	no tag	no tag
219	cub22	Heidi	F	0	1-Aug-00	X	Cub Loss	.	.	no tag	no tag
220	cub23	Heidi	F	0	11-Mar-00	ND	Cub Loss	641044	4357747	no tag	no tag
220	cub23	Heidi	F	0	1-Aug-00	X	Cub Loss	.	.	no tag	no tag
221	Coalville		M	2	3-Jun-01	T	No Data	641636	4368267	0368g	0384g
221	Coalville		M	2	26-Jul-01	T	No Data	659070	4368414	0368g	0384g
221	Coalville		M	3	10-Jun-02	T	No Data	654162	4366584	0368g	0384g
221	Coalville		M	3	22-Jun-02	T	No Data	660695	4368614	0368g	0384g
222	Fozzy		M	4	4-Jun-01	T	No Data	642892	4363786	0043o	115o
223	Tino		M	4	4-Jun-01	T	Hunter	640685	4368124	0382g	0377g
223	Tino		M	4	14-Jun-01	T	Hunter	644330	4366888	0382g	0377g
223	Tino		M	4	28-Jun-01	T	Hunter	643537	4364325	0382g	0377g
223	Tino		M	4	11-Jul-01	T	Hunter	646666	4367838	0382g	0377g
223	Tino		M	5	24-Aug-02	X	Hunter	.	.	0382g	0377g
224	Sage		F	6	12-Jun-01	T	No Data	640685	4368124	103o	104o
224	Sage		F	6	16-Jun-01	T	No Data	639720	4367088	103o	104o
224	Sage		F	7	2-Mar-02	D	No Data	638716	4367487	103o	104o

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
224	Sage		F	7	19-Jul-02	T	No Data	642472	4367288	103o	104o
225	Snow		F	4	13-Jun-01	T	No Data	643960	4370850	0050o	0045o
226	Holyfield		F	4	14-Jun-01	T	No Data	637984	4367881	0038o	125o
226	Holyfield		F	5	2-Mar-02	D	No Data	623626	4371037	0038o	125o
226	Holyfield		F	6	7-Mar-03	D	No Data	624932	4371095	0038o	125o
227	Jeffs		F	2	16-Jun-01	T	No Data	648706	4370505	0355g	0365g
227	Jeffs		F	2	9-Aug-01	T	No Data	651246	4367847	0355g	0365g
228	Jag		M	2	17-Jun-01	T	No Data	645201	4368138	0361w	0362g
228	Jag		M	2	15-Jul-01	T	No Data	646666	4367838	0361w	0362g
229	Brazil		F	6	18-Jun-01	T	No Data	643000	4367316	0425y	0381g
229	Brazil		F	6	30-Jun-01	T	No Data	641636	4368267	0425y	0381g
231	RostraRippus		F	2	19-Jun-01	T	Hunter	644330	4366888	0422y	0408y
231	RostraRippus		F	2	28-Jun-01	T	Hunter	645201	4368138	0422y	0408y
231	RostraRippus		F	3	15-Aug-02	T	Hunter	642892	4363786	0422y	0408y
231	RostraRippus		F	4	20-Sep-03	X	Hunter	.	.	0422y	0408y
232	Rompun		M	2	19-Jun-01	T	No Data	643601	4370210	0410y	0409y
234	Murray		M	9	27-Jun-01	T	No Data	643960	4370850	0402y	0403y
236	Lyndsey		F	1	14-Jul-01	T	No Data	652567	4377585	0447y	0440y
236	Lyndsey		F	1	27-Jul-01	T	No Data	651331	4376055	0447y	0440y
236	Lyndsey		F	1	9-Aug-01	T	No Data	652431	4379010	0447y	0440y
236	Lyndsey		F	1	15-Aug-01	T	No Data	.	.	0447y	0440y
238	Eb(Ebony)		M	4	18-Jul-01	T	No Data	658507	4367965	0419y	0417y
239	Pacer		M	3	24-Jul-01	T	No Data	648706	4370505	0406y	0407y
240	Patches		M	2	26-Jul-01	T	Hunter	643000	4367316	0416y	0412y
240	Patches		M	3	29-Aug-02	X	Hunter	.	.	0416y	0412y
241	MollyMohawk		F	2	26-Jul-01	T	No Data	659122	4364390	71g sq	73g sq
242	Brian-Albert		M	3	29-Jul-01	T	Hunter	640685	4368124	52g sq	65g sq
242	Brian-Albert		M	5	29-May-03	X	Hunter	.	.	52g sq	65g sq
243	Colleen		F	3	30-Jul-01	T	Hunter	658162	4365660	75g sq	53g sq
243	Colleen		F	4	2-Jul-02	T	Hunter	655075	4364395	75g sq	53g sq
243	Colleen		F	5	2-Mar-03	D	Hunter	654454	4358561	75g sq	53g sq
243	Colleen		F	6	13-Mar-04	D	Hunter	655980	4360924	75g sq	53g sq
243	Colleen		F	6	18-Sep-04	X	Hunter	.	.	75g sq	53g sq
244	Mari	Willow	F	0	10-Aug-01	T	No Data	648706	4370505	69g sq	70g sq
244	Mari	Willow	F	0	28-Dec-01	D	No Data	649816	4374873	69g sq	70g sq
244	Mari	Willow	F	1	19-Aug-02	T	No Data	652248	4371479	69g sq	0393w sq
244	Mari	Willow	F	1	20-Aug-02	T	No Data	648770	4372018	69g sq	0393w sq
245	Unk Soldier#5		M	8	11-Aug-01	T	Hunter	662939	4369661	59g sq	61g sq
245	Unk Soldier#5		M	9	2-Sep-02	X	Hunter	.	.	59g sq	61g sq
246	cub26	Heidi	M	0	4-Mar-02	ND	Cub Loss	642148	4353907	no tag	no tag
247	Theodore		M	3	6-Jun-02	T	No Data	659122	4364390	54g sq	55g sq
247	Theodore		M	3	6-Jul-02	T	No Data	659070	4368414	54g sq	55g sq
247	Theodore		M	3	18-Jul-02	T	No Data	658507	4367965	54g sq	55g sq
248	Spit		M	9	10-Jun-02	T	No Data	662975	4376705	68g sq	60g sq
249	Beast		M	8	12-Jun-02	T	No Data	659070	4368414	72g sq	no tag
250	OliveOyle		F	2	13-Jun-02	T	Depredation	649232	4367345	0346w sq	0343w sq
250	OliveOyle		F	2	22-Jun-02	T	Depredation	649232	4367345	0346w sq	0343w sq

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
250	OliveOyle		F	2	20-Sep-02	X	Depredation	.	.	0346w sq	0343w sq
251	Rainer		M	12	19-Jun-02	T	No Data	662617	4374245	0347w sq	0345w sq
252	Stomp		M	5	21-Jun-02	T	Hunter	658162	4365660	0341w sq	0342w sq
252	Stomp		M	5	3-Jul-02	T	Hunter	654754	4368049	0341w sq	0342w sq
252	Stomp		M	5	10-Oct-02	X	Hunter	.	.	0341w sq	0342w sq
253	Boden		M	8	22-Jun-02	T	No Data	659070	4368414	0331w sq	0330w sq
253	Boden		M	8	5-Jul-02	T	No Data	654162	4366584	0331w sq	0330w sq
254	Slider		M	2	22-Jun-02	T	No Data	652567	4377585	0332w sq	0333w sq
254	Slider		M	2	17-Jul-02	T	No Data	651949	4375476	0332w sq	0333w sq
254	Slider		M	2	18-Jul-02	T	No Data	652567	4377585	0332w sq	0333w sq
255	Triumph		M	4	23-Jun-02	T	No Data	652144	4374343	0339w sq	0338w sq
256	PeanutButter		F	3	24-Jun-02	T	No Data	655075	4364395	0337w sq	0336w sq
257	Chewy		M	5	24-Jun-02	T	No Data	658020	4372404	0335w sq	0334w sq
258	Biff		M	15	17-Jul-02	T	No Data	647388	4367645	0387w sq	0344w sq
259	TinyTim		M	.	18-Jul-02	T	No Data	648499	4371248	0309w sq	0328w sq
259	TinyTim		M	.	4-Aug-02	T	No Data	649067	4368145	0309w sq	0328w sq
259	TinyTim		M	.	5-Aug-02	T	No Data	647638	4369325	0309w sq	0328w sq
260	Unk Soldier#6		M	9	19-Jul-02	T	No Data	643601	4370210	0388w sq	0327w sq
261	Unk Soldier#7		M	10	22-Jul-02	T	Research	642472	4367288	.	.
261	Unk Soldier#7		M	10	22-Jul-02	X	Research	.	.	.	.
262	MsTJ		F	1	31-Jul-02	T	No Data	648499	4371248	0340w sq	0321w sq
262	MsTJ		F	1	14-Aug-02	T	No Data	647388	4367645	0340w sq	0321w sq
262	MsTJ		F	1	15-Aug-02	T	No Data	647638	4369325	0340w sq	0321w sq
262	MsTJ		F	1	19-Aug-02	T	No Data	648770	4372018	0340w sq	0321w sq
263	Crystal		F	5	4-Aug-02	T	No Data	643729	4366988	0323w sq	0322w sq
263	Crystal		F	5	7-Aug-02	T	No Data	643000	4367316	0323w sq	0322w sq
264	Zorro		M	10	14-Aug-02	T	No Data	639234	4364058	0324w sq	0326w sq
265	Rupert		M	1	17-Aug-02	T	No Data	651591	4368622	0378w sq	0390w sq
266	Wisc.-Davison		M	.	21-Aug-02	T	No Data	642472	4367288	0394w sq	0395w sq
267	Friday's Yrlg.	Friday	U	0	13-Sep-91	S	No Data	.	.	no tag	no tag
267	Friday's Yrlg.	Friday	U	1	20-Mar-92	D	No Data	.	.	no tag	no tag
268	Miniosa	Allyson	F	1	27-Dec-01	D	No Data	641430	4369497	062g	063g
269	Chipeta	Chica	F	0	3-Mar-03	ND	Collared	658341	4369588	no tag	no tag
269	Chipeta	Chica	F	1	12-Mar-04	D	Collared	659348	4372055	0391w	0396w
270	cub30	Chica	U	0	3-Mar-03	ND	Cub Loss	658341	4369588	no tag	no tag
271	cub31	Tatiana	F	0	4-Mar-03	ND	Cub Loss	654302	4367157	no tag	no tag
272	cub32	Tatiana	M	0	4-Mar-03	ND	Cub Loss	654302	4367157	no tag	no tag
273	Mariah's Yrlg.	Mariah	U	1	3-Mar-03	D	No Data	.	.	no tag	no tag
274	cub27	Xina	M	0	1-Mar-03	ND	Cub Loss	656168	4388791	no tag	no tag
275	cub28	Xina	M	0	1-Mar-03	ND	Cub Loss	656168	4388791	no tag	no tag
276	cub29	Xina	M	0	1-Mar-03	ND	Cub Loss	656168	4388791	no tag	no tag
277	Shauntel	Penelope	F	0	28-Feb-03	ND	Collared	649454	4385321	no tag	no tag
277	Shauntel	Penelope	F	1	2-Jan-04	D	Collared	651749	4381011	no tag	no tag
277	Shauntel	Penelope	F	1	5-Mar-04	D	Collared	651417	4381517	0384w sq	0355w sq
278	Streak	Karren	F	0	7-Mar-04	ND	No Data	652974	4375564	no tag	no tag
279	cub33	Soula	M	0	6-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag
279	cub33	Soula	M	0	27-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag
280	cub34	Soula	M	0	6-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag

ID	Name	Mother	Sex	Age	Date	Type	Fate	X-Coord	Y-Coord	Ear Tag L	Ear Tag R
280	cub34	Soula	M	0	27-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag
281	cub35	Soula	M	0	6-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag
281	cub35	Soula	M	0	27-Mar-04	ND	Cub Loss	641553	4371120	no tag	no tag
282	cub36	Mariah	M	0	13-Mar-04	ND	No Data	662924	4368771	no tag	no tag
283	cub37	Mariah	M	0	13-Mar-04	ND	No Data	662924	4368771	no tag	no tag
284	cub38	Mariah	F	0	13-Mar-04	ND	No Data	662924	4368771	no tag	no tag
285	cub39	Heidi	F	0	4-Mar-04	ND	No Data	641648	4362734	no tag	no tag
286	cub40	Heidi	M	0	4-Mar-04	ND	No Data	641648	4362734	no tag	no tag
287	cub41	Colleen	M	0	13-Mar-04	ND	Cub Loss	655980	4360924	no tag	no tag

APPENDIX II: UNRETRIEVED RADIO COLLARS

This appendix contains information for radio collars on bears in the East Tavaputs Plateau, UT which are unaccounted for or currently active. Year of last observation is noted. Bear ID numbers and names correspond to those in Appendix I.

ID	Name	Collar Frequency	Status	Year of Last Observation
5	Tick	148.370	Off Air	1991
3	Lafayette	148.009	Off Air	1993
34	Lemon Drop	149.280	Off Air	1996
171	Eva	148.830	Off Air	1997
10	Bathsheba	148.940	Off Air	1998
103	Erica	148.980	Off Air	2001
225	Snow	148.020	Off Air	2001
229	Brazil	148.590	Off Air	2001
195	Candy	148.580	Off Air	2002
224	Sage	148.080	Off Air	2002
27	Willow	149.300	Off Air	2003
177	Annie	148.170	Off Air	2003[a]
208	Twilight	148.550	Off Air	2003[a]
226	Holyfield	148.820	Off Air	2003
135	Kathryn	148.240	Active	2002
21	Heidi	148.070	Active	2004
172	Chica	148.630	Active	2004
38	Xina	148.150	Active	2004
163	Mariah	148.760	Active	2004
39	Bucky	148.350	Active	2004
269	Chipeta[b]	148.200	Active	2004
277	Shauntel[b]	148.300	Active	2004

[a] Heard weak signal from plane on 1 March 2004, but collars not functioning 3 days later.
[b] Yearling in 2004.

ERRATA—BLACK BEARS OF UTAH'S EAST TAVAPUTS PLATEAU

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p. 20, Fig. 1 Cell labeled as *14* should be numbered *12*.

p. 21, Table 1 Portion of table was not shown.

Table 1. Total trap nights and captures for each cell on the East Tavaputs Plateau, UT study site.

Cell	Trap Nights	Total Captures (Observed)
1	15	0
2	362	16
3	832	33
4	1157	29
5	246	11
6	376	13
7	100	3
8	1740	68
9	1039	48
10	1519	31
11	1567	46
12	589	20
13	63	0
14	116	0
15	No Traps	0
16	536	13
17	569	26
18	No Traps	0

p. 28, Table 2 In the last column headed *Known Survival*, subscripts indicate the age (in years) of the surviving offspring at last capture or, when followed directly by an X, age at death.

In the row containing data for Erica, ♂$_{2y}$, X should read ♂$_{2y}$ X (no comma).

p. 57 *groung* should read *ground*

p. 71 *Wisconson* should read *Wisconsin*

p. 73 *Ursus Americanus* should read *Ursus americanus*