ECOLOGY AND POPULATION DYNAMICS OF BLACK BEARS IN MINNESOTA

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SUMMARY OF FINDINGS

During April 2016–March 2017, we monitored 14 black bears (*Ursus americanus)* previously radiocollared 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. Additionally, we collared 19 more bears (among a total of 28 captured) in the CNF. The young, male-biased capture sample in the CNF was indicative of heavy hunting pressure. Hunting has been the primary source of mortality in all areas, although vehicle collisions have been a significant source of mortality for bears wandering off Camp Ripley, which is flanked by highways. In the 2016 hunting season, 20−23% (depending on fate of 1 bear that disappeared) of collared bears were shot, even though hunters were asked to avoid killing collared bears, and they were all marked with conspicuously large, colorful ear tags.

Reproduction was strongly affected by food supply. The NW area had the highest reproductive rate, due to early maturity, large litters, and litter intervals rarely exceeding 2 years. Camp Ripley bears matured early but had the highest proportion of 3-year litter intervals. Litter sizes of 3 were most common in NW and CNF, whereas litter sizes of 2 were most common in VNP; in Camp Ripley, 3-year-old mothers all had litters of 2, whereas older mothers had an equal proportion of 2- and 3-cub litters.

Camera traps set outside den sites revealed dates of initial den emergence (22 Feb−24 Mar) and final departure from the den site (11 Mar−20 Apr). Bears spent 1−41 days going in and out of the den after they first emerged, before departing the area. Much of the activity outside the den—and an apparent motivation for coming out—was to collect dry bedding material. We suggest that early, warm springs, with melting snow, may prompt bears to emerge early from wet dens.

INTRODUCTION AND STUDY AREAS

Telemetry-based research on black bears was initiated by the Minnesota Department of Natural Resources (MNDNR) in 1981, and has been ongoing continuously since then. Objectives shifted over the years, and study areas were added to encompass the range of habitats and food productivity across the bear range. For the first 10 years, the bear study was limited to the Chippewa National Forest (CNF), near the geographic center of the Minnesota bear range (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 dominated by aspen (*Populus*

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tremuloides, P. grandidentata) of varying ages. Camp Ripley Training Center, a National Guard facility at the southern periphery of the bear range, was added as a second study site in 1991. Camp Ripley is unhunted, but bears may be killed by hunters when they range outside Camp, which they often do in the fall. Oaks (*Quercus* sp.) are plentiful within Camp, and cornfields border the site. Voyageurs National Park (VNP), at the northern edge of the Minnesota range (but bordering bear range in Canada) was added as a third study site in 1997. Soils are shallow and rocky in this area, and foods are generally less plentiful than in the other sites. Being a national park, it is unhunted, but like Camp Ripley, bears may be hunted when they range outside VNP.

In 2007, we initiated work in a fourth study site at the northwestern edge of the Minnesota bear range (henceforth NW; Figure 1). This area differs from the other 3 areas in a number of respects: (1) it is largely agricultural (including crop fields, like corn and sunflowers that bears consume), (2) most of the land, including various small woodlots, is privately owned, with some larger blocks of forest contained within MNDNR Wildlife Management Areas (WMAs) and a National Wildlife Refuge (NWR); (3) the bear range in this area appears to be expanding and bear numbers have been increasing, whereas, until recently, most other parts of the bear range have had stable or declining bear numbers; and (4) hunting pressure in this area is unregulated (it is within the no-quota zone, so there is no restriction on hunting licenses).

We used these 4 study sites to examine spatial variation in bear population dynamics and ecology to help inform bear management.

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. Understand factors affecting emergence and departure from dens.

METHODS

During May−August, 2016, we captured bears in the CNF with barrel traps 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 all new females and larger males that we thought would not disperse from the study area.

This year we used mainly GPS-Iridium collars (Telonics Inc., Mesa, AZ) or VHF collars with an attached GPS pod (Telemetry Solutions, Concord, CA), except in VNP where we used only VHF collars. All collared bears had brightly-colored, cattle-size ear tags (7x6 cm; Dalton Ltd., UK) that would be plainly visible to hunters. Bears that were not collared had small inconspicuous ear tags.

We monitored survival of bears during the summer. Mortalities also were reported to us when bears were shot as a nuisance, hit by a car, or killed by a hunter. 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, although the individual letters to hunters was not initiated until 2011.

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.

We monitored heart rates of a subset of bears using a new Insertable Cardiac Monitor developed for human heart patients (Reveal LINQ™, Medtronic Inc., Minneapolis, MN). The device provided wireless transmission of heart and activity data to an antenna buried under the nest material in the den, which was then relayed by cell phone to a base station (see Laske et al. 2014). These data are not presented in this report, but will be used to inform our research questions about factors affecting den emergence.

We set remote cameras (camera traps; Reconyx, Inc., Holmen, WI) outside bear dens to gain information about dates and behaviors of bears emerging from dens and departing from the den site. Bears that emerged from dens <48 hours after our den visit were excluded from the analysis.

RESULTS AND DISCUSSION

Radiocollaring and Monitoring

As of April 2016, the start of the current year's work, we were monitoring 16 radiocollared bears: 1 in the CNF, 6 at Camp Ripley, 3 in VNP, and 6 in the NW (Table 1). Two NW bears lost their collars (1 breakaway link degraded after the bear could not be handled in the den, and 1 yearling removed the collar put on in the den). We captured 28 new bears (21M; 7F) in the CNF, and collared 19. We selectively collared all females and larger males. Only 4 bears were >5 years old (Figure 2). The heavy skew toward males and young age structure of the captured bears suggests that this area has been subjected to heavy hunting, and many of the bears had immigrated from elsewhere.

Mortality

Since 1981 we have recorded the cause of death for 367 radiocollared bears, 78% of which died (or likely died) from legal hunting (Table 2). Vehicle collisions are another significant source of mortality at Camp Ripley, which is flanked by 2 highways.

Despite our request (for the past 16 years) not to shoot collared bears (with large ear tags), 6 or 7 collared bears were shot by licensed hunters during September 2016 (Table 1). This represents 20−23% of the collared bears monitored at the time. The actual mortality rate is somewhat higher, as most of the collared bears at Camp Ripley were on the reserve, not available to hunters. Conversely, all 3 VNP bears were outside the park during the fall and photographed at hunters' baits (Figure 3). The high harvest mortality rate was a reflection of poor fall foods, and thus ready attraction to hunters' baits.

The bears shot by hunters were from all 4 study sites (Table 1), so the sample represents a large portion of the bear range. But since we are also aware of hunters who passed up shooting collared bears (observed or photographed at their baits), as per our request, it seems likely that the population at large was subjected to an even higher mortality rate than the collared bears.

However, among 18 bears that we ear-tagged but did not collar this year, none were reported killed by hunters. We suspect that the reporting rate of tags is less than for collars, but if they were subjected to the same mortality rate as collared bears, it seems somewhat enigmatic that ~4 would not be reported, especially since we only requested that hunters refrain from shooting bears with collars and large ear tags (bears without collars had very small ear tags that would be difficult to see before shooting). One explanation is that only 2 of the 18 ear-tagged bears

were >2 years old, so in a year when many bears were at hunters' baits, hunters could select for larger bears. Only 1 of the hunter-killed collared bears was <4 years old.

Reproduction

Since 1982, within the 4 study areas, we have checked 290 litters with 745 cubs ($\bar{x}$ = 2.6 cubs/litter), of which 50.7% were male (Tables 3–6). The sex ratio of cubs has become female-biased in all study areas except the CNF, where we have checked an average of only 1 litter per year for the past 10 years. The increased collaring in the CNF this year will provide a larger sample of reproductive bears in the future.

At Camp Ripley, all 5 collared females produced cubs in 2015, so none produced in 2016; all but 1 of these produced cubs in 2017. The 1 bear that did not produce cubs was unusual: since 2005, when this bear was 3 years old, she has produced a litter every-other year (6 litters, 15 cubs), and her body condition was more than ample to produce cubs this year (44% body fat, 365 lbs in Dec; 324 lbs in Mar). We know that this bear has been a nuisance, and has been shot at, although we did not see any obvious injuries, other than a healing wound from where we removed an archery broadhead from her shoulder last year. Overall, bears at Camp Ripley, despite being large, have had a higher rate of missed litters (3-year litter intervals) than bears in the other study sites (Table 7).

One of 2 collared females in NW produced cubs in 2017 (the other had yearlings). Both collared bears in VNP were too young to have cubs (both 3 years old; no VNP bears have produced cubs at 3). One 6-year-old bear in the CNF produced her first cubs; 3 CNF 4-year-olds did not have a first litter yet. However, 2 bears caught in the CNF had cubs with them in summer 2016, 1 of which was 4 and 1 was only 3 years old. Of 91 female bears in the CNF monitored through 3 years old, this is only the third to have cubs at this young age.

Reproductive rates (cubs/female 4+ years old: combining litter size, litter frequency, and age of first reproduction into a single parameter) were highest in the NW study area, and lowest in VNP (Figure 4). This is somewhat ironic in terms of Minnesota's bear management, given that the NW study site is outside "core" bear range and, accordingly, is within a management zone where bear hunting license sales are unrestricted (no-quota). The NW site contains not only agricultural crops consumed by bears, but also an abundance of natural foods, especially along the edges of woodlots (Ditmer et al. 2015). In all areas except the NW, reproductive rates were higher for ≥7-year-old bears than 4- to 6-year-olds because many bears in this younger age group either had not yet reproduced or just had their first litter, which tended to be smaller (fewer cubs). The most striking differences among study sites were in the reproductive rates of these 4–6 year-olds (Figure 4).

Bears in the CNF and NW produced more 3-cub litters than 2-cub litters, whereas 2-cub litters were most common at Camp Ripley and VNP (Figure 5). The relatively small litter sizes at Camp Ripley were due to many of those bears producing cubs when only 3 years old (all 3-year-old mothers had litters of 2 cubs). Eliminating these bears, litter sizes of 2 and 3 cubs were about equal at Camp Ripley (Figure 5).

Age of first reproduction was dramatically different among areas. By 4 years of age, >80% of bears at Camp Ripley and in the NW had produced surviving cubs (observed in the den at 1 year; Figure 6). Only 37% of bears on the CNF produced surviving cubs by 4 years old and no bears at VNP produced cubs by 4 years of age. Camp Ripley bears sacrificed litter size for earlier age of reproduction (Figures 5 and 6). NW bears had both large litters and early age of first reproduction, so were most prolific of all the sites.

Mortality of cubs during their first year of life averaged 19% (annual range 0–31% for years with at least 10 cubs monitored), with mortality of male cubs (25%) exceeding that of females (16%; $\chi^2 = 6.38$, $P = 0.01$). The timing and causes of cub mortality are unknown.

Camera Trap Photos at Dens

We obtained camera-trap photos of bears that yielded dates of natural emergence and departure from 14 dens: 1 in 2015, 6 in 2016, and 7 in 2017. Dates of first emergence ranged from 22 February to 24 March (Figure 7). After first emergence (which we defined as completely exiting the den, not just poking their head out), bears remained at the den site for 1−41 days. This span of time is similar to that reported by Miller et al. (2016; 0−47 days) for 21 black bear dens monitored with camera traps in Utah. Between the time of emergence and eventual departure from the den site, bears moved back and forth between the den site and outside the den.

When outside the den, but before leaving the vicinity of the den (defined as beyond the detection of the remote cameras), bears were involved in the following principal behaviors: raking more bedding material into the den, stretching/walking, laying in the sun, eating snow or drinking water, monitoring cubs playing and climbing trees. We thus interpret the period between den emergence and departure to be a time where bears: (1) attempt to stay dry in the den while snow is melting and causing some discomfort; (2) regain muscle strength; (3) warm body temperature; and (4) rehydrate. Often, in March, we observed bears poking their head outside the den to lick snow while not coming completely out of the den (Figure 8).

Miller et al. (2016) quantitatively assessed the proportion of time that bears in Utah invested in various activities outside the den, most of which was simply standing or walking, suggesting that muscular activity was important. Although we have not yet quantified time by activity, the photographs in our study indicate a substantial investment in gathering more bedding material. In fact, it often appeared that the primary reason for coming out of the den was to get more bedding, apparently because the den had gotten wet—in some cases, the photos showed that bears had gotten wet from water in their dens (Figure 9). Bears in Utah also commonly augmented their nests, although they spent comparatively little time doing so. Miller et al. (2016) did not mention whether dens in Utah were wet.

The span of time over which individual bears departed the den site (11 March to 20 April) was even wider than the span of dates of first den emergence times. We suspect that bears employed different thresholds for leaving. Bears with young cubs tended to stay until cubs were mobile and able to climb trees. Solitary bears or mothers with yearlings often waited for most of the snow to melt; however, some did not. In one case, an adult male bear was in an excavated den that seemed to have gotten wet, and it left the vicinity of the den only 1 day after first emerging, despite the surrounding area being totally snow-covered (Figure 10). The photos show that the bear was wet, and there was no obvious place near the den to obtain more bedding material (grass, leaves or conifer boughs). Conversely, bears that were able to rake in copious bedding material had more incentive to remain. We speculate that with warmer weather in late winter, issues of wet dens will become an increasing concern for bears, and those that cannot rake in dry bedding material will be prompted to leave the den site earlier than they might otherwise choose. In an extreme case, 1 study bear was flooded from its den during a thaw in December. The water pooled and froze in the den, and the bear apparently sat outside the den all winter. Possibly as a reaction to flooding underground dens, we note that an unusually low proportion of CNF bears denned underground (2 males, 2 females of 15 total dens = 27% in 2016; 56% of females denned underground in the 1980s; Garshelis 1987).

Above-ground dens may be drier but also expose the bear to direct stresses of the weather (e.g., rain or snow on their back) and possible confrontations with predators. In one case a dog

visited an occupied den under a root mass, but remained outside. In another unusual case, a bear in a brush pile left to retrieve a leg from a dead deer. It simply rolled around on top of the leg, but never ate it. Shortly after the bear departed the den, a wolf came by and devoured the deer leg (Figure 11).

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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 2016−March 2017.

	CNF	Camp Ripley	VNP	NW
Collared sample April 2016	1	6	3	6
Trapped	19			
Killed in vehicle collision	1			
Killed by Minnesota hunter[a]	3 or 4[b]	1	1	1
Natural mortality				
Dropped radiocollar				2
Failed radiocollar	0 or 1[b]			1[c]
Collared in den				
Collared sample April 2016	15	5	2	2

[a] Hunters were asked not to shoot collared bears (although it was still legal).
[b] One GPS-Iridium collared bear disappeared after the first week of the hunting season (either shot and not reported or collar failed; categorized as 'likely shot by hunter' in Table 2).
[c] One GPS-Iridium collared bear disappeared in mid-July; we suspect that the radiocollar failed.

Table 2. Causes of mortality of radiocollared black bears ≥1 year old in 4 Minnesota study sites, 1981–2017. 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[a]	230	13	16	14	273
Likely shot by hunter[b]	9	1	0	4	14
Shot as nuisance	22	2	1	3	28
Vehicle collision	13	9	1	3	26
Other human-caused death	9	1	0	0	10
Natural mortality	8[c]	3	5	0	16[c]
Died from unknown causes	4	2	0	3	9
Total deaths	295	31	23	27	376

[a] 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.
[b] Lost track of during the bear hunting season, or collar seemingly removed by a hunter.
[c] 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, 1982–2017. 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[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%
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%	—[b]
2015	0	0	—	—	—
2016	0	0	—	—	—
2017	1	3	3.0	—	—
Overall	180	475	2.6	53%	19%

[a] Cubs that were absent from their mother's den as yearlings were considered dead.
[b] Mother was killed by a hunter so status of cubs unknown.

Table 4. Black bear cubs examined in dens in northwestern Minnesota during March, 2007–2017.

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%	
Overall	31	86	2.8	43%	17%[a]

[a] 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 1992–2017.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year[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%	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[b]	—[b]	—	—	—
2015	6	15	2.5	20%	10%
2016	0	0	—	—	—
2017	4	10	2.5	60%	—
Overall	50	119	2.4	49%	20%

[a] Blanks indicate no cubs were born to collared females or collared mothers with cubs died before the subsequent den visit to assess cub survival.
[b] Cubs heard, litter not handled. Camera set outside den indicated that all cubs died. This litter not included in total.

Table 6. Black bear cubs examined in dens in Voyageurs National Park, Minnesota, during March 1999–2017. All adult collared females were killed by hunters in fall 2007, so no reproductive data were obtained during 2008–2009.

Year	Litters checked	Number of cubs	Mean cubs/litter	% Male cubs	Mortality after 1 year[a]
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[b]	0	—	—	—
2017	0	0	—	—	—
Overall	29	65	2.2	48%	25%

[a] 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.
[b] One bear that likely had cubs was not checked because access to her den was precluded by poor ice conditions.

Table 7. Intervals between surviving litters for black bears within 4 study sites in Minnesota (see Figure 1) through March 2017 (CNF since 1981, Camp Ripley since 1991, VNP since 1997, NW since 2007). Cubs are generally born in January and remain with their mother for about 17 months, so the normal reproductive interval is 2 years. Reproductive intervals here include only litters where at least 1 cub survived through the next denning period (1 year), so intervals <2 years are impossible.

Study area	2-year reproductive intervals	≥3-year reproductive intervals	% intervals ≥3 years
CNF	110	8[a]	7%
Camp Ripley	26	5	16%
VNP	15	1	6%
NW	17	0[b]	0%

[a] Including the only case of an interval spanning >3 years, due to whole litter loss followed by a non-reproductive year.
[b] Excluding 1 missed litter (3-year interval) that was due to the bear leaving the den after disturbance and aborting the litter.

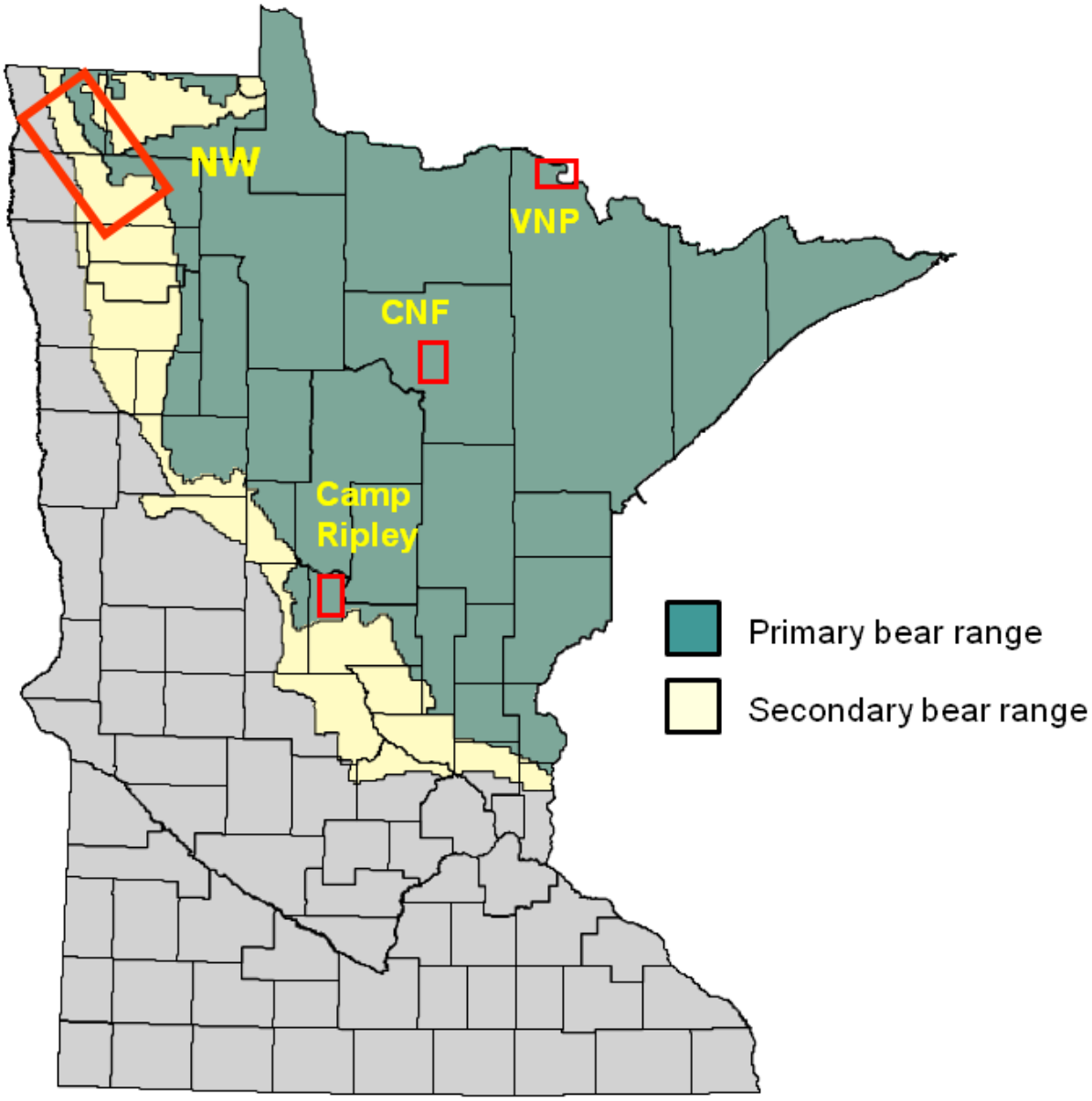

Figure 1. Location of 4 study sites within Minnesota's bear range: CNF (Chippewa National Forest, central bear range; 1981–2017); VNP (Voyageurs National Park, northern fringe of range; 1997–2017); Camp Ripley Military Reserve (near southern edge of range; 1991–2017); NW (northwestern fringe of range; 2007–2017).

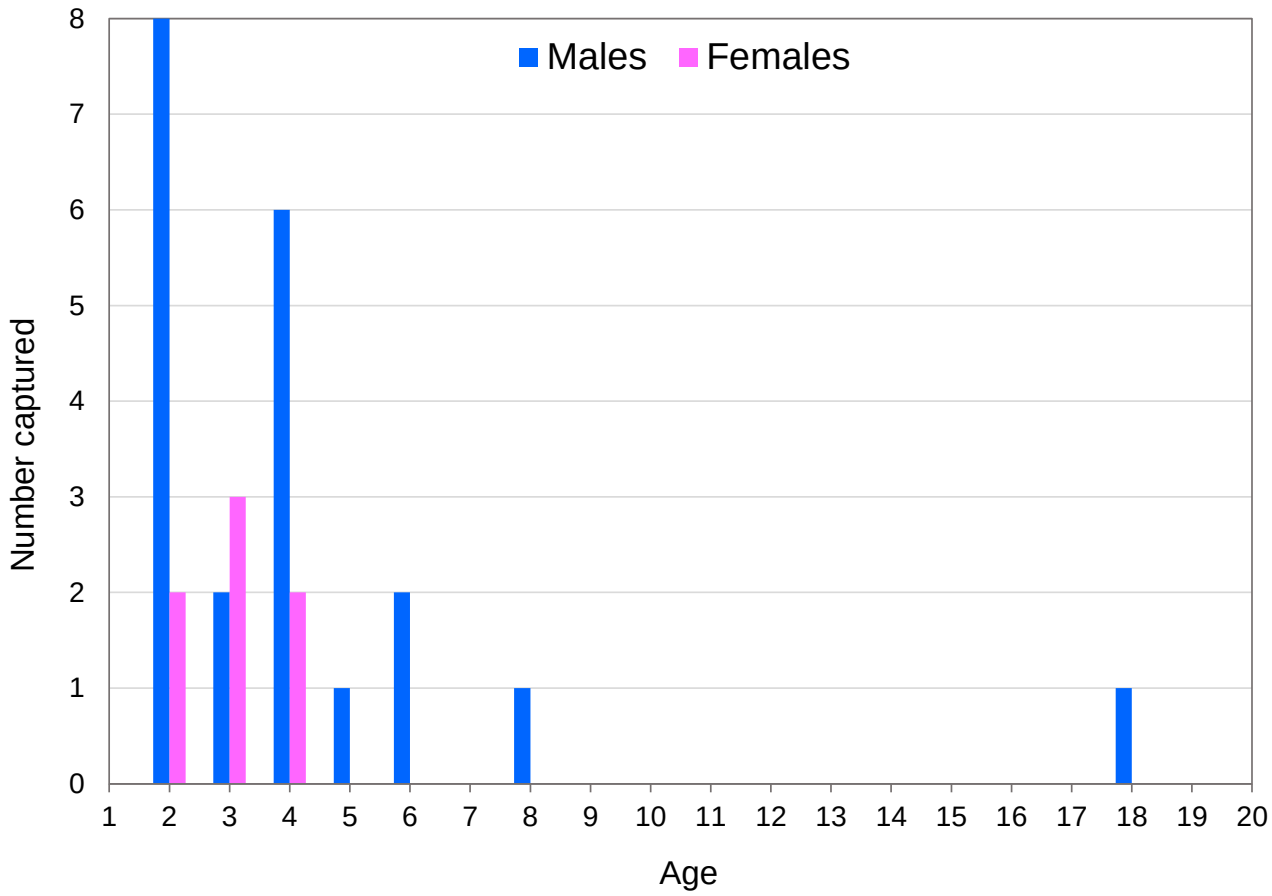

Figure 2. Bears captured by sex and age in the CNF, Minnesota, May−Aug, 2016. All 7 females were collared. Ages were not known at time of capture, so among males, we selected bears to collar based on weight and capture location (not collared: 7 of 8 2-year-olds, 1 4-year-old, 1 6 year-old).

Figure 3. All 3 collared bears at VNP, in Minnesota, visited hunters' baits well outside the park during the 2016 hunting season. A hunter selected the adult female (top). Hunters passed up on the 2 subadult females. (Trail camera photos courtesy of K. Keeler).

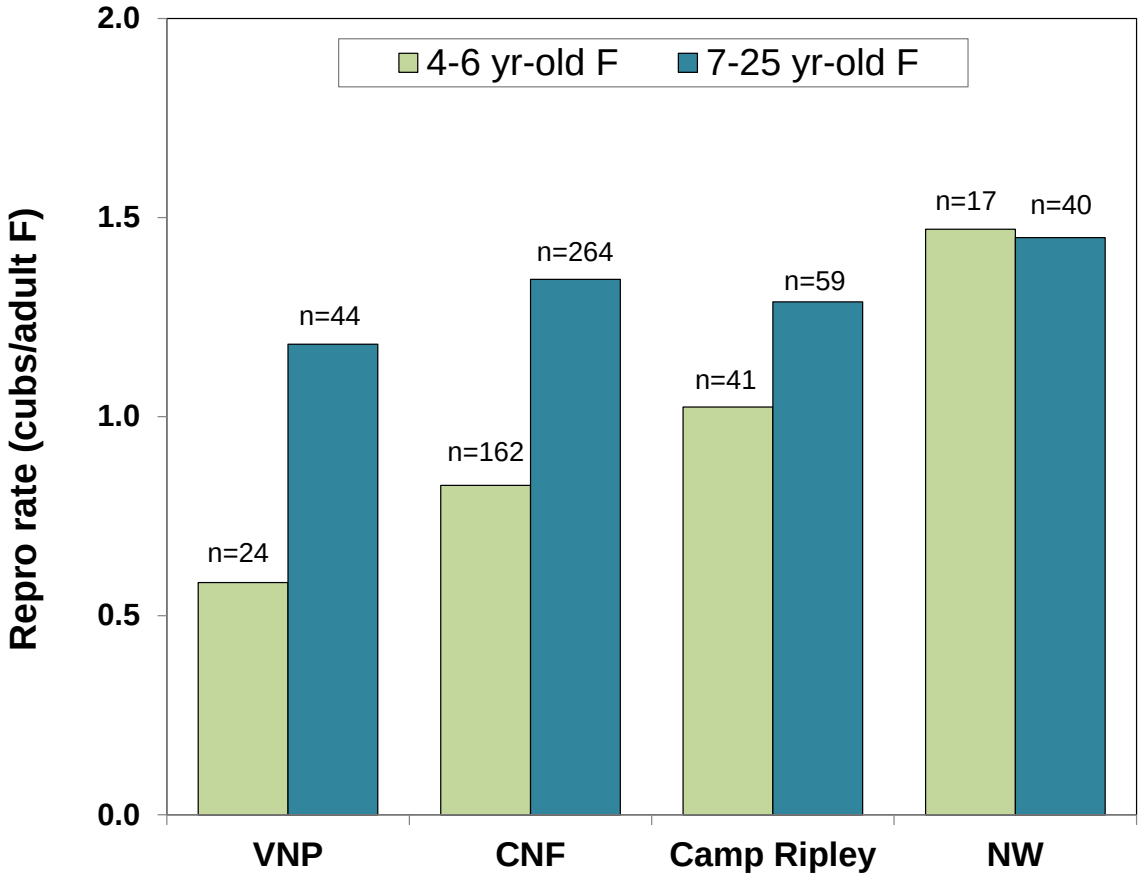

Figure 4. Reproductive rates of radiocollared bears within 4 study sites (see Figure 1) through March 2017 (VNP, Minnesota, since 1997, CNF since 1981, Camp Ripley since 1991, NW since 2007). Data include only litters that survived 1 year (even if some cubs in the litter died). Sample sizes refer to the number of female bear-years of monitoring in each area for each age group. Some bears in CNF, Camp Ripley, and NW produced cubs at 3 years old, but are not included here.

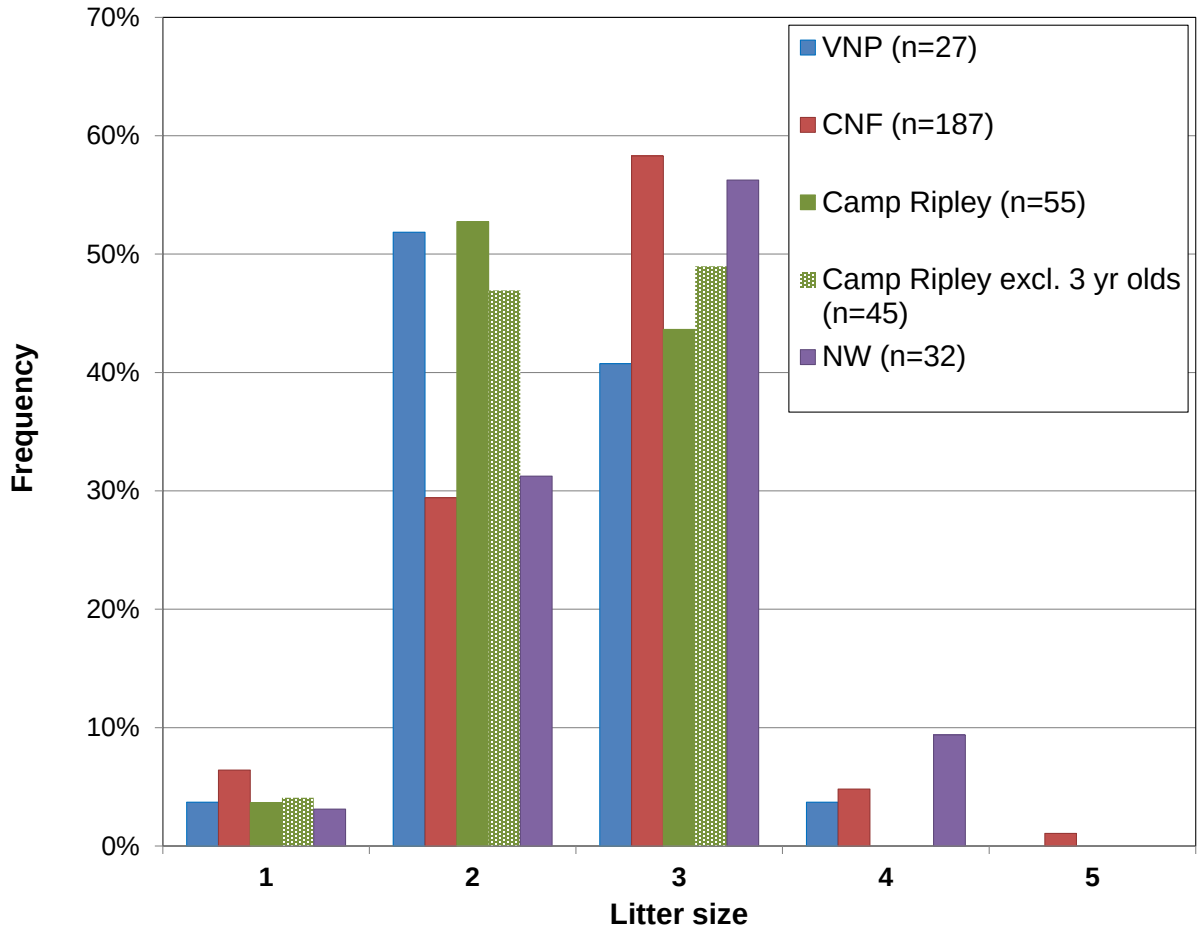

Figure 5. Frequency of cub litter sizes (examined in natal dens in March) within 4 study sites (see Figure 1) through March 2017 in Minnesota. Data include only litters that survived 1 year (even if some cubs in the litter died). Camp Ripley data are shown for mothers of all ages, as well as excluding 3-year-old mothers. For the other sites, elimination of 3-year-olds did not make a difference.

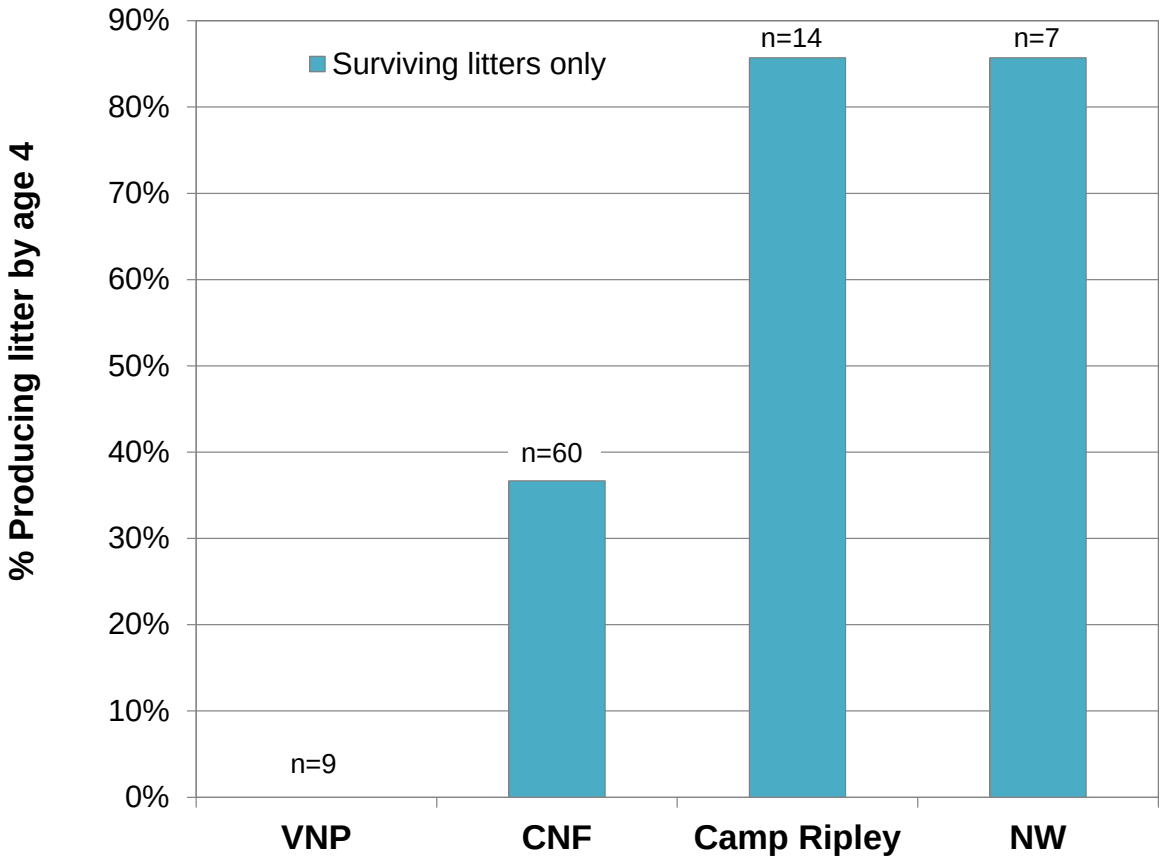

Figure 6. Percent of radiocollared females on each Minnesota study site that produced a surviving litter of cubs by 4 years old. Births of cubs were detected in natal dens in March each year (through March 2017). A surviving litter was one in which at least 1 yearling was present in the mother's den the next winter. Note that no females in VNP produced cubs by 4 years of age.

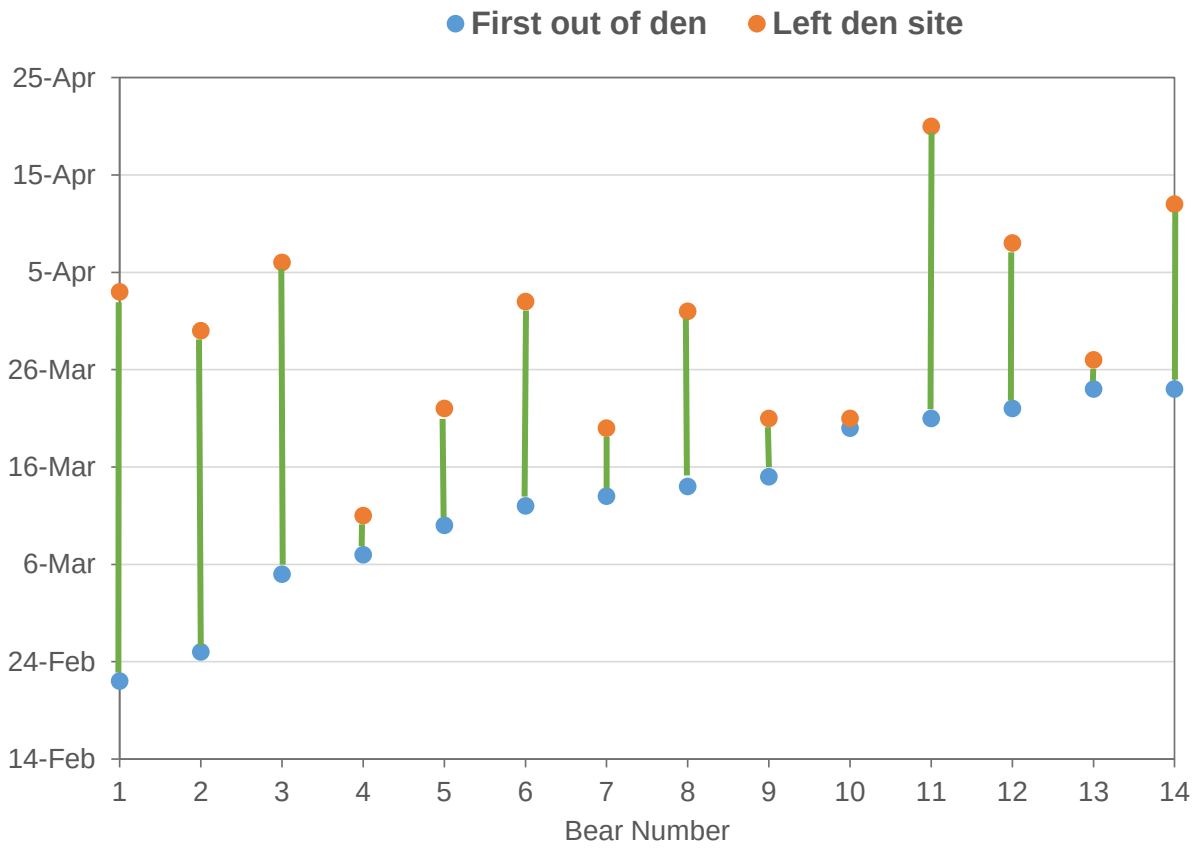

Figure 7. Dates of first emergence from dens, and eventual departure from the den site, for 14 radiocollared black bears monitored with remote cameras in Minnesota, 2015−2017. Green lines show the time period (1−41 days) that the bear remained at the den site following initial emergence.

Figure 8. Hibernating bears do not eat or drink through the winter, but in the month before leaving the den site, they sought to rehydrate, as shown by this camera-trap photo of a CNF bear emerging from its underground den to lick snow, March 12, 2017 Minnesota.

Figure 9. Camera-trap photos of Minnesota's CNF bears emerging from dens showed that they frequently sought dry bedding material as melting snow leaked into their dens. Top row: mother with cubs in nest den pulling in spruce boughs. Middle row: mother with wet hind end coming out on March 22, 2017, to pull in a small balsam twig. Bottom row: same mother coming out again a week later, with water dripping from her hind end as well as that of her yearling; last photo shows mother rearranging the nest at the front of the den (original nest was in the rear) while the yearlings explored outside.

Figure 10. Camera trap photo of a large adult male in an underground den in the CNF in Minnesota, first peering out of its den on March 14, 2017, seemingly to assess the conditions outside (we did not consider this to be den emergence because it did not come completely out of the den). A week later, clearly very wet (bottom photo), the bear fully emerged, and left a day later, despite the area being still totally snow covered.

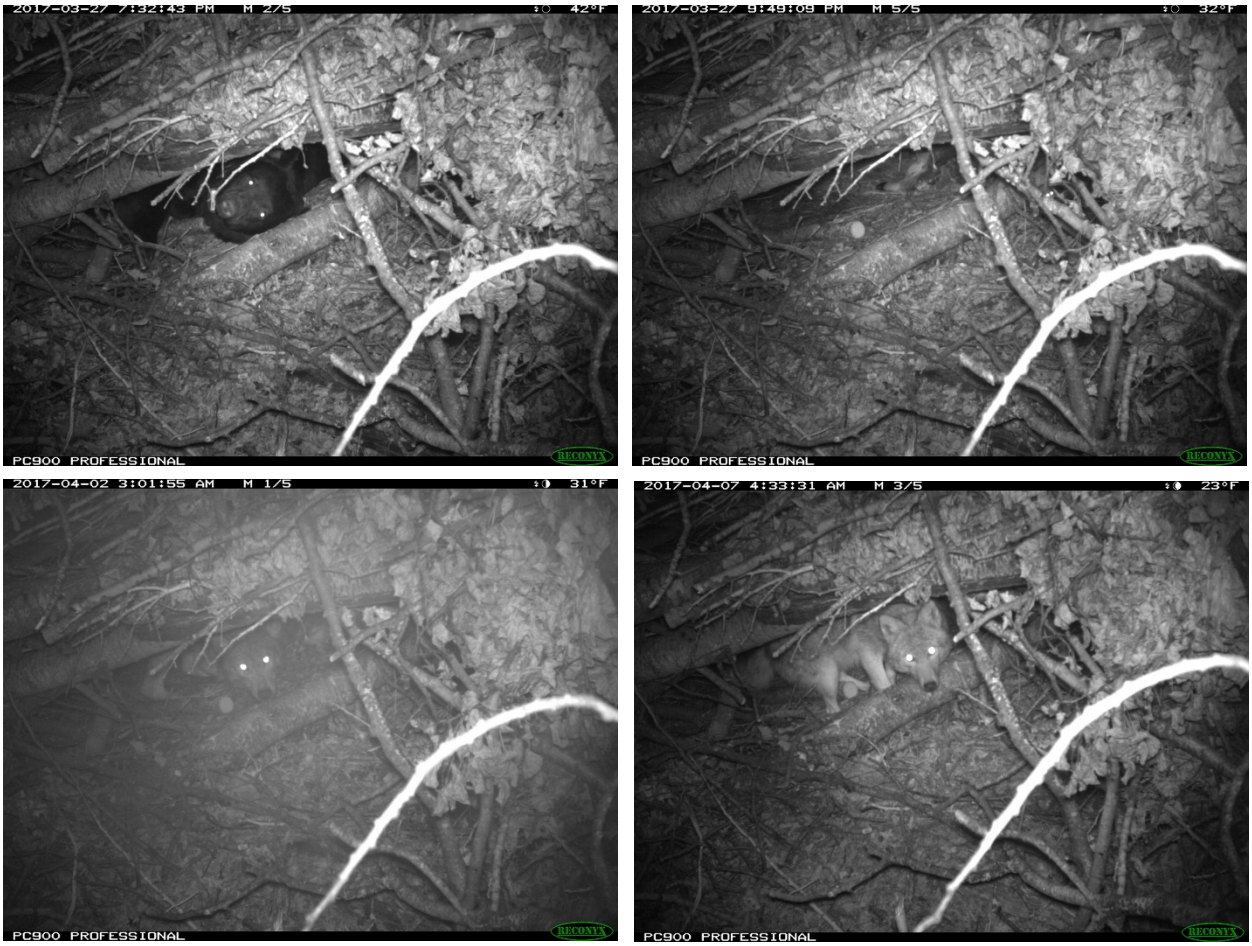

Figure 11. A young male bear, denned in a brush pile in the CNF in Minnesota, retrieved a leg of a dead deer and rolled around on it (top left; leg visible top right after bear left den, March 27, 2017). A few days after the bear departed, a wolf entered the den and ate the leg (bottom left, April 2). Five days later a wolf entered the den again, even though the deer leg was gone.