ECOLOGY AND POPULATION DYNAMICS OF BLACK BEARS IN MINNESOTA

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SUMMARY OF FINDINGS

During April 2007–March 2008, we monitored 45 radiocollared black bears (*Ursus americanus)* at 4 study sites representing different portions of the bear's geographic range in Minnesota: Voyageurs National Park (VNP, northern), Chippewa National Forest (CNF; central), Camp Ripley (southern), and a new site at the northwestern edge of the range, where we collared 19 bears (14 with Global Positioning System (GPS) collars). Mortality data were obtained through collars turned in by hunters or collars tracked to carcasses. Hunting continues to be the largest source of mortality of collared bears, even though hunters were asked not to shoot bears with bright orange radiocollars, and even though 2 study sites are closed to hunting (bears were killed when they wandered outside these areas during the fall). The rate of hunting mortality among radio-collared bears during the past 5 years is not sustainable population-wide. Reproductive output was highest in the southern study site and declined northward in response to diminishing food availability. Our objective in the new study site is to ascertain food availability per bear in a highly fragmented (agricultural) habitat, and from this, to make predictions about future range expansion.

INTRODUCTION

A lack of knowledge about bear ecology and effects of harvest on bear populations spurred the initiation of a long-term telemetry-based bear research project by the Minnesota Department of Natural Resources (MNDNR) in the early 1980s. For the first 10 years, the study was limited to the Chippewa National Forest (CNF), near the center of the Minnesota bear range. After becoming aware of significant geographic differences in sizes, growth rates, and productivity of bears across the state, apparently related to varying food supplies, we started other satellite bear projects in different study sites. Each of these began as graduate student projects, supported in part by the MNDNR. After completion of these student projects, we continued studies of bears at Camp Ripley Military Reserve, near the southern fringe of the Minnesota bear range, and in Voyageurs National Park (VNP), on the Canadian border.

These study sites differ enormously. The CNF is one of the most heavily hunted areas of the state, with large public (national, state, and county), heavily-roaded forests dominated by aspen (*Populus tremuloides, P. grandidentata)* of varying ages. Camp Ripley is unhunted, but bears may be killed by hunters when they range outside, which they often do in the fall, as the reserve is only 6–10 km wide. Oaks are far more plentiful here than in the 2 study sites further north. VNP, being a national park, is also unhunted, but again bears may be hunted when they range outside. Soils are shallow and rocky in the park, and foods are generally less plentiful than the other sites.

This year we also initiated a project in a new area at the northwestern edge of the Minnesota bear range (henceforth NW). This area differs from the other 3 areas in a number of respects: (1) it is largely agricultural, interspersed with MNDNR Wildlife Management Areas, a National Wildlife Refuge, and small private woodlots; (2) the bear range in this area appears to be expanding and bear numbers increasing; and (3) hunting pressure in this area is unregulated (it is within the no-quota zone, so there is no restriction on numbers of hunting licenses, and each hunter can kill 2 bears).

OBJECTIVES

- Monitor temporal and spatial variation in cub production and survival;
- Monitor rates and sources of mortality;
- Compare body condition indices across sites and years (not covered in this report);
- Assess habitat requirements for bears in an agricultural fringe area; and
- Predict range expansion of bears in northwestern Minnesota.

METHODS

We attached radiocollars with breakaway and/or expandable devices to bears either when they were captured during the summer or when they were handled as yearlings in the den of their radiocollared mother. We trapped bears this year only in the NW study site, using barrel traps baited with raw bacon, and anesthetized them with ketamine-xylazine. In this area, we used principally GPS collars, programmed to collect locations every 2-4 hours. These data will be used to assess fine-scale movements and habitat use in this highly fragmented landscape.

During December–March, we visited all radio-instrumented bears once or twice at their den site. We immobilized bears in dens with an intramuscular injection of Telazol, administered with a jab stick or Dan-Inject dart gun. Bears were then removed from the den for processing, which included changing or refitting the collar (removing GPS collars for downloading data), attaching a first collar on yearlings, measuring, weighing, and obtaining blood and hair samples. We also measured biolelectrical impedance (to calculate percent body fat) and vital rates of all immobilized bears. Additionally, with the cooperation of investigators from the University of Minnesota (Dr. Paul Iaizzo) and Medtronic (Dr. Tim Laske), heart condition was measured with a 12-lead EKG and ultrasound on a select sample of bears in early and late winter. Bears were returned to their den after processing.

We assessed reproduction by observing cubs in dens of radiocollared mothers. We sexed and weighed cubs without drugging them. We evaluated cub mortality by examining dens of radio-collared mothers the following year: cubs that were not present as yearlings with their mother were presumed to have died.

During the non-denning period we monitored mortality of radio-instrumented bears from an airplane periodically through the summer. We listened to their radio signals, and if a pulse rate was in mortality mode (no movement of the collar in >4 hours), we tracked the collar on the ground to locate the dead animal or the shed radiocollar. If a carcass was located, we attempted to discern the cause of death. During the hunting season, hunters routinely reported collared bears that they had killed.

We conducted food sampling on plots in various woodlands in the NW study site, representing all the principle forest types in that area. Experience in our previous studies indicated that fruit production is often high at the forest edge, so we situated plots such that we sampled both the edge and interior of the woodlot. We sampled 12 circular plots, each 3-m radius, per stand. Within each plot, we separately estimated the percent areal coverage and productivity of all principle fruiting species that bears consume. We visually rated fruit production on a 0-4 scale, with 0 = no fruit, 1 = below average fruit production, 2 = average fruit production, 3 = above average fruit production, and 4 = bumper crop. We picked samples of fruits representing each of these categories so that we could convert these subjective scorings to food biomass estimates.

We sampled acorns differently because they are difficult to reliably score and convert to biomass from observations of the tree canopy; furthermore, as bears tend to feed on acorns after they have fallen, plots on the ground more accurately reflect their availability to bears. We sampled 15 1-m^2 plots in each of several stands with oaks, again with some plots along the forest edge. The leaf litter was brushed away and all the acorns and caps counted and collected. Using these data on food availability and GPS collar data on bear movements and home range size, we will ascertain food biomass available per bear's home range at different times throughout the year.

RESULTS AND DISCUSSION

Since 1981 we have handled >800 individual bears and radiocollared >500. As of April 2007, the start of the current year's work, we were monitoring 27 collared bears: 6 in the CNF, 10 at Camp Ripley, 8 in VNP, and 3 in the new NW study site (which we collared in their dens).

Trapping

We trapped in the NW study site from late May through July, and sporadically during August. A total of 1,254 trapnights (typically 18-20 traps set per night) yielded 19 captures of 17 individual bears (1 new bear per 74 trapnights). Trapping success was higher in May-June than later, when an abundance of Juneberries and other fruits reduced the effectiveness of our baits (Figure 1). Trapping success also was reduced by interference (capture or consumption of the bait) by non-target animals: we caught 30 raccoons, 9 skunks, 6 fishers, and 1 domestic cat.

Of the 17 captured bears, 11 were fitted with GPS collars, 5 with VHF collars, and 1 was released without being handled (judged to be a cub). The trapping sample was biased toward males (12M:4F; Figure 1), but we preferentially put GPS collars on females (7M:4F, plus 3F collared in their den).

Mortality

Legal hunting has been the predominant cause of mortality among radiocollared bears from all study sites; 78% of mortalities that we observed were due, or likely due to hunting (Table 1). In earlier years of this study, hunters were encouraged to treat collared bears as they would any other bear so that the mortality rate of collared bears would be representative of the population at large. With fewer collared bears left in the study, and the focus now primarily on reproduction rather than mortality, we sought to protect the remaining sample of bears. We asked hunters not to shoot radio-collared bears, and we fitted these bears with bright orange collars so hunters could more easily see them in dim light conditions. Nevertheless, 12 of 36 bears (33%) with functional radiocollars were killed during this year's hunt (September-October 2007). We observed similarly high harvest rates for radiocollared bears each year since 2003.

In the NW study site, where our research was widely publicized by local media and wildlife managers, we learned that several hunters took greater precautions in not shooting collared bears (e.g., noticing collars on photos from trail cameras). Conversely, 4 of 8 collared bears from VNP were shot by hunters in a small area just outside the park boundaries. These bears were apparently attracted by hunters' baits and also an abundant supply of wild plums in that area. All of these bears were adult females (10, 14, 18, and 22 years old), 3 of which had cubs with them. The remaining 4 radiocollared bears in VNP were all subadults. We do not know whether they remained within the park boundaries during the hunting season.

Two other mortalities occurred this year: an 18 year-old Camp Ripley female died of unknown causes (when we located her body it was too decomposed to ascertain cause of death) and 1 NW bear was killed in a collision with a vehicle. Vehicle kills and nuisance kills have been equivalent in terms of mortalities of radiocollared bears (Table 1), although few nuisance kills have occurred in the past 10 years.

Reproduction

Of 11 mature bears checked in dens during March 2008, 7 (64%) had cubs and 4 had yearlings. Additionally, a 34-year-old has been post-senescent since 1999, when she was 25 years old.

Bears at Camp Ripley, where hard mast (especially oak) is abundant, grow faster and thus have an earlier age of first reproduction than at CNF and VNP (data not yet available for NW). This is reflected in the reproductive rates (cubs born/female) of 4–6 year-old females, which was nearly twice as high at Camp Ripley as at VNP (where no bears produced cubs at 4 years old), and intermediate at CNF (Table 2). This north-south gradient was also apparent in the reproductive rates of older bears, due to fewer missed reproductive opportunities in Camp Ripley and more whole-litter losses and skipped litters at VNP (Table 2). If no bears skipped litters, all would be on a 2-year reproductive cycle, and thus 50% of females would have cubs, on average, per year. The proportion of females with cubs was lowest in VNP and highest in Camp Ripley (where it exceeded 50% as an artifact of sampling; Table 2).

Mean litter size was somewhat higher in the central CNF site (2.6 cubs/litter; Table 3) than at the other sites (2.3–2.4 cubs/litter; Tables 4–5; data insufficient in NW, Table 6). However, counting only litters where at least 1 cub survived 1 year, litter sizes were remarkably similar across areas for 7+ year-old bears (mainly multiparous mothers; Table 2). In all areas, litter size was smaller for younger females, nearly all of which were first-time mothers (Table 2). Notably, 2 collared bears produced litters of 5 cubs last year and 2 produced litters of 4 this year, which is unusual given our small sample.

Average sex ratio of cubs shortly after birth was slightly, but consistently male-biased (52–53%) at all study sites. Observed year-to-year variation in cub sex ratios (Tables 3–6) was likely attributable to sampling error. In all areas, the mortality rate of male cubs was higher than (1.5-2x) that of females. Overall, cub mortality appeared to be lower in CNF (18%; Table 3) than in the other sites (23–28%; Tables 4–5). The difference, though, was not statistically significant.

Cub production and cub mortality did not show an upward or downward trend during our 27 years of monitoring. However, statewide bear harvests have shown an increasing proportion of yearlings, suggesting a changing statewide age structure, or possibly changing selectivity by hunters (with varying numbers of hunters).

Fruit Sampling

From July 9 to August 15, we sampled 78 stands for soft mast and hazelnut production in the NW study site, including: 28 aspen, 21 oak, 9 balsam poplar, 6 lowland hardwood, 5 conifer, 4 lowland conifer, 2 lowland shrub, and 2 hardwood stands. Sampling of lowland shrub and lowland conifer stands was discontinued when it became apparent that they contained little bear forage. We sampled acorns in 21 oak and 12 mixed stands.

Juneberry (*Amelanchier* sp.), chokecherry (*Prunus virginiana*), sarsaparilla (*Aralia nudicaulis*), American hazel (*Corylus americana*), and beaked hazel (*C. cornuta*) were all widely distributed in the study area and had exceptional fruit production in 2007. Wild plum (*Prunus* sp.) and hawthorn (*Crataegus* sp.) were largely restricted to sandy oak beach ridges and also had bumper crops. Nannyberry (*Viburnum lentago*) was restricted to the southern and western edges of aspen stands and produced well. Highbush cranberry (*V. trilobum*) was mostly restricted to lowland areas and also produced well. Raspberry (*Rubus idaeus*) produced well but was largely limited to the few scattered conifer stands in the study area. Other bear foods encountered in the study area included pin cherry (*P. pensylvanica*), red-osier dogwood (*Cornus sericea*), grey dogwood (*C. racemosa*), downy arrowwood (*V. rafinesquianum*), *Ribes* spp., swamp buckthorn (*Rhamnus* sp.), and blueberry (*Vaccinium angustifolium*), none of which were common or produced much fruit.

FUTURE DIRECTION

We plan to continue monitoring bears on these 4 study sites, although sample sizes have been greatly diminished by the exceedingly high harvest of collared bears for the past few years. Our main emphasis in the next few years will be at the new study site in northwestern Minnesota. Our goal there is to assess the factors that may limit range expansion, including highly fragmented forested habitat, availability of agricultural crops that bears can eat, and human-related mortality.

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Table 1. Causes of mortality of radiocollared black bears ≥1 year old from the Chippewa National Forest (CNF), Camp Ripley, Voyageurs National Park (VNP), and Northwestern (NW) Minnesota, 1981–2007. Bears did not necessarily die in the area where they usually lived (e.g., hunting was not permitted within Camp Ripley or VNP, but bears were killed by hunters when they traveled outside these areas).

	CNF	Camp Ripley	VNP	NW	All combined
Shot by hunter	220	11	14	3	248
Likely shot by hunter[a]	8	1	0	0	9
Shot as nuisance	22	2	1	0	25
Vehicle collision	12	7	1	1	21
Other human-caused death	9	0	0	0	9
Natural mortality	7	3	4	0	14
Died from unknown causes	3	2	0	0	5
Total deaths	281	26	20	4	331

[a] Lost track of during the hunting season.

Table 2. Reproductive rates (cubs/female), mean litter size, and proportion of females with cubs (in all cases, counting only litters in which at least 1 cub survived 1 year) in winter dens (March) in VNP (1997–2008), CNF (1981–2008) and Camp Ripley (1991–2008) (n = 4+ year-old female-years of observation). Reproduction increased from north (VNP) to south (Camp Ripley). Data from the new study site in the northwest are as yet too sparse to add to the table.

	VNP (n = 56)			**CNF** (n = 403)			**Camp Ripley** (n = 45)		
Age of female	Repro rate	Litter size	Prop w/ cubs	Repro rate	Litter size	Prop w/ cubs	Repro rate	Litter size	Prop w/ cubs
4–6 yrs	0.59	2.0	0.29	0.84	2.3	0.37	1.04	2.2	0.48
7–25 yrs	1.15	2.7	0.44	1.34	2.8	0.48	1.50	2.7	0.55
4–25 yrs	0.98	2.5	0.39	1.15	2.6	0.44	1.24	2.4	0.51

Table 3. Black bear cubs examined in dens of radiocollared mothers in or near the Chippewa National Forest during March, 1982–2008. High hunting mortality of radiocollared bears has reduced the sample size in recent years to the extent that the data are no longer suitable for monitoring.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
1982	4	12	3.0	67%	25%
1983	7	17	2.4	65%	15%
1984	6	16	2.7	80%	0%
1985	9	22	2.4	38%	31%
1986	11	27	2.5	48%	17%
1987	5	15	3.0	40%	8%
1988	15	37	2.5	65%	10%
1989	9	22	2.4	59%	0%
1990	10	23	2.3	52%	20%
1991	8	20	2.5	45%	25%
1992	10	25	2.5	48%	25%
1993	9	23	2.6	57%	19%
1994	7	17	2.4	41%	29%
1995	13	38	2.9	47%	14%
1996	5	12	2.4	25%	25%
1997	9	27	3.0	48%	23%[b]
1998	2	6	3.0	67%	0%
1999	7	15	2.1	47%	9%
2000	2	6	3.0	50%	17%
2001	5	17	3.4	76%	15%
2002	0	0	—	—	—
2003	4	9	2.3	22%	0%
2004	5	13	2.6	46%	33%
2005	6	18	3.0	33%	28%
2006	2	6	3.0	83%	33%
2007	2	6	3.0	67%	17%
2008	1	3	3.0	100%	—
Overall	173	452	2.6	52%	18%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cubs were born to collared females.
[b] Excluding 1 cub that was killed by a hunter after being translocated away from its mother.

Table 4. Black bear cubs examined in dens of radiocollared mothers in Camp Ripley Military Reserve during March, 1992–2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
1992	1	3	3.0	67%	0%
1993	3	7	2.3	57%	43%
1994	1	1	1.0	100%	—
1995	1	2	2.0	50%	0%
1996	0	0	—	—	—
1997	1	3	3.0	100%	33%
1998	0	0	—	—	—
1999	2	5	2.5	60%	20%
2000	1	2	2.0	0%	0%
2001	1	3	3.0	0%	33%
2002	0	0	—	—	—
2003	3	8	2.7	63%	33%
2004	1	2	2.0	50%	—
2005	3	6	2.0	33%	33%
2006	2	5	2.5	60%	—
2007	3	7	2.3	43%	0%
2008	2	5	2.5	60%	—
Overall	25	59	2.4	53%	23%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cubs were born to collared females or collared mothers with cubs died before the subsequent den visit. Presumed deaths of orphaned cubs are not counted here as cub mortality.

Table 5. Black bear cubs examined in dens of radiocollared mothers in Voyageurs National Park during March, 1999–2007. All adult collared females were killed by hunters in fall 2007, so there are no data for 2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
1999	5	8	1.6	63%	20%
2000	2	5	2.5	60%	80%
2001	3	4	1.3	50%	75%
2002	0	0	—	—	—
2003	5	13	2.6	54%	8%
2004	0	0	—	—	—
2005	5	13	2.6	46%	20%
2006	1	2	2.0	50%	0%
2007	3	9	3.0	44%	—
Overall	24	54	2.3	52%	28%

[a] Cubs that were absent from their mother's den as yearlings were considered dead. Blanks indicate no cub mortality data because no cubs were born to collared females.

Table 6. Black bear cubs examined in dens of radiocollared mothers in Northwestern Minnesota during March, 2007–2008.

Year	Litters checked	No. of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 yr[a]
2007	2	6	3.0	33%	100%[b]
2008	4	12	3.0	67%	—
Overall	6	18	3.0	56%	—

[a] Cubs that were absent from their mother's den as yearlings were considered dead.
[b] Only one 5-cub litter was monitored, and all the cubs died (mother produced a litter of 4 cubs the next year).

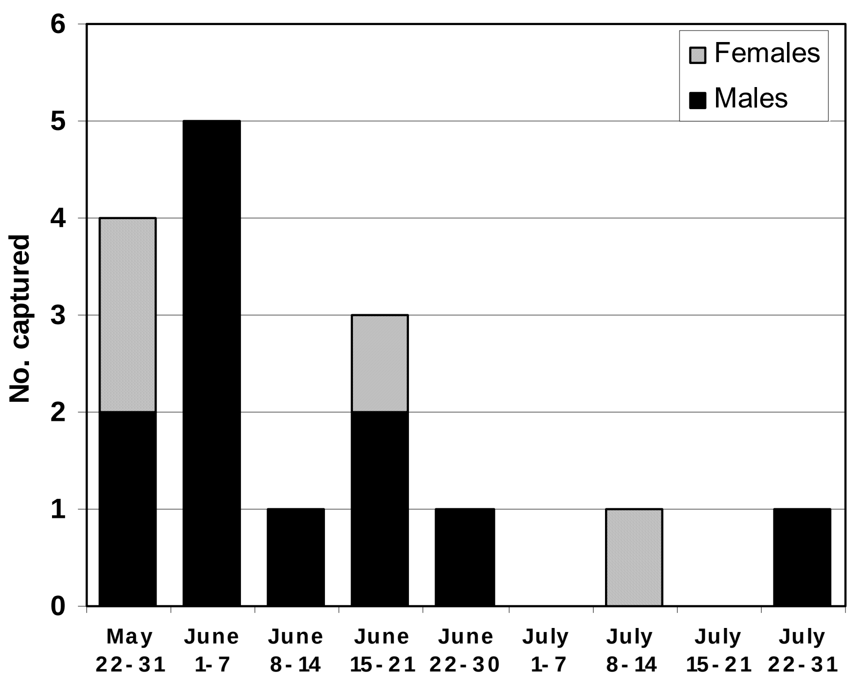

Figure 1. Trapping success in new study area in Northwestern Minnesota, May-Aug, 2008.