



# ECOLOGY AND POPULATION DYNAMICS OF BLACK BEARS IN MINNESOTA

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## SUMMARY OF FINDINGS

During April 2018–March 2019, we monitored 31 American black bears (*Ursus americanus*) previously radiocollared (mostly with GPS collars) at 4 study sites representing contrasting portions of the bear's geographic range in Minnesota: Voyageurs National Park (VNP, northern extreme, poorest food), Chippewa National Forest (CNF; central), Camp Ripley Training Center (southern fringe), and a site at the northwestern (NW) edge of the range. During summer, we captured and collared 6 more bears in the CNF, and in winter collared 5 female yearlings in this area. Hunting has been the primary source of mortality in all areas; even though VNP and Camp Ripley are unhunted, bears may wander off to other areas in fall where they are vulnerable to hunters. Hunters were asked not to shoot collared bears, all of which are conspicuously marked with large colorful eartags. Two were shot and not reported to us this year. Reproduction was strongly affected by food supply. Bears grew fastest and matured earliest in the NW and Camp Ripley. Age of primiparity was most delayed in VNP. Litter size, though, did not correspond with weight. Bears in the CNF are tending to use more nest dens and fewer underground dens than they did in the 1980s and early 1990s. We posit that this behavioral shift may be an effort to use dens that do not flood with early spring snowmelt.

## INTRODUCTION

Telemetry-based research on American black bears (*Ursus americanus*) was initiated by the Minnesota Department of Natural Resources (MNDNR) in 1981, and has been ongoing continuously since then. For the first 10 years, the bear study was limited to a site near the geographic center of the Minnesota bear range, in an area mainly within or abutting the Chippewa National Forest (CNF; Figure 1). The CNF is one of the most heavily hunted areas of the state, with large, easily-accessible tracts of public (national, state, and county) forests. A chief goal at that time was to assess causes of mortality, specifically the relative impacts of hunting. This study began just as the MDNR switched from an unrestricted bear hunt to a quota on bear hunting license sales in 1982, in reaction to a concern that the population was being over-hunted. We used black radiocollars and inconspicuous eartags, and requested that hunters treat study bears as they would any other bear.

Commensurately, we studied the reproductive rate, and factors influencing that rate (Noyce and Garshelis 1994). The view among bear biologists at that time was that black bears had one of the lowest reproductive rates of any large mammal in North America. But, we found higher rates of reproduction in Minnesota than studies in western states.

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Using physical mark–recapture, where collared bears were the marked population, we tracked an increase in the study population on the CNF through the 1980s, despite heavy hunting, with harvest rates often exceeding 20% (Garshelis 1991, Garshelis et al. 1988). We found no other factor that significantly affected the population size or trend. A striking finding was that bears rarely died of natural causes. For example, despite (or because of) being in winter dens for 6 months per year, winter weather conditions had no effect on their survival.

We also gained considerable new information about the ecology of bears. Notable findings included: a flexible diet, but with conspicuous effects of food supply on rates of mortality (from hunting: Noyce and Garshelis 1997) and reproduction; varied use of habitat that reflected the changing availability of foods during the course of the year and among years, as well as bears apparently striving for dietary diversity (Garshelis and Noyce 2008); extensive seasonal movements (migrations) to take advantage of richer food sources outside their normal home ranges (Noyce and Garshelis 2011, 2014); and diverse sites and structures used as den sites, which showed no relation to reproduction or survival.

To better understand the dynamics of bear populations across Minnesota, we added more study sites, including 2 sites where bear hunting was prohibited, and 1 site at the front of a recent geographic expansion, where the habitat was dominated by agriculture. We hypothesized that causes of mortality and rates of reproduction would differ among these sites.

## **OBJECTIVES**

1. Compare sources of bear mortality in different parts of the bear range.
2. Quantify temporal and spatial variation in cub production and survival.
3. Assess whether bears are using different types of dens now, compared to the 1980s.

## **STUDY SITES**

During the 1980s, the CNF study site was heavily logged, resulting in a matrix of stands of various ages, with many small unpaved logging roads. A unique feature of this study site is that the east side is dominated by upland forests, largely aspen (*Populus tremuloides*, *P. grandidentata*), whereas a large swath of the western part of this area is a forested bog. In recent years, more roads have been paved and/or widened; also, forest cutting on federal lands has diminished, so forests have aged and the amount of aspen on the landscape has declined. Nearly all bear foods are found in the understory. Oaks (*Quercus* sp.) are not common anywhere in this area, and commercial agriculture is nonexistent.

In 1991 our study expanded to include Camp Ripley Training Center, a National Guard facility at the southern periphery of the primary bear range (Figure 1). Bear hunting is prohibited on Camp Ripley, but bears may be hunted if they range outside. Oaks are plentiful. The 210-km<sup>2</sup> area is long and narrow (6–10 km wide), and bordered by highways and cornfields.

In 1997 we added Voyageurs National Park (VNP), located along the northern edge of the Minnesota bear range (bordering Canada; Figure 1). The study site is a 300-km<sup>2</sup> roadless peninsula bounded by 3 large lakes. VNP had the poorest and shallowest soils, no timber cutting, and a largely coniferous forest, so provided the least food for bears. Hunting is prohibited, but bears are exposed to hunting if they leave the park.

In 2007, we initiated work at the northwestern edge of Minnesota's bear range (NW; Figure 1). This area is largely agricultural, although only 2% of the land area is planted with crops consumed by bears. Forested land, which comprises less than 20% of the area, is patchily distributed in small, privately-owned woodlots and state Wildlife Management Areas, which are open to hunting. The density of roads is high. A low density of bears occupied this area until 1995, when poor natural food in neighboring areas spurred an influx of bears attracted to corn and sunflowers. Since then the density of bears in this area has remained higher.

## **METHODS**

During May–July, 2018, we captured bears in the CNF with barrel traps or Aldrich foot snares, and immobilized them with ketamine-xylazine. During December–March, we visited all radiocollared bears once or twice at their den site and immobilized them with Telazol. For all handling, we measured and weighed bears, assessed body condition, took blood and hair samples, and extracted a vestigial first premolar to estimate age on all bears whose age was unknown (i.e., first handling of bears older than cubs). We changed or refit the collar, as necessary. We collared bears that we thought would not disperse from the study area. We used GPS-Iridium collars (Telonics Inc., Mesa, AZ) on all but yearlings in the CNF, and mainly very high frequency (VHF) collars on the other study sites. All collared bears had brightly-colored, cattle-size ear tags (7x6 cm; Dalton Ltd., UK) that would be plainly visible to hunters. Licensed hunters could legally shoot collared bears, although they were asked not to. Prior to the hunting season (1 September–mid-October), hunters were mailed a letter requesting that they not shoot collared bears with large ear tags, and this request was also made through news releases. Requests to hunters to voluntarily not shoot collared bears have been made through the news media and MNDNR hunting regulations and website since 2001.

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

When visiting bears in dens, we categorized the type of den (open nest, brush, under roots, excavated, or other). These are the same categories used since the 1980s, enabling a comparison across time.

## **RESULTS AND DISCUSSION**

### **Radiocollaring and Monitoring**

As of April 2018, the start of the current year's work, we were monitoring 31 radiocollared bears: 17 in the CNF, 9 at Camp Ripley, 2 in VNP, and 3 in the NW (Table 1). During May–July we captured and collared 6 bears (all males) in the CNF. One of these had been initially collared in 2016, but the collar had failed.

The sex ratio of our sample in the CNF is heavily skewed toward males (13M, 5F), reflecting, it seems, a skewed sex ratio in this population. To increase the number of females in our sample at this site, we collared 5 CNF female yearlings in their dens. At all other study sites, we are monitoring only females.

### **Mortality**

Since 1981 we have recorded the cause of death for 387 radiocollared bears, 76% of which died (or likely died) from legal hunting (Table 2). In all 4 study sites, legal hunting was the primary cause of mortality (Figure 2), despite (a) Camp Ripley and VNP being unhunted (but bears wander outside during fall on foraging trips), and (b) hunters being asked to not shoot

collared bears with large ear tags for the past 18 years (spanning the full period of the NW study).

During the 2018 bear hunting season, 2 collared CNF bears were shot (Table 1). Neither of these were reported to us. We found the collar of one of these under the snow when we were going to what we thought was the bear's den site. For the other, we found the collar in a U.S. Forest Service truck (the employee previously found it in the woods during the bear hunting season, so we suppose it was shot by a hunter).

Vehicle collisions are another significant source of mortality. One large (507 lbs in December) CNF male was struck and killed by a logging truck in June 2018. Vehicle collisions are most common at Camp Ripley (Figure 2), which is flanked by 2 highways with fast-moving traffic.

The only other mortality this year was a yearling female in the NW who seemed to have been killed by wolves. She did not have a GPS collar and so we do not know when she died; we found her collar in March 2019, when searching for her den. We did not find her remains, but the collar was severely chewed by wolves, and was not near any roads or dwellings. However, it was near a private landowner's deer-feeding area, where wolves were common. This was the first natural mortality in the NW study site. Only 17 of 387 (4%) of bears died of natural mortality among all sites since this study began (Table 2).

### **Reproduction**

Since 1982, within the 4 study areas, we handled 315 litters with 819 cubs. We observed spatial differences in reproduction, but no consistent temporal trends have been evident.

Litter size averaged 2.6 cubs (range of study site means = 2.2–2.8; Tables 3–6). In CNF and NW, 3-cub litters were most common (Figure 3). In VNP, 2-cub litters were most common. In Camp Ripley, 3-year-old first-time mothers tended to have 2-cub litters; excluding these, an equal number had 2- and 3-cub litters (Figure 3). Since 2005, we have not observed a litter of <3 cubs in the CNF (Table 3). We cannot explain why CNF bears, which are generally not as heavy as Camp Ripley bears, tended to produce larger litters. This year, the only collared female in CNF that produced cubs was just 158 lbs in the den yet had a litter of 4.

Sex ratio of cubs in March litters was 50.5% male (Tables 3–6). The sex ratio among yearlings in winter dens was more female-skewed (48.0% male), due to a higher mortality among male cubs (23.4%) than female cubs (15.2%). We were unable to check 3 of the dens with yearlings in Camp Ripley this year because the females denned in road culverts or in the impact area (where we were not allowed). Denning in road culverts is common in Camp Ripley. One male in the CNF denned in a culvert, which was the first time a bear selected a culvert den in the CNF since our study began in 1982.

Cubs remained with their mother for about 17 months, so the normal reproductive interval is 2 years. All bears that were expected to have cubs this year, based on this normal cycle, did so. Overall, bears at Camp Ripley, despite being relatively large, have had a higher rate of missed litters (3-year litter intervals) than bears in the other study sites (Table 7).

No collared bears produced a first litter this year. Two 5-year-old females (sisters) in VNP that could have done so, did not; an advanced age of primiparity is not unusual for this area. Previously, 3 bears in VNP produced first litters (with at least 1 surviving cub) at 5 years old, 3 at 6, and 1 at 9. By contrast, 38% of females in the CNF and 86% in Camp Ripley and the NW produced a first surviving litter by age 4. The differing ages of primiparity reflect the differing growth rates of bears at these study sites.

## Types of Dens

During the 1980s through early-1990s, underground dens (either fully excavated or under tree roots) were the most common den type in the CNF, for both females (73%) and males (66%). Brush piles were used as dens by ~20% of both sexes, and above-ground open nests were used by 6% of females and 14% of males. Although underground dens are still most common, a significant shift toward greater use of nests occurred for both sexes in the CNF during 2016–2019 (Figure 4; sexes combined  $X^2=12.8$ ,  $P=0.0004$ ). Remote cameras at dens showed some bears being flooded out of underground dens during spring thawing, forcing them to abandon the dens or emerge to collect more bedding material in an effort to stay dry. Although we have no data on this behavior before 2016 (when we first began using cameras at dens), it seems logical that earlier spring temperatures would result in earlier flooded dens, and bears may be responding to this by switching away from underground dens, which collect water from melting snow dripping in from the ceiling and entrance. In choosing a nest den, bears tradeoff less protection from cold and snow (which accumulates on their back) in mid-winter for drier dens in spring (Figure 5).

## ACKNOWLEDGMENTS

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Table 1. Fates of radiocollared black bears in Chippewa National Forest (CNF), Camp Ripley, Voyageurs National Park (VNP), and northwestern Minnesota (NW) study sites, April 2018–March 2019.

	CNF	Camp Ripley	VNP	NW
Collared sample April 2018	17	9	2	3
Trapped and collared	6			
Collared in den	5			
Killed in vehicle collision	1			
Killed by Minnesota hunter <sup>a</sup>	2			
Natural mortality				1
Removed radiocollar	1			
Dropped radiocollar	1			
Collared sample April 2019	23	9	2	2

<sup>a</sup> Hunters were asked not to shoot collared bears (although it was still legal). Neither of these collars were turned in.

Table 2. Causes of mortality of radiocollared black bears  $\geq 1$  year old in 4 Minnesota study sites, 1981–2019. 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 <sup>a</sup>	237	13	16	14	280
Likely shot by hunter <sup>b</sup>	9	1	0	4	14
Shot as nuisance	22	2	1	3	28
Vehicle collision	14	10	1	3	28
Other human-caused death	9	1	0	0	10
Natural mortality	8 <sup>c</sup>	3	5	1	17 <sup>c</sup>
Died from unknown causes	5	2	0	3	10
Total deaths	304	32	23	28	387

<sup>a</sup> Since 2001, the MNDNR has asked hunters not to shoot collared bears, so the proportion killed due to this cause is no longer representative of the population at large.

<sup>b</sup> Lost track of during the bear hunting season, or collar seemingly removed by a hunter.

<sup>c</sup> Only 1 bear died of “old age”.

Table 3. Black bear cubs examined in dens of radiocollared mothers in or near the Chippewa National Forest, Minnesota, during March, 1982–2019. High hunting mortality of radiocollared bears severely reduced the sample size in recent years.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year <sup>a</sup>
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%
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%	33%
2009	1	3	3.0	33%	33%
2010	1	4	4.0	100%	50%
2011	1	4	4.0	25%	50%
2012	1	3	3.0	67%	33%
2013	1	3	3.0	67%	0%
2014	1	3	3.0	67%	— <sup>b</sup>
2015	0	0	—	—	—
2016	0	0	—	—	—
2017	1	3	3.0	—	0%
2018	4	12	3.0	42%	0%
2019	1	4	4.0	50%	—
Overall	185	491	2.7	53%	18%

<sup>a</sup> Cubs that were absent from their mother's den as yearlings were considered dead.

<sup>b</sup> Mother was killed by a hunter so status of cubs unknown.



Table 4. Black bear cubs examined in dens in northwestern Minnesota during March, 2007–2019.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year
2007	2	6	3.0	33%	100%
2008	5	15	3.0	67%	22%
2009	1	3	3.0	33%	33%
2010	6	17	2.8	41%	13%
2011	2	4	2.0	75%	25%
2012	4	10	2.5	60%	10%
2013	3	9	3.0	67%	18%
2014	3	8	2.7	0%	33%
2015	2	5	2.5	60%	0%
2016	2	6	3.0	50%	0%
2017	1	3	3.0	0%	0%
2018	1	4	4.0	50%	25%
2019	1	2	2.0	50%	
Overall	33	92	2.8	44%	17% <sup>a</sup>

<sup>a</sup> Excludes the total loss of a 5-cub litter in 2007 (which was not within the designated study area).

Table 5. Black bear cubs examined in dens in or near Camp Ripley Training Center, Minnesota, during March, 1992–2019.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year <sup>a</sup>
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%	0%
2009	3	7	2.3	29%	29%
2010	2	4	2.0	75%	25%
2011	3	8	2.7	50%	25%
2012	1	2	2.0	100%	0%
2013	6	14	2.3	50%	21%
2014	1 <sup>b</sup>	— <sup>b</sup>	—	—	—
2015	6	15	2.5	20%	10%
2016	0	0	—	—	—
2017	4	10	2.5	60%	0%
2018	2	5	2.5		— <sup>c</sup>
2019	3	7	2.3		
Overall	52	124	2.4	49%	18%

<sup>a</sup> Blanks indicate no cubs were born to collared females or collared mothers with cubs died before the subsequent den visit to assess cub survival.

<sup>b</sup> Cubs heard, litter not handled. Camera set outside den indicated that all cubs died. This litter not included in total.

<sup>c</sup> No yearling dens could be checked: all were in culverts or in impact area.

Table 6. Black bear cubs examined in dens in Voyageurs National Park, Minnesota, during March, 1999–2019. All adult collared females were killed by hunters in fall 2007, so sample sizes greatly diminished afterward.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year <sup>a</sup>
1999	5	8	1.6	63%	20%
2000	2	5	2.5	60%	80%
2001	3	4	1.3	50%	75%
2002	0		—	—	—
2003	5	13	2.6	54%	8%
2004	0		—	—	—
2005	5	13	2.6	46%	20%
2006	1	2	2.0	50%	0%
2007	3	9	3.0	44%	—
2008	0		—	—	—
2009	0		—	—	—
2010	1	2	2.0	50%	0%
2011	1	2	2.0	0%	0%
2012	1	2	2.0	0%	50%
2013	1	2	2.0	50%	—
2014	1	3	3.0	33%	0%
2015	0	0	—	—	—
2016	0 <sup>b</sup>	0	—	—	—
2017	0	0	—	—	—
2018	0	0	—	—	—
2019	0	0	—	—	—
Overall	29	65	2.2	48%	25%

<sup>a</sup> Blanks indicate no cub mortality data because no cubs were born to collared females, or collared mothers were lost from study (died or lost collar) before denning with yearlings.

<sup>b</sup> One bear that likely had cubs was not checked because access to her den was precluded by poor ice conditions.

Table 7. Intervals between litters (where at least 1 cub survived) for black bears within 4 study sites in Minnesota through March 2019 (CNF since 1981, Camp Ripley since 1991, VNP since 1997, NW since 2007). Cubs typically remain with their mother for about 17 months, so the normal reproductive interval is 2 years.

Study area	2-year reproductive intervals	≥3-year reproductive intervals	% intervals ≥3 years
CNF	112	8	7%
Camp Ripley	35	5	13%
VNP	15	1	6%
NW	19	0 <sup>a</sup>	0%

<sup>a</sup> Excluding 1 missed litter (3-year interval) that was due to the bear leaving the den after disturbance and aborting the litter.

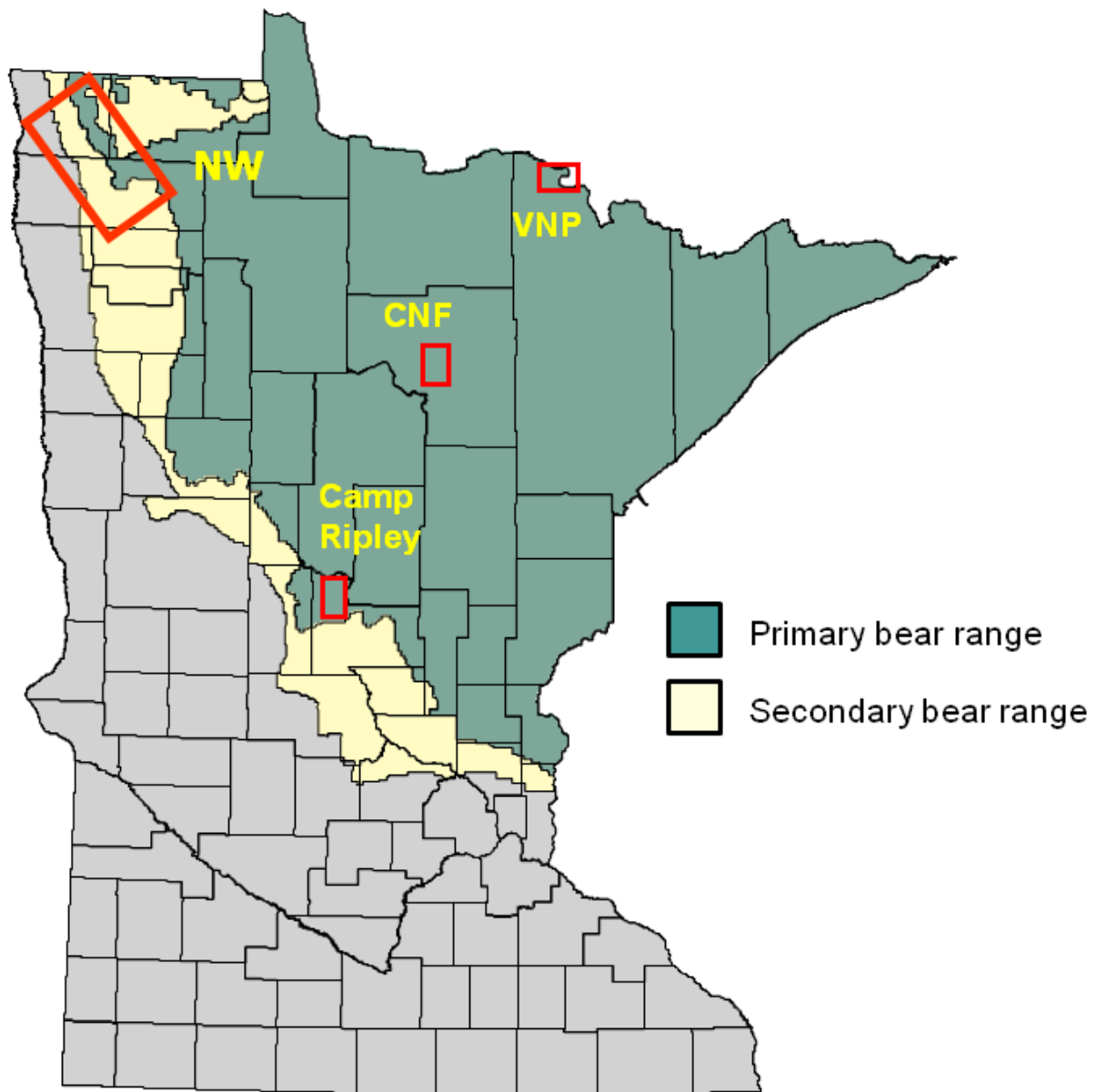


Figure 1. Location of 4 study sites within Minnesota's bear range: CNF (Chippewa National Forest, central bear range; 1981–2019); VNP (Voyageurs National Park, northern fringe of range; 1997–2019); Camp Ripley Military Reserve (near southern edge of range; 1991–2019); NW (northwestern fringe of range; 2007–2019).

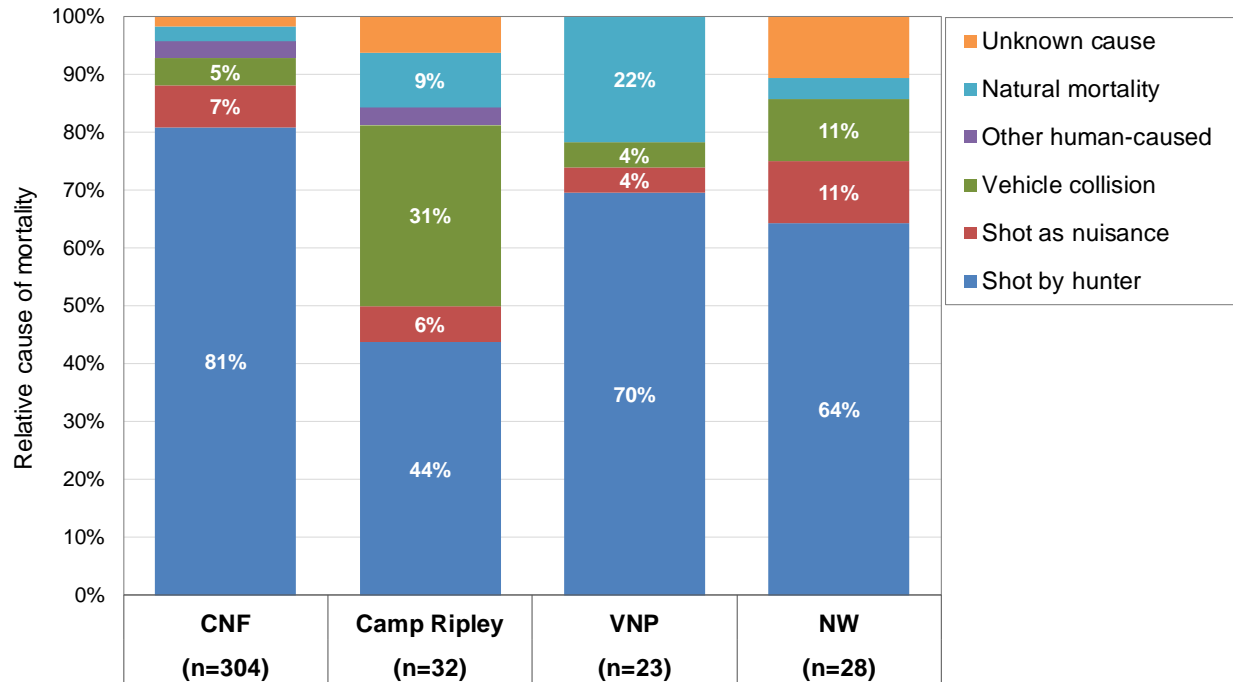


Figure 2. Proportional causes of death of radiocollared bears in each of 4 study sites in Minnesota, since the beginning of the study in each area through the 2018 hunting season (see map and dates for each study site in Figure 1). CNF expectedly had the highest proportion of bears killed by hunters because this is primarily public land that is heavily hunted. Camp Ripley and VNP are unhunted but bears are vulnerable when they leave on foraging forays. Hunters were asked not to shoot collared bears during the entire span of the NW study, so the proportion killed by hunters there is an underestimate.

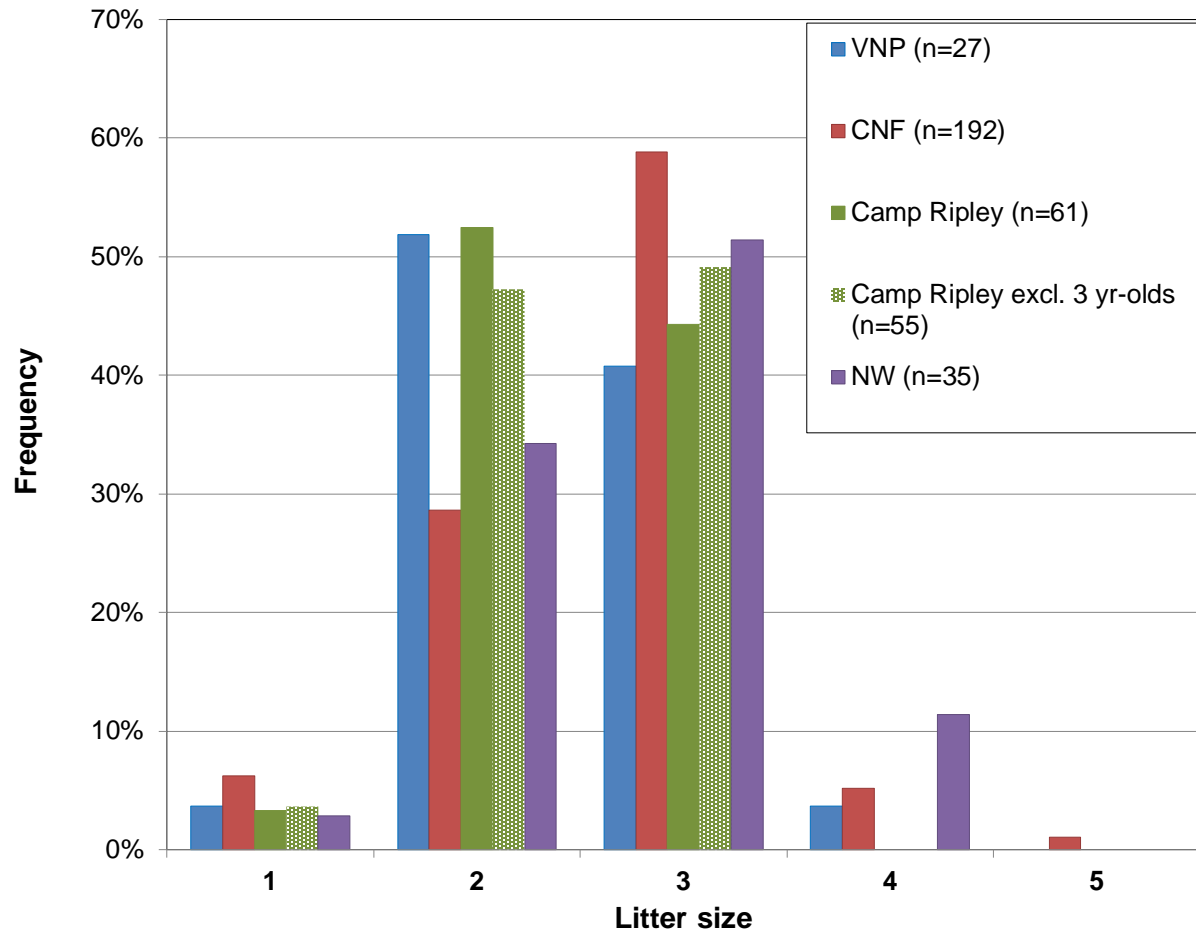


Figure 3. Frequency of cub litter sizes (examined in natal dens in March) within 4 Minnesota study sites (see Figure 1) through March 2019. Data include only litters that survived 1 year (even if some cubs in the litter died). Camp Ripley data are shown for mothers of all ages, as well as excluding 3-year-old mothers. For the other sites, elimination of 3-year-olds did not make a difference.

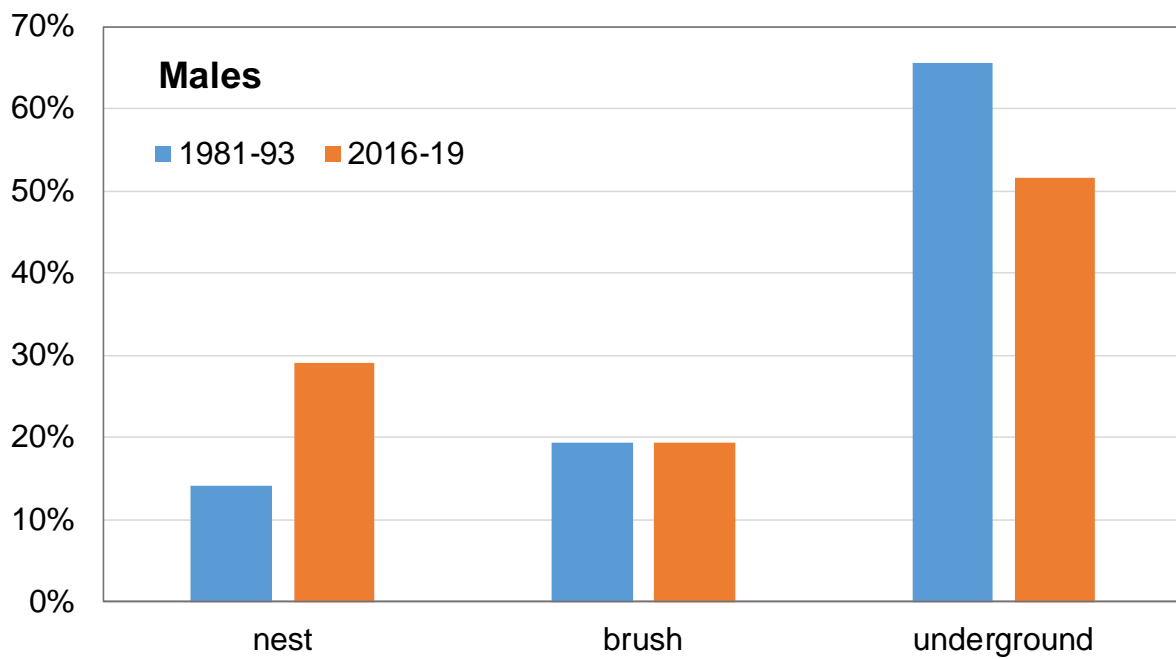
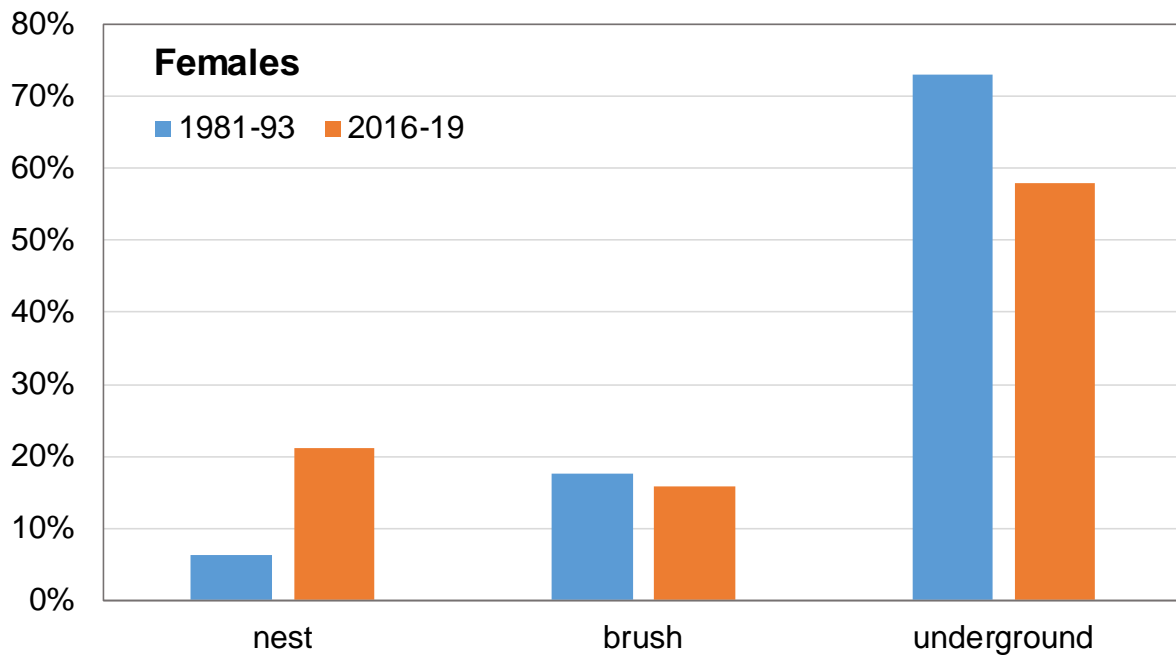


Figure 4. Types of dens used by black bears in the CNF study site in Minnesota during the early years of this study (1981–1993) versus recently (2016–2019).



Figure 5. Nest dens (left) are being used more frequently by bears now than they were 30 years ago in Minnesota, possibly because bears remain drier in nests during early spring thaws than underground dens (right), where snowmelt seeps in from the ceiling and entrance.