EXHIBIT 1

CABINET-YAAK GRIZZLY BEAR RECOVERY AREA 2017 RESEARCH AND MONITORING PROGRESS REPORT

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This annual report is cumulative and represents data collected since the inception of this monitoring program in 1983. New information collected or made available to this study is incorporated, reanalyzed, and summarized annually. Information in this report supersedes previous reports. Please obtain permission prior to citation. Cite this report as follows: **Kasworm, W. F., T. G. Radandt, J.E. Teisberg, A. Welander, M. Proctor, and H. Cooley. 2018. Cabinet-Yaak grizzly bear recovery area 2017 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 102 pp.**

ABSTRACT

Seventeen grizzly bears were monitored with radio collars during portions of 2017. Research monitoring included eight females (three adults and five subadults) and nine males (six adults and three subadults) in the Cabinet-Yaak ecosystem (CYE). Two bears were from the Cabinet Mountains (1 subadult male and 1 subadult female) and part of the augmentation program. Four bears were collared for conflict management purposes. Grizzly bear monitoring and research has been ongoing in the Cabinet Mountains since 1988 and in the Yaak River since 1986. Sixty-nine resident bears were captured and monitored through telemetry in the two areas from 1986–2017. Research in the Cabinet Mountains indicated that only a small population remained as of 1988. Concern over persistence of grizzly bear populations within this area resulted in a pilot program in 1990 that tested population augmentation techniques. Four subadult female bears with no history of conflicts with humans were captured in southeast British Columbia and moved to the Cabinet Mountains for release during 1990–94. Three of four transplanted bears remained within the target area for at least one year. Hair snag sampling and DNA analysis during 2000–04 identified one of the original transplanted bears. The animal was a 2 year-old female when released in 1993. Genetic analysis conducted in 2005 identified at least 3 first generation offspring and 2 second generation offspring from this individual. The success of the augmentation test program prompted additional augmentation in cooperation with Montana Fish Wildlife and Parks (MTFWP). Nine female bears and 6 male bears were moved from the Flathead River to the Cabinet Mountains during 2005–17. Three of these individuals died during their first year from human related causes. Two were illegally shot and one was struck by a train. Five bears left the target area for the augmentation effort.

Numbers of females with cubs in the Cabinet-Yaak grizzly bear recovery zone (CYE) varied from 2–3 per year and averaged 2.7 per year from 2012–17. Eleven of 22 bear management units (BMUs) had sightings of females with young. Human caused mortality averaged 1.0 bears per year (0.2 females and 0.8 males) from 2012–17. Six grizzly bears (1 female and 5 males) died due to known or probable human causes during 2012–2017, including one adult female (under investigation), 1 adult male (self-defense), 3 subadult males (self-defense, human under investigation, and poaching), and one male cub (under investigation).

Using all methods of detection (capture, rub tree DNA, corral DNA, photos), we detected a minimum of 35 individual grizzly bears in 2016. Thirteen bears were detected in the Cabinets (7 males, 6 females). Twenty-three bears were detected in the Yaak (14 male, 8 female, 1 unknown sex). One bear was documented in both the Cabinets and the Yaak. Genetics data from 2017 was not complete at the time of this report.

Sex- and age-specific survival and reproductive rates yielded an estimated finite rate of increase (λ) of 1.021 (95% C.I. 0.949–1.087) for 1983–2017 using Booter software with the unpaired litter size and birth interval option. Finite rate of population change was an annual 2.1% for 1983–2017. The probability that the population was stable or increasing was 73%.

Berry counts indicated above average production for huckleberry, average production for buffaloberry and mountain ash, and less than average production for serviceberry during 2017.

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INTRODUCTION

Grizzly bear (*Ursus arctos*) populations south of Canada are currently listed as Threatened under the terms of the 1973 Endangered Species Act (16 U.S.C. 1531-1543). In 1993 a revised Recovery Plan for grizzly bears was adopted to aid the recovery of this species within ecosystems that they or their habitat occupy (USFWS 1993). Seven areas were identified in the Recovery Plan, one of which was the Cabinet-Yaak Grizzly Bear Recovery Zone (CYE) of extreme northwestern Montana and northeast Idaho (Fig. 1). This area lies directly south of Canada and encompasses approximately 6800 km^2. The Kootenai River bisects the CYE, with grizzly bear habitat within the Cabinet Mountains to the south and the Yaak River drainage to the north (Fig. 2). The degree of grizzly bear movement between the two portions was believed to be minimal but several movements by males into the Cabinet Mountains from the Yaak River and the Selkirk Mountains have occurred since 2012.

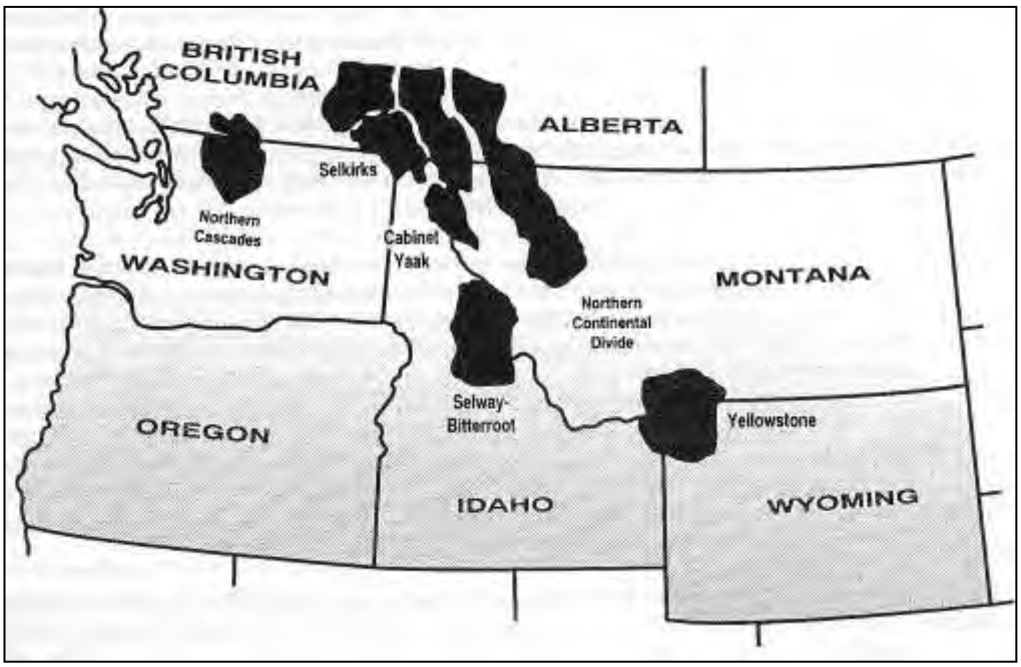


Figure 1. Grizzly bear recovery areas in the U.S., southern British Columbia, and Alberta, Canada.

Research on resident grizzly bears began south of the Kootenai River during the late 1970's. Erickson (1978) reported the results of a survey he conducted for bears and their sign in the Cabinet Mountains and concluded the population consisted of approximately a dozen animals. A trapping effort in 1979 and 1980 in the same area failed to capture a grizzly bear, but a female and yearling were observed (Thier 1981). In 1983 trapping efforts were resumed and intensified (Kasworm and Manley 1988). Three individual grizzly bears were captured and radio-collared during 1983–1987. Minimal reproduction was observed during the period and the population was believed to be declining toward extinction. To reverse this trend, a formal plan was proposed in 1987 to augment the Cabinet Mountains portion of the population with subadult female bears from outside the area (USFWS 1990, Servheen et al. 1987).

Two approaches for augmenting grizzly bears were proposed. The first involved transplanting adult or subadult grizzly bears from other areas of similar habitat to the Cabinet

Mountains. Transplants would involve bears from remote areas that would have no history of conflict with humans. The use of subadult females was recommended because of their smaller home ranges and potential reproductive contribution. The second approach relied on the cross fostering of grizzly bear cubs to American black bear (*Ursus americanus*) females. Under this approach, grizzly bear cubs from zoos would be placed in the maternal dens of black bear females during March or April. The fostering of orphaned black bear cubs to surrogate black bear females has been used successfully in several areas (Alt and Beecham 1984, Alt 1984).

During public review of the augmentation program, many concerns were expressed which included human safety, conflicts with other land-uses, and long-term grizzly bear population goals. A citizen's involvement committee was formed to aid information exchange between the public and the agencies. Representatives of several local organizations donated their time to further this purpose. The first product of this group was a question and answer brochure regarding grizzly bears in the CYE. This brochure was mailed to all box holders in Lincoln and Sanders counties. In response to concerns expressed by the committee, the augmentation proposal was modified to eliminate cross fostering and to reduce total numbers of transplanted bears to four individuals over five years. The beginning date of augmentation was also postponed for one year to allow additional public information and education programs.

Prior to 1986, little work was conducted on grizzly bears in the Yaak River portion of the CYE. Bears that used the area were thought to be largely transitory from Canada. However, a black bear study in the Yaak River drainage in 1986 and 1987 resulted in the capture and radio-collaring of five individual grizzly bears (Thier 1990). The Yaak River area has traditionally been an important source of timber for area mills, with timber harvesting the dominant use of the area. A pine beetle (*Dendroctonus ponderosae*) epidemic began in the mid 1970's. Large stands of lodgepole pine (*Pinus contorta*) were infected, which resulted in an accelerated timber-harvesting program with clearcutting the dominant silvicultural technique. A concern of environmental degradation, as well as the effects of timber harvesting on the local grizzly bear population, prompted a lawsuit against the Forest Service by a local citizen's group in 1983 (USFS 1989). To obtain additional information on the population status and habitat needs of grizzlies using the area, the U.S. Forest Service and Montana Department of Fish, Wildlife, and Parks (MFWP) cooperated with the U.S. Fish and Wildlife Service (USFWS) with initiating a long term study. Field work began in June of 1989.

OBJECTIVES

A. Cabinet Mountains Population Augmentation:

Test grizzly bear augmentation techniques in the Cabinet Mountains to determine if transplanted bears will remain in the area of release and ultimately contribute to the population through reproduction.

B. Recovery Zone Research and Monitoring:

1. Document grizzly bear distribution in the Cabinet/Yaak Grizzly Bear Ecosystem.
2. Describe and monitor the grizzly bear population in terms of reproductive success, age structure, mortality causes, population trend, and population estimates and report this information through the grizzly bear recovery plan monitoring process.
3. Determine habitat use and movement patterns of grizzly bears. Determine habitat preference by season and assess the relationship between human-altered habitats such as logged areas and grizzly bear habitat use. Evaluate grizzly bear movement permeability of the Kootenai River valley between the Cabinet Mountains and the Yaak River drainage and across the Moyie River Valley in British Columbia.
4. Determine the relationship between human activity and grizzly bear habitat use through the

identification of areas used more or less than expected in relation to ongoing timber management activities, open and closed roads, and human residences.

5. Identify mortality sources and management techniques to limit human-caused mortality of grizzly bears.
6. Conduct black bear studies incidental to grizzly bear investigations to determine interspecific relations. Data on black bear densities, reproduction, mortality, movements, habitat-use, and food habits relative to grizzly bears will be gathered and analyzed.

STUDY AREA

The CYE (48° N, 116° W) encompasses approximately 6,800 km^2 of northwest Montana and northern Idaho (Fig. 2). The Cabinet Mountains constitute about 58% of the CYE and lie south of the Kootenai River. The Yaak River portion borders Canadian grizzly populations to the north. There are two potential linkage areas between the Yaak and the Cabinets – one between Libby and Troy and one between Troy and the Idaho border. Prior to 2012 we were unable to document any grizzly bear movement between these areas or grizzly bear use within these linkage zones, however since that time we have documented at least 4 instances where bears have been radio tracked moving from the Selkirk Mountains or the Yaak River in the Cabinet Mountains. Approximately 90% of the recovery area is on public land administered by the Kootenai, Lolo, and Panhandle National Forests. Plum Creek Timber Company Inc. and Stimson Corp. are the main corporations holding a significant amount of land in the area. Individual ownership exists primarily along major rivers, and there are numerous patented mining claims along the Cabinet Mountains Wilderness boundary.

Figure 2. Cabinet-Yaak grizzly bear recovery zone.

The Cabinet Mountains Wilderness encompasses 381 km^2 of higher elevations of the study area in the Cabinet Mountains. Bonners Ferry, Libby, Noxon, Sandpoint, Troy, Thompson Falls, and Trout Creek are the primary communities adjacent to the Cabinet Mountains.

Elevations in the Cabinet Mountains range from 610 m along the Kootenai River to 2,664 m at Snowshoe Peak. The area has a Pacific maritime climate characterized by short, warm summers and heavy, wet winter snowfalls. Lower, drier slopes support stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), whereas grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) dominate lower elevation moist sites. Subalpine fir (*Abies lasiocarpa*), spruce (*Picea spp*.), and mountain hemlock (*Tsuga mertensiana*) dominate stands between 1,500 m and timberline. Mixed coniferous and deciduous tree stands are interspersed with riparian shrub fields and wet meadows along major drainages. Huckleberry (*Vaccinium spp*.) and mixed shrub fields are partially a result of wildfires that occurred in 1910 and 1929 and more recent stand replacing fires. Fire suppression has reduced wildfires as a natural force creating or maintaining berry-producing shrub fields.

The Yaak River drainage lies in the extreme northwestern corner of Montana, northeastern Idaho, and southern British Columbia and is bounded on the east and south by Lake Koocanusa and the Kootenai River, to the west by the Moyie River, and to the north by the international boundary. Two north-south trending mountain ranges dominate the landscape - the McGillivray range in the east and the Purcell range to the west. Topography is varied, with rugged, alpine glaciated peaks present in the Northwest Peaks Scenic Area. Rounded peaks and ridges cover most of the remaining area, a result of continental glaciation. Coniferous forests dominate, with cutting units the primary source of diversity. Much of the Yaak River is low gradient and the river tends to meander, creating lush riparian zones and meadows. Elevations range from 550 m at the confluence of the Kootenai and Moyie Rivers to 2348 m atop Northwest Peak. Vegetation is diverse, with an overstory of western hemlock and western red cedar the indicated climax species on much of the study area. Ponderosa pine and Douglas-fir are common at lower elevations on south and west slopes. Subalpine fir and spruce dominate the upper elevations and cirque basins. Large stands of lodgepole pine and western larch (*Larix occidentalis*) occur at mid and upper elevations and are largely the result of extensive wildfires in the past. In recent decades, several stand altering fires have occurred in the Yaak River. Additionally, the Kootenai and Idaho Pandhandle National Forests have implemented prescribed fire to promote grizzly bear habitat in recent years.

Understory and non-forested habitats include graminoid parks consisting primarily of fescue (*Festuca* spp.) and bluebunch wheatgrass (*Agropyron spicatum*), which occur at moderate to high elevations. Riparian shrub fields of red-osier dogwood (*Cornus stolonifera*) and hawthorn (*Crataegus douglasii*) are prevalent along major drainages. Buffaloberry (*Shepherdia canadensis*) is common under stands of open lodgepole pine while serviceberry (*Amelanchier alnifolia*) and chokecherry (*Prunus virginiana*) prevail on drier, rockier sites. Huckleberry shrub fields are often found under open timber canopies adjacent to graminoid parks, in old burns, in cutting units, and intermixed with beargrass (*Xerophyllum tenax*). Recent wildfires at upper elevations have had more influence on habitat in the CYE. An outbreak of pine bark beetles resulted in logging large areas at lower elevations during the 1980's. Large portions of upper elevations had been logged earlier in response to a spruce bark beetle (*Dendroctonus obesus*) epidemic.

During 1990–1994, Cabinet Mountains population augmentation trapping was conducted in the upper North Fork of the Flathead River drainage and the Wigwam River drainage in southeast British Columbia, approximately 10–40 km north of the U.S. border. Trapping was also conducted south of the international border in the North Fork of the Flathead River in 1992. Since 2005, augmentation trapping has occurred south of the international border in the Flathead River drainage.

METHODS

This annual report is cumulative and represents almost all data collected since the inception of this monitoring program since 1983. New information collected or made available to this study was incorporated into summaries and may change previous results.

Grizzly Bear Observations and Mortality

All grizzly bear observations and reports of sign (tracks, digs, etc.) by study personnel and the public were recorded. Grizzly bear sighting forms were sent to a variety of field personnel from different agencies to maximize the number of reports received. Sightings of grizzly bears were rated 1–5 with 5 being the best quality and 1 being the poorest. General definitions of categories are presented below, but it was difficult to describe all circumstances under which sightings were reported. Only sightings receiving ratings of 4 or 5 were judged credible for use in reports. Sightings that rate 1 or 2 may not be recorded in the database.

5 - Highest quality reports typically from study personnel or highly qualified observers. Sightings not obtained by highly qualified observers must have physical evidence such as pictures, track measurements, hair, or sightings of marked bears where marks are accurately described.

4 - Good quality reports that provide credible, convincing descriptions of grizzly bears or their sign. Typically these reports include a physical description of the animal mentioning several characteristics. Observer had sufficient time and was close enough or had binoculars to aid identification. Observer demonstrates sufficient knowledge of characteristics to be regarded as a credible observer. Background or experience of observer may influence credibility.

3 - Moderate quality reports that do not provide convincing descriptions of grizzly bears. Reports may mention 1 or 2 characteristics, but the observer does not demonstrate sufficient knowledge of characteristics to make a reliable identification. Observer may have gotten a quick glimpse of the bear or been too far away for a good quality observation.

2 - Lower quality observations that provide little description of the bear other than the observer's judgment that it was a grizzly bear.

1 - Lowest quality observations of animals that may not have been grizzly bears. This category may also involve second hand reports from other than the observer.

Reported grizzly bear mortality includes all bears known to have died within the U.S. and within 16 km of the international border in Canada. Many bears collared in the U.S. have home ranges that extend into Canada. Mortality occurring in this area within Canada can affect calculations for U.S. populations. All radio collared bear mortality was reported regardless of location in the U.S. or Canada.

Survival and Mortality Calculations

Survival rates for all age classes except cubs were calculated by use of the Kaplan-Meier procedure as modified for staggered entry of animals (Pollock et al. 1989, Wakkinen and Kasworm 2004). Assumptions of this method include: marked individuals were representative of the population, individuals had independent probabilities of survival, capture and radio collaring did not affect future survival, censoring mechanisms were random, a time origin could be defined, and newly collared animals had the same survival function as previously collared animals. Censoring was defined as radio-collared animals lost due to radio failure, radio loss, or emigration of the animal from the study area. Kaplan-Meier estimates may differ slightly from Booter survival estimates used in the trend calculation. Survival rates were calculated separately for native, augmentation, and management bears because of biases associated with initial capture and expected differences in survival functions.

Our time origin for each bear began at capture. If a bear changed age classification while radio-collared (i.e., subadult to adult), the change occurred on the first of February (the assigned birth date of all bears). Weekly intervals were used in the Kaplan-Meier procedure during which survival rates were assumed constant. No mortality was observed during the denning season. Animals were intermittently added to the sample over the study. Mortality dates were established based on radio telemetry, collar retrieval, and mortality site inspection. Radio failure dates were estimated using the last radiolocation date when the animal was alive.

Cub recruitment rates to 1 year of age were estimated as: {1 - (cub mortalities / total cubs observed)}, based on observations of radio-collared females (Hovey and McLellan 1996). Mortality was assumed when a cub disappeared or if the mother died. Cubs were defined as bears < 1.0 year old.

Bears captured and relocated to the Cabinet Mountains as part of population augmentation were not included in the population trend calculation (Appendix Table 1). None of these animals had any prior history of nuisance activity. Bears captured initially as objects of conflict captures were not included. Several native bears that were captured as part of a preemptive move to avoid nuisance activity were included.

Use of known human-caused mortality counts probably results in under-estimates of total human-caused mortality. Numerous mortalities identified by this study were reported only because animals wore a radio-collar at the time of death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry et al. 2002). The correction factor was not applied to natural mortality, management removals, mortality of radio collared bears or bears that died of unknown causes. All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes.

Cabinet Mountains augmentation individuals were counted as mortalities when removed from the Northern Continental Divide Recovery Zone and are not counted again as mortalities in the CYE if they die during their first year (Appendix Table 2). Mortalities in Canada are not counted toward recovery goals (USFWS 1993) even though bears initially marked within the CYE have died in Canada. Bears originating in Canada that die in the US are counted.

Reproduction

Reproduction data was gathered through observations of radio-collared females with offspring and genetics data analyzed for maternity relationships. Because of possible undocumented neonatal loss of cubs, no determination of litter size was made if an observation was made in late summer or fall. Inter-birth interval was defined as length of time between subsequent births. Age of first parturition was determined by presence or lack of cubs from observations of aged radio-collared bears and maternity relationships in genetics data from known age individuals.

Population Growth Rate

We used the software program Booter 1.0 (© F. Hovey, Simon Fraser University, Burnaby, B.C.) to estimate the finite rate of increase (λ, or lambda) for the study area's grizzly bear populations. The estimate of λ was based on adult and subadult female survival, yearling and cub survival, age at first parturition, reproductive rate, and maximum age of reproduction.

Booter uses the following revised Lotka equation (Hovey and McLellan 1996), which assumes a stable age distribution:

$$(1) \quad 0 = \lambda^{a} - S_a \lambda^{a-1} - S_c S_y S_s^{a-2} m[1 - (S_a / \lambda)^{w-a+1}],$$

where S_a, S_s, S_y, and S_c are adult female, subadult female, yearling, and cub survival rates, respectively, a = age of first parturition, m = rate of reproduction, and w = maximum age. Booter calculates annual survival rates with a seasonal hazard function estimated from censored telemetry collected through all years of monitoring in calculation of λ. This technique was used on adults, subadults, and yearlings. Point estimates and confidence intervals may be slightly different from those produced by Kaplan-Meier techniques (differences in Tables 14 and 15). Survival rate for each class was calculated as:

$$(2) \quad S_i = \prod_{j=1}^{k} e^{-L_j(D_{ij} - T_{ij})}$$

where S_i is survival of age class i, k is the number of seasons, D_{ij} is the number of recorded deaths for age class i in season j, T_{ij} is the number of days observed by radio telemetry, and L_j is the length of season j in days. Cub survival rates were estimated by 1 - (cub mortalities / total cubs born), based on observations of radio-collared females. Intervals were based on the following season definitions: spring (1 April - 31 May), summer (1 June - 31 August), autumn (1 September - 30 November), and winter (1 December - 31 March). Intervals were defined by seasons when survival rates were assumed constant and corresponded with traditional spring and autumn hunting seasons and the denning season.

Booter provides several options to calculate a reproductive rate (m) and we selected three to provide a range of variation (McLellan 1989). The default calculation requires a reproductive rate for each bear based upon the number of cubs produced divided by the number of years monitored. We input this number for each adult female for which we had at least one litter size and at least three successive years of radio monitoring, captures, or observations to determine reproductive data. We ran the model with this data and produced a trend calculation. Among other options, Booter allows use of paired or unpaired litter size and birth interval data with sample size restricted to the number of females. If paired data is selected, only those bears with both a known litter size and associated inter-birth interval are used. The unpaired option allows the use of bears from which accurate counts of cubs were not obtained but interval was known, for instances where litter size was known but radio failure or death limited knowledge of intervals. To calculate reproductive rates under both these options, the following formula was used (from Booter 1.0):

$$(3) \quad m = \frac{\displaystyle\sum_{i=1}^{n} \frac{\sum_{j=1}^{p} L_{ij}}{\sum_{j=1}^{k} B_{IJ}}}{n}$$

where n = number of females; j = observations of litter size (L) or inter-birth interval (B) for female i; p = number of observations of L for female i; and k = number of observations of B for female i. Note k and p may or may not be equal. Cub sex ratio was assumed to be 50:50 and maximum age of female reproduction (w) was set at 27 years (Schwartz et al. 2003). Average annual exponential rate of increase was calculated as $r = \log_e \lambda$ (Caughley 1977).

Capture and Marking

Capture and handling of bears followed an approved Animal Use Protocol through the University of Montana, Missoula, MT (061-14CSCFC111714). Capture of black bears and grizzly bears was performed under state permits 2016-022 and federal permit TE704930-0. Bears were captured with leg-hold snares following the techniques described by Johnson and Pelton (1980) and Jonkel (1993). Snares were manufactured in house following the Aldrich Snare Co. (Clallam Bay, WA) design and consist of 6.5 mm braided steel aircraft cable. Bears were immobilized with either Telazol (tiletamine hydrochloride and zolazepam hydrochloride), a mixture of Ketaset (ketamine hydrochloride) and Rompun (xylazine hydrochloride), a mixture of Telazol and Dexmedetomidine, or a combination of Telazol and Rompun. Yohimbine and Atipamezole were the primary antagonists for Rompun and Dexmedetomidine. Drugs were administered intramuscularly with a syringe mounted on a pole (jab-stick), homemade blowgun, modified air pistol, or cartridge powered dart gun. Immobilized bears were measured, weighed, and a first premolar tooth was extracted for age determination (Stoneberg and Jonkel 1966). Blood, tissue and/or hair samples were taken from most bears for genetic and food use studies. Immobilized bears were given oxygen at a rate of 2–3 liters per minute. Recovering bears were dosed with Atropine and Diazepam.

All grizzly bears and some adult black bears (≥ 4.0 years old) were fitted with radio collars or ear tag transmitters when captured. Some bears were collared with Global Positioning System (GPS) radio collars. Collars were manufactured by Telonics® (Mesa, AZ) and ear tag transmitters were manufactured by Advanced Telemetry Systems® (Isanti, MN). To prevent permanent attachment, a canvas spacer was placed in the collars so that they would drop off in 1–3 years (Hellgren et al. 1988).

Trapping efforts were typically conducted from May through September. In 1986–87, snares were placed in areas where black bear captures were maximized on a defined study area of 214 km^2 (Thier 1990). Snares were placed over a broader area during 1989–94 to maximize grizzly bear captures. Trap sites were usually located within 200 m of an open road to allow vehicle access. Beginning in 1995, an effort was made to capture and re-collar known grizzly bears in the Yaak River and augmentation bears in the Cabinet Mountains. In 2003, trapping was initiated in the Salish Mountains south of Eureka, Montana to investigate bear movements in the intervening area between the Northern Continental Divide and Cabinet-Yaak recovery zones. Trapping was conducted along Highway 2 in northwest Montana and along Highway 3 in southeast British Columbia to collar bears with GPS radio collars during 2004–2010. During 2011, trapping was initiated along Highway 95 near McArthur Lake in northern Idaho and along Interstate 90 near Lookout Pass in Montana and Idaho. All 4 studies were designed to examine bear population connectivity across river valleys with highways and human habitation. Highway 2, 95, and I-90 studies utilized black bears as surrogates for grizzly bears because of the small number of grizzly bears in the valley. The Highway 3 effort in British Columbia collared grizzly bears and black bears. Much of the trapping effort in the Yaak and Cabinet Mountains areas involved the use of horses on backcountry trails and closed logging roads. Traps were checked daily. Bait consisted primarily of road-killed ungulates.

Trapping for population augmentation was conducted in the North Fork of the Flathead River in British Columbia during 1990–94. Only unmarked female grizzly bears < 6 years old (or prior to first reproduction) and > 35 kg were deemed suitable for transplant. Other captured grizzly bears were released with some collared to aid an ongoing BC bear study. Capture efforts for bears transplanted in 2005–17 occurred primarily in the North Fork and South Fork of the Flathead River in the US by MTFWP. No suitable bears were captured in 1992 or 2007.

Hair Sampling for DNA Analysis

This project originally sought evidence of grizzly bears in the Cabinet Mountains using DNA to understand the fates of 4 bears transplanted during 1990–94. The program used genetic information from hair-snagging with remote-camera photo verification to identify transplanted bears or their offspring living in the Cabinet Mountains. Since then, sampling has expanded into the Yaak drainage and project objectives now include: observations of females with young, sex ratio of captured bears, relatedness as well as genetic diversity measures of captured bears, and evidence of interpopulation movements of individuals.

Sampling occurred from May–October of 2002–17 in the CYE in Idaho and Montana following standard hair snagging techniques (Woods *et al.* 1999). Sampling sites were established based on location of previous sightings, sign, and radio telemetry from bears in the Cabinet Mountains and Yaak drainage. A 5 km x 5 km grid (25 km^2) was used to distribute sample sites across the area in 2003 (n=184). Each grid cell contained a single sample point near the center of the cell. Actual site location was modified on the basis of access to the site and habitat quality near the site. Sites were baited with 2 liters of a blood and fish mixture to attract bears across a barbwire perimeter placed to snag hair. Sites were deployed for 2 weeks prior to hair collection. One third of sites were sampled during each of the months of June, July, and August. Sample sites were stratified by elevation with lowest elevation sites sampled in June and highest elevation sites sampled in August. Remote cameras were used at some sites. Hair was collected and labeled to indicate: number and color of hairs collected, site location, date, and barb number. These data aided sorting hair to minimize lab costs. Samples collected as a part of this effort and other hair samples collected in the Cabinet Mountains in previous years that were either from known grizzly bears or samples that outwardly appeared to be grizzly bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Hairs visually identified as black bear hair by technicians at the Laboratory were not processed and hairs processed and determined to be black bear were not genotyped. Dr. Michael Proctor (Birchdale Ecological Consulting) is a cooperator on this project and assisted with genetic interpretations. He has previously analyzed genetic samples from the Yaak portion of this recovery zone (Proctor 2003). Hair snag sampling effort during 2012 was altered and reduced to avoid conflicts with a US Geological Survey (USGS) study to estimate CYE grizzly bear population size (Kendall et al. 2015). USGS was concerned that our sample sites might influence capture success at their sites.

The USGS study established and sampled 1373 rub trees across the CYE during 2012. The study made preliminary data available regarding the success of this effort by providing us coordinates of all trees and those trees that produced grizzly bear samples. Sites that produced grizzly bear hair and adjacent sites that were easily sampled in conjunction with successful sites were resampled 2–4 times during 2013–17. Collected hairs were evaluated by study personnel and samples not judged to be probable black bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping.

Radio Monitoring

Attempts were made to obtain aerial radiolocations on all instrumented grizzly bears at least once each week during the 7–8 month period in which they were active. GPS collars attempted a location fix every 1–2 hours. Collar releases were programmed to drop in early October for retrieval. Expected collar life varied from 1-3 field seasons over the course of the study depending upon model of collar and programming. Augmentation bears were monitored daily following release for at least the first two weeks and usually three times per week following. In addition, efforts were made to obtain as many ground locations as possible on all bears, usually by triangulating from a vehicle. Life home ranges (minimum convex polygons; Hayne 1959) were calculated for grizzly bears during the study period. We generated home range polygons using XTools within ArcGIS.

Grizzly and black bears were collared with GPS collars during 2004–10 to study movements across the Moyie River Valley and Highway 3 in British Columbia. Black bears were tested for their potential to act as surrogates that would predict grizzly bear movements.

Collars attempted locations every 1–2 hours depending on configuration and data were stored within the collar. Weekly aircraft radio monitoring was conducted to check for mortality signals and approximate location. From 2004 to 2007, black bears were fitted with similar GPS radio collars to study movements across the Kootenai River Valley and Highway 2 in Montana, as part of linkage monitoring between the Yaak River and Cabinet Mountains. In 2008–2012, black bears were fitted with GPS collars in the Yaak River study area and along the Clark Fork River on the south end of the Cabinet Mountains study area.

Scat analysis

Bear scats were collected, tagged, and either dried or frozen. We only considered scats associated with definite grizzly bear sign (tracks, hair, and radio location of instrumented bear) as from grizzly bears. Food habits analysis was completed by William Callaghan (Florence, MT) and Kevin Frey (Bozeman, MT). Samples were rinsed with hot and cold water over 2 different size mesh screens (0.40 and 0.24 cm). The retained contents were identified to species with the aid of microscopes. We recorded plant part and visually estimated percent volume. We corrected scat volumes with correction factors that incorporate different digestibilities of various food items (Hewitt and Robbins 1996).

Isotope analysis

Hair samples from known age, captured grizzly bears were collected and analyzed for stable isotopic ratios. Stable isotope signatures indicate source of assimilated (i.e., digested) diet of grizzly bears. Nitrogen stable isotope ratios (^{15}N) indicate trophic level of the animal; an increased amount of ingested animal matter yields higher nitrogen isotope ratios while lower values tie to more plant-based diets. In our ecosystem, carbon isotope signatures vary depending on the amount of native C3 vs. C4 plant matter ingested. Corn, a C4 plant, has elevated ^{13}C/^{12}C ratios relative to native C3 plants. Because much of the human food stream is composed of corn, carbon stable isotope signatures allow for verification or identification of human food conditioned bears.

Hair samples were rinsed with a 2:1 chloroform:methanol solution to remove surface contaminants. Samples were then ground in a ball mill to homogenize the sample. Powdered hair was then weighed and sealed in tin boats. Isotope ratios of δ^{13}C and δ^{15}N were assessed by continuous flow methods using an elemental analyzer (ECS 4010, Costech Analytical, Valencia, California) and a mass spectrometer (Delta PlusXP, Thermofinnigan, Bremen, Germany) (Brenna et al. 1997, Qi et al. 2003).

Berry Production

Quantitative comparisons of annual fluctuations and site-specific influences on fruit production of huckleberry and buffaloberry were made using methods similar to those established in Glacier National Park (Kendall 1986). Transect line origins were marked by a painted tree or by surveyors' ribbon. A specific azimuth was followed from the origin through homogenous habitat. At 0.5 m intervals, a 0.04 m^2 frame (2 x 2 decimeter) was placed on the ground or held over shrubs and all fruits and pedicels within the perimeter of the frame were counted. If no portion of a plant was intercepted, the frame was advanced at 0.5 meter intervals and empty frames were counted. Fifty frames containing the desired species were counted on each transect. Timbered shrub fields and mixed shrub cutting units were the primary sampling areas to examine the influence of timber harvesting on berry production within a variety of aspects and elevations. Notes on berry phenology, berry size, and plant condition were recorded. Service berry, mountain ash, and buffaloberry production was estimated from 10 marked plants at several sites scattered across the recovery area. Since 1989 several sites have been added or relocated to achieve goals for geographic distribution. Some transects were eliminated because plant succession or fire had affected production. Monitoring goals identified an annual trend of berry production and did not include documenting the effects of succession.

Huckleberry sampling began in 1989 at 11 transect sites. Fifteen sites were sampled in 2017. Buffaloberry sampling began in 1990 at 5 sites. Due to the dioecious (separate male and female plants) nature of buffaloberry all frame count transects were dropped in 2007 in favor of marking 10 plants per site and counting the berries on marked plants. Two sites were sampled in 2017. Serviceberry productivity was estimated by counting berries on 10 marked plants at 5 sample sites beginning in 1990. Five sites were sampled in 2017. In 2001, three new plots were established to document berry production of mountain ash (*Sorbus scopulina*). Ten plants were permanently marked at each site for berry counts, similar to the serviceberry plots. Production counts occurred at 3 sites in 2017.

Temperature and relative humidity data recorders (LogTag®, Auckland, New Zealand) were placed at sites beginning in 2011. These devices record conditions at 90 minute intervals and will be retrieved, downloaded, and replaced at annual intervals. We used a berries/plot or berries/plant calculation as an index of berry productivity. Transects were treated as the independent observation unit. For each year observed, mean numbers of berries/plant (berries/plot) were used as our transect productivity indices. For each year, we indicate whether berry productivity is above average (annual 95% confidence interval falls above study-wide mean), average (confidence interval encompasses the study-wide mean), or below average (confidence interval falls below study-wide mean).

RESULTS AND DISCUSSION

Research and monitoring with telemetry and full time personnel were present since 1983 and therefore this date represents the most intense period of data collection. All tables and calculations are updated when new information becomes available. For instance, genetic analysis determined the sex of a previously unknown mortality (2012) and a bear originally identified as a probable mortality (2003) was removed when genetic evidence later indicated that the bear survived that incident.

Grizzly Bear Observations and Recovery Plan Targets

Grizzly bear observations and mortality from public and agency sightings or records were appended to databases. These databases include information from the U.S. and Canada. The file includes over 1,600 credible sightings, tracks, scats, digs, and hair dating from 1960 (Fig. 3) and 149 mortalities dating from 1949 (Appendix Table 2, Fig. 3). Credible sightings were those rating 4 or 5 on the 5 point scale (see page 9). Sixty-nine instances of grizzly bear mortality were detected inside or within 16 km of the CYE (including Canada) during 1982–2017 (Table 1). Seventy-five credible sightings were reported to this study that rated 4 or 5 (most credible) during 2017. Thirty-eight of these sightings occurred in the Yaak portion of the CYE and 37 sightings occurred in the Cabinet Mountains portion of the CYE (Table 2 and Fig. 3).

<u>Recovery Target 1: 6 females with cubs over a running 6-year average both inside the recovery zone and within a 10 mile area immediately surrounding the recovery zone</u>.
Five credible sightings of a female with cubs occurred during 2017 in Bear Management Units (BMUs) 5, 6, and 16 (Tables 2, 3, 4, 5, Fig. 4 and 5). There appeared to be 3 unduplicated females with cubs in the recovery area or within 10 miles during 2017. Three credible sightings of a female with yearlings or 2-year-olds occurred in BMUs 6 and 17. Unduplicated sightings of females with cubs (excluding Canada) varied from 2–3 per year and averaged 2.7 per year from 2012–17 (Tables 3, 4).

Recovery Target 2: 18 of 22 BMU's occupied by females with young from a running 6-year sum of verified evidence.

Eleven of 22 BMUs in the recovery zone had sightings of females with young (cubs, yearlings, or 2-year-olds) during 2012–17 (Figs. 4, 5, Table 6). Occupied BMUs were: 2, 5, 6, 8, 11, 12, 13, 14, 15, 16, and 17.

Recovery Target 3: The running 6-year average of known, human-caused mortality should not exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. .

No known human caused mortality occurred during 2017. Six known or probable human caused mortalities of grizzly bears have occurred in or within 10 miles of the CYE in the U.S. during 2012–17 (Table 1), including 1 female (Deer Ridge) and 5 males (BMUs 12, 13, 19, 22, Deer Ridge units). These mortalities included one adult female (human caused, under investigation), 1 adult male (self-defense), 3 subadult males (self-defense, poaching, and a human caused under investigation), and one male cub (human caused, under investigation). We estimated minimum population size by dividing observed females with cubs during 2015–17 (8) minus any human-caused adult female mortality (0) by 0.6 (sightability correction factor as specified in the recovery plan) then dividing by 0.284 (adult female proportion of population, as specified in the recovery plan) (Tables 3, 4) (USFWS 1993). This resulted in a minimum population of 46 individuals. The recovery plan states; "any attempt to use this parameter to indicate trends or precise population size would be an invalid use of these data". Applying the 4% mortality limit to the minimum calculated population resulted in a total mortality limit of 1.9 bears per year. The female limit is 0.6 females per year (30% of 1.9). Average annual human caused mortality for 2012–17 was 1.0 bears/year and 0.2 females/year. These mortality levels for total bears and female mortality were less than the calculated limit during 2012–17. The recovery plan established a goal of zero human-caused mortality for this recovery zone due to the initial low number of bears, however it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem." Therefore, even if the goal of zero mortality is not met, it is important to evaluate the targets to determine if we are making progress towards recovery. During the 2012–17 reporting period we are meeting all mortality targets and moving closer to recovery. All tables and calculations are updated as new information becomes available.

Table 1. Known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak grizzly bear recovery zone (including Canada). Includes all radio collared bears regardless of mortality location, 1982–2017.

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
October, 1982	None	M	AD	Human, Poaching	Grouse Creek, ID	No	Yes	USFS
October, 1984	None	Unk	Unk	Human, Mistaken Identity, Black bear	Harvey Creek, ID	Yes	Yes	USFS
9/21/1985	14	M	AD	Human, Self Defense	Lyons Gulch, MT	No	Yes	USFS
7/14/1986	106 cub	Unk	Cub	Natural	Burnt Creek, MT	Unk	No	USFS
10/25/1987	None	F	Cub	Human, Mistaken Identity, Elk	Flattail Creek, MT	No	Yes	USFS
5/29/1988[1]	134	M	AD	Human, Legal Hunter kill	Moyie River, BC	Yes	Yes	BC
10/31/1988	None	F	AD	Human, Self Defense	Seventeen Mile Creek, MT	No	Yes	USFS
7/6/1989	129	F	3	Human, Research	Burnt Creek, MT	Yes	No	USFS
1990	192	M	2	Human, Poaching	Poverty Creek, MT	Yes	Yes	USFS
1992	678	F	37	Unknown	Trail Creek, MT	No	Yes	USFS
7/22/1993	258[2]	F	7	Natural	Libby Creek, MT	No	No	USFS
7/22/1993	258-cub	Unk	Cub	Natural	Libby Creek, MT	No	No	USFS

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
10/4/1995[1]	None	M	AD	Human, Management	Ryan Creek, BC	Yes	Yes	PRIV
5/6/1996	302	M	3	Human, Undetermined	Dodge Creek, MT	Yes	No	USFS
October, 1996[1]	355	M	AD	Human, Undetermined	Gold Creek, BC	Yes	No	BC
June? 1997	None	M	AD	Human, Poaching	Libby Creek, MT	Unk	Yes	PRIV
6/4/1999	106	F	21	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	M	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	F	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
10/12/1999[1]	596	F	2	Human, Self Defense	Hart Creek, BC	Yes	Yes	BC
11/15/1999	358	M	15	Human, Management	Yaak River, MT	Yes	Yes	PRIV
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
7/1/2000	303-cub	Unk	Cub	Natural	Fowler Creek, MT	Unk	No	USFS
11/15/2000	592	F	3	Human, Undetermined	Pete Creek MT	Yes	No	USFS
5/5/2001	None	F	1	Human, Mistaken Identity, Black Bear	Spread Creek, MT	Yes	Yes	USFS
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
9/6/2001	128	M	18	Human, Undetermined	Swamp Creek, MT[3]	Yes	No	PRIV
October, 2001	None	F	AD	Human, Train collision	Elk Creek, MT	Yes	Yes	MRL
6/24/2002[1]	None	Unk	Unk	Human, Mistaken Identity, Hounds	Bloom Creek, BC	Yes	Yes	BC
7/1/2002	577	F	1	Natural	Marten Creek, MT	Yes	No	USFS
10/28/2002	None	F	4	Human, Undetermined	Porcupine Creek, MT	Yes	Yes	USFS
11/18/2002	353/584	F	7	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	F	Cub	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	Unk	Cub	Human, Poaching	Yaak River, MT	Yes	No	PRIV
10/15/2004[1]	None	F	AD	Human, Management	Newgate, BC	Yes	Yes	PRIV
2005?	363	M	14	Human, Undetermined	Curley Creek, MT	Yes	Yes	PRIV
10/9/2005	694	F	2	Human, Undetermined	Pipe Creek, MT	Yes	No	PCT
10/9/2005	None	F	2	Human, Train collision	Government Creek, MT	Yes	Yes	MRL
10/19/2005	668	M	3	Human, Mistaken Identity, Black bear	Yaak River, MT	Yes	Yes	PRIV
5/28/2006[1]	None	F	4	Human, Research	Cold Creek, BC	Yes	No	BC
6/1/2006[1]	292	F	5	Human, Management	Moyie River, BC	Yes	Yes	PRIV
9/22/2007	354	F	11	Human, Self Defense	Canuck Creek, MT	Yes	Yes	USFS
9/24/2008	?	M	3	Human, Under Investigation	Fishtrap Creek, MT	Yes	Yes	PCT
10/20/2008[2]	790	F	3	Human, Poaching	Clark Fork River. MT	Yes	Yes	PRIV
10/20/2008[2]	635	F	4	Human, Train collision	Clark Fork River. MT	Yes	Yes	MRL
11/15/2008[1]	651	M	13	Human, Mistaken Identity, Wolf Trap	NF Yahk River, BC	Yes	Yes	BC
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/7/2009[3]	None	M	3-4	Human, Mistaken Identity, Black bear	Bentley Creek, ID[3]	Yes	Yes	PRIV
11/1/2009	286	F	Adult	Human, Self Defense	EF Bull River, MT	No	Yes	USFS
6/25/2010	675-cub	Unk	Cub	Natural	American Creek, MT	Unk	No	USFS
7/7/2010	303-cub	Unk	Cub	Natural	Bearfite Creek, MT	Unk	No	USFS
9/6/2010[1]	1374	M	2	Human, Under Investigation	Hawkins Creek, BC	Yes	No	BC
9/24/2010[1]	None	M	2	Human, Wolf Trap, Selkirk Relocation	Cold Creek, BC	Yes	Yes	BC
10/11/2010	None	M	AD	Human, Under Investigation	Pine Creek, MT	No	Yes	USFS
2011	None	F	1	Unknown	EF Rock Creek, MT	No	Yes	USFS
9/16/2011	None	M	AD	Human, Mistaken Identity	Faro Creek, MT	No	Yes	USFS
11/13/2011	799	M	4	Human, Mistaken Identity	Cherry Creek, MT	Yes	Yes	USFS
11/24/2011	732	M	3	Human, Defense of life	Pipe Creek, MT	Yes	Yes	PRIV
November 2011	342	M	19	Human, Under Investigation	Little Creek, MT	Yes	Yes	PRIV
5/18/2012	None	F	AD	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
5/18/ 2012	None	M	Cub	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
October 2012[1]	5381	M	8	Human, Management	Duck Creek, BC	Yes	Yes	PRIV
10/26/2014	79575279	M	6	Human, Self defense	Little Thompson River, MT	Yes	Yes	PRIV
5/15/2015[1]	552-ygl	Unk	1	Natural	Linklater Creek, BC	Unk	No	BC
5/23/2015[2]	921	F	3	Natural	NF Ross Creek, MT	No	No	USFS
5/24/2015	None	M	4?	Human, Poaching	Yaak River, MT	Yes	Yes	USFS
8/12/2015	818	M	2	Human, Self Defense	Moyie River, ID	Yes	Yes	PRIV

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
9/30/2015[2]	924	M	2	Human, Mistaken Identity	Beaver Creek, ID	Yes	Yes	USFS
10/11/2015	1001	M	6	Human, Under Investigation	Grouse Creek, ID	Yes	No	PRIV
9/1/2017[1]	922	M	5	Human, Self defense	Porthill Creek, BC	Yes	Yes	BC

[1]The recovery plan (USFWS 1993) specifies that human-caused mortality or female with young sightings from Canada will not be counted toward recovery goals in this recovery zone. BC – British Columbia, MRL – Montana Rail Link, PRIV – Individual Private, PCT – Plum Creek Timber Company, and USFS – U.S. Forest Service.
[2]Bears transplanted to the Cabinet Mountains under the population augmentation program were counted as mortalities in their place of origin and are not counted toward recovery goals in this recovery zone.
[3]Bear Killed more than 10 miles outside recovery zone in the US and not counted in recovery calculations.

Table 2. Credible grizzly bear sightings, credible female with young sightings, and known human caused mortality by bear management unit (BMU) or area, 2017.

BMU OR AREA	2017 Credible[1] Grizzly Bear Sightings	2017 Sightings of Females with Cubs (Total)	2017 Sightings of Females with Cubs (Unduplicated[2])	2017 Sightings of Females with Yearlings or 2-year-olds (Total)	2017 Sightings of Females with Yearlings or 2 year-olds (Unduplicated[2])	2017 Human Caused Mortality
1	1	0	0	0	0	0
2	4	0	0	0	0	0
3	1	0	0	0	0	0
4	0	0	0	0	0	0
5	24	2	1	1	1	0
6	4	1	1	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	1	0	0	0	0	0
10	1	0	0	0	0	0
11	6	0	0	0	0	0
12	4	0	0	0	0	0
13	7	0	0	0	0	0
14	2	0	0	0	0	0
15	0	0	0	0	0	0
16	4	2	1	0	0	0
17	10	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
Deer Ridge	1	0	0	0	0	0
Fisher[4]	1	0	0	0	0	0
South Clark Fork[4]	1	0	0	0	0	0
West Kootenai	3	0	0	2	2	0
2017 TOTAL	75	5	3	3	3	0

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see methods).
[2]Sightings may duplicate the same animal in different locations. Only the first sighting of a duplicated female with cubs is counted toward total females (Table 3), however subsequent sighting contribute toward occupancy (Table 8).
[3]Areas in Canada outside of Cabinet-Yaak recovery zone that do not count toward recovery goals.
[4] Areas with portions <16 km outside the Cabinet-Yaak recovery zone that do not count toward recovery goals.

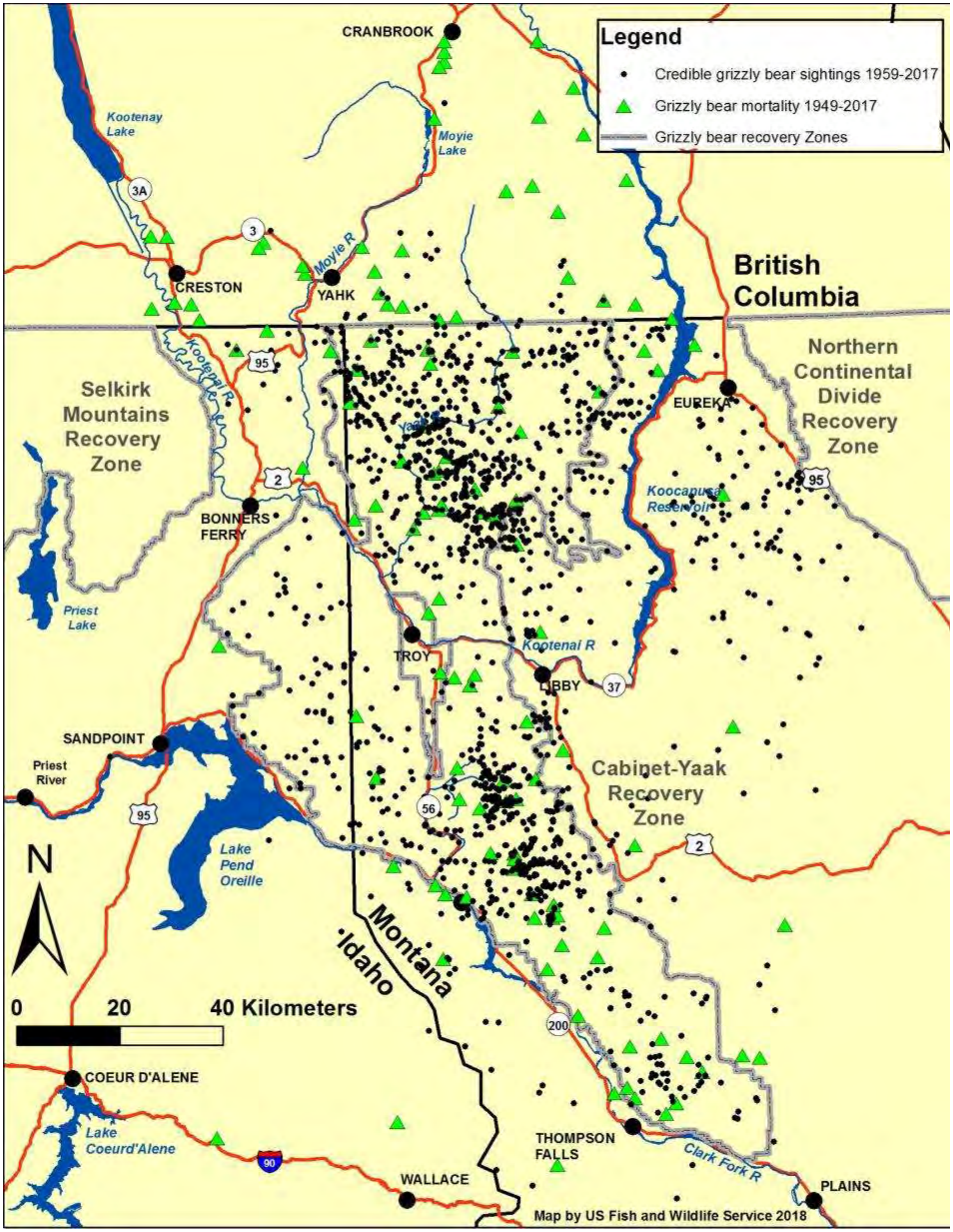


Figure 3. Grizzly bear observations (1959–2017) and known or probable mortalities from all causes (1949–2017) in the Cabinet-Yaak recovery area.

Table 3. Status of the Cabinet-Yaak recovery zone during 2012–2017 in relation to the demographic recovery targets from the grizzly bear recovery plan (USFWS 1993).

Recovery Criteria	Target	2012–2017
Females w/cubs (6-yr avg)	6	2.7 (16/6)
Human Caused Mortality limit (4% of minimum estimate)[1]	1.9	1.0 (6 yr avg)
Female Human Caused mortality limit (30% of total mortality)[1]	0.6	0.2 (6 yr avg)
Distribution of females w/young	18 of 22	11 of 22

[1] The grizzly bear recovery plan states "Because of low estimated population and uncertainty in estimates, the current human-caused mortality goal to facilitate recovery of the population is zero. In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem".

Table 4. Annual Cabinet-Yaak recovery zone (excluding Canada) grizzly bear unduplicated counts of females with cubs (FWC's) and known human-caused mortality, 1988–2017.

YEAR	ANNUAL FWC'S	ANNUAL HUMAN CAUSED ADULT FEMALE MORTALITY	ANNUAL HUMAN CAUSED ALL FEMALE MORTALITY	ANNUAL HUMAN CAUSED TOTAL MORTALITY	4% TOTAL HUMAN CAUSED MORTALITY LIMIT[1]	30% ALL FEMALE HUMAN CAUSED MORTALITY LIMIT[1]	TOTAL HUMAN CAUSED MORTALITY 6 YEAR AVERAGE	FEMALE HUMAN CAUSED MORTALITY 6 YEAR AVERAGE
1988	1	1	1	1	0.0	0.0		
1989	0	0	1	1	0.0	0.0		
1990	1	0	0	1	0.0	0.0		
1991	1	0	0	0	0.0	0.0		
1992	1	0	0	0	0.0	0.0		
1993	2	0	0	0	0.9	0.3	0.5	0.3
1994	1	0	0	0	0.9	0.3	0.3	0.2
1995	1	0	0	0	0.9	0.3	0.2	0.0
1996	1	0	0	1	0.7	0.2	0.2	0.0
1997	3	0	0	1	1.2	0.4	0.3	0.0
1998	0	0	0	0	0.9	0.3	0.3	0.0
1999	0	0	0	1	0.7	0.2	0.5	0.0
2000	2	0	1	1	0.5	0.1	0.7	0.2
2001	1	1	2	2	0.5	0.1	1.0	0.5
2002	4	1	4	4	1.2	0.4	1.5	1.2
2003	2	0	0	0	1.2	0.4	1.3	1.2
2004	1	0	0	0	1.4	0.4	1.3	1.2
2005	1	0	2	4	0.9	0.3	1.8	1.5
2006	1	0	0	0	0.7	0.2	1.7	1.3
2007	4	1	1	1	1.2	0.4	1.5	1.2
2008	3	0	0	1	1.6	0.5	1.0	0.5
2009	2	1	1	1	1.6	0.5	1.2	0.7
2010	4	0	0	1	1.9	0.6	1.3	0.7
2011	1	0	0	4	1.4	0.4	1.3	0.3
2012	3	1	1	2	1.6	0.5	1.7	0.5
2013	2	0	0	0	1.2	0.4	1.5	0.3
2014	3	0	0	1	1.6	0.5	1.5	0.3
2015	2	0	0	3	1.6	0.5	1.8	0.2
2016	3	0	0	0	1.9	0.6	1.7	0.2
2017	3	0	0	0	1.9	0.6	1.0	0.2

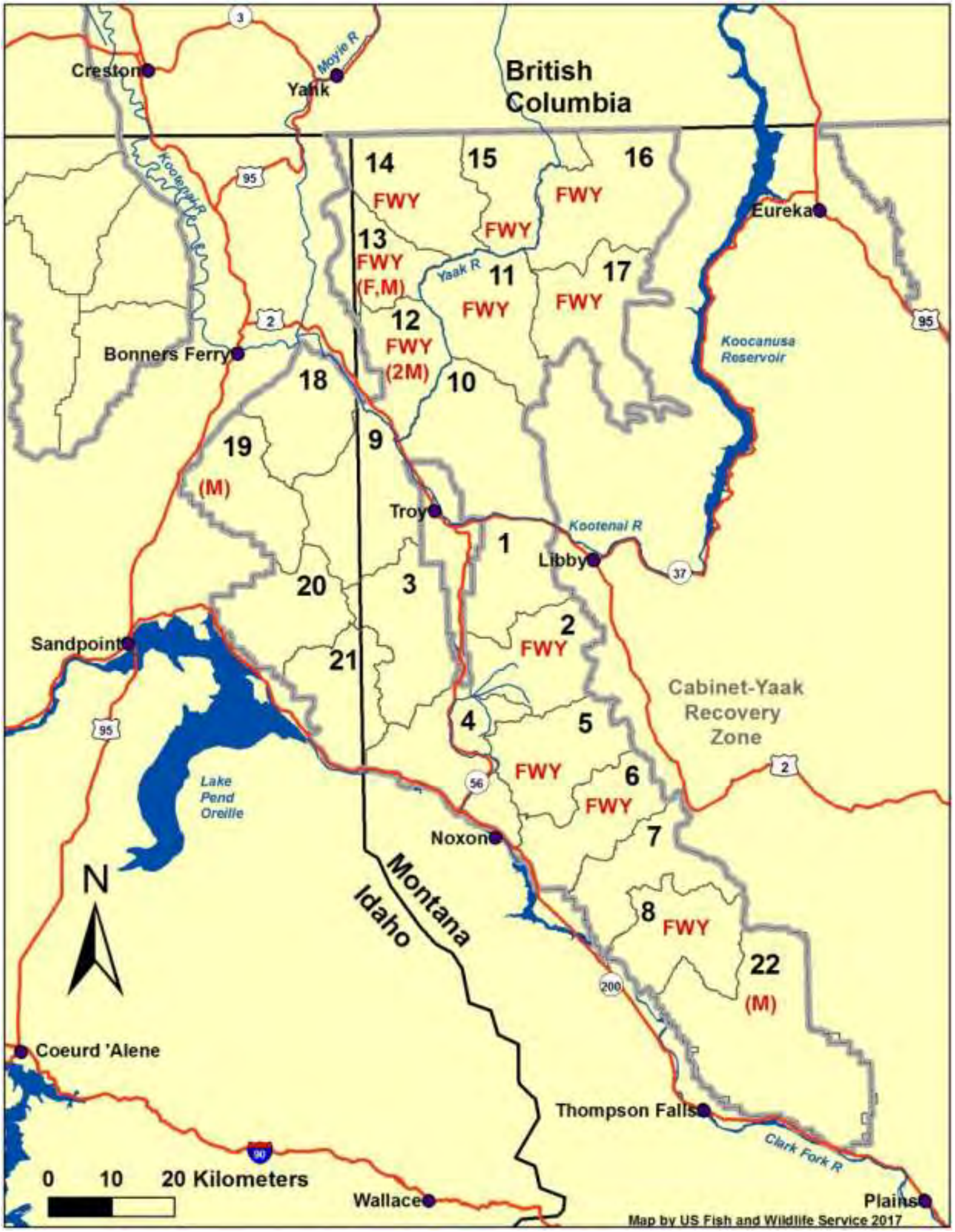


Figure 4. Female with young occupancy and known or probable mortality within Bear Management Units (BMUs) in the Cabinet-Yaak recovery zone 2012–2017. (FWC indicates occupancy of a female with cubs, FWY is occupancy of a female with young and sex of any mortality is in parentheses).

Table 5. Credible observations of females with young in or within 10 miles of the Cabinet-Yaak recovery zone, 1988–2017. Canadian credible observations shown in parentheses.

Year	Total credible[1] sightings females with young	Unduplicated females with cubs	Unduplicated females with yearlings or 2-year-olds	Unduplicated adult females without young	Minimum probable adult females
1990	9	1	2	0	3
1991	4	1	1	1	2
1992	8	1	5	1	6
1993	6	2	1	0	3
1994	5	1	2	0	3
1995	8	1	2	0	3
1996	5	1	1	0	2
1997	14 (1)	3	4	0	7
1998	6 (1)	0	2 (1)	2	2 (1)
1999	2	0	2	3	2
2000	6 (1)	2 (1)	1	0	3 (1)
2001	5 (2)	1 (1)	3	0	4 (1)
2002	10 (1)	4 (1)	1	0	5 (1)
2003	11	2	4	0	6
2004	11	1	4	0	5
2005	10 (1)	1	4 (1)	1	5 (1)
2006	7 (1)	2 (1)	2	1	4 (1)
2007	17	4	2	2	6
2008	7 (1)	3 (1)	3	1	6 (1)
2009	5 (0)	2 (0)	2 (0)	1	4 (0)
2010	14 (0)	4 (0)	2 (0)	1	6 (0)
2011	4 (0)	1 (0)	1 (0)	1	2 (0)
2012	12 (0)	3 (0)	3 (0)	0	6 (0)
2013	9 (0)	2 (0)	5 (0)	0	7 (0)
2014	20 (1)	3 (0)	3 (0)	1	7 (0)
2015	19 (1)	2 (0)	5 (0)	2	9 (0)
2016	11 (0)	3 (0)	3 (0)	2	8 (0)
2017	8 (0)	3 (0)	3 (0)	2	8 (0)

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see page 8).

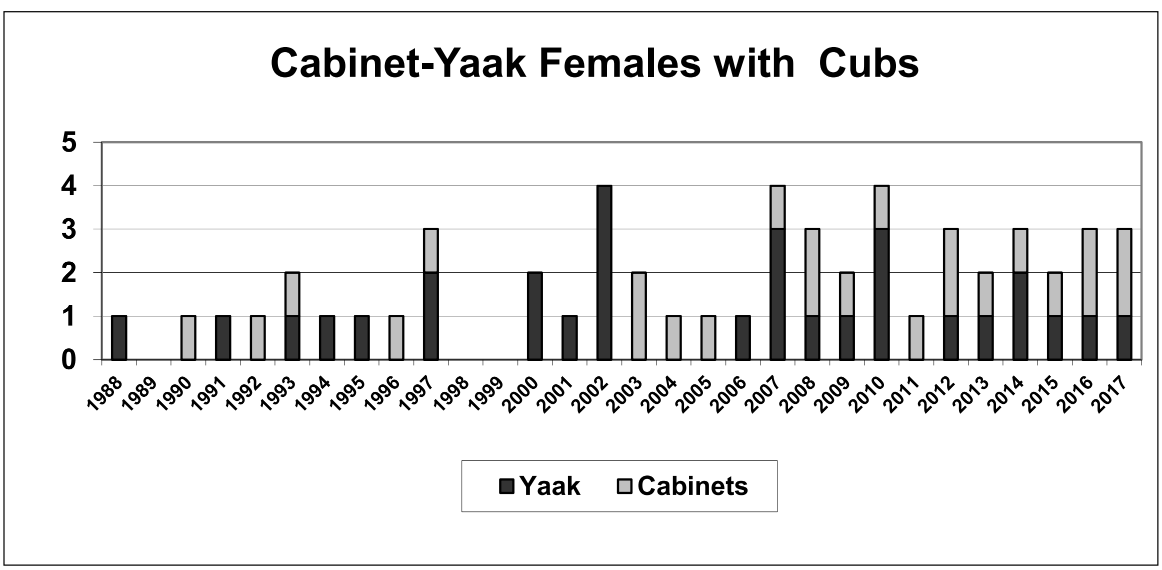


Figure 5. Credible observations of females with cubs in or within 10 miles of the Cabinet-Yaak recovery zone (excluding Canada), 1988–2017. Credible sightings are those rated 4 or 5 on a 5 point scale.

Table 6. Occupancy of bear management units by grizzly bear females with young in the Cabinet-Yaak recovery zone 1990–2017.

	1 - CEDAR	2 - SNOWSHOE	3 - SPAR	4 - BULL	5 - ST. PAUL	6 - WANLESS	7 - SILVER BUTTE	8 - VERMILION	9 - CALLAHAN	10 - PULPIT	11 - RODERICK	12 - NEWTON	13 - KENO	14 - NW PEAK	15 - GARVER	16 - E FORK YAAK	17 - BIG CREEK	18 - BOULDER	19 - GROUSE	20 - N LIGHTNING	21 - SCOTCHMAN	22 - MT HEADLEY
1988	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
1989	N	N	N	Y	N	N	Y	N	N	N	Y	N	Y	Y	Y	N	N	N	N	N	N	N
1990	N	Y	N	N	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	N	N	N	N	N	Y
1991	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1992	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	Y	N	N
1993	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1994	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N
1995	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	N
1996	N	N	N	N	N	Y	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N
1997	N	Y	N	Y	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	N	N	N	N	Y	N
1998	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N
1999	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N
2000	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2001	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	Y	N	N	N	N	N
2002	N	Y	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	N	N
2003	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	Y	N
2004	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2005	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
2006	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
2007	N	N	Y	Y	Y	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2008	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
2009	N	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
2010	N	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2011	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	N	N	N
2012	N	Y	N	N	Y	N	N	N	N	N	Y	N	N	N	N	Y	Y	N	N	N	N	N
2013	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	Y	Y	Y	Y	N	N	N	N	N
2014	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N
2015	N	N	N	N	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N
2016	N	N	N	N	Y	N	N	Y	N	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N
2017	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N

Cabinet Mountains Population Augmentation

From 1990–94 four female grizzly bears were captured in the Flathead River Valley of British Columbia and released in the Cabinet Mountains (Table 7). Twenty-two different grizzly bears were captured during 840 trap-nights to obtain the 4 subadult females. Capture rates were 1 grizzly bear/38 trap-nights and 1 suitable subadult female/210 trap-nights. One transplanted bear and her cub died of unknown causes one year after release. The remaining three bears were monitored until collars dropped. The program was designed to determine if transplanted bears would remain in the target area and ultimately contribute to the population through reproduction. Three of four transplanted bears remained in the target area for more than one year. One of the transplanted bears produced a cub, but had likely bred prior to translocation and did not satisfy our criteria for reproduction with resident males.

In 2005 the augmentation program was reinitiated through capture by MFWP personnel and monitoring by this project. During 2005–16, 9 female and 6 male grizzly bears were released in the Cabinet Mountains (Table 7). No bears were released in 2017 due to fire activity in the capture area of the Flathead River drainage. A 2 year-old male was released in the West Cabinet Mountains on July 25, 2016. The bear remained in the West Cabinet Mountains until November when it moved east into the Cabinet Mountains Wilderness and then south as far as the Thompson River before moving north and denning on Grave Peak in late November.

Of 19 bears released through 2017, 6 are known to have left the target area (one was recaptured and brought back and one returned a year after leaving), three were killed within 4 months of release, and one was killed 16 years after release. One animal is known to have produced at least 10 first generation offspring, 13 second generation offspring, and one third generation offspring. Another female is known to have produced two offspring.

Table 7. Sex, age, capture date, capture location, release location, and fate of augmentation grizzly bears moved to the Cabinet Mountains, 1990–2017.

Bear	Sex	Age	Capture date	Capture Location	Cabinet Mtns Release Location	Fate
218	F	5	7/21/1990	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1990, Lost collar Aug. 1991, observed July 1992.
258	F	6	7/21/1992	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1992 Produced 1 cub 1993, Natural mortality July 1993.
286	F	2	7/14/1993	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1993–95 Lost collar at den Apr. 1995, hair snag 2004–2009, self-defense mortality November 2009.
311	F	3	7/12/1994	NF Flathead R, BC	EF Bull River	Lost collar July 1994, recaptured Oct. 1995 south of Eureka, MT, released EF Bull River, Signal lost Nov. 1995.
A1	F	7-8	9/30/2005	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2005–06, Lost collar Sept. 2007.
782	F	2	8/17/2006	SF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2006–07, Lost collar Aug. 2008.
635	F	4	7/23/2008	Stillwater R, MT	EF Bull River	Killed by train near Heron, MT Oct. 2008.
790	F	3	8/7/2008	Swan R, MT	EF Bull River	Illegally killed near Noxon, MT Oct. 2008.
715	F	10	9/17/2009	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2009–10, returned to NF Flathead R, May 2010. Lost collar June 2010.
713	M	5	7/18/2010	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2010, Lost collar Sept. 2011.
714	F	4	7/24/2010	NF Flathead R, MT	Silverbutte Cr	Returned to NF Flathead July 2010. Lost collar Oct. 2013.
725	F	2	7/25/2011	MF Flathead R, MT	Spar Lake	Moved to Glacier National Park, Sept. 2011 den, returned to Cabinet Mtns Aug. 2012 and den, moved to Glacier National Park and returned to Cabinet Mtns, lost collar Oct. 2013
723	M	2	8/18/2011	Whitefish R, MT	Spar Lake	Den Cabinet Mtns 2011. Lost collar June 2012.
918	M	2	7/6/2012	Whitefish R, MT	EF Bull River	Den Cabinet Mtns 2012–-13. Lost collar Oct. 2014.
919	M	4	7/30/2013	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2013. Lost collar Aug. 2014.
920	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2014–15.
921	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2014. Died of unknown cause May 2015.
924	M	2	7/25/2015	SF Flathead R, MT	Spar Lake	Mistaken identity mortality Sept. 2015
926	M	3	7/25/2016	SF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2016. Lost collar July 2017

Cabinet-Yaak Hair Sampling and DNA Analysis

Hair snag sampling occurred at barb wire corrals baited with a scent lure during 2000–2017 (Table 8 and Fig. 6). Sampling occurred from May–October but varied within years. Sites were selected based on prior grizzly bear telemetry, sightings, and access. Remote cameras supplemented hair snagging at most sites and were useful in identifying family groups and approximate ages of sampled bears. In 2002, study personnel assisted an MTFWP black bear population estimate effort that sampled 285 sites in the Yaak River portion of the CYE. During 2003, 184 sites on a 5 km^2 grid were sampled on 4,300 km^2 in the Cabinet Mountains portion of the CYE. In 2009, 98 sites were sampled south of the Clark Fork River. Other years had much lower numbers of sampled sites. Collectively, USFWS and USGS crews have sampled 1,941 corral traps from 2000–2017 (Table 8 and Fig. 6). Through 2016, five percent of site visits provided hair from at least 54 grizzly bears. Genetic analysis from 2017 field collected samples is not yet complete; we will report on these results in the 2018 report.

Table 8. Hair snagging corrals and success in the Cabinet-Yaak study area, 2000–2017.

Year	Number of corral sessions[1]	Sessions with grizzly bear pictures(%[2])	Sessions with grizzly bear hair(%[2])	Individual grizzly bear genotypes	Locations with grizzly bear pictures or hair	Comments
2000	1	0	0	0		
2001	3	0	0	0		
2002	319	4 (1)	9 (3)	9	MF Bull R., W Fisher Cr., EF Rock Cr., NF Big Cr., NF Sullivan, Pete Cr., 4th July Cr., Spread Cr., Solo Joe Cr.	
2003	184	1 (1)	1 (1)	1	WF Rock Cr., W Fisher Cr.	
2004	14	1 (7)	2 (14)	3	EF Bull R., EF Rock Cr.	
2005	17	2 (12)	1 (6)	1	EF Bull R., Libby Cr.	
2006	19	1 (5)	3 (16)	3	Cub Cr., Silverbutte Cr., Bear Cr., and EF Rock Cr.	
2007	36	4 (11)	4 (11)	9	Devils Club Cr., EF Rock Cr., Bear Cr., W F Rock Cr., W Fisher Cr., Pete Cr., NF Meadow Cr.	Female with young EF Rock Cr., Female with young WF Rock Cr.
2008	21	1 (5)	1 (5)	1	EF Bull R.	
2009	125	4 (3)	2 (2)	4	Bear Cr., Libby Cr., NF Callahan Cr., W Fisher Cr.	Female with young Bear Cr.
2010	27	4 (15)	3 (11)	5	EF Rock Cr., W Fisher Cr., Cub Cr., Drift Cr.	Female with young EF Rock Cr.
2011	72	8 (11)	9 (13)	13	EF Rock Cr., Bear Cr., W Fisher Cr., NF 17-mile Cr., Spruce Cr., Hensley Cr., Chippewa Cr., Solo Joe Cr.	Siblings Spruce Cr., Female with young Solo Joe Cr.
2012	854	1 (2)	48 (6)	29	Beaver Cr. (USFWS); myriad others from USGS population estimate efforts (Kendall et al. 2016)	USFWS effort genotyped 1 GB from 64 corral sessions
2013	5	2 (40)	2 (40)	2	W. Fisher Cr.EF Rock Cr.	Female with young W Fisher Cr.
2014	41	7 (17)	3 (7)	4	Boyd Cr., Miller Cr., Libby Cr., Midge Cr., Faro Cr., Spread Cr.	Female with young Faro Cr.
2015	72	9 (13)	5 (7)	7	Pete Cr., Hellroaring Cr., Boulder Cr. (Cabinets), NF EF Bull Cr., Libby Cr., Rock Cr., Bear Cr.	Female with young Hellroaring Cr.; Female with cubs Bear Cr. and Libby Cr.
2016	39	9 (23)	6 (15)	10	Spruce Cr. (Yaak), Hellroaring Cr., Windy Cr., WF Yaak Cr., Papoose Cr., NF EF Bull Cr., Libby Cr.	Female with young Hellroaring Cr., NF EF Bull Cr.; Female with cub Windy Cr.
2017	92	17 (18)	awaiting	results	Snowshoe Cr., SF Callahan Cr., Spruce Lakes, Rock Cr., Libby Cr., Poorman Cr., Cherry Cr., Bear Cr., EF Bull Cr., Hellroaring Cr., WF Yaak R., Lake Cr., Baree Cr.	Female with cubs Rock Cr., Female with young Bear Cr., Female with young EF Bull R.
Total	1941	75 (4)	99 (5)	53[3]		

[1]Some corral sites were deployed for multiple sessions per year. A "session" is typically 3-4 weeks long and defined as the interval between site set-up and revisits to collect samples and photos.
[2]Percent success at all corral sessions
[3]Some individuals captured multiple times among years.

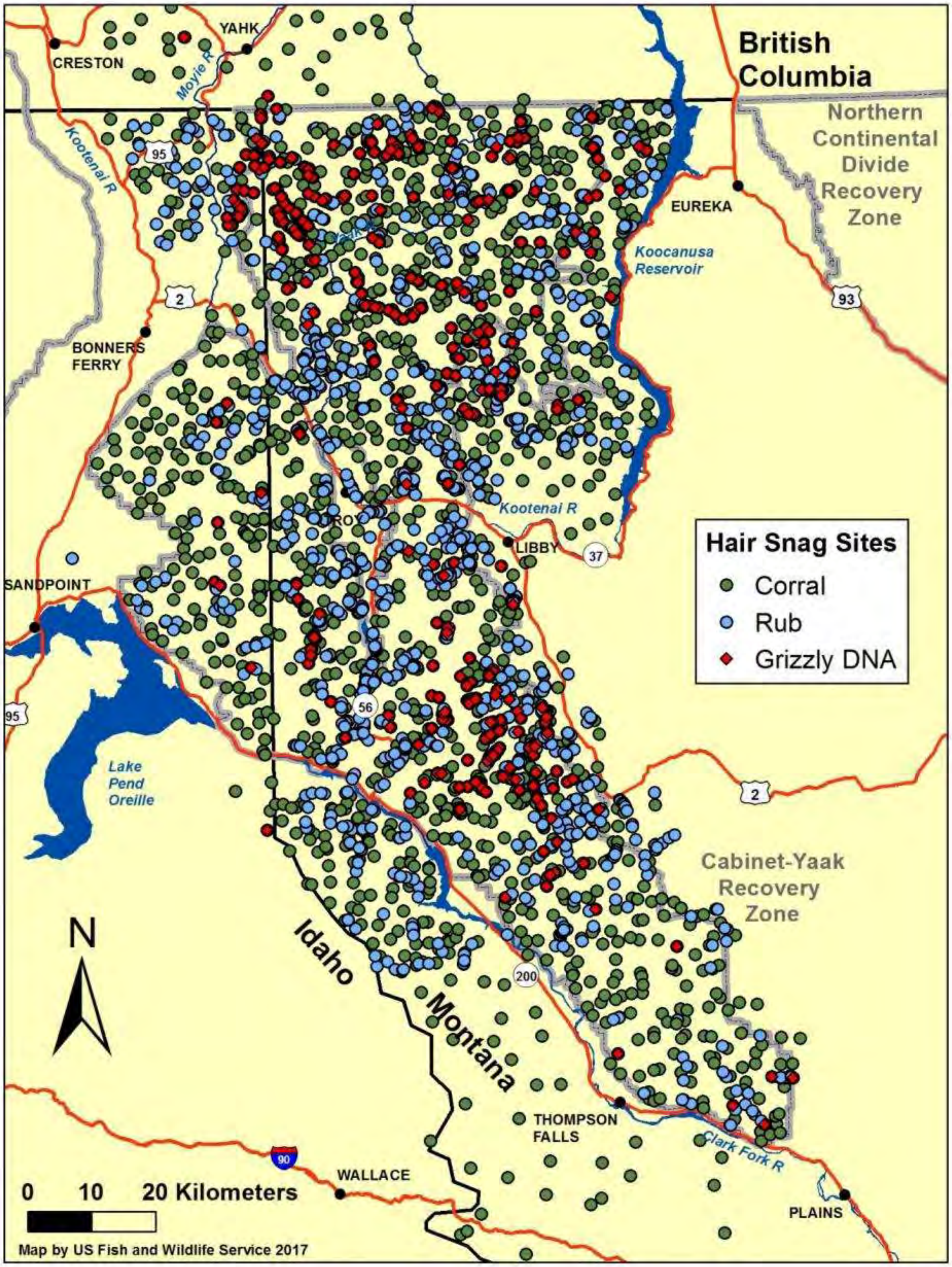


Figure 6. Location of hair snag sample sites in the Cabinet Mountains, 2000–17. Sites with grizzly bear hair and genotyped DNA are identified.

In 2017, we collected 2953 samples from visits to 900 individual rub trees (Table 9). Samples were evaluated during cataloging and 1,413 were judged not to be black bears and sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Lab analysis on 2017 samples is still in progress, and we will report on results in the 2018 report. Since 2013, we have genetically identified 50 individual grizzly bears (30 males, 20 females) from 8,972 samples collected via rub effort.

Table 9. Grizzly bear hair rubs and success in the Cabinet-Yaak study area, 2012–2017.

Year	Number of rubs checked	Number of samples collected (%GB[1])	Number of samples sent to Lab (%GB[1])	Number of rubs with grizzly DNA	Individual grizzly bear genotypes	Males	Females
2012[2]	1376	8356 (2)	4639 (3)	85	33	19	14
2013	449	1038 (6)	479 (12)	33	17	9	8
2014	592	1895 (7)	707 (19)	50	24	14	10
2015	765	2258 (6)	616 (22)	76	30	20	10
2016	781	3781 (5)	1043 (19)	89	29	18	11
2017	900	2953(--)	884 (--)	--	--	--	--
Total[3]	1554[4]	17328 (4)	7484 (9)	204[4]	59[5]	37[5]	22[5]

[1] Percentage of samples yielding a grizzly bear DNA genotype.

[2] 2012 results from USGS population estimation study (Kendall et al. 2016). 2013-16 efforts are entirely from USFWS Cabinet-Yaak GB Recovery Program.

[3]Totals are through 2016. 2017 genetic results from the lab are not yet complete.

[4] Unique rub locations. Some rub locations visited multiple times among years.

[5]Some individuals captured multiple times among years.

Grizzly Bear Genetic Sample Summary

We provide data from and prior to 2016 as 2017 sample results have not been completed by the laboratory at the writing of this report. Using all methods of detection (capture, rub tree DNA, corral DNA, photos), we detected a minimum 35 individual grizzly bears in 2016. Thirteen bears were detected in the Cabinets (7 males, 6 females). Twenty-three bears were detected in the Yaak (14 male, 8 female, 1 unknown sex). Of these 35 individuals, one male bear was documented in both the Cabinets and the Yaak.

Captures, genotypes from hair or tissue, and observations of grizzly bears by study personnel in the Cabinet-Yaak study area were summarized during 1986–2016 (Appendix 3). Individuals not radio-collared or genotyped were conservatively separated by size, age, location, coloration, genetic information, or reproductive status. Conservative classification of sightings may result in unique individuals being documented as one individual. Individual status or relationships may change with new information.

One hundred seventy-six individuals were identified within the Cabinet-Yaak study area with 164 bears captured or genotyped and 20 unmarked individuals observed during 1986–2016 (Appendix 3). Sixty-eight of these animals are known or suspected to have died. Human causes were linked to 48 of these mortalities. Nineteen were believed to have died of natural causes. Thirteen of these 19 mortalities involved cubs. Four mortalities were from unknown causes. Twelve bears were known to have emigrated from the population. Three were augmentation bears returning to their area of capture, one was an augmentation bear that moved south out of the recovery area and was killed, three went north of BC Highway 3 where one was killed, three bears went east of the recovery area where two are known dead, and two went west to the Selkirk Mountains. All bears known to have left the population are either augmentation bears or male individuals.

We determined parent-offspring relationships of Yaak grizzly bears using sample genotypes from 1986–2016. A majority of our detected sample in the Yaak descends from female grizzly bear 106 (Figure 7). She produced 5 known litters, and her matrilines tie to 42 known 1st, 2nd, and 3rd generation offspring. Since 1986, we have genetically detected 37 female grizzly bears in the US Yaak and BC Yahk, 26 (70%) of which are direct maternal descendants of bear 106. Since 2014, all female bears detected in the Yaak are her maternal descendants. In 2015-16, we detected 1 daughter, 7 granddaughters, and 3 great-granddaughters of 106.

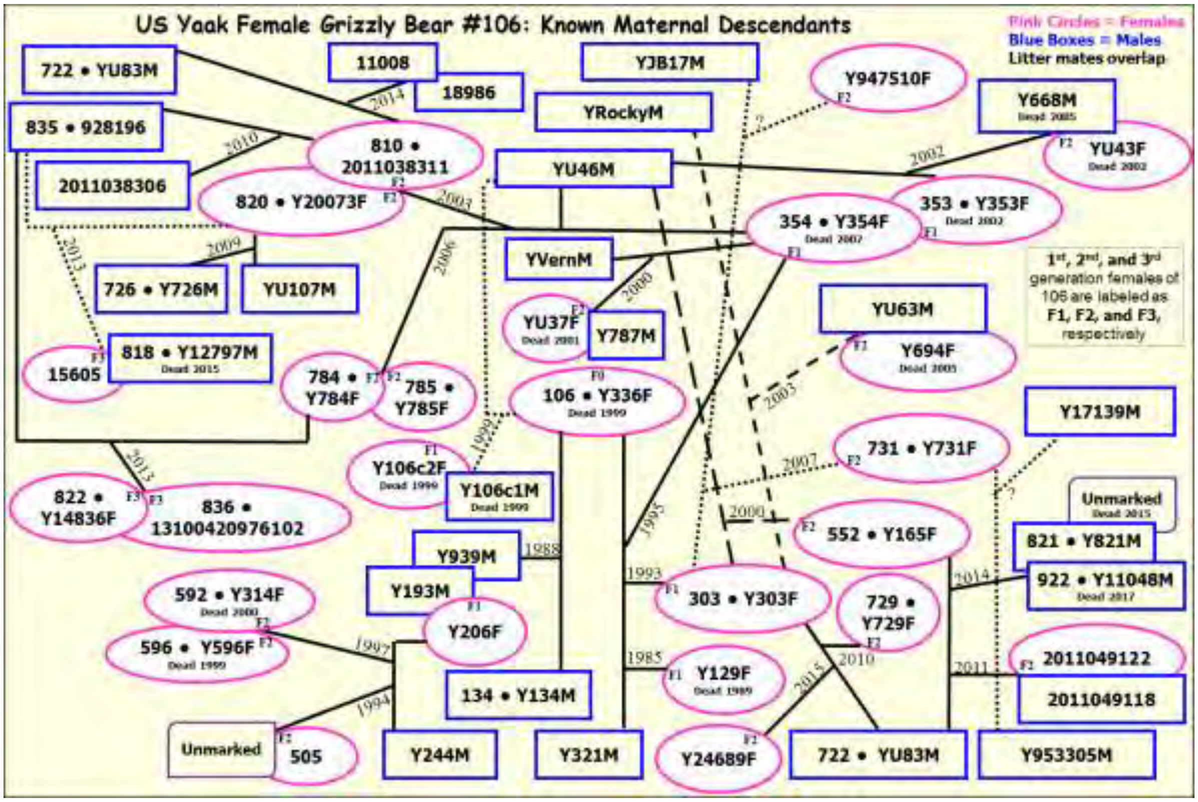


Figure 7. Most likely pedigree displaying matrilineal ancestry of female grizzly bear 106 in the Yaak River, 1986–2016. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 the first generation, F2 the second generation, and F3 the third generation. Numbers along lines indicate when the descendant litter was produced.

Claws from a grizzly bear were discovered in Baree Creek of the Cabinet Mountains, in 1993. Analysis of DNA from these claws matched bear 678 originally captured in the Cabinet Mountains in 1983 when 28 years-old. Tissue present on the claws suggested that she died no earlier than 1992. Bear 678 would have been at least 37 years old at the estimated time of death. Pedigree analysis also indicated that the 3 bears captured in the Cabinet Mountains from 1983-1988 were a triad with bear 680 being the offspring of bears 678 and 14.

The Cabinet Mountains population was estimated to be 15 bears or fewer in 1988 on the basis of independent tracks, sightings, and expert opinion (Kasworm and Manley 1988). However the lack of resident bears identified since 1989 suggests the population may have been well below the level of 15 individuals. Genetic samples from the Cabinet Mountains (1983–2016) were analyzed and determined to originate from 60 different grizzly bears. Three of these were from captures during 1983–1988, 19 were from augmentation bears during 1990–2016 (1 augmentation bear 218 genetically unmarked), and 38 from captures, mortalities, or hair snagging during 1997–2016.

One of these genotypes identified by hair snagging was from grizzly bear 286. She was released in the Cabinet Mountains as part of population augmentation in 1993 as a 2 year-old (Kasworm et al. 2007). She was 13 years-old when the first hair sample was obtained during 2004. Pedigree analysis indicates she has produced at least 10 first generation offspring, 15 second generation offspring, and 1 third generation offspring. Six of those first generation offspring are adult females, 5 of which are known to have reproduced, and the sixth detected genetically in 2016 (Fig. 8). Bear 286 was killed in a self-defense incident with a hunter in November of 2009. Only 10 genotyped bears not known to be augmentation bears or their offspring have been identified in the Cabinet Mountains since 1990 and four are known to be dead. Of these 10 bears, two are adult males that bred with 286 to contribute to the first generation. Four are a family group (adult female with 3 cubs) identified south of the Clark Fork River in 2002. One bear was a subadult male captured near Thompson Falls in 2011 in an incident involving livestock depredation. Another was a male migrant from the Selkirk Mountains identified in 2012, who is now known to have moved back to the Selkirks. Another was an adult male killed by self-defense in the Little Thompson River during 2014. This bear was known to have originated in the Northern Continental Divide Population to the northeast and moved into the Cabinet-Yaak during 2014. The remaining bear is an adult male born in 2009 in the Yaak whose range included the Cabinets and the Yaak in 2016. The augmentation effort appears to be the primary reason grizzly bears remain and were increasing in the Cabinet Mountains.

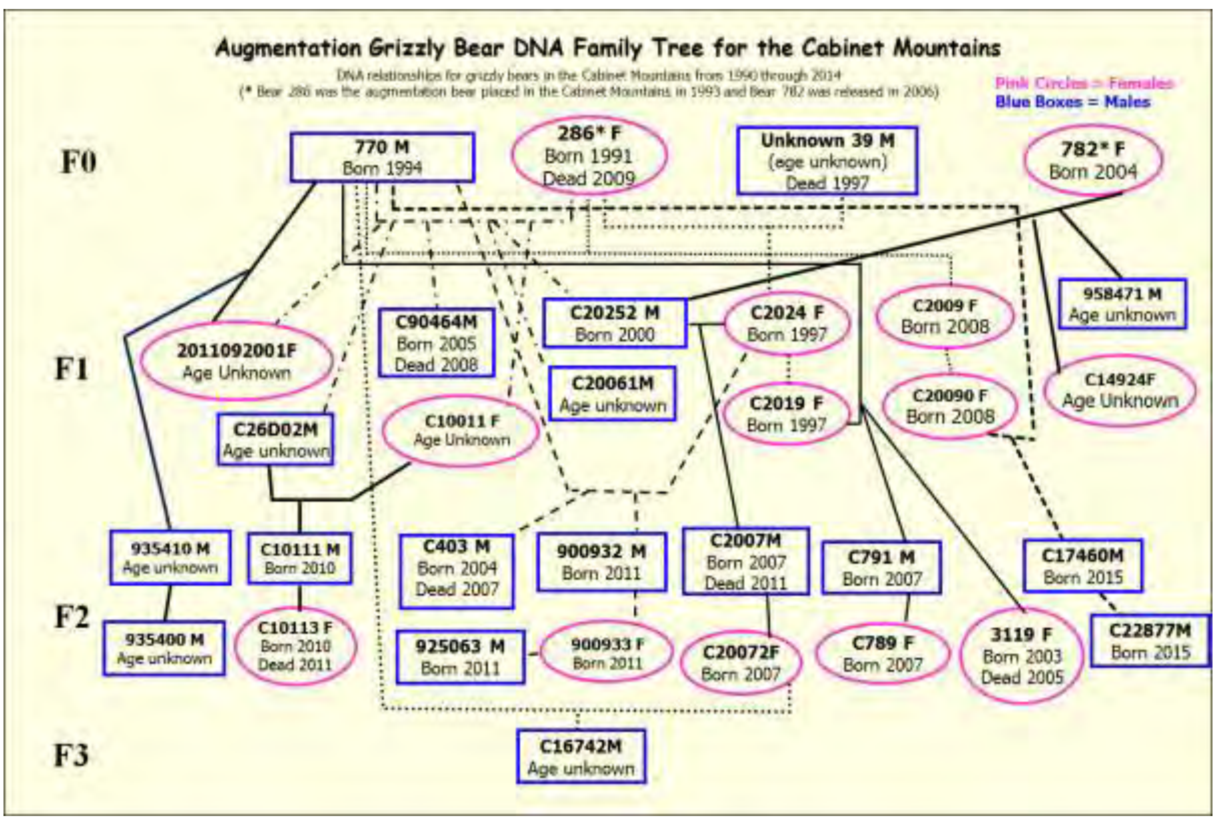


Figure 8. Most likely pedigree resulting from translocated female grizzly bears 286 and 782 in the Cabinet Mountains, 1993–2016. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 is the first generation of offspring for translocated female 286 or 782, F2 is the second generation and F3 is the third generation.

Grizzly Bear Movements and Gene Flow Within and Between Recovery Areas

Population linkage is a goal of the recovery plan for the Cabinet-Yaak recovery area (USFWS 1993). The population goal of approximately 100 animals requires genetic connectivity to maintain genetic health over time. While movement data from telemetry or genetic methods may be a precursor of linkage, gene flow in the form of reproduction by immigrant individuals is the best measure of connectivity.

Capture, telemetry, and genetic data were analyzed to evaluate movement and subsequent reproduction resulting in gene flow into and out of the CYE. Thirty-six grizzly bears were identified as immigrants, emigrants, or were the offspring of immigrants to the CYE (Appendix Table T4). While movement and gene flow out of the CYE may benefit other populations, gene flow into the CYE is most beneficial to genetic health. Fourteen individuals (11 males and 3 females) are known to have moved into the CYE from adjacent populations; however eight of these were killed or removed (Figure 9). Most of these immigrants originated in the North Purcells or South Selkirks with only three originating in the NCDE. Of those three, two are known dead. Gene flow has been identified through reproduction by three immigrants (two males and one female) resulting in 4 offspring in the CYE. All three immigrants producing gene flow originated in the North Purcells.

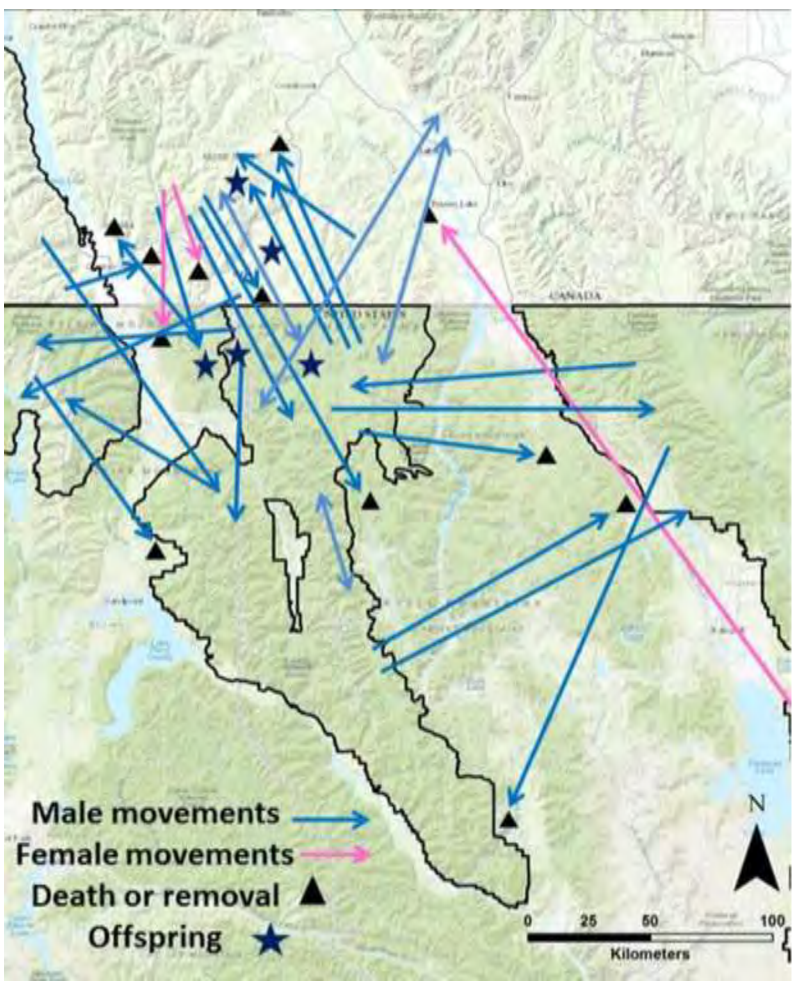


Figure 9. Known immigration or emigration events (blue and pink lines) and gene flow (black stars) in the Cabinet-Yaak, 1988–2017

Known Grizzly Bear Mortality

There were no known instances of grizzly bear mortality in or within 16 km of the CYE (including BC) during 2017. Fifty-five instances of known and probable grizzly bear mortality from all causes were detected inside or near the CYE (excluding Canada) during 1982–2017 (Tables 1 and 10, Fig. 9). Forty were human caused, 13 were natural mortality, and 2 were unknown cause. There were 18 instances of known grizzly bear mortality in Canada within 16 km of the CYE in the Yahk and South Purcell population units from 1982–2017 (Tables 1 and 10, Fig. 10). Thirteen were human caused and 5 were natural mortalities.

Table 10. Cause, timing, and location of known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada), 1982–2017. Radio collared bears included regardless of mortality location.

	Mortality cause											
Country/ age / sex / season / ownership	Defense of life	Legal Hunt	Hound hunting	Management removal	Mistaken identity	Natural	Poaching	Trap predation	Vehicle collision	Unknown, human	Unknown	Total
U.S.												
Age / sex												
Adult female	3					2	1		1	1	1	9
Subadult female						1	1	1	2	3		8
Adult male	2			1	1		2			4		10
Subadult male	2				4		2			3		11
Yearling					1	1					1	3
Cub					1	9	2			1		13
Unknown					1							1
Total	7			1	8	13	8	1	3	11	2	55
Season[1]												
Spring					1	1	1			3		5
Summer	1				1	12	1	1				17
Autumn	6			1	6		5		3	8		29
Unknown							1			1	2	4
Ownership												
US Private	3			1	2		5		3	5		19
US Public	4				6	13	3	1		7	2	36
Canada												
Adult female				2								2
Subadult female	1							1				2
Adult male	1	1		2	1					1		6
Subadult male				1						1		2
Yearling						1						1
Cub						4						4
Unknown			1									1
Total	1	1	1	5	1	5		1		2		18
Season[1]												
Spring		1		1		1		1				4
Summer			1	1		4						6
Autumn	2			3	1					2		8
Unknown												
Ownership												
BC Private				4								4
BC Public	2	1	1	1	1	5		1		2		14

[1]Spring = April 1 – May 31, Summer = June 1 – August 31, Autumn = September 1 – November 30

Sixty-seven percent (14 of 21) of known human-caused mortalities occurring on the US National Forests were <500m of an open road and 33% were >500m from an open road (7 of 21). Thirty-three percent (7 of 21) of known human caused mortalities occurring on the National

Forests were located within core habitat (area greater than 500m from an open or gated road).

Mortality rates were examined by breaking the data into periods of increase (1982—-98, 2007—16) and decrease (1999–2006) in population trend. From 1982—98, 16 instances of known mortality occurred in the U.S. and Canada, with12 (71%) of these mortalities being human-caused (Table 1). The annual rate of known human caused mortality was 0.76 mortalities per year. Twenty-seven instances of known mortality occurred during 1999–2006 with 18 (67%) of these mortalities human-caused. Annual rate of known human-caused mortality was 2.25 per year. Thirty instances of known mortality occurred from 2007–17 with 23 (77%) of these mortalities human-caused. Annual rate of known human-caused mortality was 2.1 per year. Though the rate of known human caused mortality increased slightly between the two most recent time periods, it is important to consider the rate of female mortality. The loss of females is the most critical factor affecting the trend because of their reproductive contribution to current and future growth. The rate of known female mortality was 0.29 during 1982–98. Total known female mortality rate decreased from 1.88 during 1999–2006 to 0.64 during 2007–17 and known human caused female mortality rate decreased from 1.50 to 0.45. This decline of female mortality is largely responsible for the improving population trend from 2007–17 (Pages 37–42).

The increase in total known mortality beginning in 1999 may be linked to poor food production during 1998–2004 (Fig. 10). Huckleberry production during these years was about half the long term average. Poor berry production years can be expected at various times, but in this case there were several successive years of poor production. Huckleberries are the major source of late summer food that enables bears to accumulate sufficient fat to survive the denning period and females to produce and nurture cubs. Poor nutrition may not allow females to produce cubs in the following year and cause females to travel further for food, exposing young to greater risk of mortality from conflicts with humans, predators, or accidental deaths. One female bear lost litters of 2 cubs each during spring of 2000 and 2001. Another mortality incident involved a female with 2 cubs that appeared to have been killed by another bear in 1999. The effect of cub mortality may be greatest in succeeding years when some of these animals might have been recruited to the reproductive segment of the population.

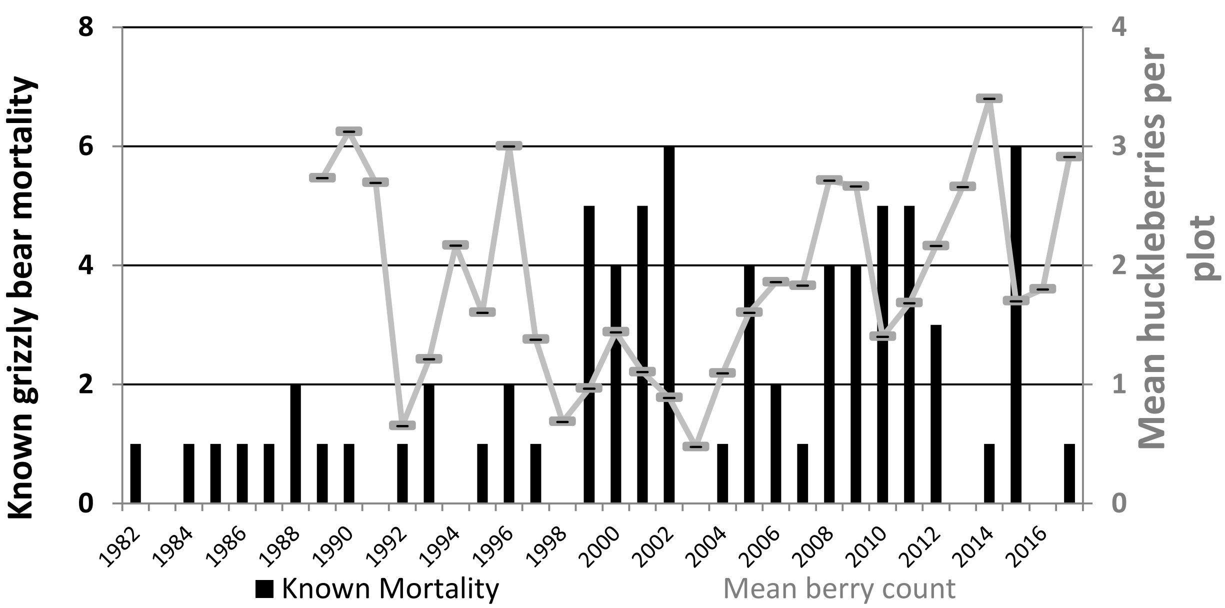


Figure 10. Known grizzly bear annual mortality from all causes in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and all radio collared bears by cause, 1982–2017 and huckleberry production counts, 1989–2017.

Use of known human-caused mortality counts probably under-estimates total human-caused mortality. Numerous mortalities identified by this study were reported only because animals wore a radio-collar at death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry et al. 2002). The correction factor was not applied to natural mortality, management removals, mortality of radio collared bears or bears that died of unknown causes (Table 11). All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes. Seventeen radio-collared bears died from human causes during 1982–2017. Ten of these were reported by the public (59%) and 7 were unreported (41%). The Bayesian statistical analysis described by Cherry et al. (2002) was used to calculate unreported mortality in 3 year running periods in the Yellowstone ecosystem, but samples sizes in the CYE are much smaller, so we grouped data based on the cumulative population trend (ʎ, Fig 11). The unreported estimate added 17 mortalities to the 72 known mortalities from 1982–2017. The unreported estimate includes bears killed in Canada which are not counted in the recovery criteria (USFWS 1993). There were an additional 18 natural mortalities that were determined via telemetry.

Table 11. Annual human-caused grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and estimates of unreported mortality, 1982–2017 (including all radio collared bears regardless of mortality location).

Years	Population trend	Management or research	Radio monitored	Unknown cause	Public reported	Unreported estimate	Total
1982-1998	Improving	2	4	1	6	4	20
1999-2006	Declining	4	8	0	6	4	31
2007-2017	Improving	1	8	1	13	9	38
Total		7	20	2	25	17	89

Grizzly Bear Mortality, Reproduction, Population Trend, and Population Estimate

This report segment updates information on survival rates, cause-specific mortality, and population trend following the methods used in Wakkinen and Kasworm (2004).

Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival and cause-specific mortality rates were calculated for 6 sex and age classes of native grizzly bears from 1983–2017 (Table 12). We calculated survival and mortality rates for augmentation and management bears separately (see below).

Table 12. Survival and cause-specific mortality rates of native grizzly bear sex and age classes based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2017.

	Demographic parameters and mortality rates					
Parameter	Adult female	Adult male	Subadult female	Subadult male	Yearling	Cub
Individuals / bear-years	15 / 45.1	26 / 35.6	21 / 23.5	20 /14.5	33 / 16.3	38 / 38[a]
Survival[b] (95% CI)	0.956 (0.899–1.0)	0.890 (0.792-0.990)	0.838 (0.693–0.982)	0.800 (0.605-0.994)	0.889 (0.744–1.0)	0.632 (0.479–0.785)
Mortality rate by cause						
Legal Hunt Canada	0	0.031	0	0	0	0
Natural	0.023	0	0	0	0.111	0.316
Defense of life	0	0.051	0.038	0.048	0	0
Mistaken ID	0	0	0	0.062	0	0
Poaching	0.021	0	0	0	0	0.053
Trap predation	0	0	0.048	0	0	0
Unknown human	0	0.028	0.076	0.091	0	0

[a] Cub survival based on counts of individuals alive and dead.
[b]Kaplan-Meier survival estimate which may differ from BOOTER survival estimate.

Mortality rates of all sex and age classes of resident non-management radio-collared grizzly bears ≥2 years old were summarized by cause and location of death (Table 13). Rates were categorized by public or private land and human or natural causes. Rates were further stratified by death locations in British Columbia or U.S. and broken into three time periods. The three periods (1983–1998, 1999-2006, and 2007–2017) correspond to a period of population increase followed by a period of decline followed by a period of increase in long term population trend (λ). Grizzly bear survival of all sex and age classes decreased from 0.899 during 1983–1998 to 0.792 during 1999–2006 and then rose to 0.934. Some of this decrease in the 1999–2006 period could be attributed to an increase in natural mortality probably related to poor berry production during 1998–2004. Mortality on private lands in the U.S. increased during this period, suggesting that bears were searching more widely for foods to replace the low berry crop. Several mortalities occurring during 1999–2006 were associated with sanitation issues on private lands. Declines in mortality rate on private lands beginning in 2007 correspond to and may be the result of the initiation of the MFWP bear management specialist position. Several deaths of management bears occurred on private lands, but were not included in this calculation due to capture biases (traps were set only once a conflict occurred and removed after capture). Point estimates for human caused mortality occurring on public lands in the U.S. and British Columbia decreased from 1983–1998 to 1999–2006 and again from 1999–2006 to 2007–2017. This apparent decrease in mortality rates on public lands from 1983–1998 to 1999–2006 is particularly noteworthy given the increase in overall mortality rates. Implementation of access management on U.S. public lands could be a factor in this apparent decline.

Table 13. Survival and cause-specific mortality rates of native radio-collared grizzly bears ≥2 years old by location of death based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2017.

Parameter	1983–1998	1999–2006	2007–2017
Individuals / bear-years	23 / 48.9	21 / 20.3	41 / 49.4
Survival[b] (95% CI)	0.899 (0.819–0.979)	0.792 (0.634–0.950)	0.941 (0.874–1.0)
Mortality rate by location and cause			
Public / natural	0	0.059	0
U.S. public / human	0.061	0.036	0.008
U.S. private / human	0	0.075	0.032
B.C. public / human	0.040	0.038	0.019
B.C. private / human	0	0	0

Augmentation Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 19 augmentation grizzly bears from 1990–2017. Bears that left the area, but did not die were censored. Thirteen female and six male bears ranged in age from 2–10, but were pooled for this calculation because of small sample size. Survival for augmentation bears was 0.782 (95% CI=0.622–0.942, n=19) with 1 instance of natural mortality, 1 poaching, 1 mistaken identity, and 1 train collision among 18 radio-collared bears monitored for 20.7 bear-years. The natural mortality occurred during summer, poaching, mistaken identity, and train mortality occurred during autumn. The female that died of a natural mortality produced a cub before her death, but it is believed the cub died at the same time.

Management Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 13 management grizzly bears from 2003–17. Eleven bears were males and two were females aged 2–17, but were pooled for this calculation because of small sample size. Survival rate was 0.686 (95% CI=0.435–0.937, n=11) with 1 instance of mistaken identity, 1 defense of life, and 1 unknown but human-caused mortality among 12 radio-collared bears monitored for 7.3 bear-years. All mortality occurred during autumn.

Grizzly Bear Reproduction

Mean age of first parturition among native grizzly bears was 6.5 years (95% CI=6.1–6.9, n=11, Table 16). Three of four bears used in the calculation were radio-collared from ages 2–8. The fourth individual was captured with a cub at age 6 years old. We assumed this was her first reproductive event given her age. Seven other first ages of reproduction were established through genetic parentage analysis and known age of offspring. Twenty-one litters comprised of 45 cubs were observed through both monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation, for a mean litter size of 2.17 (95% CI=1.94–2.40, n=21, Table 14). Twenty reproductive intervals were determined through both monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation (Table 15). Mean inter-birth interval was calculated as 2.80 years (95% CI=2.36–3.24, n=20). Booter software provides several options to calculate a reproductive rate (*m*) and we selected unpaired litter size and birth interval data with sample size restricted to the number of females. The unpaired option allows use of bears from which accurate counts of cubs were not obtained but interval was known, or instances where litter size was known but radio failure or death limited knowledge of birth interval. Estimated reproductive rate using the unpaired option was 0.378 female cubs/year/adult female (95% CI=0.296–0.491, n=13 adult females, Table 16). In all calculations the sex ratio of cubs born was assumed to be 1:1. Reproductive rates do not include augmentation bears.

Table 14. Grizzly bear reproductive data from the Cabinet-Yaak 1983–2017.

Bear	Year	Cubs	Age at first reproduction	Reproductive Interval[1]	Cubs (relationship and fate, if known)
106	1986	2		2	1 dead in 1986, ♀ 129 dead in 1989
106	1988	3		3	♂ 192 dead in 1991, ♂ 193, ♀ 206
106	1991	2		2	2 cubs 1 male other unknown sex and fate
106	1993	2		2	♂ 302 dead in 1996, ♀ 303
106	1995	2		4	♀ 353 dead in 2002, ♀ 354 dead in 2007
106	1999	2			♀ 106 and 2 cubs dead in 1999
206	1994	2	6	3	♀ 505
206	1997	2			♀ 596 dead in 1999, ♀ 592 dead in 2000
538	1997	1	6	3	1 yearling separated from ♀ 538 in 1998
538	2000	2		1	2 cubs dead in 2000
538	2001	2		1	2 cubs dead in 2001
538	2002	2			2 cubs of unknown sex and fate
303	2000	2	7	3	1 cub dead in 2000, ♀ 552
303	2003			4	At least 2 cubs
303	2007			3	
303	2010	3			1 cub dead in 2010
303	2014				Observed with courting male in May 2014
303	2016				1 yearling observed in 2016
354	2000		5	3	Genetic data indicated reproduction of at least two cubs in 2000
354	2003			3	At least 2 cubs
354	2006				At least 2 cubs
353	2002	3	7		♀ 353 dead in 2002, 3 cubs (1 female) all assumed dead in 2002
772	2003		6	4	Genetic data indicated reproduction of at least one cub in 2003
772	2007	3			♀ 789, ♂ 791, Unknown sex dead in 2007

Bear	Year	Cubs	Age at first reproduction	Reproductive Interval[1]	Cubs (relationship and fate, if known)
675	2009	2	7	1	2 cubs dead in 2009
675	2010	1			1 cub dead in 2010
552	2011	2		3	♀ 2011049122, ♂ 2011049118
552	2014	3			3 cubs, 2 males and one of unknown sex
784	2013		7		At least 2 cubs
810	2010		7	4	At least one cub
810	2014	2			2 cubs observed at camera site, August 2014
820	2009		6	4	At least one cub
820	2013				At least 2 cubs
831	2004		7	3	At least 1 cub
831	2007				At least 2 cubs
831	2012				At least 3 cubs

[1]Number of years from birth to subsequent birth.

Population Trend

Approximately 95% of the survival data and 85% of the reproductive data used in population trend calculations came from bears monitored in the Yaak River portion of this population, hence this result is most indicative of that portion of the recovery area. However only the Kootenai River divides the Cabinet Mountains from the Yaak River and the trend produced from this data would appear to be applicable to the entire population of native bears in the absence of population augmentation. We have no data to suggest that mortality or reproductive rates are different between the Yaak River and the Cabinet Mountains. The Cabinet Mountains portion of the population was estimated to be <15 in 1988 (Kasworm and Manley 1988) and subsequent lack of identification of resident bears through genetic techniques would suggest the population was possibly 5–10. Population augmentation has added 19 bears into this population since 1990 and a mark recapture population estimate from 2012 indicated the population was 22–24 individuals (Kendall et al. 2016). These data indicate the Cabinet Mountains population has increased by 2–4 times since 1988, but this increase is largely a product of the augmentation effort with reproduction from that segment.

The estimated finite rate of increase (λ) for 1983–2017 using Booter software with the unpaired litter size and birth interval data option was 1.021 (95% CI=0.949–1.087, Table 15). Finite rate of change over the same period was an annual 2.1% (Caughley 1977). Subadult female survival and adult female survival accounted for most of the uncertainty in λ, with reproductive rate, yearling survival, cub survival, and age at first parturition contributing much smaller amounts. The sample sizes available to calculate population trend are small and yielded wide confidence intervals around our estimate of trend (i.e., λ). The probability that the population was stable or increasing was 73%.

Finite rates of increase calculated for the period 1983–1998 (λ = 1.067) suggested an increasing population (Wakkinen and Kasworm 2004). Sample size concerns limited calculation of point estimates of cumulative annual rate of change until 1998 (Fig. 9). Annual survival rates for adult and subadult females were 0.948 and 0.901 respectively, during 1983-1998, and then declined to 0.926 and 0.740 for the period of 1983-2006, respectively. Cumulative lambda calculations reached the lowest point in 2006 (Fig. 10). Human-caused mortality has accounted for much of this decline in annual survival rates and population trend. During 2017, adult female survival and subadult female survival had increased to 0.956 and 0.838 respectively and resulted in an improving population trend estimate since 2006. Improving survival by reducing human-caused mortality is crucial for recovery of this population (Proctor et al 2004).

Table 15. Booter unpaired method estimated annual survival rates, age at first parturition, reproductive rates, and population trend of native grizzly bears in the Cabinet–Yaak recovery zone, 1983–2017.

Parameter	Sample size	Estimate (95% CI)	SE	Variance (%)[a]
Adult female survival[b] (S_a)	16 / 44.9[c]	0.956 (0.883–1.0)	0.031	25.3
Subadult female survival[b] (S_s)	18 / 23.8[c]	0.838 (0.687–0.964)	0.074	59.6
Yearling survival[b] (S_y)	33 / 16.2[c]	0.937 (0.791–1.0)	0.062	1.7
Cub survival[b] (S_c)[d]	38/38	0.632 (0.474–0.790)	0.080	6.1
Age first parturition (*a*)	11	6.5 (6.1–6.8)	0.200	0.7
Maximum age (*w*)	Fixed	27		
Unpaired Reproductive rate (*m*)[e]	13/20/21[f]	0.359 (0.286–0.463)	0.046	6.4
Unpaired Lambda (λ)	5000 bootstrap runs	1.021 (0.949–1.087)	0.036	

[a] Percent of lambda explained by each parameter
[b]Booter survival calculation which may differ from Kaplan-Meier estimates in Table 13.
[c]individuals / bear-years
[d]Cub survival based on counts of individuals alive and dead
[e]Number of female cubs produced/year/adult female. Sex ratio assumed to be 1:1.
[f]Sample size for individual reproductive adult females / sample size for birth interval / sample size for litter size from Table 15.

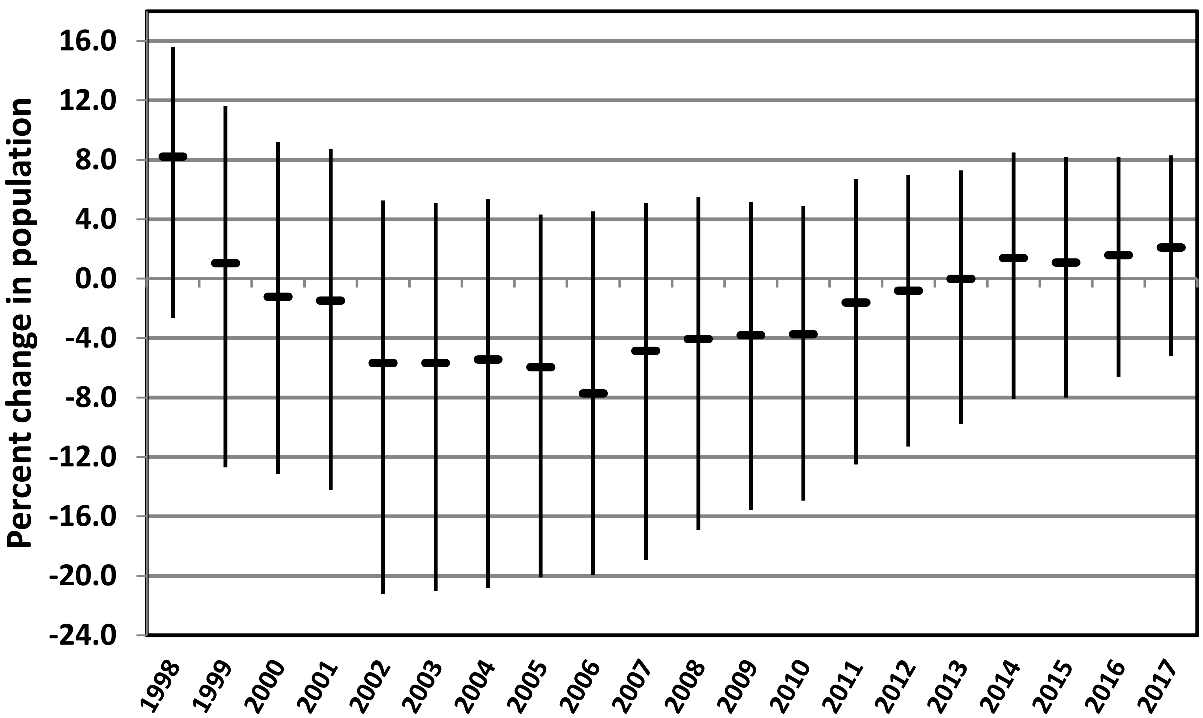


Figure 11. Point estimate and 95% confidence intervals for cumulative annual calculation of population rate of change for native grizzly bears in the Cabinet-Yaak recovery area, 1983–2017. Each entry represents the annual rate of change from 1983 to that date.

Population Estimate

During 2012 the USGS used mark-recapture techniques to estimate the CYE grizzly bear population at 48–50 (CI=44-62)(Kendall et al. 2016). Using the midpoint of this starting estimate, the calculated rate of increase (2.1%), and the numbers and fates of individuals in the augmentation program (five additions but two mortalities = net gain of three if all still alive) we estimate the 2017 population at approximately 55-60 individuals.

Capture and Marking

Seven grizzly bear captures of 2 males and 5 females occurred during 2017. Five captures occurred for research purposes and 2 were management captures. Ninety-one individual grizzly bears have been captured 135 times as part of this monitoring program since 1983 (Tables 16 and 17). One hundred fifteen captures occurred for research purposes and 20 captures occurred for management purposes.

Cabinet Mountains

Research trapping was conducted in the Cabinet Mountains portion of the CYE from 1983–87. Three adult grizzly bears were captured during this effort (1 female and 2 males). No trapping occurred from 1988–1994 as effort was directed toward the Yaak River. In 1995 an effort was initiated to recapture relocated bears in order to determine success of the population augmentation program and capture any native bears in the Cabinet Mountains. During 1983–2017, 7,560 trap-nights were expended to capture 12 known individual grizzly bears and 315 individual black bears (Table 16 and 17, Fig. 12). Rates of capture by individual were 1 grizzly bear/630 trap-nights and 1 black bear/24 trap-nights. A trap-night was defined as one site with one or more snares set for one night. None of the augmentation bears were captured during subsequent trapping efforts. Much of the trapping effort before 2002 involved use of horses on backcountry trails and closed roads. In 2003, two culvert traps were airlifted to the East Fork of Rock Creek by helicopter. Traps were operated during the last week of August and first week of September. Three black bears were captured. No grizzly bears were captured, though one was observed near the traps.

Yaak River, Purcell Mountains South of BC Highway 3

Trapping was conducted in the Yaak portion of the CYE during 1986–87 as part of a black bear graduate study (Thier 1990). Trapping was continued from 1989–2017 by USFWS. One-hundred four captures of 58 individual grizzly bears and 531 captures of 447 individual black bears were made during 10,915 trap-nights during 1986–2017 (Tables 16 and 17, Fig. 12). Rates of capture by individual were 1 grizzly bear/188 trap-nights and 1 black bear/24 trap-nights.

Trapping effort was concentrated in home ranges of known bears during 1995–2017 to recapture adult females with known life histories. Much of the effort involved using horses and bicycles in areas inaccessible to vehicles, such as backcountry trails and closed roads.

Salish Mountains

Trapping occurred in the Salish Mountains, south of Eureka, Montana, in 2003. An adult female grizzly bear (5 years old), and 5 black bears were captured during 63 trap-nights of effort (Tables 16, 17).

Moyie River and Goat River Valleys North of Highway 3, British Columbia

Eight grizzly bears and 32 black bears were captured in the Moyie and Goat River valleys north of Highway 3 in BC in 2004-08 (Table 16 and Fig. 12). Trapping was conducted in cooperation with M. Proctor (Birchdale Ecological Consultants, Kaslo, BC) and BC Ministry of Environment. Rates of capture by individual were 1 grizzly bear/32 trap-nights and 1 black bear/8 trap-nights.

Population Linkage Kootenai River Valley, Montana

Twelve black bears were captured and fitted with GPS radio collars during 2004-07 to determine bear crossing patterns of the Kootenai River valley near the junction of Highway 2 and 508. These captures were distributed north (6 females and 3 males) and south of the Kootenai River (1 female and 2 males).

Population Linkage Clark Fork River Valley, Montana

Seventeen black bears were captured and fitted with GPS radio collars in the Clark Fork River Valley during 2008–11 to examine bear crossing opportunities near the junction of Highways 200 and 56. Eleven of these bears (3 females and 8 males) were north of the Clark Fork River and 6 bears (6 males) south of the river.

Population Linkage Interstate 90 Corridor, Montana and Idaho

In 2011 and 2012, we collared black bears with GPS radio collars along I-90 between St. Regis, MT and the MT-ID border (near Lookout Pass). Twenty bears were captured 23 times during 446 trap-nights of effort, resulting in 19 trap-nights/capture (Table 16). A total of 16 bears were collared (15 in Montana, 1 in Idaho). Eight of the bears (2 females and 6 males) were collared north of the interstate highway and 8 (3 females and 5 males) were collared south of the highway.

Population Linkage Highway 95 Corridor, Idaho

We began an effort in 2011 to collar black bears with GPS radio collars along Highway 95 between Bonners Ferry and Sandpoint, Idaho. Effort centered on the McArthur Lake State Wildlife Management Area. Nineteen black bears were captured during 413 trap-nights, or 22 trap-nights/capture (Table 16). Fourteen bears were collared. Nine of those bears (4 females and 5 males) were collared west of the highway, and 5 (5 males) were east of the highway.

Table 16. Research capture effort and success for grizzly bears and black bears within study areas, 1983–2017.

Area / Year(s)	Trap-nights	Grizzly Bear Captures	Black Bear Captures	Trap-nights / Grizzly Bear	Trap-nights / Black Bear
Cabinet Mountains,1983–17					
Total Captures	7560	15	433	504	17
Individuals[1]	7560	12	315	630	24
Salish Mountains, 2003[1]	63	1	5	63	13
Yaak River South Hwy 3, 1986–17					
Total Captures	10915	104	531	105	21
Individuals[1]	10915	58	447	188	24
Purcells N. Hwy 3, BC 2004–09					
Total Captures	390	10	37	39	11
Individuals[1]	390	9	32	43	12
Interstate 90, 2011–12					
Total Captures	446	0	23	0	19
Individuals[1]	446	0	20	0	22
Hwy 95, ID, 2011					
Total Captures	408	0	19	0	21
Individuals[1]	408	0	19	0	21

[1]Only captures of individual bears included. Recaptures are not included in summary.

Table 17. Grizzly bear capture information from the Cabinet-Yaak and Purcell populations, 1983–2017. Multiple captures of a single bear in a single year are not included.

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
678	6/29/83	F	28	86	Bear Cr., MT	Research
680	6/19/84	M	11	(181)	Libby Cr., MT	Research
680	5/12/85	M	12	(181)	Bear Cr., MT	Research
678	6/01/85	F	30	79	Cherry Cr., MT	Research
14	6/19/85	M	27	(159)	Cherry Cr., MT	Research
101	4/30/86	M	(8)	(171)	N Fk 17 Mile Cr., MT	Research
678	5/21/86	F	31	65	Cherry Cr., MT	Research
106	5/23/86	F	8	92	Otis Cr., MT	Research
128	5/10/87	M	4	(114)	Lang Cr., MT	Research
129	5/20/87	F	1	32	Pheasant Cr., MT	Research
106	6/20/87	F	9	(91)	Grizzly Cr., MT	Research
134	6/24/87	M	8	(181)	Otis Cr., MT	Research
129	7/06/89	F	3	(80)	Grizzly Cr., MT	Research
192	10/14/89	M	1	90	Large Cr., MT	Research
193	10/14/89	M	1	79	Large Cr., MT	Research
193	6/03/90	M	2	77	Burnt Cr., MT	Research
206	6/03/90	F	2	70	Burnt Cr., MT	Research
106	9/25/90	F	12	(136)	Burnt Cr., MT	Research
206	5/24/91	F	3	77	Burnt Cr., MT	Research
244	6/17/92	M	6	140	Yaak R., MT	Research
106	9/04/92	F	14	144	Burnt Cr., MT	Research
34	6/26/93	F	(15)	158	Spread Cr., MT	Research
206	10/06/93	F	5	(159)	Pete Cr., MT	Research
505	9/14/94	F	Cub	45	Jungle Cr., MT	Research
302	10/07/94	M	1	95	Cool Cr., MT	Research
303	10/07/94	F	1	113	Cool Cr., MT	Research
106	9/20/95	F	17	(169)	Cool Cr., MT	Research
353	9/20/95	F	Cub	43	Cool Cr., MT	Research
354	9/20/95	F	Cub	47	Cool Cr., MT	Research
302	9/24/95	M	2	113	Cool Cr., MT	Research
342	5/22/96	M	4	(146)	Zulu Cr., MT	Research
363	5/27/96	M	4	(158)	Zulu Cr., MT	Research
303	5/27/96	F	3	(113)	Zulu Cr., MT	Research
355	9/12/96	M	(6)	(203)	Rampike Cr., MT	Research
358	9/22/96	M	8	(225)	Pete Cr., MT	Research
353	9/23/96	F	1	83	Cool Cr., MT	Research
354	9/23/96	F	1	88	Cool Cr., MT	Research
384	6/12/97	M	7	(248)	Zulu Cr., MT	Research
128	6/15/97	M	14	(270)	Cool Cr., MT	Research
386	6/20/97	M	5	(180)	Zulu Cr., MT	Research
363	6/26/97	M	5	(180)	Cool Cr., MT	Research
538	9/25/97	F	6	(135)	Rampike Cr., MT	Research
354	9/27/97	F	2	99	Burnt Cr., MT	Research
354	8/20/98	F	3	(90)	Cool Cr., MT	Research
106	8/29/98	F	20	(146)	Burnt Cr., MT	Research
363	8/30/98	M	6	(203)	Burnt Cr., MT	Research
342	9/17/98	M	6	(203)	Clay Cr., MT	Research
303	9/21/98	F	5	(113)	Clay Cr., MT	Research
592	8/17/99	F	2	(91)	Pete Cr., MT	Research
596	8/23/99	F	2	(91)	French Cr., MT	Research
358	11/15/99	M	11	279	Yaak R., MT	Management, open freezer, killed goats
538	7/16/00	F	9	(171)	Moyie River, BC	Research
552	7/16/01	F	1	(36)	Copeland Cr., MT	Research
577	5/22/02	F	1	23	Elk Cr., MT	Management, pre-emptive move
578	5/22/02	M	1	23	Elk Cr., MT	Management, pre-emptive move

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
579	5/22/02	M	1	30	Elk Cr., MT	Management, pre-emptive move
353	6/15/02	F	7	(136)	Burnt Cr., MT	Research
651	9/25/02	M	7	(227)	Spread Cr., MT	Research
787	5/17/03	M	3	71	Deer Cr. ID	Management, garbage feeding
342	5/23/03	M	11	(227)	Burnt Cr., MT	Research
648	8/18/03	F	5	(159)	McGuire Cr., MT, Salish Mtns.	Research
244	9/25/03	M	17	(205)	N Fk Hellroaring Cr., MT	Research
10	6/17/04	F	11	(159)	Irishman C., BC	Research
11	6/20/04	M	7	(205)	Irishman C., BC	Research
12	7/22/04	F	11	(148)	Irishman C., BC	Research
576	10/21/04	M	2	(114)	Young Cr., MT	Management, garbage feeding
675	10/22/04	F	2	100	Young Cr., MT	Management, pre-emptive move
677	5/13/05	M	6	105	Canuck Cr., BC	Research
688	6/13/05	M	3	93	EF Kidd Cr., BC	Research
576	6/17/05	M	3	133	Teepee Cr., BC	Research
690	6/17/05	F	1	52	EF Kidd Cr., BC	Research
17	6/18/05	M	8	175	Norge Pass, BC	Research
2	6/20/05	M	7+	209	EF Kidd Cr., BC	Research
292	7/6/05	F	4	(114)	Mission Cr., ID	Research
694	7/15/05	F	2	73	Kelsey Cr., MT	Research
770	9/20/05	M	11	(250)	Chippewa Cr., MT	Research
M1	10/4/05	M	(2)	(80)	Pipe Cr., MT	Management, garbage feeding
668	10/11/05	M	3	120	Yaak R., MT	Management, garbage feeding
103	5/23/06	M	3	125	Canuck Cr., BC	Research
---	5/28/06	F	4	(125)	Cold Cr., BC (Trap predation)	Research
5381	6/6/06	M	4	(200)	Hellroaring Cr., ID	Research
651	6/28/06	M	11	198	Cold Cr., BC	Research
780	9/22/06	M	6	(250)	S Fk Callahan Cr., MT	Research
130	6/18/07	F	26	113	Arrow Cr., BC	Research
131	6/28/07	F	(5)	(80)	Arrow Cr., BC	Research
784	9/23/07	F	1	(80)	Spread Cr., MT	Research
772	9/18/07	F	10	116	Pilgrim Cr., MT	Management, fruit trees
789	9/18/07	F	Cub	36	Pilgrim Cr., MT	Management, fruit trees
791	9/18/07	M	Cub	39	Pilgrim Cr., MT	Management, fruit trees
785	10/15/07	F	1	75	Pete Cr., MT	Research
675	5/23/09	F	7	89	Elmer Cr. BC	Research
784	7/24/09	F	3	(136)	Hensley Cr., MT	Research
731	9/17/09	F	2	(125)	Fowler Cr., MT	Research
5381	11/21/09	M	4	(273)	Kidd Cr., BC	Research
799	5/21/10	M	3	(102)	Rock Cr., MT	Research
737	7/21/10	M	4	129	Messler Cr., MT	Research
1374	8/30/10	M	2	98	Young Cr., MT	Management, garbage feeding
726	5/24/11	M	2	77	Meadow Cr., MT	Research
722	5/31/11	M	12	261	Otis Cr., MT	Research
729	6/18/11	F	1	33	Beulah Cr., MT	Research
724	7/13/11	M	2	159	Graves Cr., MT	Management, killed pigs
732	10/27/11	M	5	139	Otis Cr., MT	Management, killed chickens
729	6/26/12	F	2	(80)	Pipe Cr., MT	Research
737	9/19/12	M	6	(159)	Basin Cr., MT	Research
552	9/24/12	F	12	(136)	Basin Cr., MT	Research
826	6/28/13	M	(5)	(136)	Pipe Cr., MT	Research
303	7/23/13	F	20	132	Pipe Cr., MT	Research
831	6/21/14	F	14	81	Libby Cr., MT	Research
807	6/24/14	M	4	111	Canuck Cr., ID	Research
808	6/27/14	M	4	130	Spruce Cr., ID	Research
722	8/21/14	M	15	(182)	Hellroaring Cr., MT	Research
835	8/24/14	M	19	185	Hellroaring Cr., MT	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
836	9/19/14	F	1	75	Hellroaring Cr., MT	Research
837	9/29/14	M	6	(227)	Hellroaring Cr., MT	Research
729	5/19/15	F	5	107	Cool Cr., MT	Research
839	6/19/15	M	4	78	Bear Cr., MT	Research
810	7/16/15	F	12	120	Hellroaring Cr., MT	Research
818	7/18/15	M	2	82	Meadow Cr., MT	Research
820	8/20/15	F	12	149	Hellroaring Cr., MT	Research
726	10/5/15	M	6	227	Libby Cr., MT	Management, beehives
836	7/18/16	F	3	87	Hellroaring Cr., MT	Research
822	8/15/16	F	3	92	Hellroaring Cr., MT	Research
824	8/18/16	M	(12)	197	Hellroaring Cr., MT	Research
9811	8/19/16	M	(2)	(91)	Hellroaring Cr., MT	Research
821	8/27/16	M	2	127	Hellroaring Cr., MT	Research
853	9/21/16	M	5	120	Boulder Cr., MT	Research
722	9/29/16	M	17	238	17 Mile Cr., MT	Management, pigs and chickens
922	10/10/16	M	2	130	Upper Yaak R., MT	Management, chicken feed
726	6/18/17	M	8	(195+)	Beulah Cr., MT	Research
1026	6/21/17	F	2	63	Upper Yaak R., MT	Management, habituated
1028	6/21/17	F	2	64	Upper Yaak R., MT	Management, habituated
861	6/25/17	M	2	55	Bear Cr., MT	Research
840	6/26/17	F	2	53	Cruien Cr., MT	Research
842	7/25/17	F	4	93	Fourth of July Cr., MT	Research
810	9/18/17	F	14	150	Hellroaring Cr., MT	Research

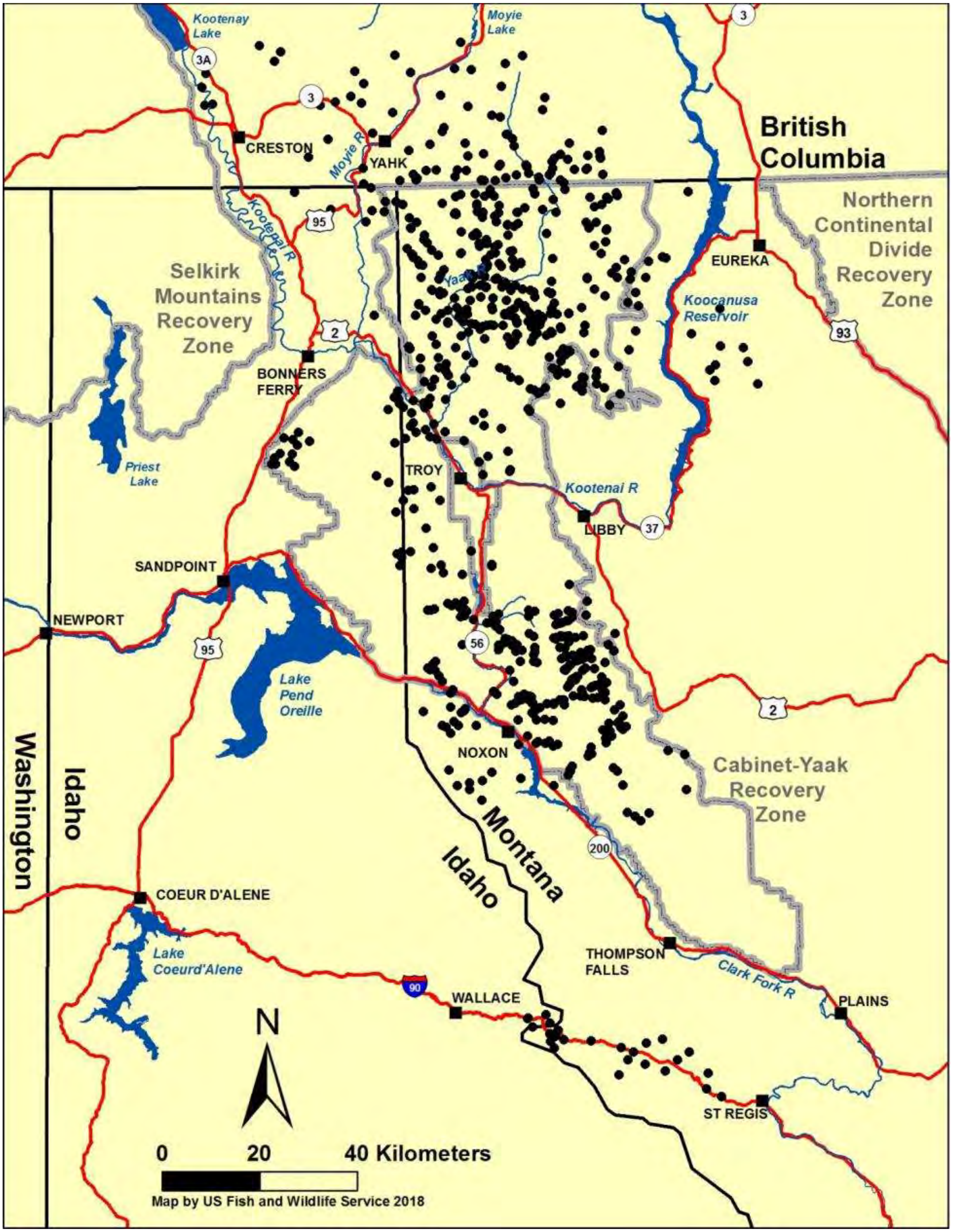


Figure 12. Trap site locations in the Cabinet-Yaak study areas 1983–2017.

Grizzly Bear Monitoring and Home Ranges

Seventeen grizzly bears were monitored with radio collars during portions of 2017. Research monitoring included eight females (three adults and five subadults) and nine males (six adults and three subadults) in the CYE. Two bears from the Cabinet Mountains (1 subadult male and 1 subadult female) were part of the augmentation program. Four bears were collared for conflict management purposes.

Aerial telemetry locations and GPS collar locations were used to calculate home ranges. The convex polygon life ranges were computed for bears monitored during 1983-2017 (Table 18 and Appendix Figs. A1-A95). Resident, non-augmentation bears with multiannual home range estimates and sample sizes in excess of 50 locations were used to calculate basic statistics. Adult male life range averaged 1,935 km^2 (95% CI ± 408, n = 28) and adult female life range averaged 605 km^2 (95% CI ± 361, n = 14) using the minimum convex polygon estimator.

Young female bears typically utilize home ranges adjacent to or a part of their mother's home range. The minimum convex polygon estimator for bear 106 was 658 km^2 during her 1986–99 life time. Her home range was smallest during 1986, 1988, 1991, 1993, and 1995 when she had cubs. Four known female offspring of bear 106 established home ranges around their maternal range. Bear 206 has established a home range adjacent to and north of her mother's home range. Bear 303 has established a home range east of her mother's home range and female 354 may have established her home range west of her mothers. Bear 353 lived within her mother's old range, before her death.

Home ranges of collared grizzly bears overlap extensively on a yearly and lifetime basis. However, bears typically utilize the same space at different times. Male home ranges overlap several females to increase breeding potential, but males and females consort only during the brief period of courtship and breeding. Adult male bears, whose home ranges overlap, seldom use the same habitat at the same time to avoid conflict.

Table 18. Home range sizes of native (independent or family groups) and transplanted grizzly bears in the Cabinet-Yaak recovery zone, Purcell Mountains and Salish Mountains 1983–2017.

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
678	F	28-34	1983-89	VHF	173	658	Cabinet Mtns, MT
680	M	11-12	1984-85	VHF	75	1,947	Cabinet Mtns, MT
14	M	27	1985	VHF	23	589	Cabinet Mtns, MT
101	M	8	1986	VHF	38	787	Yaak River, MT
106	F	8-20	1986-99	VHF	379	852	Yaak River, MT
128	M	4-14	1987-97	VHF	204	2,895	Yaak River, MT
129	F	1-3	1987-89	VHF	42	60	Yaak River, MT
134	M	8-9	1987-88	VHF	20	594	Yaak River, MT
192	M	2	1990	VHF	10	574	Yaak River, MT
193	M	2	1990	VHF	34	642	Yaak River, MT
206	F	2-7	1990-95	VHF	208	1,332	Yaak River, MT
218[1]	F	5-6	1990-91	VHF	95	541	Cabinet Mtns, MT
244	M	6-18	1992-04	VHF	158	1,406	Yaak River, MT
258[1]	F	6-7	1992-93	VHF	54	400	Cabinet Mtns, MT
286[1]	F	2-3	1993-94	VHF	82	266	Cabinet Mtns, MT
311[1]	F	3-4	1994-95	VHF	16	209	Cabinet Mtns, MT
302	M	1-3	1994-96	VHF	60	514	Yaak River, MT
303	F	1-22	1994-01, 2011-16	GPS & VHF	12,177	605	Yaak River, MT
342	M	4-12	1996-04	VHF	134	1,653	Yaak River, MT
355	M	(6)	1996	VHF	5	N/A	Yaak River, MT & BC
358	M	8-10	1996-98	VHF	55	1,442	Yaak River, MT & BC

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
363	M	4-7	1996-99	VHF	120	538	Yaak River, MT
386	M	5-6	1997-98	VHF	29	1,895	Yaak River, MT
354	F	2-4	1997-99	VHF	70	537	Yaak River, MT
538	F	6-11	1997-02	VHF	232	835	Yaak River, MT & BC
592	F	2-3	1999-00	VHF	59	471	Yaak River, MT & BC
596	F	2	1999	VHF	10	283	Yaak River, MT & BC
552	F	1-15	2001, 2012-15	GPS & VHF	1,431	1,210	Yaak River, MT
577	F	1	2002	VHF	11	2	Cabinet Mtns, MT
578	M	1	2002	VHF	3	N/A	Cabinet Mtns, MT
579	M	1	2002	VHF	10	5	Cabinet Mtns, MT
353	F	7	2002	VHF	37	119	Yaak River, MT
651	M	7-11	2002-03,06	GPS & VHF	1,827	1,004	Yaak River, MT & BC
787[2]	M	3-4	2003-04	VHF	84	1,862	Yaak River, MT
648	F	5-7	2003-05	VHF	85	948	Salish Mtns, MT
576[2]	M	3-4	2005-06	GPS & VHF	2,290	1,320	Yaak River, MT & BC
675	F	2-8	2004-10	GPS & VHF	1,827	714	Yaak River, MT & BC
10	F	11	2004	GPS	1,977	176	Moyie River, BC
11	M	7	2004	GPS	894	1,453	Moyie River, BC
12	F	11	2004	GPS	1,612	333	Moyie River, BC
17	M	8	2005	GPS	1,903	3,074	Yaak River, MT & BC
677	M	6	2005	GPS	519	3,361	Yaak River, MT & BC
688	M	3-4	2005-06	GPS	3,421	1,544	Moyie & Goat River, BC
694	F	2	2005	VHF	11	89	Yaak River, MT
292	F	4	2005	GPS	7,062	253	Moyie & Goat River, BC & ID
770	M	11-12	2005-06	VHF	20	326	Cabinet Mtns, MT
2	M	(7-9)	2005-06	GPS	1,337	2,860	Moyie / Yahk, BC
A1[1]	F	(8-10)	2005-07	VHF	73	725	Cabinet Mtns, MT
782[1]	F	2-5	2006-08	GPS	1,126	1,932	Cabinet Mtns, MT
780	M	6-8	2006-08	VHF	56	1,374	Cabinet Mtns, MT
103	M	2-4	2006-07	GPS	4,872	6,545	Kootenai, & Pend Oreille River, BC, ID, & WA
5381	M	4-5	2006-07	GPS	11,491	1,949	Moyie & Goat River, BC & ID
130	F	26-27	2007-08	GPS	3,986	281	Goat River, BC
131	F	(5)	2007-08	GPS	3,270	276	Goat River, BC
784	F	1-3	2007-09	GPS	2,606	524	Yaak River, MT
785	F	1-2	2007-08	GPS	362	207	Yaak River, MT
772	F	10	2007	VHF	14	446	Cabinet Mtns, MT
635[1]	F	4	2008	GPS	285	451	Cabinet Mtns, MT
790[1]	F	3	2008	GPS	227	423	Cabinet Mtns, MT
715[1]	F	(10-11)	2009-10	GPS	437	6,666	Cabinet Mtns, MT
731	F	2-4	2009-11	GPS	1,652	852	Yaak River, MT
799	M	2-4	2010-11	GPS	1,422	805	Cabinet Mtns, MT
713[1]	M	5-6	2010-11	GPS & VHF	562	5,999	Cabinet Mtns, MT
714[1]	F	5-6	2010-12	GPS	1,684	2,389	Cabinet Mtns & Flathead, MT
737	M	4-7	2010-13	GPS & VHF	1,626	2,667	Yaak River, MT & BC
1374	M	2	2010	GPS	14	381	Yaak River, MT & BC
722[2]	M	12-17	2011-17	GPS	1,945	3,412	Yaak River, MT & BC
723[1]	M	1-3	2011-12	GPS	430	1,063	Cabinet Mtns, MT
724[2]	M	1-3	2011-12	VHF	29	873	Cabinet Mtns, MT
725[1]	F	2-4	2011-13	GPS	3,194	3,314	Cabinet Mtns & Flathead, MT
726	M	2-3,6-8	2011-12,15-17	GPS	6,335	3,751	Kootenai & Yaak River, MT

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km²)	Area of use
729	F	1-7	2011-13, 15-17	GPS	17,356	560	Yaak River, MT
732[2]	M	5	2011	GPS	875	458	Yaak River, MT
918[1]	M	2-4	2012-14	GPS	1,192	587	Cabinet Mtns, MT
826	M	-5	2013	GPS	164	1,820	Yaak& Kootenai River, MT & BC
919[1]	M	4-5	2013-14	GPS	345	436	Cabinet Mtns, MT
808	M	4-5	2014-15	GPS	1,273	1,722	Yaak River, MT
831	F	14	2014	GPS	434	218	Cabinet Mtns, MT
835	M	19-21	2014-16	GPS	826	4,145	Yaak River, MT
836	F	1-4	2014--17	GPS	3,772	1,816	Yaak River, MT
837	M	6-8	2014-16	GPS	1,173	1,553	Yaak River, MT
920[1]	F	3-5	2014-16	GPS	5,108	913	Cabinet Mtns, MT
921[1]	F	2-3	2014-15	GPS	2,033	259	Cabinet Mtns, MT
810	F	12,14	2015,2017	GPS	3,150	230	Yaak River, MT
818	M	2	2015	GPS	461	225	Yaak River, MT
839	M	3-4	2015-16	GPS & VHF	2,595	6,819	Cabinet & Whitefish Mtns, MT
820	F	12-14	2015-17	GPS	2,537	295	Yaak River, MT
924[1]	M	2	2015	GPS	741	2,068	Cabinet Mtns, MT
1001	M	6	2015	GPS	1,352	1,357	Selkirk Mtns, BC
807	M	4-7	2014-17	GPS	2,568	3,319	Selkirk Mtns, ID&Yaak River, MT
821	M	2-3	2016-17	GPS	2,467	4,405	Yaak River, MT
822	F	3	2016	GPS	497	328	Yaak River, MT
824	M	(12-13)	2016-14	GPS	455	884	Yaak River, MT & BC
853	M	5-6	2016-17	GPS	938	736	Kootenay River, BC
9811	M	(2-3)	2016-17	GPS	3,135	660	Moyie River, MT,ID,BC
922[2]	M	4-5	2016-17	GPS	938	2,148	Kootenai Rr., ID Yaak Rr, MT
926[1]	M	4-5	2016-17	GPS	2,834	3,328	Cabinet Mtns, MT
840	F	(2)	2017	GPS	1,128	348	Pipe Cr., MT
842	F	(3)	2017	GPS	1,019	495	Yaak River, MT
861	M	(2)	2017	GPS	704	68	Cabinet Mtns, MT
1026	F	(2)	2017	GPS	3,435	1,556	Creston Valley, BC Yaak Rr., MT
1028	F	(2)	2017	GPS	1,639	708	Yaak Rr.,MT St. Mary's Rr. ,BC

[1]Augmentation bears.
[2]Management bears.

Grizzly Bear Denning Chronology

We summarized den entry and exit dates of radio-collared grizzly bears using primarily VHF and GPS location data (1983–2017). Radio-collars deployed since the late 2000s include an activity monitoring device (i.e., accelerometer), which allows an additional, more detailed assessment of den entrance and exit and activity during the denning period.

Den entry dates (n = 114) ranged from the third week of October to the last week of December. One hundred nine (96%) entries occurred between the 4th week of October and the 3rd week of December (Fig. 13). Grizzly bears in the Cabinet Mountains (median entry in 2nd week of November) entered dens 2 weeks earlier than bears in the Yaak River drainage (median entry during 4th week of November). Males generally entered dens later than females. Female-offspring family groups tended to enter dens later than independent adult females (Fig. 14). By December 1, 38% of Cabinet and Yaak grizzly bears have not yet entered winter dens.

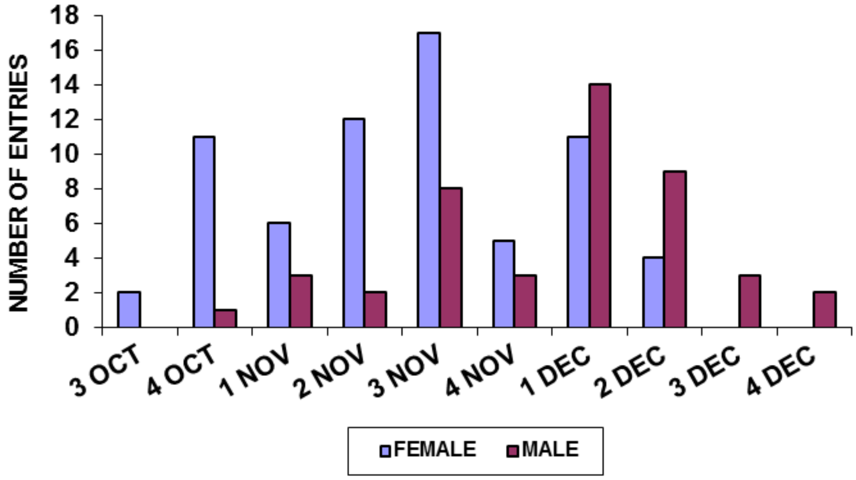


Figure 13. Month and week of den entry for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2017.

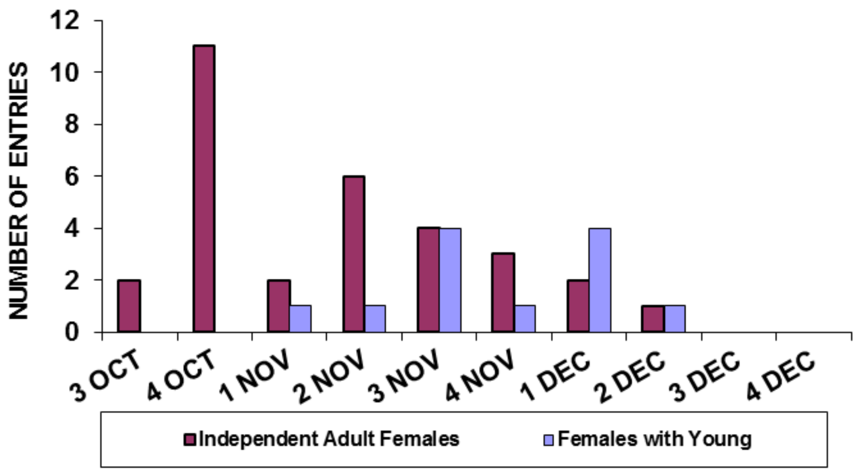


Figure 14. Month and week of den entry for adult female, radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2017.

Den exit dates (n = 104) ranged from the first week of March to the third week of May (Fig. 15). One-hundred (96%) exit dates occurred from the 2nd week of March through the 2nd week of May. Grizzly bears in the Cabinet Mountains generally exited dens one week later than bears in the Yaak river drainage. Males tended to exit dens two weeks earlier than females. Seventy percent of den exits occurred during the month of April. By May 1, 13% of Cabinet and Yaak grizzly bears were still in dens, over half of which were females with cubs-of-the-year (COY). Females with cubs appear to exit dens later than other adult females (median exit during 1st week of May; Fig. 16). All adult females with COY remained at dens until at least the 15th of April.

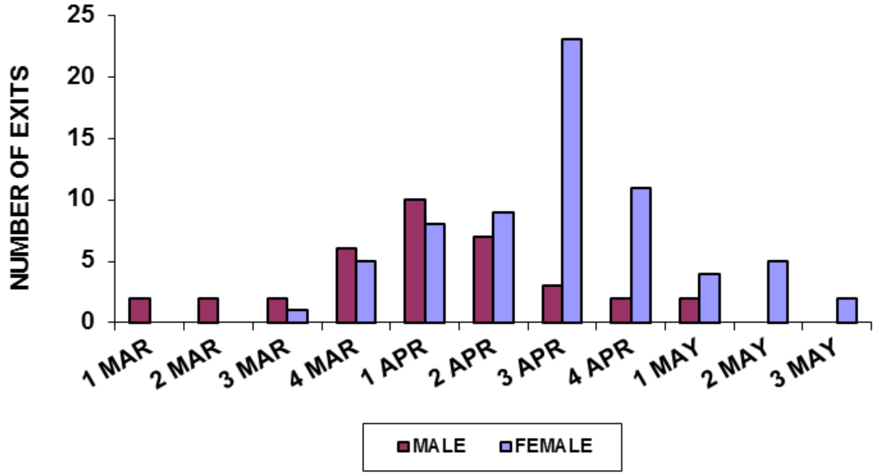


Figure 15. Month and week of den exit for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2017.

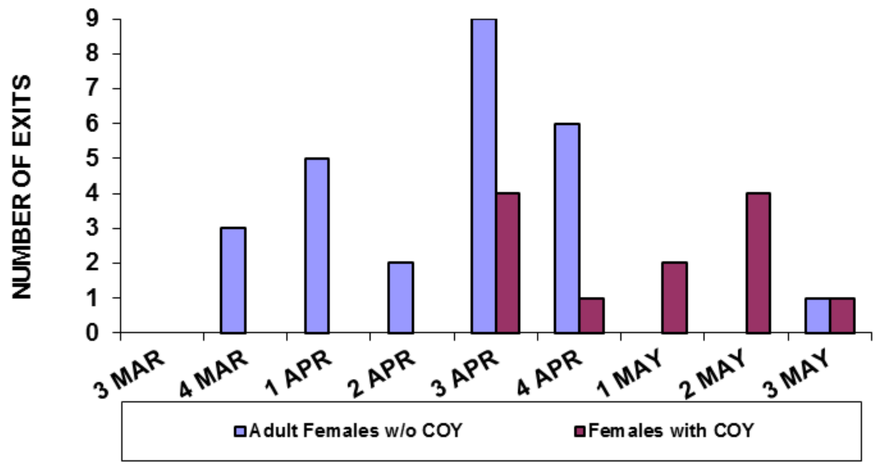


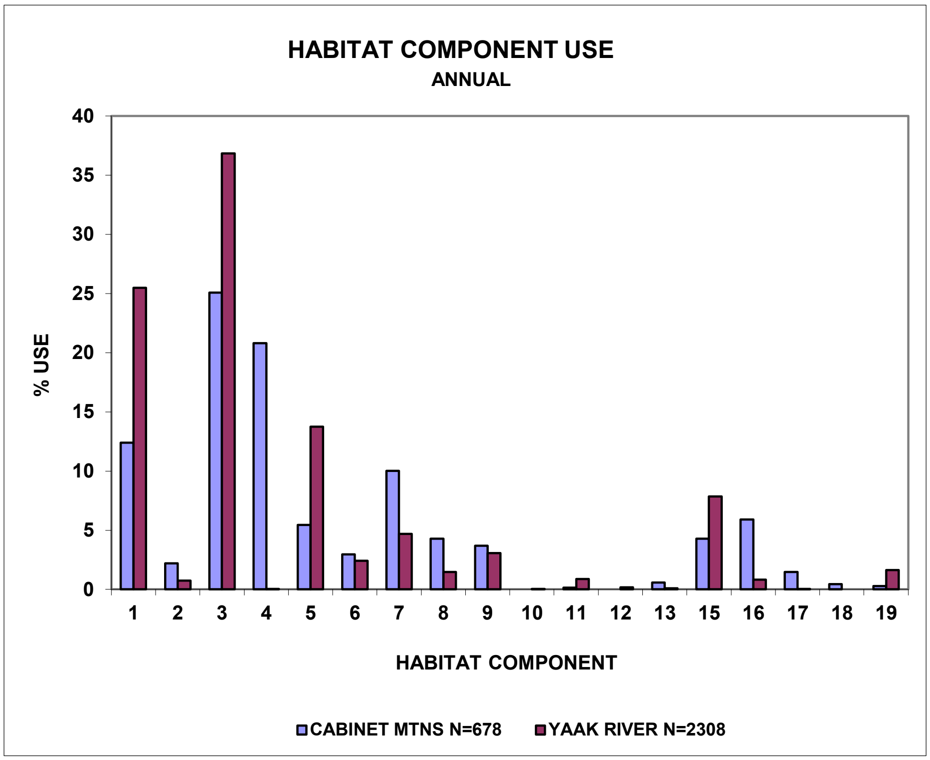
Figure 19. Month and week of den exit for adult female, radio-collared grizzly bears (with and without cubs-of-the year [COY]) in the Cabinet-Yaak grizzly bear recovery zone, 1983–2017.

Grizzly Bear Use of Habitat Components

Grizzly bear use of habitat components was summarized on a seasonal basis during 1983–2009. Only VHF radio locations (1983–2009) were used in this analysis. Radio locations derived from GPS radio collars will be analyzed separately through resource selection function techniques in the future. Spring was defined as den exit through 15 June, summer was 16 June through 15 September, and autumn was 16 September through den entry. VHF radiolocation sample sizes for the Cabinet Mountains were: 152 in spring, 379 in summer, and 130 in autumn. Radiolocation sample sizes for the Yaak River were: 480 in spring, 1061 in summer, and 713 in autumn. Den site sample sizes were 17 in the Cabinet Mountains and 54 in the Yaak River.

Radio collared grizzly bears in the Cabinet Mountains and Yaak River made greatest annual use of closed timber, timbered shrub fields, mixed shrub snow chutes, mixed shrub /

cutting units, alder shrub fields, huckleberry shrub fields, and graminoid and beargrass sidehill parks (Fig. 17). Primary differences between the Yaak River and the Cabinet Mountains in annual use of habitat components include greater use of mixed shrub snow chutes, alder shrub fields, huckleberry shrub fields, and beargrass sidehill parks in the Cabinet Mountains and greater use of closed timber, timbered shrub fields, mixed shrub/cutting units, and graminoid sidehill parks in the Yaak River. A description of all 19 habitat components is in Appendix 5.



Habitat Components

1. Closed Timber
2. Open Timber
3. Timbered Shrub field
4. Mixed Shrub/Snow chute
5. Mixed Shrub/Cutting Unit
6. Mixed Shrub/Burn
7. Alder Shrub
8. Huckleberry Shrub
9. Riparian Stream bottom
10. Marsh
11. Wet Meadow
12. Dry Meadow
13. Drainage Forb field
14. Snow chute
15. Graminoid Sidehill Park
16. Beargrass Sidehill Park
17. Slab rock
18. Talus/Rock/Scree
19. Timbered Grass

Figure 17. Annual habitat component use in the Cabinet Mountains and Yaak River, 1983–2009.

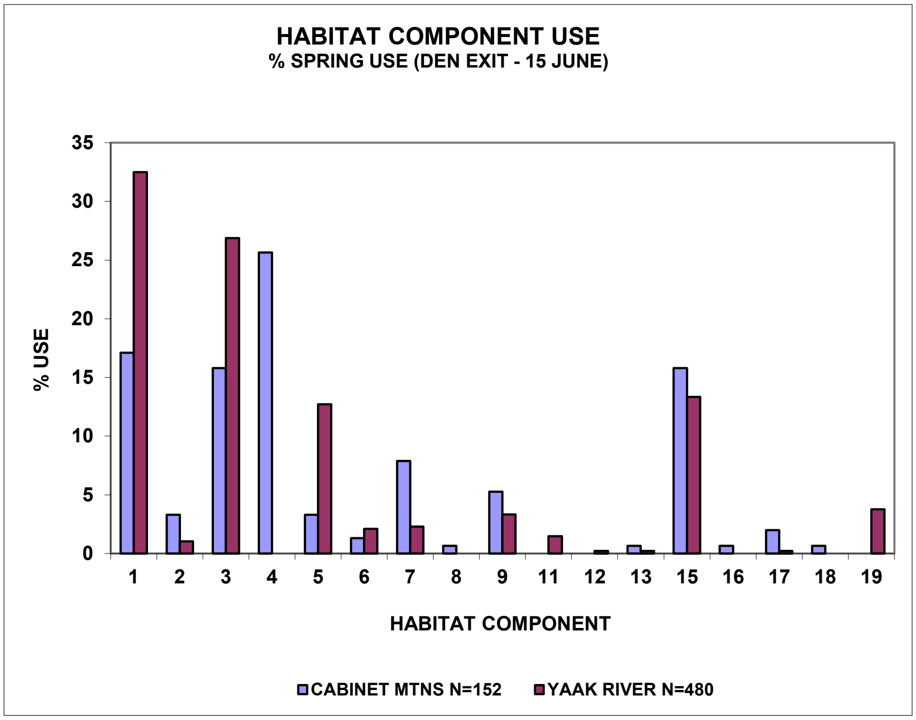
Spring use of habitat components by grizzly bears in the Cabinet Mountains and Yaak River drainage was dominated by closed timber, timbered shrub fields, mixed shrub snow chutes, mixed shrub cutting units, alder shrub fields, and graminoid sidehill parks (Fig. 18). Notable differences between study areas include heavier use of snow chutes, alder, and graminoid parks in the Cabinet Mountains and heavier use of closed timber, timbered shrub fields, and cutting units in the Yaak River. Food habits indicate that bears are utilizing grasses, sedges, succulent forbs, and corms of glacier lily and biscuitroot during spring (Kasworm and Thier 1993). Snow chutes, cutting units, alder, and graminoid parks provide these items.

Summer use of habitat components by grizzly bears in the Cabinet Mountains and Yaak River drainage was dominated by closed timber, timbered shrub fields, mixed shrub snow chutes, mixed shrub cutting units, mixed shrub burns, alder shrub fields, huckleberry shrub fields, graminoid sidehill parks, and beargrass sidehill parks (Fig. 19). Differences between study areas include heavier use of snow chutes, huckleberry shrub fields, and beargrass parks in the Cabinet Mountains and heavier use of closed timber, timbered shrub fields, cutting units, and graminoid parks in the Yaak River. Food habits indicate heavy use of succulent forbs, insects, and berries (mostly huckleberries) (Kasworm and Thier 1993).

Autumn use of habitat components by grizzly bears in the Cabinet Mountains and the Yaak River drainage was dominated by closed timber, timbered shrub fields, mixed shrub snow chutes, mixed shrub cutting units, mixed shrub burns, alder shrub fields, huckleberry shrub fields, graminoid sidehill parks, and beargrass sidehill parks (Fig. 20). Differences between study areas include heavier use of snow chutes, huckleberry shrub fields, and beargrass parks in the Cabinet Mountains and heavier use of closed timber, timbered shrub fields, cutting units, and graminoid parks in the Yaak River. Autumn bear diets reverted back to grasses and sedges during late rains and subsequent green-up. Berries can still be important when they are still available at higher elevations or mountain ash berries which persist on plants beyond first snowfall. Bears utilize carrion and gut piles from hunter harvested or wounded deer and elk.

Differences in use between the Cabinet Mountains and the Yaak River study areas appear related to amounts or availability of these components in each study area. Much of the use of closed timber and timbered shrub fields occurred adjacent to other components that provided food and may have been used for cover or bedding areas.

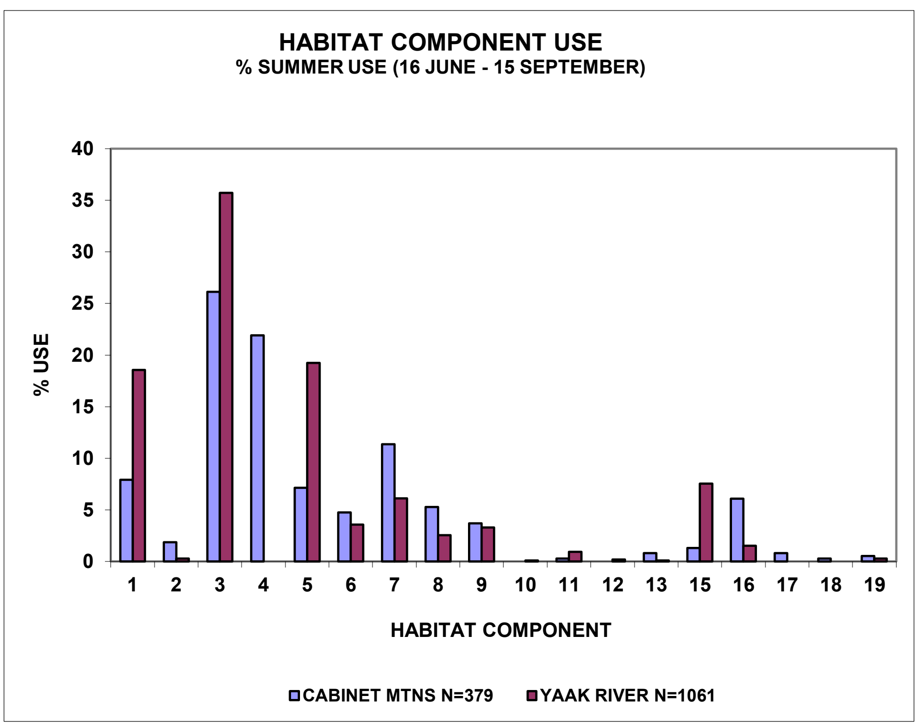
Den use of habitat components by grizzly bears in the Cabinet Mountains and Yaak River drainage was dominated by closed timber, timbered shrub fields, graminoid sidehill parks, and beargrass sidehill parks (Fig. 21). Differences between the two study areas include heavier use of beargrass parks in the Cabinet Mountains and heavier use of closed timber, timbered shrub fields, and graminoid parks in the Yaak River.



Habitat Components

1. Closed Timber
2. Open Timber
3. Timbered Shrub field
4. Mixed Shrub/Snow chute
5. Mixed Shrub/Cutting Unit
6. Mixed Shrub/Burn
7. Alder Shrub
8. Huckleberry Shrub
9. Riparian Stream bottom
10. Marsh
11. Wet Meadow
12. Dry Meadow
13. Drainage Forb field
14. Snow chute
15. Graminoid Sidehill Park
16. Beargrass Sidehill Park
17. Slab rock
18. Talus/Rock/Scree
19. Timbered Grass

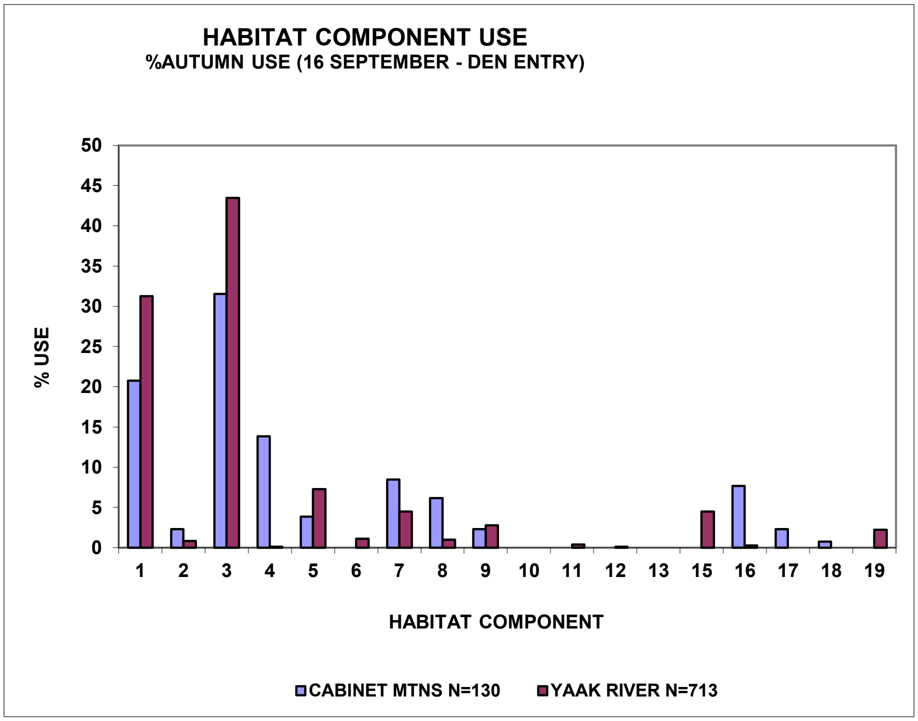
Figure 18. Spring habitat component use in the Cabinet Mountains and Yaak River, 1983-2009.



Habitat Components

1. Closed Timber
2. Open Timber
3. Timbered Shrub field
4. Mixed Shrub/Snow chute
5. Mixed Shrub/Cutting Unit
6. Mixed Shrub/Burn
7. Alder Shrub
8. Huckleberry Shrub
9. Riparian Stream bottom
10. Marsh
11. Wet Meadow
12. Dry Meadow
13. Drainage Forb field
14. Snow chute
15. Graminoid Sidehill Park
16. Beargrass Sidehill Park
17. Slab rock
18. Talus/Rock/Scree
19. Timbered Grass

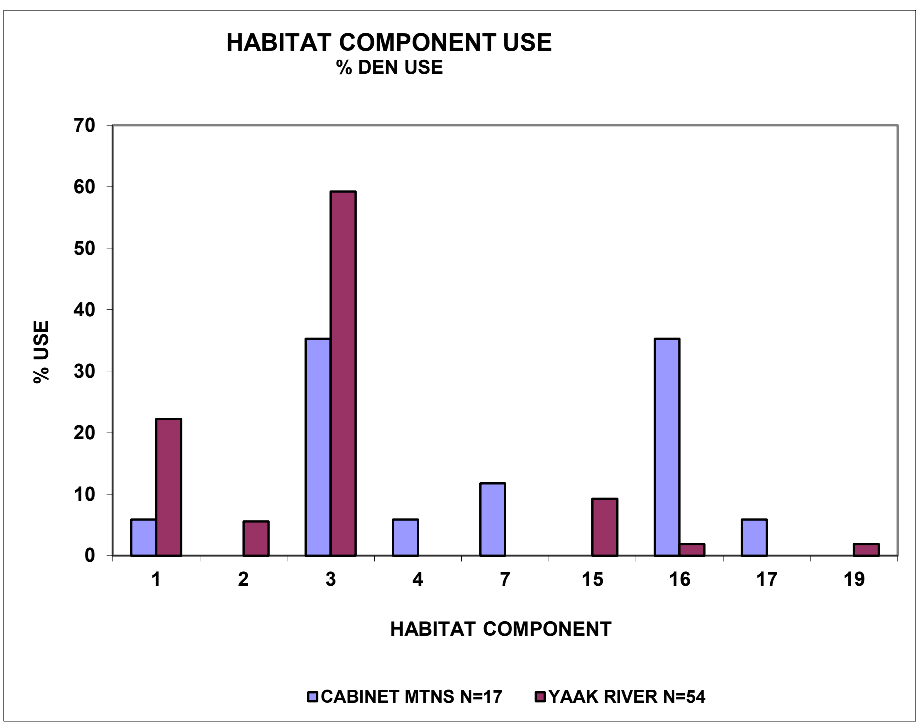
Figure 19. Summer habitat component use in the Cabinet Mountains and Yaak River, 1983-2009.



Habitat Components

1. Closed Timber
2. Open Timber
3. Timbered Shrub field
4. Mixed Shrub/Snow chute
5. Mixed Shrub/Cutting Unit
6. Mixed Shrub/Burn
7. Alder Shrub
8. Huckleberry Shrub
9. Riparian Stream bottom
10. Marsh
11. Wet Meadow
12. Dry Meadow
13. Drainage Forb field
14. Snow chute
15. Graminoid Sidehill Park
16. Beargrass Sidehill Park
17. Slab rock
18. Talus/Rock/Scree
19. Timbered Grass

Figure 20. Autumn habitat component use in the Cabinet Mountains and Yaak River, 1983-2009.



Habitat Components

1. Closed Timber
2. Open Timber
3. Timbered Shrub field
4. Mixed Shrub/Snow chute
5. Mixed Shrub/Cutting Unit
6. Mixed Shrub/Burn
7. Alder Shrub
8. Huckleberry Shrub
9. Riparian Stream bottom
10. Marsh
11. Wet Meadow
12. Dry Meadow
13. Drainage Forb field
14. Snow chute
15. Graminoid Sidehill Park
16. Beargrass Sidehill Park
17. Slab rock
18. Talus/Rock/Scree
19. Timbered Grass

Figure 21. Den habitat component use in the Cabinet Mountains and Yaak River, 1983-2009.

Grizzly Bear Use by Elevation

Differences in elevation between the Cabinet Mountains and the Yaak River study areas are reflected in the bear location data from both areas (Figs. 22). Annual mean elevation used by grizzly bears in the Cabinet Mountains was 1,575 meters compared to 1,497 meters for the Yaak River. Monthly mean elevation followed similar patterns with Cabinet Mountain grizzly bears utilizing higher elevations during most months except November. Sample size in the Cabinet Mountains during November was small, but bears were generally forced into lower elevations by snowfall prior to den entry and may have been responding to increased amount of carrion in the form of gut piles and wounded animals from ungulate hunters. Mean den elevation in the Cabinet Mountains was 1,875 meters and 1,698 meters in the Yaak River.

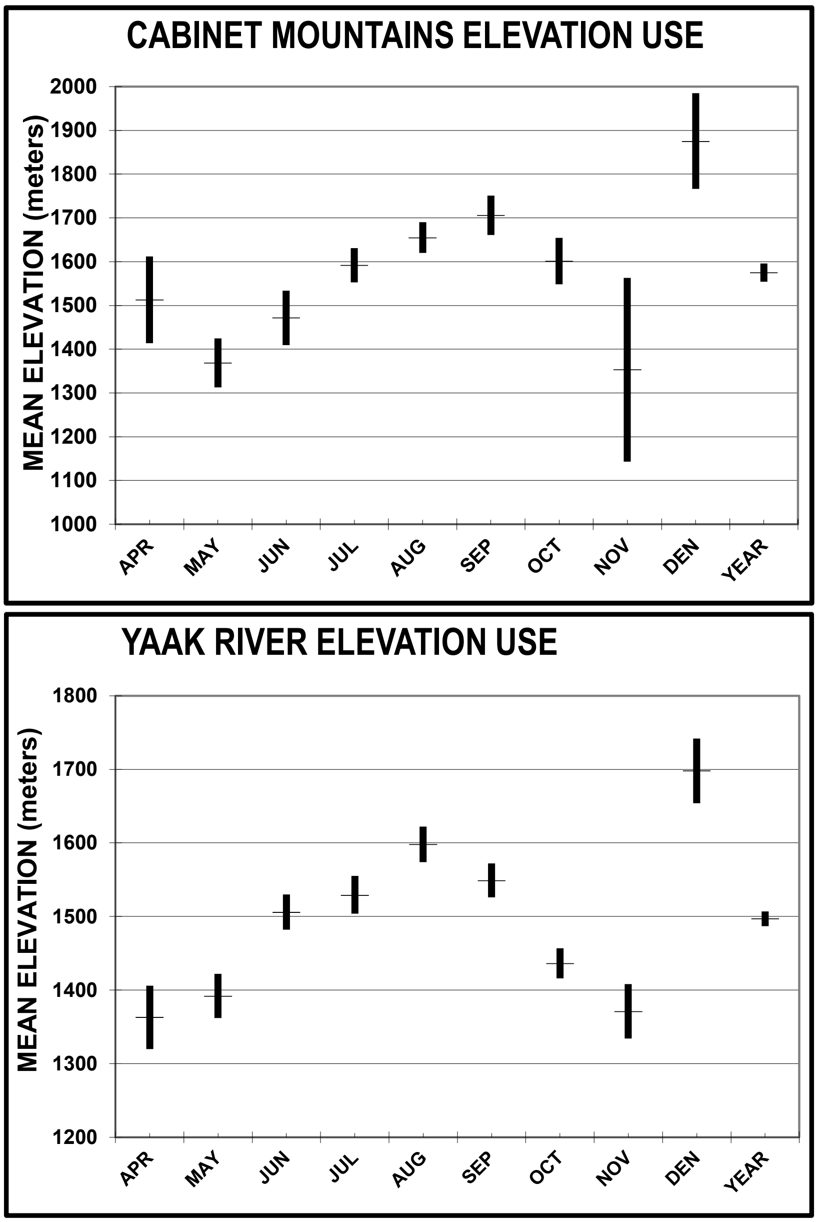
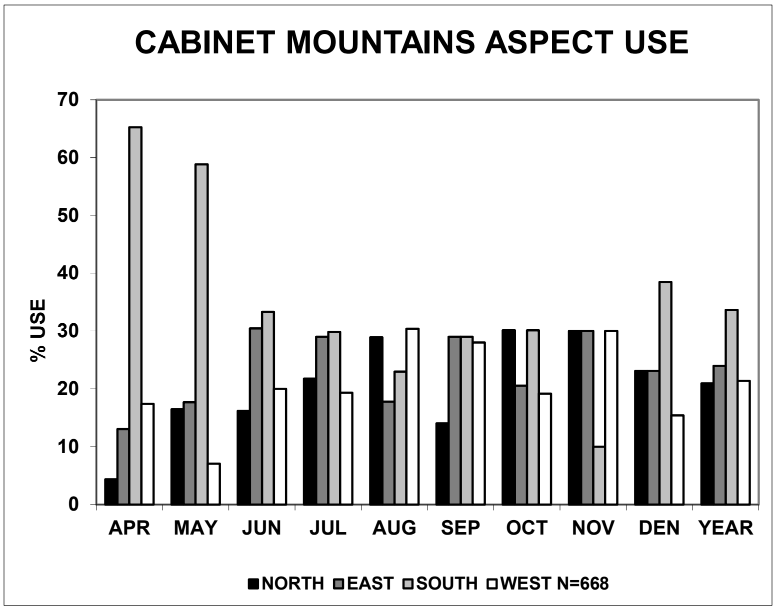


Figure 22. Mean elevation and 95% confidence intervals of radiolocations in the Cabinet Mountains and Yaak River, 1983–2009.

Grizzly Bear Use by Aspect

Use of aspect by grizzly bears varied between the Cabinet Mountains and Yaak River study areas, particularly during early spring (Figs. 23). South aspects received greatest use in the Cabinet Mountains during April and May. However, grizzly bears in the Yaak area showed more balanced use of all aspects during that time. Generally, grizzly bears in the Cabinet Mountains made greater use of southerly slopes during all months than the Yaak River. South aspects were most heavily used by grizzly bears in the Cabinet Mountains for den sites, but used least in the Yaak River. Elevation, slope, and the resultant vegetation in addition to snow melt likely interacted to produce the observed patterns of use.



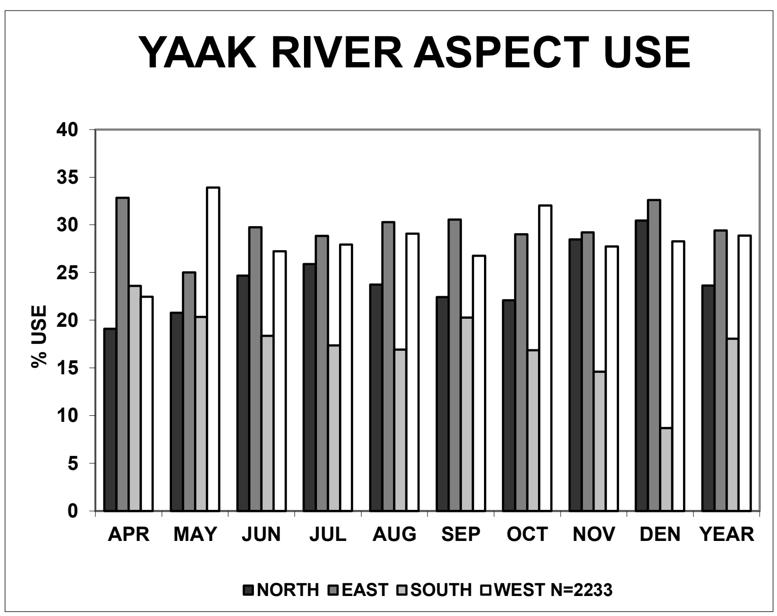


Figure 23. Aspect of radiolocations in the Cabinet Mountains and Yaak River, 1986-2009.

Grizzly Bear Spring Habitat Description

After den emergence in spring, bears seek sites that melt snow early and produce green vegetation. These sites can often overlap with ungulate winter range and provide winterkill carrion. Spring habitat use in both study areas (April and May) indicated use of low elevation sites. Cabinet Mountain radio locations indicated most use below 1,600 m with primary use of southerly facing snow chutes, alder shrub fields, grassy sidehill parks, and closed timber. Yaak River radio locations indicated most use below 1,400 m with primary use of closed timber, timbered shrub fields, cutting units, and grassy sidehill parks on virtually all aspects. Lower elevation of the Yaak River area may allow snow to melt and vegetation to green-up earlier. We have developed seasonal habitat Resource Selection Function maps that are undergoing testing for future use.

Inter-ecosystem Isotope Analysis

We are using isotope analysis to compare grizzly bear food use (plant vs. animal matter) between ecosystems, among sex-age classes, and across management status. Samples currently analyzed are only from grizzly bears of known sex and age. The majority of samples come from capture events; future analysis will include samples from known grizzly bears at hair rub and hair corral sites. To date, we have obtained carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios from 237 grizzly bear hair and blood samples between 1984 and 2015 from the Cabinet-Yaak and Selkirk ecosystems. Across the Selkirk and Cabinet-Yaak ecosystems, adult males consume slightly more animal matter (22%) than adult females (14%) and subadults (13%). Adult females in the Yaak River consume higher proportions of animal matter (22%) than do adult females in the Cabinets (10%) and the Selkirks (6%).

We estimate that 14 percent of the annual diet of Cabinet Mountain grizzly bears (n = 19 hair samples from non-management bears) is derived from animal matter. Adult males had slightly higher $\delta^{15}N$ stable isotope signatures (4.2‰) than adult females (3.1‰), indicating greater use of available animal matter (24% vs. 10% animal matter, respectively).

Yaak grizzly bear diets contained nearly 22% animal matter (n = 84 hair samples). Adult female use of animal matter varied widely; $\delta^{15}N$ and diet values ranged as low as 2.3‰ (~6% animal matter) to as high as 7.2‰ (~80% animal matter).

Sampled grizzly bears in the Selkirk ecosystem consumed less animal matter than Cabinet and Yaak bears (12%; n = 36 hair samples). Diets of non-management, adult female bears include only 7% animal matter. However, one adult female captured in a management incident in the Creston Valley fed on animal matter at a rate of 82%. We suspect bears such as her likely gain meat from bone piles or dead livestock at nearby dairy operations.

Across ecosystems, management bears had slightly higher proportions of meat (26%) in assimilated diets than research bears (17%). Management bears did not necessarily have higher $\delta^{13}C$ signatures as would indicate a more corn-based or anthropogenic food source (-23‰ for both research and management bears). In fact, highest $\delta^{13}C$ in our dataset came from a research female caught in Corn Creek of the Creston Valley, BC in 2008. By all indications, she likely fed extensively on corn from nearby fields without human conflict.

By analyzing different hair types that initiate growth at different times of the year, we have observed increases in proportion of animal matter in bear diets as they transition from summer months (diet estimated from guard hairs) to fall months (diet from underfur). Previous studies have emphasized the importance of splitting these hair types due to temporal differences in growing period (Jones et al. 2006). We currently have 45 bear capture events with paired guard hair and underfur samples collected at capture. In all cases, grizzly bears have either 1) the same dietary meat proportion in summer vs. fall or 2) have higher amounts of meat in their fall diet. On average, grizzly bears meat consumption nearly doubles from summer to fall (10.7%summer to 17.6% fall). Fall shifts toward meat use were not isolated to a specific sex-age class. Larger shifts include: an adult male (4327) shifting from 31% meat in summer to 82%

meat in fall, an adult female (mortality 5/18/2012) consuming 14% in spring time, then 38% in the fall, and a subadult female grizzly (675) with a summer diet consisting of 6% meat and fall diet of 16% meat. We suspect that wounding loss and gut piles from hunted ungulates contribute to observed increases in meat use by grizzly bears in fall months.

Food Habits from Scat Analysis

Grizzly bear scats (n = 180) were collected in the Cabinet Mountains between 1981 and 1992. Graminoids (grasses and sedges) were consumed frequently (43% of scats) by grizzly bears in May. Additionally, meat, presumably from winter-killed deer and moose, accounted for 40% of all dry matter consumed in April and May (Fig. 24). In June, the use of forbs increased markedly, yet grasses and sedges were still a dominant food category. Cow parsnip (*Heracleum lanatum*), clover (*Trifolium spp.*), and dandelion (*Taraxacum officinale*) were commonly used in June; over half (52%) of scats in June included parts of at least one of these three forbs. By July, forbs (mainly *Heracleum*) comprised 32% of dry matter consumed by grizzly bears. Only 8% of dry matter consumed in July came from grasses and sedges; graminoids begin to cure in July and provide far less digestible nutrition. Grizzly bears began to feed upon foods from shrubs (huckleberry and whortleberry [*Vaccinium spp.*], serviceberry [*Amelanchier alnifolia*]) and insects (mainly ants) in July. Food habits during August and September were dominated by use of shrub (*Vaccinium* spp., in particular), yet September habits include an increased use of animal matter. Unlike black bears, grizzly bears targeted animal matter (deer, elk, moose) in October. We suspect hunter-discarded gut piles or other remains account for a fair amount of the available animal meat. Fall regrowth of forbs (mainly clover) and graminoids contributed 25% of dry matter consumed by sampled grizzly bears in October. Mammal and shrub food items (i.e., the most calorie-dense foods available in Cabinet-Yaak Ecosystem) constitute 64% of total dry matter consumed annually by grizzly bears.

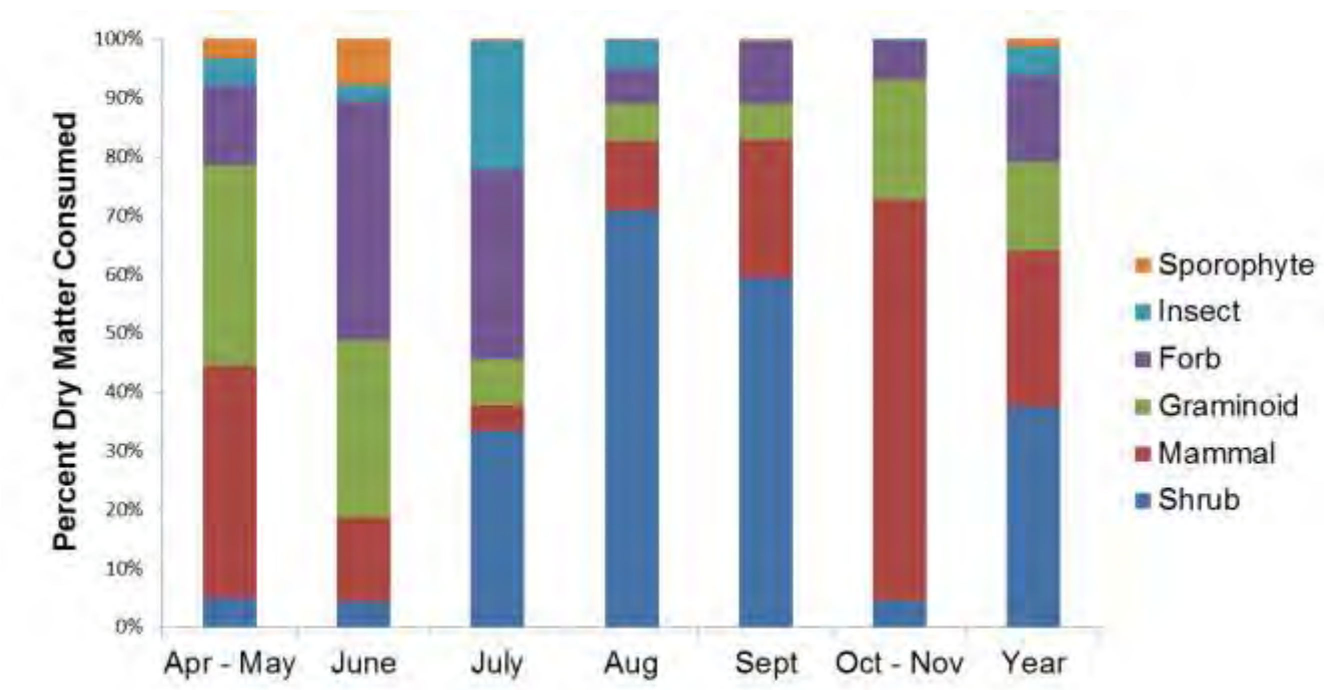


Figure 24. Monthly percent of total dry matter of foods consumed by grizzly bears in the Cabinet Mountains and Yaak River, 1981-1992.

Black bear scats (n = 618) were collected between 1984 and 1992. Relative use of foods was quite similar to that of grizzly bears between April and August (Fig. 25) However, black bear food habits in September and October were quite different from grizzly bears. Black bears tend to use berries of shrubs (*Vaccinium* spp., *Sorbus* spp. [mountain-ash], *Amelanchier alnifolia,* and *Arctostaphylos* spp. [bear berry]) more frequently as fall progresses (percent dry matter consumed, August = 74%; September = 82%; October = 91%). In October, black bears fed heavily on mountain-ash. In contrast, grizzly bears increase relative dry matter consumption of animal meat in fall months (August = 12%, September = 24%; October = 68%). We suggest this difference in food use may be explained by either 1) early den entrance dates for black bears (i.e., den entrance before open of big game hunting season), 2) higher energetic demand of larger grizzly bears (i.e., consumption of calorie-dense foods is metabolically preferred by larger bears; Welch et al. 1997), 3) interspecific exclusion of black bears by grizzly bears (i.e., exploitative competition), and/or 4) differences in risk behavior between the two species. On a annual basis, black bears consumed less high-quality, calorie-dense foods (meat and berries; 42%) relative to lower-quality foods such as graminoids and forbs (46%).

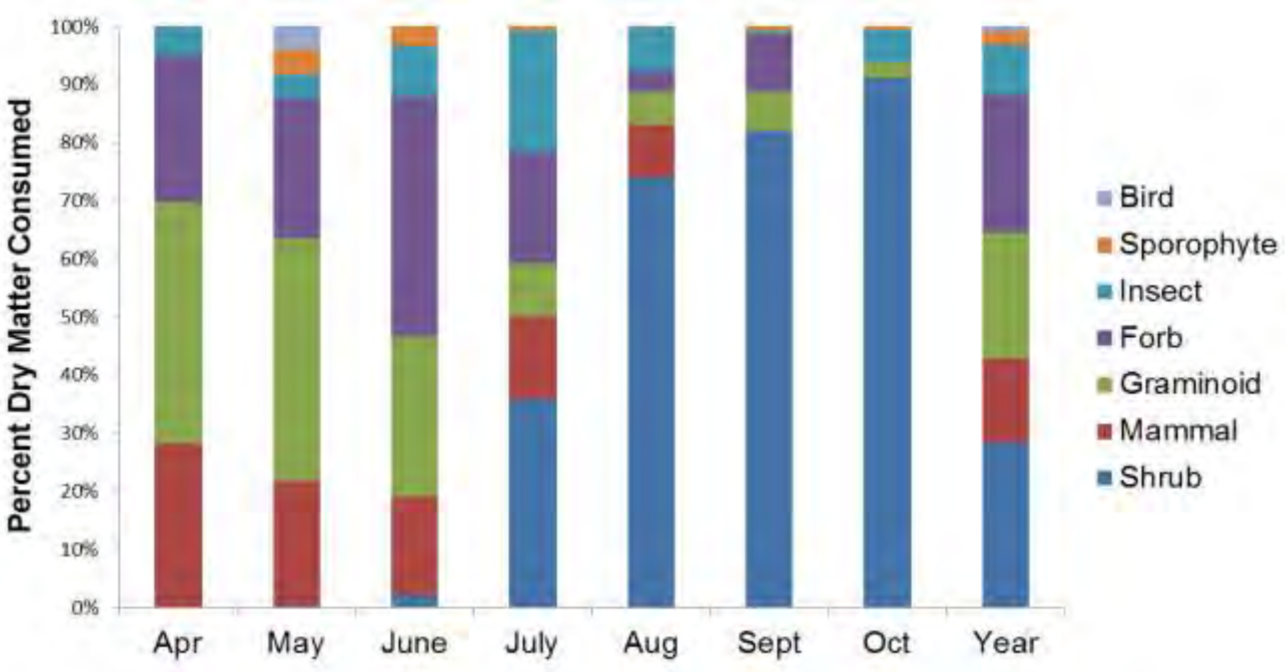


Figure 25. Monthly percent of total dry matter of foods consumed by black bears in the Cabinet Mountains and Yaak River, 1984-1992.

Berry Production

Because of its relatively far-ranging distribution in the Cabinet-Yaak and life history of inhabiting larger areas (e.g. shrub fields) than other berry-producing plants, huckleberries appear to provide a greater amount of food for bears in the Cabinet-Yaak. However, serviceberry and mountain ash may provide significant secondary food sources in some years when huckleberry crops have failed (e.g. 2001 and 2003). Mountain ash may be particularly valuable to bears in years of low food production because the berries persist and remain on the plants until after frost and leaf drop. Low berry counts for all three of these species would appear most detrimental for bears attempting to store fat for winter denning (e.g., 2002, 2004, and 2015). Because of its sparse distribution, buffalo berries appear to be the least-available berry food for grizzly bears in the Cabinet-Yaak. Below-average production among all species surveyed occurred in 1992, 1998–2000, 2002, 2004, and 2015. The 2015 berry season marked the first time we have observed below average counts for all four berry species in one year. Sampling sites for these species of fruiting shrubs have been selected to be diverse in terms of geography, elevation, aspect, and overstory canopy (Fig. 26).

Fluctuations in berry production in the Cabinet-Yaak may be influenced by climatic variables. Holden et al. (2012) found huckleberry production in the Cabinet-Yaak to be highest in years with cool springs and high July diurnal temperature ranges. Serviceberry production was also highest in years with cool springs and high winter snowpack. Future changes in climate may influence the availability of these foods to Cabinet-Yaak grizzly bears.

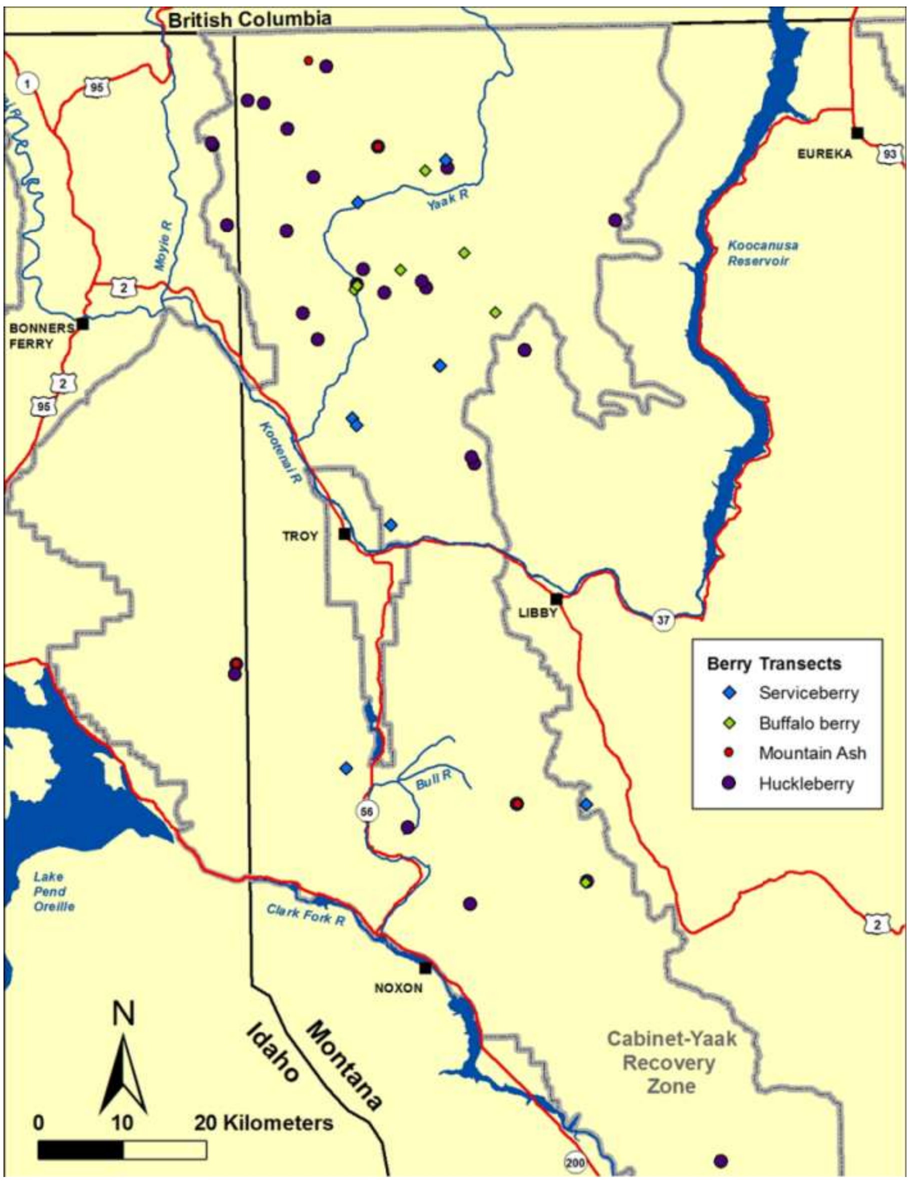


Figure 26. Locations of all serviceberry, buffaloberry, mountain ash, and huckleberry sampling sites within the Cabinet-Yaak study area, 1989-2017. Some locations show multiple berry species sites in close proximity.

Huckleberry

We evaluated berry production at a median number of 18 (range = 11–23) huckleberry transects per year within the Cabinet-Yaak study area from 1989–2017 (Fig. 27). During this study period, the mean number of berries per plot was 1.8 (95% CI ± 0.13). Mean annual berry counts between 1989 and 2017 ranged from 0.5–3.4. Statistically below-average berry counts occurred in 1992–93, 1997–99, 2001–04, 2010, and 2015. Above average counts occurred in 1990, 1996, 2008–09, 2012–14, and 2017. Highest mean annual counts occurred in 2014. Mean annual counts for the past decade (2008–2017) have averaged 2.2 berries per plot, 83% higher than mean annual counts during the previous decade (1998–2007; 1.2 berries per plot). Based upon these production indices, the 9-year period from 1997–2005 was a prolonged stretch of time without above average annual huckleberry production. Of interest is whether this lower-than-average production had influence on population reproduction and survival.

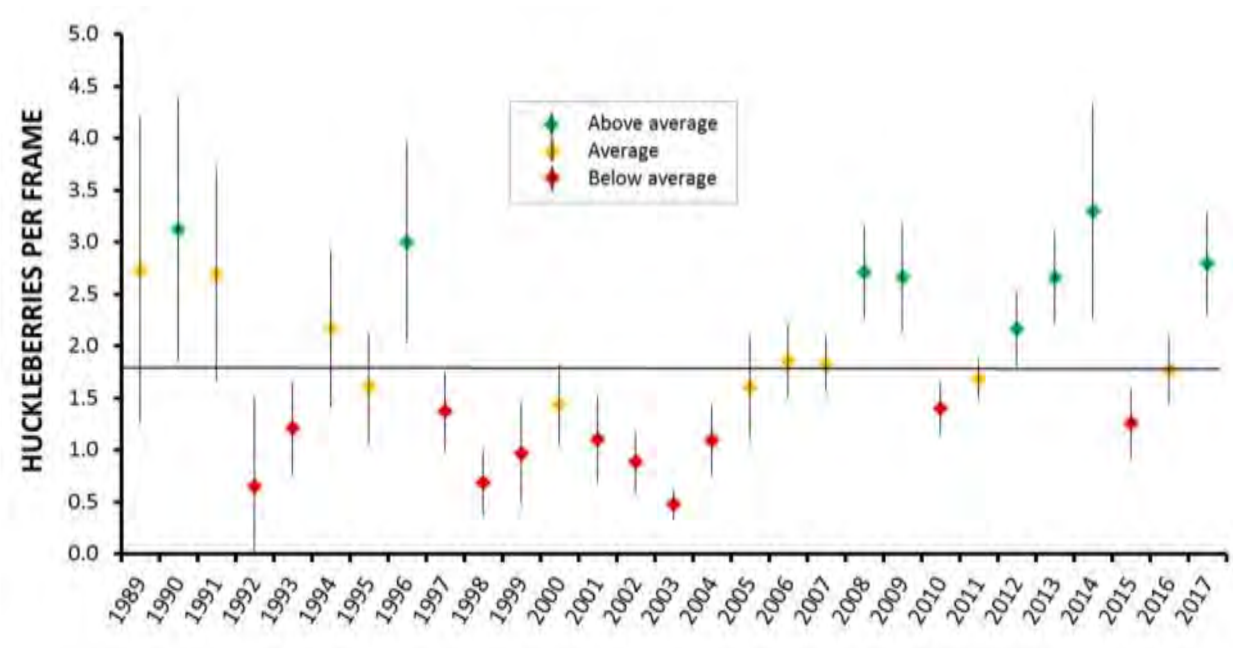


Figure 27. Mean berries per plant (±95% confidence interval) for huckleberry transects in the Cabinet-Yaak, 1990–2017. Horizontal line indicates study-wide mean production, 1990–2017.

Serviceberry

We evaluated berry production at a median number of six (range = 5–7) serviceberry transects per year from 1990 to 2017 (Fig. 28). The overall mean berry count per plant was 107 (95% CI ± 24) during the study. Mean berry counts per plant ranged from 12 to 355 during the 25+ year index. Statistically below-average counts occurred during 1994, 1999, 2004–06, 2010, and 2012–17. Above average counts occurred only in 1997. Considering the entirety of the data, the past ten years have been particularly less productive (2008–17; 70 berries per plant), and long-term average counts have been decreasing for over two decades now (211 berries per plant from 1990–97, 70 from 1998–2007).

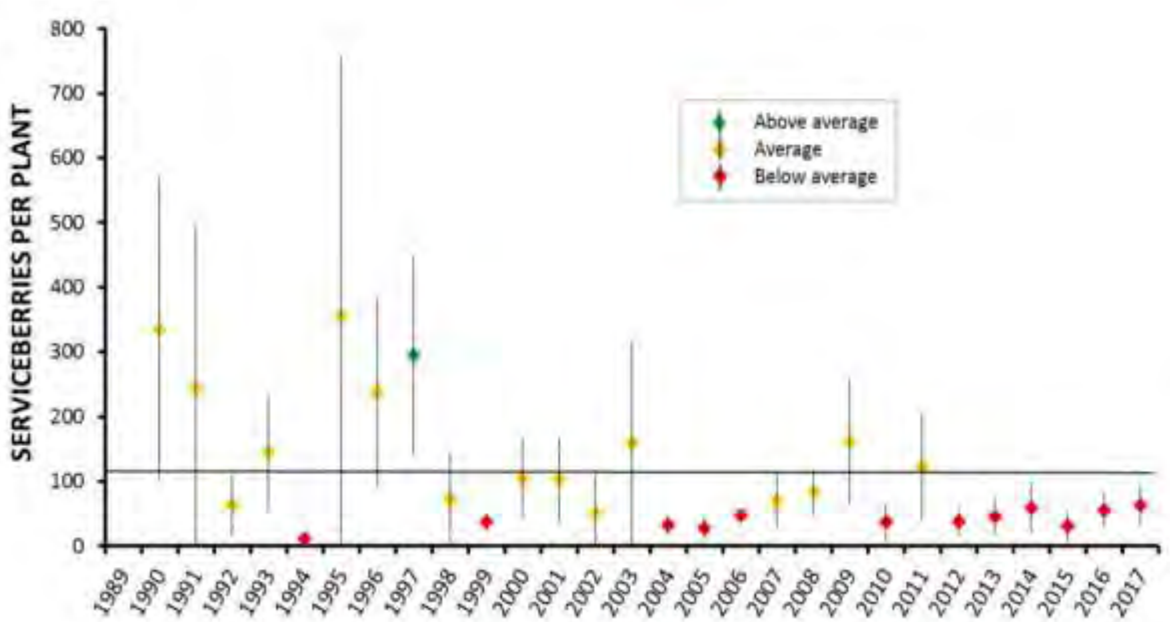


Figure 28. Mean berries per plant (±95% confidence interval) for serviceberry transects in the Cabinet-Yaak, 1990–2017. Horizontal line indicates study-wide mean production, 1990–2017.

Mountain Ash

Three sites were evaluated for mountain ash production each year, from 2001 to 2017 (Fig. 29). Total mean berry count was 164 berries per plant (95% CI ± 55). Statistically below-average production occurred in 2003, 2006, 2010–11, 2013, and 2015. Above average production occurred only in 2008.

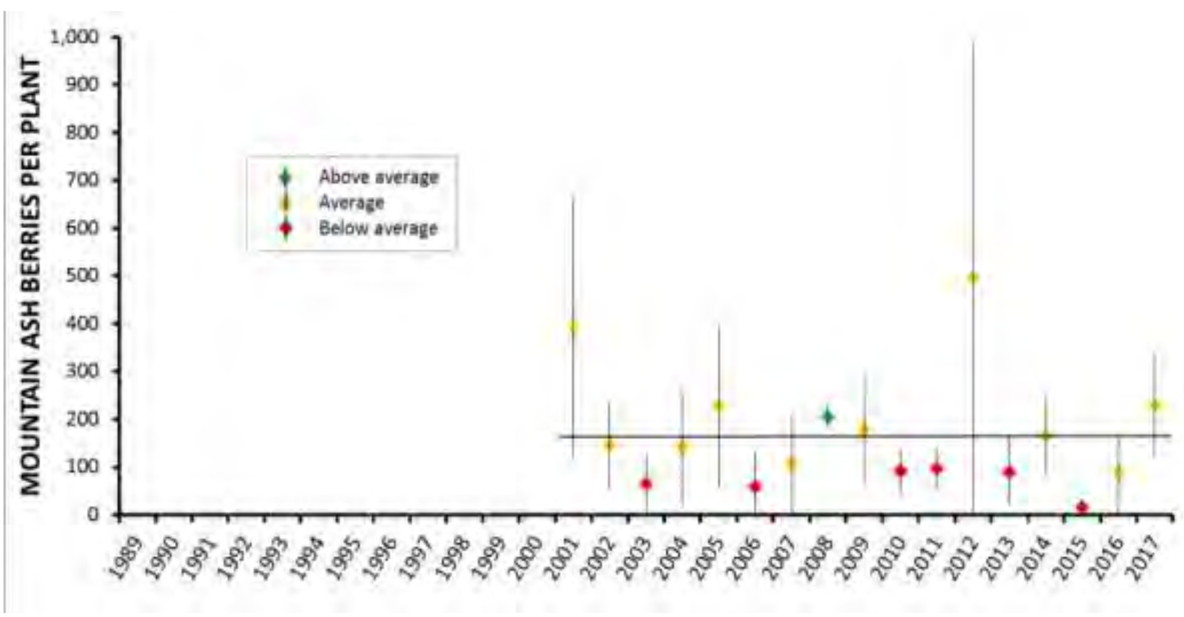


Figure 29. Mean berries per plant (±95% confidence interval) for mountain ash transects in the Cabinet-Yaak, 1990–2017. Horizontal line indicates study-wide mean production, 1990–2017.

Buffaloberry

Five buffaloberry transects (5 plants at each transect) were evaluated during 1990–99 and 2002–03. No sites were sampled during 2004–06 seasons. One new transect (10 plants) was established in 2007; this was the only transect sampled in 2007. Another transect (10 plants) was added in 2008. These two transects were observed in 2008–17. All told, a median of 4 sites were evaluated annually (range 1–5) between 1990 and 2017. Mean berry count per plant from all transects was 181 (95% CI ± 47) during the study period. Mean berry counts ranged between 15 to 627 berries per plot from 1990 to 2017 (Fig. 30), with statistically below-average counts in 1998–99, 2002–03, 2007, 2013, and 2015–16. Above-average counts occurred in 1990, 2010, and 2011.

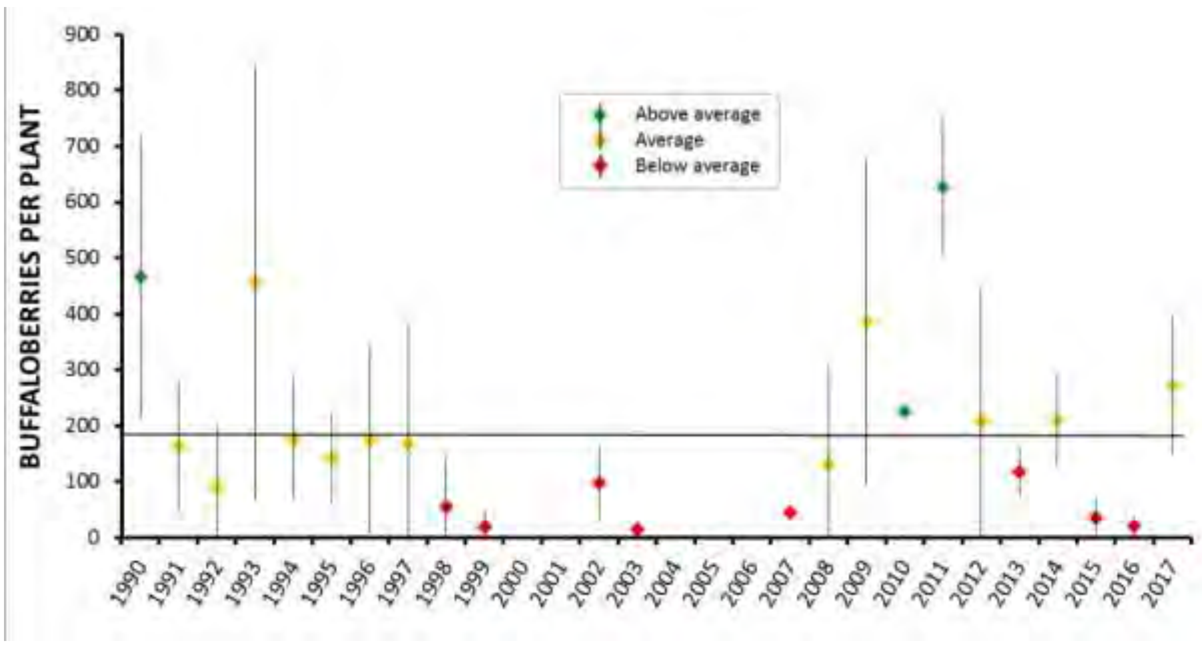


Figure 30. Mean berries per plant (±95% confidence interval) for buffaloberry transects in the Cabinet-Yaak, 1990–2017. Horizontal line indicates study-wide mean production, 1990–2017.

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LITERATURE CITED

Alt, G. L. 1984. Cub adoption in the black bear. Journal of Mammalogy 65:511-512.

Alt, G. L. and J. J. Beecham. 1984. Reintroduction of orphaned black bear cubs into the wild. Wildlife Society Bulletin 12:169-174.

Brenna, J. T., T.N. Corso, H.J. Tobias and R.J. Caimi. 1997. High-precision continuous-flow isotope ratio mass spectrometry. Mass Spectrometry Reviews. 16:227–258.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York.

Cherry, S., M.A. Haroldson, J. Robison-Cox, and C.C. Schwartz. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175-184.

Erickson, A. W. 1978. Grizzly bear management in the Cabinet Mountains of western Montana. U.S. Forest Service Contract 242-46, Kootenai National Forest.

Hayne, D. W. 1959. Calculation of size of home range. Journal of Mammalogy 30:1-18.

Hellgren, E. C., D. W. Carney, N. P. Garner, and M. R. Vaughn. 1988. Use of breakaway cotton spacers on radio collars. Wildlife Society Bulletin 16:216-218.

Hewitt, D. G., and C. T. Robbins. 1996. Estimating grizzly bear food habits from fecal analysis. Wildlife Society Bulletin 24:547–550.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Hovey, F. W. and B. N. McLellan. 1996. Estimating growth of grizzly bears from the Flathead River drainage using computer simulations of reproductive and survival rates. Canadian Journal of Zoology 74:1409-1416.

Johnson, K. G. and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46-54.

Jones, E. S., D. C. Heard, and M. P. Gillingham. 2006.Temporal variation in stable carbon and nitrogen isotopes of grizzly bear guardhair and underfur. Wildlife Society Bulletin 34:1320–1325.

Jonkel, J. J. 1993. A manual for handling bears for managers and researchers. Edited by T.J. Thier, U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F. and T. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of northwest Montana. Montana Department of Fish, Wildlife, and Parks, Helena.

Kasworm, W. F. and T. J. Thier. 1993. Cabinet-Yaak ecosystem grizzly bear and black bear research, 1992 progress report. U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana. National Park Service Progress Report. 42 pp.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Lewis, J. S. 2007. Effects of human influences on black bear habitat selection and movement patterns within a highway corridor. MS Thesis University of Idaho, Moscow. 152 pp

McLellan, B. N. 1989. Dynamics of a grizzly bear population during a period of industrial resource extraction. III Natality and rate of increase. Canadian Journal of Zoology 67:1861-1864.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7-15.

Proctor, M.F., 2003. Genetic analysis of movement, dispersal and population fragmentation of grizzly bears in southwestern Canada. PhD Thesis. University of Calgary. 147 pp.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Qi, H., Coplen, T.B., Geilmann, H., Brand, W.A. and Böhlke, J.K. 2003. Two new organic reference materials for δ13C and δ15N measurements and a new value for the δ13C of NBS 22 oil. Rapid Communications in Mass Spectrometry. 17:2483–2487.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr. , R. A. Sellars, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. Kasworm, R. Smith, and S. Herrero. 2003. Reproductive maturation and senescence in the female brown/grizzly bear. Ursus. 14:109-119.

Stoneberg, R. and C. Jonkel. 1966. Age determination in black bears by cementum layers. Journal of Wildlife Management 30:411-414.

Thier, T. J. 1981. Cabinet Mountains grizzly bear studies, 1979-1980. Border Grizzly Project Special Report 50. University of Montana, Missoula.

Thier, T. J. 1990. Population characteristics and the effects of hunting on black bears in a portion of northwestern Montana. M.S. Thesis. University of Montana, Missoula.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana.

U.S. Forest Service. 1989. Upper Yaak draft environmental impact statement. U.S. Forest Service, Kootenai National Forest.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

Welch, C.A., J. Keay, K.C. Kendall, and C.T. Robbins. 1997. Constraints on frugivory by bears. Ecology 78:1105–1119.

Woods, J.G., D. Paetkau, D. Lewis, B.N. McLellan, M. Proctor, and C. Strobeck. 1999. Genetic tagging of free-ranging black and brown bears. Wildlife Society Bulletin. 27:616-627.

PUBLICATIONS OR REPORTS INVOLVING THIS RESEARCH PROGRAM

Canepa, S., K. Annis, and W. Kasworm. 2008. Public opinion and knowledge survey of grizzly bears in the Cabinet-Yaak Ecosystem. Cabinet-Yaak and Selkirk Mountains Subcommitte of the Interagency Grizzly bear Committee, Missoula, Montana. 88 pp.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Jansen, H.T., T. Leise, G. Stenhouse, K. Pigeon, W. Kasworm, J. Teisberg, T. Radandt, R. Dallmann, S. Brown and C T. Robbins. 2016. The bear circadian clock doesn't 'sleep' during winter dormancy. Frontiers in Zoology 13:42 15 pages.

Kasworm, W. F. and T. L. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of Northwest Montana. Montana Department Fish, Wildlife, Parks, Helena.

Kasworm, W. F. 1989. Telling the difference. Wyoming Wildlife. Volume 53, No. 8, pages 28-33.

Kasworm, W. F. and T. L. Manley. 1990. Influences of roads and trails on grizzly bears and black bears in Northwest Montana. International Conference on Bear Research and Management 8:79-84.

Kasworm, W. F. and T. J. Thier. 1994. Adult black bear reproduction, survival, and mortality sources in northwest Montana. International Conference on Bear Research and Management 9:223-230.

Kasworm, W. F., T. J. Thier, and C. Servheen. 1998. Grizzly bear recovery efforts in the Cabinet-Yaak ecosystem. Ursus 10:147-153.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Knick, S. T. and W. Kasworm. 1989. Shooting mortality in small populations of grizzly bears. Wildlife Society Bulletin 17:11-15.

Mace, R., K. Aune, W. Kasworm, R. Klaver, and J. Claar. 1987. Incidence of Human Conflicts by Research Grizzly Bears. Wildlife Society Bulletin 15:170-173.

McCall, B. S., M.S. Mitchell, M.K. Schwartz, J. Hayden, S.A. Cushman, P. Zager, W.F. Kasworm. 2013. Combined use of mark-recapture and genetic analyses reveals response of a black bear population to changes in food productivity. Journal of Wildlife Management 77:1572-1582.

McLellan, B. N., F. W. Hovey, R. D. Mace, J. G. Woods, D. W. Carney, M. L. Gibeau, W. L. Wakkinen, and W. F. Kasworm. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, Washington, and Idaho. Journal of Wildlife Management 63:911-920.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Proctor, M. P., D. Paetkau, B. N. Mclellan, G. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in Western Canada and the Northern United States. Wildlife Monographs 180:1-46.

Proctor, M. P., Nielson, S. E., W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. Machutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada–United States trans-border region. Journal of Wildlife Management 79:544-558.

Romain-Bondi, K.A., R. B. Wielgus, L. Waits, W.F. Kasworm, M. Austin, and W. Wakkinen. 2004. Density and population size estimates for North Cascade grizzly bears using DNA hair-sampling techniques. Biological Conservation 117:417-428.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr., R. A. Sellers, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. F. Kasworm, R. Smith and S. Herrero. 2003. Reproductive maturation and senescence in the female brown bear. Ursus 14:109-119.

Servheen, C., W. Kasworm, and A. Christensen. 1987. Approaches to augmenting grizzly bear populations in the Cabinet Mountains of Montana. International Conference on Bear Research and Management 7:363-367.

Servheen, C., W. F. Kasworm, and T. J. Thier. 1995. Transplanting grizzly bears *Ursus arctos horribilis* as a management tool - results from the Cabinet Mountains, Montana, USA. Biological Conservation 71:261-268.

Servheen, C., J. Waller and W. Kasworm. 1998. Fragmentation effects of high-speed highways on grizzly bear populations shared between the United States and Canada. 1998 International Conference on Wildlife Ecology and Transportation, Pages 97-103.

Swensen, J. E., W. F. Kasworm, S. T. Stewart, C. A. Simmons, and K. Aune. 1987. Interpopulation applicability of equations to predict live weight in black bears. International Conference on Bear Research and Management 7:359-362.

Thier, T. J. and W. F. Kasworm. 1992. Recovery of a Grizzly Bear From a Serious Gunshot Wound. The Montana Game Warden 4(1):24-25.

U.S. Fish and Wildlife Service. 1990. Final environmental assessment - grizzly bear population augmentation test, Cabinet-Yaak ecosystem. U.S. Fish and Wildlife Service, Missoula.

Wakkinen, W. L. and W. F. Kasworm. 1997. Grizzly bear and road density relationships in the Selkirk and Cabinet-Yaak recovery zones. U.S. Fish and Wildlife Service, Missoula, MT.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

APPENDIX

Table T1. Mortality assignment of augmentation bears removed from one recovery area and released in another target recovery area.

#	Scenario	Where Mortality Credited and Year [1]	
		Source	Target
1	Bear stays in Target recovery area[2] past Year 1.	Mortality removal year	No mortality
2	Bear dies in Target recovery area[2] during Year 1.	Mortality removal year	No mortality
3	Bear dies in Target recovery area[2] after Year 1.	Mortality removal year	Mortality, Year 2 or later
4	Bear returns to Source area[2] and is alive in Year 1.	No mortality	No mortality
5	Bear returns to Source area[2] and is alive after Year 1.	No mortality	No mortality
6	Bear returns to Source area[2] and dies there after Year 1.	Mortality removal year only	No mortality
7	Bear dies outside both Target and Source areas[2] within Year 1.	Mortality removal year	No mortality
8	Bear dies outside both Target and Source areas[2] after Year 1.	Mortality removal year	No mortality
9	Collar failure/lost bear in Target area[2] within Year 1.	Mortality removal year	No mortality
10	Collar failure/lost bear in Target area[2] after Year 1.	Mortality removal year	No mortality

[1] Year 1 begins on the day the bear is released in the target area and ends after 365 days. One year was chosen to give the animal an opportunity to locate and use all seasonal habitats. This rule set may conditionally require a bookkeeping correction to remove the mortality in the source area in the year of removal.

[2] Target and Source areas include 10 mile buffer around Recovery Zones. Bears dying in Canada only count against mortality limits in the Selkirk Mountains, where the Recovery Plan defines a Recovery Zone that includes Canada. If an augmentation bear leaves the target recovery area and dies, it counts as source area mortality in the removal year but it does not count as target area mortality. If an augmentation bear leaves the target recovery area in year 2 or later it counts as source area mortality in year 1 and target area mortality in year 2 or later if the mortality was human caused. While this approach counts a bear as dead twice, the second mortality represents a human caused mortality issue outside of a bear learning a new area and should be counted in the target area. (Mortalities in Canada only count inside the Selkirk recovery zone inside Canada and the 10 mile buffer will not apply to that portion of the Selkirk recovery area in Canada. Areas adjacent to the Canadian Selkirks have more robust, contiguous populations, several of which are hunted and mortality should not be counted against the Selkirk recovery area. The 10 mile buffer was promoted inside the US because this area was believed to contain animals that spent a portion of their time outside the recovery area, but were believed to be part of that recovery area population.)

Table T2. Known grizzly bear mortality in or near the Cabinet-Yaak recovery zone and the Yahk grizzly bear population unit in British Columbia, 1949-2016.

YEAR	LOCATION	TOTAL	SEX / AGE	MORTALITY CAUSE
1949	COPPER CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1950	SQUAW CR, MT	1	SUBADULT	UNKNOWN
1951	PETE CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1951	PAPOOSE CR, MT	2	SUBADULTS	UNKNOWN
1951	GOAT CR, MT	1	SUBADULT MALE	UNKNOWN
1952	FELIX CR, MT	6	2 ADULT FEMALES, 4 YEARLINGS	HUMAN, MANAGEMENT REMOVAL
1953	OBRIEN CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1953	KENELTY MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	20-ODD MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	BURNT CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	17-MILE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	N F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	S F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	TAYLOR PK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBUTTE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBOW CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1955	WOLF CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1955	MT HEADLEY, MT	1	SUBADULT	HUMAN, MANAGEMENT REMOVAL
1955	BAREE LK, MT	1	ADULT MALE	UNKNOWN
1955	BAREE LK, MT	1	ADULT FEMALE	UNKNOWN
1955	BEAR CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1958	SQUAW CR, MT	1	ADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1959	E F ROCK CR, MT	2	ADULT FEMALE, 1 CUB	HUMAN, LEGAL HUNTER KILL
1959	W F THOMPSON R, MT	4	ADULT FEMALE, 3 CUBS	UNKNOWN
1959	CLIFF CR, MT	1	UNKNOWN	UNKNOWN
1960	PROSPECT CR, MT	2	ADULT FEMALE, 1 CUB	UNKNOWN
1964	GRAVES CR, MT	2	SUBADULTS	UNKNOWN
1964	WANLESS LK, MT	3	SUBADULTS (ADULT WOUNDED)	UNKNOWN
1965	SNOWSHOE CR, MT	2	SUBADULTS	UNKNOWN
1965	PINKHAM CR, MT	1	UNKNOWN	UNKNOWN
1967	SOPHIE LK, MT	1	UNKNOWN	UNKNOWN
1968	BEAR CR, MT	1	ADULT FEMALE	HUMAN, ILLEGAL KILL
1968	GRANITE CR, MT	1	SUBADULT MALE	HUMAN, MANAGEMENT REMOVAL
1969	PRISCILLA PK, MT	1	ADULT FEMALE	UNKNOWN
1970	THOMPSON R, MT	1	UNKNOWN	UNKNOWN
1970	CAMERON CR, MT	1	SUBADULT MALE	UNKNOWN
1970	SQUAW CR, MT	2	ADULT FEMALE, SUBADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1971	MURR CR, MT	1	ADULT FEMALE	UNKNOWN
1972	ROCK CR, MT	1	SUBADULT	HUMAN, MISTAKEN IDENTITY (Black Bear)
1974	SWAMP CR, MT	1	ADULT MALE	HUMAN, LEGAL HUNTER KILL
1977	RABBIT CR, MT	1	ADULT MALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1978	MOYIE LAKE, BC	1	SUBADULT MALE	HUMAN, MANAGEMENT
1982	GROUSE, ID	1	ADULT MALE	HUMAN, ILLEGAL KILL
1984	HARVEY CR, ID	1	UNKNOWN	HUMAN, MISTAKEN IDENTITY (Black Bear)
1985	LYONS CR, MT	1	ADULT MALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1986	BURNT CR, MT	1	CUB	UNKNOWN (NATURAL)
1987	FLATTAIL CR, MT	1	FEMALE CUB	HUMAN, MISTAKEN IDENTITY (Elk)
1988	LEWISBY CR, BC	1	ADULT MALE	HUMAN, LEGAL HUNTER KILL (BC)
1988	N F 17-MILE CR, MT	1	ADULT FEMALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1989	BURNT CR, MT	1	SUBADULT FEMALE	HUMAN, RESEARCH TRAP (Predation)
1990	POVERTY CR, MT	1	SUBADULT MALE	HUMAN, ILLEGAL

YEAR	LOCATION	TOTAL	SEX / AGE	MORTALITY CAUSE
1992	TRAIL CR, MT	1	ADULT FEMALE	UNKNOWN
1993	LIBBY CR, MT	2	ADULT FEMALE AND CUB	UNKNOWN (NATURAL)
1994	JIM CR, BC	1	SUBADULT MALE	HUMAN, MANAGEMENT
1994	SOUTHWEST CRANBROOK, BC	3	2 FEMALES AND 1 MALE	HUMAN, MANAGEMENT
1995	RYAN CR, BC	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1996	DODGE CR, MT	1	SUBADULT MALE	HUMAN, UNDETERMINED
1996	GOLD CR, BC	1	ADULT MALE	HUMAN, UNDETERMINED
1997	LIBBY CR, MT	1	ADULT MALE	HUMAN, ILLEGAL
1997	PLUMBOB CR, BC	1	MALE	HUMAN, MANAGEMENT
1997	WARDNER, BC	1	ADULT FEMALE	HUMAN, MANAGEMENT
1997	MAYOOK, CR,BC	1	SUBADULT MALE	HUMAN, ILLEGAL KILL
1999	17 MILE CR, MT	3	ADULT FEMALE, 2 CUBS	NATURAL MORTALITY (Predation)
1999	W FK YAHK R, BC	1	SUBADULT FEMALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1999	E FK YAAK R, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
2000	HAWKINS CR, BC	2	2 CUBS	UNKNOWN (NATURAL)
2000	FOWLER CR, MT	1	1 CUB	UNKNOWN (NATURAL)
2000	PETE CR, MT	1	SUBADULT FEMALE	HUMAN, UNDETERMINED
2001	COLD CR, BC	2	2 CUBS	UNKNOWN (NATURAL)
2001	SPREAD CR, MT	1	SUBADULT FEMALE	HUMAN, MISTAKEN IDENTITY (Black Bear)
2001	ELK CR, MT	1	ADULT FEMALE	HUMAN, TRAIN COLLISION
2002	MARTEN CR, MT	1	SUBADULT FEMALE	NATURAL
2002	PORCUPINE CR, MT	1	SUBADULT FEMALE	HUMAN, UNDETERMINED (Illegal)
2002	YAAK R, MT	4	ADULT FEMALE, 3 CUBS	HUMAN, ILLEGAL
2002	BLOOM CR, BC	1	UNKNOWN	HUMAN, BLACK BEAR HOUND HUNTERS
2002	KOOTENAY R, BC	1	FEMALE	HUMAN, DEFENSE OF LIFE
2004	WEST FORT STEELE, BC	1	MALE	HUMAN, DEFENSE OF LIFE AT DUMP
2004	JIM CR, BC	1	ADULT MALE	HUMAN, MISTAKEN IDENTITY
2004	NEWGATE,BC	1	ADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
2005	RUSSELL CR, BC	1	ADULT MALE	HUMAN, LEGAL HUNTER KILL (BC)
2005	GOVERNMENT CR, MT	1	SUBADULT FEMALE	HUMAN, TRAIN COLLISION
2005	PIPE CR, MT	1	SUBADULT FEMALE	HUMAN, ILLEGAL
2005	YAAK R, MT	1	SUBADULT MALE	HUMAN, ILLEGAL
2005?	CURLEY CR, MT	1	ADULT	HUMAN, UNDETERMINED
2006	COLD CR, BC	1	ADULT FEMALE	HUMAN, RESEARCH TRAP (Predation)
2006	RAINY CR, BC	1	ADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
2007	SPREAD CR, MT	1	ADULT FEMALE	HUMAN, DEFENSE OF LIFE
2008	FISHTRAP CR, MT	1	UNKNOWN SUBADULT	HUMAN, UNDER INVESTIGATION
2008	CLARK FORK RIVER, MT	1	SUBADULT FEMALE	HUMAN, TRAIN COLLISION
2008	CLARK FORK RIVER, MT	1	SUBADULT FEMALE	HUMAN, POACHING
2008	NF YAHK RIVER, BC	1	ADULT MALE	HUMAN.MISTAKEN IDENTITY, WOLF TRAP
2009	COPPER CR, ID	2	2 CUBS	UNKNOWN (NATURAL)
2009	BENTLEY CR, ID	1	SUBADULT MALE	HUMAN, MISTAKEN IDENTITY (Black Bear)
2009	EF BULL R, MT	1	ADULT FEMALE	HUMAN, DEFENSE OF LIFE
2010	AMERICAN CREEK, MT	1	CUB	NATURAL
2010	HAWKINS CREEK, BC	1	SUBADULT MALE	HUMAN, UNDER INVESTIGATION
2010	BEARFITE CR, MT	1	CUB	NATURAL
2010	COLD CR, BC	1	SUBADULT MALE	HUMAN, WOLF TRAP, SELKIRK RELOCATION
2010	PINE CR, MT	1	ADULT MALE	HUMAN, POACHING
2011	EF ROCK CR, MT	1	SUBADULT	UNKNOWN
2011	FARO CR, MT	1	ADULT MALE	HUMAN, MISTAKEN IDENTITY (Black Bear)
2011	CHERRY CR, MT	1	SUBADULT MALE	HUMAN, MISTAKEN IDENTITY (Black Bear)
2011	PIPE CR, MT	1	SUBADULT MALE	HUMAN, DEFENSE OF LIFE
2011	LITTLE CR, MT	1	ADULT MALE	HUMAN, UNDER INVESTIGATION
2012	MISSION CR, ID	2	ADULT FEMALE, 1 CUB	HUMAN, UNDER INVESTIGATION
2012	DUCK CR., BC	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL

YEAR	LOCATION	TOTAL	SEX / AGE	MORTALITY CAUSE
2014	L. THOMPSON R., MT	1	ADULT MALE	HUMAN, DEFENSE OF LIFE
2015	LINKLATER CR., BC	1	YEARLING	NATURAL
2015	NF ROSS CR., MT	1	SUBADULT FEMALE	NATURAL
2015	YAAK R., MT	1	SUBADULT MALE	HUMAN, ILLEGAL
2015	SINK CR., BC	1	YEARLING	NATURAL
2015	MOYIE R., ID	1	SUBADULT MALE	HUMAN, DEFENSE OF LIFE
2015	BEAVER CR., ID	1	SUBADULT MALE	HUMAN, MISTAKEN IDENTITY (Black Bear)

Table T3. Grizzly bears captured, observed, photographed, or genotyped by study personnel in the Cabinet Mountains and Yaak River, 1986–2016.

Cabinets

Bear ID	Genetic Lab ID	Sex	Years detected	Comments
678	C678F	F	1983-89, 93	Born 1955. Monitored 1983-89. Unknown cause mortality 1993.
680	C680M	M	1984-86	Born. 1973. Monitored 1984-85. Observed 1986.
14	C306M	M	1985	Born 1959. Monitored 1985. Self-defense mortality 1985.
218	Unmarked	F	1990-92	Born 1985. Augmentation, Monitor 1990-91. Observed 1992.
258	Ca258F	F	1992-93	Born 1986,Augmentation,Monitor 1992-93.One cub 1993.Natural mortality 1993
286	Ca172F	F	1993-95, 02, 05, 09	Born 1991. Augmentation, Monitor 1993-95. DNA 2005. Self-defense mortality 2009.
Unmarked	Unmarked	?	1993	Born 1993. Probable natural mortality 1993.
311	NY311F	F	1994-95	Born 1991. Augmentation, Monitor 1994-95.
UNK 39	CUk39M	M	1997	Human Undetermined mortality 1997.
770	CU29M	M	2000, 02, 05-16	Born 1994. Photo 2002?, 08, 13. Monitored 2005-06. DNA 2000, 05-16
UNK 38	C23F	F	2001	Adult female train mortality 2001.
831	C20241F	F	2001-02, 07, 11-16	Born 1997? Sibling 772. DNA 2001-02, 04, 07, 11-16. Photo 2011, 13-14; Monitored 2014
577	C577F	F	2002	Born 2001. Natural mortality 2002. Sibling 578 and 579.
578	C578M	M	2002	Born 2001. Sibling 577 and 579.
579	C579M	M	2002-03	Born 2001. Sibling 577 and 578. Observed 2003.
772	C20191F	F	2002-03, 07-08	Born 1997. DNA 2002-03, 2007. Monitored 2007 with 2 cubs. observed 2008
3119	C3119gF	F	2003-05	Born 2003. Train mortality 2005.
780	C20252M	M	2002,06-08,10-16	Born 2000. Monitored 2006-08. DNA 2002, 2010-16
403	C403M	M	2004, 07	Born 2004. At least 1 cub photo with adult female. Mortality 2007 in NCDE.
A1	CaA1F	F	2005-08	Born 1997? Augmentation Monitor 2005-07. Observe with 780 2008?
200618415	C20061M	M	2006	DNA 2006.
782	Ca782F	F	2006-08,12,14	Born 2004. Augmentation Monitor 2006-08. DNA 2008, 2012, 2014.
789	C789F	F	2007, 08	Born 2007. Marked 2007. DNA 2007. Observed 2008.
791	C791M	M	2007, 08	Born 2007. Marked 2007. DNA 2007. Observed 2008.
799	C2007M	M	2007, 10-11	Born 2007. DNA 2007, 2011 Monitor 2010-11 as 799. Mortality 2011.
200721053	C20072F	F	2007, 11-12, 14, 16	Born 2007. DNA 2007, 2011-12, 2014, 2016.
635	Ca635F	F	2008	Born 2004. Augmentation Monitor 2008. Train mortality 2008
790	Ca790F	F	2008	Born 2005. Augmentation Monitor 2008. Poaching mortality 2008
C90464M	C90464M	M	2008	Born 2005. Human under investigation mortality 2008.
C067801	C67801	M	2009	Rose Lake, ID, Mortality Mistaken ID 2009
G 2009001005	C20090F	F	2009-10, 12, 15-16	Born 2008.Yearling cub of 286,DNA 2009-10,12,15-16,Photo 2009-10,15,16
715	Ca715F	F	2009-10	Born 1998? Augmentation Monitor 2009. Returned to Flathead 2010.
2009001002	C2009F	F	2009, 11-12, 16	Born 2008. Yearling cub of 286, DNA and Photo 2009, 11, 16, DNA 2012, 16
26D02a	C26D02M	M	2009, 11- 14	Montanore scat dog DNA 2009. Cub photo with 286 in 2005? DNA 2011-14
2010011131	C10111M	M	2010	Born 2010, DNA/photo 2010
2010011205	C10011F	F	2010, 16	Adult 2010, DNA/photo 2010, DNA 2016
714	Ca714F	F	2010	Monitored 2010, Augmentation. Returned to Flathead 2010.

Cabinets

Bear ID	Genetic Lab ID	Sex	Years detected	Comments
2010011328	C10113F	F	2010-11	Born 2010, DNA/photo 2010, Unknown mortality 2011
713	Ca713M	M	2010-12, 15	Augmentation Monitored 2010-11. DNA 2011-12, 15. Flathead capture 2012
2011092001	2011092001	F	2011-12	DNA 2011-12. Photo 2011
724	Ca724M	M	2011-12	Management Monitored 2011-12
725	Ca725F	F	2011-13	Augmentation Monitored 2011-13, returned to Flathead then back to Cabinets
723	Ca723M	M	2011-12,14	Augmentation Monitored 2011-12
928442	928442	M	2012	DNA 2012. Selkirk immigrant. Moved back to Selkirks by 2015
935400	935400	M	2012	DNA 2012
935410	935410	M	2012, 15	DNA 2012, 2015
958471	958471	M	2012, 15-16	DNA 2012, 2015-16
918	Ca918M	M	2012-14	Augmentation Monitored 2012-14
839	900932	M	2012-15	Born 2011 to 831. DNA 2012-13, 2015. Photo 2014. Monitored 2014-15
925063	925063	F	2012-14, 16	Born 2011 to 831. DNA 2012-14, 2016. Photo 2014. Monitored 2014
919	Ca919M	M	2013-14	Augmentation Monitored 2013-14
900933	900933	F	2012-15	Born 2011 to 831. DNA 2012, 2014-15. Photo 2013-15. Monitored 2014
79575279	C90467M	M	2014	Defense Mortality 2014
C14924F	C14924F	F	2014	DNA 2014
920	Ca920F	F	2014-16	Augmentation Monitored 2014-16
921	Ca921F	F	2014-15	Augmentation Monitored 2014-15. Mortality (natural cause) in 2015
C16742M	16742	M	2015	Born to C20072F, unknown age. DNA 2015
C17460M	17460	M	2015-16	Born 2015 to C20090F., DNA/photo 2015-16
924	Ca924M	M	2015	Augmentation monitored 2015. Human-caused mortality 2015
C22877M	C22877M	M	2016	Born 2015 to C20090F. Photo 2015. DNA/photo 2016
926	Ca926M	M	2016-17	Augmentation monitored 2016-17
726	Y726M	M	2015-16	Born 2009. Monitored 2015-16. DNA 2016. Range includes Cabinets and Yaak.

Yaak River

Bear ID	Genetic Lab ID	Sex	Years detected	Comments
Unmarked	Unmarked	?	1986	Born 1986. Natural mortality 1986.
106	Y336F	F	1986-99	Born 1978. Monitor 1986-99. Natural mortality 1999.
101	Unmarked	M	1986-87	Born 1978. Monitor 1986-87.
129	Y129F	F	1986-89	Born 1986. Monitor 1986-89. Trap predation mortality 1989.
Unk3	Y308F	F	1987	Born 1987 cub of 25. Mistaken-ID mortality 1987
134	UI Tube 871	M	1987-88	Born 1978. Monitor 1987-88. BC hunting mortality 1988.
128	Y128M	M	1987-92, 97, 01	Born 1983. Monitor 1987-92 and 1997. Natural Mortality 2001
25	Y25F	F	1988	Self Defense Adult female mortality 1988
193	Y193M	M	1988-90	1988 cub of 106. Monitor 1988-90.
192	Y939M	M	1988-90	1988 cub of 106. Monitor 1988-90. Poaching mortality 1990.
206	Y206F	F	1988-95, 97	1988 cub of 106. Monitor 1988-95. Observed 1997 with 2 cubs
UNK22	Y321M	M	1991	DNA 1991
R178	Y178M	M	1991-92, 01	1991 cub of 106.Monitor 1991-92. DNA BC 2001
Unmarked	Unmarked	?	1991-92	1991 cub of 106.Monitor 1991-92.
244	Y244M	M	1992-94, 03-04	Born 1986.Monitor 1992-94 & 2003-04.
34	Unmarked	F	1993	Transplanted to Bloom Cr by BC 1993, captured in US 1993.
355	Y355M	M	1993, 96	Born 1990. Monitor 1996. Human, Undetermined mortality 1996.
358	Y330M	M	1993, 96-99	Born 1988. Monitor 1996-98. Management removal mortality 1999.
302	Unmarked	M	1993-96	Born 1993. cub of 106. Monitor 1993-96. Human Undetermined mortality 1996.
303	Y303F	F	1993-01,03,07,10-16	1993 cub of 106. Monitor 1994-2001, 2010-16. Observe 2003 2 cubs, 3 cubs 2010. DNA 2012, 15-16. Photo 2011-13.
Unmarked	Unmarked	F	1994, 98	Unmarked female consort of 244 and 363.
Unmarked	Unmarked	?	1994-95, 98	1994 cub of 206, sibling of bear 505. Monitor 1994-95, Observed 1998?
505	Unmarked	F	1994-95, 98	1994 cub of 206. Monitor 1994-95. Observed 1998?

Yaak River

Bear ID	Genetic Lab ID	Sex	Years detected	Comments
353	Y353F	F	1995-99, 02	1995 cub of 106. Monitor 1995-97, 2002. Observed 1998-99. Poaching mortality 2002.
354	Y354F	F	1995-99, 07	1995 cub of 106. Monitor 1995-99. Self-defense mortality 2007.
342	YU46M	M	1996-99, 02-04, 11	Born 1992. Monitor 1996-99, 2003-04. DNA 2002, 2011. Human, under investigation mortality 2011.
363	Y363M	M	1996-99, 05	Born 1992.Monitor 1996-99. DNA 2005, Human Undetermined mortality 2005?
68853	Y68853F	F	1997	1997 mortality, Wardner, BC Management removal.
72832	Y72832M	M	1997	1998 mortality, Mayook, BC Unknown.
384	Y384M	M	1997,	Born 1990. Monitor 1997.
596	Y596F	F	1997, 99	1997 cub of 206. Monitor 1999. Self defense mortality 1999.
538	Y538F	F	1997-02	Born 1991.Monitor 1997-02.
386	YVernM	M	1997-98, 00-01, 05	Born 1992.Monitor 1997-98. DNA 2005.
592	Y314F	F	1998, 99-00	1997 cub of 206. Monitor 1999. DNA 1999. Human Undetermined mortality 2000.
UNK55	YU55F	F	1999	1997 cub of 538. Monitor 1997-98. Found skull 1999 at 386 lost collar in BC.
106cub1	Y106c1M	M	1999,	1999 cub of 106. Natural Mortality 1999.
106cub2	Y106c2F	F	1999,	Born 1999. cub of bear 106. Natural Mortality 1999.
UNK26	N323M	M	1999, 2012	DNA 1999, 2012
Unmarked	Unmarked	?	2000	2000 cub of 538. Natural Mortality 2000.
Unmarked	Unmarked	?	2000	2000 cub of 538. Natural Mortality 2000.
Unmarked	Unmarked	?	2000	2000 cub of 303. Natural Mortality 2000.
552	Y165F	F	2000-02, 11-16	2000 cub of 303. Monitor 2000-01,12-15,DNA 2001-02,11-16,Photo 2012,14,16
Unmarked	Unmarked	?	2001	2001 cub of 538. Natural Mortality 2001.
Unmarked	Unmarked	?	2001	2001 cub of 538. Natural Mortality 2001.
UNK37	YU37F	F	2001	2000 cub of 354. Unmarked yearling mistaken identity mortality 2001
M-0235	Y235F	F	2002	DNA 2002. Human Undetermined mortality 2002.
7434	Y7434F	F	2002	DNA 2002
688	PTerryM	M	2002, 05-06	2002 cub of 538. Crossed Highway 3 to North. Monitor 2005-06.
10165b	Y10165F	F	2005, 06	2002 cub of 538, DNA 2004-05, BC. Trap predation mortality 2006.
Unmarked	Unmarked	?	2002	2002 cub of 353. Assumed Human mortality 2002.
UNK43	YU43F	F	2002	2002 cub of 353. Poaching mortality 2002.
651	YRockyM	M	2002, 2005-06, 08	Born 1995.Monitor 2002,2005-06. Human,Mistaken Identity Wolf Trap 2008 BC
787	Y787M	M	2002-04	2000 cub of 354. DNA 2002 Monitor 2003-04.
576	Y576M	M	2004-06	Born 2002.Monitor 2004-06. DNA 2005.
675	Y675F	F	2004-11	Born 2002.Monitor 2004-10. Lost 2 cubs 2009. Lost 1 cub 2010. DNA 2011-12
Unmarked	Unmarked	F	2004	Management capture and removal 2004, BC.
10252c	Y10252cF	F	2005	DNA 2005, BC
10252b	Y10252M	M	2005	DNA 2005, BC
10303g	Y10303M	M	2005	DNA 2005, BC
M1	YU63M	M	2005	2003 cub of 303.Monitor 2005 Relocated NW Peak. Lost contact.
677	YCoryM	M	2005	Born 1999.Monitor 2005.
694	Y694F	F	2005	2003 cub of 303.Monitor 2005. Human Undetermined mortality 2005.
17	YJB17M	M	2005	Born 1997. DNA 2002 Monitor 2005.
668	Y668M	M	2005	Born 2002, cub of 353,.Monitor 2005. Mistaken ID 2005
31	S31M	M	2005	Immigrant from Selkirks. Hunter harvest 2005. BC.
292	YMarilF	F	2005-06	Born 2001.Monitor 2005. Human Mortality 2006.
103	YHydeM	M	2006	Born 2003.Monitor 2006. Went to Selkirks 2006
5381	P9190M	M	2006,09-10, 12	Born 2002.Monitor 2006,2009-10. Management removal 2012.
820	Y20073F	F	2007-08,11-12,15-16	Born 2003 to 354. DNA 2007, 12, 15-16. Photo 2011, 15. Monitored 2015-16
Unmarked	Unmarked	?	2007	Born 2007. Cub of 303
731	Y731F	F	2007, 09-12, 15	Born 2007 to 303, observed 2007. Monitored 2009-11. DNA 2011-12, 15
785	Y785F	F	2007-08	2006 cub of 354. Radio Monitored 2007-08
784	Y784F	F	2007-09, 14-15	2006 cub of 354. Radio Monitored 2007-09, 14-15. Photo 2014-15.
Unmarked	Unmarked	?	2009	Born 2009. Cub of 675. Natural mortality 2009.

Yaak River

Bear ID	Genetic Lab ID	Sex	Years detected	Comments
Unmarked	Unmarked	?	2009	Born 2009. Cub of 675. Natural mortality 2009.
722	YU83M	M	2009, 11-16	DNA 2009, 12-16. Monitored 2011-12, 14, 16. Photo 2011, 14-16
737	YGB737M	M	2010-16	Monitored 2010-13. DNA 2012, 14-16. Photo 2012, 14
Unmarked	Unmarked	?	2010	Born 2010. Cub of 675. Natural mortality 2010.
1374	P1374M	M	2010	Monitored 2010. Human under investigation mortality 2010
Unk107	YU107M	M	2010	Human under investigation mortality 2010.
726	Y726M	M	2011-12,14-16	Born 2009 to 820. DNA 2012, 14-16. Photo 2011. Monitor 2011-12, 15-16. Range includes Cabinets and Yaak.
Unmarked	Unmarked	?	2010	Born 2010. Cub of 303. Natural mortality 2010.
729	Y729F	F	2010-16	Born 2010. Cub of 303. DNA 2013-16. Monitor 2011-13, 15-16
Unmarked	Unmarked	?	2010-13	Born 2010. Cub of 303. Photo 2011-13
Unk123	Y732M	M	2011	Born 2006. Management capture 2011. Self-defense mortality 2011
2011038306	2011038306	M	2011-13	Born to 810. DNA 2011-13. Photo 2011
810	2011038311	F	2011-12,14-16	Born 2003 to 354. DNA 2011-12, 13-16. Photo 2011, 14-16. Monitored 2015
2011049118	2011049118	M	2011-12	Born 2011 to 552. DNA 2011-12. Photo 2012
2011049122	2011049122	F	2011-13	Born 2011 to 552. DNA 2011-13. Photo 2012
UNK 116	200354a	M	2011	DNA 2011 Mistaken ID mortality
10569c1	10569F	F	2005, 12	DNA 2005 (BC). Hall Mtn Mortality 2012
Y90479M	Y90479M	M	2012	Hall Mtn Mortality 2012 cub born 2012
953305	953305	M	2012	DNA 2012
955503	955503	M	2012	DNA 2012
826	922947	M	2012-13	Monitored 2013. DNA 2012-13
835	928196	M	2012-16	Born 1995. DNA 2012-16. Photo 2014. Monitored 2014-16
947510	947510	F	2012-13	DNA 2012-13
824	958729	M	2012-16	Monitored 2016. DNA 2012-16. Photo 2016.
13082220975203	13082220975203	M	2013	DNA 2013
836	13100420976102	F	2013-16	Born 2013 to 784. DNA 2013-16. Photo 2014-16. Monitored 2014-16
807	YGB807M	M	2014-15	Monitored 2014-15. DNA 2014-15. Photo 2014. Went to Selkirks in 2015
808	YGB808M	M	2014-16	Monitored 2014-15. DNA 2015-16. Photo 2014
837	YGB837M	M	2014-16	Monitored 2014-16. DNA 2014-16. Photo 2014-15
Unmarked	Unmarked	?	2014-15	Born 2014 to 552. Monitored 2014-15. Natural mortality 2015.
821	Y821M	M	2014-16	Born 2014 to 552. Monitored 2014-16. DNA 2016. Range includes Cabinets and Yaak. Photo 2016.
822	Y14836F	F	2014-16	Born 2013 to 784. DNA 2014-16. Photo 2014-16. Monitored 2014-16
818	Y12797M	M	2014-15	Born 2013 to 820. DNA 2014. Monitored 2015. Human-caused mortality 2015
922	Y11048M	M	2014-16	Born 2014 to 552. DNA 2014-16. Photo 2014, 16. Monitored 2014-16
Y11008M	11008	M	2014-16	Born 2014 to 810. DNA 2015-16. Photo 2014-16. Monitored 2015
Y18986M	18986	M	2014-16	Born 2014 to 810. DNA 2015-16. Photo 2014-16. Monitored 2015
Y15605F	15605	F	2015	Born 2013 to 820. DNA 2015. Photo 2015?
853	16496	M	2015-16	Monitored 2016. DNA 2015-16. Photo 2016
Y16749M	16749	M	2015	Born to Selkirk Female 226, apparent immigrant. DNA 2015. Photo 2015?
Y17139M	17139	M	2015	Born to 731. DNA 2015
Y91208M	Y91208M	M	2015	Human-caused, illegal mortality 2015
Y22270M	Y22270M	M	2016	DNA 2016
Y24689F	Y24689F	F	2015-16	Born to 303 in 2015. DNA 2015-16
9811	Y9811M	M	2016	Monitored 2016. DNA/photo 2016. Observed with a sibling at trapsite in 2016.
Unmarked	Unmarked	?	2016	Apparent sibling of 9811, Observed and photo at trapsite in 2016.

Table T4. Movement and gene flow to or from the Cabinet-Yaak recovery area.

Area Start / Finish	Action	Bear ID	Sex	Age	Year	Basis	Comments
CAB / NCDE	Movement	C403M	M	2-3	2007	Telemetry, Genetics	Captured Marion, MT 2006 NCDE, traveled to Whitefish, relocated to Whitefish Range. Train kill 2007
NCDE / SPur	Movement	YGB737M	M	4	2010	Genetics	Captured and monitored 2010-15. Parentage in NCDE by USGS.
NCDE / SPur	Movement	43-44	F	3	2013	Capture, Mortality	Management bear relocated at least twice in NCDE. Traveld to SPur, shot after Killing chickens by landowner.
NPur / SPur	Movement	P9183M	M	Unk	2004-05	Genetics	DNA captured NPur and SPur.
NPur / SPur	Movement	PKiddM	M	7	2004	Telemetry	Radio collared June 2004, Travels from NPur to SPur, offspring in SPur.
NPur / SPur	Movement	YMarilF	F	4-5	2005-06	Telemetry, Genetic assignment	Radio collared July 2005 in SPur, Genetic assignment to the NPur. Management removal 2006.
NPur / SPur	Movement	Y732M	M	3	2011	Genetics	Born in NPur and Traveled to SPur. Mortality 2011.
NPur / SPur	Movement	10569F	F	6	2005, 2012	Genetics, Mortality	Father SPur YVernM, Mother NPur PIrishF, DNA capture NPur 2005, Mortality with cub SPur 2012
NPur / SPur	Gene flow	Y90479M	M	0.5	2012	Genetics, Mortality	Father Y576M Mother 10569F Mortality 2012
SPur / NCDE	Movement	N323M	M	Unk	1999	Genetics	Hair snagged 1999 in SPur. Hair snagged NCDE USGS 1998-2006. USGS assigned to SPur.
SPur / Salish	Movement	Y128M	M	18	2001	Mortality	Capture 1987. Monitored 1987-92 and 1997 SPur. Recaptured August 2001 in Salish, Mortality 2001.
SPur / NPur	Movement	Y128M	M	4-14	1987-92, 1997	Telemetry	Capture May 1987 SPur. Monitored 1987-92 and 1997. Monitored NPur and produced offspring.
SPur / NPur	Movement	YVernM	M	7-12	1997, 2002	Telemetry, Genetics	Radio collared SPur 1997. Hair snag NPur 2002.Sired offspring NPur and SPur.
SPur / NPur	Movement	YRockyM	M	8-12	2002-06	Telemetry	Captured and collared SPur 2002. Recapture 2006. Traveled NPur in 2006.
SPur / NPur	Movement	134	M	8-9	1987-88	Telemetry	Radio collar in SPur 1987. Hunter kill 1988 NPur
SPur / NPur	Movement	P9190M	M	4-5	2006-07	Telemetry	Radio collared June 2006 SPur. Traveled to NPur
SPur / NPur	Movement	PTerryM	M	3	2005	Telemetry, Genetics	Father SPS Y178M , Mother SPS Y538F Travel to NPur from SPur.
SPur / SSelK	Movement	YHydeM	M	3	2006-07	Telemetry	Captured in SPur Yaak 2006. Bear traveled to SSelk 2006-07
SSelk / CABS / SSelk	Movement	928442	M	5	2012	Genetics	Father SSelk S9058aM, Mother SSelk SBettyF, Hair snagged USGS 2012 Cabs and in Sselk 2015
SSelk / SPur	Movement	S31M	M	6	2004-05	Telemetry, Mortality	Father SSelk SS3KM, Mother SSelk S1MF, Management capture 2003 and Relocated. Hunter kill 2005 SPur
SPur / CABS / SPur	Movement	Y726M	M	6	2015-16	Telemetry	Travel from SPur to Cabs and back
SPur / SRock	Movement	922947	M	5	2013	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SPur / SRock	Movement	928196	M	20	2015-16	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SSelk / CABS	Movement	S1001M	M	6	2015	Telemetry, Mortality	Travel from SSelk to CabsABS. Mortality 2015
CAB / NCDE	Movement	900932	M	4	2015-16	Telemetry	Travel east from Cabs to NCDE

SPur / NPur	Movement	958729	M	12	2016	Telemetry	Travel north from SPur to NPur
SPur / SSelK	Movement	Y11048M	M	4	2017	Telemetry, Mortality	Travel west from SPur to Sselk. Mortality 2017
SPur / SSelK	Movement	YGB807M	M	5	2015-17	Telemetry	Travel west from SPur to Sselk.
SPur / CABS	Movement	Y821M	M	3	2017	Telemetry	Travel from SPur to Cabs
NPur / SPur	Gene flow	YGB837M	M	6	2014	Genetics	Parents both NPur, Father NPur PKiddM, Mother NPur PIrishF
SPur / NPur	Gene flow	P9194F	F	Unk	2004-05	Genetics	Father SPur Y128M , Mother NPur P9127F, Origin of father probably NPur
NPur / SPur	Gene flow	Y787M	M	3	2003	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
NPur / SPur	Gene flow	YU37F	F	1	2001	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
SSelk / SPur	Movement	16749	M	Unk	2015	Genetics	Father C134B2V2, Mother JillS226F Both Sselk. Male offspring 16749 SPur
NCDE / CAB	Movement	C90467M	M	6	2014	Genetics, Mortality	Management bear from NCDE traveled to Cabs, mortality 2014
NPur / SPur	Movement	P1374M	M	2	2010	Genetics, Mortality	Hair snag as cub in 2008 NPur? Management capture SPur 2010,relocated, Mortality 2010

[1]Cabs – Cabinet Mountains, NCDE – Northern Continental Divide, NPur – Purcell Mountains north of Highway 3, SPur – Purcell Mountains south of Highway 3, SSelk – South Selkirk Mountains south of Nelson, BC

Appendix 5. Grizzly Bear Home Ranges

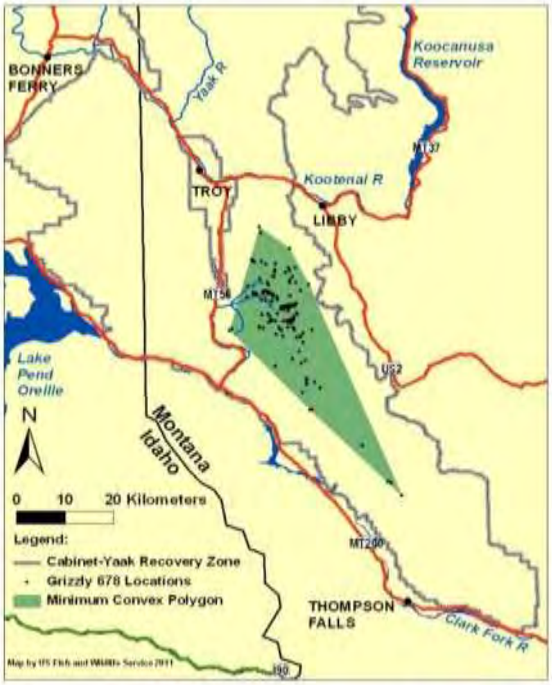


Figure A1. Radio locations and minimum convex (shaded) life range of female grizzly bear 678 in the Cabinet Mountains, 1983-89.

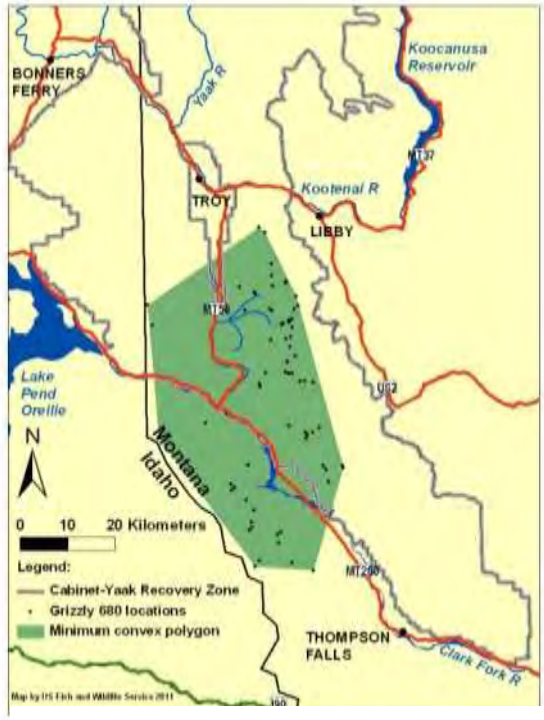


Figure A2. Radio locations and minimum convex (shaded) life range of male grizzly bear 680 in the Cabinet Mountains, 1984-85.

Figure A3. Radio locations and minimum convex (shaded) life range of male grizzly bear 14 in the Cabinet Mountains, 1985.

Figure A4. Radio locations and minimum convex (shaded) life range of male grizzly bear 101 in the Yaak River, 1986-87.

Figure A5. Radio locations and minimum convex (shaded) life range of female grizzly bear 106 in the Yaak River, 1986-99.

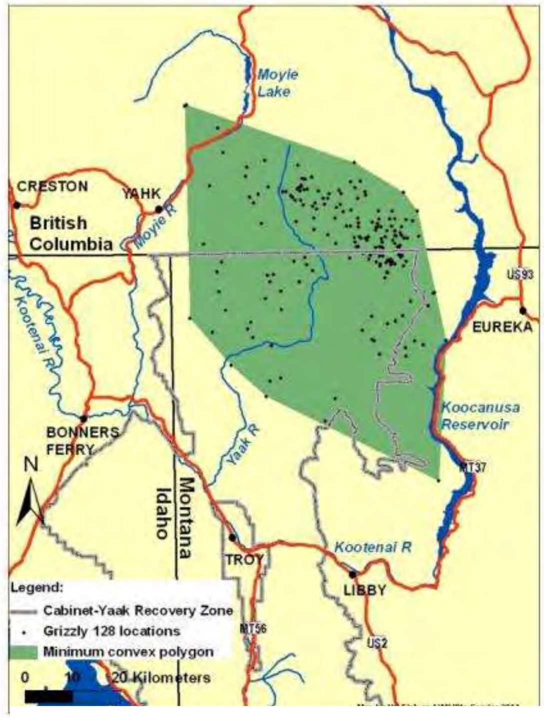


Figure A6. Radio locations and minimum convex (shaded) life range of male grizzly bear 128 in the Yaak River, 1987-97.

Figure A7. Radio locations and minimum convex (shaded) life range of female grizzly bear 129 in the Yaak River, 1987-89.

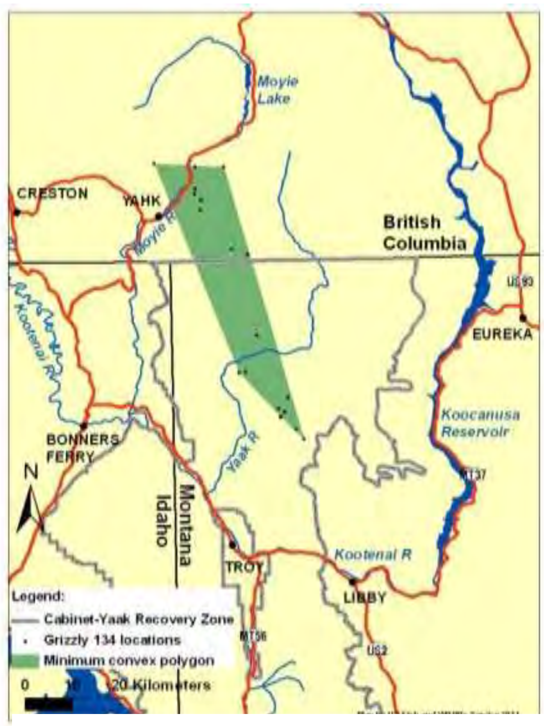


Figure A8. Radio locations and minimum convex (shaded) life range of male grizzly bear 134 in the Yaak River, 1987-88.

Figure A9. Radio locations and minimum convex (shaded) life range of male grizzly bear 192 in the Yaak River, 1990.

Figure A10. Radio locations and minimum convex (shaded) life range of male grizzly bear 193 in the Yaak River, 1990.

Figure A11. Radio locations and minimum convex (shaded) life range of female grizzly bear 206 in the Yaak River, 1991-94.

Figure A12. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 218 in the Cabinet Mountains, 1990-91.

Figure A13. Radio locations and minimum convex (shaded) life range of male grizzly bear 244 in the Yaak River, 1992-03.

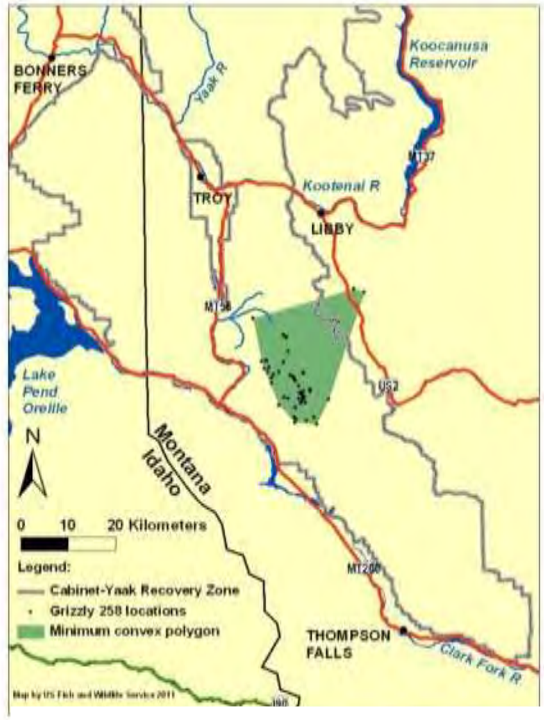


Figure A14. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 258 in the Cabinet Mountains, 1992-93.

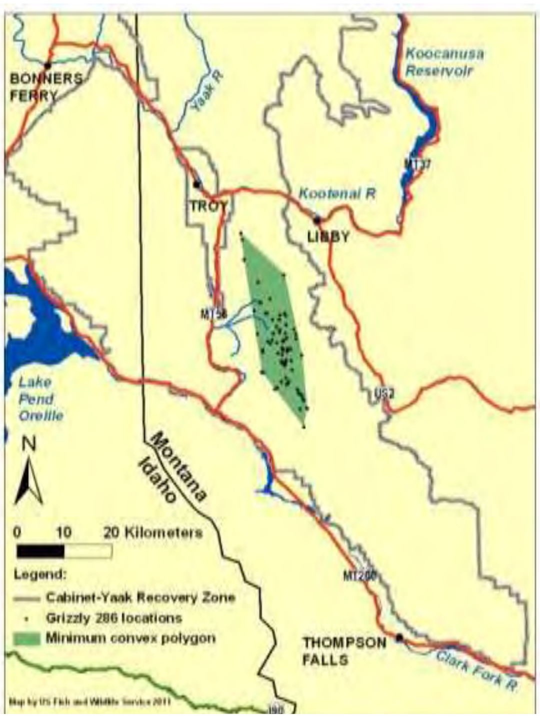


Figure A15. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 286 in the Cabinet Mountains, 1993-95.

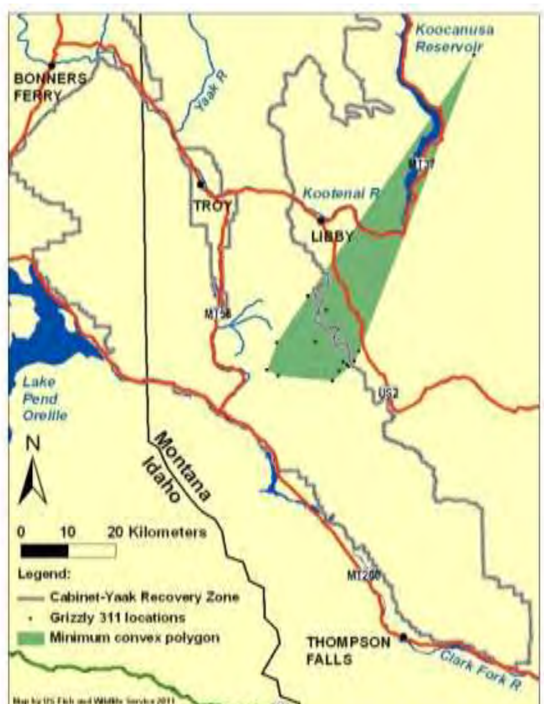


Figure A16. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 311 in the Cabinet Mountains, 1994-95.

Figure A17. Radio locations and minimum convex (shaded) life range of male grizzly bear 302 in the Yaak River, 1994-96.

Figure A18. Radio locations and minimum convex (shaded) life range of female grizzly bear 303 in the Yaak River, 1994-01 and 2011-16.

Figure A19. Radio locations and minimum convex (shaded) life range of male grizzly bear 342 in the Yaak River, 1995-01.

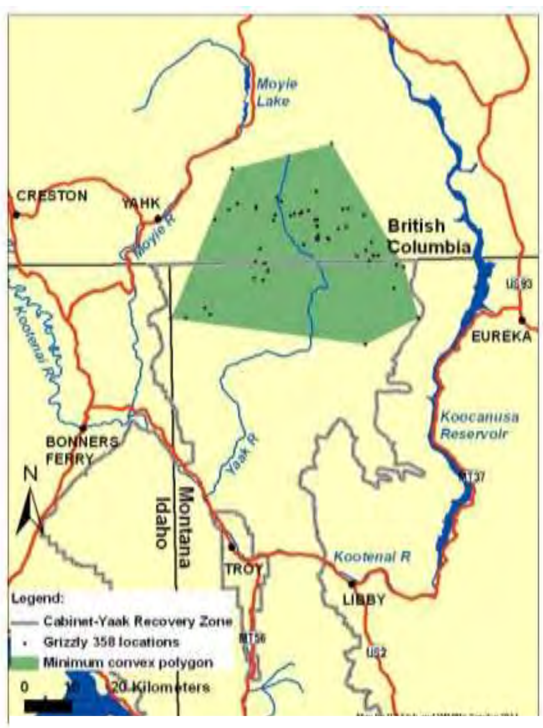


Figure A20. Radio locations and minimum convex (shaded) life range of male grizzly bear 358 in the Yaak River, 1996-98.

Figure A21. Radio locations and minimum convex (shaded) life range of male grizzly bear 363 in the Yaak River, 1996-99.

Figure A22. Radio locations and minimum convex (shaded) life range of male grizzly bear 386 in the Yaak River, 1997-99.

Figure A23. Radio locations and minimum convex (shaded) life range of female grizzly bear 354 in the Yaak River, 1997-99.

Figure A24. Radio locations and minimum convex (shaded) life range of female grizzly bear 538 in the Yaak River, 1997-02.

Figure A25. Radio locations and minimum convex (shaded) life range of female grizzly bear 592 in the Yaak River, 1999-00.

Figure A26. Radio locations and minimum convex (shaded) life range of female grizzly bear 596 in the Yaak River, 1999.

Figure A27. Radio locations and minimum convex (shaded) life range of female grizzly bear 577 in the Cabinet Mountains, 2002.

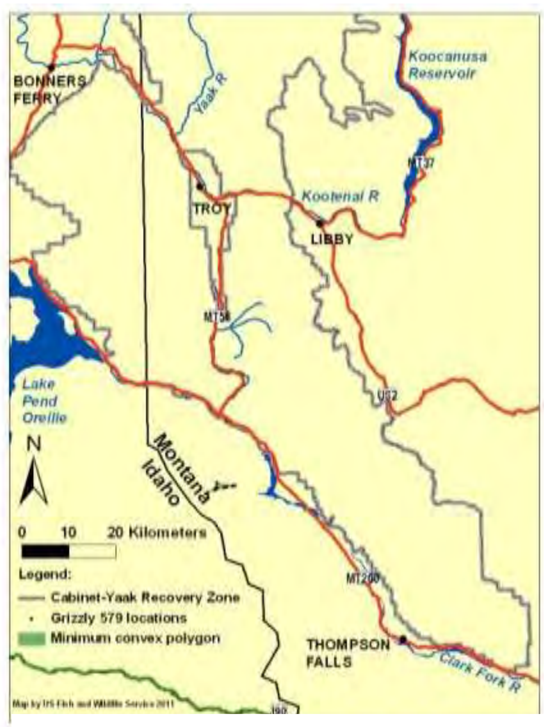


Figure A28. Radio locations and minimum convex (shaded) life range of male grizzly bear 579 in the Cabinet Mountains, 2002.

Figure A29. Radio locations and minimum convex (shaded) life range of female grizzly bear 353 in the Yaak River, 2002.

Figure A30. Radio locations and minimum convex (shaded) life range of male grizzly bear 651 in the Yaak River, 2002-06.

Figure A31. Radio locations and minimum convex (shaded) life range of male grizzly bear 787 in the Yaak River, 2003-04.

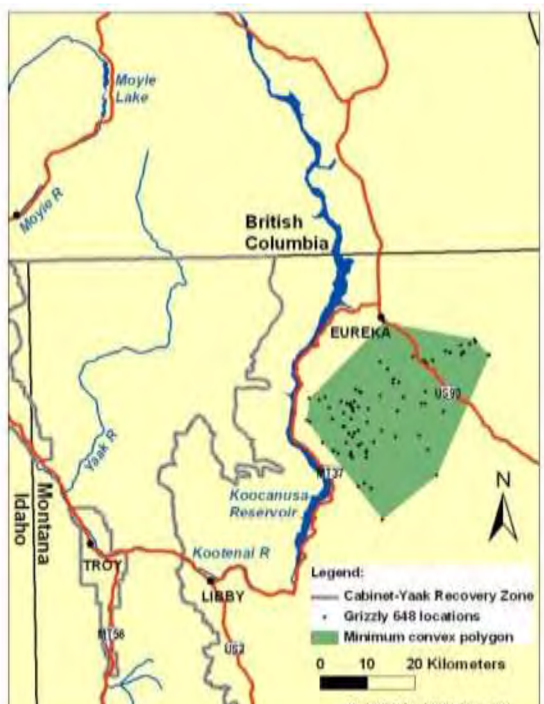


Figure A32. Radio locations and minimum convex (shaded) life range of female grizzly bear 648 in the Salish Mountains, 2003-05.

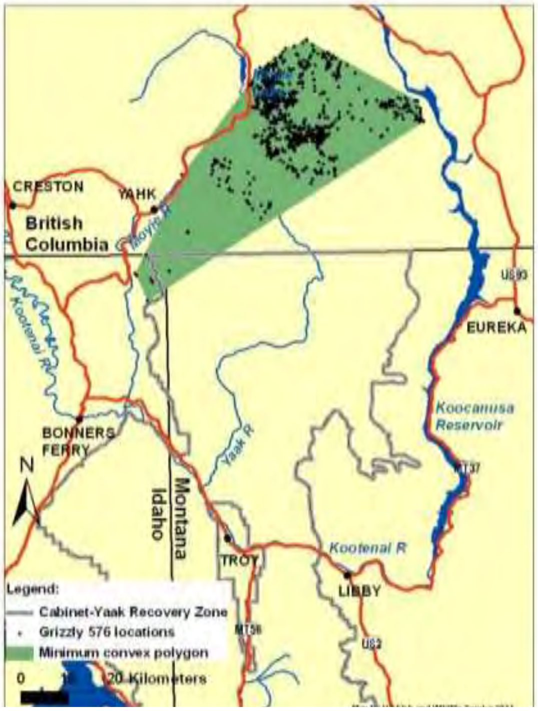


Figure A33. Radio locations and minimum convex (shaded) life range of male grizzly bear 576 in the Yaak River, 2004-06.

Figure A34. Radio locations and minimum convex (shaded) life range of female grizzly bear 675 in the Yaak River, 2004-10.

Figure A35. Radio locations and minimum convex (shaded) life range of female grizzly bear 10 in the Purcell Mountains, 2004.

Figure A36. Radio locations and minimum convex (shaded) life range of male grizzly bear 11 in the Purcell Mountains, 2004.

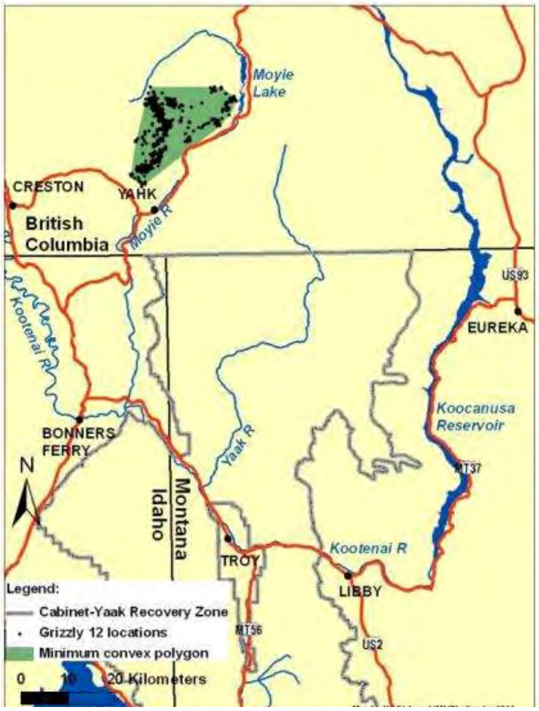


Figure A37. Radio locations and minimum convex (shaded) life range of female grizzly bear 12 in the Purcell Mountains, 2004.

Figure A38. Radio locations and minimum convex (shaded) life range of male grizzly bear 17 in the Purcell Mountains, 2004.

Figure A39. Radio locations and minimum convex (shaded) life range of male grizzly bear 677 in the Purcell Mountains, 2005.

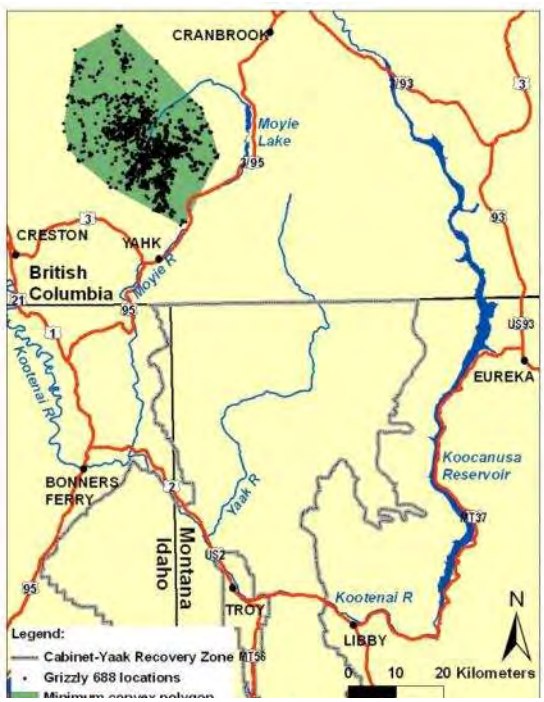


Figure A40. Radio locations and minimum convex (shaded) life range of male grizzly bear 688 in the Purcell Mountains, 2005-06.

Figure A41. Radio locations and minimum convex (shaded) life range of female grizzly bear 694 in the Yaak River, 2005.

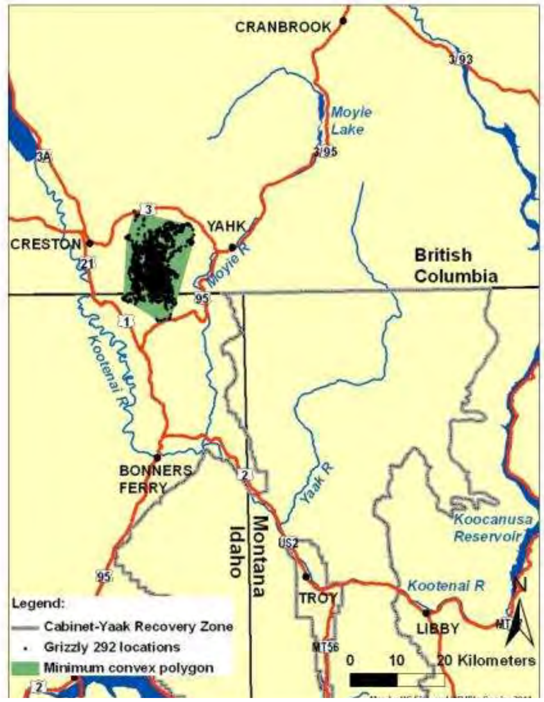


Figure A42. Radio locations and minimum convex (shaded) life range of female grizzly bear 292 in the Purcell Mountains, 2005.

Figure A43. Radio locations and minimum convex (shaded) life range of male grizzly bear 770 in the Cabinet Mountains, 2005-06.

Figure A44. Radio locations and minimum convex (shaded) life ranges of male grizzly bear 2 in the Purcell Mountains, 2005.

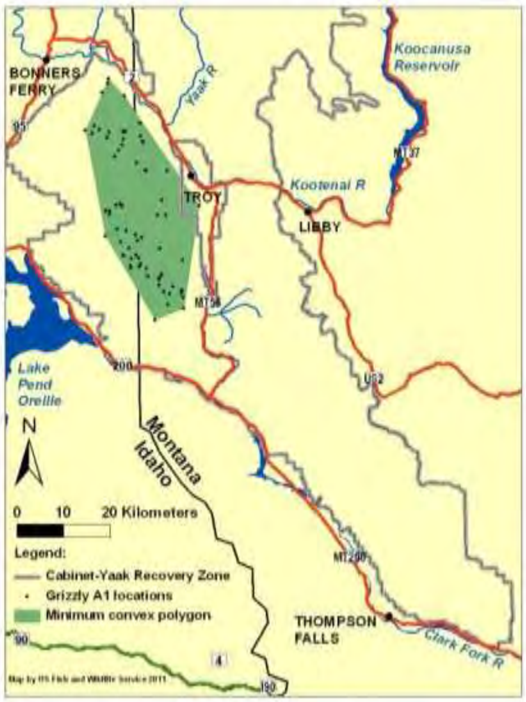


Figure A45. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear A1 in the Cabinet Mountains, 2005-07.

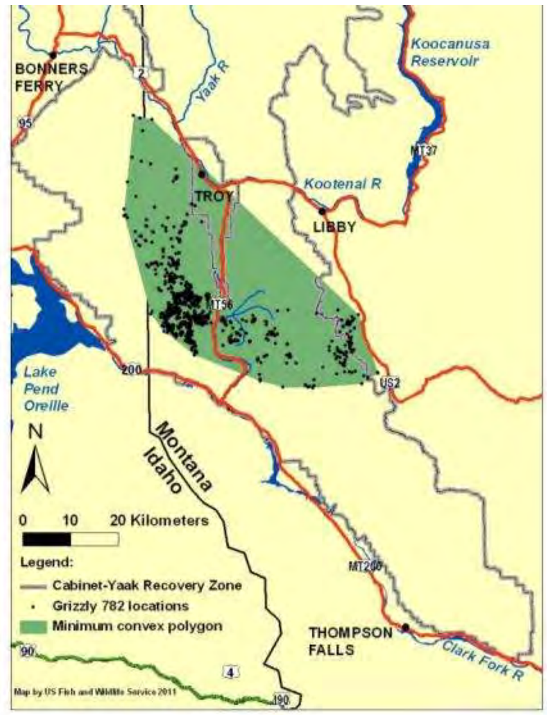
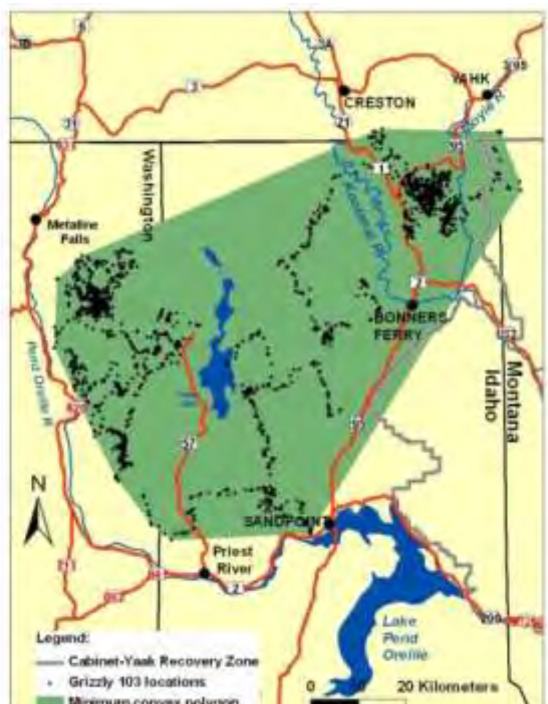


Figure A46. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 782 in the Cabinet Mountains, 2006-07.

Figure A47. Radio locations and minimum convex (shaded) life range of male grizzly bear 780 in the Cabinet Mountains, 2006-08.



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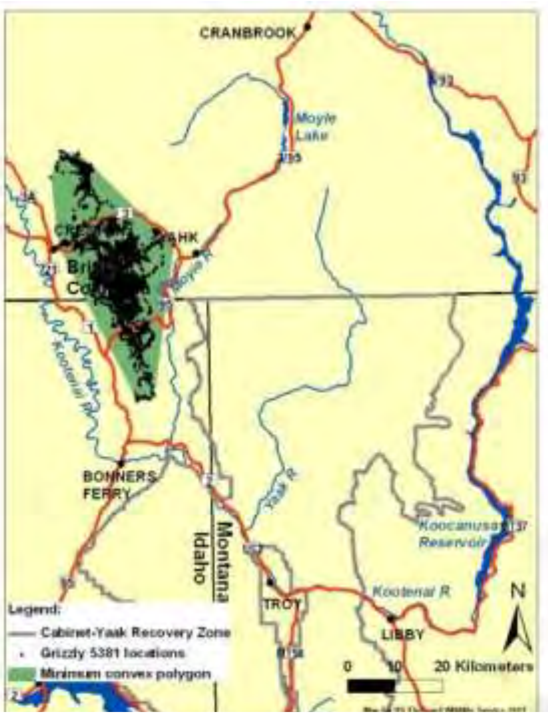
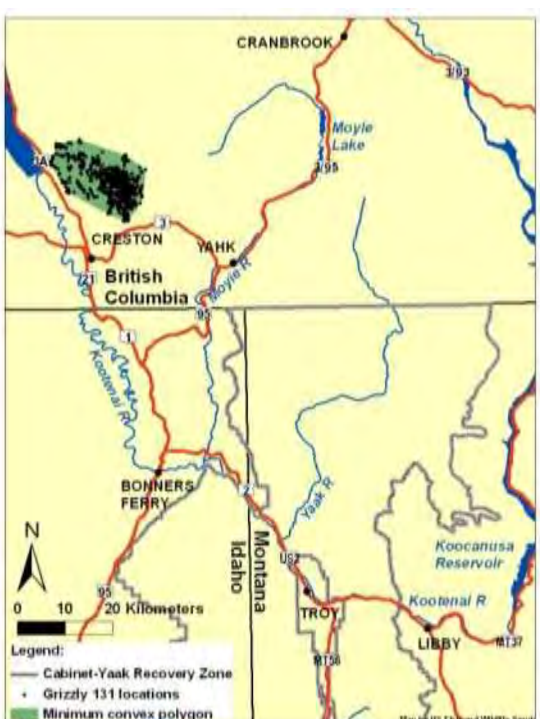


Figure A49. Radio locations and minimum convex (shaded) life range of male grizzly bear 5381 in the Purcell Mountains, 2006-07.

Figure A50. Radio locations and minimum convex (shaded) life range of female grizzly bear 130 in the Purcell Mountains, 2007-08.



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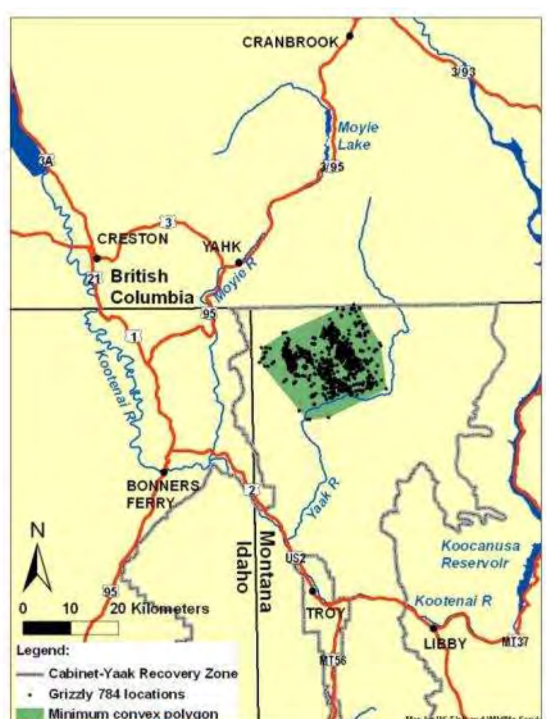

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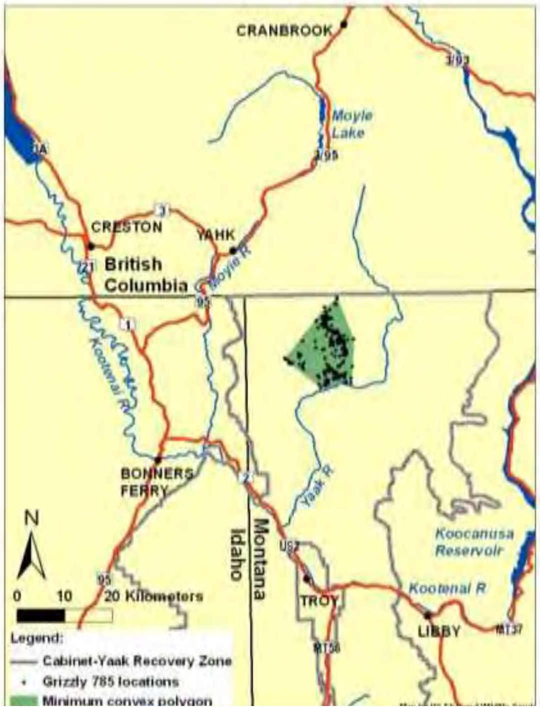


Figure A53. Radio locations and minimum convex (shaded) life range of female grizzly bear 785 in the Yaak River, 2007-08.

Figure A54. Radio locations and minimum convex (shaded) life range of female grizzly bear 772 in the Cabinet Mountains, 2007.

Figure A55. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 635 in the Cabinet Mountains, 2008.

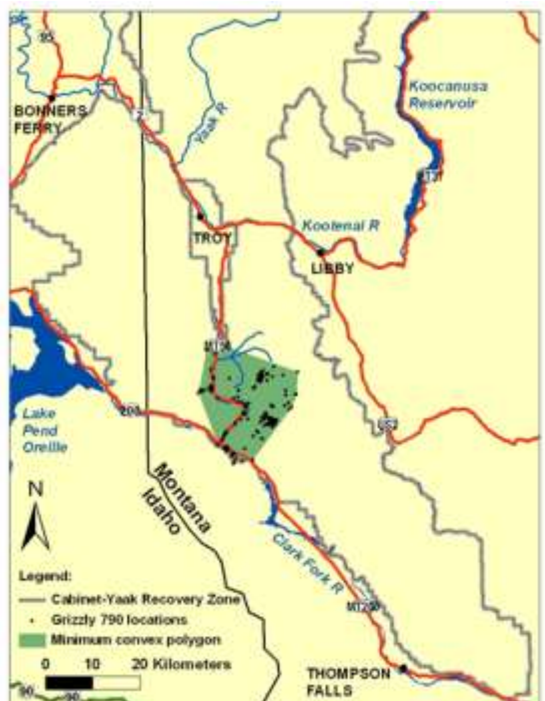


Figure A56. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 790 in the Cabinet Mountains, 2008.

Figure A57. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 715 in the Cabinet Mountains, 2009-10.

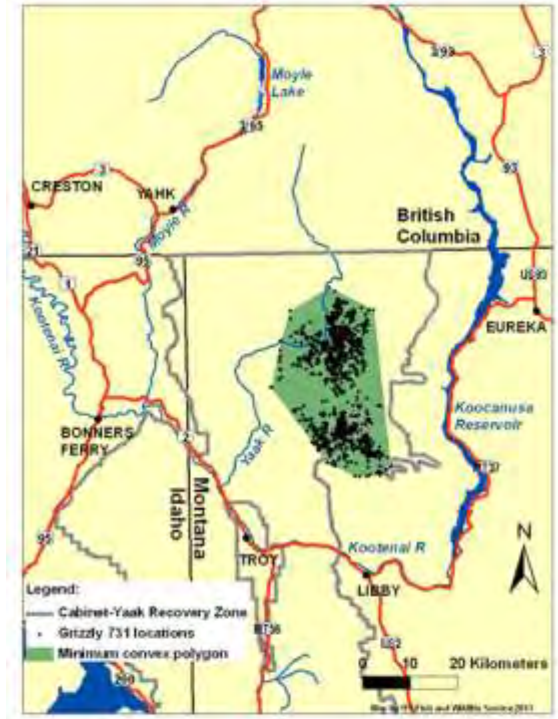


Figure A58. Radio locations and minimum convex (shaded) life range of female grizzly bear 731 in the Yaak River, 2009-11.

Figure A59. Radio locations and minimum convex (shaded) life range of male grizzly bear 799 in the Cabinet Mountains, 2009-10.

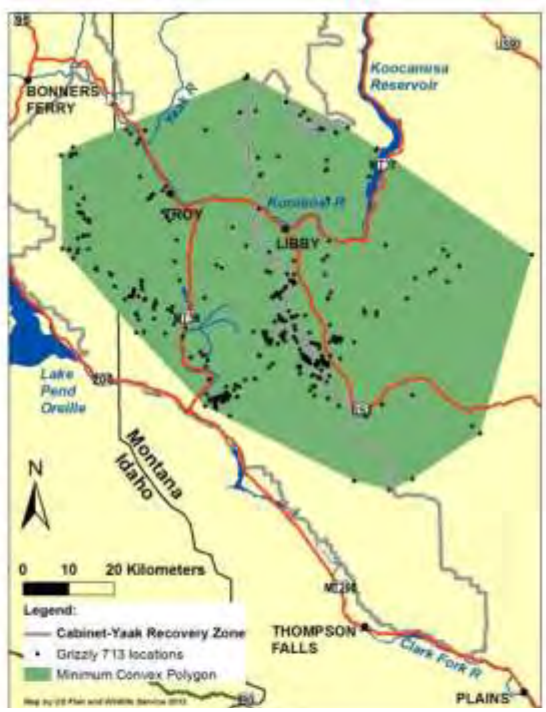


Figure A60. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 713 in the Cabinet Mountains, 2010-11.

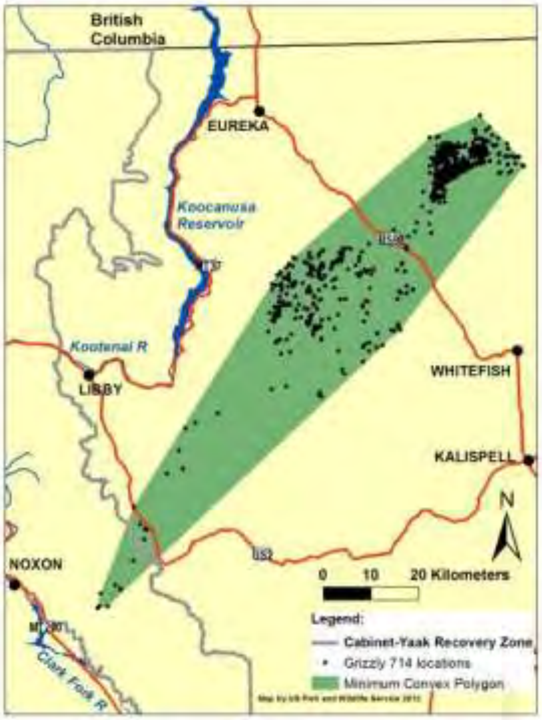


Figure A61. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 714 in the Cabinet Mountains, 2010-12.

Figure A62. Radio locations and minimum convex (shaded) life range of male grizzly bear 1374 in the Yaak River, 2010.

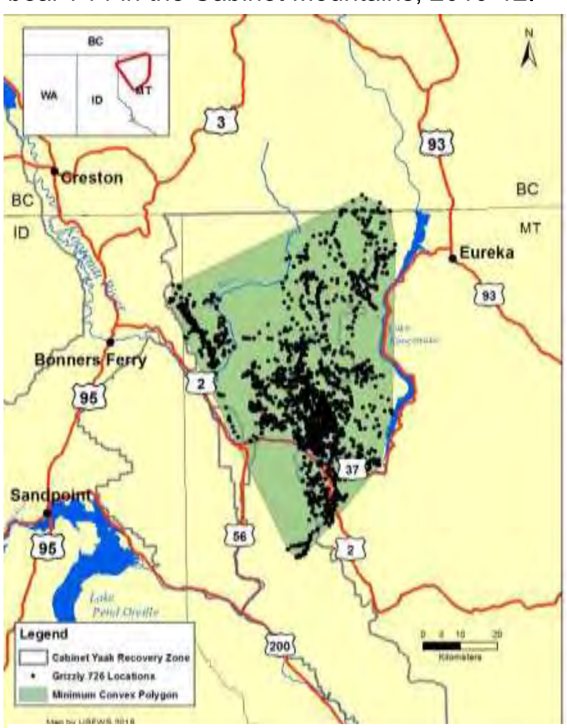


Figure A63 Radio locations and minimum convex (shaded) life range of male grizzly bear 726 in the Yaak River, 2011-12, 2015-17.

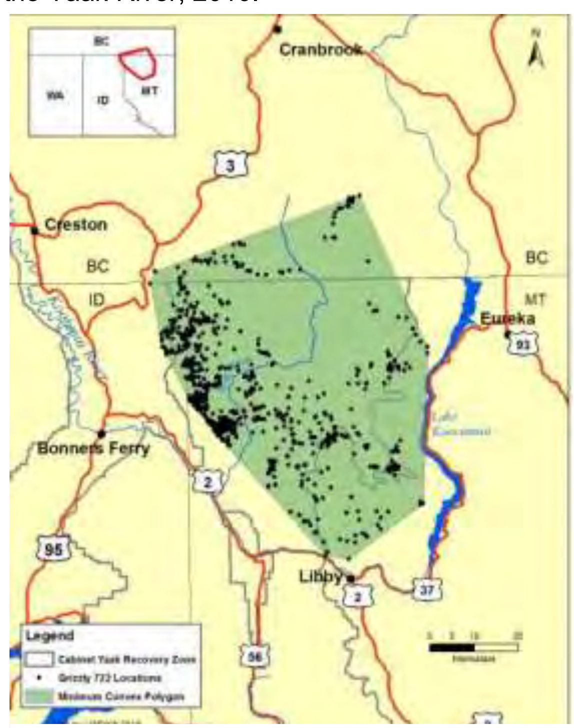


Figure A64. Radio locations and minimum convex (shaded) life range of male grizzly bear 722 in the Yaak River, 2011-12, 2014, 2016-17.

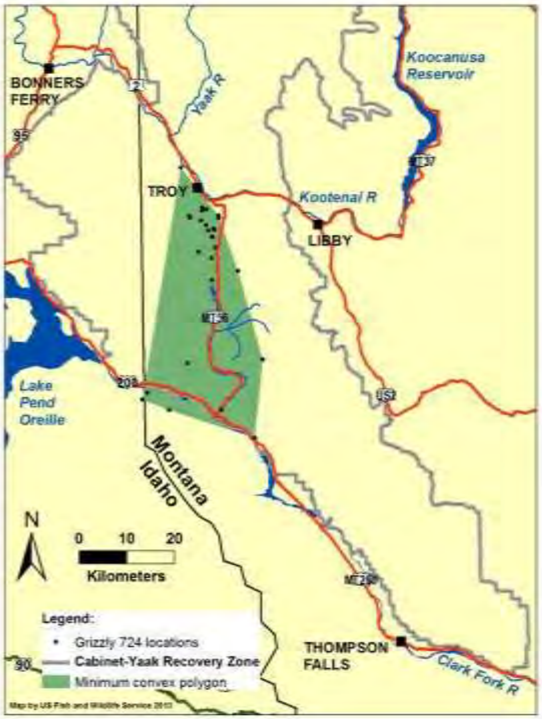


Figure A65. Radio locations and minimum convex (shaded) life range of management male grizzly bear 724 in the Cabinet Mountains, 2011-12.

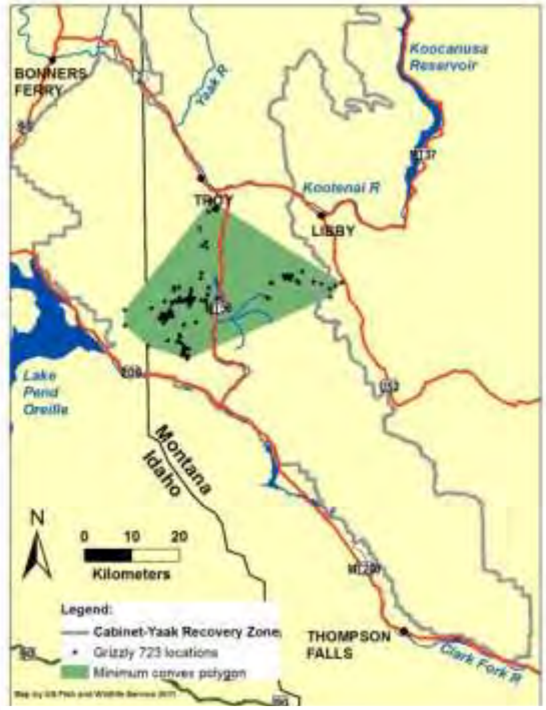


Figure A66. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 723 in the Cabinet Mountains, 2011-12.

Figure A67. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 725 in the Cabinet Mountains, 2011-13.

Figure A68. Radio locations and minimum convex (shaded) life range of management male grizzly bear 732 in the Yaak River, 2011.

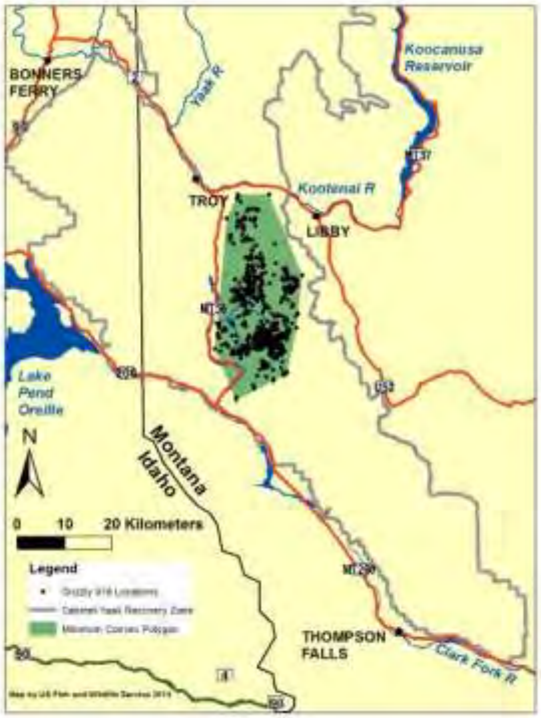


Figure A69. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 918 in the Cabinet Mountains, 2012-14.

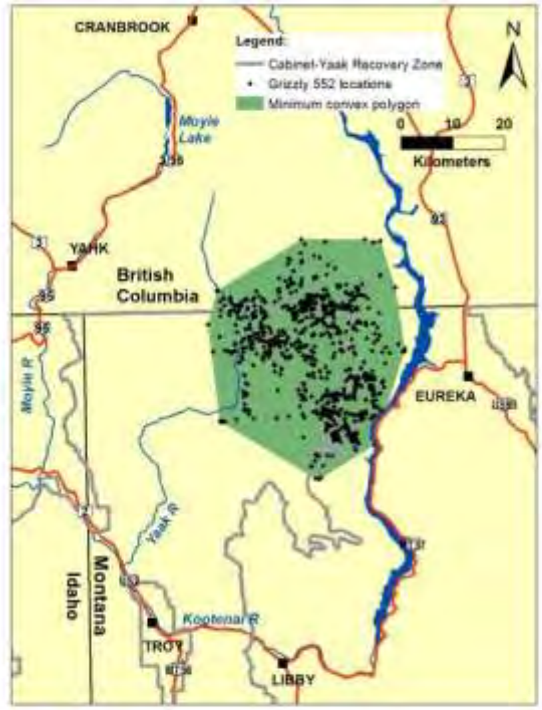


Figure A70. Radio locations and minimum convex (shaded) life range of female grizzly bear 552 in the Yaak River, 2012-15.

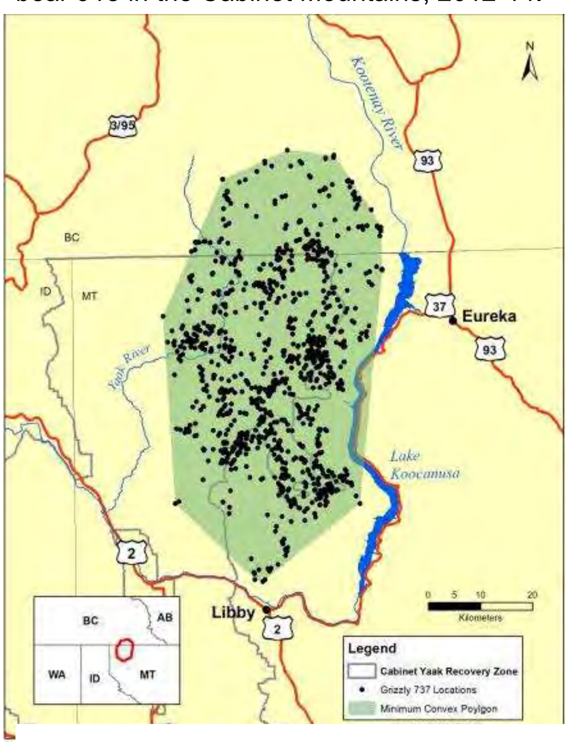


Figure A71. Radio locations and minimum convex (shaded) life range of male grizzly bear 737 in the Yaak River, 2010-13.

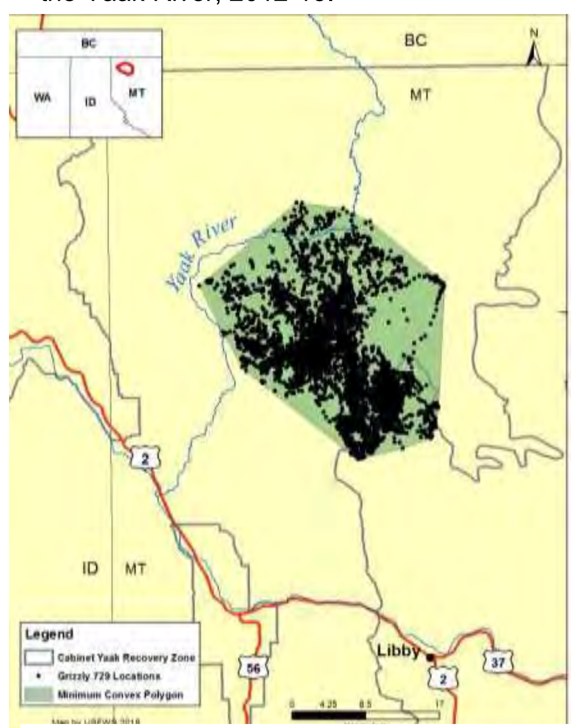


Figure A72. Radio locations and minimum convex (shaded) life range of female grizzly bear 729 in the Yaak River, 2013-17.

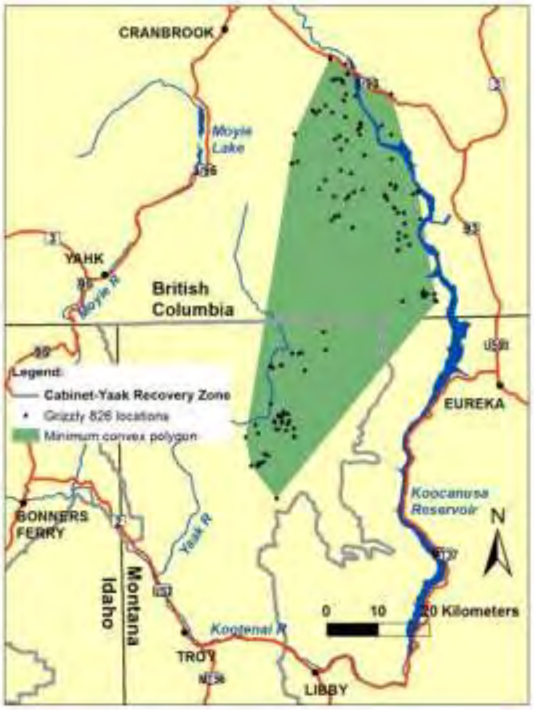


Figure A73. Radio locations and minimum convex (shaded) life range of male grizzly bear 826 in the Yaak River, 2013.

Figure A74. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 919 in the Cabinet Mountains, 2013-14.

Figure A75. Radio locations and minimum convex (shaded) life range of female grizzly bear 831 in the Cabinet Mountains, 2014.

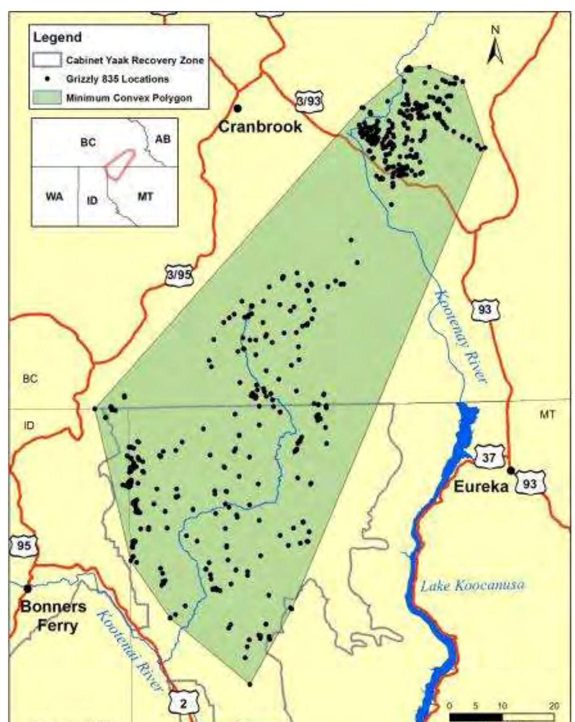
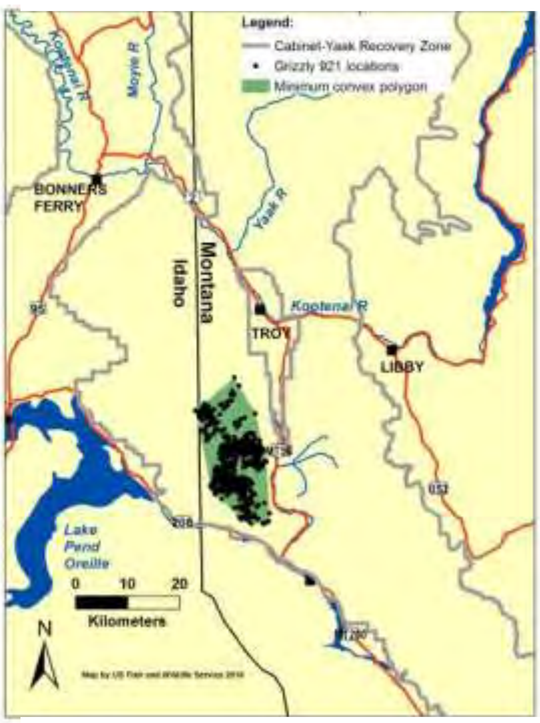


Figure A76. Radio locations and minimum convex (shaded) life range of male grizzly bear 835 in the Yaak River, 2014-16.

Figure A77. Radio locations and minimum convex (shaded) life range of male grizzly bear 837 in the Cabinet Mountains, 2014-16.

Figure A78. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 920 in the Cabinet Mountains, 2014-16.



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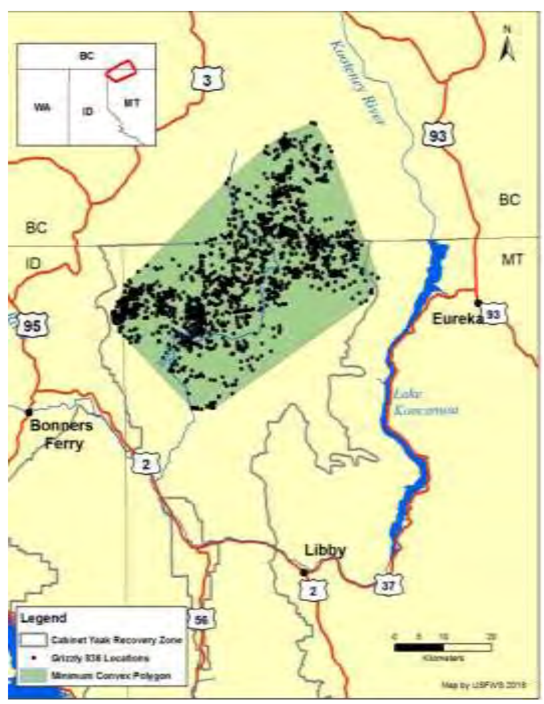

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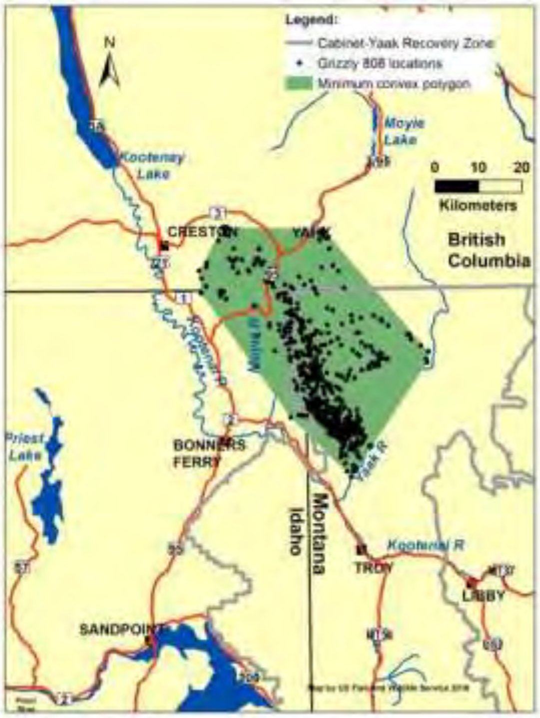


Figure A81. Radio locations and minimum convex (shaded) life range of male grizzly bear 808 in the Yaak River, 2014-15.

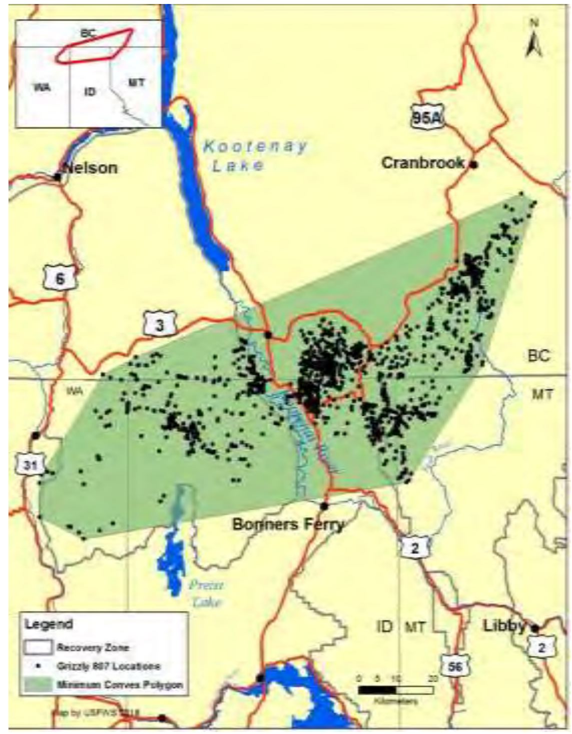


Figure A82. Radio locations and minimum convex (shaded) life range of male grizzly bear 807 in the Yaak River and Selkirk Mountains, 2014-17.

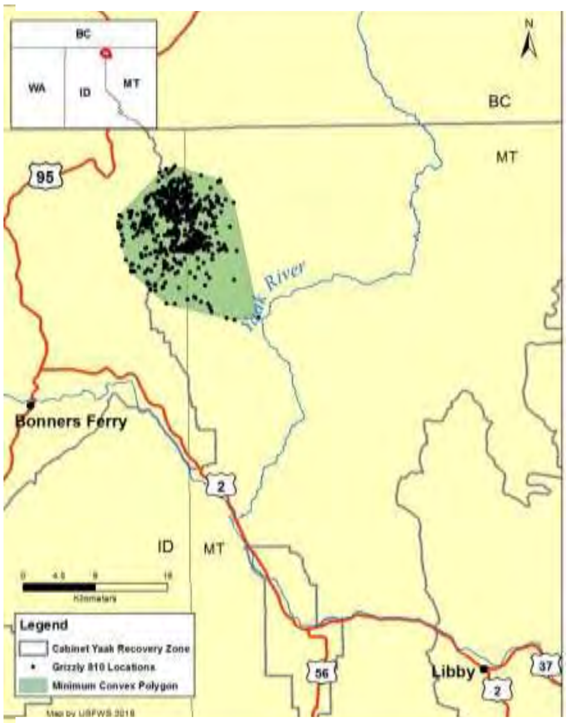


Figure A83. Radio locations and minimum convex (shaded) life range of female grizzly bear 810 in the Yaak River, 2015-17.

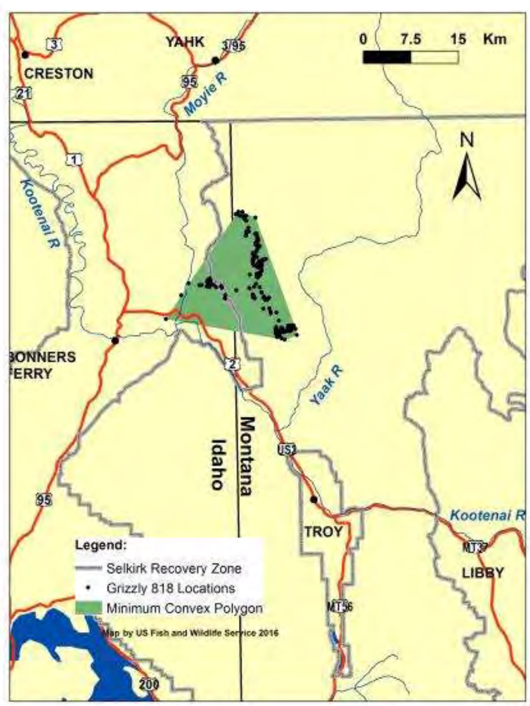


Figure A84. Radio locations and minimum convex (shaded) life range of male grizzly bear 818 in the Yaak River, 2015.

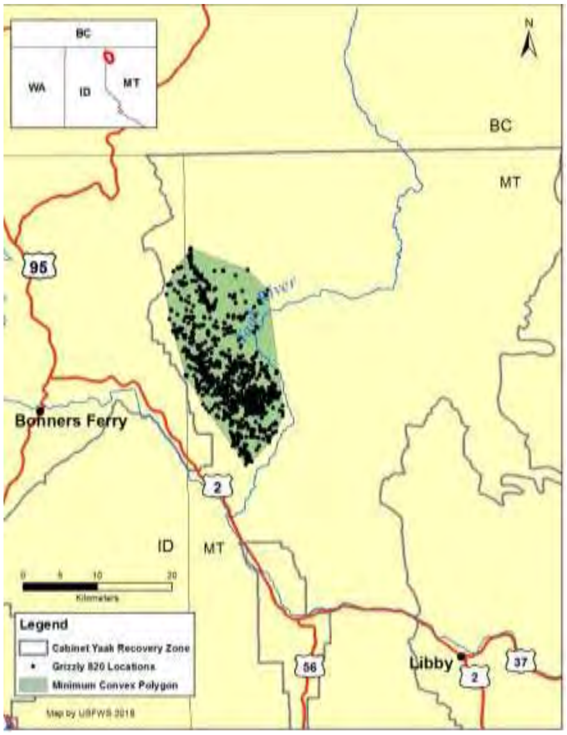


Figure A85. Radio locations and minimum convex (shaded) life range of female grizzly bear 820 in the Yaak River, 2015-17.

Figure A86. Radio locations and minimum convex (shaded) life range of male grizzly bear 839 in the Cabinet Mountains, 2015-16.

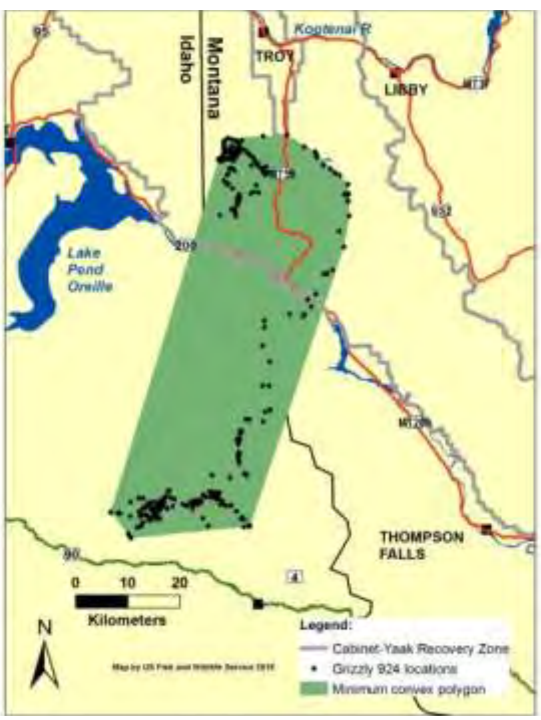


Figure A87. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 924 in the Cabinet Mountains, 2015.

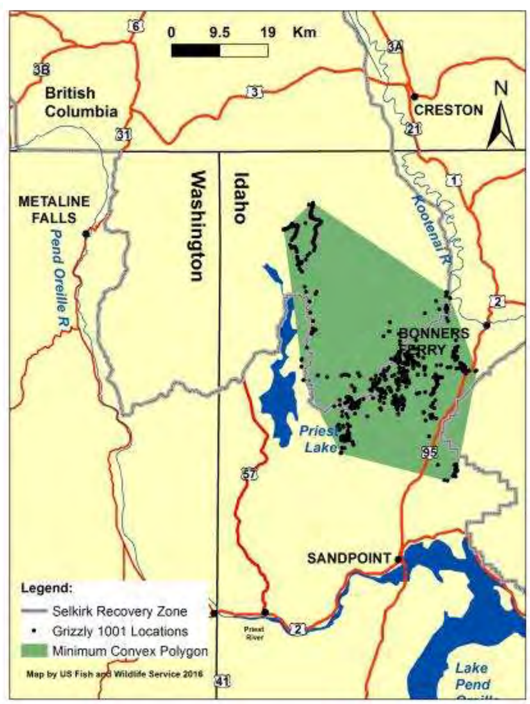
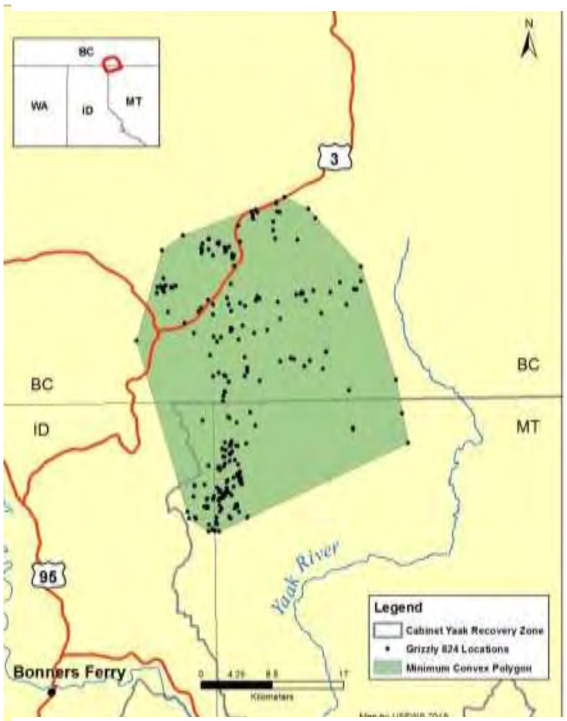


Figure A88. Radio locations and minimum convex (shaded) life range of male grizzly bear 1001 in the Selkirk and Cabinet Mountains, 2015.

Figure A89. Radio locations and minimum convex (shaded) life range of male grizzly bear 821 in the Yaak River, 2016-17.

Figure A90. Radio locations and minimum convex (shaded) life range of male grizzly bear 822 in the Yaak River, 2016.



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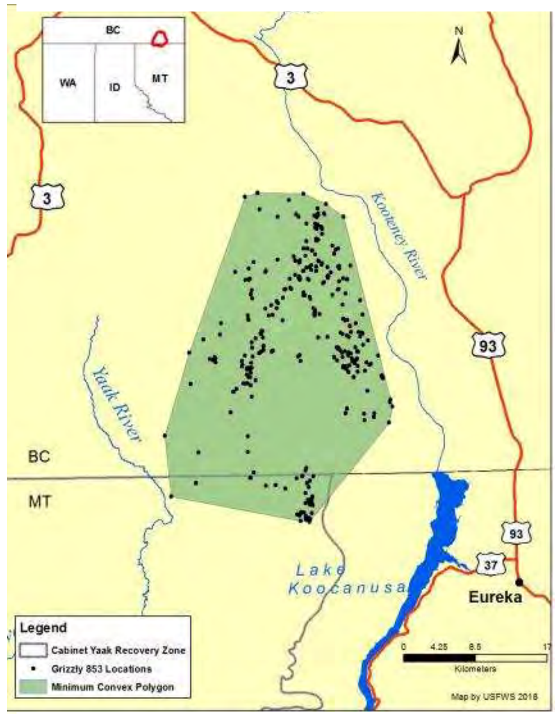

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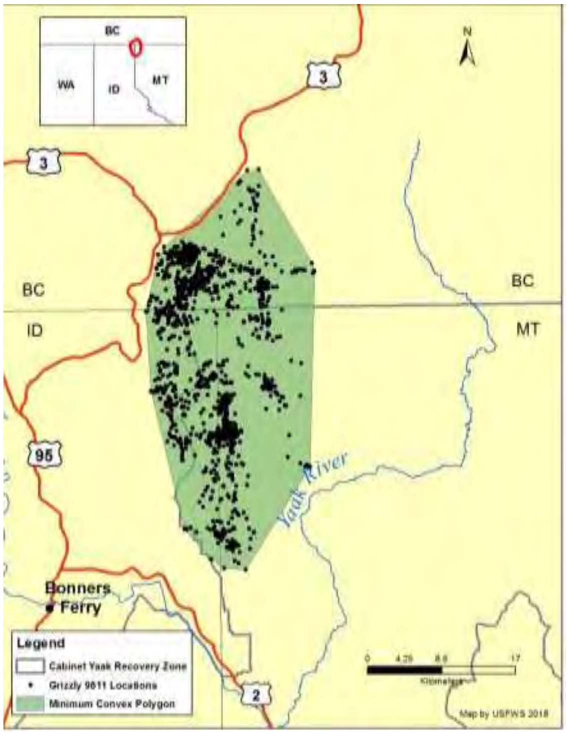
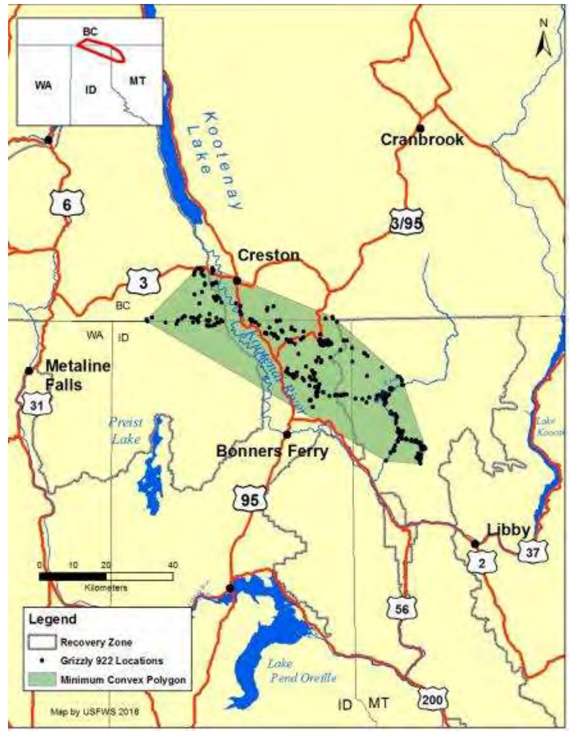


Figure A93. Radio locations and minimum convex (shaded) life range of male grizzly bear 9811 in the Yaak River, 2016-17.



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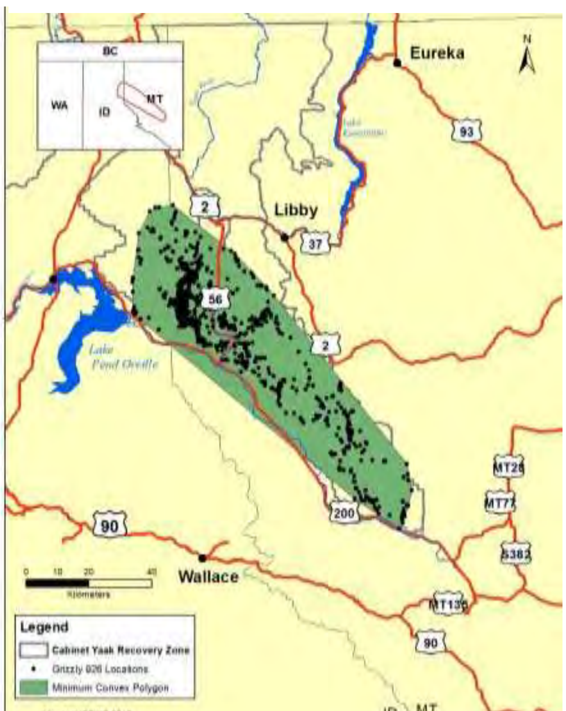

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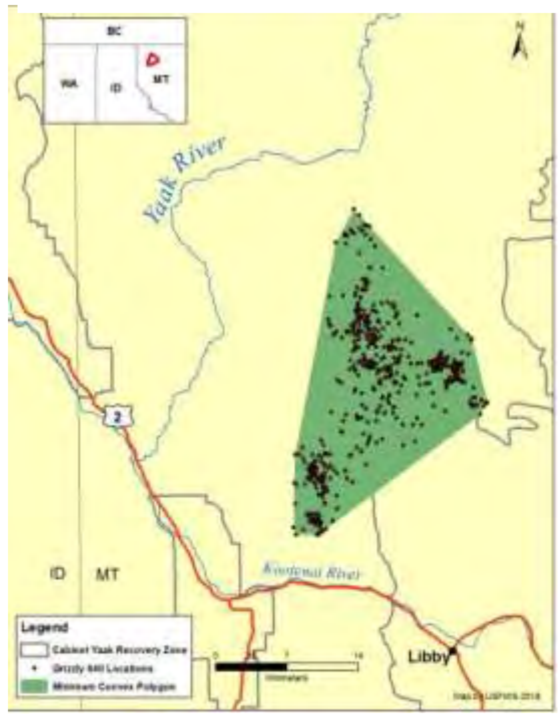


Figure A96. Radio locations and minimum convex (shaded) life range of female grizzly bear 840 in the Yaak River, 2016-17.

Figure A97. Radio locations and minimum convex (shaded) life range of female grizzly bear 842 in the Yaak River, 2017.

Figure A98. Radio locations and minimum convex (shaded) life range of male grizzly bear 861 in the Cabinet Mountains, 2017.

Figure A99. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1026 in the Yaak River, 2017.

Figure A100. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1028 in the Yaak River, 2017.

Table T4. Description of Habitat Components.

1. Closed Timber - Timber stands with tree cover greater than 60%, and a variable but often sparse understory.

2. Open Timber - Timbered sites with tree canopy cover of 30-60% and a sparse grass -forb understory. Found on dry exposures with a limited undergrowth of a few rhizomatous species.

3. Timbered Shrub field - Open timbered sites with tree cover of 30 to 60%, and a shrub dominated understory. Except for more xeric aspects, the shrub layer is well developed, and the forb layer is characteristically sparse due to limited light penetration.

4. Mixed Shrub/Snow chute - Shrub dominated communities resulting from, and often maintained by sudden snow slides on steep timbered drainages. They exist as narrow, linear openings in the forest canopy, or as extensive, broad chutes covering an entire slope.

5. Mixed Shrub/Cutting Unit - Open sites which have been harvested and are currently dominated by shrubs. Structure and composition is variable depending on harvest method, site treatment, habitat type, topographic position and time since harvest.

6. Mixed Shrub/Burn - Open sites, dominated by shrubs, which have developed following fire. Structure and composition is dependent on fire intensity, habitat type, topographic position and time since burn.

7. Alder Shrub - Tall shrub community dominated by alder (*Alnus sinuata*), almost to the exclusion of all other shrub species, with a herbaceous understory. Component can develop as a result of disturbance, but is often restricted to mesic sites.

8. Huckleberry Shrub - Seral shrub fields dominated by *Vaccinium* species. This open, low structured shrub field is created and at times maintained by fire. Timber harvest and snow slides may have the same developmental effect.

9. Riparian Stream bottom - Stream bottom habitat is identified by riparian plant associations, which reflect the influence of increased soil moisture. Considerable variation in vegetation composition and structure, with some sites being open and some timbered. The development and extent of riparian habitat is dependent on timber canopy and stream channel gradient.

10. Marsh - Open sedge dominated communities that are perennially moist, often containing standing water. Can exist as either unbroken monotypic communities or as infringing zones around open shallow lakes and ponds.

11. Wet Meadow - Mesic graminoid dominated communities along flat low elevation watersheds, and in slightly concave depressions at high elevations. Floristic composition varies between and within open meadows depending on slight differences in soil moisture.

12. Dry Meadow - Open graminoid dominated sites with level or gradual sloping topography, most commonly occurring at low elevations. Can be created by timber harvest, livestock grazing and fire. Vegetation composition is variable depending on the severity of soil disturbance and

topographic position of the site, and unless maintained, most sites reestablish shrub or regenerating conifer canopies.

13. Drainage Forb field - High elevation herbaceous fields with gradual to steep topography. Forb fields exist where sufficient soils have accumulated and where snowmelt percolating through shallow stony soils provides an endless supply of water through the growing season. Late in phenological development, a number of forbs continue to grow and flower into September and October.

14. Snow chute - Open, forb dominated snow chutes are the result of recent massive snow slides that remove both tree and shrub cover. Snow chutes in early successional herbaceous stages are uncommon, and occupy a site for a few years prior to shrub development.

15. Graminoid Sidehill Park - Graminoid dominated communities on moderate to steep slopes with convex topography, from mid to high elevations. Local topographic, edaphic and climatic influences combine to limit tree growth.

16. Beargrass Sidehill Park - Beargrass (*Xerophyllum tenex*) dominated communities on moderate to steep slopes with convex topography, from mid to high elevations. Generally located on shallow, well drained soils of south to west aspects. They exist as large homogenous openings along upper slopes and ridges, and small patches on basin headwalls.

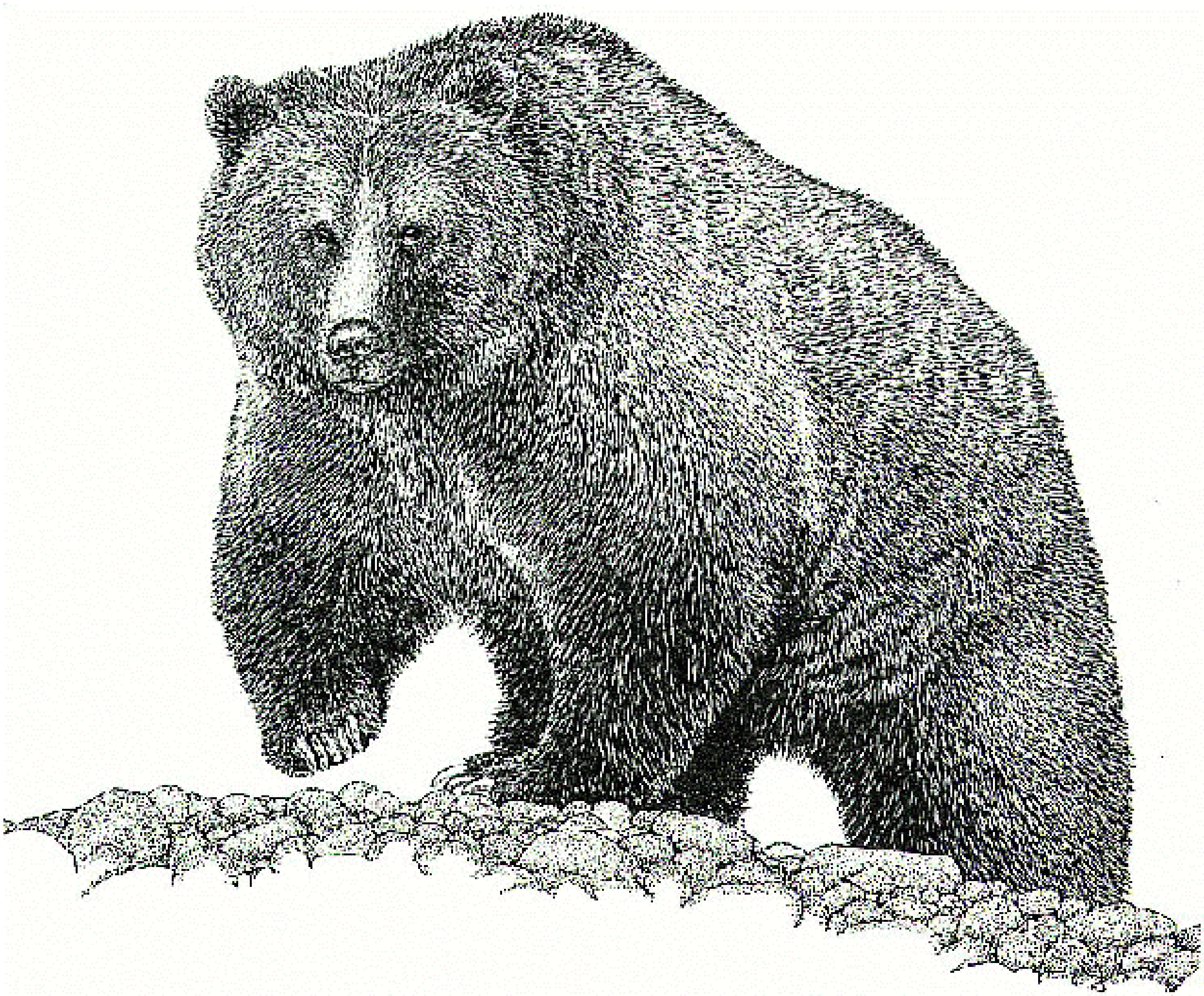
17. Slab rock - Open sites of exposed blocks of scoured - glaciated bedrock, occurring at high elevations on steep to gentle topography.

18. Talus/Rock/Scree - Very steep to moderate slopes and benches of loose rock fragments of variable size, with very sparse vegetation.

19. Timbered Grass - Open timbered sites with 30 to 60% tree canopy coverage and a graminoid dominated understory. Generally occur on well-drained soils, with gentle to steep slopes with south to west aspects.

EXHIBIT 2

CABINET-YAAK GRIZZLY BEAR RECOVERY AREA 2019 RESEARCH AND MONITORING PROGRESS REPORT



PREPARED BY
WAYNE F. KASWORM, THOMAS G. RADANDT, JUSTIN E. TEISBERG, TYLER VENT, ALEX WELANDER, MICHAEL PROCTOR, HILARY COOLEY, AND JENNIFER FORTIN-NOREUS
2020

UNITED STATES FISH AND WILDLIFE SERVICE
GRIZZLY BEAR RECOVERY COORDINATOR'S OFFICE
UNIVERSITY OF MONTANA, MAIN HALL ROOM 309
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This annual report is cumulative and represents data collected, reanalyzed and summarized annually since the inception of this monitoring program in 1983. Information in this report supersedes previous reports. Please obtain permission prior to citation. Cite as follows: **Kasworm, W. F., T. G. Radandt, J. E. Teisberg, T. Vent, A. Welander, M. Proctor, H. Cooley and J. Fortin-Noreus. 2020. Cabinet-Yaak grizzly bear recovery area 2019 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 105 pp.**

ABSTRACT

Twelve grizzly bears were monitored with radio-collars during portions of 2019. Research monitoring included four females (two adults and two subadults) and eight males (three adult and five subadults) in the Cabinet-Yaak Ecosystem (CYE). Two subadult males and a subadult female were from the Cabinet Mountains augmentation program. One adult male bear was collared for conflict management purposes. Grizzly bear monitoring and research has been ongoing in the Cabinet Mountains since 1983 and in the Yaak River since 1986. Eighty-one resident bears were captured and monitored through telemetry in the two areas from 1983–2019. Research in the Cabinet Mountains indicated that only a small population remained as of 1988. Concern over persistence of grizzly bear populations within this area resulted in a pilot program in 1990 that tested population augmentation techniques. Four subadult female bears with no history of conflicts with humans were captured in southeast British Columbia for release in the Cabinet Mountains during 1990–94. Three of four transplanted bears remained within the target area for at least one year. Hair snag sampling and DNA analysis during 2000–04 identified one of the original transplanted bears. The animal was a 2-year-old female when released in 1993. Genetic analysis conducted in 2005 identified at least three first-generation offspring and two second-generation offspring from this individual. Success of the augmentation test program prompted additional augmentation in cooperation with Montana Fish, Wildlife, and Parks (MFWP). Ten female bears and eight male bears were moved from the Flathead River to the Cabinet Mountains during 2005–19. Three of these individuals died during their first year from human related causes. Two were illegally shot and one was struck by a train. Eight bears left the target area for augmentation, but three returned.

Numbers of females with cubs in the CYE varied from 2–5 per year and averaged 3.0 per year, 2014–19. Eleven of 22 bear management units (BMUs) had sightings of females with young. Human caused mortality averaged 1.5 bears per year (0.5 female and 1.0 male), 2014–19. Ten grizzly bears (3 females and 7 males) died due to known or probable human causes during 2014–2019, including 2 adult females (under investigation, self-defense), 2 adult males (self-defense and management), 4 subadult males (self-defense, 2 human under investigation, and poaching), and 2 cubs (believed to be male and a female, under investigation).

Using all methods (capture, collared individuals, rub tree DNA, corral DNA, opportune DNA sampling, photos, credible observations), we detected a minimum 54 individual grizzly bears alive and in the CYE grizzly bear population at some point during 2018. Two of these bears were known dead and an additional 2 assumed dead by end of 2018. Twenty-five bears were detected in the Cabinets (14 male, 10 female, 1 unknown sex). Thirty-one bears were detected in the Yaak (19 male, 10 female, 2 unknown sex). Two subadult male bears were detected in both the Yaak and Cabinets in 2018.

Sex- and age-specific survival and reproductive rates yielded an estimated finite rate of increase (λ) of 1.009 (95% C.I. 0.931–1.073) for 1983–2019 using Booter software with the unpaired litter size and birth interval option. Finite rate of population change was an annual 0.9% for 1983–2019. The probability that the population was stable or increasing was 60%.

Berry counts indicated average production for huckleberry, buffaloberry, and mountain ash and less than average production for serviceberry during 2019.

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INTRODUCTION

Grizzly bear (*Ursus arctos*) populations south of Canada are currently listed as Threatened under the terms of the 1973 Endangered Species Act (16 U.S.C. 1531-1543). In 1993 a revised Recovery Plan for grizzly bears was adopted to aid the recovery of this species within ecosystems that they or their habitat occupy (USFWS 1993). Seven areas were identified in the Recovery Plan, one of which was the Cabinet-Yaak Grizzly Bear Recovery Zone (CYE) of extreme northwestern Montana and northeast Idaho (Fig. 1). This area lies directly south of Canada and encompasses approximately 6800 km^2. The Kootenai River bisects the CYE, with grizzly bear habitat within the Cabinet Mountains to the south and the Yaak River drainage to the north (Fig. 2). The degree of grizzly bear movement between the two portions was believed to be minimal but several movements by males into the Cabinet Mountains from the Yaak River and the Selkirk Mountains have occurred since 2012.

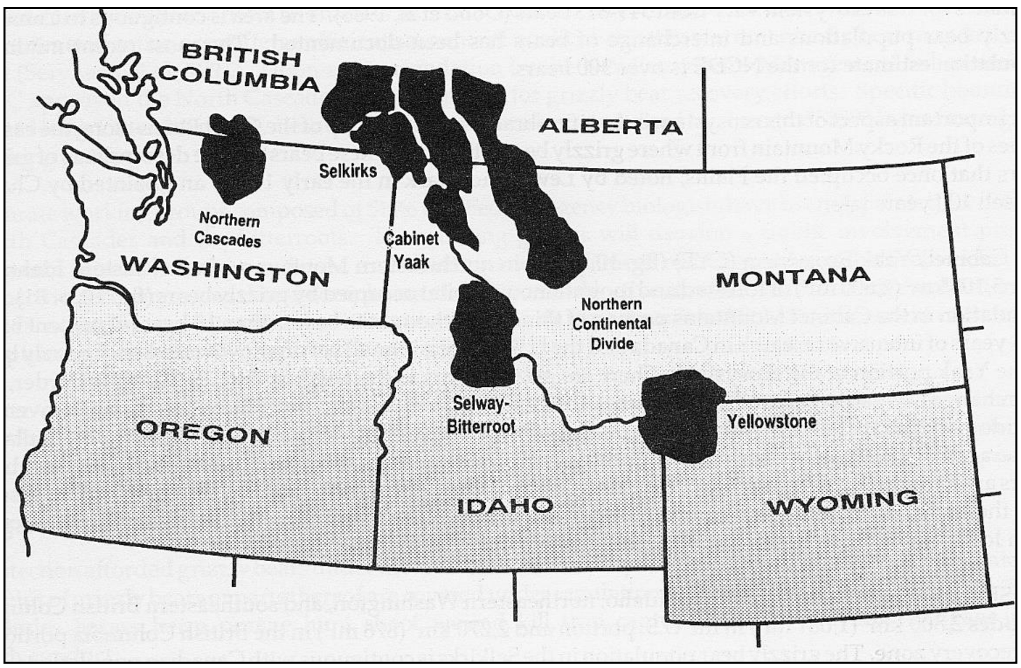

Figure 1. Grizzly bear recovery areas in the U.S., southern British Columbia, and Alberta, Canada.

Research on resident grizzly bears began south of the Kootenai River during the late 1970's. Erickson (1978) reported the results of a survey he conducted for bears and their sign in the Cabinet Mountains and concluded the population consisted of approximately a dozen animals. A trapping effort in 1979 and 1980 in the same area failed to capture a grizzly bear, but a female and yearling were observed (Thier 1981). In 1983 trapping efforts were resumed and intensified (Kasworm and Manley 1988). Three individual grizzly bears were captured and radio-collared during 1983–1987. Minimal reproduction was observed during the period and the population was believed to be declining toward extinction. To reverse this trend, a formal plan was proposed in 1987 to augment the Cabinet Mountains portion of the population with subadult female bears from outside the area (USFWS 1990, Servheen et al. 1987).

Two approaches for augmenting grizzly bears were proposed. The first involved transplanting adult or subadult grizzly bears from other areas of similar habitat to the Cabinet Mountains. Transplants would involve bears from remote areas that would have no history of conflict with humans. The use of subadult females was recommended because of their smaller home ranges and potential reproductive contribution. The second approach relied on the cross fostering of grizzly bear cubs to American black bear (*Ursus americanus*) females. Under this approach, grizzly bear cubs from zoos would be placed in the maternal dens of black bear females during March or April. The fostering of orphaned black bear cubs to surrogate black bear females has been used successfully in several areas (Alt and Beecham 1984, Alt 1984).

During public review of the augmentation program, many concerns were expressed which included human safety, conflicts with other land-uses, and long-term grizzly bear population goals. A citizen's involvement committee was formed to aid information exchange between the public and the agencies. Representatives of several local organizations donated their time to further this purpose. The first product of this group was a question and answer brochure regarding grizzly bears in the CYE. This brochure was mailed to all box holders in Lincoln and Sanders counties. In response to concerns expressed by the committee, the augmentation proposal was modified to eliminate cross fostering and to reduce total numbers of transplanted bears to four individuals over five years. The beginning date of augmentation was also postponed for one year to allow additional public information and education programs.

Prior to 1986, little work was conducted on grizzly bears in the Yaak River portion of the CYE. Bears that used the area were thought to be largely transitory from Canada. However, a black bear study in the Yaak River drainage in 1986 and 1987 resulted in the capture and radio-collaring of five individual grizzly bears (Thier 1990). The Yaak River area has traditionally been an important source of timber for area mills, with timber harvesting the dominant use of the area. A pine beetle (*Dendroctonus ponderosae*) epidemic began in the mid 1970's. Large stands of lodgepole pine (*Pinus contorta*) were infected, which resulted in an accelerated timber-harvesting program with clearcutting the dominant silvicultural technique. A concern of environmental degradation, as well as the effects of timber harvesting on the local grizzly bear population, prompted a lawsuit against the Forest Service by a local citizen's group in 1983 (USFS 1989). To obtain additional information on the population status and habitat needs of grizzly bears using the area, the U.S. Forest Service and (MFWP) cooperated with the U.S. Fish and Wildlife Service (USFWS) initiating a long term study. Field work began in June of 1989.

A population viability analysis recommended four areas of emphasis in future management for recovery of this population (Proctor *et al*. 2004). Those recommendations included: reducing human caused mortality, implementing population augmentation in the Cabinet Mountains, enhancing population interchange by improving internal and external population linkage, and motorized access management on public lands to reduce mortality risk and habitat displacement. Recovery efforts have and will continue to emphasize these recommendations.

OBJECTIVES

A. Cabinet Mountains Population Augmentation:

Test grizzly bear augmentation techniques in the Cabinet Mountains to determine if transplanted bears will remain in the area of release and ultimately contribute to the population through reproduction.

B. Recovery Zone Research and Monitoring:

1. Document grizzly bear distribution in the CYE.
2. Describe and monitor the grizzly bear population in terms of reproductive success, age structure, mortality causes, population trend, and population estimates and report this information through the grizzly bear recovery plan monitoring process.
3. Determine habitat use and movement patterns of grizzly bears. Determine habitat preference by season and assess the relationship between human-altered habitats such as logged

areas and grizzly bear habitat use. Evaluate grizzly bear movement permeability of the Kootenai River valley between the Cabinet Mountains and the Yaak River drainage and across the Moyie River Valley in British Columbia.

4. Determine the relationship between human activity and grizzly bear habitat use through the identification of areas used more or less than expected in relation to ongoing timber management activities, open and closed roads, and human residences.
5. Identify mortality sources and management techniques to limit human-caused mortality of grizzly bears.
6. Conduct black bear studies incidental to grizzly bear investigations to determine interspecific relations. Data on black bear densities, reproduction, mortality, movements, habitat-use, and food habits relative to grizzly bears will be gathered and analyzed.

STUDY AREA

The CYE (48º N, 116º W) encompasses approximately 6,800 km^2 of northwest Montana and northern Idaho (Fig. 2). The Cabinet Mountains constitute about 58% of the CYE and lie south of the Kootenai River. The Yaak River portion borders Canadian grizzly populations to the north. There are two potential linkage areas between the Yaak and the Cabinets – one between Libby and Troy and one between Troy and the Idaho border. Prior to 2012 we were unable to document any grizzly bear movement between these areas or grizzly bear use within these linkage zones; however, since that time we have documented several instances of male bears moving from the Selkirk Mountains or the Yaak River into the Cabinet Mountains. Approximately 90% of the recovery area is on public land administered by the Kootenai, Lolo, and Panhandle National Forests. Plum Creek Timber Company Inc. and Stimson Corp. are the main corporations holding a significant amount of land in the area. Individual ownership exists primarily along major rivers, and there are numerous patented mining claims along the Cabinet Mountains Wilderness boundary. The Cabinet Mountains Wilderness encompasses 381 km^2 of higher elevations of the study area in the Cabinet Mountains. Bonners Ferry,

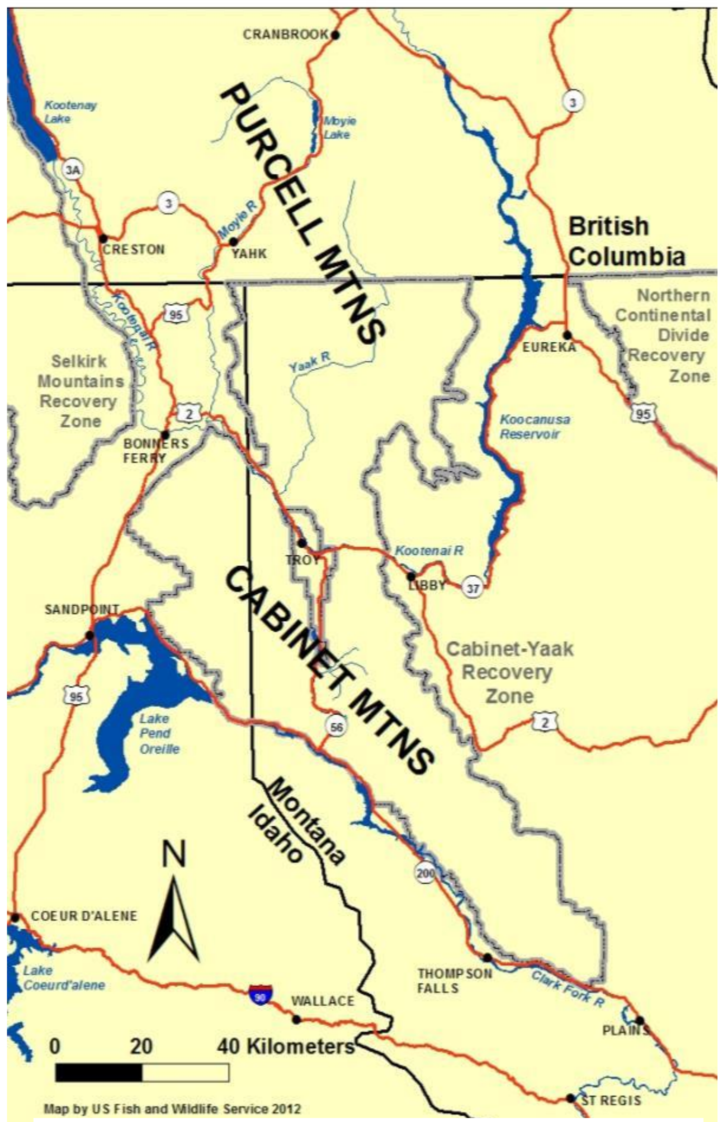

Figure 2. Cabinet-Yaak grizzly bear recovery zone.

Libby, Noxon, Sandpoint, Troy, Thompson Falls, and Trout Creek are the primary communities adjacent to the Cabinet Mountains.

Elevations in the Cabinet Mountains range from 610 m along the Kootenai River to 2,664 m at Snowshoe Peak. The area has a Pacific maritime climate characterized by short, warm summers and heavy, wet winter snowfalls. Lower, drier slopes support stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), whereas grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) dominate lower elevation moist sites. Subalpine fir (*Abies lasiocarpa*), spruce (*Picea spp*.), and mountain hemlock (*Tsuga mertensiana*) dominate stands between 1,500 m and timberline. Mixed coniferous and deciduous tree stands are interspersed with riparian shrub fields and wet meadows along major drainages. Huckleberry (*Vaccinium spp*.) and mixed shrub fields are partially a result of wildfires that occurred in 1910 and 1929 and more recent stand replacing fires. Fire suppression has reduced wildfires as a natural force creating or maintaining berry-producing shrub fields.

The Yaak River drainage lies in the extreme northwestern corner of Montana, northeastern Idaho, and southern British Columbia and is bounded on the east and south by Lake Koocanusa and the Kootenai River, to the west by the Moyie River, and to the north by the international boundary. Two north-south trending mountain ranges dominate the landscape - the McGillivray range in the east and the Purcell range to the west. Topography is varied, with rugged, alpine glaciated peaks present in the Northwest Peaks Scenic Area. Rounded peaks and ridges cover most of the remaining area, a result of continental glaciation. Coniferous forests dominate, with cutting units the primary source of diversity. Much of the Yaak River is low gradient and the river tends to meander, creating lush riparian zones and meadows. Elevations range from 550 m at the confluence of the Kootenai and Moyie Rivers to 2348 m atop Northwest Peak. Vegetation is diverse, with an overstory of western hemlock and western red cedar the indicated climax species on much of the study area. Ponderosa pine and Douglas-fir are common at lower elevations on south and west slopes. Subalpine fir and spruce dominate the upper elevations and cirque basins. Large stands of lodgepole pine and western larch (*Larix occidentalis*) occur at mid and upper elevations and are largely the result of extensive wildfires in the past. In recent decades, several stand altering fires have occurred in the Yaak River. Additionally, the Kootenai and Idaho Panhandle National Forests have implemented prescribed fire to promote grizzly bear habitat in recent years.

Understory and non-forested habitats include graminoid parks consisting primarily of fescue (*Festuca* spp.) and bluebunch wheatgrass (*Agropyron spicatum*), which occur at moderate to high elevations. Riparian shrub fields of red-osier dogwood (*Cornus stolonifera*) and hawthorn (*Crataegus douglasii*) are prevalent along major drainages. Buffaloberry (*Shepherdia canadensis*) is common under stands of open lodgepole pine while serviceberry (*Amelanchier alnifolia*) and chokecherry (*Prunus virginiana*) prevail on drier, rockier sites. Huckleberry shrub fields are often found under open timber canopies adjacent to graminoid parks, in old burns, in cutting units, and intermixed with beargrass (*Xerophyllum tenax*). Recent wildfires at upper elevations have had more influence on habitat in the CYE. An outbreak of pine bark beetles resulted in logging large areas at lower elevations during the 1980's. Large portions of upper elevations had been logged earlier in response to a spruce bark beetle (*Dendroctonus obesus*) epidemic.

During 1990–1994, Cabinet Mountains population augmentation trapping was conducted in the upper North Fork of the Flathead River drainage and the Wigwam River drainage in southeast British Columbia, approximately 10–40 km north of the U.S. border. Trapping was also conducted south of the international border in the North Fork of the Flathead River in 1992. Since 2005, augmentation trapping has occurred south of the international border in the Flathead River drainage.

METHODS

This annual report is cumulative and represents almost all data collected since the inception of this monitoring program since 1983. New information collected or made available to this study was incorporated into summaries and may change previous results.

Grizzly Bear Observations and Mortality

All grizzly bear observations and reports of sign (tracks, digs, etc.) by study personnel and the public were recorded. Grizzly bear sighting forms were sent to a variety of field personnel from different agencies to maximize the number of reports received. Sightings of grizzly bears were rated 1–5 with 5 being the best quality and 1 being the poorest. General definitions of categories are presented below, but it was difficult to describe all circumstances under which sightings were reported. Only sightings receiving ratings of 4 or 5 were judged credible for use in reports. Sightings that rate 1 or 2 may not be recorded in the database.

5 - Highest quality reports typically from study personnel or highly qualified observers. Sightings not obtained by highly qualified observers must have physical evidence such as pictures, track measurements, hair, or sightings of marked bears where marks are accurately described.

4 - Good quality reports that provide credible, convincing descriptions of grizzly bears or their sign. Typically, these reports include a physical description of the animal mentioning several characteristics. Observer had sufficient time and was close enough or had binoculars to aid identification. Observer demonstrates sufficient knowledge of characteristics to be regarded as a credible observer. Background or experience of observer may influence credibility.

3 - Moderate quality reports that do not provide convincing descriptions of grizzly bears. Reports may mention one or two characteristics, but the observer does not demonstrate sufficient knowledge of characteristics to make a reliable identification. Observer may have gotten a quick glimpse of the bear or been too far away for a good quality observation.

2 - Lower quality observations that provide little description of the bear other than the observer's judgment that it was a grizzly bear.

1 - Lowest quality observations of animals that may not have been grizzly bears. This category may also involve second hand reports from someone other than the observer.

Reported grizzly bear mortality includes all bears known to have died within the U.S. and within 16 km of the international border in Canada. Many bears collared in the U.S. have home ranges that extend into Canada. Mortality occurring in this area within Canada can affect calculations for U.S. populations. All radio collared bear mortality was reported regardless of location in the U.S. or Canada.

Survival and Mortality Calculations

Survival rates for all age classes except cubs were calculated by use of the Kaplan-Meier procedure as modified for staggered entry of animals (Pollock et al. 1989, Wakkinen and Kasworm 2004). Assumptions of this method include: marked individuals were representative of the population, individuals had independent probabilities of survival, capture and radio collaring did not affect future survival, censoring mechanisms were random, a time origin could be defined, and newly collared animals had the same survival function as previously collared animals. Censoring was defined as radio-collared animals lost due to radio failure, radio loss, or emigration of the animal from the study area. Kaplan-Meier estimates may differ slightly from Booter survival estimates used in the trend calculation. Survival rates were calculated separately for native, augmentation, and management bears because of biases associated with the unknown proportion of management bears in the population and known differences in survival functions.

Our time origin for each bear began at capture. If a bear changed age classification while radio-collared (i.e., subadult to adult), the change occurred on the first of February (the assigned birth date of all bears). Weekly intervals were used in the Kaplan-Meier procedure during which survival rates were assumed constant. No mortality was observed during the denning season. Animals were intermittently added to the sample over the study. Mortality dates were established based on radio telemetry, collar retrieval, and mortality site inspection. Radio failure dates were estimated using the last radiolocation date when the animal was alive.

Cub recruitment rates to 1 year of age were estimated as: {1 - (cub mortalities / total cubs observed)}, based on observations of radio-collared females (Hovey and McLellan 1996). Mortality was assumed when a cub disappeared or if the mother died. Cubs were defined as bears < 1.0-year-old.

Use of known human-caused mortality counts probably results in under-estimates of total human-caused mortality. Numerous mortalities identified by this study were reported only because animals wore a radio-collar at the time of death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry *et al*. 2002). The correction factor was not applied to natural mortality, management removals, mortality of radio-collared bears, or bears that died of unknown causes. All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes.

Cabinet Mountains augmentation individuals were counted as mortalities when removed from the Northern Continental Divide Ecosystem and are not counted again as mortalities in the CYE if they die during their first year (Appendix Table T2). Mortalities in Canada are not counted toward recovery goals (USFWS 1993) even though bears initially marked within the CYE have died in Canada. Bears originating in Canada that die in the US are counted.

Reproduction

Reproduction data was gathered through observations of radio-collared females with offspring and genetics data analyzed for maternity relationships. Because of possible undocumented neonatal loss of cubs, no determination of litter size was made if an observation was made in late summer or fall. Inter-birth interval was defined as length of time between subsequent births. Age of first parturition was determined by presence or lack of cubs from observations of aged radio-collared bears and maternity relationships in genetics data from known age individuals.

Population Growth Rate

We used the software program Booter 1.0 (© F. Hovey, Simon Fraser University, Burnaby, B.C.) to estimate the finite rate of increase (λ, or lambda) for the study area's grizzly bear populations. The estimate of λ was based on adult and subadult female survival, yearling and cub survival, age at first parturition, reproductive rate, and maximum age of reproduction.

Booter uses the following revised Lotka equation (Hovey and McLellan 1996), which assumes a stable age distribution:

(1) $$0 = \lambda^{a} - S_a \lambda^{a-1} - S_c S_y S_s^{a-2} m[1 - (S_a / \lambda)^{w-a+1}],$$

where S_a, S_s, S_y, and S_c are adult female, subadult female, yearling, and cub survival rates, respectively, a = age of first parturition, m = rate of reproduction, and w = maximum age. Booter calculates annual survival rates with a seasonal hazard function estimated from censored telemetry collected through all years of monitoring in calculation of λ. This technique was used on adults, subadults, and yearlings. Point estimates and confidence intervals may be slightly different from those produced by Kaplan-Meier techniques (differences in Tables 14 and 15). Survival rate for each class was calculated as:

$$(2) \quad S_i = \prod_{j=1}^{k} e^{-L_j(D_{ij} - T_{ij})}$$

where S_i is survival of age class *i*, *k* is the number of seasons, D_{ij} is the number of recorded deaths for age class *i* in season *j*, T_{ij} is the number of days observed by radio telemetry, and L_j is the length of season *j* in days. Cub survival rates were estimated by 1 - (cub mortalities / total cubs born), based on observations of radio-collared females. Intervals were based on the following season definitions: spring (1 April - 31 May), summer (1 June - 31 August), autumn (1 September - 30 November), and winter (1 December - 31 March). Intervals were defined by seasons when survival rates were assumed constant and corresponded with traditional spring and autumn hunting seasons and the denning season.

Booter provides several options to calculate a reproductive rate (*m*) and we selected three to provide a range of variation (McLellan 1989). The default calculation requires a reproductive rate for each bear based upon the number of cubs produced divided by the number of years monitored. We input this number for each adult female for which we had at least one litter size and at least three successive years of radio monitoring, captures, or observations to determine reproductive data. We ran the model with this data and produced a trend calculation. Among other options, Booter allows use of paired or unpaired litter size and birth interval data with sample size restricted to the number of females. If paired data is selected, only those bears with both a known litter size and associated inter-birth interval are used. The unpaired option allows the use of bears from which accurate counts of cubs were not obtained but interval was known, for instances where litter size was known but radio failure or death limited knowledge of intervals. To calculate reproductive rates under both these options, the following formula was used (from Booter 1.0):

$$(3) \quad m = \frac{\sum_{i=1}^{n} \dfrac{\sum_{j=1}^{p} L_{ij}}{\sum_{j=1}^{k} B_{IJ}}}{n}$$

where n = number of females; *j* = observations of litter size (*L*) or inter-birth interval (*B*) for female *i*; *p* = number of observations of *L* for female *i*; and *k* = number of observations of *B* for female *i*. Note *k* and *p* may or may not be equal. Cub sex ratio was assumed to be 50:50 and maximum age of female reproduction (*w*) was set at 27 years (Schwartz *et al*. 2003). Average annual exponential rate of increase was calculated as $r = \log_e \lambda$ (Caughley 1977).

Bears captured and relocated to the Cabinet Mountains as part of population augmentation were not included in the population trend calculation (Appendix Table T1). None of these animals had any prior history of nuisance activity. Bears captured initially as objects of conflict captures were not included. Several native bears that were captured as part of a preemptive move to avoid nuisance activity were included. Currently collared bears that became management bears while wearing a collar were included.

Capture and Marking

Capture and handling of bears followed an approved Animal Use Protocol through the University of Montana, Missoula, MT (061-14CSCFC111714). Capture of black bears and grizzly bears was performed under state permits 2019-013 and federal permit TE704930-2. Bears were captured with leg-hold snares following the techniques described by Johnson and Pelton (1980) and Jonkel (1993). Snares were manufactured in house following the Aldrich Snare Co. (Clallam Bay, WA) design and consist of 6.5 mm braided steel aircraft cable. Bears were immobilized with either Telazol (tiletamine hydrochloride and zolazepam hydrochloride), a mixture of Ketaset (ketamine hydrochloride) and Rompun (xylazine hydrochloride), a mixture of Telazol and Dexmedetomidine, or a combination of Telazol and Rompun. Yohimbine and Atipamezole were the primary antagonists for Rompun and Dexmedetomidine. Drugs were administered intramuscularly with a syringe mounted on a pole (jab-stick), homemade blowgun, modified air pistol, or cartridge powered dart gun. Immobilized bears were measured, weighed, and a first premolar tooth was extracted for age determination (Stoneberg and Jonkel 1966). Blood, tissue and/or hair samples were taken from most bears for genetic and food use studies. Immobilized bears were given oxygen at a rate of 2–3 liters per minute. Recovering bears were dosed with Atropine and Diazepam.

All grizzly bears (including management bears captured at conflict sites) and some adult black bears (≥ 4.0 years old) were fitted with radio collars or ear tag transmitters when captured. Some bears were collared with Global Positioning System (GPS) radio collars. Collars were manufactured by Telonics® (Mesa, AZ) and ear tag transmitters were manufactured by Advanced Telemetry Systems® (Isanti, MN). To prevent permanent attachment, a canvas spacer was placed in the collars so that they would drop off in 1–3 years (Hellgren *et al*. 1988).

Trapping efforts were typically conducted from May through September. In 1986–87, snares were placed in areas where black bear captures were maximized on a defined study area of 214 km^2 (Thier 1990). Snares were placed over a broader area during 1989–94 to maximize grizzly bear captures. Trap sites were usually located within 200 m of an open road to allow vehicle access. Beginning in 1995, an effort was made to capture and re-collar known grizzly bears in the Yaak River and augmentation bears in the Cabinet Mountains. In 2003, trapping was initiated in the Salish Mountains south of Eureka, Montana to investigate bear movements in the intervening area between the Northern Continental Divide and CYE recovery zones. Trapping was conducted along Highway 2 in northwest Montana and along Highway 3 in southeast British Columbia to collar bears with GPS radio collars during 2004–2010. During 2011, trapping was initiated along Highway 95 near McArthur Lake in northern Idaho and along Interstate 90 near Lookout Pass in Montana and Idaho. All four studies were designed to examine bear population connectivity across river valleys with highways and human habitation. Highway 2, 95, and I-90 studies utilized black bears as surrogates for grizzly bears because of the small number of grizzly bears in the valley. The Highway 3 effort in British Columbia collared grizzly bears and black bears. Much of the trapping effort in the Yaak and Cabinet Mountains areas involved the use of horses on backcountry trails and closed logging roads. Traps were checked daily. Bait consisted primarily of road-killed ungulates.

Trapping for population augmentation was conducted in the North Fork of the Flathead River in British Columbia during 1990–94. Only female grizzly bears < 6 years old (or prior to first reproduction) and > 35 kg were deemed suitable for transplant. Other captured grizzly bears were released with some collared to aid an ongoing BC bear study. Capture efforts for bears transplanted in 2005–19 occurred primarily in the North Fork and South Fork of the Flathead River in the US by MFWP. No suitable bears were captured in 1991, 2007, or 2017.

Hair Sampling for DNA Analysis

This project originally sought evidence of grizzly bears in the Cabinet Mountains using DNA to understand the fates of four bears transplanted during 1990–94. The program used genetic information from hair-snagging with remote-camera photo verification to identify transplanted bears or their offspring living in the Cabinet Mountains. Since then, sampling has expanded into the Yaak drainage and project objectives now include: observations of females with young, sex ratio of captured bears, relatedness as well as genetic diversity measures of captured bears, and evidence of interpopulation movements of individuals.

Sampling occurred from May–October of 2002–19 in the CYE in Idaho and Montana following standard hair snagging techniques (Woods *et al.* 1999). Sampling sites were established based on location of previous sightings, sign, and radio telemetry from bears in the CYE. A 5 km x 5 km grid (25 km^2) was used to distribute sample sites across the Cabinet Mountains in 2003 (n=184). Each grid cell contained a single sample point near the center of the cell. Actual site location was modified on the basis of access to the site and habitat quality near the site. Sites were baited with 2 liters of a blood and fish mixture to attract bears across a barbwire perimeter placed to snag hair. Sites were deployed for 2 weeks prior to hair collection. One third of sites were sampled during each of the months of June, July, and August. Sample sites were stratified by elevation with lowest elevation sites sampled in June and highest elevation sites sampled in August. Trail cameras were used at some sites. Hair was collected and labeled to indicate: number and color of hairs, site location, date, and barb number. These data aided sorting hair to minimize lab costs. Solid black hairs were judged to be from black bears and not analyzed further. Samples collected as a part of this effort and other hair samples collected in previous years either from known grizzly bears or samples that outwardly appeared to be grizzly bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Hairs visually identified as black bear hair by technicians at the Laboratory were not processed and hairs processed and determined to be black bear were not genotyped. Dr. Michael Proctor (Birchdale Ecological) is a cooperator on this project and assisted with genetic interpretations. He has previously analyzed genetic samples from the Yaak portion of this recovery zone (Proctor 2003). Hair snag sampling effort during 2012 was altered and reduced to avoid conflicts with a US Geological Survey (USGS) study to estimate CYE grizzly bear population size (Kendall *et al*. 2015). USGS was concerned that our sample sites might influence capture success at their sites.

The USGS study established and sampled 1,373 rub trees across the CYE during 2012. The study made preliminary data available regarding the success of this effort by providing us coordinates of all trees and those trees that produced grizzly bear samples. Sites that produced grizzly bear hair and adjacent sites that were easily sampled in conjunction with successful sites were resampled 2–4 times during 2013–19. Collected hairs were evaluated by study personnel and samples not judged to be probable black bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping.

Radio Monitoring

Attempts were made to obtain aerial radiolocations on all instrumented grizzly bears at least once each week during the 7–8 month period in which they were active. GPS collars attempted a location fix every 1–2 hours. Collar releases were programmed to drop in early October for retrieval. Expected collar life varied from 1–3 field seasons over the course of the study depending upon model of collar and programming. Augmentation bears were monitored daily following release for at least the first two weeks and usually three times per week following. In addition, efforts were made to obtain as many ground locations as possible on all bears, usually by triangulating from a vehicle. Life home ranges (minimum convex polygons; Hayne 1959) were calculated for grizzly bears during the study period. We generated home range polygons using ArcMap 10.

Grizzly and black bears were collared with GPS collars during 2004–10 to study movements across the Moyie River Valley and Highway 3 in British Columbia. Black bears were tested for their potential to act as surrogates that would predict grizzly bear movements. Collars attempted locations every 1–2 hours depending on configuration and data were stored within the collar. Weekly aircraft radio monitoring was conducted to check for mortality signals and approximate location. From 2004 to 2007, black bears were fitted with similar GPS radio collars to study movements across the Kootenai River Valley and Highway 2 in Montana, as part of linkage monitoring between the Yaak River and Cabinet Mountains. In 2008–2012, black bears were fitted with GPS collars in the Yaak River study area and along the Clark Fork River on the south end of the Cabinet Mountains study area.

Scat analysis

Bear scats were collected, tagged, and either dried or frozen. We only considered scats associated with definite grizzly bear sign (tracks, hair, and radio location of instrumented bear) as from grizzly bears. Food habits analysis was completed by William Callaghan (Florence, MT) and Kevin Frey (Bozeman, MT). Samples were rinsed with hot and cold water over 2 different size mesh screens (0.40 and 0.24 cm). The retained contents were identified to species with the aid of microscopes. We recorded plant part and visually estimated percent volume. We corrected scat volumes with correction factors that incorporate different digestibilities of various food items (Hewitt and Robbins 1996).

Isotope analysis

Hair samples from known age, captured grizzly bears were collected and analyzed for stable isotopic ratios. Stable isotope signatures indicate source of assimilated (i.e., digested) diet of grizzly bears. Nitrogen stable isotope ratios (^{15}N) indicate trophic level of the animal; an increased amount of ingested animal matter yields higher nitrogen isotope ratios while lower values tie to more plant-based diets. In our ecosystem, carbon isotope signatures vary depending on the amount of native C3 vs. C4 plant matter ingested. Corn, a C4 plant, has elevated ^{13}C/^{12}C ratios relative to native C3 plants. Because much of the human food stream is composed of corn, carbon stable isotope signatures allow for verification or identification of human food conditioned bears.

Hair samples were rinsed with a 2:1 chloroform:methanol solution to remove surface contaminants. Samples were then ground in a ball mill to homogenize the sample. Powdered hair was then weighed and sealed in tin boats. Isotope ratios of δ^{13}C and δ^{15}N were assessed by continuous flow methods using an elemental analyzer (ECS 4010, Costech Analytical, Valencia, California) and a mass spectrometer (Delta PlusXP, Thermofinnigan, Bremen, Germany) (Brenna *et al*. 1997, Qi *et al*. 2003).

Berry Production

Quantitative comparisons of annual fluctuations and site-specific influences on fruit production of huckleberry and buffaloberry were made using methods similar to those established in Glacier National Park (Kendall 1986). Transect line origins were marked by a painted tree or by surveyors' ribbon. A specific azimuth was followed from the origin through homogenous habitat. At 0.5 m intervals, a 0.04 m^2 frame (2 x 2 decimeter) was placed on the ground or held over shrubs and all fruits and pedicels within the perimeter of the frame were counted. If no portion of a plant was intercepted, the frame was advanced at 0.5 meter intervals and empty frames were counted. Fifty frames containing the desired species were counted on each transect. Timbered shrub fields and mixed shrub cutting units were the primary sampling areas to examine the influence of timber harvesting on berry production within a variety of aspects and elevations. Notes on berry phenology, berry size, and plant condition were recorded. Service berry, mountain ash, and buffaloberry production was estimated from 10 marked plants at several sites scattered across the recovery area. Since 1989 several sites have been added or relocated to achieve goals for geographic distribution. Some transects were eliminated because plant succession or fire had affected production. Monitoring goals identified an annual trend of berry production and did not include documenting the effects of succession.

Huckleberry sampling began in 1989 at 11 transect sites. Sixteen sites were sampled in 2019. Buffaloberry sampling began in 1990 at 5 sites. Due to the dioecious (separate male and female plants) nature of buffaloberry all frame count transects were dropped in 2007 in favor of marking 10 plants per site and counting the berries on marked plants. Two sites were sampled in 2019. Serviceberry productivity was estimated by counting berries on 10 marked plants at 5 sample sites beginning in 1990. Six sites were sampled in 2019. In 2001, three new plots were established to document berry production of mountain ash (*Sorbus scopulina*). Ten plants were permanently marked at each site for berry counts, similar to the serviceberry plots. Production counts occurred at 3 sites in 2019.

Temperature and relative humidity data recorders (LogTag®, Auckland, New Zealand) were placed at sites beginning in 2011. These devices record conditions at 90 minute intervals and will be retrieved, downloaded, and replaced at annual intervals. We used a berries/plot or berries/plant calculation as an index of berry productivity. Transects were treated as the independent observation unit. For each year observed, mean numbers of berries/plant (berries/plot) were used as our transect productivity indices. For each year, we indicate whether berry productivity is above average (annual 95% confidence interval falls above study-wide mean), average (confidence interval encompasses the study-wide mean), or below average (confidence interval falls below study-wide mean).

Body Condition

Field measurements and bioelectric impedance analysis (BIA) of captured bears allows us to estimate body condition of grizzly bears in the Cabinet-Yaak (Farley and Robbins 1994). More specifically, these methods allow for estimation of body fat content, an important indicator of quality of food resources and a predictor of cub production for adult females. We attempted estimation on captured bears, characterized by sex-age class, reproductive status, area of capture, and management status. ANOVA and post-hoc Tukey-HSD tests were performed to test for differences in body fat content across factors (management status, sex, and month of capture. Body condition (primarily, body fat content) of reproductive-aged females offers an *indirect* metric of whether females were of a physiological condition that supports cub production (Robbins et al. 2012).

RESULTS AND DISCUSSION

Research and monitoring with telemetry and full time personnel were present since 1983 and therefore this date represents the most intense period of data collection. All tables and calculations are updated when new information becomes available. For instance, genetic analysis determined the sex of a previously unknown mortality (2012) and a bear originally identified as a probable mortality (2003) was removed when genetic evidence later indicated that the bear survived that incident.

Grizzly Bear Observations and Recovery Plan Targets

Grizzly bear observations and mortality from public and agency sightings or records were appended to databases. These databases include information from the U.S. and Canada. The file includes almost 1,900 credible sightings, tracks, scats, digs, hair, and trail camera photographs dating from 1960 (Fig. 3) and over 130 mortalities dating from 1949 (Table 1, Appendix Table 2, Fig. 3). Credible sightings were those rating 4 or 5 on the 5-point scale (see page 9). Seventy-six instances of grizzly bear mortality were detected inside or within 16 km of the CYE (including Canada) during 1982–2019 (Table 1). Sixty-two credible sightings were reported to this study that rated 4 or 5 (most credible) during 2019. Thirty-four of these sightings occurred in the Yaak portion of the CYE and 28 sightings occurred in the Cabinet Mountains portion of the CYE (Table 2 and Fig. 3). Sightings of females with young or mortalities that occur outside the recovery zone are counted in the closest BMU.

Recovery Target 1: 6 females with cubs over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone.
Two credible sightings of a female with cubs occurred during 2019 in Bear Management Units (BMUs) 11 and 12 (Tables 2, 3, 4, 5, Fig. 4 and 5). There appeared to be 2 unduplicated females with cubs in the recovery area or within 10 miles during 2019. Eight credible sightings of a female with yearlings or 2-year-olds occurred in BMU 5, 6, 13, 14, and 17. Unduplicated sightings of females with cubs (excluding Canada) varied from 2–5 per year and averaged 3.0 per year from 2014–19 (Tables 3, 4). This target has not been met.

Recovery Target 2: 18 of 22 BMU's occupied by females with young from a running 6-year sum of verified evidence.

Twelve of 22 BMUs in the recovery zone had sightings of females with young (cubs, yearlings, or 2-year-olds) during 2014–19 (Figs. 4, 5, Table 6). Occupied BMUs were: 2, 4, 5, 6, 8, 11, 12, 13, 14, 15, 16, and 17. This target has not been met.

Recovery Target 3: The running 6-year average of known, human-caused mortality should not exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. .

Two known or probable human caused mortalities occurred during 2019. Ten known or probable human caused mortalities of grizzly bears have occurred in or within 10 miles of the CYE in the U.S. during 2014–19 (Table 1), including 3 females (Deer Ridge) and 7 males (BMUs 2, 5, 12, 13, 19, 22, West Kootenai and Deer Ridge units). These mortalities included two adult females (under investigation and self-defense), 2 adult males (self-defense and management), 4 subadult males (self-defense, poaching, and two human caused under investigation), and 1 male and 1 female cub (human caused, under investigation). We estimated minimum population size by dividing observed females with cubs during 2017–19 (10) minus any human-caused adult female mortality (2) by 0.6 (sightability correction factor as specified in the recovery plan) then divide the resulting dividend by 0.284 (adult female proportion of population, as specified in the recovery plan) (Tables 3, 4) (USFWS 1993). This resulted in a minimum population of 47 individuals. The recovery plan states; "any attempt to use this parameter to indicate trends or precise population size would be an invalid use of these data". Applying the 4% mortality limit to the minimum calculated population resulted in a total mortality limit of 1.9 bears per year. The female limit is 0.6 females per year (30% of 1.9). Average annual human caused mortality for 2014–19 was 1.5 bears/year and 0.5 females/year. These mortality levels for total bears and female mortality were less than the calculated limit during 2014–19. The recovery plan established a goal of zero human-caused mortality for this recovery zone due to the initial low number of bears, however it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem." Therefore, even if the goal of zero mortality is not met, it is important to evaluate the targets to determine if we are making progress towards recovery. During the 2014–19 reporting period we are meeting all mortality targets and moving closer to recovery. All tables and calculations were updated as new information becomes available.

Table 1. Known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak grizzly bear recovery zone (including Canada). Includes all radio collared bears regardless of location, 1982–2019.

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
October, 1982	None	M	AD	Human, Poaching	Grouse Creek, ID	No	Yes	USFS
October, 1984	None	Unk	Unk	Human, Mistaken Identity, Black bear	Harvey Creek, ID	Yes	Yes	USFS
9/21/1985	14	M	AD	Human, Self Defense	Lyons Gulch, MT	No	Yes	USFS
7/14/1986	106 cub	Unk	Cub	Natural	Burnt Creek, MT	Unk	No	USFS
10/25/1987	None	F	Cub	Human, Mistaken Identity, Elk	Flattail Creek, MT	No	Yes	USFS
5/29/1988[1]	134	M	AD	Human, Legal Hunter kill	Moyie River, BC	Yes	Yes	BC
10/31/1988	None	F	AD	Human, Self Defense	Seventeen Mile Creek, MT	No	Yes	USFS
7/6/1989	129	F	3	Human, Research	Burnt Creek, MT	Yes	No	USFS
1990	192	M	2	Human, Poaching	Poverty Creek, MT	Yes	Yes	USFS
1992	678	F	37	Unknown	Trail Creek, MT	No	Yes	USFS
7/22/1993	258[2]	F	7	Natural	Libby Creek, MT	No	No	USFS
7/22/1993	258-cub	Unk	Cub	Natural	Libby Creek, MT	No	No	USFS
10/4/1995[1]	None	M	AD	Human, Management	Ryan Creek, BC	Yes	Yes	PRIV
5/6/1996	302	M	3	Human, Undetermined	Dodge Creek, MT	Yes	No	USFS
October, 1996[1]	355	M	AD	Human, Undetermined	Gold Creek, BC	Yes	No	BC
June? 1997	None	M	AD	Human, Poaching	Libby Creek, MT	Unk	Yes	PRIV
6/4/1999	106	F	21	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	M	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	F	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
10/12/1999[1]	596	F	2	Human, Self Defense	Hart Creek, BC	Yes	Yes	BC
11/15/1999	358	M	15	Human, Management	Yaak River, MT	Yes	Yes	PRIV
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
7/1/2000	303-cub	Unk	Cub	Natural	Fowler Creek, MT	Unk	No	USFS
11/15/2000	592	F	3	Human, Undetermined	Pete Creek MT	Yes	No	USFS
5/5/2001	None	F	1	Human, Mistaken Identity, Black Bear	Spread Creek, MT	Yes	Yes	USFS
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
9/6/2001	128	M	18	Human, Undetermined	Swamp Creek, MT[3]	Yes	No	PRIV
October, 2001	None	F	AD	Human, Train collision	Elk Creek, MT	Yes	Yes	MRL
6/24/2002[1]	None	Unk	Unk	Human, Mistaken Identity, Hounds	Bloom Creek, BC	Yes	Yes	BC
7/1/2002	577	F	1	Natural	Marten Creek, MT	Yes	No	USFS
10/28/2002	None	F	4	Human, Undetermined	Porcupine Creek, MT	Yes	Yes	USFS
11/18/2002	353/584	F	7	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	F	Cub	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	Unk	Cub	Human, Poaching	Yaak River, MT	Yes	No	PRIV
10/15/2004[1]	None	F	AD	Human, Management	Newgate, BC	Yes	Yes	PRIV
2005?	363	M	14	Human, Undetermined	Curley Creek, MT	Yes	Yes	PRIV
10/9/2005	694	F	2	Human, Undetermined	Pipe Creek, MT	Yes	No	PCT
10/9/2005	None	F	2	Human, Train collision	Government Creek, MT	Yes	Yes	MRL
10/19/2005	668	M	3	Human, Mistaken Identity, Black bear	Yaak River, MT	Yes	Yes	PRIV
5/28/2006[1]	None	F	4	Human, Research	Cold Creek, BC	Yes	No	BC
6/1/2006[1]	292	F	5	Human, Management	Moyie River, BC	Yes	Yes	PRIV
9/22/2007	354	F	11	Human, Self Defense	Canuck Creek, MT	Yes	Yes	USFS
9/24/2008	?	M	3	Human, Under Investigation	Fishtrap Creek, MT	Yes	Yes	PCT
10/20/2008[2]	790	F	3	Human, Poaching	Clark Fork River. MT	Yes	Yes	PRIV
10/20/2008[2]	635	F	4	Human, Train collision	Clark Fork River. MT	Yes	Yes	MRL
11/15/2008[1]	651	M	13	Human, Mistaken Identity, Wolf Trap	NF Yahk River, BC	Yes	Yes	BC
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/7/2009[3]	None	M	3-4	Human, Mistaken Identity, Black bear	Bentley Creek, ID[3]	Yes	Yes	PRIV
11/1/2009	286	F	Adult	Human, Self Defense	EF Bull River, MT	No	Yes	USFS
6/25/2010	675-cub	Unk	Cub	Natural	American Creek, MT	Unk	No	USFS
7/7/2010	303-cub	Unk	Cub	Natural	Bearfite Creek, MT	Unk	No	USFS
9/6/2010[1]	1374	M	2	Human, Under Investigation	Hawkins Creek, BC	Yes	No	BC

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
9/24/2010[1]	None	M	2	Human, Wolf Trap, Selkirk Relocation	Cold Creek, BC	Yes	Yes	BC
10/11/2010	None	M	AD	Human, Under Investigation	Pine Creek, MT	No	Yes	USFS
2011	None	F	1	Unknown	EF Rock Creek, MT	No	Yes	USFS
9/16/2011	None	M	AD	Human, Mistaken Identity	Faro Creek, MT	No	Yes	USFS
11/13/2011	799	M	4	Human, Mistaken Identity	Cherry Creek, MT	Yes	Yes	USFS
11/24/2011	732	M	3	Human, Defense of life	Pipe Creek, MT	Yes	Yes	PRIV
November 2011	342	M	19	Human, Under Investigation	Little Creek, MT	Yes	Yes	PRIV
5/18/2012	None	F	AD	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
5/18/ 2012	None	M	Cub	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
October 2012[1]	5381	M	8	Human, Management	Duck Creek, BC	Yes	Yes	PRIV
10/26/2014	79575279	M	6	Human, Self defense	Little Thompson River, MT	Yes	Yes	PRIV
5/15/2015[1]	552-ygl	Unk	1	Natural	Linklater Creek, BC	Unk	No	BC
5/23/2015[2]	921	F	3	Natural	NF Ross Creek, MT	No	No	USFS
5/24/2015	None	M	4?	Human, Poaching	Yaak River, MT	Yes	Yes	USFS
8/12/2015	818	M	2	Human, Self Defense	Moyie River, ID	Yes	Yes	PRIV
9/30/2015[2]	924	M	2	Human, Mistaken Identity	Beaver Creek, ID[3]	Yes	Yes	PRIV
10/11/2015	1001	M	6	Human, Under Investigation	Grouse Creek, ID	Yes	No	PRIV
9/1/2017[1]	922	M	5	Human, Self defense	Porthill Creek, BC[3]	Yes	Yes	BC
4/16/2018	821	M	4	Unknown probable	Pine Creek, MT	Yes	Yes	PRIV
5/21/2018	9077	M	3	Human, Under Investigation	Bristow Creek, MT	Yes	No	USFS
9/5/2018	810	F	15	Human, Under Investigation	Spruce Creek, ID	Yes	No	USFS
9/5/2018	None	Unk	Cub	Human, Under Investigation probable	Spruce Creek, ID	Yes	No	USFS
9/5/2018	None	Unk	Cub	Human, Under Investigation probable	Spruce Creek, ID	Yes	No	USFS
5/24/2019	None	Unk	Cub	Natural	Skin Creek, MT	No	No	USFS
5/24/2019	None	Unk	Cub	Natural	Skin Creek, MT	No	No	USFS
8/2/2019	None	F	Adult	Human, Self Defense	EF Bull River, MT	No	Yes	USFS
11/10/2019	770	M	25	Human, Management	Libby Creek, MT	Yes	Yes	PRIV

[1]The recovery plan (USFWS 1993) specifies that human-caused mortality or female with young sightings from Canada will not be counted toward recovery goals in the CYGBRZ. BC – British Columbia, MRL – Montana Rail Link, PRIV – Individual Private, PCT – Plum Creek Timber Company, USFS – U.S. Forest Service.
[2]Bears transplanted to the Cabinet Mountains under the population augmentation program were counted as mortalities in their place of origin and are not counted toward recovery goals in this recovery zone.
[3]Bear Killed more than 10 miles outside recovery zone in the US and not counted in recovery calculations.

Table 2. Credible grizzly bear sightings, credible female with young sightings, and known human caused mortality by bear management unit (BMU) or area, 2019.

BMU OR AREA	2019 Credible Grizzly Bear Sightings	2019 Sightings of Females with Cubs (Total)	2019 Sightings of Females with Cubs (Unduplicated)	2019 Sightings of Females with Yearlings or 2-year-olds (Total)	2019 Sightings of Females with Yearlings or 2 year-olds (unduplicated)	2019 Human Caused Mortality
1	0	0	0	0	0	0
2	0	0	0	0	0	1
3	5	0	0	0	0	0
4	2	0	0	1	1	0
5	10	0	0	2	1	1
6	4	0	0	0	0	0
7	0	0	0	0	0	0
8	1	0	0	0	0	0
9	1	0	0	0	0	0
10	4	0	0	0	0	0
11	3	1	1	0	0	0
12	5	1	1	2	1	0
13	10	0	0	2	1	0
14	6	0	0	0	0	0
15	1	0	0	0	0	0
16	0	0	0	0	0	0
17	2	0	0	1	1	0
18	0	0	0	0	0	0
19	2	0	0	0	0	0
20	0	0	0	0	0	0
21	1	0	0	0	0	0
22	0	0	0	0	0	0
BC Yahk GBPU	0	0	0	0	0	0
Cabinet Face	0	0	0	0	0	0
Deer Ridge	0	0	0	0	0	0
Fisher	2	0	0	0	0	0
South Clark Fork	0	0	0	0	0	0
Tobacco	0	0	0	0	0	0
West Kootenai	3	0	0	0	0	0
West RZ	0	0	0	0	0	0
2019 TOTAL	62	2	2	8	5	2

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see methods).
[2]Sightings may duplicate the same animal in different locations. Only the first sighting of a duplicated female with cubs is counted toward total females (Table 3), however subsequent sighting contribute toward occupancy (Table 8).
[3]Areas in Canada outside of Cabinet-Yaak recovery zone that do not count toward recovery goals.
[4]Areas with portions <16 km outside the Cabinet-Yaak recovery zone that do not count toward recovery goals.

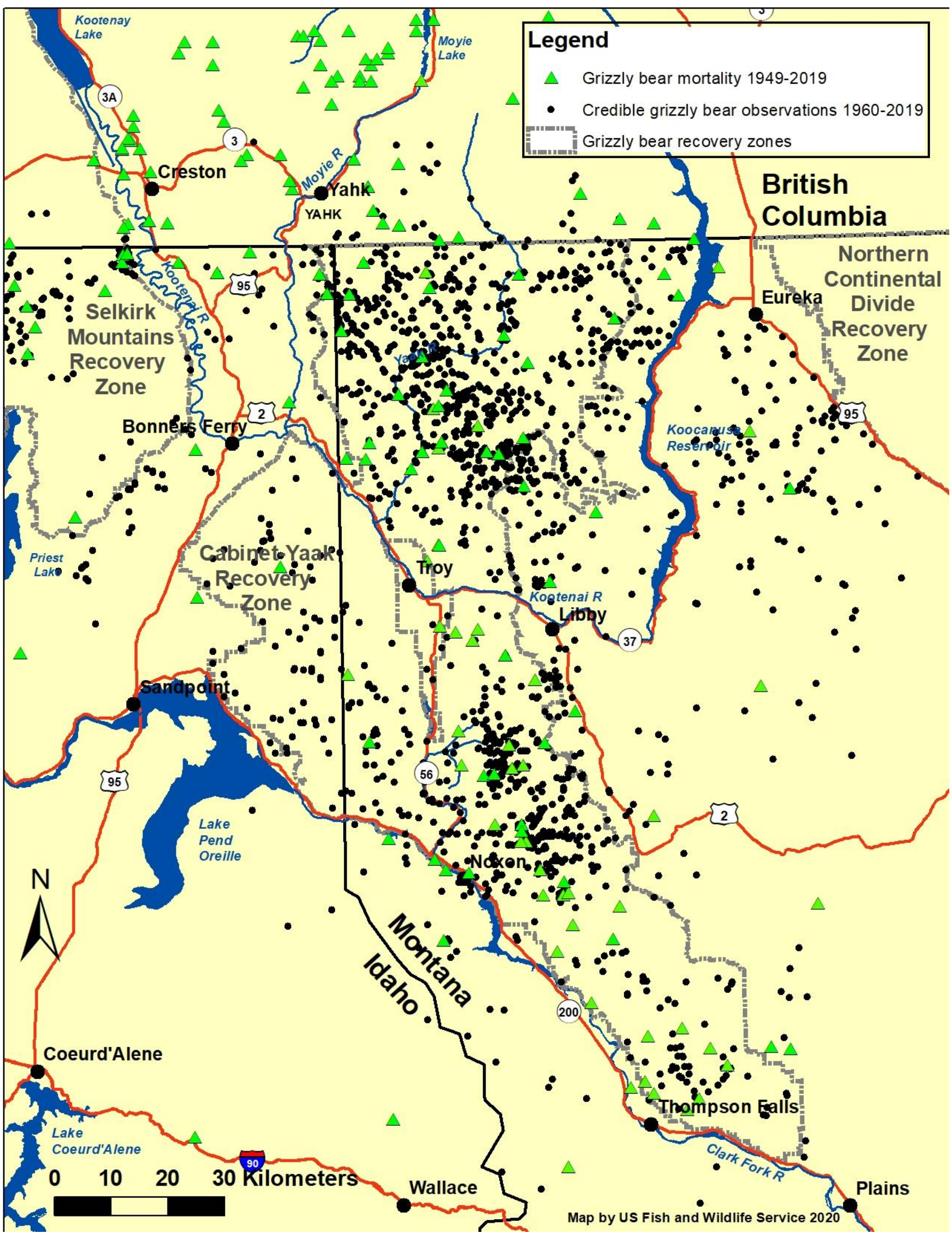

Figure 3. Grizzly bear observations (1959–2019) and known or probable mortalities from all causes (1949–2019) in and around the Cabinet-Yaak recovery area.

Table 3. Status of the Cabinet-Yaak recovery zone during 2014–2019 in relation to the demographic recovery targets from the grizzly bear recovery plan (USFWS 1993).

Recovery Criteria	Target	2014–2019
Females w/cubs (6-yr avg)	6	3.0 (18/6)
Human Caused Mortality limit (4% of minimum estimate)[1]	1.7	1.5 (6 yr avg)
Female Human Caused mortality limit (30% of total mortality)[1]	0.6	0.5 (6 yr avg)
Distribution of females w/young	18 of 22	11 of 22

[1] The grizzly bear recovery plan states "Because of low estimated population and uncertainty in estimates, the current human-caused mortality goal to facilitate recovery of the population is zero. In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem".

Table 4. Annual Cabinet-Yaak recovery zone (excluding Canada) grizzly bear unduplicated counts of females with cubs (FWC's) and known human-caused mortality, 1993–2019.

YEAR	ANNUAL FWC'S	ANNUAL HUMAN CAUSED ADULT FEMALE MORTALITY	ANNUAL HUMAN CAUSED ALL FEMALE MORTALITY	ANNUAL HUMAN CAUSED TOTAL MORTALITY	4% TOTAL HUMAN CAUSED MORTALITY LIMIT[1]	30% ALL FEMALE HUMAN CAUSED MORTALITY LIMIT[1]	TOTAL HUMAN CAUSED MORTALITY 6 YEAR AVERAGE	FEMALE HUMAN CAUSED MORTALITY 6 YEAR AVERAGE
1993	2	0	0	0	0.9	0.3	0.5	0.3
1994	1	0	0	0	0.9	0.3	0.3	0.2
1995	1	0	0	0	0.9	0.3	0.2	0.0
1996	1	0	0	1	0.7	0.2	0.2	0.0
1997	3	0	0	1	1.2	0.4	0.3	0.0
1998	0	0	0	0	0.9	0.3	0.3	0.0
1999	0	0	0	1	0.7	0.2	0.5	0.0
2000	2	0	1	1	0.5	0.1	0.7	0.2
2001	1	1	2	2	0.5	0.1	1.0	0.5
2002	4	1	4	4	1.2	0.4	1.5	1.2
2003	2	0	0	0	1.2	0.4	1.3	1.2
2004	1	0	0	0	1.4	0.4	1.3	1.2
2005	1	0	2	4	0.9	0.3	1.8	1.5
2006	1	0	0	0	0.7	0.2	1.7	1.3
2007	4	1	1	1	1.2	0.4	1.5	1.2
2008	3	0	0	1	1.6	0.5	1.0	0.5
2009	2	1	1	1	1.6	0.5	1.2	0.7
2010	4	0	0	1	1.9	0.6	1.3	0.7
2011	1	0	0	4	1.4	0.4	1.3	0.3
2012	3	1	1	2	1.6	0.5	1.7	0.5
2013	2	0	0	0	1.2	0.4	1.5	0.3
2014	3	0	0	1	1.6	0.5	1.5	0.3
2015	2	0	0	3	1.6	0.5	1.8	0.2
2016	3	0	0	0	1.9	0.6	1.7	0.2
2017	3	0	0	0	1.9	0.6	1.0	0.2
2018	5	1	2	4	2.3	0.7	1.3	0.3
2019	2	1	1	2	1.9	0.6	1.7	0.5

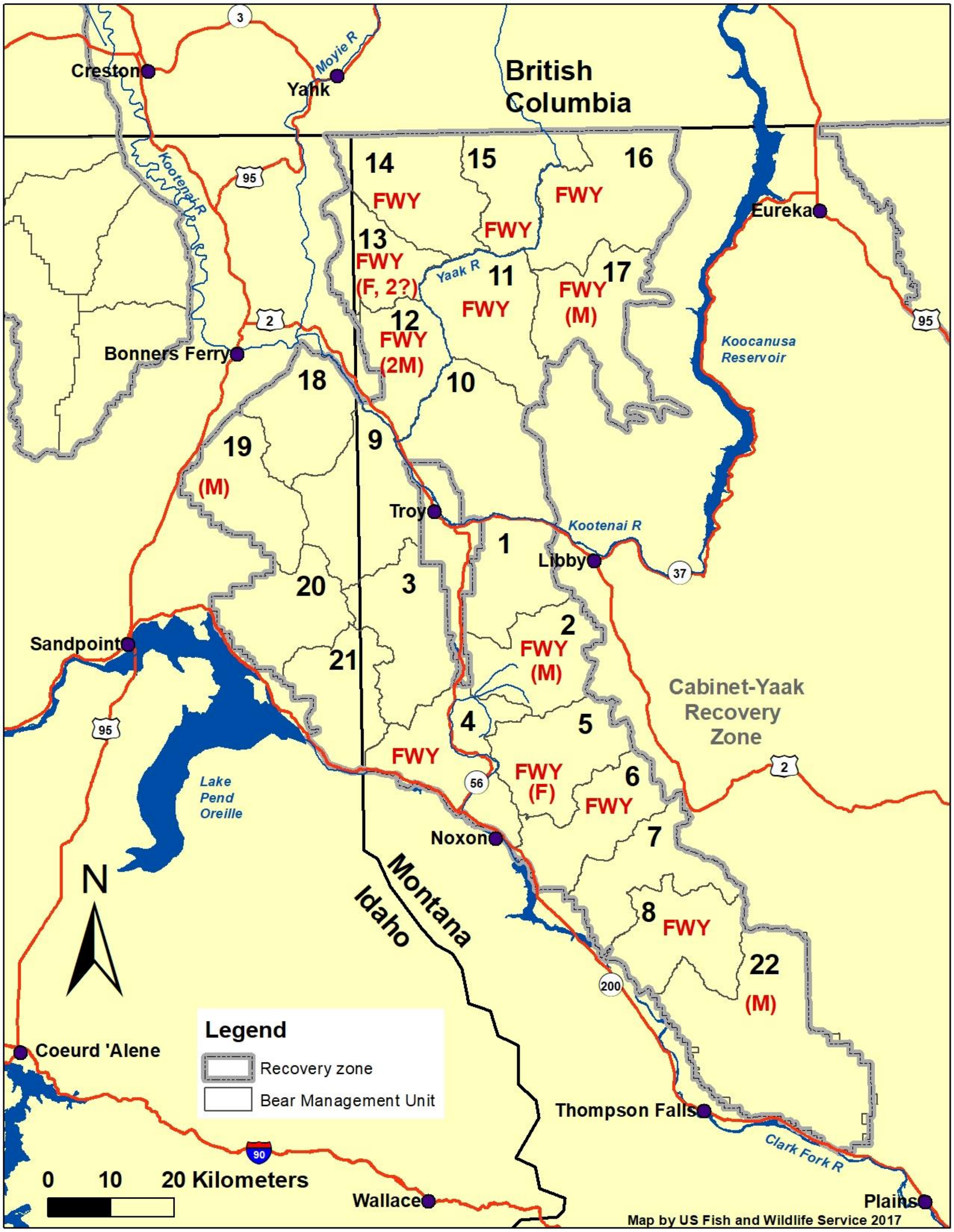

Figure 4. Female with young occupancy and known or probable mortality within Bear Management Units (BMUs) in the Cabinet-Yaak recovery zone 2014–2019. (FWY is occupancy of a female with young and sex of any mortality is in parentheses).

Table 5. Credible observations of females with young in or within 10 miles of the Cabinet-Yaak recovery zone, 1988–2019. Canadian credible observations shown in parentheses.

Year	Total credible[1] sightings females with young	Unduplicated females with cubs	Unduplicated females with yearlings or 2-year-olds	Unduplicated adult females without young	Minimum probable adult females[2]
1990	9	1	2	0	3
1991	4	1	1	1	2
1992	8	1	5	1	6
1993	6	2	1	0	3
1994	5	1	2	0	3
1995	8	1	2	0	3
1996	5	1	1	0	2
1997	14 (1)	3	4	0	7
1998	6 (1)	0	2 (1)	2	2 (1)
1999	2	0	2	3	2
2000	6 (1)	2 (1)	1	0	3 (1)
2001	5 (2)	1 (1)	3	0	4 (1)
2002	10 (1)	4 (1)	1	0	5 (1)
2003	11	2	4	0	6
2004	11	1	4	0	5
2005	10 (1)	1	4 (1)	1	5 (1)
2006	7 (1)	2 (1)	2	1	4 (1)
2007	17	4	2	2	6
2008	7 (1)	3 (1)	3	1	6 (1)
2009	5 (0)	2 (0)	2 (0)	1	4 (0)
2010	14 (0)	4 (0)	2 (0)	1	6 (0)
2011	4 (0)	1 (0)	1 (0)	1	2 (0)
2012	12 (0)	3 (0)	3 (0)	0	6 (0)
2013	9 (0)	2 (0)	5 (0)	0	7 (0)
2014	20 (1)	3 (0)	3 (0)	1	7 (0)
2015	19 (1)	2 (0)	5 (0)	2	9 (0)
2016	11 (0)	3 (0)	3 (0)	2	8 (0)
2017	8 (0)	3 (0)	3 (0)	2	8 (0)
2018	20 (0)	5 (0)	2 (0)	1	8 (0)
2019	10 (0)	2 (0)	5 (0)	1	8 (0)

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see page 8).
[2]Minimum does not count females detected by mortality.

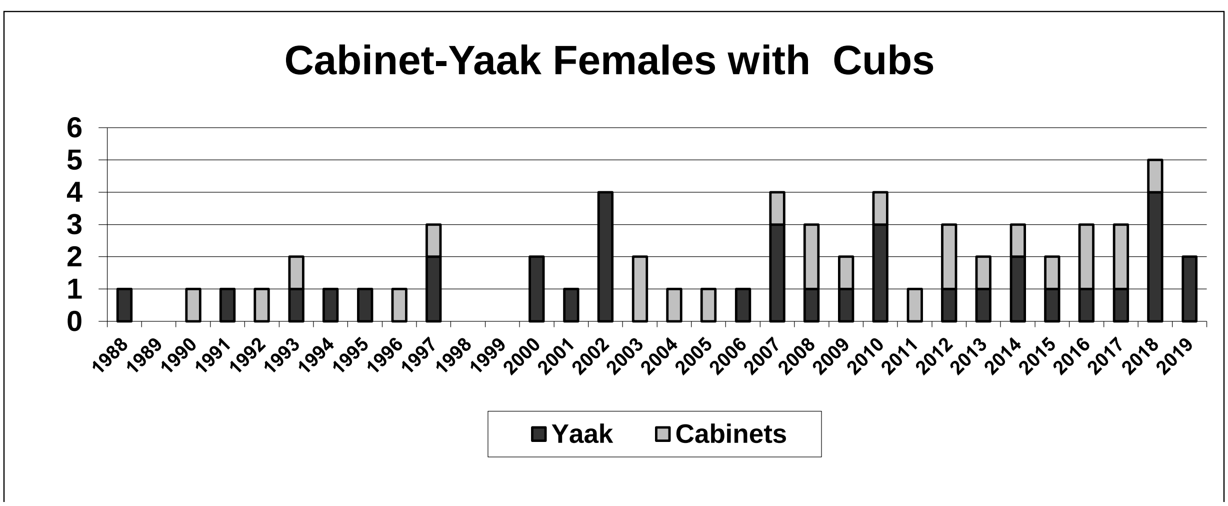

Figure 5. Credible observations of females with cubs in or within 10 miles of the Cabinet-Yaak recovery zone (excluding Canada), 1988–2019. Credible sightings are those rated 4 or 5 on a 5 point scale.

Table 6. Occupancy of bear management units by grizzly bear females with young in the Cabinet-Yaak recovery zone 1990–2019.

	1 - CEDAR	2 - SNOWSHOE	3 - SPAR	4 - BULL	5 - ST. PAUL	6 - WANLESS	7 - SILVER BUTTE	8 - VERMILION	9 - CALLAHAN	10 - PULPIT	11 - RODERICK	12 - NEWTON	13 - KENO	14 - NW PEAK	15 - GARVER	16 - E FORK YAAK	17 - BIG CREEK	18 - BOULDER	19 - GROUSE	20 - N LIGHTNING	21 - SCOTCHMAN	22 - MT HEADLEY
1988	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
1989	N	N	N	Y	N	N	Y	N	N	N	Y	N	Y	Y	Y	N	N	N	N	N	N	N
1990	N	Y	N	N	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	N	N	N	N	N	Y
1991	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1992	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	Y	N	N
1993	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1994	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N
1995	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	N
1996	N	N	N	N	N	Y	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N
1997	N	Y	N	Y	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	N	N	N	N	Y	N
1998	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N
1999	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N
2000	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2001	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	Y	N	N	N	N	N
2002	N	Y	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	N	N
2003	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	Y	N
2004	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2005	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
2006	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
2007	N	N	Y	Y	Y	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2008	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
2009	N	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
2010	N	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2011	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	N	N	N
2012	N	Y	N	N	Y	N	N	N	N	N	Y	N	N	N	N	Y	Y	N	N	N	N	N
2013	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	Y	Y	Y	Y	N	N	N	N	N
2014	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N
2015	N	N	N	N	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N
2016	N	N	N	N	Y	N	N	Y	N	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N
2017	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
2018	N	N	N	N	Y	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N
2019	N	N	N	Y	Y	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N

Cabinet Mountains Population Augmentation

Two bears were released in 2019, including a 2-year-old female was released on July 13, 2019 followed by a 3 year-old male on July 16, 2019. Both bears were released at the same site in the West Cabinet Mountains. The female remained in the West Cabinet Mountains prior to denning approximately 4 miles west of her release site. The male bear initially moved north and spent much of the summer just north of the Kootenai River before returning to the West Cabinets in early October. The bear was observed numerous time by landowners northwest of Clark Fork, ID, before moving to the Cabinet Mountains Wilderness to den in mid-December.

Bear 927was released in 2018 and monitored throughout 2019. He was released in the West Cabinet Mountains but moved south of the Clark Fork River in July before being photographed at a black bear bait site on private property in late August of 2018. Landowner concerns prompted Idaho Fish and Game to capture the bear and it was released in the East Cabinet Mountains near the Wilderness. The bear returned to the area south of the Clark Fork River but did not revisit the bait site and spent most of September and October in Montana where black bear baiting is not allowed. The bear moved north of the Clark Fork River in

November and denned in the West Cabinet Mountains in 2018. In late March of 2019 he emerged from his den and moved south, crossing the Clark Fork River in late April. He continued south crossing Interstate 90 in early June and US highway 12 in early July. He spent much of July, August, and early September in the Selway Bitterroot Wilderness before returning to the Cabinet Mountains Wilderness where he denned in mid-December (Figure 6). This is the first confirmed instance of a grizzly bear in the Selway-Bitterroot Wilderness in over 50 years.

In summary, four female grizzly bears were captured in the Flathead River of British Columbia and released in the Cabinet Mountains from 1990–94 (Table 7). Twenty-two different grizzly bears were captured during 840 trap-nights to obtain the 4 subadult females. Capture rates were 1 grizzly bear/38 trap-nights and 1 suitable subadult female/210 trap-nights. One transplanted bear and her cub died of unknown causes one year after release. The remaining three bears were monitored until collars dropped. The program was designed to determine if transplanted bears would remain in the target area and ultimately contribute to the population through reproduction. Three of four transplanted bears remained in the target area for more than one year. One of the transplanted bears produced a cub, but had likely bred prior to translocation and did not satisfy our criteria for reproduction with resident males. One other female was known to have reproduced. In 2005 the augmentation program was reinitiated through capture by MFWP personnel and monitoring by this project. During 2005–19, 10 female and 8 male grizzly bears were released in the Cabinet Mountains (Table 7).

Of 22 bears released through 2019, 8 are known to have left the target area (one was recaptured and brought back, two returned in the same year, and one returned a year after leaving), three were killed within 4 months of release, and one was killed 16 years after release. One animal was known to have produced at least 10 first-generation offspring, 16 second-generation offspring, and one third-generation offspring. Another female was known to have produced three offspring and a male was known to have produced one offspring.

Table 7. Sex, age, capture date, capture location, release location, and fate of augmentation grizzly bears moved to the Cabinet Mountains, 1990–2019.

Bear	Sex	Age	Capture date	Capture Location	Cabinet Mtns Release Location	Fate
218	F	5	7/21/1990	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1990, Lost collar Aug. 1991, observed July 1992.
258	F	6	7/21/1992	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1992 Produced 1 cub 1993, Natural mortality July 1993.
286	F	2	7/14/1993	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1993–95 Lost collar at den Apr. 1995, hair snag 2004–2009, self-defense mortality November 2009.
311	F	3	7/12/1994	NF Flathead R, BC	EF Bull River	Lost collar July 1994, recaptured Oct. 1995 south of Eureka, MT, released EF Bull River, Signal lost Nov. 1995.
A1	F	7-8	9/30/2005	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2005–06, Lost collar Sept. 2007.
782	F	2	8/17/2006	SF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2006–07, Lost collar Aug. 2008.
635	F	4	7/23/2008	Stillwater R, MT	EF Bull River	Killed by train near Heron, MT Oct. 2008.
790	F	3	8/7/2008	Swan R, MT	EF Bull River	Illegally killed near Noxon, MT Oct. 2008.
715	F	10	9/17/2009	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2009–10, returned to NF Flathead R, May 2010. Lost collar June 2010.
713	M	5	7/18/2010	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2010, Lost collar Sept. 2011.
714	F	4	7/24/2010	NF Flathead R, MT	Silverbutte Cr	Returned to NF Flathead July 2010. Lost collar Oct. 2013.

Bear	Sex	Age	Capture date	Capture Location	Cabinet Mtns Release Location	Fate
725	F	2	7/25/2011	MF Flathead R, MT	Spar Lake	Moved to Glacier National Park, Sept. 2011 den, returned to Cabinet Mtns Aug. 2012 and den, moved to Glacier National Park and returned to Cabinet Mtns, lost collar Oct. 2013
723	M	2	8/18/2011	Whitefish R, MT	Spar Lake	Den Cabinet Mtns 2011. Lost collar June 2012.
918	M	2	7/6/2012	Whitefish R, MT	EF Bull River	Den Cabinet Mtns 2012-–13. Lost collar Oct. 2014.
919	M	4	7/30/2013	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2013. Lost collar Aug. 2014.
920	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2014–15.
921	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2014. Died of unknown cause May 2015.
924	M	2	7/25/2015	SF Flathead R, MT	Spar Lake	Mistaken identity mortality Sept. 2015
926	M	3	7/25/2016	SF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2016. Lost collar July 2017
927	M	2	7/20/2018	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2018 and Cabinets 2019
923	F	2	7/12/2019	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2019
892	M	3	7/14/2019	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2019

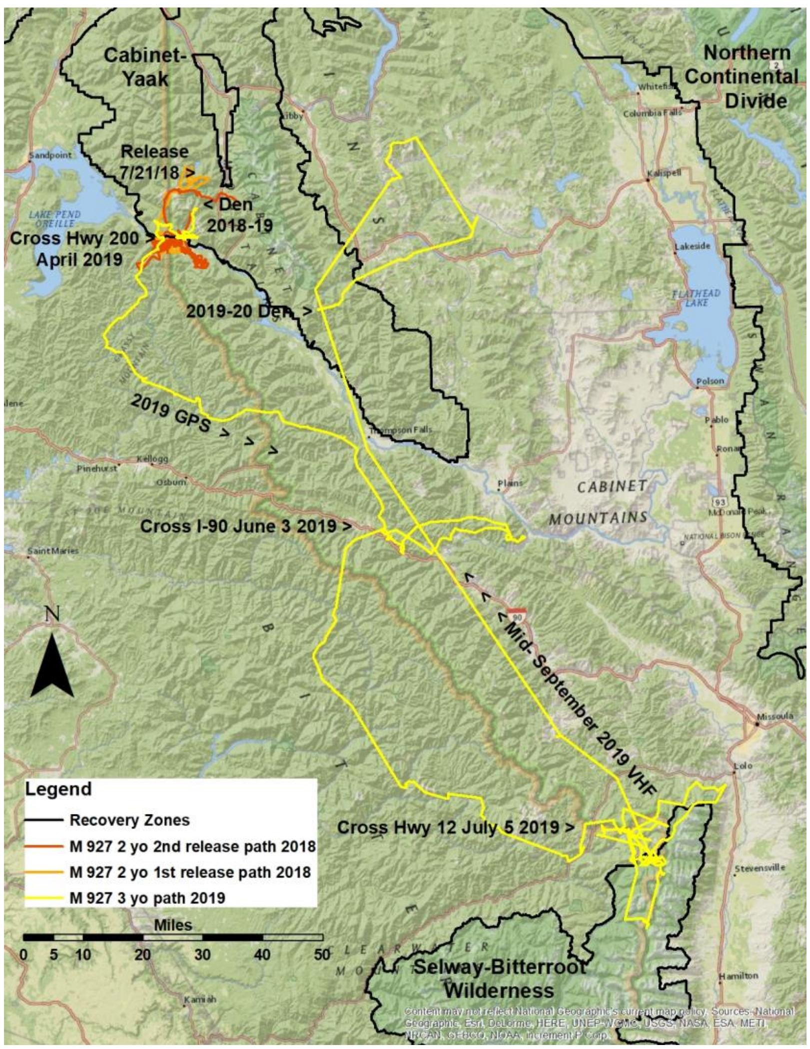

Figure 6. Path of male augmentation grizzly bear 927 in the Cabinet and Bitterroot Mountains of 2018-19.

Cabinet-Yaak Hair Sampling and DNA Analysis

Hair snag sampling occurred at barb wire corrals baited with a scent lure during 2000–2019 (Table 8 and Fig. 7). Sampling occurred from May–October but varied within years. Sites were selected based on prior grizzly bear telemetry, sightings, and access. Remote cameras supplemented hair snagging at most sites and were useful in identifying family groups and approximate ages of sampled bears. Genetic analysis from 2019 field collected samples is not yet complete; we will report on these results in the 2020 report. In 2002, study personnel assisted an MFWP black bear population estimate effort that sampled 285 sites in the Yaak River portion of the CYE. During 2003, 184 sites on a 5 km^2 grid were sampled on 4,300 km^2 in the Cabinet Mountains portion of the CYE. In 2009, 98 sites were sampled south of the Clark Fork River. Other years had much lower numbers of sampled sites. Collectively, USFWS and USGS crews have sampled 2,045 corral traps from 2000–2019 (Table 8 and Fig. 7). Through 2018, corral traps alone were successful during six percent of site visits and provided hair from at least 71 grizzly bears.

Table 8. Hair snagging corrals and success in the Cabinet-Yaak study area, 2000–2019. DNA genetic results not yet complete for 2019 samples.

Year	Number of corral sessions[1]	Sessions with grizzly bear DNA(%[2])	Sessions with grizzly bear photos or DNA(%[2])	Individual grizzly bear genotypes	BMUs with grizzly bear pictures or hair	Comments
2000	1	0	0	0		
2001	3	0	0	0		
2002	319	9 (3)	10 (3)	9	BMUs 2, 5, 6, 12, 14, 16, 17	
2003	184	1 (1)	1 (1)	1	BMUs 5, 6	
2004	14	2 (14)	2 (14)	3	BMU 5	
2005	17	1 (6)	2 (12)	1	BMU 5	
2006	19	3 (16)	3 (16)	3	BMUs 3, 5, 7	
2007	36	4 (11)	5 (14)	9	BMUs 5, 11, 13	Female with young BMU 5
2008	21	1 (5)	1 (5)	1	BMU 5	
2009	125	2 (2)	4 (3)	4	BMUs 5, 6, 9	Female with young BMU 5
2010	27	3 (11)	4 (15)	5	BMUs 3, 5, 6	Female with young BMU 5
2011	72	9 (13)	12 (17)	13	BMUs 3, 4, 5, 6, 11, 13, 14, 15, 16, 17	Female with young BMU 16
2012	854	48 (6)	48 (6)	29	BMUs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20	
2013	5	2 (40)	2 (40)	2	BMUs 2, 3, 5, 6, 7, 11, 13, 14, 15, 16, 17	Female with young BMU 6
2014	41	3 (7)	8 (7)	4	BMUs 1, 2, 3, 5, 6, 11, 12, 13, 14, 15, 16, 17, 19	Female with young BMU 13
2015	72	5 (7)	12 (17)	7	BMUs 2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 15, 16, 17	Female with young BMU 13; Female with cubs BMU 5
2016	39	6 (15)	9 (23)	10	BMUs 2, 3, 5, 6, 7, 10, 11, 13, 14, 15, 16, 17, 19	Female with young BMU 13, 5; Female with cub BMU 16
2017	92	18 (20)	18 (20)	18	BMUs 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	Female with cubs BMU 5, Female with young BMU 5
2018	55	13 (24)	16 (29)	17	BMUs 1, 2, 3, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17	Female with cubs BMU 5, 13, 14 Female with young BMU 6
2019	49	--	10 (20)[3]	--	BMUs 4, 5, 6, 8, 10, 13	Female with young BMU 13
Total	2045	130 (6)	163 (8)	71[4]		

[1]Some corral sites were deployed for multiple sessions per year. A “session” is typically 3-4 weeks long and defined as the interval between site set-up and revisits to collect samples and photos.
[2]Percent success at all corral sessions
[3]Sites with photos only. Awaiting 2018 genetic results.
[4]Some individuals captured multiple times among years.

In 2019, we collected 2,167 samples from 2,187 visits to 840 individual rub trees (Table 9). Samples were evaluated during cataloging and 1,727 were judged to be black bears (based on solid black coloration), leaving 440 to be sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Lab analysis on 2019 samples is still in progress, and we will report on results in the 2020 report. From 2013–2018, we genetically identified 75 individual grizzly bears (46 males, 29 females) from 13,638 samples collected via rub effort alone.

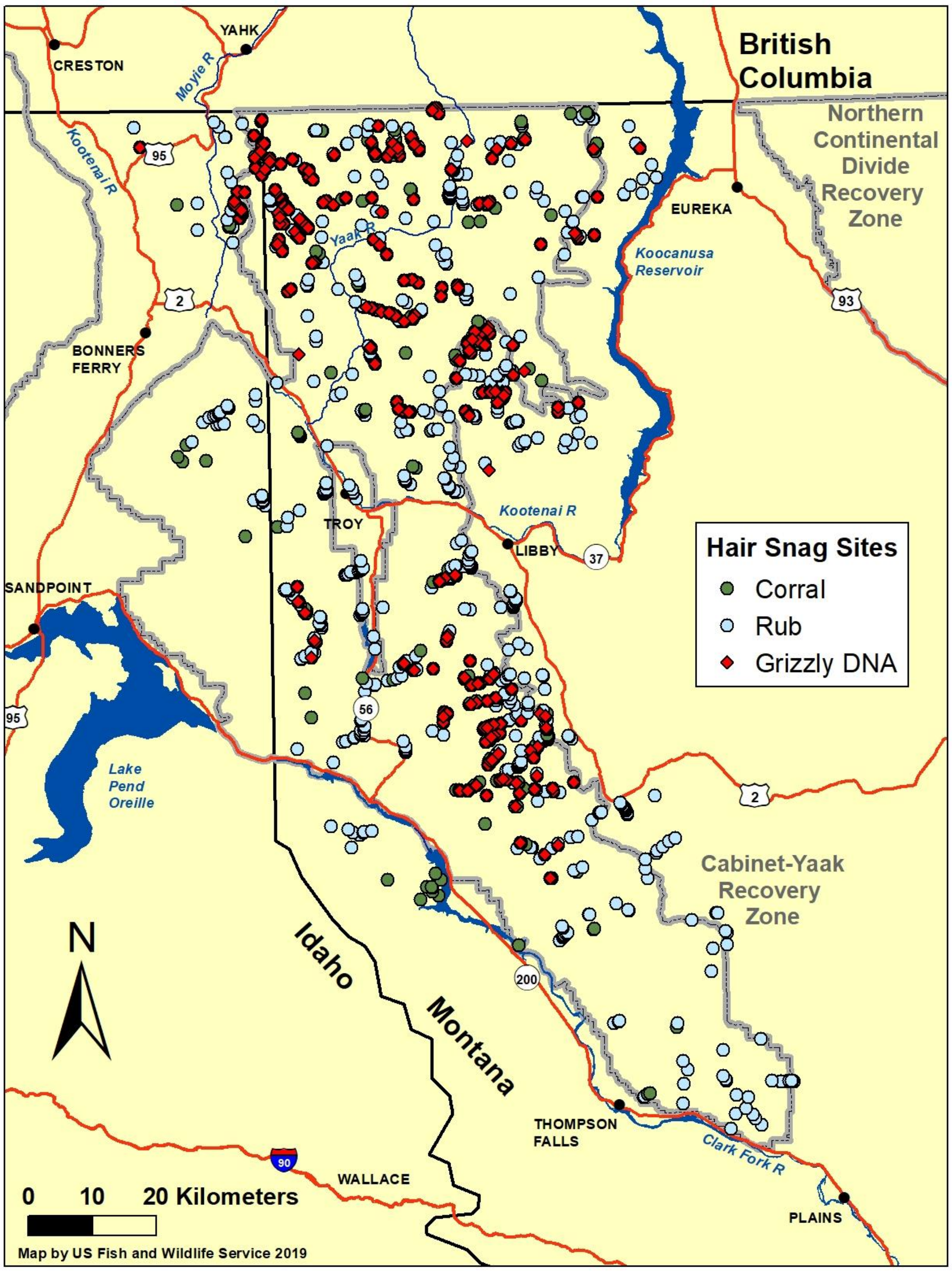

Figure 7. Location of hair snag sample sites in the Cabinet-Yaak Ecosystem study area, 2013–19. Sites with grizzly bear DNA are identified (2013–18).

Table 9. Grizzly bear hair rubs and success in the Cabinet-Yaak study area, 2012–2019.

Year	Number of rubs checked	Number of samples collected (%GB[1])	Number of samples sent to Lab (%GB[1])	Number of rubs with grizzly DNA	Individual grizzly bear genotypes	Males	Females
2012[2]	1376	8356 (2)	4639 (3)	85	33	19	14
2013	488	1038 (6)	480 (12)	33	17	9	8
2014	583	1894 (7)	708 (19)	50	24	14	10
2015	693	2258 (6)	617 (22)	76	30	20	10
2016	780	3781 (5)	1049 (19)	90	29	18	11
2017	836	2958 (13)	676 (55)	147	38	24	14
2018	782	2267 (8)	476 (39)	97	37	23	14
2019	840	2167 (--)	440 (--)	--	--	--	--
Total[3]	1630[4]	22552 (6)	8645 (14)	286[4]	83[5]	53[5]	30[5]

[1] Percentage of samples yielding a grizzly bear DNA genotype.

[2] 2012 results from USGS population estimation study (Kendall et al. 2016). 2013-18 efforts are from USFWS coordinated efforts.

[3]Totals are through 2018. 2019 genetic results from the lab are not yet complete.

[4] Unique rub locations. Some rub locations visited multiple times among years.

[5]Some individuals captured multiple times among years.

Grizzly Bear Genetic Sample Summary

We provide data from and prior to 2018 as 2019 sample results have not been completed by the laboratory. Using all methods (capture, collared individuals, all sources of DNA, sampling, photos, credible observations), we detected a minimum 54 individual grizzly bears alive and in the CYE grizzly bear population at some point during 2018. Two of these bears were known dead and an additional 2 assumed dead by end of 2018. Twenty-five bears were detected in the Cabinets (14 male, 10 female, 1 unknown sex). Thirty-one bears were detected in the Yaak (19 male, 10 female, 2 unknown sex). Two subadult male bears were detected in both the Yaak and Cabinets in 2018.

Captures, genotypes, and observations of grizzly bears by study personnel in the CYE study area were summarized during 1986–2018. Individuals not radio-collared or genotyped were conservatively separated by size, age, location, coloration, or reproductive status. Conservative classification of sightings may result in unique individuals being documented as one individual. Individual status or relationships may change with new information.

Two hundred thirteen individuals were identified within the CYE study area with 184 bears captured or genotyped and 29 unmarked individuals observed during 1986–2018. Fifty-four were known to be alive during 2018. Seventy-two of these animals are known or suspected to have died and the remainder have an unknown fate. Human causes were linked to 52 of these mortalities. Nineteen were believed to have died of natural causes. Thirteen of these 19 mortalities involved cubs. Four mortalities were from unknown causes. Twelve bears were known to have emigrated from the population. Three were augmentation bears returning to their area of capture, one was an augmentation bear that moved south of the recovery area and was killed, three went north of BC Highway 3 where one was killed, three bears went east of the recovery area where two are known dead, and two went west to the Selkirk Mountains. All bears known to have left the population are either augmentation bears or male individuals.

We determined parent-offspring relationships of Yaak grizzly bears using sample genotypes from 1986–2018. A majority of our detected sample in the Yaak descends from female grizzly bear 106 (Figure 8). She produced five known litters, and her matrilines tie to 58 known first, second, and third generation offspring. In 2018, we identified her first fourth generation offspring, male Y38004M. Since 1986, we have genetically detected 41 female grizzly bears in the US Yaak and BC Yahk, 28 (68%) of which are direct maternal descendants of bear 106. Since 2014, all female bears detected in the US Yaak are her maternal descendants. In 2015–18, we detected 1 daughter, 7 granddaughters, and 5 great-granddaughters of 106.

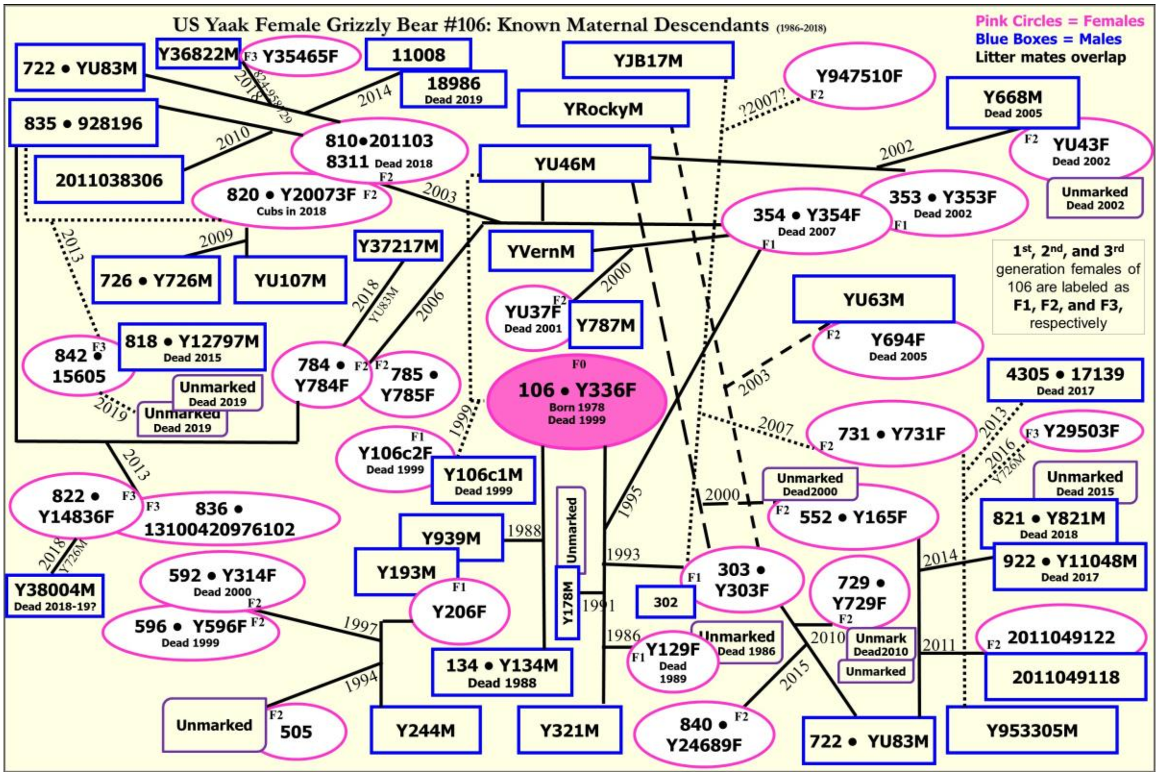

Figure 8. Most likely pedigree displaying matrilineal ancestry of female grizzly bear 106 in the Yaak River, 1986–2018. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 the first generation, F2 the second generation, and F3 the third generation. Numbers along lines indicate when the descendant litter was produced.

Claws from a grizzly bear were discovered in Baree Creek of the Cabinet Mountains in 1993. Analysis of DNA from these claws matched bear 678 originally captured in the Cabinet Mountains in 1983 when 28 years old. Tissue present on the claws suggested that she died no earlier than 1992. Bear 678 would have been at least 37 years old at the estimated time of death. Pedigree analysis also indicated that the three bears captured in the Cabinet Mountains from 1983–1988 were a triad with bear 680 being the offspring of bears 678 and 14.

The Cabinet Mountains population was estimated to be 15 bears or fewer in 1988 on the basis of independent tracks, sightings, and expert opinion (Kasworm and Manley 1988). However, lack of resident bears identified since 1989 suggests the population was well below 15 individuals. Genetic samples from the Cabinet Mountains (1983–2018) were determined to originate from 71 different grizzly bears. Three of these were from captures during 1983–1988, 19 were from augmentation bears during 1990–2018 (1 augmentation bear 218 genetically unmarked), and 51 from captures, mortalities, or hair snagging during 1997–2018.

One of these genotypes identified by hair snagging was from grizzly bear 286. She was released in the Cabinet Mountains as part of population augmentation in 1993 as a 2-year-old (Kasworm *et al*. 2007). She was 13 years old when the first hair sample was obtained during 2004. Pedigree analysis indicates she has produced at least 10 first generation offspring, 20 second generation offspring, and 3 third generation offspring. Six of those first generation offspring were females, and all 6 are known to have reproduced (Fig. 9). Bear 286 was killed in a self-defense incident with a hunter in November of 2009.

The augmentation effort appears to be the primary reason grizzly bears remain and are increasing in the Cabinet Mountains. Only 13 genotyped bears not known to be augmentation bears or their offspring have been identified in the Cabinet Mountains since 1990 and seven are known dead. The following describes each individual and fate. Two are adult males that bred with 286 to produce first generation of augmentation offspring. Four are a family group (adult female with 3 cubs) identified south of the Clark Fork River in 2002. The adult female and one of the young are known dead. Three are males with past human-bear conflict histories in the Northern Continental Divide population (NCDE) to the northeast and subsequently traveled to the CYE in 2014-2018, including: 1) an adult male killed in self-defense in the Little Thompson River in 2014, 2) a subadult male caught in Flathead Valley in spring of 2016, traveled to Cabinets fall 2016 or spring 2017, and traveled back toward NCDE and died by poaching in May 2017, 3) subadult male caught spring 2018 between the NCDE and Cabinets, relocated into the Yaak and soon thereafter died by human-cause (under investigation) in May 2018. One bear was a subadult male captured near Thompson Falls in 2011 in an incident involving livestock depredation, unknown status thereafter. Two bears were male migrants from the Selkirk Mountains: 1) identified in 2012, who is now known to have moved back to the Selkirks before breeding, has bred and remains in Selkirks in 2018, 2) a collared subadult male with movement in 2018 but lost collar in fall 2018. The remaining bear is an adult male born in 2009 in the Yaak whose range included the Cabinets and Yaak in 2016 but only detected in the Yaak in 2018.

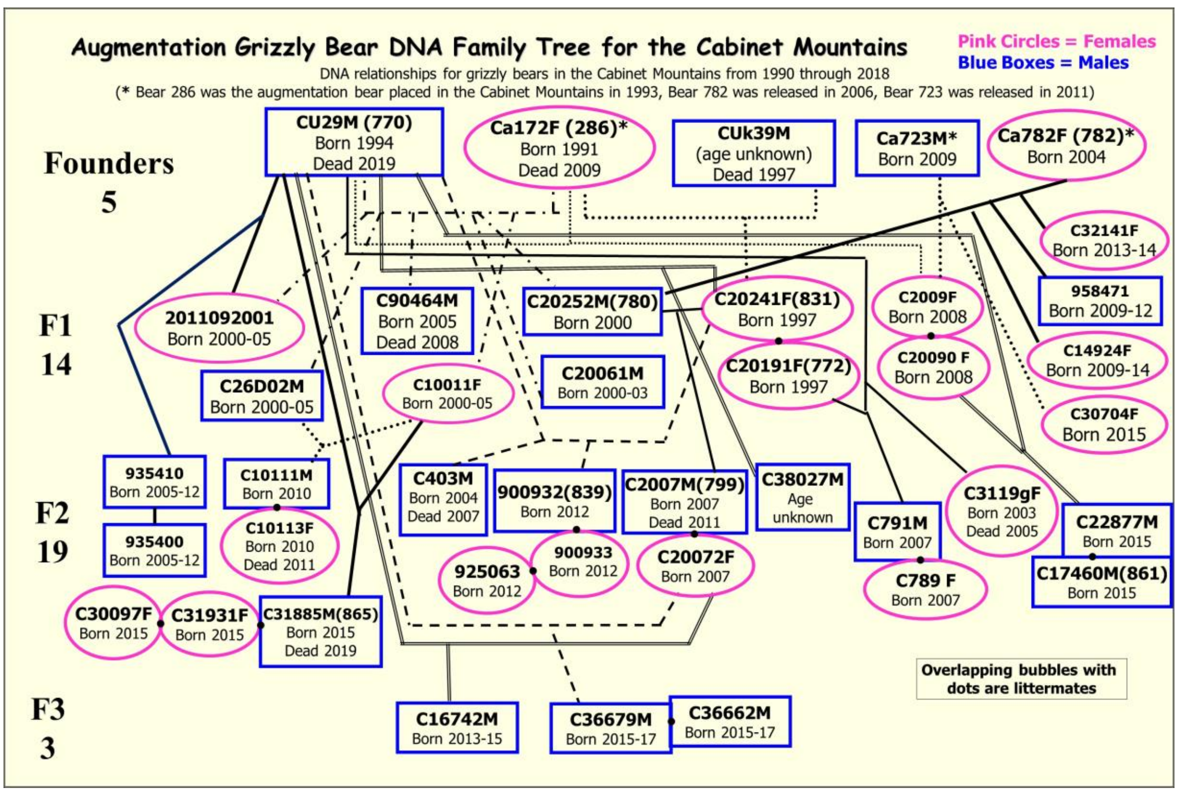

Figure 9. Most likely pedigree resulting from translocated female grizzly bears 286 and 782 in the Cabinet Mountains, 1993–2018. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 is the first generation of offspring for translocated females 286 or 782 and male 723, F2 is the second generation and F3 is the third generation.

Grizzly Bear Movements and Gene Flow Within and Between Recovery Areas

Population linkage is a goal of the CYE recovery plan (USFWS 1993). The population goal of approximately 100 animals requires genetic connectivity to maintain genetic health over time. Movement data from telemetry or genetic methods may be a precursor of linkage, but gene flow through reproduction by immigrant individuals is the best measure of connectivity.

Capture, telemetry, and genetic data were analyzed to evaluate movement and subsequent reproduction resulting in gene flow into and out of the CYE. Thirty-six grizzly bears were identified as immigrants, emigrants, or were the offspring of immigrants to the CYE from 1983–2019 (Appendix Table T4). While movement and gene flow out of the CYE may benefit other populations, gene flow into the CYE is most beneficial to genetic health. Fourteen individuals (11 males and 3 females) are known to have moved into the CYE from adjacent populations; however eight of these were killed or removed (Figure 10). Most of these immigrants originated in the North Purcells or South Selkirks with only three originating in the NCDE. Of those three, two are known dead. Gene flow has been identified through reproduction by three immigrants (two males and one female) resulting in 4 offspring in the CYE. All three immigrants producing gene flow originated in the North Purcells.

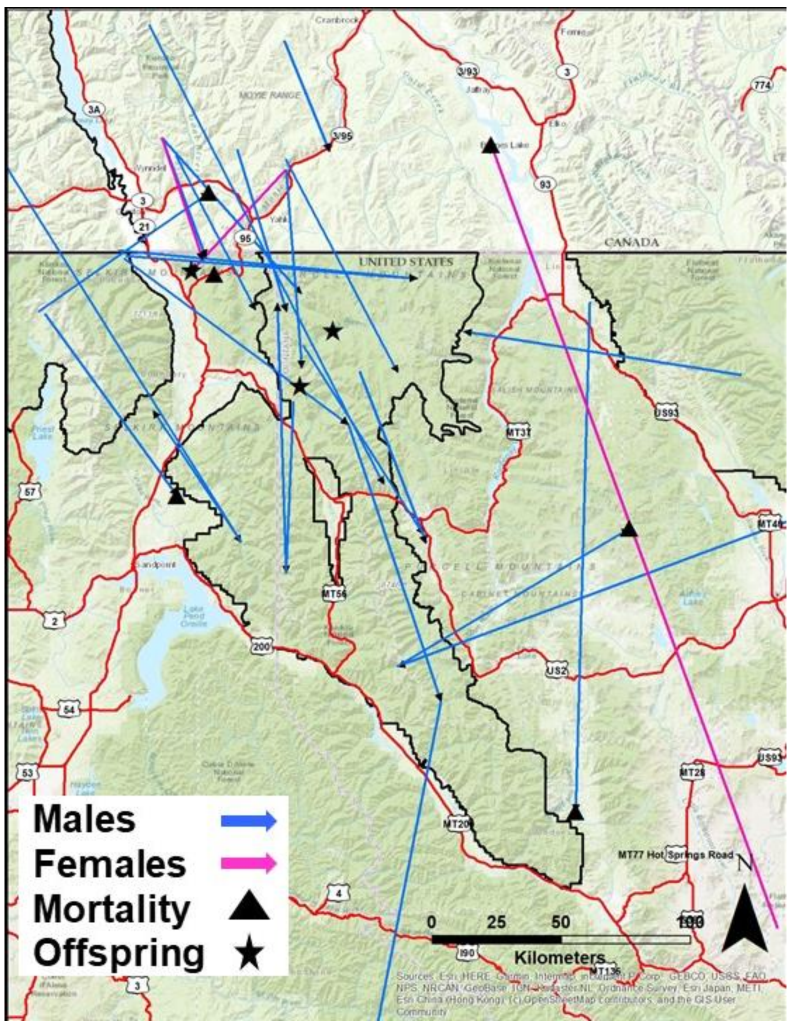

Figure 10. Known immigration or emigration events (blue and pink lines) and gene flow (black stars) in the Cabinet-Yaak, 1988–2018

Known Grizzly Bear Mortality

There were four instances of known or probable grizzly bear mortality in or within 16 km of the CYE (including BC) during 2019 (one adult male, one adult female, 2 cubs-of-the-year). Two were known human-caused (one adult male, one adult female). Two cubs were known dead of assumed natural mortality. Sixty-four instances of known and probable grizzly bear mortality from all causes were detected inside or near the CYE (excluding Canada) during 1982–2019 (Tables 1 and 10, Fig. 11). Forty-six were human caused, 15 were natural mortality, and 3 were unknown cause. There were 18 instances of known grizzly bear mortality in Canada within 16 km of the CYE in the Yahk and South Purcell population units from 1982–2019 (Tables 1 and 10, Fig. 11). Thirteen were human-caused and 5 were natural mortalities.

Table 10. Cause, timing, and location of known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada), 1982–2019. Radio collared bears included regardless of mortality location.

	Mortality cause											
Country/ age / sex / season / ownership	Defense of life	Legal Hunt	Hound hunting	Management removal	Mistaken identity	Natural	Poaching	Trap predation	Vehicle collision	Unknown, human	Unknown	Total
U.S.												
Age / sex												
Adult female	4					2	1		1	2	1	11
Subadult female						1	1	1	2	3		8
Adult male	2			2	1		2			4		11
Subadult male	2				4		2			4	1	13
Yearling					1	1					1	3
Cub					1	11	2			3		17
Unknown					1							1
Total	7			1	8	15	8	1	3	16	3	64
Season[1]												
Spring					1	3	1			4	1	10
Summer	1				1	12	1	1				16
Autumn	7			2	6		5		3	11		34
Unknown							1			1	2	4
Ownership												
US Private	3			2	2		5		3	5	1	21
US Public	5				6	15	3	1		11	2	43
Canada												
Adult female				2								2
Subadult female	1							1				2
Adult male	1	1		2	1					1		6
Subadult male				1						1		2
Yearling						1						1
Cub						4						4
Unknown			1									1
Total	2	1	1	5	1	5		1		2		18
Season[1]												
Spring		1		1		1		1				4
Summer			1	1		4						6
Autumn	2			3	1					2		8
Unknown												
Ownership												
BC Private				4								4
BC Public	2	1	1	1	1	5		1		2		14

[1]Spring = April 1 – May 31, Summer = June 1 – August 31, Autumn = September 1 – November 30

Sixty-nine percent (18 of 26) of known human-caused mortalities occurring on the US National Forests were <500m of an open road and 31% were >500m from an open road from 1982–2019 (8 of 26). Thirty-one percent (8 of 26) of known human-caused mortalities occurring on National Forests were located within core habitat (area greater than 500m from an open or gated road).

Mortality rates were examined by breaking the data into periods of increase (1982–98, 2007–19) and decrease (1999–2006) in population trend. From 1982–98, 16 instances of known mortality occurred in the U.S. and Canada, with 12 (75%) of these mortalities being human-caused (Table 1). The annual rate of known human-caused mortality was 0.71 mortalities per year. Twenty-seven instances of known mortality occurred during 1999–2006 with 18 (67%) of these mortalities human-caused. Annual rate of known human-caused mortality was 2.25 per year. Thirty-nine instances of known mortality occurred from 2007–19 with 29 (74%) of these mortalities human-caused. Annual rate of known human-caused mortality was 2.23 per year. Though the rate of known human caused mortality was similar between the two most recent time periods, it is important to consider the rate of female mortality. The loss of females is the most critical factor affecting the trend because of their reproductive contribution to current and future growth. The rate of known female mortality was 0.29 and human caused female mortality was 0.18 during 1982–98. Both total known female and human-caused female mortality rate increased from 1982–98 to 1999–2006 periods. Total known female mortality rate decreased from 1.88 during 1999–2006 to 0.85 during 2007–19 and known human-caused female mortality rate decreased from 1.5 to 0.62. This decline of female mortality is largely responsible for the improving population trend from 2007–19 (Pages 39–42). Efforts to detect mortality were probably lowest during 1982–98 because of fewer collared bears and less personnel presence in the Yaak portion of the recovery zone. Comparisons involving the two most recent time periods represent more similar amounts of effort to detect mortality.

The increase in total known mortality beginning in 1999 may be linked to poor food production during 1998–2004 (Fig. 11). Huckleberry production during these years was about half the long term average. Poor berry production years can be expected at various times, but in this case there were several successive years of poor production. Huckleberries are the major source of late summer food that enables bears to accumulate sufficient fat to survive the denning period and females to produce and nurture cubs. Poor nutrition may not allow females to produce cubs in the following year and cause females to travel further for food, exposing young to greater risk of mortality from conflicts with humans, predators, or accidental deaths. One female bear lost litters of 2 cubs each during spring of 2000 and 2001. Another mortality incident involved a female with 2 cubs that appeared to have been killed by another bear in 1999. The effect of cub mortality may be greatest in succeeding years when some of these animals might have been recruited to the reproductive segment of the population.

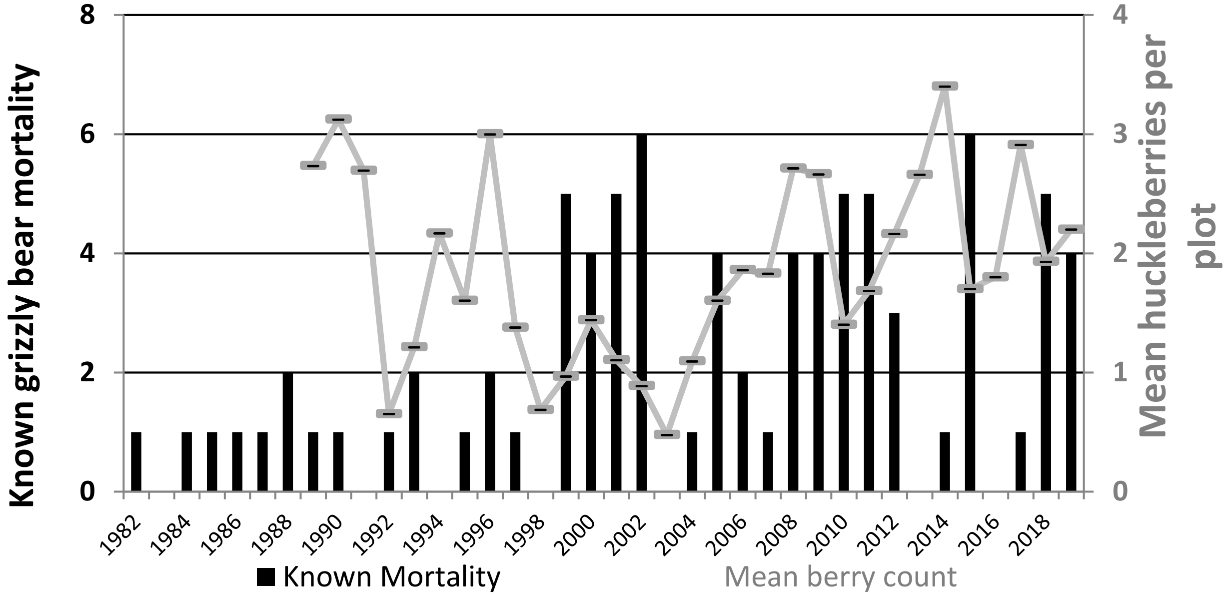

Figure 11. Known grizzly bear annual mortality from all causes in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and all radio-collared bears by cause, 1982–2018 and huckleberry production counts, 1989–2018.

Using counts of known human-caused mortality probably under-estimates total human-caused mortality. Numerous mortalities identified by this study were reported only because animals wore a radio-collar at death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry *et al*. 2002). Correction factors were not applied to natural mortality, management removals, mortality of radio-collared bears or bears that died of unknown causes (Table 11). All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes. Twenty-three radio-collared bears died from human causes during 1982–2019. Ten of these were reported by the public (53%) and 9 were unreported (47%). The Bayesian statistical analysis described by Cherry *et al*. (2002) was used to calculate unreported mortality in 3 year running periods in the Yellowstone ecosystem, but samples sizes in the CYE are much smaller, so we grouped data based on the cumulative population trend (ʎ, Fig. 11). The unreported estimate added 23 mortalities to the 81 known mortalities from 1982–2019. The unreported estimate includes bears killed in BC which are not counted in recovery criteria (USFWS 1993).

Table 11. Annual human-caused grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and estimates of unreported mortality, 1982–2019 (including all radio-collared bears regardless of mortality location).

Years	Population trend	Natural	Management or research	Radio monitored	Unknown cause	Public reported	Unreported estimate	Total
1982-1998	Improving	3	2	4	1	6	5	21
1999-2006	Declining	9	4	7	0	7	6	33
2007-2019	Improving	7	3	12	2	14	12	50
Total		19	9	23	3	27	23	104

Grizzly Bear Survival, Reproduction, Population Trend, and Population Estimate

This report segment updates information on survival rates, cause-specific mortality, and population trend following the methods used in Wakkinen and Kasworm (2004).

Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival and cause-specific mortality rates were calculated for 6 sex and age classes of native grizzly bears from 1983–2019 (Table 12). We calculated survival and mortality rates for augmentation and management bears separately (see below).

Table 12. Survival and cause-specific mortality rates of native grizzly bear sex and age classes based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2019.

	Demographic parameters and mortality rates					
Parameter	Adult female	Adult male	Subadult female	Subadult male	Yearling	Cub
Individuals / bear-years	17 / 48.9	26 / 36.7	20 / 25.3	23 /18.1	33 / 16.4	44 / 44[a]
Survival[b] (95% CI)	0.939 (0.874–1.0)	0.893 (0.798-0.989)	0.850 (0.712–0.988)	0.833 (0.660-01.0)	0.892 (0.748–1.0)	0.576 (0.415–0.736)
Mortality rate by cause						
Legal Hunt Canada	0	0.031	0	0	0	0
Natural	0.021	0	0	0	0.108	0.326
Defense of life	0	0.027	0.036	0.040	0	0
Mistaken ID	0	0	0	0.056	0	0
Poaching	0.019	0	0	0	0	0.048
Trap predation	0	0	0.042	0	0	0
Unknown human	0.021	0.048	0.073	0.071	0	0.052

[a]Cub survival based on counts of individuals alive and dead.
[b]Kaplan-Meier survival estimate which may differ from BOOTER survival estimate.

Mortality rates of all sex and age classes of resident non-management radio-collared grizzly bears ≥2 years old were summarized by cause and location of death (Table 13). Rates were categorized by public or private land and human or natural causes. Rates were further stratified by death locations in British Columbia or U.S. and broken into three time periods. The three periods (1983–1998, 1999-2006, and 2007–2019) correspond to a period of population increase followed by a period of decline followed by a period of increase in long term population trend (λ). Grizzly bear survival of all sex and age classes decreased from 0.899 during 1983–1998 to 0.792 during 1999–2006 and then rose to 0.935. Some of this decrease in the 1999–2006 period could be attributed to an increase in natural mortality probably related to poor berry production during 1998–2004. Mortality on private lands in the U.S. increased during this period, suggesting that bears were searching more widely for foods to replace the low berry crop. Several mortalities occurring during 1999–2006 were associated with sanitation issues on private lands. Declines in mortality rate on private lands beginning in 2007 correspond to and may be the result of the initiation of the MFWP bear management specialist position. Several deaths of management bears occurred on private lands, but were not included in this calculation due to capture biases (traps were set only once a conflict occurred and removed after capture). Point estimates for human-caused mortality occurring on public lands in the U.S. and British Columbia decreased from 1983–1998 to 1999–2006 and again from 1999–2006 to 2007–2019. This apparent decrease in mortality rates on public lands from 1983–1998 to 1999–2006 is particularly noteworthy given the increase in overall mortality rates. Implementation of access management on U.S. public lands could be a factor in this apparent decline.

Table 13. Survival and cause-specific mortality rates of native radio-collared grizzly bears ≥2 years old by location of death based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2019.

Parameter	1983–1998	1999–2006	2007–2019
Individuals / bear-years	23 / 48.9	21 / 20.3	44 / 59.6
Survival[b] (95% CI)	0.899 (0.819–0.979)	0.792 (0.634–0.950)	0.935 (0.871–1.0)
Mortality rate by location and cause			
Public / natural	0	0.059	0
U.S. public / human	0.061	0.036	0.033
U.S. private / human	0	0.075	0.032
B.C. public / human	0.040	0.038	0
B.C. private / human	0	0	0

Augmentation Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 22 augmentation grizzly bears from 1990–2019. Bears that left the area were censored. Thirteen female and seven male bears ranged in age from 2–10, but were pooled for calculation because of small sample size. Survival for augmentation bears was 0.802 (95% CI=0.659–0.945, n=22) with a natural mortality (female), a poaching (female), a mistaken identity (male), a train collision (female), and an unknown cause (female) among 22 radio-collared bears monitored for 23.4 bear-years. The natural mortality occurred during spring, the unknown mortality occurred during summer, and the poaching, mistaken identity, and train mortality occurred during autumn. The female that died of unknown cause produced a cub before her death, and it is assumed the cub died.

Management Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 16 management grizzly bears captured at conflict sites from 2003–19. Fourteen bears were males and two were females aged 2–25 but were pooled for this calculation because of small sample size. Survival rate was 0.575 (95% CI=0.343–0.808, n=16) with an instance of mistaken identity, a self-defense, a management removal, and two unknown but human-caused mortality among 16 radio-collared bears monitored for 8.3 bear-years. One mortality occurred during spring and four occurred during autumn. All mortality involved males.

Grizzly Bear Reproduction

Reproductive parameters originated from all bears monitored 1983–2019. Mean age of first parturition among native grizzly bears was 6.3 years (95% CI=5.9–6.7, n=14, Table 14). Five bears used in the calculation were radio-collared from ages 2–8. One individual was captured with a cub at age 6 years old. We assumed this was a first reproductive event given her age. Eight other first ages of reproduction were established through genetic parentage analysis and known age of offspring. Twenty-seven litters comprised of 59 cubs were observed through both monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation, for a mean litter size of 2.19 (95% CI=2.01–2.37, n=27, Table 14). Twenty-four reproductive intervals were determined through monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation (Table 14). Mean inter-birth interval was calculated as 3.00 years (95% CI=2.57–3.43, n=24). Booter software provides several options to calculate reproductive rate (*m*) and we selected unpaired litter size and birth interval data with sample size restricted to the number of females. The unpaired option allows use of bears from which accurate counts of cubs were not obtained but interval was known, or instances where litter size was known but radio failure or death limited knowledge of birth interval. Estimated reproductive rate using the unpaired option was 0.361 female cubs/year/adult female (95% CI=0.286–0.467, n=12 adult females, Table 15). Sex ratio of cubs born was assumed to be 1:1. Reproductive rates do not include augmentation bears.

Table 14. Grizzly bear reproductive data from the Cabinet-Yaak 1983–2019.

Bear	Year	Age at first reproduction	Cubs	Reproductive Interval[1]	Cubs (relationship and fate, if known)
106	1986		2	2	1 dead in 1986, ♀ 129 dead in 1989
106	1988		3	3	♂ 192 dead in 1991, ♂ 193, ♀ 206
106	1991		2	2	2 cubs 1 male other unknown sex and fate
106	1993		2	2	♂ 302 dead in 1996, ♀ 303
106	1995		2	4	♀ 353 dead in 2002, ♀ 354 dead in 2007
106	1999		2		♀ 106 and 2 cubs dead in 1999
206	1994	6	2	3	♀ 505
206	1997		2		♀ 596 dead in 1999, ♀ 592 dead in 2000
538	1997	6		3	1 yearling separated from ♀ 538 in 1998
538	2000		2	1	2 cubs dead in 2000
538	2001		2	1	2 cubs dead in 2001
538	2002		2		2 cubs of unknown sex and fate
303	2000	7	2	3	1 cub dead in 2000, ♀ 552
303	2003			4	At least 2 cubs
303	2007			3	
303	2010		3		1 cub dead in 2010
303	2013				Observed with courting male in May 2014
303	2016				1 yearling observed in 2016
354	2000	5		3	Genetic data indicated reproduction of at least two cubs in 2000
354	2003			3	At least 2 cubs
354	2006				At least 2 cubs
353	2002	7	3		♀ 353 dead in 2002, 3 cubs (1 female) all assumed dead in 2002
772	2003	6		4	Genetic data indicated reproduction of at least one cub in 2003
772	2007		3		♀ 789, ♂ 791, Unknown sex dead in 2007
675	2009	7	2	1	2 cubs dead in 2009
675	2010		1		1 cub dead in 2010
552	2011		2	3	♀ 2011049122, ♂ 2011049118
552	2014		3		3 cubs, 2 males and one of unknown sex
784	2013	7			At least 2 cubs
810	2010	7		4	At least one cub
810	2014		2		2 cubs observed at camera site, August 2014
810	2018		2		2 cubs observed June 2018
820	2009	6		4	At least one cub
820	2013		2		2 cubs ♀ 842, ♂ 818, 818 dead in 2015
820	2018		2	5	2 cubs observed July 2018
831	2004	7		3	At least 1 cub
831	2007			4	At least 2 cubs
831	2011		3	4	At least 3 cubs
831	2017		3		Photo with 3 cubs July 2017
822	2018	5			Photo June 2018 with at least one cub
842	2019	6	2		2 cubs dead in 2019

[1]Number of years from birth to subsequent birth.

Population Trend

Approximately 95% of the survival data and 85% of the reproductive data used in population trend calculations came from bears monitored in the Yaak River portion of this population, hence this result is most indicative of that portion of the recovery area. However, only the Kootenai River divides the Cabinet Mountains from the Yaak River and the trend produced from this data would appear to be applicable to the entire population of native bears in the absence of population augmentation. We have no data to suggest that mortality or reproductive rates are different between the Yaak River and the Cabinet Mountains. The Cabinet Mountains portion of the population was estimated to be <15 in 1988 (Kasworm and Manley 1988) and subsequent lack of identification of resident bears through genetic techniques would suggest the population was possibly 5–10. Population augmentation has added 22 bears into this population since 1990 and a mark recapture population estimate from 2012 indicated the population was 22–24 individuals (Kendall *et al*. 2016). These data indicate the Cabinet Mountains population has increased by 2–4 times since 1988, but this increase is largely a product of the augmentation effort with reproduction from that segment.

The estimated finite rate of increase (λ) for 1983–2019 using Booter software with the unpaired litter size and birth interval data option was 1.009 (95% CI=0.931–1.073, Table 15). Finite rate of change over the same period was an annual 0.9% (Caughley 1977). Subadult female survival and adult female survival accounted for most of the uncertainty in λ, with reproductive rate, yearling survival, cub survival, and age at first parturition contributing much smaller amounts. The sample sizes available to calculate population trend are small and yielded wide confidence intervals around our estimate of trend (i.e., λ). The probability that the population was stable or increasing was 60%. Utilizing the entire survival and reproductive data set from 1983–2019 is partially the product of small sample sizes but also produces the effect of smoothing the data over time and results in a more conservative estimate of population trend.

Finite rates of increase calculated for the period 1983–1998 (λ = 1.067) suggested an increasing population (Wakkinen and Kasworm 2004). Lack of mortality in specific sex-age classes limited calculations for many time periods other than those shown here (Fig. 12). Annual survival rates for adult and subadult females were 0.948 and 0.901 respectively, during 1983–1998, and then declined to 0.926 and 0.740 for the period of 1983–2006, respectively. Cumulative lambda calculations reached the lowest point in 2006 (Fig. 12). Human-caused mortality has accounted for much of this decline in annual survival rates and population trend. During 2019, adult female survival and subadult female survival had increased to 0.940 and 0.847 respectively and resulted in an improving population trend estimate since 2006. Improving survival by reducing human-caused mortality is crucial for recovery of this population (Proctor *et al*. 2004).

Table 15. Booter unpaired method estimated annual survival rates, age at first parturition, reproductive rates, and population trend of native grizzly bears in the Cabinet–Yaak recovery zone, 1983–2019.

Parameter	Sample size	Estimate (95% CI)	SE	Variance (%)[a]
Adult female survival[b] (S_a)	16 / 48.5[c]	0.940 (0.856–1.0)	0.036	33.4
Subadult female survival[b] (S_s)	20 / 25.6[c]	0.847 (0.692–0.965)	0.072	51.0
Yearling survival[b] (S_y)	33 / 1632[c]	0.885 (0.723–1.0)	0.076	2.9
Cub survival[b] (S_c)[d]	44/44	0.591 (0.455–0.727)	0.074	6.2
Age first parturition (*a*)	14	6.3 (5.9–6.6)	0.188	0.5
Maximum age (*w*)	Fixed	27		
Unpaired Reproductive rate (*m*)[e]	12/24/27[f]	0.360 (0.291–0.467)	0.045	6.1
Unpaired Lambda (λ)	5000 bootstrap runs	1.009 (0.931–1.073)	0.037	

[a] Percent of lambda explained by each parameter
[b]Booter survival calculation which may differ from Kaplan-Meier estimates in Table 13.
[c]individuals / bear-years
[d]Cub survival based on counts of individuals alive and dead
[e]Number of female cubs produced/year/adult female. Sex ratio assumed to be 1:1.
[f]Sample size for individual reproductive adult females / sample size for birth interval / sample size for litter size from Table 14.

Population Estimate

During 2012, USGS used mark-recapture techniques to estimate the CYE grizzly bear population at 48–50 (95% CI = 44–62) (Kendall *et al*. 2016). Using the midpoint of this estimate (49), the calculated rate of increase (0.9%), results in a gain of 3 bears through 2019 to a population of 52. The augmentation program added 8 bears since 2012 but two of those are known dead. Based on this information, a population estimate of 55–60 bears would seem reasonable.

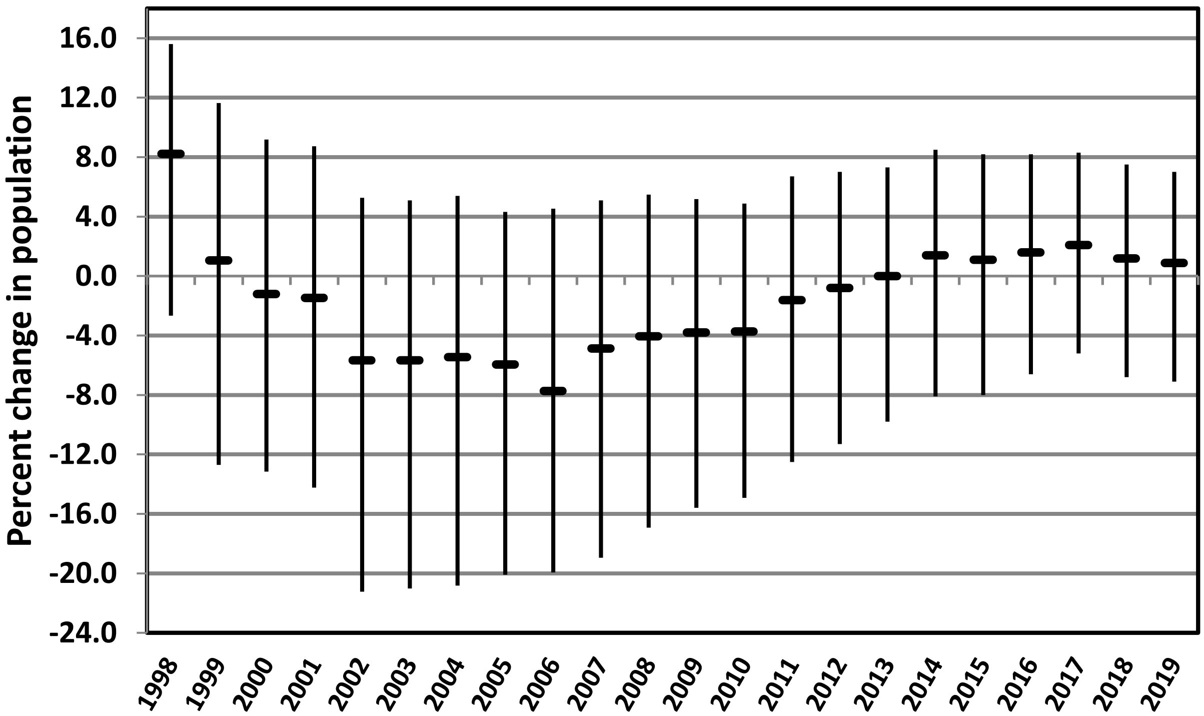

Figure 12. Point estimate and 95% confidence intervals for cumulative annual calculation of population rate of change for native grizzly bears in the Cabinet-Yaak recovery area, 1983–2019. Each entry represents the annual rate of change from 1983 to that date.

Capture and Marking

Five grizzly bears were captured within the Cabinet and Yaak study area (1 adult female, 2 adult males, and 2 subadult males) during 2019. Four grizzly bears (1 female and 3 males) were captured for research monitoring and one male was captured for management purposes. Ninety-five individual grizzly bears have been captured 144 times as part of this monitoring program since 1983 (Tables 16 and 17). One-hundred twenty captures occurred for research purposes and 24 captures occurred for management purposes.

Cabinet Mountains

Research trapping was conducted in the Cabinet Mountains portion of the CYE from 1983–87. Three adult grizzly bears were captured during this effort (1 female and 2 males). No trapping occurred from 1988–1994 as effort was directed toward the Yaak River. In 1995 an effort was initiated to recapture relocated bears in order to determine success of the population augmentation program and capture any native bears in the Cabinet Mountains. During 1983–2019, 7,667 research trap-nights were expended to capture 13 known individual grizzly bears and 317 individual black bears (Table 16 and 17, Fig. 13). Rates of capture by individual were 1 grizzly bear/590 trap-nights and 1 black bear/24 trap-nights. A trap-night was defined as one site with one or more snares set for one night. One augmentation bear was captured during subsequent trapping efforts. Much of the trapping effort before 2002 involved use of horses on backcountry trails and closed roads. In 2003, two culvert traps were airlifted to the East Fork of Rock Creek by helicopter. Traps were operated during the last week of August and first week of September. Three black bears were captured. No grizzly bears were captured, though one was observed near the traps.

Yaak River, Purcell Mountains South of BC Highway 3

Trapping was conducted in the Yaak portion of the CYE during 1986–87 as part of a black bear graduate study (Thier 1990). Research trapping was continued from 1989–2019 by USFWS. One-hundred eight captures of 59 individual grizzly bears and 542 captures of 457 individual black bears were made during 11,453 trap-nights during 1986–2019 (Tables 16 and 17, Fig. 13). Rates of capture by individual were 1 grizzly bear/194 trap-nights and 1 black bear/25 trap-nights. Trapping effort was concentrated in home ranges of known bears during 1995–2019 to recapture adult females with known histories. Much of the effort involved using horses and bicycles in areas inaccessible to vehicles, such as trails and closed roads.

Salish Mountains

Trapping occurred in the Salish Mountains, south of Eureka, Montana, in 2003. An adult female grizzly bear (5 years old), and 5 black bears were captured during 63 trap-nights of effort (Tables 16, 17).

Moyie River and Goat River Valleys North of Highway 3, British Columbia

Eight grizzly bears and 32 black bears were captured in the Moyie and Goat River valleys north of Highway 3 in BC in 2004-08 (Table 16 and Fig. 13). Trapping was conducted in cooperation with M. Proctor (Birchdale Ecological Consultants, Kaslo, BC) and BC Ministry of Environment. Rates of capture by individual were 1 grizzly bear/32 trap-nights and 1 black bear/8 trap-nights.

Population Linkage Kootenai River Valley, Montana

Twelve black bears were captured and fitted with GPS radio collars during 2004–07 to determine bear crossing patterns of the Kootenai River valley near the junction of Highway 2 and 508. These captures were distributed north (6 females and 3 males) and south of the Kootenai River (1 female and 2 males).

Population Linkage Clark Fork River Valley, Montana

Seventeen black bears were captured and fitted with GPS radio collars in the Clark Fork River Valley during 2008–11 to examine bear crossing opportunities near the junction of Highways 200 and 56. Eleven of these bears (3 females and 8 males) were north of the Clark Fork River and 6 bears (6 males) south of the river.

Population Linkage Interstate 90 Corridor, Montana and Idaho

In 2011 and 2012, we collared black bears with GPS radio collars along I-90 between St. Regis, MT and the MT-ID border (near Lookout Pass). Twenty bears were captured 23 times during 446 trap-nights of effort, resulting in 19 trap-nights/capture (Table 16). Sixteen bears were collared (15 in Montana, 1 in Idaho). Eight bears (2 females and 6 males) were collared north of the highway and 8 (3 females and 5 males) were collared south of the highway.

Population Linkage Highway 95 Corridor, Idaho

We began an effort in 2011 to collar black bears with GPS radio collars along Highway 95 between Bonners Ferry and Sandpoint, Idaho. Effort centered on the McArthur Lake State

Wildlife Management Area. Nineteen black bears were captured during 413 trap-nights, or 22 trap-nights/capture (Table 16). Fourteen bears were collared. Nine of those bears (4 females and 5 males) were collared west of the highway, and 5 (5 males) were east of the highway.

Table 16. Research capture effort and success for grizzly bears and black bears within study areas, 1983–2019.

Area / Year(s)	Trap-nights	Grizzly Bear Captures	Black Bear Captures	Trap-nights / Grizzly Bear	Trap-nights / Black Bear
Cabinet Mountains,1983–19					
Total Captures	7667	16	435	479	18
Individuals[1]	7667	13	317	590	24
Salish Mountains, 2003[1]	63	1	5	63	13
Yaak River South Hwy 3, 1986–19					
Total Captures	11453	108	542	106	21
Individuals[1]	11453	59	457	194	25
Purcells N. Hwy 3, BC 2004–09					
Total Captures	390	10	37	39	11
Individuals[1]	390	9	32	43	12
Interstate 90, 2011–12					
Total Captures	446	0	23	0	19
Individuals[1]	446	0	20	0	22
Hwy 95, ID, 2011					
Total Captures	408	0	19	0	21
Individuals[1]	408	0	19	0	21

[1]Only captures of individual bears included. Recaptures are not included in summary.

Table 17. Grizzly bear capture information from the Cabinet-Yaak and Purcell populations, 1983–2019. Multiple captures of a single bear in a single year are not included.

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
678	6/29/83	F	28	86	Bear Cr., MT	Research
680	6/19/84	M	11	(181)	Libby Cr., MT	Research
680	5/12/85	M	12	(181)	Bear Cr., MT	Research
678	6/01/85	F	30	79	Cherry Cr., MT	Research
14	6/19/85	M	27	(159)	Cherry Cr., MT	Research
101	4/30/86	M	(8)	(171)	N Fk 17 Mile Cr., MT	Research
678	5/21/86	F	31	65	Cherry Cr., MT	Research
106	5/23/86	F	8	92	Otis Cr., MT	Research
128	5/10/87	M	4	(114)	Lang Cr., MT	Research
129	5/20/87	F	1	32	Pheasant Cr., MT	Research
106	6/20/87	F	9	(91)	Grizzly Cr., MT	Research
134	6/24/87	M	8	(181)	Otis Cr., MT	Research
129	7/06/89	F	3	(80)	Grizzly Cr., MT	Research
192	10/14/89	M	1	90	Large Cr., MT	Research
193	10/14/89	M	1	79	Large Cr., MT	Research
193	6/03/90	M	2	77	Burnt Cr., MT	Research
206	6/03/90	F	2	70	Burnt Cr., MT	Research
106	9/25/90	F	12	(136)	Burnt Cr., MT	Research
206	5/24/91	F	3	77	Burnt Cr., MT	Research
244	6/17/92	M	6	140	Yaak R., MT	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
106	9/04/92	F	14	144	Burnt Cr., MT	Research
34	6/26/93	F	(15)	158	Spread Cr., MT	Research
206	10/06/93	F	5	(159)	Pete Cr., MT	Research
505	9/14/94	F	Cub	45	Jungle Cr., MT	Research
302	10/07/94	M	1	95	Cool Cr., MT	Research
303	10/07/94	F	1	113	Cool Cr., MT	Research
106	9/20/95	F	17	(169)	Cool Cr., MT	Research
353	9/20/95	F	Cub	43	Cool Cr., MT	Research
354	9/20/95	F	Cub	47	Cool Cr., MT	Research
302	9/24/95	M	2	113	Cool Cr., MT	Research
342	5/22/96	M	4	(146)	Zulu Cr., MT	Research
363	5/27/96	M	4	(158)	Zulu Cr., MT	Research
303	5/27/96	F	3	(113)	Zulu Cr., MT	Research
355	9/12/96	M	(6)	(203)	Rampike Cr., MT	Research
358	9/22/96	M	8	(225)	Pete Cr., MT	Research
353	9/23/96	F	1	83	Cool Cr., MT	Research
354	9/23/96	F	1	88	Cool Cr., MT	Research
384	6/12/97	M	7	(248)	Zulu Cr., MT	Research
128	6/15/97	M	14	(270)	Cool Cr., MT	Research
386	6/20/97	M	5	(180)	Zulu Cr., MT	Research
363	6/26/97	M	5	(180)	Cool Cr., MT	Research
538	9/25/97	F	6	(135)	Rampike Cr., MT	Research
354	9/27/97	F	2	99	Burnt Cr., MT	Research
354	8/20/98	F	3	(90)	Cool Cr., MT	Research
106	8/29/98	F	20	(146)	Burnt Cr., MT	Research
363	8/30/98	M	6	(203)	Burnt Cr., MT	Research
342	9/17/98	M	6	(203)	Clay Cr., MT	Research
303	9/21/98	F	5	(113)	Clay Cr., MT	Research
592	8/17/99	F	2	(91)	Pete Cr., MT	Research
596	8/23/99	F	2	(91)	French Cr., MT	Research
358	11/15/99	M	11	279	Yaak R., MT	Management, open freezer, killed goats
538	7/16/00	F	9	(171)	Moyie River, BC	Research
552	7/16/01	F	1	(36)	Copeland Cr., MT	Research
577	5/22/02	F	1	23	Elk Cr., MT	Management, pre-emptive move
578	5/22/02	M	1	23	Elk Cr., MT	Management, pre-emptive move
579	5/22/02	M	1	30	Elk Cr., MT	Management, pre-emptive move
353	6/15/02	F	7	(136)	Burnt Cr., MT	Research
651	9/25/02	M	7	(227)	Spread Cr., MT	Research
787	5/17/03	M	3	71	Deer Cr. ID	Management, garbage feeding
342	5/23/03	M	11	(227)	Burnt Cr., MT	Research
648	8/18/03	F	5	(159)	McGuire Cr., MT, Salish Mtns.	Research
244	9/25/03	M	17	(205)	N Fk Hellroaring Cr., MT	Research
10	6/17/04	F	11	(159)	Irishman C., BC	Research
11	6/20/04	M	7	(205)	Irishman C., BC	Research
12	7/22/04	F	11	(148)	Irishman C., BC	Research
576	10/21/04	M	2	(114)	Young Cr., MT	Management, garbage feeding
675	10/22/04	F	2	100	Young Cr., MT	Management, pre-emptive move
677	5/13/05	M	6	105	Canuck Cr., BC	Research
688	6/13/05	M	3	93	EF Kidd Cr., BC	Research
576	6/17/05	M	3	133	Teepee Cr., BC	Research
690	6/17/05	F	1	52	EF Kidd Cr., BC	Research
17	6/18/05	M	8	175	Norge Pass, BC	Research
2	6/20/05	M	7+	209	EF Kidd Cr., BC	Research
292	7/6/05	F	4	(114)	Mission Cr., ID	Research
694	7/15/05	F	2	73	Kelsey Cr., MT	Research
770	9/20/05	M	11	(250)	Chippewa Cr., MT	Research
M1	10/4/05	M	(2)	(80)	Pipe Cr., MT	Management, garbage feeding

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
668	10/11/05	M	3	120	Yaak R., MT	Management, garbage feeding
103	5/23/06	M	3	125	Canuck Cr., BC	Research
---	5/28/06	F	4	(125)	Cold Cr., BC (Trap predation)	Research
5381	6/6/06	M	4	(200)	Hellroaring Cr., ID	Research
651	6/28/06	M	11	198	Cold Cr., BC	Research
780	9/22/06	M	6	(250)	S Fk Callahan Cr., MT	Research
130	6/18/07	F	26	113	Arrow Cr., BC	Research
131	6/28/07	F	(5)	(80)	Arrow Cr., BC	Research
784	9/23/07	F	1	(80)	Spread Cr., MT	Research
772	9/18/07	F	10	116	Pilgrim Cr., MT	Management, fruit trees
789	9/18/07	F	Cub	36	Pilgrim Cr., MT	Management, fruit trees
791	9/18/07	M	Cub	39	Pilgrim Cr., MT	Management, fruit trees
785	10/15/07	F	1	75	Pete Cr., MT	Research
675	5/23/09	F	7	89	Elmer Cr. BC	Research
784	7/24/09	F	3	(136)	Hensley Cr., MT	Research
731	9/17/09	F	2	(125)	Fowler Cr., MT	Research
5381	11/21/09	M	4	(273)	Kidd Cr., BC	Research
799	5/21/10	M	3	(102)	Rock Cr., MT	Research
737	7/21/10	M	4	129	Messler Cr., MT	Research
1374	8/30/10	M	2	98	Young Cr., MT	Management, garbage feeding
726	5/24/11	M	2	77	Meadow Cr., MT	Research
722	5/31/11	M	12	261	Otis Cr., MT	Research
729	6/18/11	F	1	33	Beulah Cr., MT	Research
724	7/13/11	M	2	159	Graves Cr., MT	Management, killed pigs
732	10/27/11	M	5	139	Otis Cr., MT	Management, killed chickens
729	6/26/12	F	2	(80)	Pipe Cr., MT	Research
737	9/19/12	M	6	(159)	Basin Cr., MT	Research
552	9/24/12	F	12	(136)	Basin Cr., MT	Research
826	6/28/13	M	(5)	(136)	Pipe Cr., MT	Research
303	7/23/13	F	20	132	Pipe Cr., MT	Research
831	6/21/14	F	14	81	Libby Cr., MT	Research
807	6/24/14	M	4	111	Canuck Cr., ID	Research
808	6/27/14	M	4	130	Spruce Cr., ID	Research
722	8/21/14	M	15	(182)	Hellroaring Cr., MT	Research
835	8/24/14	M	19	185	Hellroaring Cr., MT	Research
836	9/19/14	F	1	75	Hellroaring Cr., MT	Research
837	9/29/14	M	6	(227)	Hellroaring Cr., MT	Research
729	5/19/15	F	5	107	Cool Cr., MT	Research
839	6/19/15	M	4	78	Bear Cr., MT	Research
810	7/16/15	F	12	120	Hellroaring Cr., MT	Research
818	7/18/15	M	2	82	Meadow Cr., MT	Research
820	8/20/15	F	12	149	Hellroaring Cr., MT	Research
726	10/5/15	M	6	227	Libby Cr., MT	Management, beehives
836	7/18/16	F	3	87	Hellroaring Cr., MT	Research
822	8/15/16	F	3	92	Hellroaring Cr., MT	Research
824	8/18/16	M	(12)	197	Hellroaring Cr., MT	Research
9811	8/19/16	M	(2)	(91)	Hellroaring Cr., MT	Research
821	8/27/16	M	2	127	Hellroaring Cr., MT	Research
853	9/21/16	M	5	120	Boulder Cr., MT	Research
722	9/29/16	M	17	238	17 Mile Cr., MT	Management, pigs and chickens
922	10/10/16	M	2	130	Upper Yaak R., MT	Management, chicken feed
726	6/18/17	M	8	(195+)	Beulah Cr., MT	Research
1026	6/21/17	F	2	63	Upper Yaak R., MT	Management, habituated
1028	6/21/17	F	2	64	Upper Yaak R., MT	Management, habituated
861	6/25/17	M	2	55	Bear Cr., MT	Research
840	6/26/17	F	2	53	Cruien Cr., MT	Research
842	7/25/17	F	4	93	Fourth of July Cr., MT	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
810	9/18/17	F	14	150	Hellroaring Cr., MT	Research
9077	4/30/18	M	(3)	112	Thompson R., MT	Management
927	9/5/18	M	(2)	92	Dry Cr., ID	Management, Black Bear Bait Station
722	9/23/18	M	19	238	Hellroaring Cr., MT	Research
844	6/22/19	M	(3)	122	Pipe Cr, MT	Research
866	6/25/19	M	(3)	134	Bear Cr, MT	Research
835	7/23/19	M	17	175	Canuck Cr, MT	Research
822	7/25/19	F	6	109	Canuck Cr, MT	Research
770	10/11/19	M	25	207	Bear Cr,MT	Management, Livestock feed

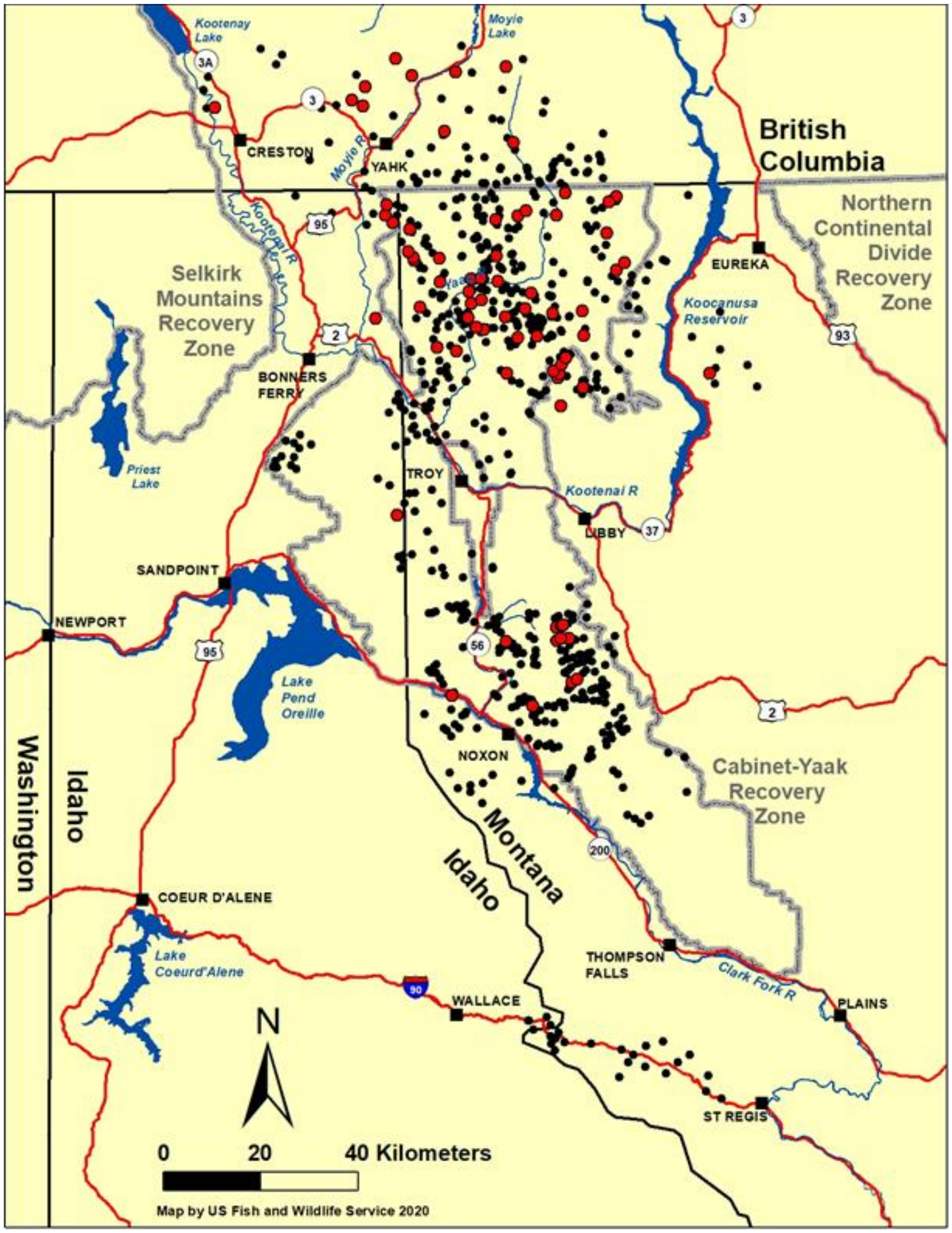

Figure 13. Trap site locations in the Cabinet-Yaak study areas 1983–2019. Red dots represent sites with ≥ one grizzly bear capture.

Grizzly Bear Monitoring and Home Ranges

Twelve grizzly bears were monitored with radio-collars during portions of 2019. Research monitoring included four females (two adults and two subadults) and eight males (three adult and five subadults) in the CYE. Two subadult males and a subadult female were from the Cabinet Mountains augmentation program. One adult male bear was collared for conflict management purposes.

Aerial telemetry locations and GPS collar locations were used to calculate home ranges. The convex polygon life ranges were computed for bears monitored during 1983–2019 (Table 18 and Appendix 4 Figs. A1-A108). Resident, non-augmentation bears with life range estimates for bears with ≥ 5 months of telemetry. were used to calculate basic statistics. Adult male life range averaged 1,990 km^2 (95% CI ± 473, n = 23) and adult female life range averaged 562 km^2 (95% CI ± 336, n = 19) using the minimum convex polygon estimator.

Young female bears typically utilize home ranges adjacent to or a part of their mother's home range. The minimum convex polygon estimator for bear 106 was 658 km^2 during her 1986–99 life time (Fig. 14). Her home range was smallest during 1986, 1988, 1991, 1993, and 1995 when she had cubs. Four known female offspring of bear 106 established home ranges around their maternal range (Fig. 14). Bear 206 has established a home range adjacent to and north of her mother's home range. Bear 303 has established a home range east of her mother's home range and female 354 may have established her home range west of her mothers. Bear 353 lived within her mother's old range, before her death. Second-generation female offspring of 106 occupied habitats east and west of first-generation offspring. In recent years, third-generation females have established home ranges south of second-generation females (Fig. 14).

Home ranges of collared grizzly bears overlap extensively on a yearly and lifetime basis. However, bears typically utilize the same space at different times. Male home ranges overlap several females to increase breeding potential, but males and females consort only during the brief period of courtship and breeding. Adult male bears, whose home ranges overlap, seldom use the same habitat at the same time to avoid conflict.

Table 18. Home range sizes of native (independent or family groups) and transplanted grizzly bears in the Cabinet-Yaak recovery zone, Purcell Mountains and Salish Mountains 1983–2019.

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
678	F	28-34	1983-89	VHF	173	658	Cabinet Mtns, MT
680	M	11-12	1984-85	VHF	75	1,947	Cabinet Mtns, MT
14	M	27	1985	VHF	23	589	Cabinet Mtns, MT
101	M	8	1986	VHF	38	787	Yaak River, MT
106	F	8-20	1986-99	VHF	379	852	Yaak River, MT
128	M	4-14	1987-97	VHF	204	2,895	Yaak River, MT
129	F	1-3	1987-89	VHF	42	60	Yaak River, MT
134	M	8-9	1987-88	VHF	20	594	Yaak River, MT
192	M	2	1990	VHF	10	574	Yaak River, MT
193	M	2	1990	VHF	34	642	Yaak River, MT
206	F	2-7	1990-95	VHF	208	1,332	Yaak River, MT
218[1]	F	5-6	1990-91	VHF	95	541	Cabinet Mtns, MT
244	M	6-18	1992-04	VHF	158	1,406	Yaak River, MT
258[1]	F	6-7	1992-93	VHF	54	400	Cabinet Mtns, MT
286[1]	F	2-3	1993-94	VHF	82	266	Cabinet Mtns, MT
311[1]	F	3-4	1994-95	VHF	16	209	Cabinet Mtns, MT
302	M	1-3	1994-96	VHF	60	514	Yaak River, MT
303	F	1-22	1994-01, 2011-16	GPS & VHF	12,177	605	Yaak River, MT

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
342	M	4-12	1996-04	VHF	134	1,653	Yaak River, MT
355	M	(6)	1996	VHF	5	N/A	Yaak River, MT & BC
358	M	8-10	1996-98	VHF	55	1,442	Yaak River, MT & BC
363	M	4-7	1996-99	VHF	120	538	Yaak River, MT
386	M	5-6	1997-98	VHF	29	1,895	Yaak River, MT
354	F	2-4	1997-99	VHF	70	537	Yaak River, MT
538	F	6-11	1997-02	VHF	232	835	Yaak River, MT & BC
592	F	2-3	1999-00	VHF	59	471	Yaak River, MT & BC
596	F	2	1999	VHF	10	283	Yaak River, MT & BC
552	F	1-15	2001, 2012-15	GPS & VHF	1,431	1,210	Yaak River, MT
577	F	1	2002	VHF	11	2	Cabinet Mtns, MT
578	M	1	2002	VHF	3	N/A	Cabinet Mtns, MT
579	M	1	2002	VHF	10	5	Cabinet Mtns, MT
353	F	7	2002	VHF	37	119	Yaak River, MT
651	M	7-11	2002-03,06	GPS & VHF	1,827	1,004	Yaak River, MT & BC
787[2]	M	3-4	2003-04	VHF	84	1,862	Yaak River, MT
648	F	5-7	2003-05	VHF	85	948	Salish Mtns, MT
576[2]	M	3-4	2005-06	GPS & VHF	2,290	1,320	Yaak River, MT & BC
675	F	2-8	2004-10	GPS & VHF	1,827	714	Yaak River, MT & BC
10	F	11	2004	GPS	1,977	176	Moyie River, BC
11	M	7	2004	GPS	894	1,453	Moyie River, BC
12	F	11	2004	GPS	1,612	333	Moyie River, BC
17	M	8	2005	GPS	1,903	3,074	Yaak River, MT & BC
677	M	6	2005	GPS	519	3,361	Yaak River, MT & BC
688	M	3-4	2005-06	GPS	3,421	1,544	Moyie & Goat River, BC
694	F	2	2005	VHF	11	89	Yaak River, MT
292	F	4	2005	GPS	7,062	253	Moyie & Goat River, BC & ID
770	M	11-12,25	2005-06,19	VHF & GPS	1039	524	Cabinet Mtns, MT
2	M	(7-9)	2005-06	GPS	1,337	2,860	Moyie / Yahk, BC
A1[1]	F	(8-10)	2005-07	VHF	73	725	Cabinet Mtns, MT
782[1]	F	2-5	2006-08	GPS	1,126	1,932	Cabinet Mtns, MT
780	M	6-8	2006-08	VHF	56	1,374	Cabinet Mtns, MT
103	M	2-4	2006-07	GPS	4,872	6,545	Kootenai, & Pend Oreille River, BC, ID, & WA
5381	M	4-5	2006-07	GPS	11,491	1,949	Moyie & Goat River, BC & ID
130	F	26-27	2007-08	GPS	3,986	281	Goat River, BC
131	F	(5)	2007-08	GPS	3,270	276	Goat River, BC
784	F	1-3	2007-09	GPS	2,606	524	Yaak River, MT
785	F	1-2	2007-08	GPS	362	207	Yaak River, MT
772	F	10	2007	VHF	14	446	Cabinet Mtns, MT
635[1]	F	4	2008	GPS	285	451	Cabinet Mtns, MT
790[1]	F	3	2008	GPS	227	423	Cabinet Mtns, MT
715[1]	F	(10-11)	2009-10	GPS	437	6,666	Cabinet Mtns, MT
731	F	2-4	2009-11	GPS	1,652	852	Yaak River, MT
799	M	2-4	2010-11	GPS	1,422	805	Cabinet Mtns, MT
713[1]	M	5-6	2010-11	GPS & VHF	562	5,999	Cabinet Mtns, MT
714[1]	F	5-6	2010-12	GPS	1,684	2,389	Cabinet Mtns & Flathead, MT
737	M	4-7	2010-13	GPS & VHF	1,626	2,667	Yaak River, MT & BC
1374	M	2	2010	GPS	14	381	Yaak River, MT & BC
722[2]	M	12-19	2011-19	GPS	3523	4,282	Yaak River, MT & BC
723[1]	M	1-3	2011-12	GPS	430	1,063	Cabinet Mtns, MT
724[2]	M	1-3	2011-12	VHF	29	873	Cabinet Mtns, MT

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km²)	Area of use
725[1]	F	2-4	2011-13	GPS	3,194	3,314	Cabinet Mtns & Flathead, MT
726	M	2-3,6-8	2011-12,15-17	GPS	6,335	3,751	Kootenai & Yaak River, MT
729	F	1-7	2011-13, 15-17	GPS	17,356	560	Yaak River, MT
732[2]	M	5	2011	GPS	875	458	Yaak River, MT
918[1]	M	2-4	2012-14	GPS	1,192	587	Cabinet Mtns, MT
826	M	-5	2013	GPS	164	1,820	Yaak& Kootenai River, MT & BC
919[1]	M	4-5	2013-14	GPS	345	436	Cabinet Mtns, MT
808	M	4-5	2014-15	GPS	1,273	1,722	Yaak River, MT
831	F	14	2014	GPS	434	218	Cabinet Mtns, MT
835	M	12-14,17	2014-16,19	GPS	826???	4,145	Yaak River, MT
836	F	1-4	2014--17	GPS	3,772	1,816	Yaak River, MT
837	M	6-8	2014-16	GPS	1,173	1,553	Yaak River, MT
920[1]	F	3-5	2014-16	GPS	5,108	913	Cabinet Mtns, MT
921[1]	F	2-3	2014-15	GPS	2,033	259	Cabinet Mtns, MT
810	F	12,14-15	2015,2017-18	GPS	3,150	413	Yaak River, MT
818	M	2	2015	GPS	461	225	Yaak River, MT
839	M	3-4	2015-16	GPS & VHF	2,595	6,819	Cabinet & Whitefish Mtns, MT
820	F	12-14	2015-18	GPS	2,537	295	Yaak River, MT
924[1]	M	2	2015	GPS	741	2,068	Cabinet Mtns, MT
1001	M	6	2015	GPS	1,352	1,357	Selkirk Mtns, BC
807	M	4-7	2014-17	GPS	2,568	3,319	Selkirk Mtns, ID&Yaak River, MT
821	M	2-3	2016-17	GPS	2,467	4,405	Yaak River, MT
822	F	3,6	2016,19	GPS	1388	593	Yaak River, MT
824	M	(12-13)	2016-14	GPS	455	884	Yaak River, MT & BC
853	M	5-6	2016-17	GPS	938	736	Kootenay River, BC
9811	M	(2-4)	2016-18	GPS	3,135	1,210	Moyie River, MT,ID,BC
922[2]	M	4-5	2016-17	GPS	938	2,148	Kootenai Rr., ID Yaak Rr, MT
926[1]	M	4-5	2016-17	GPS	2,834	3,328	Cabinet Mtns, MT
840	F	2-4	2017-19	GPS	2987	627	Pipe Cr., MT
842	F	4-6	2017-19	GPS	2776	753	Yaak River, MT
861	M	2-4	2017-19	GPS	2,376	669	Cabinet Mtns, MT
1026[2]	F	2	2017	GPS	3,435	1,556	Creston Valley, BC Yaak Rr., MT
1028[2]	F	2	2017	GPS	1,639	708	Yaak Rr.,MT St. Mary's Rr. ,BC
927[1]	M	2-3	2018-19	GPS	6232	18708	Cabinet & Bitterroot Mtns, MT, ID
9077[2]	M	(3)	2018	GPS	193	1,155	Cabinet Mtns, Yaak River, MT
1006	M	2-3	2017-18	GPS	1,921	8,092	Selkirk & Cabinet Mtns, Yaak River MT
844	M	(3)	2019	GPS	601	714	Yaak and Kootenai Rr.,MT
866	M	(3)	2019	GPS	1181	2677	Salish & Cabinet Mtns, MT
892[1]	M	(2)	2019	GPS	1096	2311	Cabinet Mtns ID, MT & Kootenai Rv., MT
923[1]	F	(2)	2019	GPS	763	383	Cabinet Mtns ID & MT

[1]Augmentation bears.

[2]Management bears.

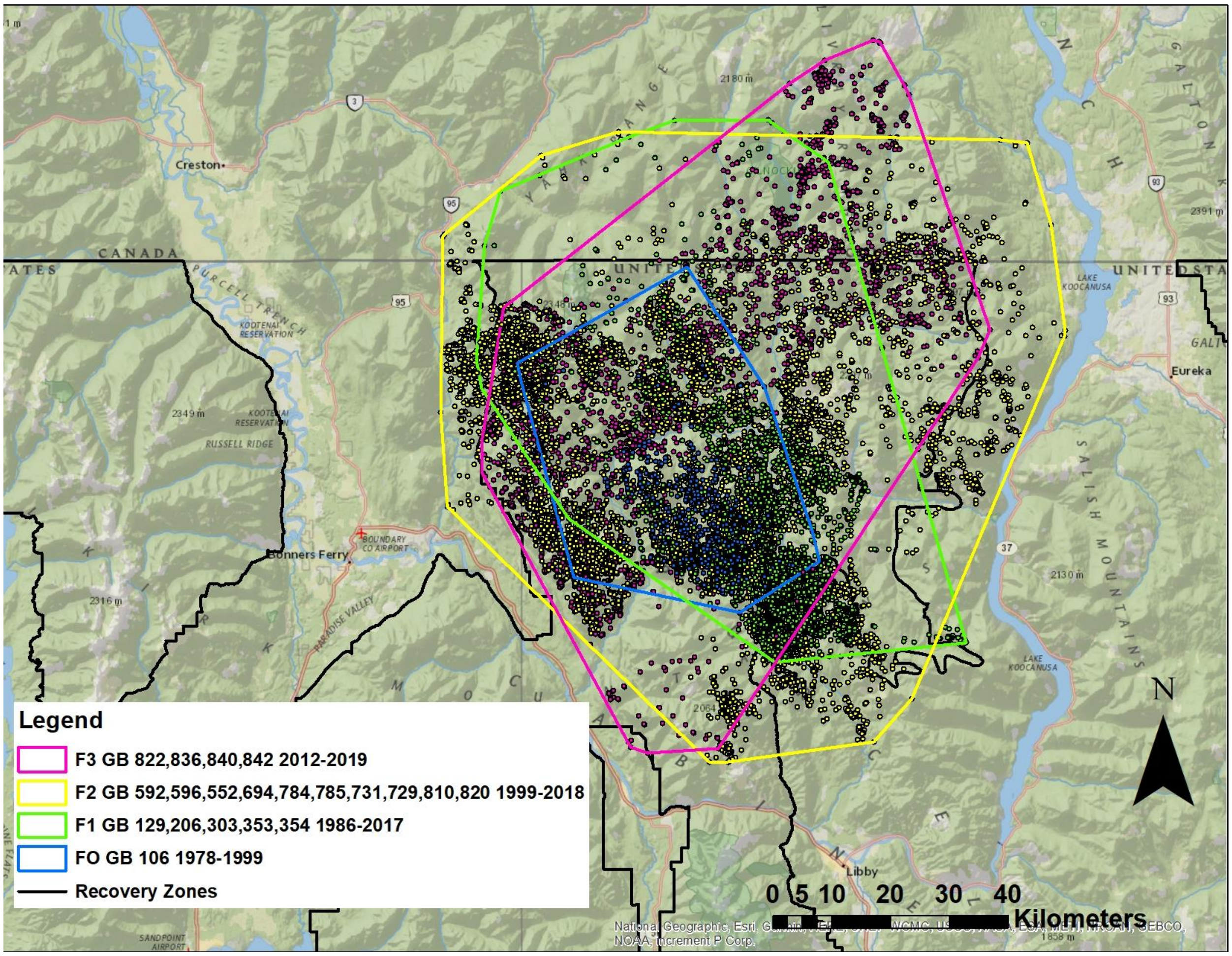

Figure 14. Generational home ranges of female grizzly bears in the Yaak River descended from bear 106, 1986-2019.

Grizzly Bear Denning Chronology

We summarized den entry and exit dates of radio-collared grizzly bears using primarily VHF and GPS location data (1983–2019). Radio-collars deployed since the late 2000s include an activity monitoring device (i.e., accelerometer), which allows an additional, more detailed assessment of den entrance and exit and activity during the denning period.

Den entry dates (n = 124) ranged from the third week of October to the last week of December. One hundred eighteen (95%) entries occurred between the 4th week of October and the 3rd week of December (Fig. 15). Grizzly bears in the Cabinet Mountains (median entry in 2nd week of November) entered dens 2 weeks earlier than bears in the Yaak River drainage (median entry during 4th week of November). Males generally entered dens later than females. Female-offspring family groups tended to enter dens later than independent adult females (Fig. 16). By December 1, 37% of Cabinet and Yaak grizzly bears had not yet entered winter dens (22% females and 56% males, Fig. 17).

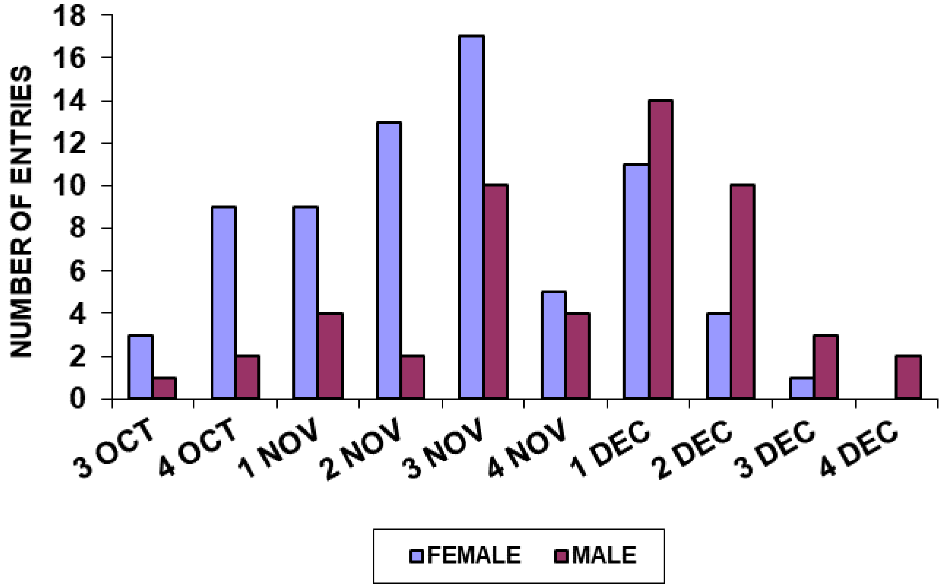

Figure 15. Month and week of den entry for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2019.

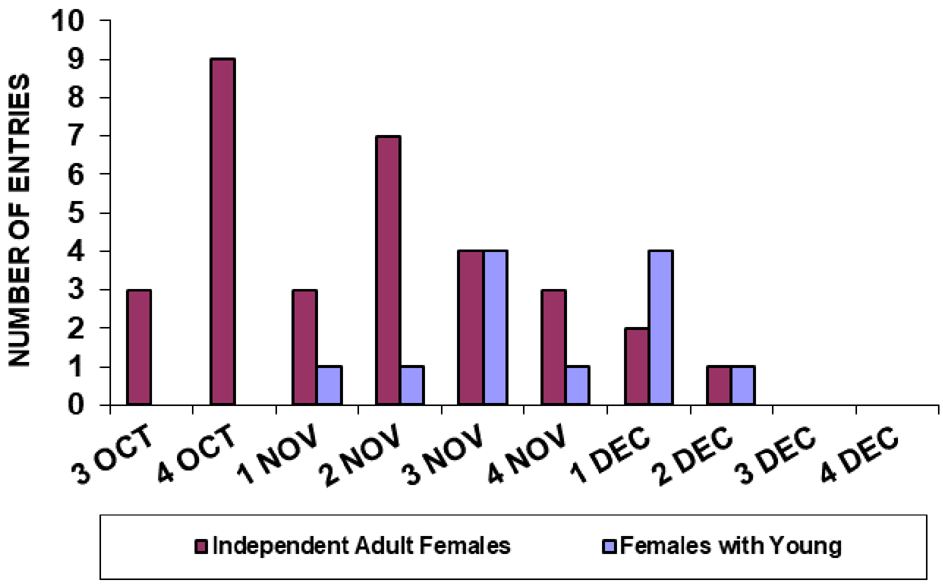

Figure 16. Month and week of den entry for adult female, radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2019.

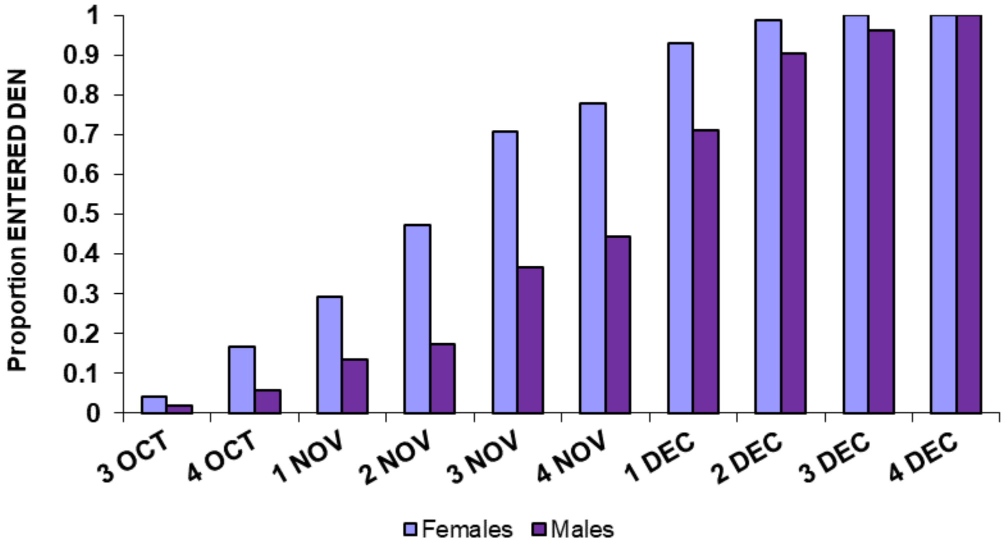

Figure 17. Cumulative proportion of den entries for female and male, radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, by month and week, 1983–2019.

Den exit dates (*n* = 113) ranged from the first week of March to the third week of May (Fig. 18). One-hundred eight (96%) exit dates occurred from the 2nd week of March through the 2nd week of May. Grizzly bears in the Cabinet Mountains generally exited dens one week later than bears in the Yaak river drainage. Males tended to exit dens two weeks earlier than females. Seventy percent of den exits occurred during the month of April. By May 1, 13% of Cabinet and Yaak grizzly bears were still in dens, well over half of which were females with cubs-of-the-year. Females with cubs appear to exit dens later than other adult females (median exit during 1st week of May; Fig. 19). All adult females with cubs remained at dens until at least April 15.

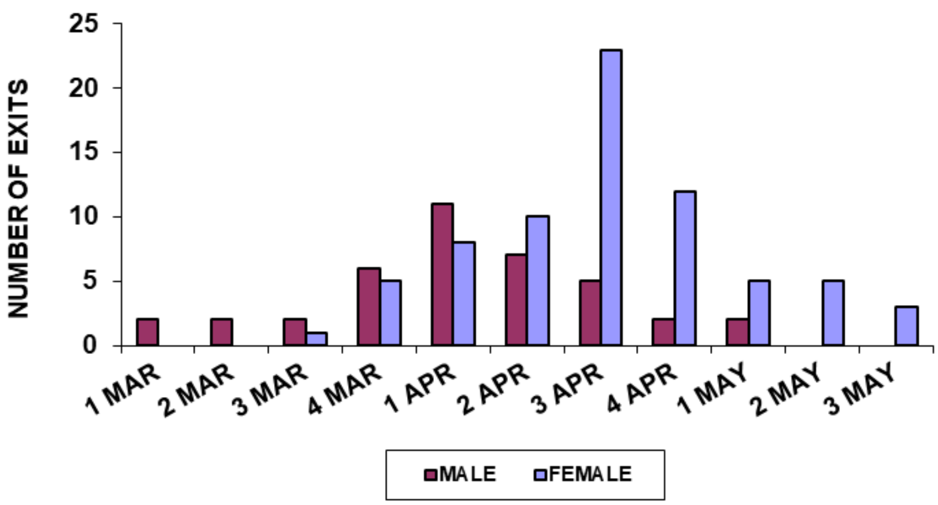

Figure 18. Month and week of den exit for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2019.

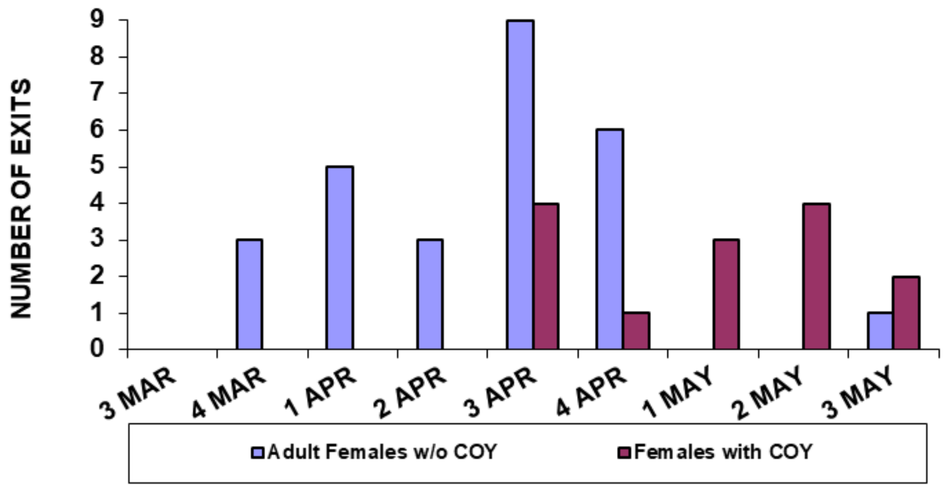

Figure 19. Month and week of den exit for adult female, radio-collared grizzly bears (with and without cubs-of-the year [COY]) in the Cabinet-Yaak grizzly bear recovery zone, 1983–2019.

Grizzly Bear Habitat Analysis

Resource selection functions were utilized to develop seasonal habitat use maps for the Cabinet-Yaak and Selkirk Mountains recovery area zones and surrounding area based on telemetry locations collected from 2004–2015. See Appendix 5 for methodology and maps. The following habitat analysis will discuss both recovery areas.

Grizzly Bear Use by Elevation

Differences in elevation between the Cabinet-Yaak and Selkirk Mountains are reflected in individual bear's radio location data (GPS &VHF) from both areas. To account for differences in sample size between VHF and GPS collared bears, monthly mean elevation for each bear was first calculated. These means were then averaged. Only bears with at least four locations per month were utilized. Grizzly bears in all three study areas exhibited the same general pattern of elevation use (Figure 20). In spring, bears are at lower elevations accessing early green vegetation. As the year progresses, bears move to higher elevations to utilize a variety of berry species. Yaak River bear's decrease in elevation during October and November correspond to the Montana general hunting season. Bears may be utilizing wounded animals and gut piles. Selkirk bears do show an increase in meat consumption later in the year, but by the first week of November 50% of bears have entered dens and may not have the ability to respond to the presence of this protein source (Kasworm et.al. 2020). The difference in Idaho and Montana's hunt season structure may account for some of the differences in fall elevation use.

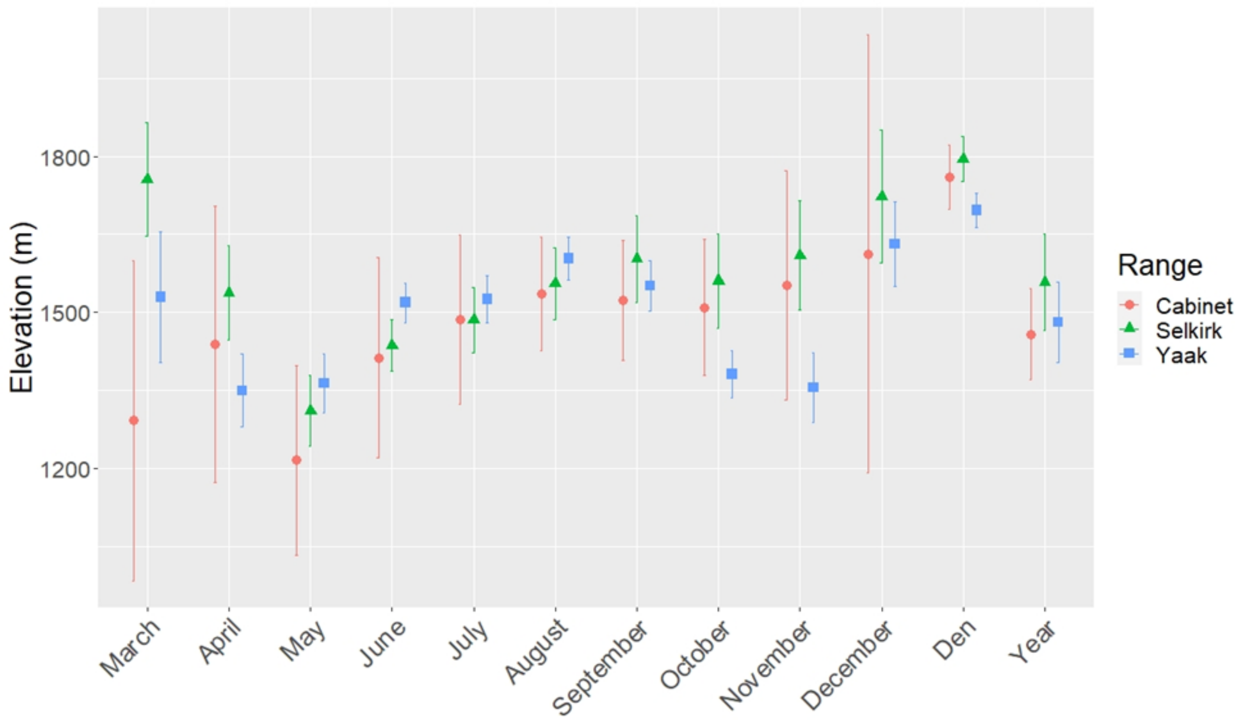

Figure 20. Mean monthly use of elevation for bears in the Cabinet-Yaak and Selkirk Mountains for VHF and GPS collared bears. Error bars represent 95% CI. Sample size in the Cabinets was nine bears from 1983-2019, Selkirk Mountains, N=91 from 1986-2019, and Yaak River, N= 57 from 1986-2019.

Grizzly Bear Use by Aspect

Annual grizzly bear VHF and GPS location summary indicates that Cabinet bears (N=7991) utilize north facing slopes more so than bears in other study areas (Figure 21). Bears in the Yaak River (N=111447) and Selkirk (N=84640) exhibit similar use of aspect, using east the most and north the least.

Bear dens in the Yaak River (N= 96) and Selkirk study area (N=88) occurred on east facing slopes more than other aspects (Figure 22). Yaak River bear dens occurred on north slopes more than other study areas. Cabinet bear dens (N=35) utilized east and south facing slopes to the same degree and north facing slopes the least. These differences may be a result of varying topography among study areas and where snow pack is present.

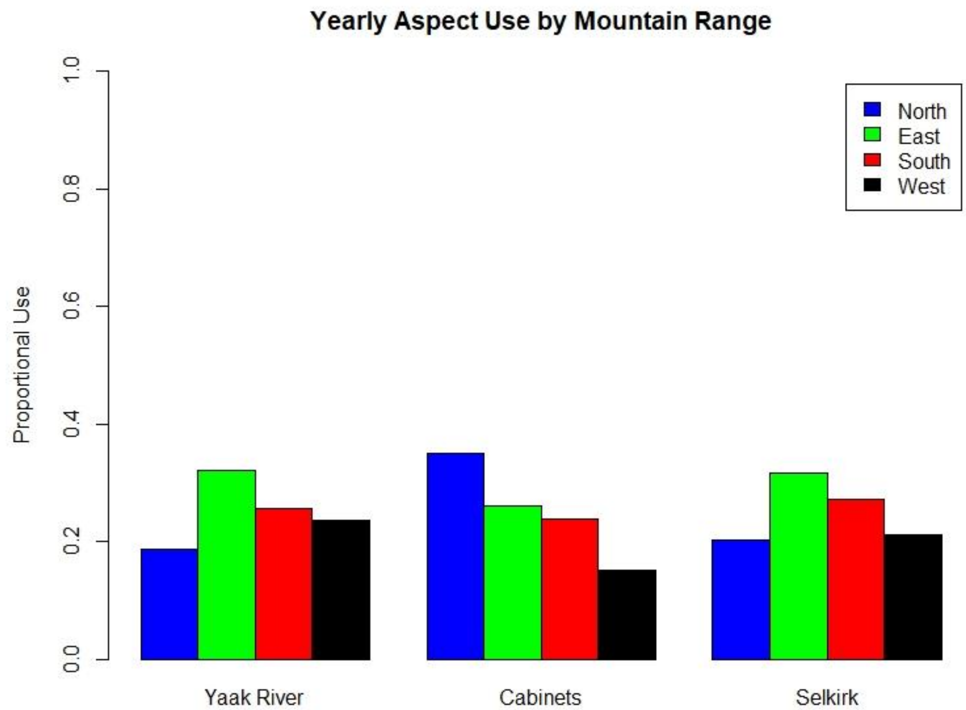

Figure 21. Yearly proportional use of aspect for grizzly bear VHF and GPS locations in the Yaak River (N=111447) from 1986-2019, the Cabinet Mountains (N=7991) from 1986-2019, and the Selkirk Mountains (N=84640) from 1986-2019.

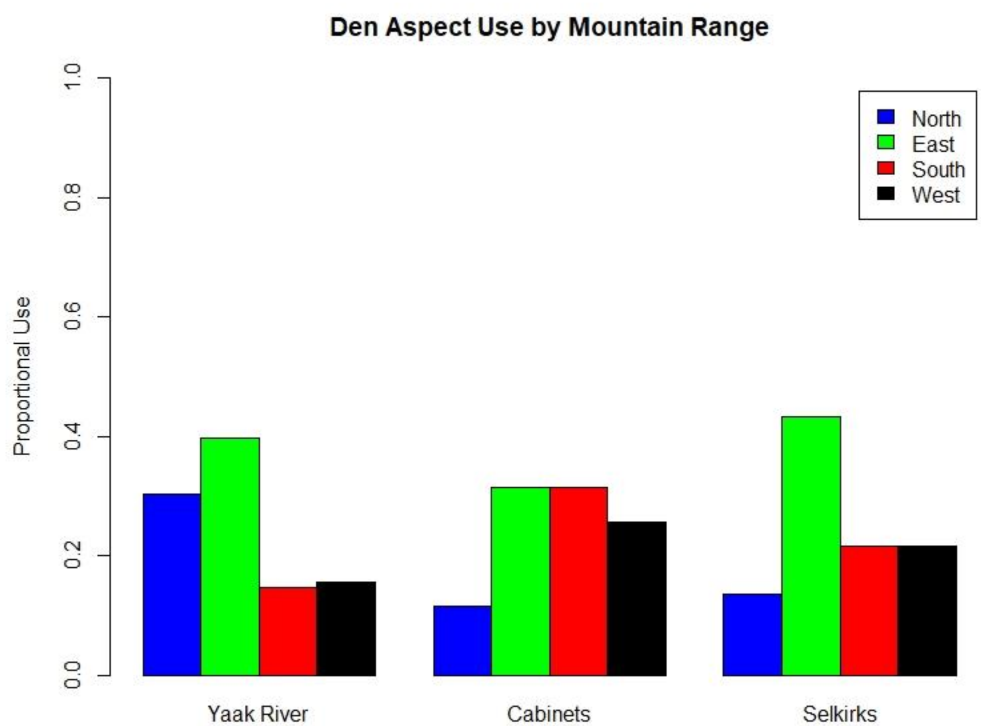

Figure 23. Aspect of grizzly bear dens in the Yaak River (N=96) from 1986-2019, the Cabinet Mountains (N=35) from 1983-2019, and the Selkirk Mountains (N=88) from 1986-2019.

Grizzly Bear Spring Habitat Description

After den emergence in spring, bears seek sites that melt snow early and produce green vegetation. These sites can often overlap with ungulate winter range and provide winterkill carrion. Spring habitat use in both study areas (April and May) indicated use of low elevation sites. Cabinet Mountain radio locations indicated most use below 1,600 m with primary use of southerly facing snow chutes, alder shrub fields, grassy sidehill parks, and closed timber. Yaak River radio locations indicated most use below 1,400 m with primary use of closed timber, timbered shrub fields, cutting units, and grassy sidehill parks on virtually all aspects. Lower elevation of the Yaak River area may allow snow to melt and vegetation to green-up earlier.

Inter-ecosystem Isotope Analysis

We are using isotope analysis to compare grizzly bear food use (plant vs. animal matter) between ecosystems, among sex-age classes, and across management status. Samples currently analyzed are only from grizzly bears of known sex and age. The majority of samples come from capture events; future analysis will include samples from known grizzly bears at hair rub and hair corral sites. To date, we have obtained carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios from 237 grizzly bear hair and blood samples between 1984 and 2015 from the CYE and Selkirk ecosystems. Across the Selkirk and CYE ecosystems, adult males consume slightly more animal matter (22%) than adult females (14%) and subadults (13%). Adult females in the Yaak River consume higher proportions of animal matter (22%) than do adult females in the Cabinets (10%) and the Selkirks (6%).

We estimate that 14% of the annual diet of Cabinet Mountain grizzly bears (n = 19 hair samples from non-management bears) is derived from animal matter. Adult males had slightly higher $\delta^{15}N$ stable isotope signatures (4.2‰) than adult females (3.1‰), indicating greater use of available animal matter (24% vs. 10% animal matter, respectively).

Yaak grizzly bear diets contained nearly 22% animal matter (n = 84 hair samples). Adult female use of animal matter varied widely; $\delta^{15}N$ and diet values ranged as low as 2.3‰ (~6% animal matter) to as high as 7.2‰ (~80% animal matter).

Sampled grizzly bears in the Selkirk ecosystem consumed less animal matter than Cabinet and Yaak bears (12%; n = 36 hair samples). Diets of non-management, adult female bears include only 7% animal matter. However, one adult female captured in a management incident in the Creston Valley fed on animal matter at a rate of 82%. We suspect bears such as her likely gain meat from bone piles or dead livestock at nearby dairy operations.

Across ecosystems, management bears had slightly higher proportions of meat (26%) in assimilated diets than research bears (17%). Management bears did not necessarily have higher $\delta^{13}C$ signatures as would indicate a more corn-based or anthropogenic food source (-23‰ for both research and management bears). In fact, highest $\delta^{13}C$ in our dataset came from a research female caught in Corn Creek of the Creston Valley, BC in 2008. By all indications, she likely fed extensively on corn from nearby fields without human conflict.

By analyzing different hair types that initiate growth at different times of the year, we have observed increases in proportion of animal matter in bear diets as they transition from summer months (diet estimated from guard hairs) to fall months (diet from underfur). Previous studies have emphasized the importance of splitting these hair types due to temporal differences in growing period (Jones *et al*. 2006). We currently have 45 bear capture events with paired guard hair and underfur samples collected at capture. In all cases, grizzly bears have either 1) the same dietary meat proportion in summer vs. fall or 2) have higher amounts of meat in their fall diet. On average, grizzly bears meat consumption nearly doubles from summer to fall (10.7% summer to 17.6% fall). Fall shifts toward meat use were not isolated to a specific sex-age class. Larger shifts include: an adult male (4327) shifting from 31% meat in summer to 82% meat in fall, an adult female (mortality 5/18/2012) consuming 14% in spring time, then 38% in the fall, and a subadult female grizzly (675) with a summer diet consisting of

6% meat and fall diet of 16% meat. We suspect that wounding loss and gut piles from hunted ungulates contribute to observed increases in meat use by grizzly bears in fall months.

Food Habits from Scat Analysis

Grizzly bear scats (n = 180) were collected in the Cabinet Mountains between 1981 and 1992. Graminoids (grasses and sedges) were consumed frequently (43% of scats) by grizzly bears in May. Additionally, meat, presumably from winter-killed deer and moose, accounted for 40% of all dry matter consumed in April and May (Fig. 24). In June, the use of forbs increased markedly, yet grasses and sedges were still a dominant food category. Cow parsnip (*Heracleum lanatum*), clover (*Trifolium spp.*), and dandelion (*Taraxacum officinale*) were commonly used in June; over half (52%) of scats in June included parts of at least one of these three forbs. By July, forbs (mainly *Heracleum*) comprised 32% of dry matter consumed by grizzly bears. Only 8% of dry matter consumed in July came from grasses and sedges; graminoids begin to cure in July and provide far less digestible nutrition. Grizzly bears began to feed upon foods from shrubs (huckleberry and whortleberry [*Vaccinium spp.*], serviceberry [*Amelanchier alnifolia*]) and insects (mainly ants) in July. Food habits during August and September were dominated by use of shrub (*Vaccinium* spp., in particular), yet September habits include an increased use of animal matter. Unlike black bears, grizzly bears targeted animal matter (deer, elk, moose) in October. We suspect hunter-discarded gut piles or other remains account for a fair amount of the available animal meat. Fall regrowth of forbs (mainly clover) and graminoids contributed 25% of dry matter consumed by sampled grizzly bears in October. Mammal and shrub food items (i.e., the most calorie-dense foods available in constitute 64% of total dry matter consumed annually by grizzly bears.

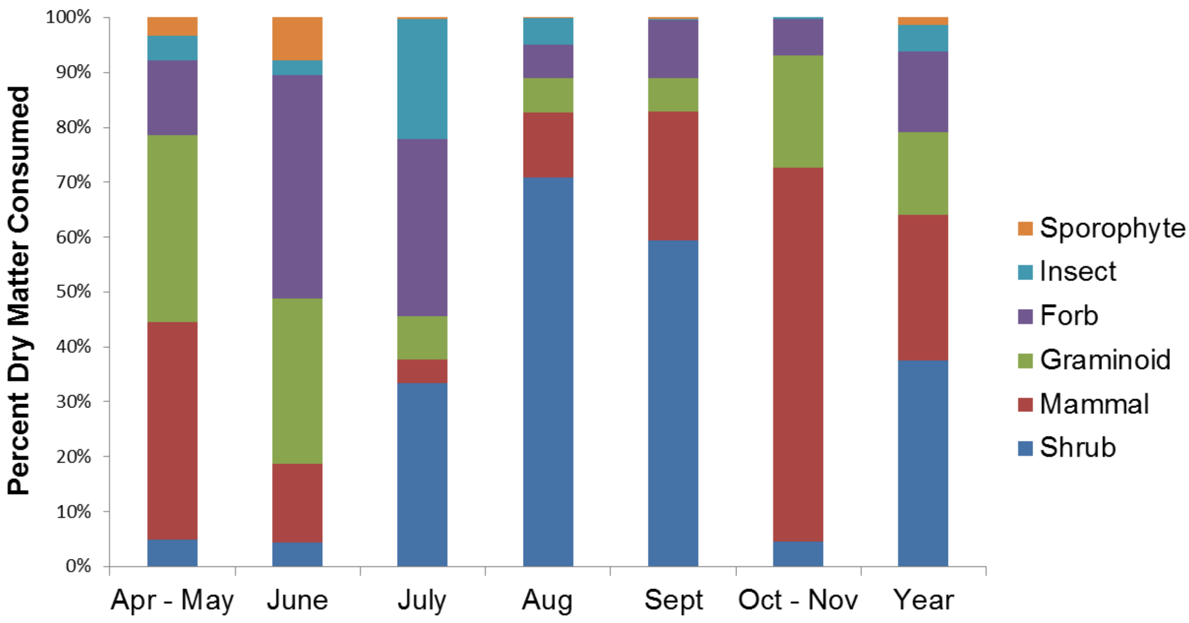

Figure 24. Monthly percent of total dry matter of foods consumed by grizzly bears in the Cabinet Mountains and Yaak River, 1981-1992.

Black bear scats (n = 618) were collected between 1984 and 1992. Relative use of foods was quite similar to that of grizzly bears between April and August (Fig. 25). However, black bear food habits in September and October were quite different from grizzly bears. Black bears tend to use berries of shrubs (*Vaccinium* spp., *Sorbus* spp. [mountain-ash], *Amelanchier alnifolia,* and *Arctostaphylos* spp. [bear berry]) more frequently as fall progresses (percent dry matter consumed, August = 74%; September = 82%; October = 91%). In October, black bears fed heavily on mountain-ash. In contrast, grizzly bears increase relative dry matter consumption of animal meat in fall months (August = 12%, September = 24%; October = 68%). We suggest this difference in food use may be explained by either 1) early den entrance dates for black bears (i.e., den entrance before open of big game hunting season), 2) higher energetic demand of larger grizzly bears (i.e., consumption of calorie-dense foods is metabolically preferred by larger bears; Welch et al. 1997), 3) interspecific exclusion of black bears by grizzly bears (i.e., exploitative competition), and/or 4) differences in risk behavior between the two species. On a annual basis, black bears consumed less high-quality, calorie-dense foods (meat and berries; 42%) relative to lower-quality foods such as graminoids and forbs (46%).

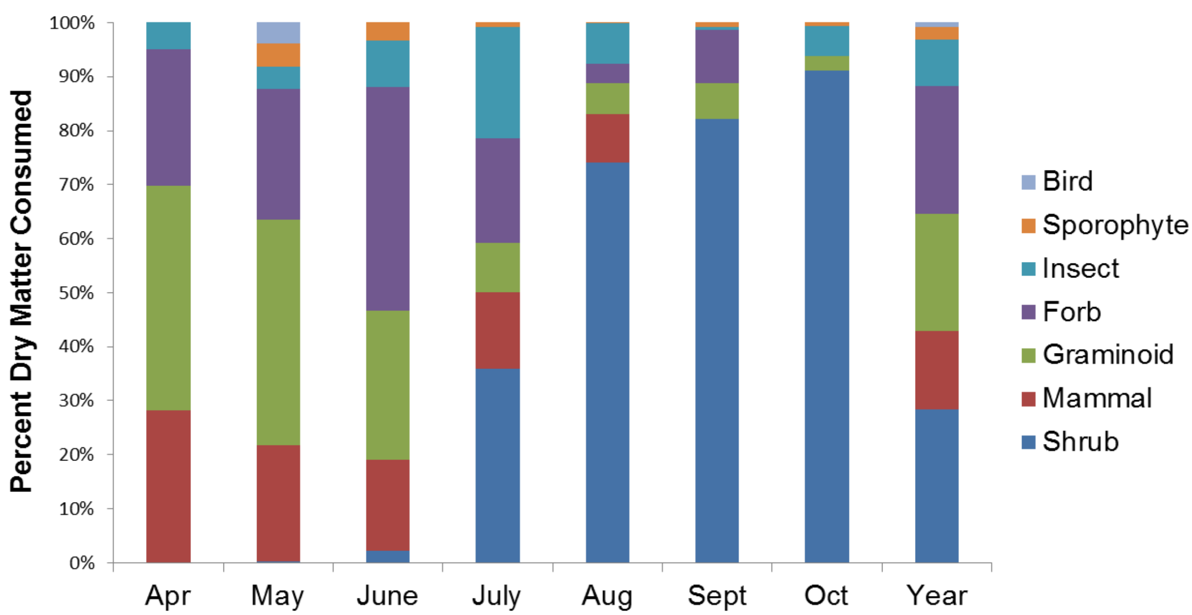

Figure 25. Monthly percent of total dry matter of foods consumed by black bears in the Cabinet Mountains and Yaak River, 1984-1992.

Berry Production

Because of its relatively far-ranging distribution in the CYE and life history of inhabiting larger areas (e.g. shrub fields) than other berry-producing plants, huckleberries appear to provide a greater amount of food for bears in the CYE. However, serviceberry and mountain ash may provide significant secondary food sources in some years when huckleberry crops have failed (e.g. 2001 and 2003). Mountain ash may be particularly valuable to bears in years of low food production because the berries persist and remain on the plants until after frost and leaf drop. Low berry counts for all three of these species would prove most detrimental for bears attempting to store fat for winter denning (e.g., 2002, 2004, and 2015). Because of its sparse distribution, buffalo berries appear to be the least-available berry food for grizzly bears in the CYE. Below-average production among all species surveyed occurred in 1992, 1998–2000, 2002, 2004, and 2015. The 2015 berry season marked the first time we have observed below average counts for all four berry species in one year. Sampling sites for each species were selected to best represent landscape level variation of geography, elevation, aspect, and overstory canopy (Fig. 26).

Fluctuations in berry production in the CYE may be influenced by climatic variables. Holden *et al*. (2012) found huckleberry production in the CYE to be highest in years with cool springs and high July diurnal temperature ranges. Serviceberry production was also highest in years with cool springs and high winter snowpack. Future changes in climate may influence the availability of these foods to CYE grizzly bears.

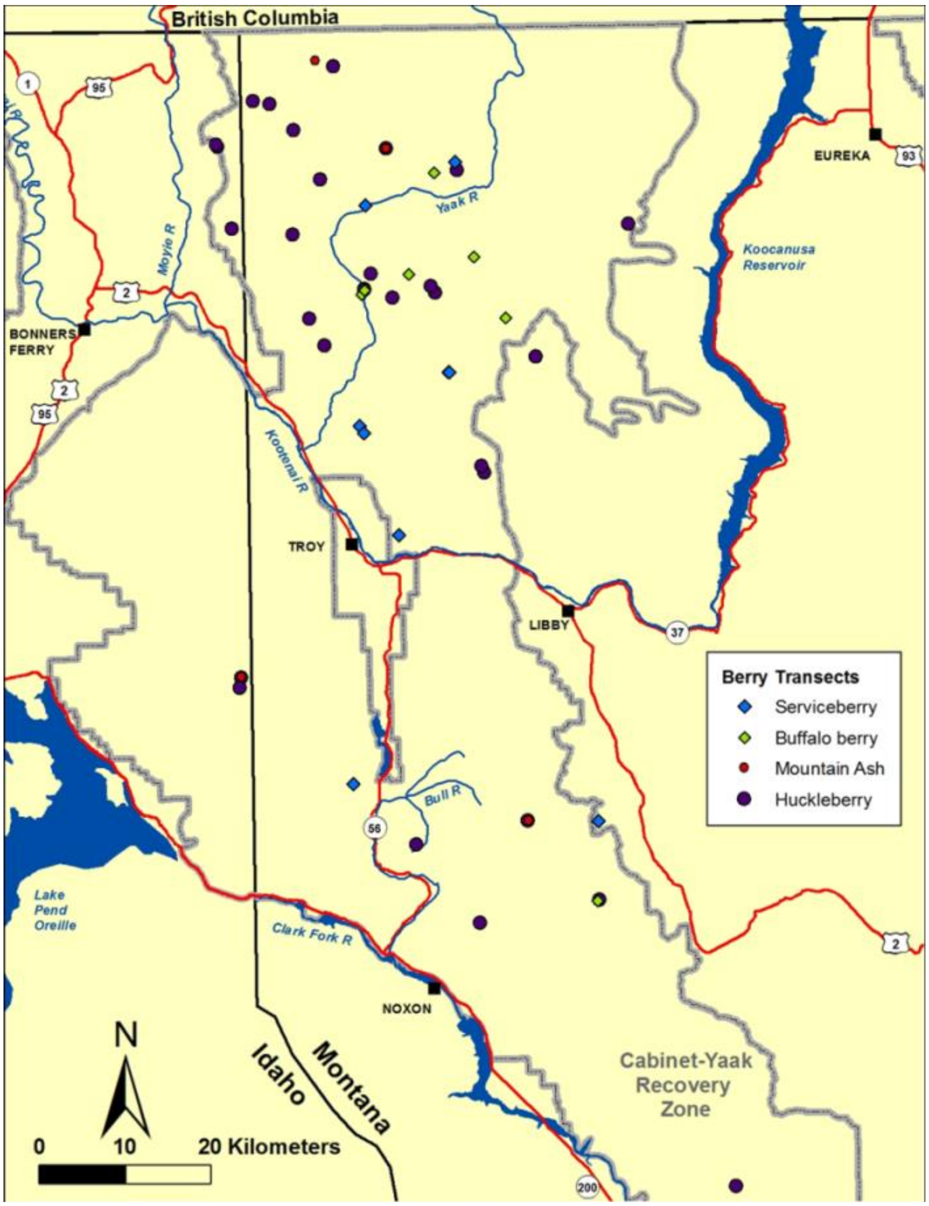

Figure 26. Locations of all serviceberry, buffaloberry, mountain ash, and huckleberry sampling sites within the CYE study area, 1989-2019. Some locations show multiple berry species sites in close proximity.

Huckleberry

We evaluated berry production at a median number of 18 (range = 11–23) huckleberry transects per year within the CYE study area from 1989–2019 (Fig. 27). During this study period, the mean number of berries per plot was 1.8 (95% CI ± 0.12). Mean annual berry counts between 1989 and 2019 ranged from 0.5–3.4. Statistically below-average berry counts occurred in 1992–93, 1997–99, 2001–04, 2010, and 2015. Above average counts occurred in 1990, 1996, 2008–09, 2012–14, and 2017. Highest mean annual counts occurred in 2014. Based upon these production indices at sampled sites, the 9-year period from 1997–2005 was a prolonged stretch of years without above average annual huckleberry production; more recent mean annual counts since 2006 average 102% higher than during the 1997-2005 period (1.1 berries per plot higher). Of interest is whether lower- and higher-than-average production had influence on population reproduction and survival.

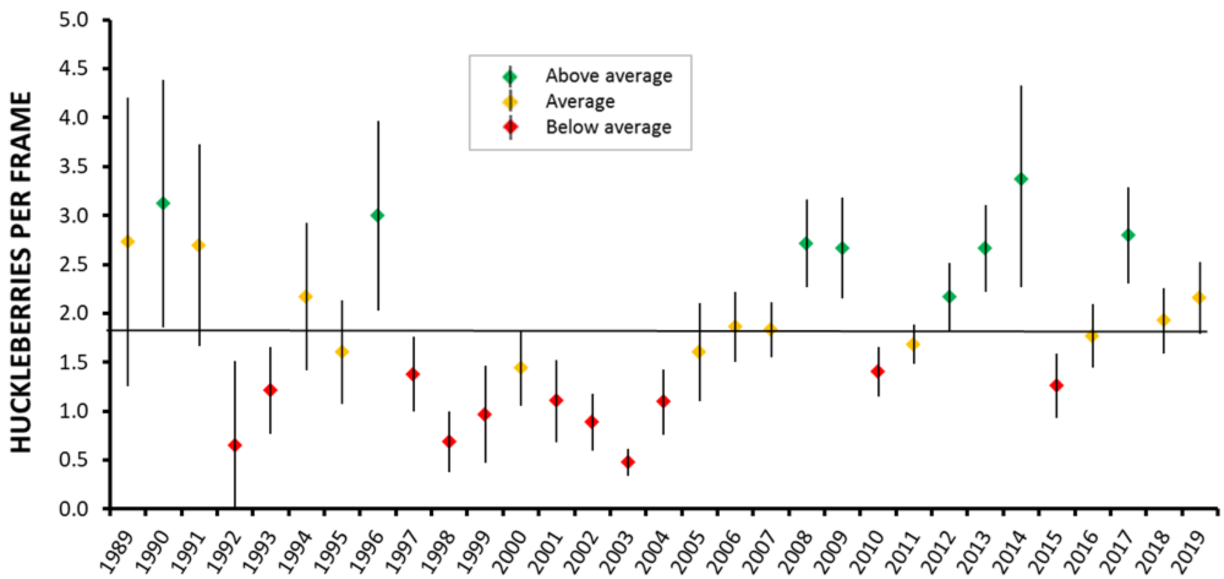

Figure 27. Mean berries per plant (± 95% confidence interval) for huckleberry transects in the Cabinet-Yaak, 1989–2019. Horizontal line indicates study-wide mean production, 1989–2019.

Serviceberry

We evaluated berry production at a median number of six (range = 5–7) serviceberry transects per year from 1990 to 2019 (Fig. 28). The overall mean berry count per plant was 106 (95% CI ± 22) during the study. Mean berry counts per plant ranged from 12 to 355 during the 25+ year index. Statistically below-average counts occurred during 1994, 1999, 2004–06, 2010, 2012–17, and 2019. Above average counts occurred only in 1997. Considering the entirety of the data, the past fifteen years have been particularly less productive (2005–19; 68 berries per plant) when compared to the first 15 (150 berries per plant from 1990–2004).

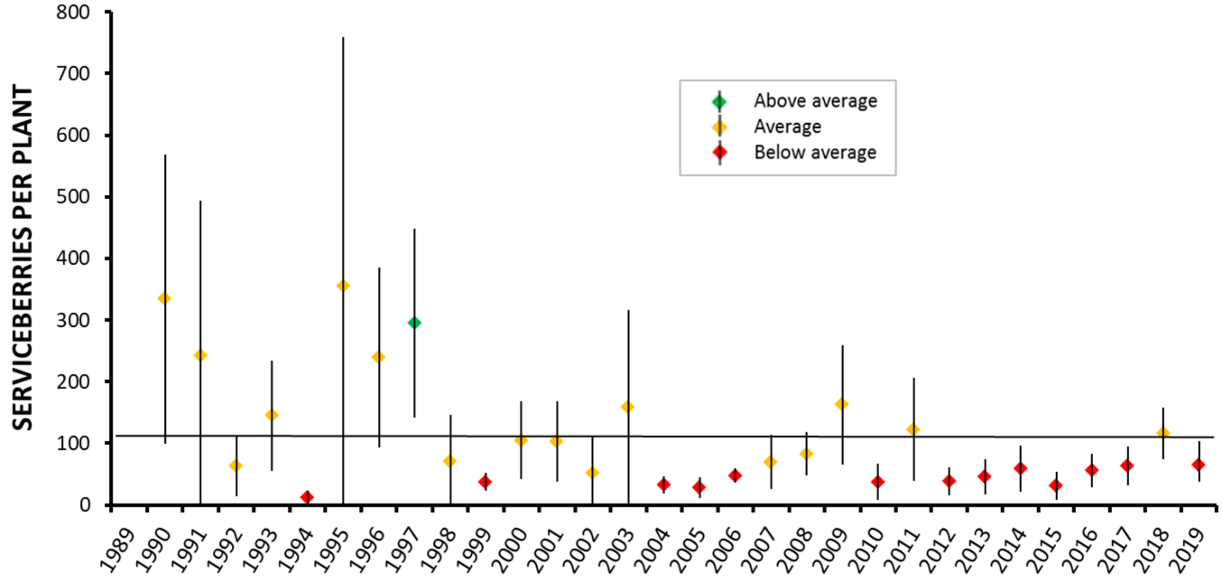

Figure 28. Mean berries per plant (± 95% confidence interval) for serviceberry transects in the Cabinet-Yaak, 1990–2019. Horizontal line indicates study-wide mean production, 1990–2019.

Mountain Ash

Three sites were evaluated for mountain ash production each year, from 2001 to 2019 (Fig. 29). Total mean berry count was 162 berries per plant (95% CI ± 50). Statistically below-average production occurred in 2003, 2006, 2010–11, 2013, and 2015. Above average production occurred only in 2008.

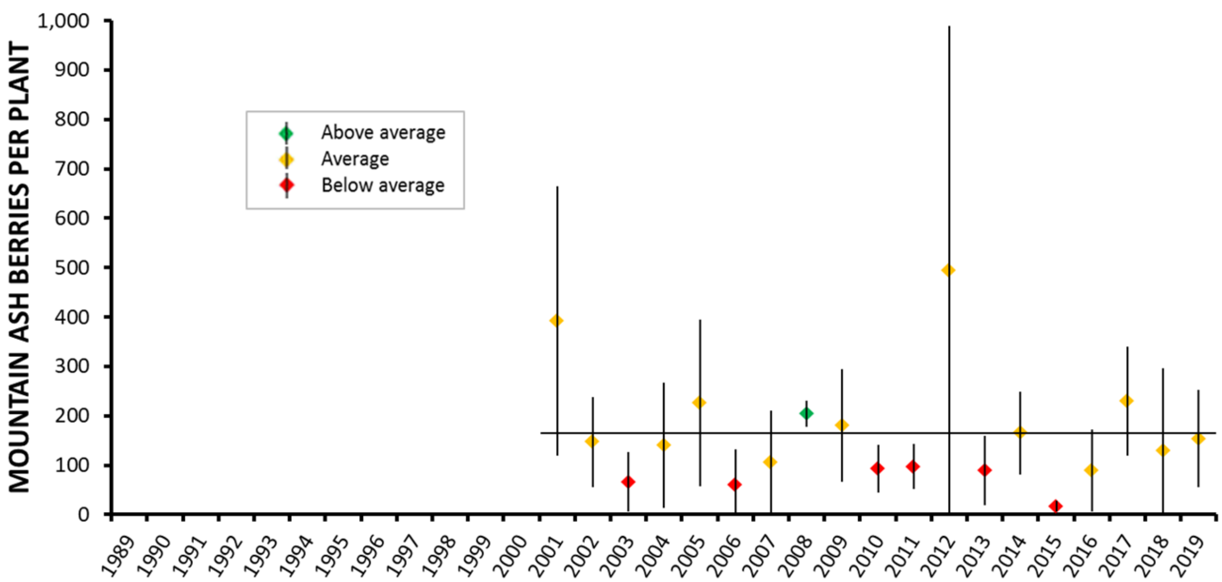

Figure 29. Mean berries per plant (± 95% confidence interval) for mountain ash transects in the Cabinet-Yaak, 2001–19. Horizontal line indicates study-wide mean production, 2001–19.

Buffaloberry

Five buffaloberry transects (5 plants at each transect) were evaluated during 1990–99 and 2002–03. No sites were sampled during 2004–06. One new transect (10 plants) was established in 2007; and was the only transect sampled. Another transect (10 plants) was added in 2008. These two transects were evaluated in 2008–19. A median of 3 sites were evaluated annually (range 1–5) between 1990 and 2019. Mean berry count per plant from all transects was 176 (95% CI ± 46) during the study period. Mean berry counts ranged between 15 to 627 berries per plant from 1990 to 2019 (Fig. 30), with statistically below-average counts in 1998–99, 2002–03, 2007, 2013, 2015–16, and 2018. Above-average counts occurred in 1990, 2010, and 2011.

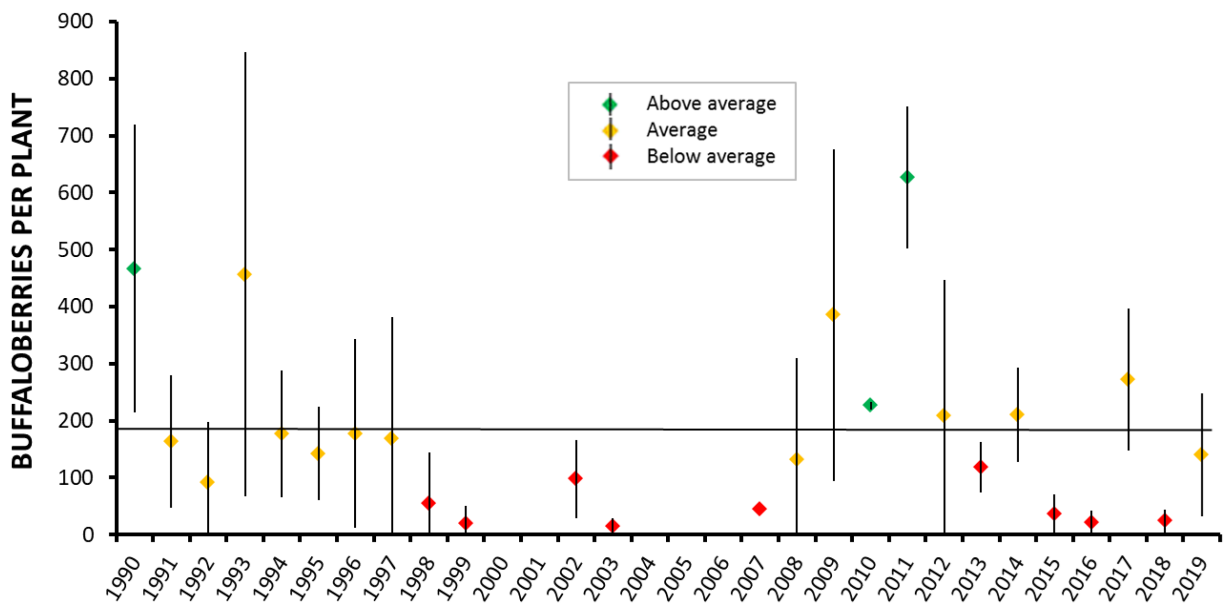

Figure 30. Mean berries per plant (± 95% confidence interval) for buffaloberry transects in the Cabinet-Yaak, 1990–2019. Horizontal line indicates study-wide mean production, 1990–2019.

Body Condition

We estimated body fat content of Cabinet-Yaak and Selkirk (CYS) grizzly bears at 99 independent capture instances, May through November 2010–19. We assessed whether body fat content of CYS grizzly bears differed by sex (56 males, 43 females), capture type (76 research, 23 management captures), and month of capture. Researchers in the Greater Yellowstone and Northern Continental Divide Ecosystems have noted that body fat content of grizzly bears varies by month, exhibiting a trend that is presumably dependent on denning (i.e., inactive) season and availability and quality of foods consumed during the active season (Schwartz et al. 2014; Teisberg et al. *in prep*). We similarly partitioned our seasonal data into categorical bins by month, as follows: May (N = 17), June (N = 39), July (N = 16), August (N = 16), and September-November (N = 11).

Body fat content of male and female grizzly bears did not differ (P = 0.077; Table 19). Body fat content of research-captured vs. management-captured grizzly bears also did not differ (P = 0.525; Table 19), suggesting that management bears do not necessarily obtain a more nutritionally-rich diet than research-captured bears. However, body fat content of CYS grizzly bears did differ by month (P < 0.0001; Fig. 31). Body fat content in September-November were significantly higher than those in all other months, and August fat contents were higher than those in June (Tukey-HSD contrasts; P<0.05). With all other months, fat content did not differ. CYS grizzly bears appear to start gaining fat as early as July. These results suggest habitat and foods available to CYS grizzly bears allow for body fat gain, such that bears are able to attain above-average body fat contents in the months preceding den entrance. Reproductive-aged, female grizzly bears experience 1) delayed implantation of already-fertilized eggs in November and 2) cub birth in the den (Jan-Feb). Studies suggest adult females must reach a pre-denning body fat content in excess of ~20% to support implantation and winter cub production (Robbins et al. 2012).

Table 19. Mean estimates of percent body fat content (kg fat / kg body mass) and effect size (+/- standard error, SE) of Cabinet-Yaak and Selkirk grizzly bears, by factors of interest, 2010–2019.

Factor / Level	Mean	SE
Capture Type		
Research	17.1	+/-0.8
Management	18.1	+/-1.3
Sex		
Female	16.4	+/-1.1
Male	18.8	+/-0.9
Month		
May	17.1	+/-1.6
June	12.7	+/-1.1
July	15.3	+/-1.7
August	18.1	+/-1.6
Sept-Nov	24.7	+/-1.9

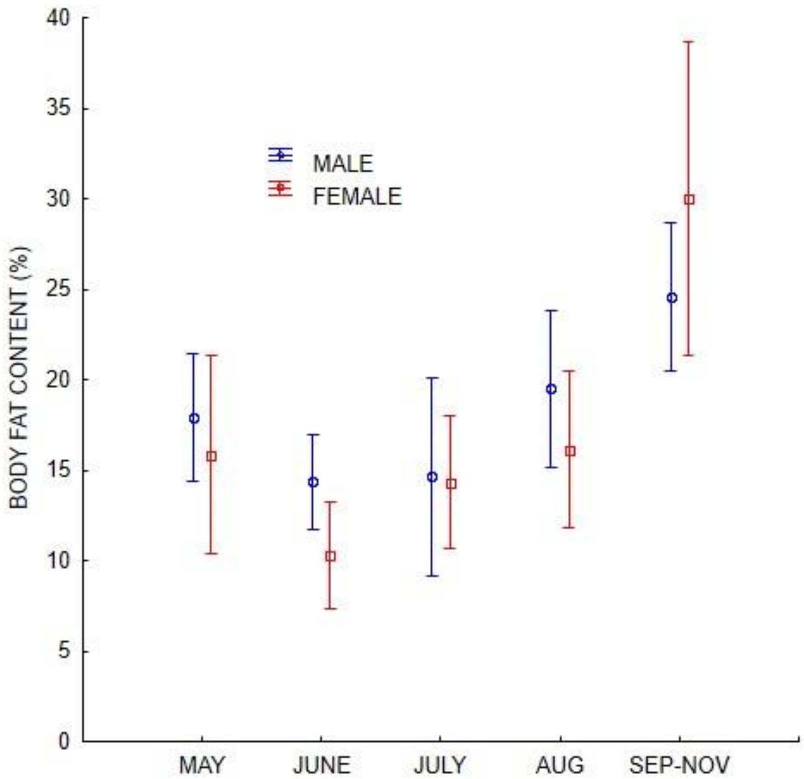

Figure 31. Mean percent body fat content (kg fat / kg body mass) of captured female and male grizzly bears in the Cabinet-Yaak and Selkirk mountains 2010–19, by month. Error bars represent 95% confidence intervals.

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LITERATURE CITED

Alt, G. L. 1984. Cub adoption in the black bear. Journal of Mammalogy 65:511-512.

Alt, G. L. and J. J. Beecham. 1984. Reintroduction of orphaned black bear cubs into the wild. Wildlife Society Bulletin 12:169-174.

Brenna, J. T., T.N. Corso, H.J. Tobias and R.J. Caimi. 1997. High-precision continuous-flow isotope ratio mass spectrometry. Mass Spectrometry Reviews. 16:227–258.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York.

Cherry, S., M.A. Haroldson, J. Robison-Cox, and C.C. Schwartz. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175-184.

Erickson, A. W. 1978. Grizzly bear management in the Cabinet Mountains of western Montana. U.S. Forest Service Contract 242-46, Kootenai National Forest.

Farley, S.D., and C.T. Robbins. 1994. Development of two methods to estimate body composition of bears. Canadian Journal of Zoology 72:220–226.

Hayne, D. W. 1959. Calculation of size of home range. Journal of Mammalogy 30:1-18.

Hellgren, E. C., D. W. Carney, N. P. Garner, and M. R. Vaughn. 1988. Use of breakaway cotton spacers on radio collars. Wildlife Society Bulletin 16:216-218.

Hewitt, D. G., and C. T. Robbins. 1996. Estimating grizzly bear food habits from fecal analysis. Wildlife Society Bulletin 24:547–550.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Hovey, F. W. and B. N. McLellan. 1996. Estimating growth of grizzly bears from the Flathead River drainage using computer simulations of reproductive and survival rates. Canadian Journal of Zoology 74:1409-1416.

Johnson, K. G. and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46-54.

Jones, E. S., D. C. Heard, and M. P. Gillingham. 2006.Temporal variation in stable carbon and nitrogen isotopes of grizzly bear guardhair and underfur. Wildlife Society Bulletin 34:1320–1325.

Jonkel, J. J. 1993. A manual for handling bears for managers and researchers. Edited by T.J. Thier, U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F. and T. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of northwest Montana. Montana Department of Fish, Wildlife, and Parks, Helena.

Kasworm, W. F. and T. J. Thier. 1993. Cabinet-Yaak ecosystem grizzly bear and black bear research, 1992 progress report. U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana. National Park Service Progress Report. 42 pp.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Lewis, J. S. 2007. Effects of human influences on black bear habitat selection and movement patterns within a highway corridor. MS Thesis University of Idaho, Moscow. 152 pp

McLellan, B. N. 1989. Dynamics of a grizzly bear population during a period of industrial resource extraction. III Natality and rate of increase. Canadian Journal of Zoology 67:1861-1864.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7-15.

Proctor, M.F., 2003. Genetic analysis of movement, dispersal and population fragmentation of grizzly bears in southwestern Canada. PhD Thesis. University of Calgary. 147 pp.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Qi, H., Coplen, T.B., Geilmann, H., Brand, W.A. and Böhlke, J.K. 2003. Two new organic reference materials for δ13C and δ15N measurements and a new value for the δ13C of NBS 22 oil. Rapid Communications in Mass Spectrometry. 17:2483–2487.

Robbins, C. T., M. Ben-David, J. K. Fortin, and O. L. Nelson. 2012. Maternal condition determines birth date and growth of newborn bear cubs. Journal of Mammalogy 93:540–546.

Schwartz, C. C., J. K. Fortin, J. E. Teisberg, M. A. Haroldson, C. Servheen, C. T. Robbins, and F. T. van Manen. 2014. Body and diet composition of sympatric black and grizzly bears in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 78:68–78.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr. , R. A. Sellars, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. Kasworm, R. Smith, and S. Herrero. 2003. Reproductive maturation and senescence in the female brown/grizzly bear. Ursus. 14:109-119.

Stoneberg, R. and C. Jonkel. 1966. Age determination in black bears by cementum layers. Journal of Wildlife Management 30:411-414.

Thier, T. J. 1981. Cabinet Mountains grizzly bear studies, 1979-1980. Border Grizzly Project Special Report 50. University of Montana, Missoula.

Thier, T. J. 1990. Population characteristics and the effects of hunting on black bears in a portion of northwestern Montana. M.S. Thesis. University of Montana, Missoula.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana.

U.S. Forest Service. 1989. Upper Yaak draft environmental impact statement. U.S. Forest Service, Kootenai National Forest.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

Welch, C.A., J. Keay, K.C. Kendall, and C.T. Robbins. 1997. Constraints on frugivory by bears. Ecology 78:1105–1119.

Woods, J.G., D. Paetkau, D. Lewis, B.N. McLellan, M. Proctor, and C. Strobeck. 1999. Genetic tagging of free-ranging black and brown bears. Wildlife Society Bulletin. 27:616-627.

PUBLICATIONS OR REPORTS INVOLVING THIS RESEARCH PROGRAM

Canepa, S., K. Annis, and W. Kasworm. 2008. Public opinion and knowledge survey of grizzly bears in the Cabinet-Yaak Ecosystem. Cabinet-Yaak and Selkirk Mountains Subcommitte of the Interagency Grizzly bear Committee, Missoula, Montana. 88 pp.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Jansen, H.T., T. Leise, G. Stenhouse, K. Pigeon, W. Kasworm, J. Teisberg, T. Radandt, R. Dallmann, S. Brown and C T. Robbins. 2016. The bear circadian clock doesn’t ‘sleep’ during winter dormancy. Frontiers in Zoology 13:42 15 pages.

Kasworm, W. F. and T. L. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of Northwest Montana. Montana Department Fish, Wildlife, Parks, Helena.

Kasworm, W. F. 1989. Telling the difference. Wyoming Wildlife. Volume 53, No. 8, pages 28-33.

Kasworm, W. F. and T. L. Manley. 1990. Influences of roads and trails on grizzly bears and black bears in Northwest Montana. International Conference on Bear Research and Management 8:79-84.

Kasworm, W. F. and T. J. Thier. 1994. Adult black bear reproduction, survival, and mortality sources in northwest Montana. International Conference on Bear Research and Management 9:223-230.

Kasworm, W. F., T. J. Thier, and C. Servheen. 1998. Grizzly bear recovery efforts in the Cabinet-Yaak ecosystem. Ursus 10:147-153.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Knick, S. T. and W. Kasworm. 1989. Shooting mortality in small populations of grizzly bears. Wildlife Society Bulletin 17:11-15.

Mace, R., K. Aune, W. Kasworm, R. Klaver, and J. Claar. 1987. Incidence of Human Conflicts by Research Grizzly Bears. Wildlife Society Bulletin 15:170-173.

McCall, B. S., M.S. Mitchell, M.K. Schwartz, J. Hayden, S.A. Cushman, P. Zager, W.F. Kasworm. 2013. Combined use of mark-recapture and genetic analyses reveals response of a black bear population to changes in food productivity. Journal of Wildlife Management 77:1572-1582.

McLellan, B. N., F. W. Hovey, R. D. Mace, J. G. Woods, D. W. Carney, M. L. Gibeau, W. L. Wakkinen, and W. F. Kasworm. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, Washington, and Idaho. Journal of Wildlife Management 63:911-920.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Proctor, M. P., D. Paetkau, B. N. Mclellan, G. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in Western Canada and Northern United States. Wildlife Monographs 180:1-46.

Proctor, M. P., Nielson, S. E., W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. Machutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada–United States trans-border region. Journal of Wildlife Management 79:544-558.

Proctor, M. P., W. F. Kasworm, K. M. Annis, A. G. Machutchon , J. E. Teisberg, T. G. Radandt, , and C. Servheen. 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human–Wildlife Interactions 12(3):348–372.

Romain-Bondi, K.A., R. B. Wielgus, L. Waits, W.F. Kasworm, M. Austin, and W. Wakkinen. 2004. Density and population size estimates for North Cascade grizzly bears using DNA hair-sampling techniques. Biological Conservation 117:417-428.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr., R. A. Sellers, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. F. Kasworm, R. Smith and S. Herrero. 2003. Reproductive maturation and senescence in the female brown bear. Ursus 14:109-119.

Servheen, C., W. Kasworm, and A. Christensen. 1987. Approaches to augmenting grizzly bear populations in the Cabinet Mountains of Montana. International Conference on Bear Research and Management 7:363-367.

Servheen, C., W. F. Kasworm, and T. J. Thier. 1995. Transplanting grizzly bears *Ursus arctos horribilis* as a management tool - results from the Cabinet Mountains, Montana, USA. Biological Conservation 71:261-268.

Servheen, C., J. Waller and W. Kasworm. 1998. Fragmentation effects of high-speed highways on grizzly bear populations shared between the United States and Canada. 1998 International Conference on Wildlife Ecology and Transportation, Pages 97-103.

Swensen, J. E., W. F. Kasworm, S. T. Stewart, C. A. Simmons, and K. Aune. 1987. Interpopulation applicability of equations to predict live weight in black bears. International Conference on Bear Research and Management 7:359-362.

Thier, T. J. and W. F. Kasworm. 1992. Recovery of a Grizzly Bear From a Serious Gunshot Wound. The Montana Game Warden 4(1):24-25.

U.S. Fish and Wildlife Service. 1990. Final environmental assessment - grizzly bear population augmentation test, Cabinet-Yaak ecosystem. U.S. Fish and Wildlife Service, Missoula.

Wakkinen, W. L. and W. F. Kasworm. 1997. Grizzly bear and road density relationships in the Selkirk and Cabinet-Yaak recovery zones. U.S. Fish and Wildlife Service, Missoula, MT.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

APPENDIX Table 1. Mortality assignment of augmentation bears removed from one recovery area and released in another target recovery area.

#	Scenario	Where Mortality Credited and Year [1]	
		Source	**Target**
1	Bear stays in Target recovery area[2] past Year 1.	Mortality removal year	No mortality
2	Bear dies in Target recovery area[2] during Year 1.	Mortality removal year	No mortality
3	Bear dies in Target recovery area[2] after Year 1.	Mortality removal year	Mortality, Year 2 or later
4	Bear returns to Source area[2] and is alive in Year 1.	No mortality	No mortality
5	Bear returns to Source area[2] and is alive after Year 1.	No mortality	No mortality
6	Bear returns to Source area[2] and dies there after Year 1.	Mortality removal year only	No mortality
7	Bear dies outside both Target and Source areas[2] within Year 1.	Mortality removal year	No mortality
8	Bear dies outside both Target and Source areas[2] after Year 1.	Mortality removal year	No mortality
9	Collar failure/lost bear in Target area[2] within Year 1.	Mortality removal year	No mortality
10	Collar failure/lost bear in Target area[2] after Year 1.	Mortality removal year	No mortality

[1] Year 1 begins on the day the bear is released in the target area and ends after 365 days. One year was chosen to give the animal an opportunity to locate and use all seasonal habitats. This rule set may conditionally require a bookkeeping correction to remove the mortality in the source area in the year of removal.

[2] Target and Source areas include 10 mile buffer around Recovery Zones. Bears dying in Canada only count against mortality limits in the Selkirk Mountains, where the Recovery Plan defines a Recovery Zone that includes Canada. If an augmentation bear leaves the target recovery area and dies, it counts as source area mortality in the removal year but it does not count as target area mortality. If an augmentation bear leaves the target recovery area in year 2 or later it counts as source area mortality in year 1 and target area mortality in year 2 or later if the mortality was human caused. While this approach counts a bear as dead twice, the second mortality represents a human caused mortality issue outside of a bear learning a new area and should be counted in the target area. (Mortalities in Canada only count inside the Selkirk recovery zone inside Canada and the 10 mile buffer will not apply to that portion of the Selkirk recovery area in Canada. Areas adjacent to the Canadian Selkirks have more robust, contiguous populations, several of which are hunted and mortality should not be counted against the Selkirk recovery area. The 10 mile buffer was promoted inside the US because this area was believed to contain animals that spent a portion of their time outside the recovery area, but were believed to be part of that recovery area population.)

APPENDIX Table 2. Known historic grizzly bear mortality pre-dating project monitoring, in or near the Cabinet-Yaak recovery zone and the Yahk grizzly bear population unit in British Columbia, 1949–78.

YEAR	LOCATION	TOTAL	SEX / AGE	MORTALITY CAUSE
1949	COPPER CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1950	SQUAW CR, MT	1	SUBADULT	UNKNOWN
1951	PETE CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1951	PAPOOSE CR, MT	2	SUBADULTS	UNKNOWN
1951	GOAT CR, MT	1	SUBADULT MALE	UNKNOWN
1952	FELIX CR, MT	6	2 ADULT FEMALES, 4 YEARLINGS	HUMAN, MANAGEMENT REMOVAL
1953	OBRIEN CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1953	KENELTY MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	20-ODD MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	BURNT CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	17-MILE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	N F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	S F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	TAYLOR PK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBUTTE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBOW CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1955	WOLF CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1955	MT HEADLEY, MT	1	SUBADULT	HUMAN, MANAGEMENT REMOVAL
1955	BAREE LK, MT	1	ADULT MALE	UNKNOWN
1955	BAREE LK, MT	1	ADULT FEMALE	UNKNOWN
1955	BEAR CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1958	SQUAW CR, MT	1	ADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1959	E F ROCK CR, MT	2	ADULT FEMALE, 1 CUB	HUMAN, LEGAL HUNTER KILL
1959	W F THOMPSON R, MT	4	ADULT FEMALE, 3 CUBS	UNKNOWN
1959	CLIFF CR, MT	1	UNKNOWN	UNKNOWN
1960	PROSPECT CR, MT	2	ADULT FEMALE, 1 CUB	UNKNOWN
1964	GRAVES CR, MT	2	SUBADULTS	UNKNOWN
1964	WANLESS LK, MT	3	SUBADULTS (ADULT WOUNDED)	UNKNOWN
1965	SNOWSHOE CR, MT	2	SUBADULTS	UNKNOWN
1965	PINKHAM CR, MT	1	UNKNOWN	UNKNOWN
1967	SOPHIE LK, MT	1	UNKNOWN	UNKNOWN
1968	BEAR CR, MT	1	ADULT FEMALE	HUMAN, ILLEGAL KILL
1968	GRANITE CR, MT	1	SUBADULT MALE	HUMAN, MANAGEMENT REMOVAL
1969	PRISCILLA PK, MT	1	ADULT FEMALE	UNKNOWN
1970	THOMPSON R, MT	1	UNKNOWN	UNKNOWN
1970	CAMERON CR, MT	1	SUBADULT MALE	UNKNOWN
1970	SQUAW CR, MT	2	ADULT FEMALE, SUBADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1971	MURR CR, MT	1	ADULT FEMALE	UNKNOWN
1972	ROCK CR, MT	1	SUBADULT	HUMAN, MISTAKEN IDENTITY (Black Bear)
1974	SWAMP CR, MT	1	ADULT MALE	HUMAN, LEGAL HUNTER KILL
1977	RABBIT CR, MT	1	ADULT MALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1978	MOYIE LAKE, BC	1	SUBADULT MALE	HUMAN, MANAGEMENT

APPENDIX Table 3. Movement and gene flow to or from the Cabinet-Yaak recovery area.

Area[1] Start / Finish	Action	Bear ID	Sex	Age	Year	Basis	Comments
Cabs / NCDE	Movement	C403M	M	2-3	2007	Telemetry, Genetics	Captured Marion, MT 2006 NCDE, traveled to Whitefish, relocated to Whitefish Range. Train kill 2007
NCDE / SPur	Movement	YGB737M	M	4	2010	Genetics	Captured and monitored 2010-15. Parentage in NCDE by USGS.
NCDE / SPur	Movement	43-44	F	3	2013	Capture, Mortality	Management bear relocated at least twice in NCDE. Traveld to SPur, shot after Killing chickens by landowner.
NPur / SPur	Movement	P9183M	M	Unk	2004-05	Genetics	DNA captured NPur and SPur.
NPur / SPur	Movement	PKiddM	M	7	2004	Telemetry	Radio collared June 2004, Travels from NPur to SPur, offspring in SPur.
NPur / SPur	Movement	YMarilF	F	4-5	2005-06	Telemetry, Genetic assignment	Radio collared July 2005 in SPur, Genetic assignment to the NPur. Management removal 2006.
NPur / SPur	Movement	Y732M	M	3	2011	Genetics	Born in NPur and Traveled to SPur. Mortality 2011.
NPur / SPur	Movement	10569F	F	6	2005, 2012	Genetics, Mortality	Father SPur YVernM, Mother NPur PIrishF, DNA capture NPur 2005, Mortality with cub SPur 2012
NPur / SPur	Gene flow	Y90479M	M	0.5	2012	Genetics, Mortality	Father Y576M Mother 10569F Mortality 2012
SPur / NCDE	Movement	N323M	M	Unk	1999	Genetics	Hair snagged 1999 in SPur. Hair snagged NCDE USGS 1998-2006. USGS assigned to SPur.
SPur / Salish	Movement	Y128M	M	18	2001	Mortality	Capture 1987. Monitored 1987-92 and 1997 SPur. Recaptured August 2001 in Salish, Mortality 2001.
SPur / NPur	Movement	Y128M	M	4-14	1987-92, 1997	Telemetry	Capture May 1987 SPur. Monitored 1987-92 and 1997. Monitored NPur and produced offspring.
SPur / NPur	Movement	YVernM	M	7-12	1997, 2002	Telemetry, Genetics	Radio collared SPur 1997. Hair snag NPur 2002.Sired offspring NPur and SPur.
SPur / NPur	Movement	YRockyM	M	8-12	2002-06	Telemetry	Captured and collared SPur 2002. Recapture 2006. Traveled NPur in 2006.
SPur / NPur	Movement	134	M	8-9	1987-88	Telemetry	Radio collar in SPur 1987. Hunter kill 1988 NPur
SPur / NPur	Movement	P9190M	M	4-5	2006-07	Telemetry	Radio collared June 2006 SPur. Traveled to NPur
SPur / NPur	Movement	PTerryM	M	3	2005	Telemetry, Genetics	Father SPS Y178M , Mother SPS Y538F Travel to NPur from SPur.
SPur / SSelK	Movement	YHydeM	M	3	2006-07	Telemetry	Captured in SPur Yaak 2006. Bear traveled to SSelk 2006-07
SSelk / Cabs / SSelk	Movement	928442	M	5	2012	Genetics	Father SSelk S9058aM, Mother SSelk SBettyF, Hair snagged USGS 2012 Cabs and in SSelk 2015
SSelk / SPur	Movement	S31M	M	6	2004-05	Telemetry, Mortality	Father SSelk SS3KM, Mother SSelk S1MF, Management capture 2003 and Relocated. Hunter kill 2005 SPur
SPur / Cabs / SPur	Movement	Y726M	M	6	2015-16	Telemetry	Travel from SPur to Cabs and back
SPur / SRock	Movement	922947	M	5	2013	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SPur / SRock	Movement	928196	M	20	2015-16	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SSelk / Cabs	Movement	S1001M	M	6	2015	Telemetry, Mortality	Travel from SSelk to Cabs. Mortality 2015
Cabs / NCDE	Movement	900932	M	4	2015-16	Telemetry	Travel east from Cabs to NCDE
SPur / NPur	Movement	958729	M	12	2016	Telemetry	Travel north from SPur to NPur

Area[1] Start / Finish	Action	Bear ID	Sex	Age	Year	Basis	Comments
SPur / SSelk	Movement	Y11048M	M	4	2017	Telemetry, Mortality	Travel west from SPur to SSelk. Mortality 2017
SPur / SSelk	Movement	YGB807M	M	5	2015-17	Telemetry	Travel west from SPur to SSelk.
SPur / Cabs	Movement	Y821M	M	3	2017	Telemetry	Travel from SPur to Cabs
NPur / SPur	Gene flow	YGB837M	M	6	2014	Genetics	Parents both NPur, Father NPur PKiddM, Mother NPur PIrishF
SPur / NPur	Gene flow	P9194F	F	Unk	2004-05	Genetics	Father SPur Y128M , Mother NPur P9127F, Origin of father probably NPur
NPur / SPur	Gene flow	Y787M	M	3	2003	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
NPur / SPur	Gene flow	YU37F	F	1	2001	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
SSelk / SPur	Movement	16749	M	Unk	2015	Genetics	Father C134B2V2, Mother JillS226F Both SSelk. Male offspring 16749 SPur
NCDE / Cabs	Movement	C90467M	M	6	2014	Genetics, Mortality	Management bear from NCDE traveled to Cabs, mortality 2014
NPur / SPur	Movement	P1374M	M	2	2010	Genetics, Mortality	Hair snag as cub in 2008 NPur? Management capture SPur 2010,relocated, Mortality 2010
NPur / SSelk / Cabs	Gene flow, Movement	S21285M	M	0.5-2	2016-18	Genetics, Telemetry	Father NPur SCptHM , Mother SSelk S11675F, S21285M traveled to Cabs in 2018, then dropped collar
SPur / SRock	Movement	18986	M	4	2018	Genetics, Telemetry	Travel north from SPur across Kootenay in BC to SRock (BC mgmt. capture)
NPur / SPur	Movement	Y29761M	M	Unk	2017	Genetics	Father P9101M, Mother PMaeveF, both NPur. Male offspring Y29761M SPur

[1]Cabs – Cabinet Mountains, NCDE – Northern Continental Divide, NPur – Purcell Mountains north of Highway 3, SPur – Purcell Mountains south of Highway 3, SSelk – South Selkirk Mountains south of Nelson, BC

APPENDIX 4. Grizzly Bear Home Ranges

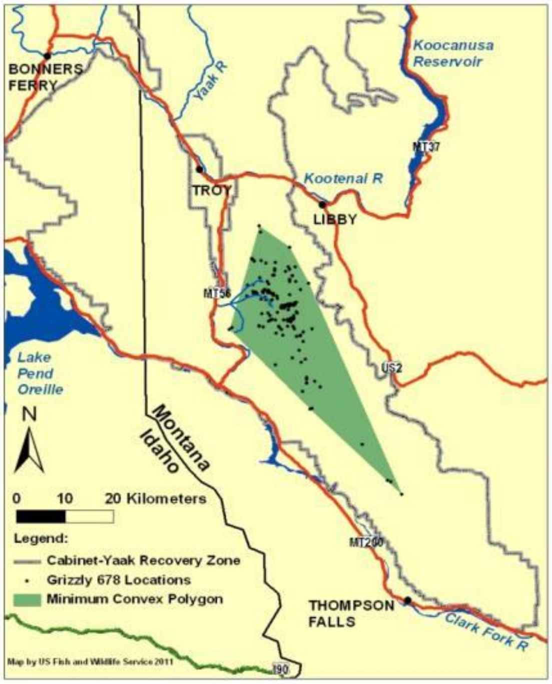


Figure A1. Radio locations and minimum convex (shaded) life range of female grizzly bear 678 in the Cabinet Mountains, 1983-89.

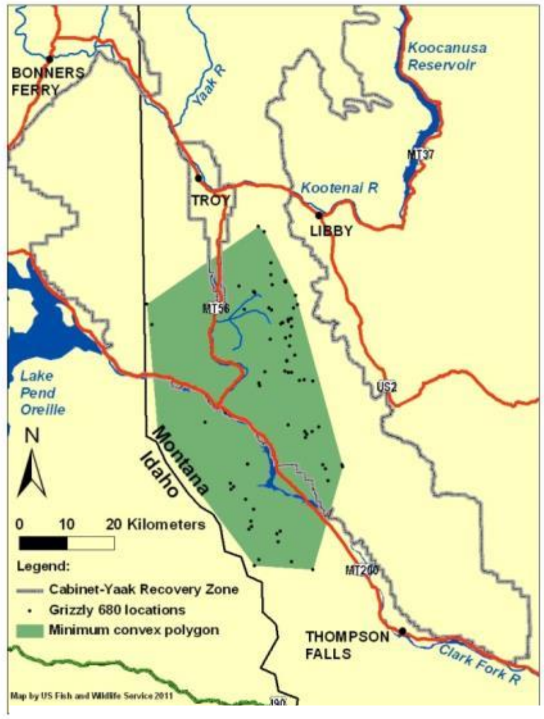


Figure A2. Radio locations and minimum convex (shaded) life range of male grizzly bear 680 in the Cabinet Mountains, 1984-85.

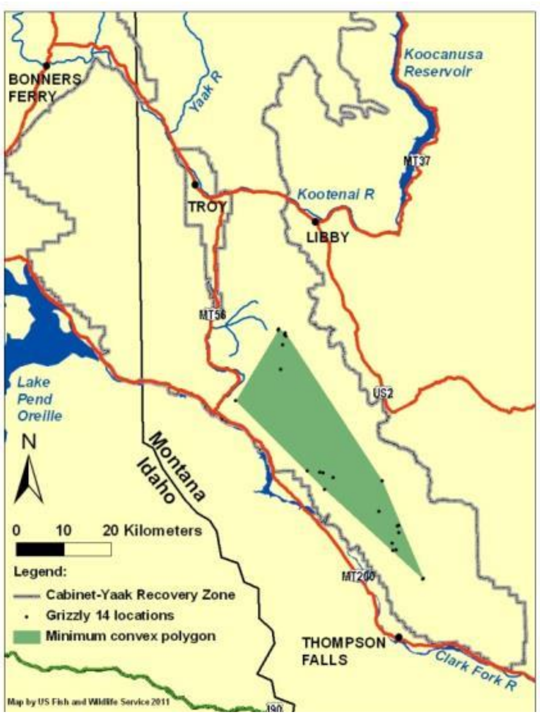


Figure A3. Radio locations and minimum convex (shaded) life range of male grizzly bear 14 in the Cabinet Mountains, 1985.

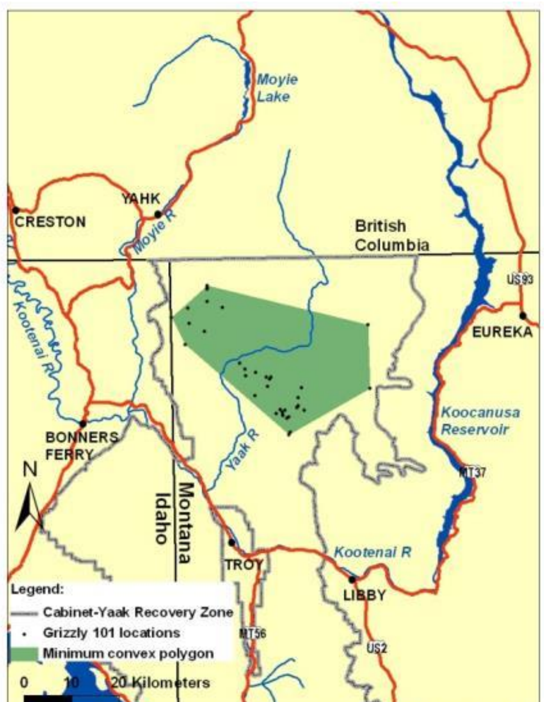


Figure A4. Radio locations and minimum convex (shaded) life range of male grizzly bear 101 in the Yaak River, 1986-87.

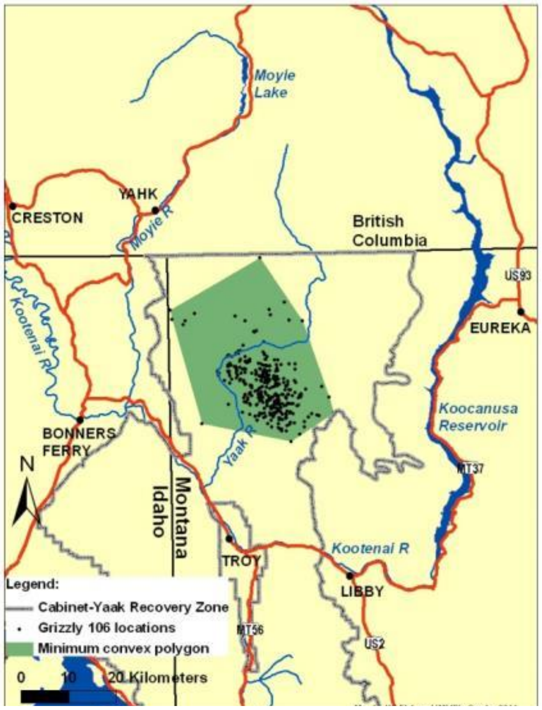


Figure A5. Radio locations and minimum convex (shaded) life range of female grizzly bear 106 in the Yaak River, 1986-99.

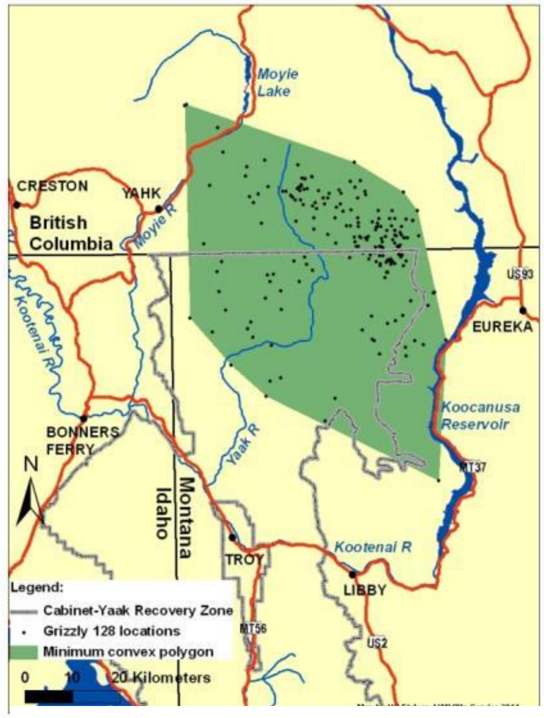


Figure A6. Radio locations and minimum convex (shaded) life range of male grizzly bear 128 in the Yaak River, 1987-97.

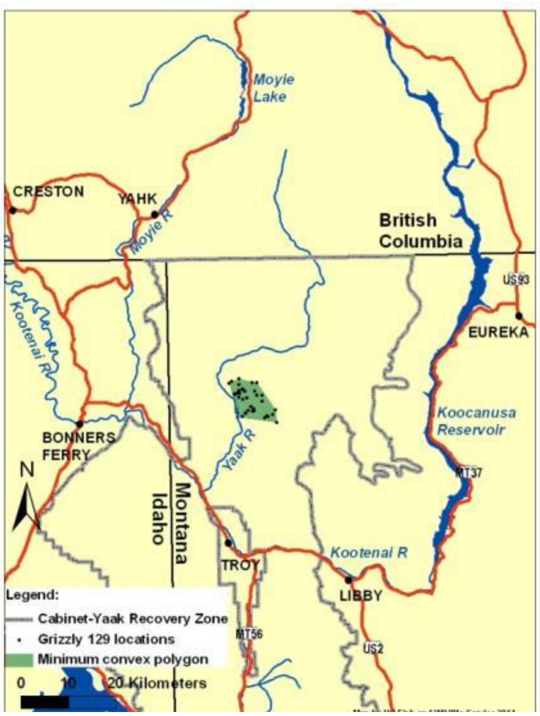


Figure A7. Radio locations and minimum convex (shaded) life range of female grizzly bear 129 in the Yaak River, 1987-89.

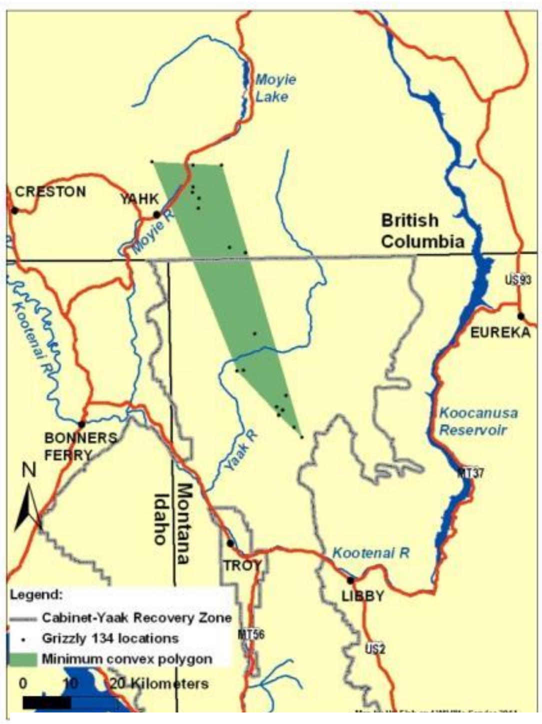


Figure A8. Radio locations and minimum convex (shaded) life range of male grizzly bear 134 in the Yaak River, 1987-88.

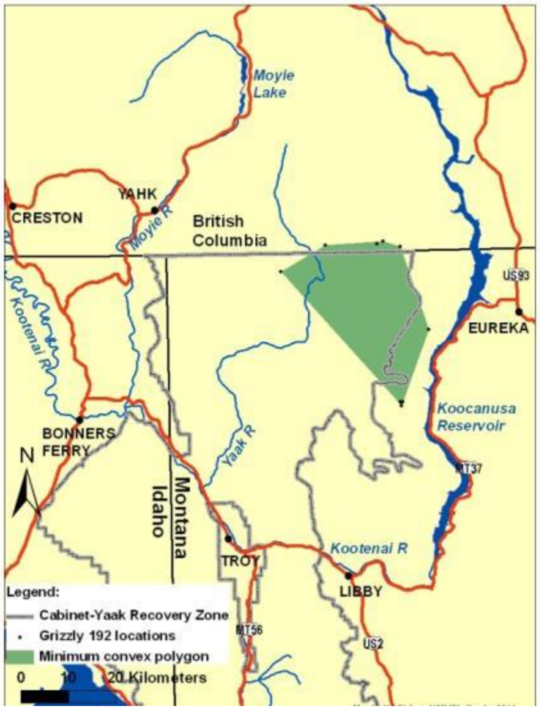


Figure A9. Radio locations and minimum convex (shaded) life range of male grizzly bear 192 in the Yaak River, 1990.

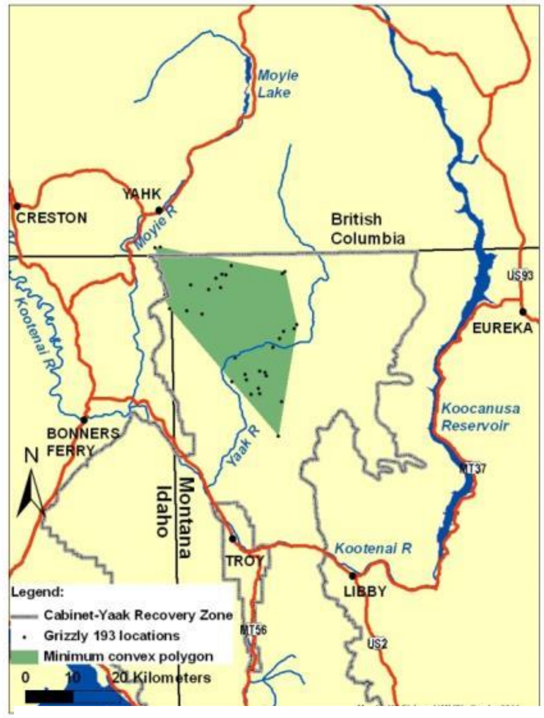


Figure A10. Radio locations and minimum convex (shaded) life range of male grizzly bear 193 in the Yaak River, 1990.

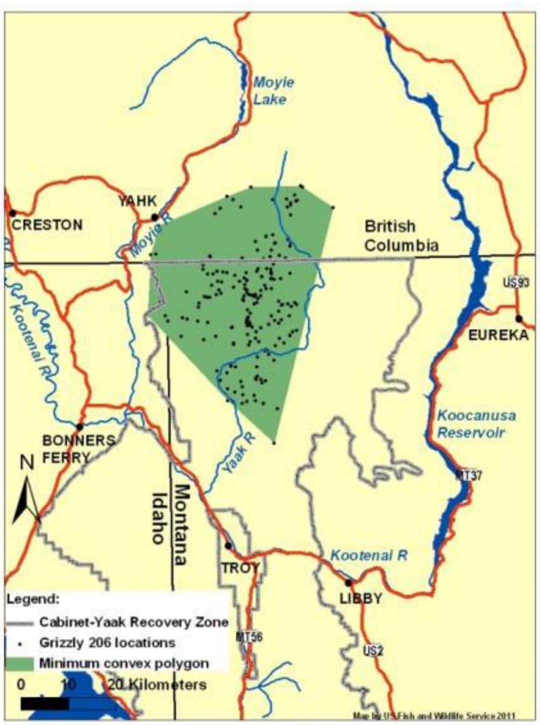


Figure A11. Radio locations and minimum convex (shaded) life range of female grizzly bear 206 in the Yaak River, 1991-94.

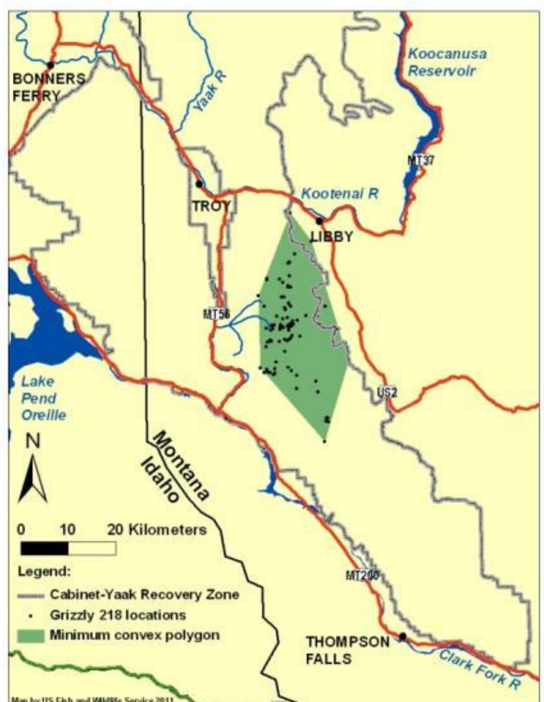


Figure A12. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 218 in the Cabinet Mountains, 1990-91.

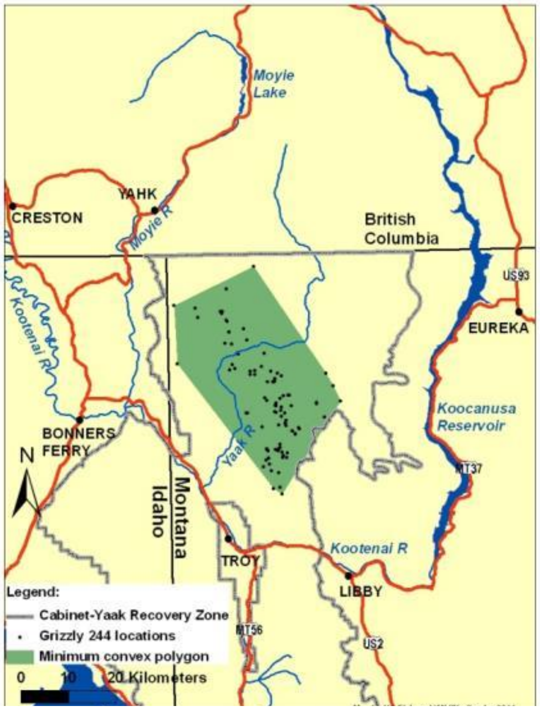


Figure A13. Radio locations and minimum convex (shaded) life range of male grizzly bear 244 in the Yaak River, 1992-03.

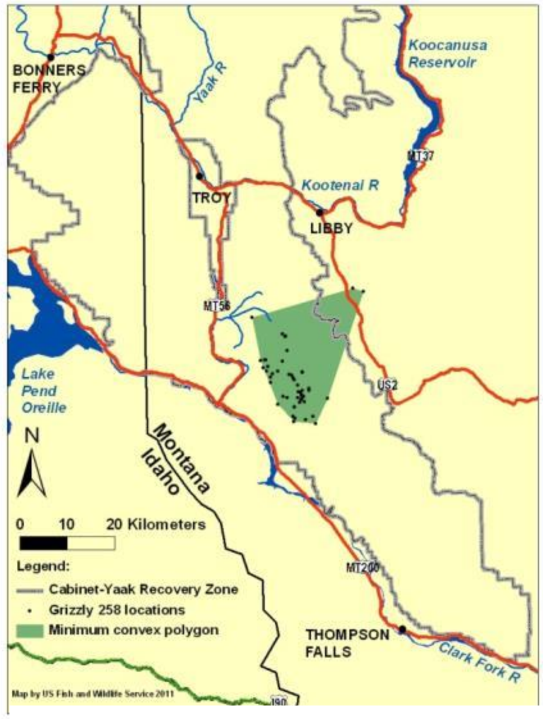


Figure A14. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 258 in the Cabinet Mountains, 1992-93.

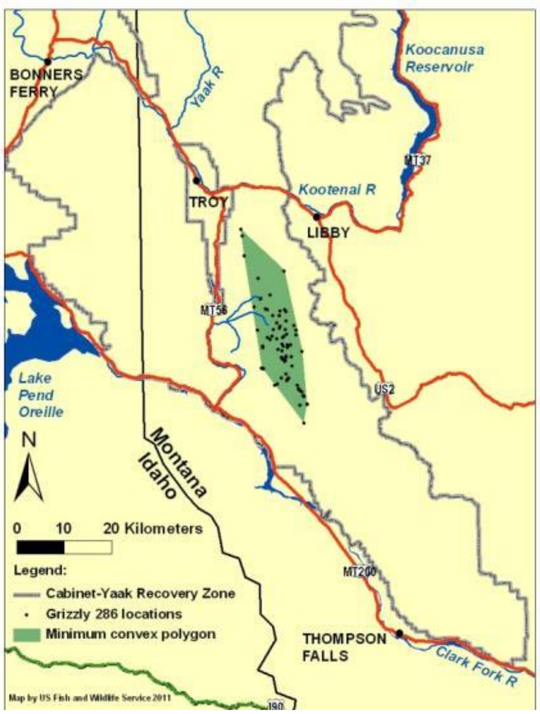


Figure A15. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 286 in the Cabinet Mountains, 1993-95.

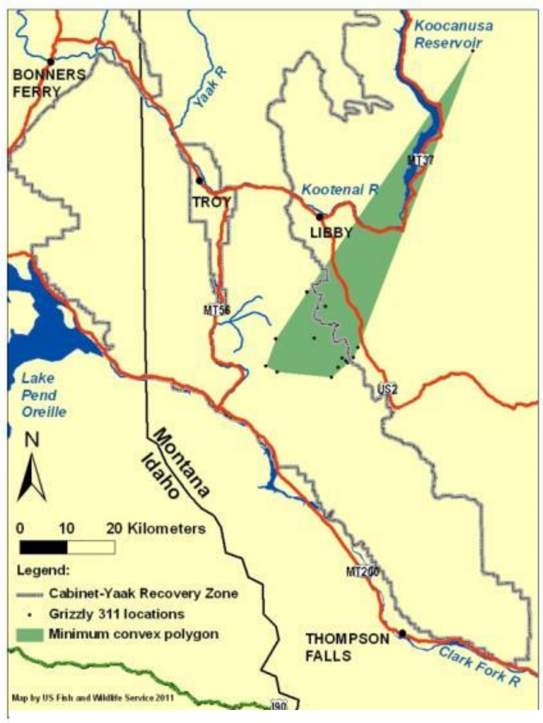


Figure A16. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 311 in the Cabinet Mountains, 1994-95.

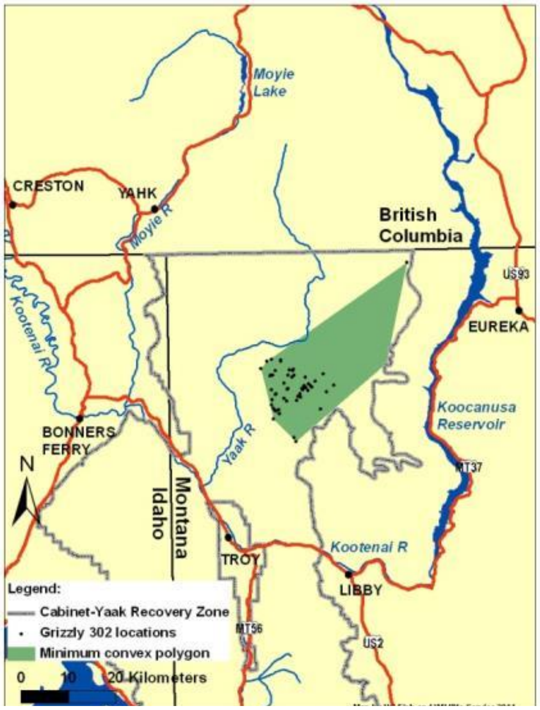


Figure A17. Radio locations and minimum convex (shaded) life range of male grizzly bear 302 in the Yaak River, 1994-96.

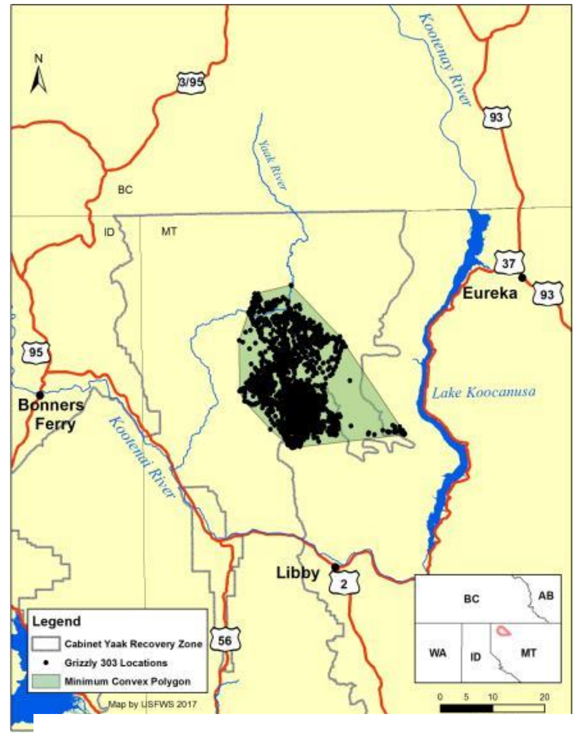


Figure A18. Radio locations and minimum convex (shaded) life range of female grizzly bear 303 in the Yaak River, 1994-01 and 2011-16.

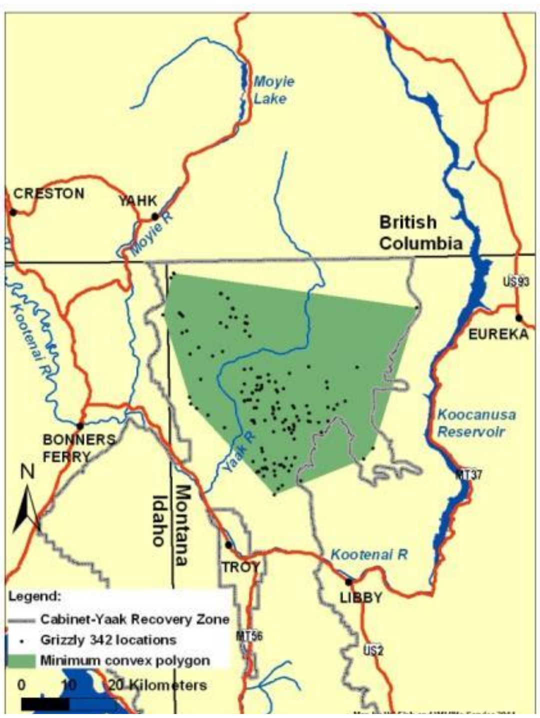


Figure A19. Radio locations and minimum convex (shaded) life range of male grizzly bear 342 in the Yaak River, 1995-01.

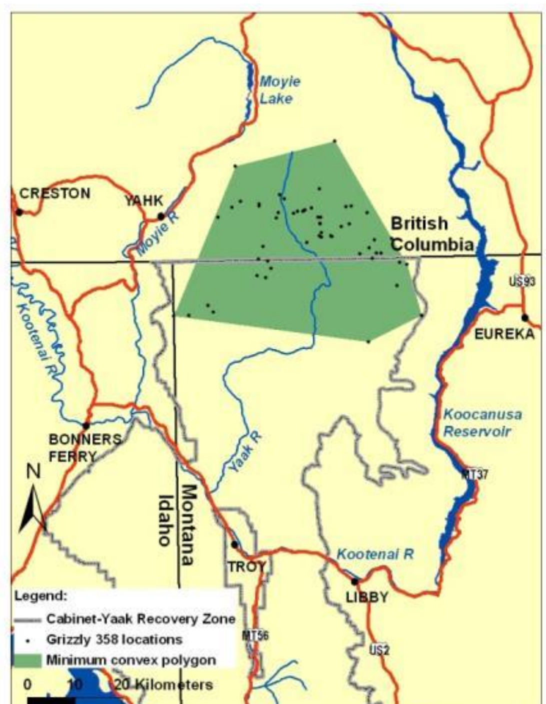


Figure A20. Radio locations and minimum convex (shaded) life range of male grizzly bear 358 in the Yaak River, 1996-98.

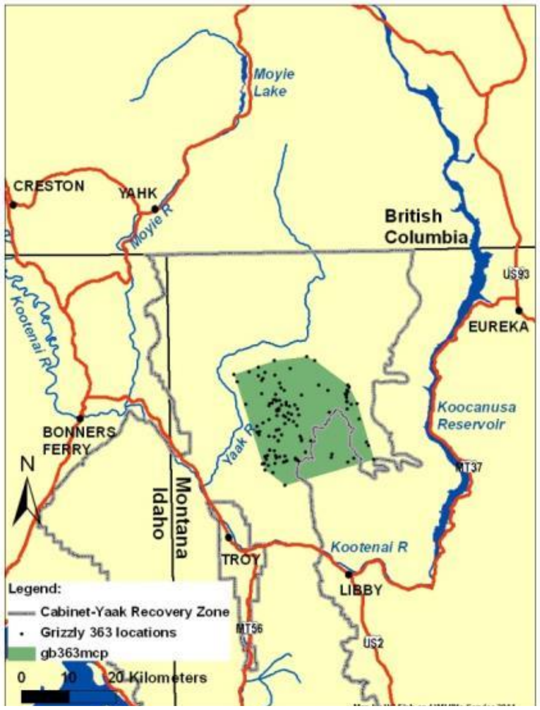


Figure A21. Radio locations and minimum convex (shaded) life range of male grizzly bear 363 in the Yaak River, 1996-99.

Figure A22. Radio locations and minimum convex (shaded) life range of male grizzly bear 386 in the Yaak River, 1997-99.

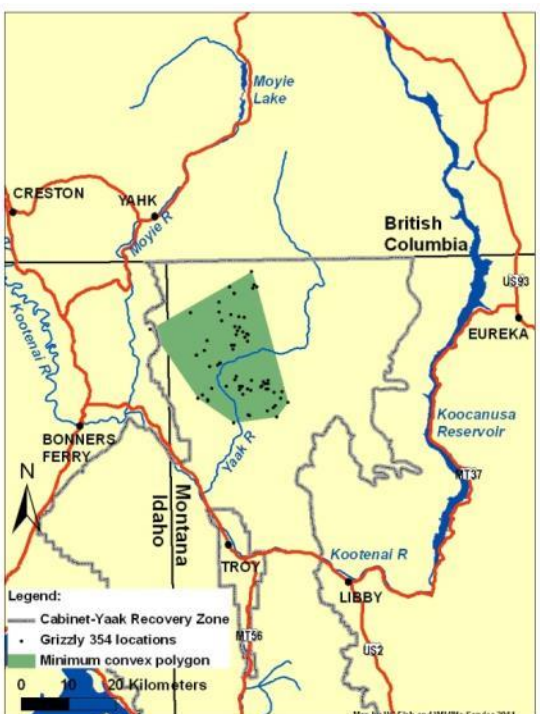


Figure A23. Radio locations and minimum convex (shaded) life range of female grizzly bear 354 in the Yaak River, 1997-99.

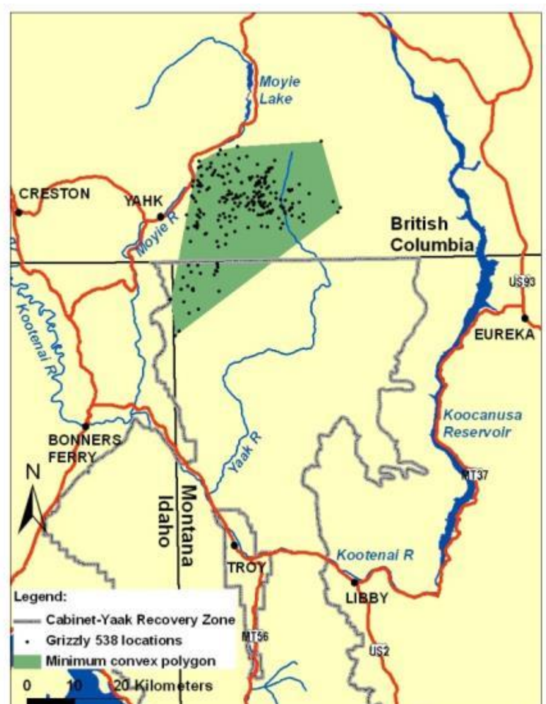


Figure A24. Radio locations and minimum convex (shaded) life range of female grizzly bear 538 in the Yaak River, 1997-02.

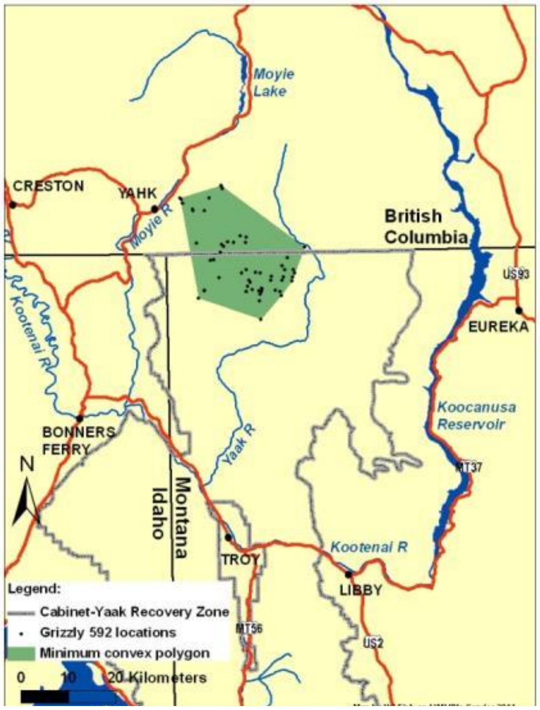


Figure A25. Radio locations and minimum convex (shaded) life range of female grizzly bear 592 in the Yaak River, 1999-00.

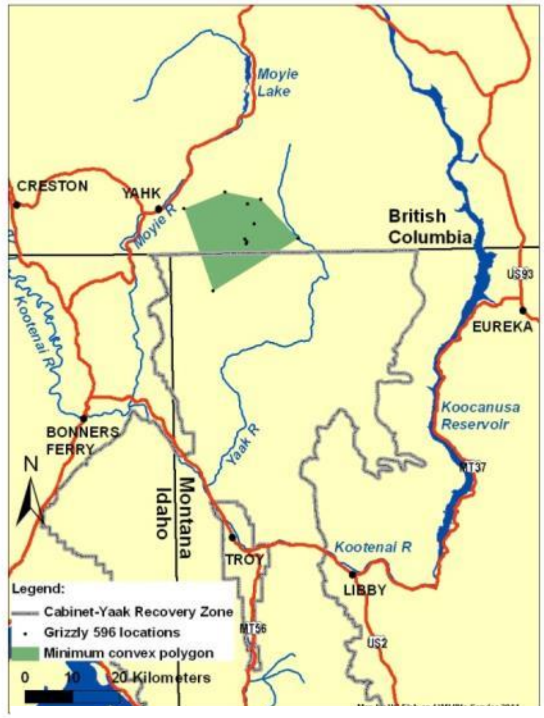


Figure A26. Radio locations and minimum convex (shaded) life range of female grizzly bear 596 in the Yaak River, 1999.

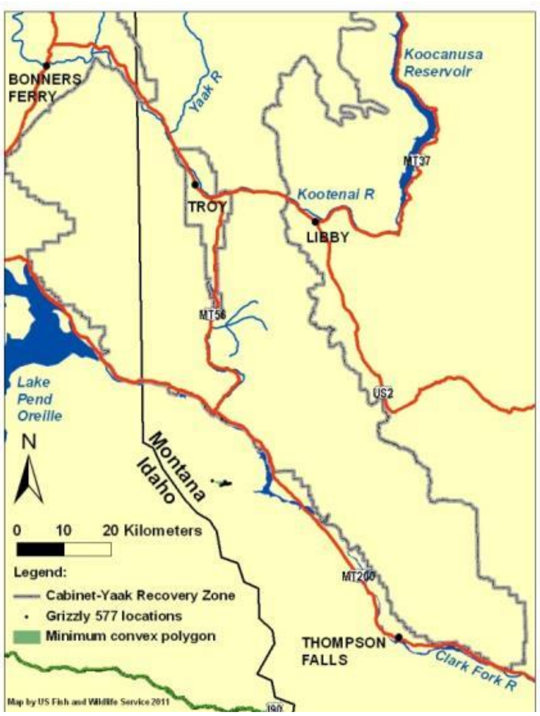


Figure A27. Radio locations and minimum convex (shaded) life range of female grizzly bear 577 in the Cabinet Mountains, 2002.

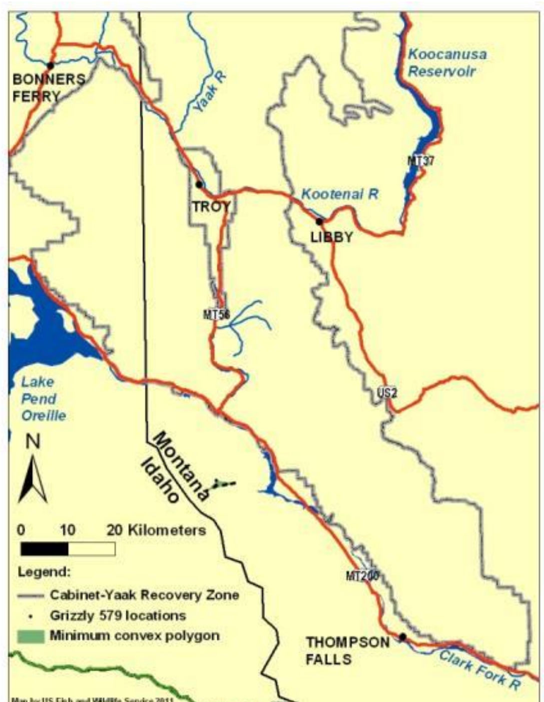


Figure A28. Radio locations and minimum convex (shaded) life range of male grizzly bear 579 in the Cabinet Mountains, 2002.

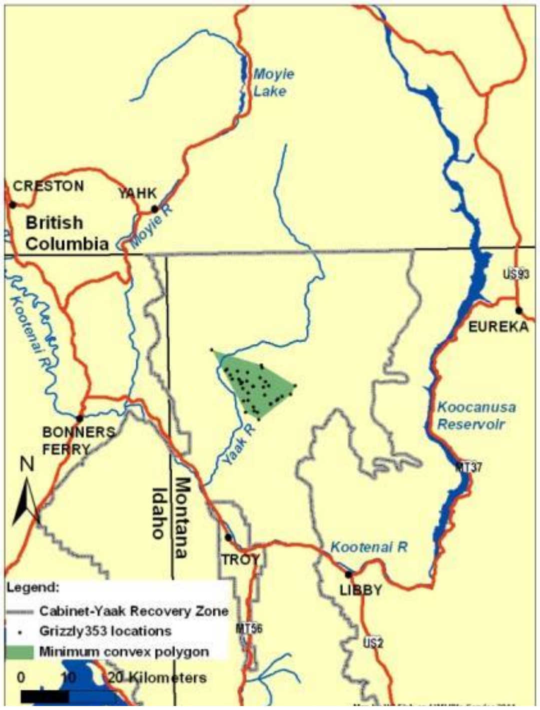


Figure A29. Radio locations and minimum convex (shaded) life range of female grizzly bear 353 in the Yaak River, 2002.

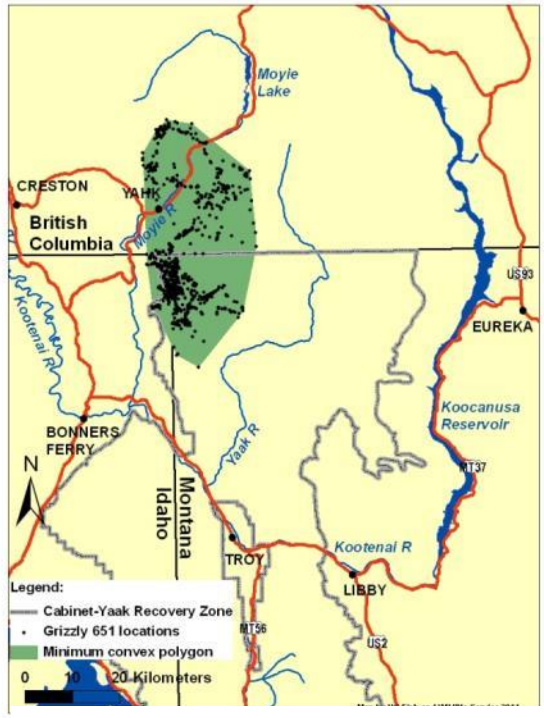


Figure A30. Radio locations and minimum convex (shaded) life range of male grizzly bear 651 in the Yaak River, 2002-06.

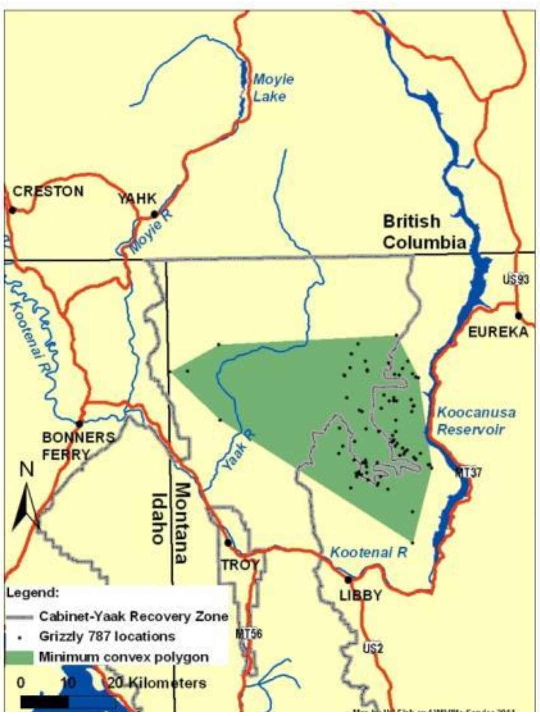


Figure A31. Radio locations and minimum convex (shaded) life range of male grizzly bear 787 in the Yaak River, 2003-04.

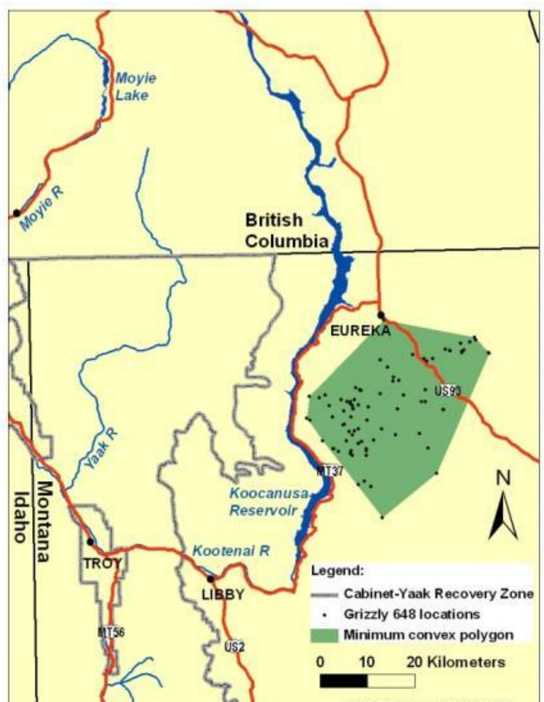


Figure A32. Radio locations and minimum convex (shaded) life range of female grizzly bear 648 in the Salish Mountains, 2003-05.

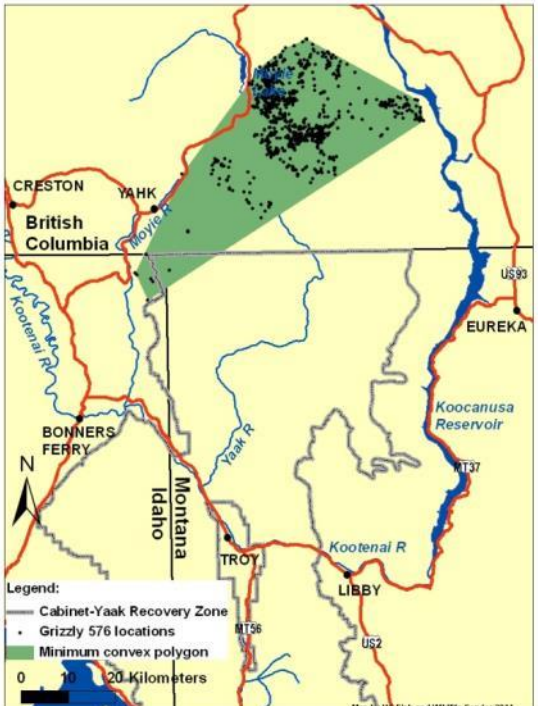


Figure A33. Radio locations and minimum convex (shaded) life range of male grizzly bear 576 in the Yaak River, 2004-06.

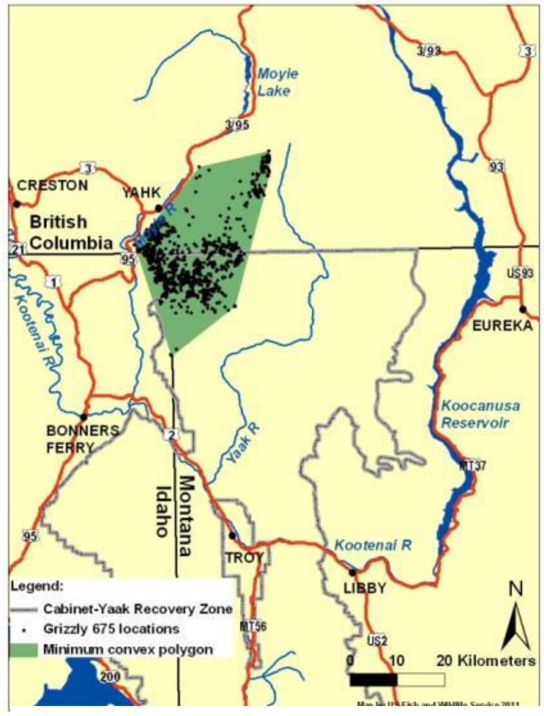


Figure A34. Radio locations and minimum convex (shaded) life range of female grizzly bear 675 in the Yaak River, 2004-10.

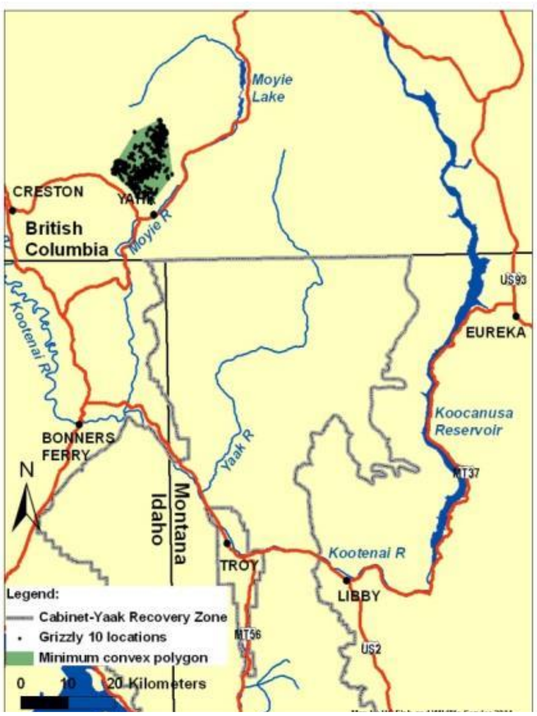


Figure A35. Radio locations and minimum convex (shaded) life range of female grizzly bear 10 in the Purcell Mountains, 2004.

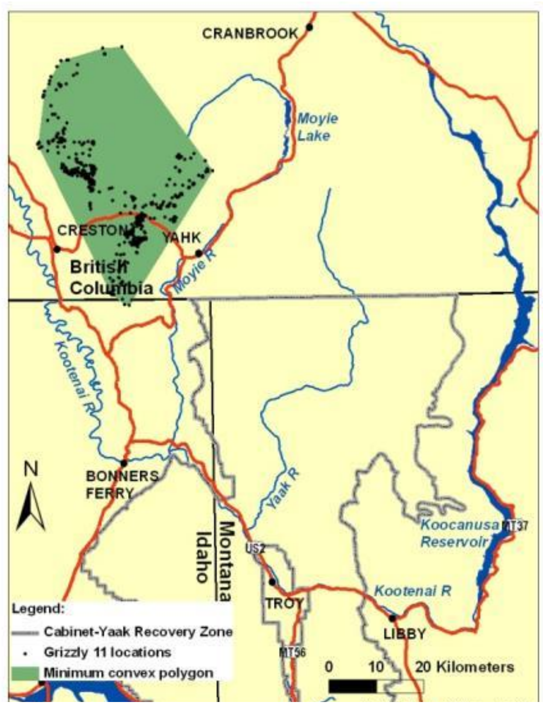


Figure A36. Radio locations and minimum convex (shaded) life range of male grizzly bear 11 in the Purcell Mountains, 2004.

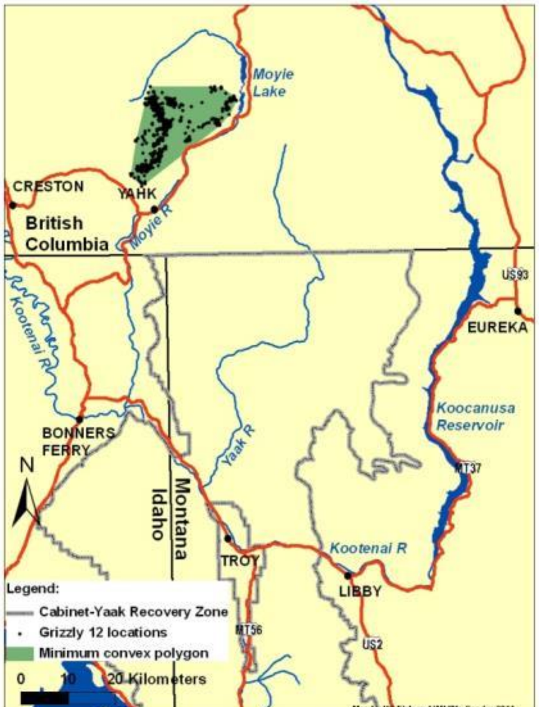


Figure A37. Radio locations and minimum convex (shaded) life range of female grizzly bear 12 in the Purcell Mountains, 2004.

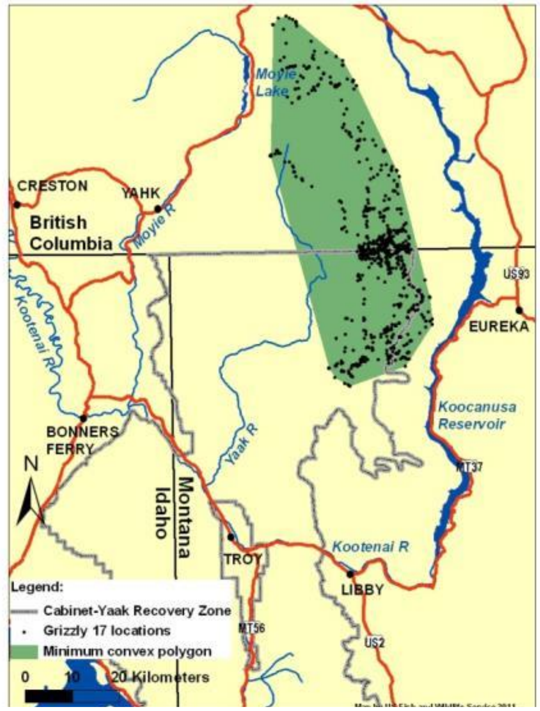


Figure A38. Radio locations and minimum convex (shaded) life range of male grizzly bear 17 in the Purcell Mountains, 2004.

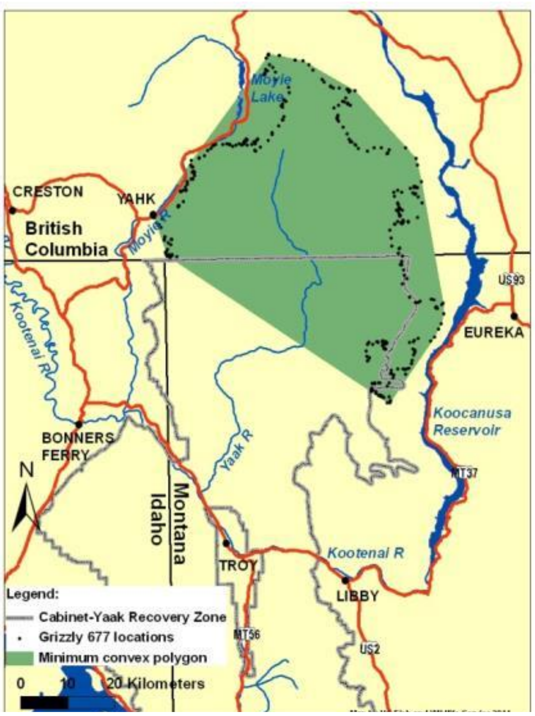


Figure A39. Radio locations and minimum convex (shaded) life range of male grizzly bear 677 in the Purcell Mountains, 2005.

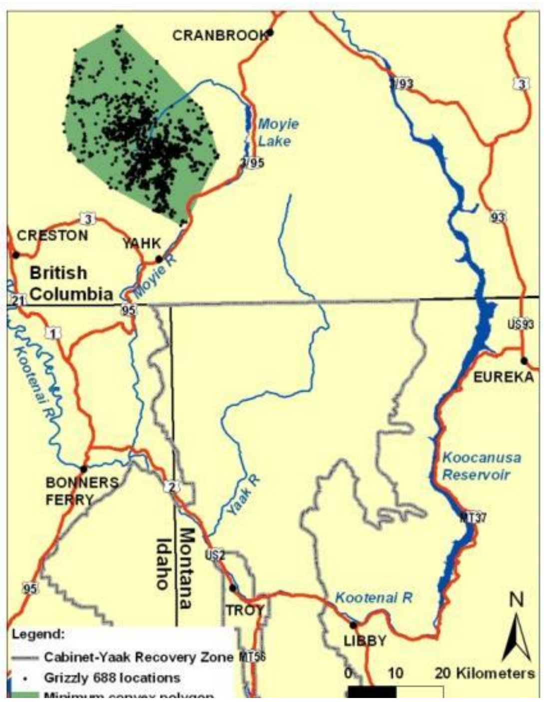


Figure A40. Radio locations and minimum convex (shaded) life range of male grizzly bear 688 in the Purcell Mountains, 2005-06.

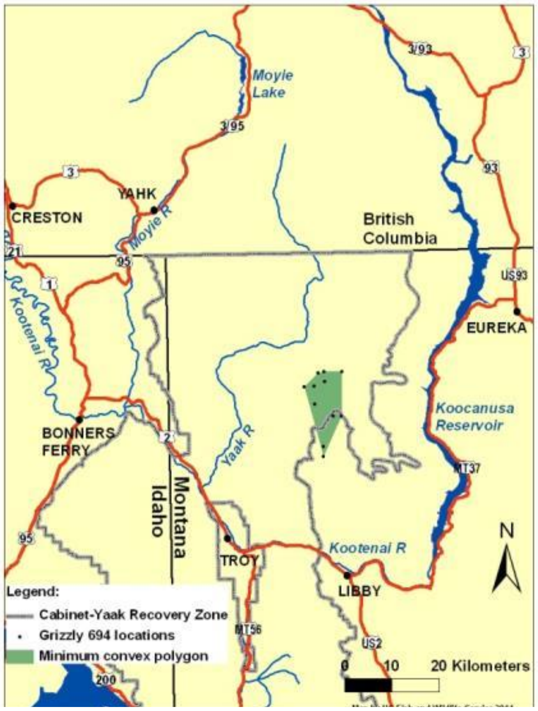


Figure A41. Radio locations and minimum convex (shaded) life range of female grizzly bear 694 in the Yaak River, 2005.

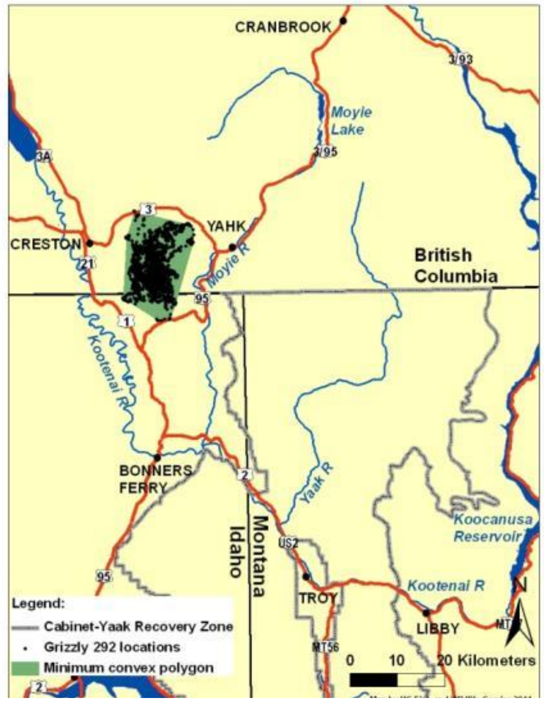


Figure A42. Radio locations and minimum convex (shaded) life range of female grizzly bear 292 in the Purcell Mountains, 2005.

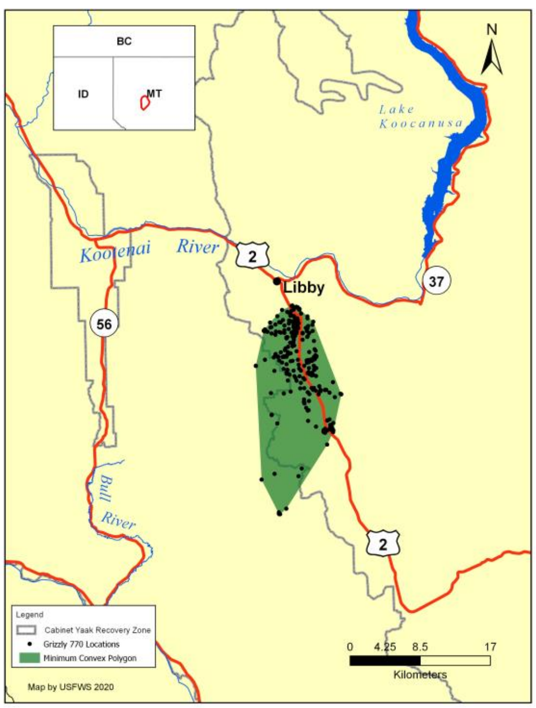


Figure A43. Radio locations and minimum convex (shaded) life range of male grizzly bear 770 in the Cabinet Mountains, 2005-06, 2019.

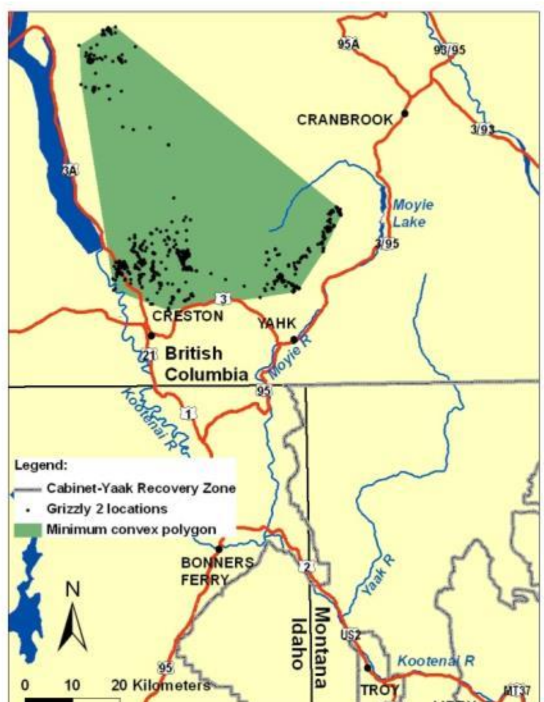


Figure A44. Radio locations and minimum convex (shaded) life ranges of male grizzly bear 2 in the Purcell Mountains, 2005.

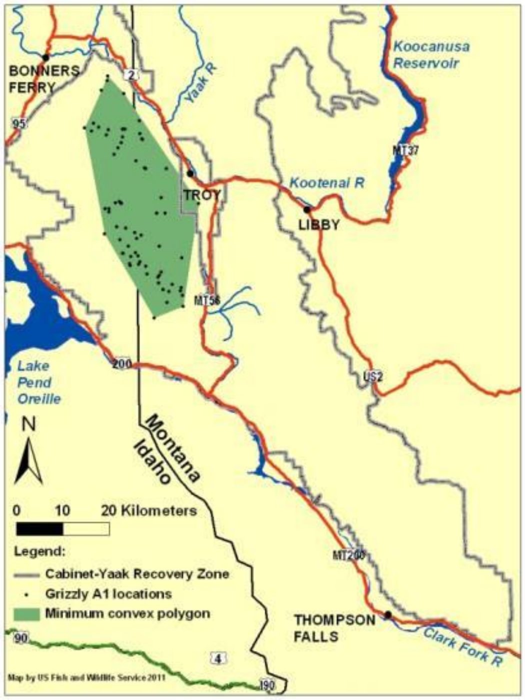


Figure A45. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear A1 in the Cabinet Mountains, 2005-07.

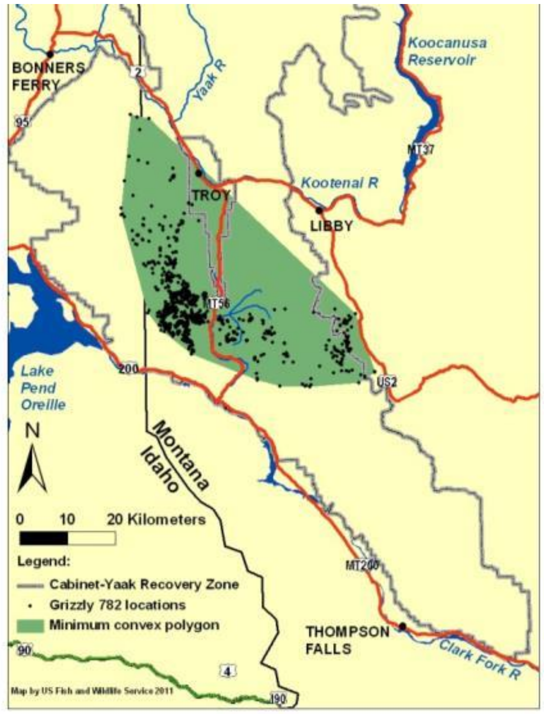


Figure A46. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 782 in the Cabinet Mountains, 2006-07.

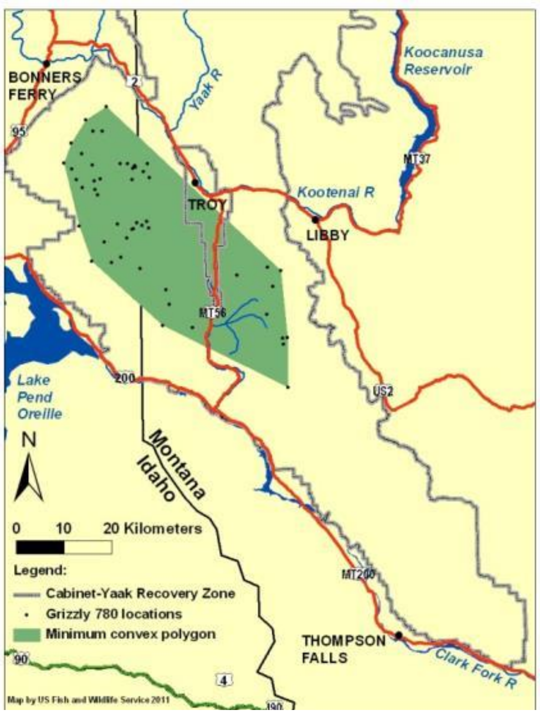


Figure A47. Radio locations and minimum convex (shaded) life range of male grizzly bear 780 in the Cabinet Mountains, 2006-08.

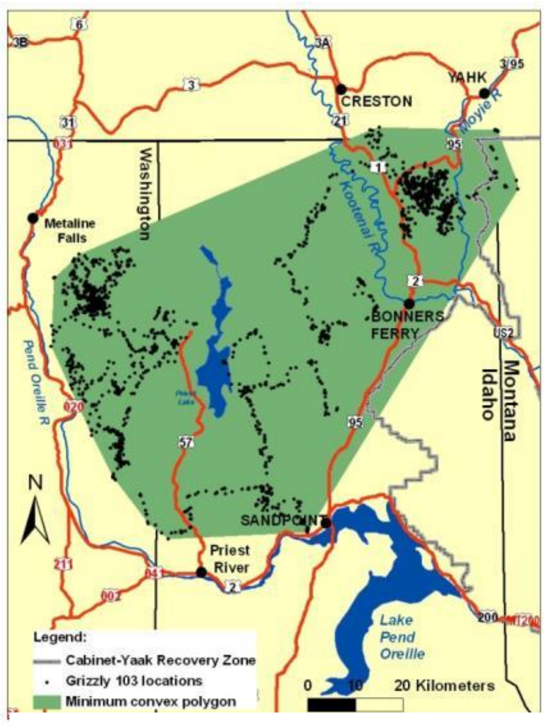


Figure A48. Radio locations and minimum convex (shaded) life range of male grizzly bear 103 in the Yaak River, 2006-07.

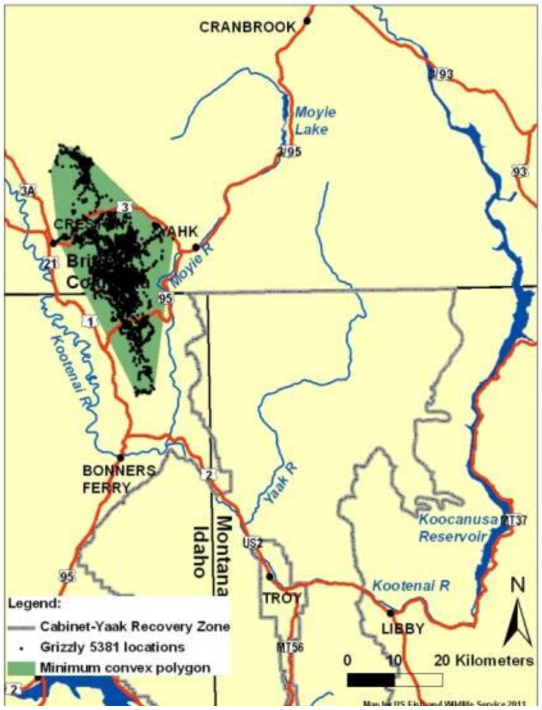


Figure A49. Radio locations and minimum convex (shaded) life range of male grizzly bear 5381 in the Purcell Mountains, 2006-07.

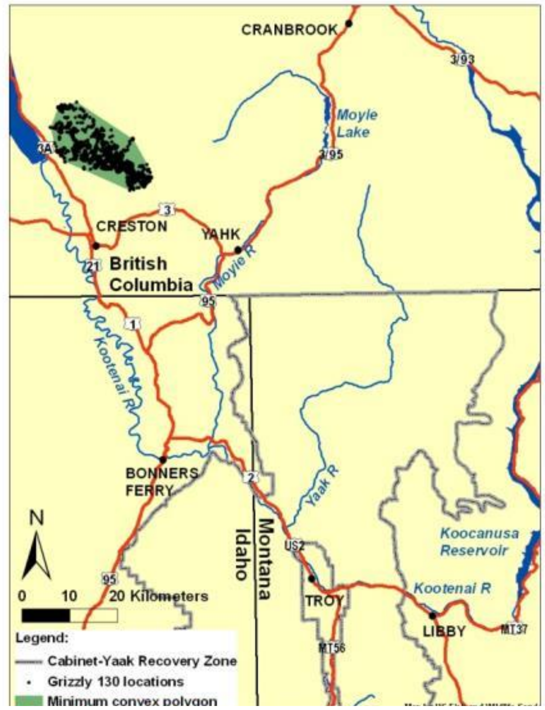


Figure A50. Radio locations and minimum convex (shaded) life range of female grizzly bear 130 in the Purcell Mountains, 2007-08.

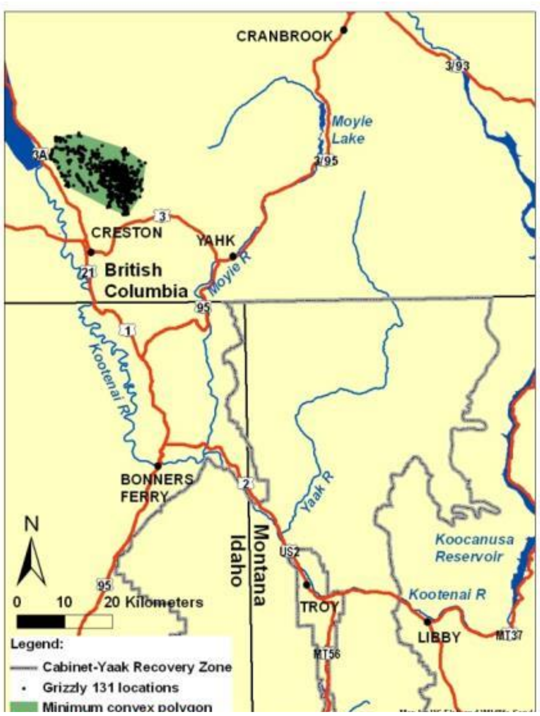


Figure A51. Radio locations and minimum convex (shaded) life range of female grizzly bear 131 in the Purcell Mountains, 2007-08.

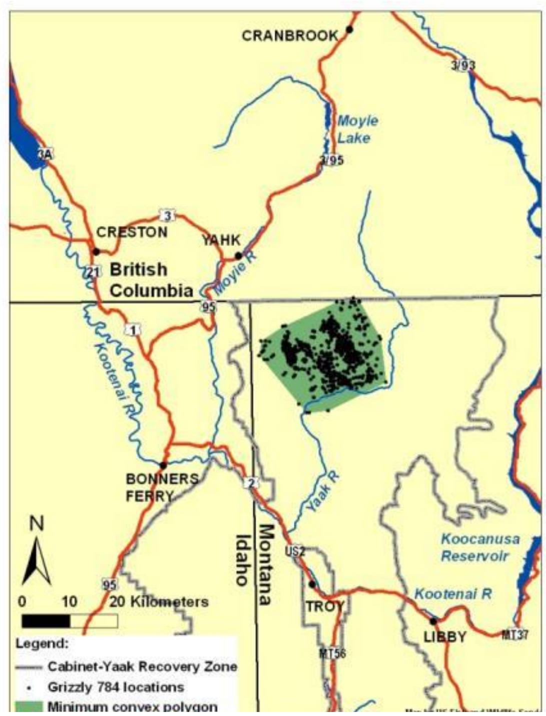


Figure A52. Radio locations and minimum convex (shaded) life range of female grizzly bear 784 in the Yaak River, 2007-09.

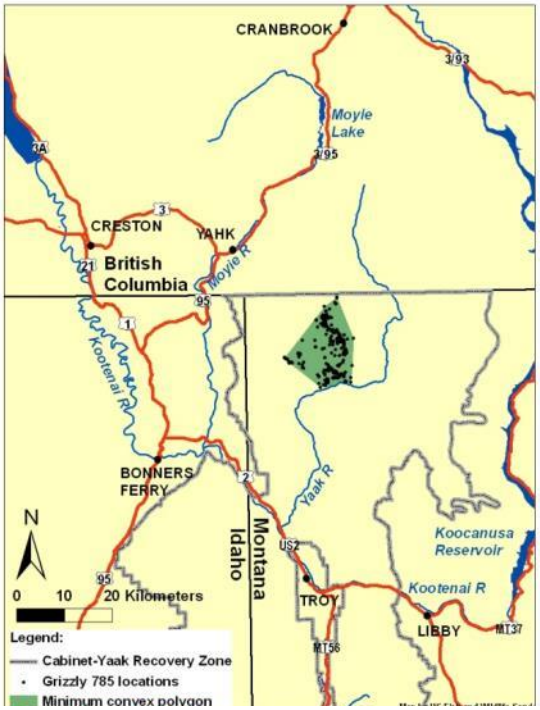


Figure A53. Radio locations and minimum convex (shaded) life range of female grizzly bear 785 in the Yaak River, 2007-08.

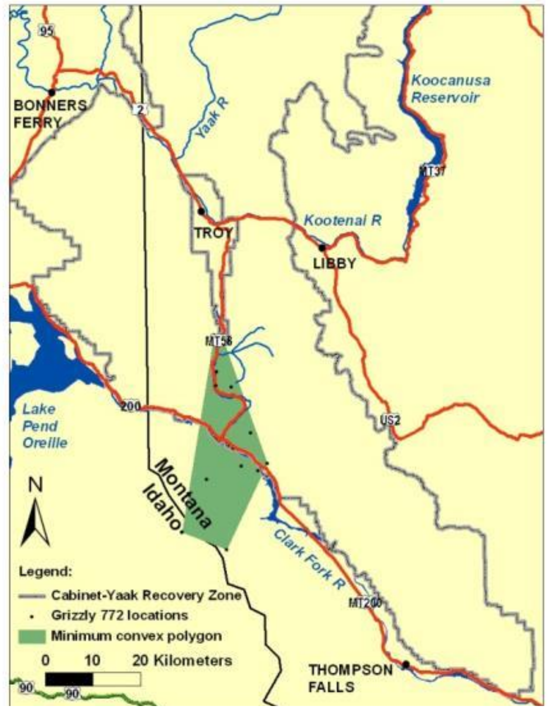


Figure A54. Radio locations and minimum convex (shaded) life range of female grizzly bear 772 in the Cabinet Mountains, 2007.

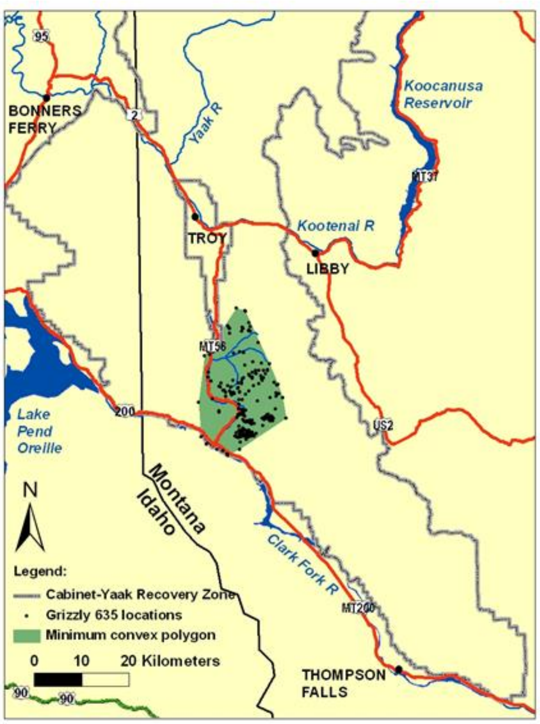


Figure A55. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 635 in the Cabinet Mountains, 2008.

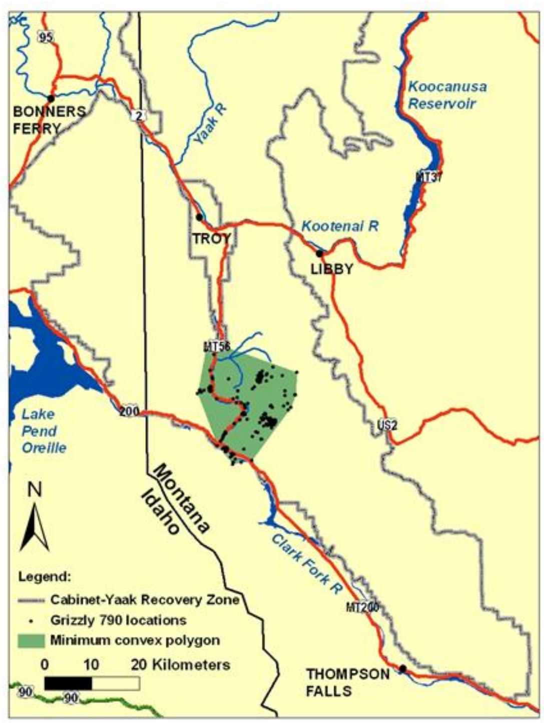


Figure A56. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 790 in the Cabinet Mountains, 2008.

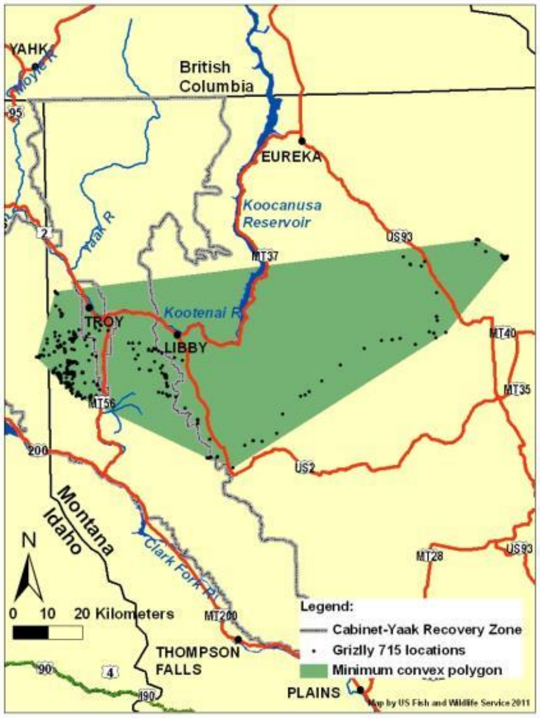


Figure A57. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 715 in the Cabinet Mountains, 2009-10.

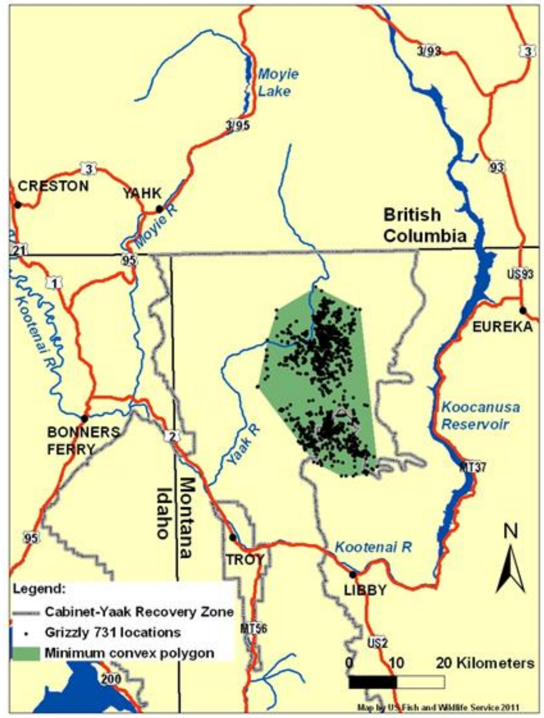


Figure A58. Radio locations and minimum convex (shaded) life range of female grizzly bear 731 in the Yaak River, 2009-11.

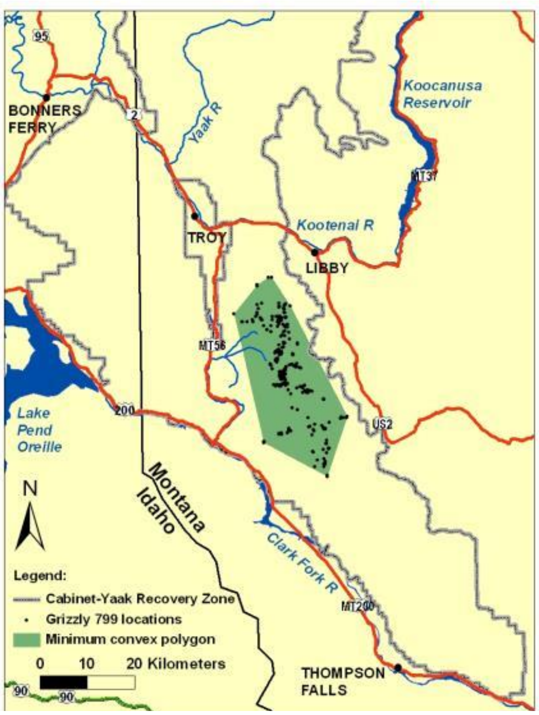


Figure A59. Radio locations and minimum convex (shaded) life range of male grizzly bear 799 in the Cabinet Mountains, 2009-10.

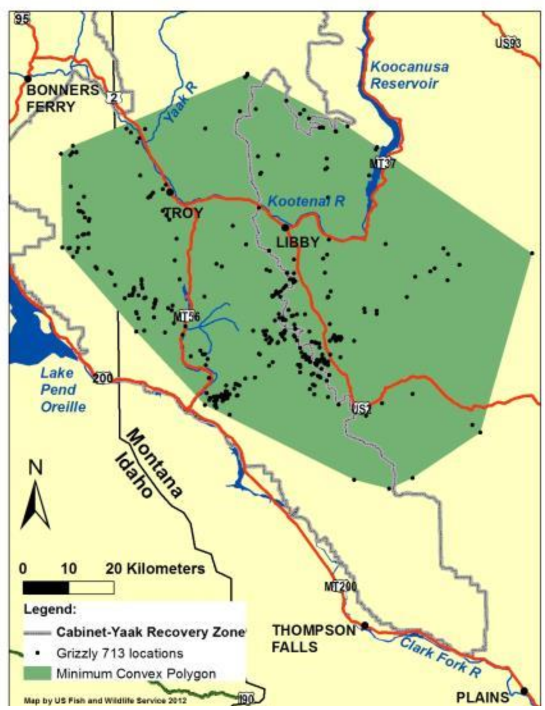


Figure A60. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 713 in the Cabinet Mountains, 2010-11.

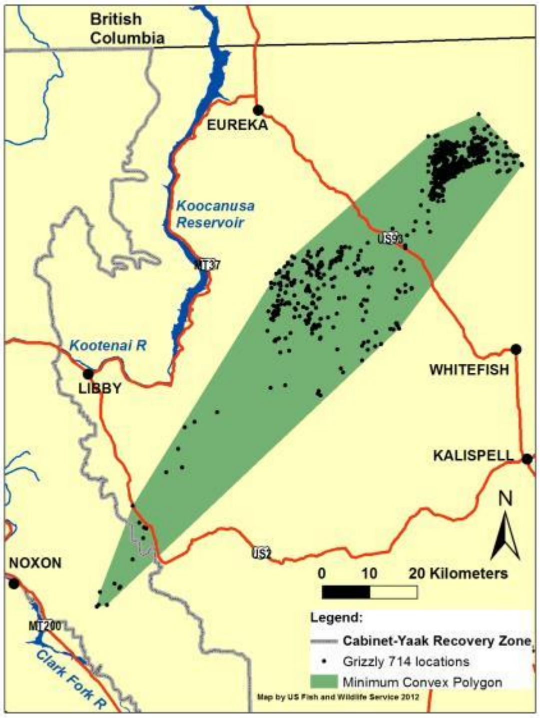


Figure A61. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 714 in the Cabinet Mountains, 2010-12.

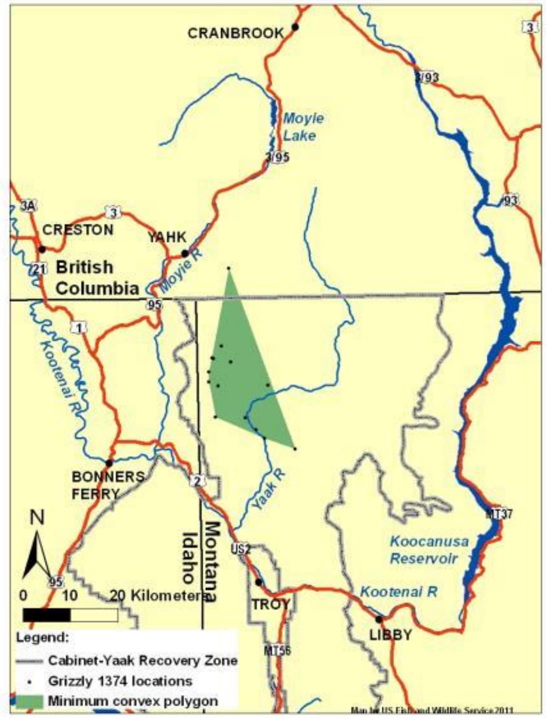


Figure A62. Radio locations and minimum convex (shaded) life range of male grizzly bear 1374 in the Yaak River, 2010.

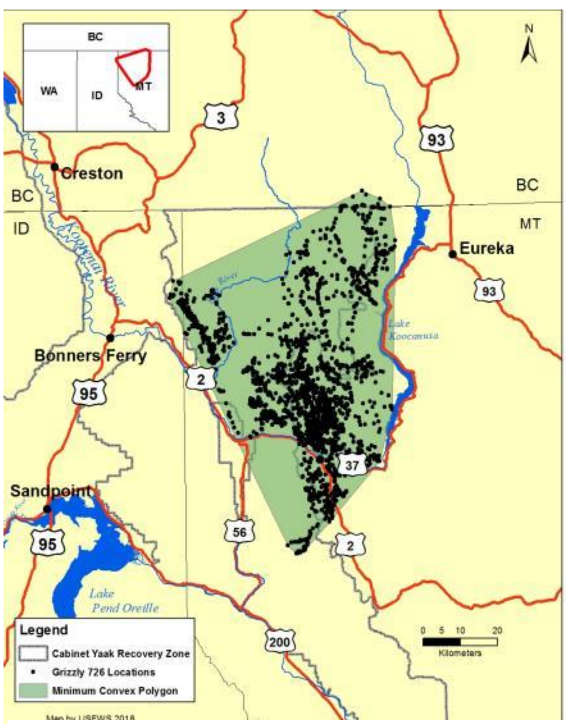


Figure A63 Radio locations and minimum convex (shaded) life range of male grizzly bear 726 in the Yaak River, 2011-12, 2015-17.

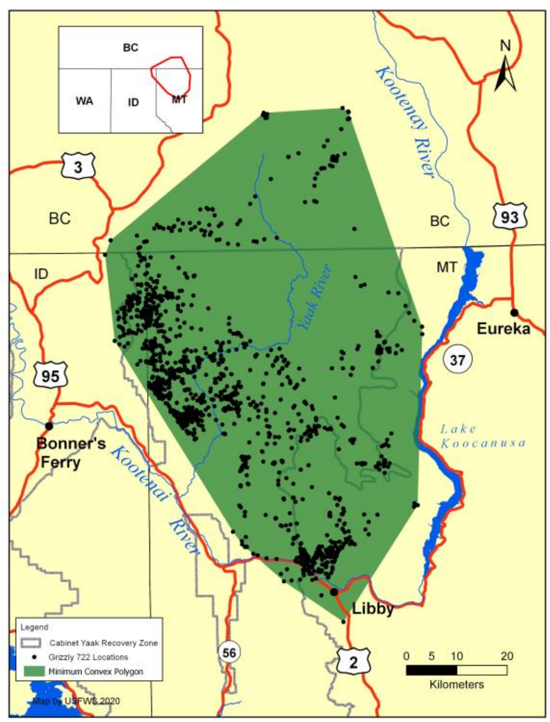


Figure A64. Radio locations and minimum convex (shaded) life range of male grizzly bear 722 in the Yaak River, 2011-12, 2014, 2016-19.

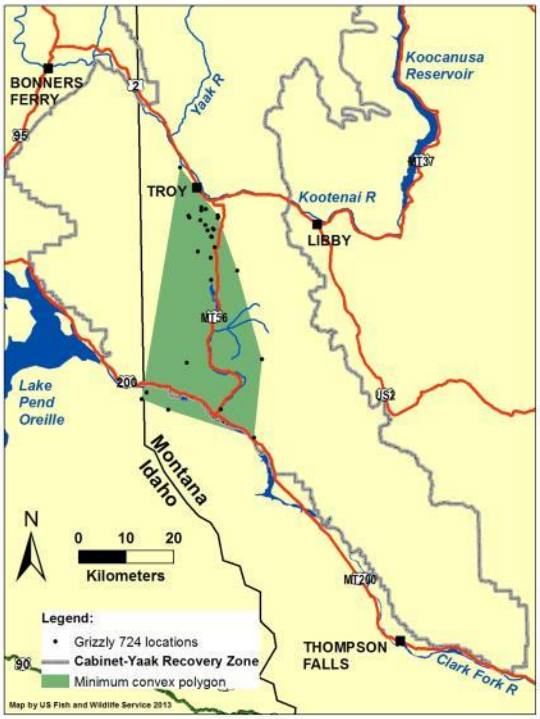


Figure A65. Radio locations and minimum convex (shaded) life range of management male grizzly bear 724 in the Cabinet Mountains, 2011-12.

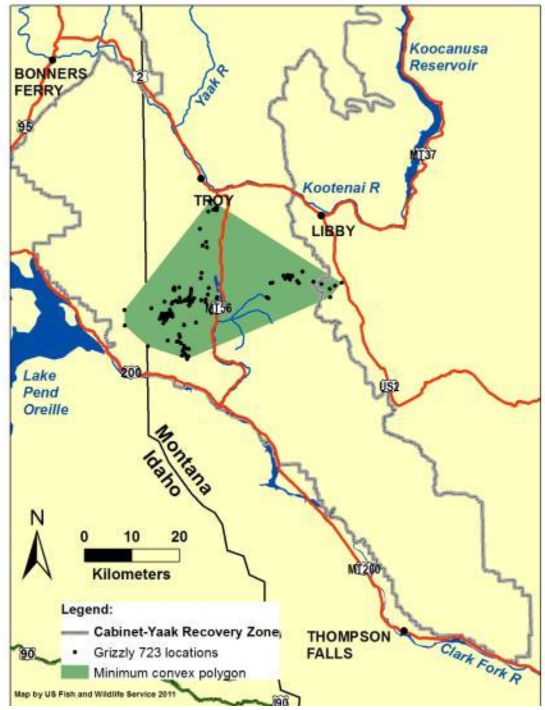


Figure A66. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 723 in the Cabinet Mountains, 2011-12.

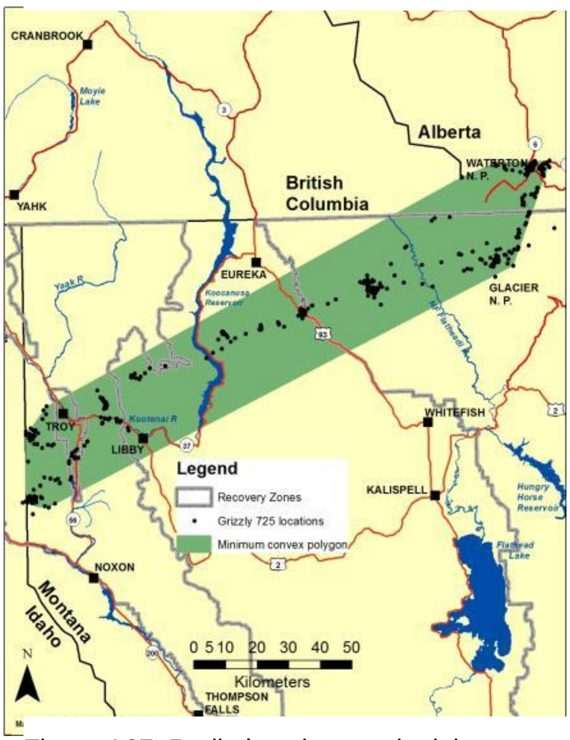


Figure A67. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 725 in the Cabinet Mountains, 2011-13.

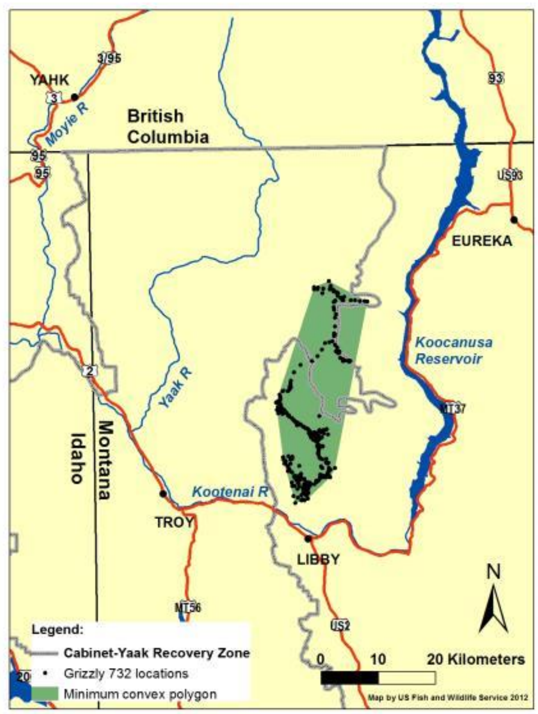


Figure A68. Radio locations and minimum convex (shaded) life range of management male grizzly bear 732 in the Yaak River, 2011.

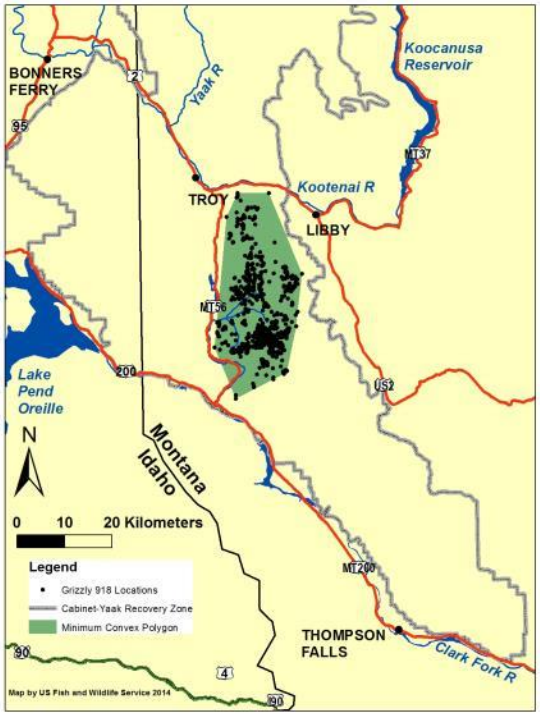


Figure A69. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 918 in the Cabinet Mountains, 2012-14.

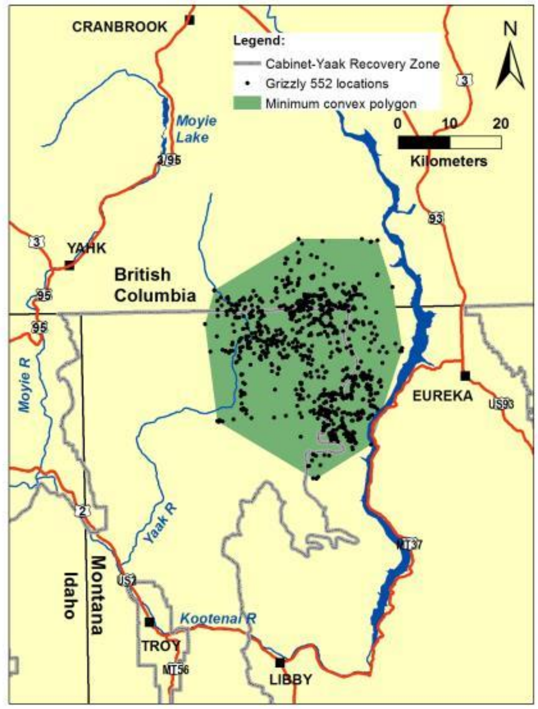


Figure A70. Radio locations and minimum convex (shaded) life range of female grizzly bear 552 in the Yaak River, 2012-15.

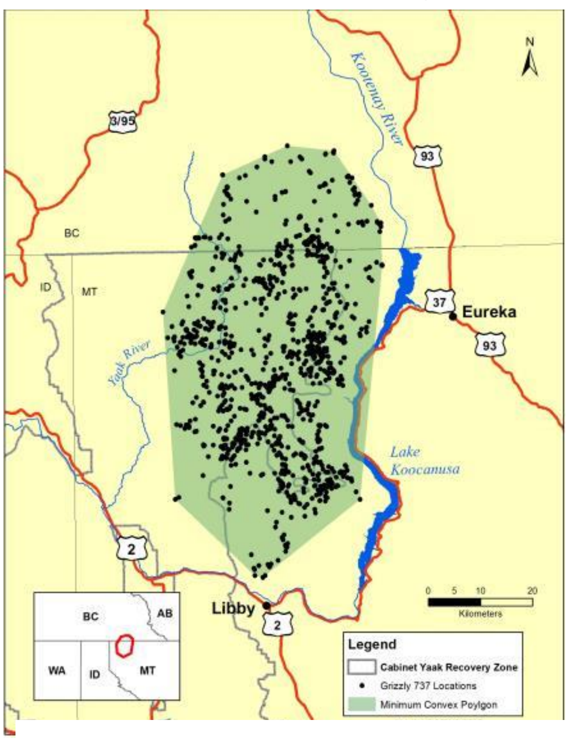
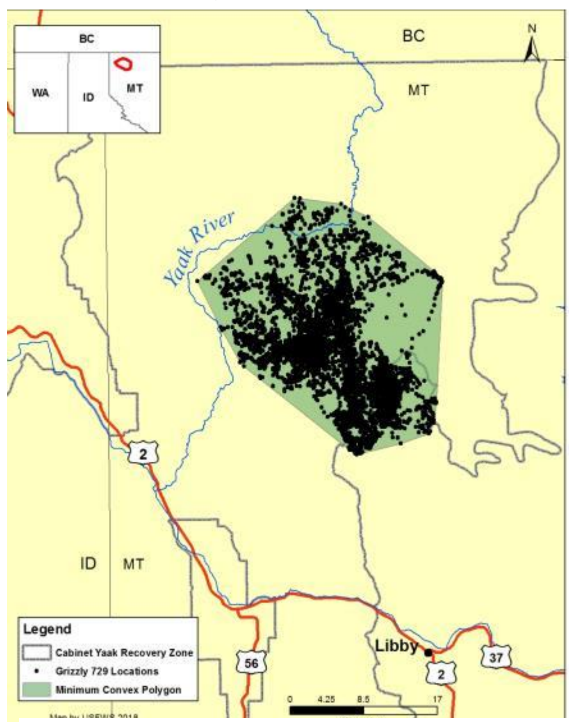


Figure A71. Radio locations and minimum convex (shaded) life range of male grizzly bear 737 in the Yaak River, 2010-13.



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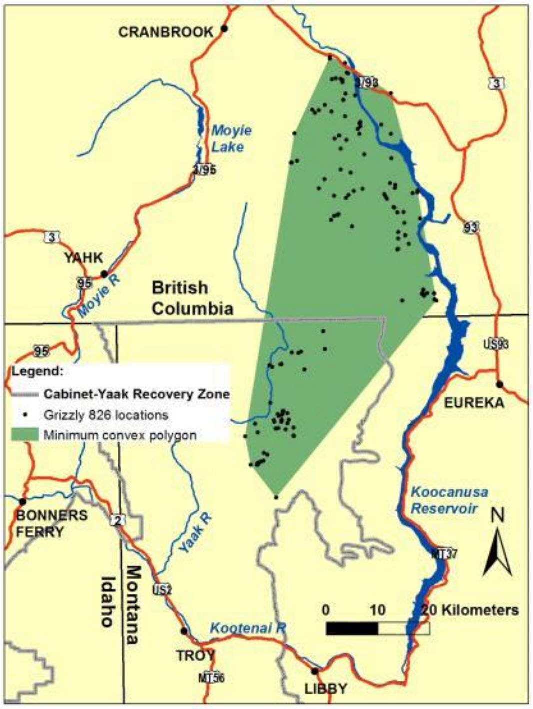

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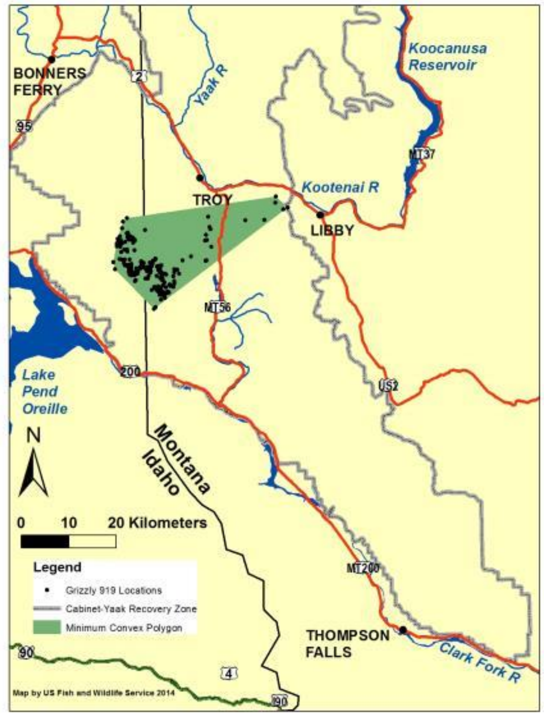

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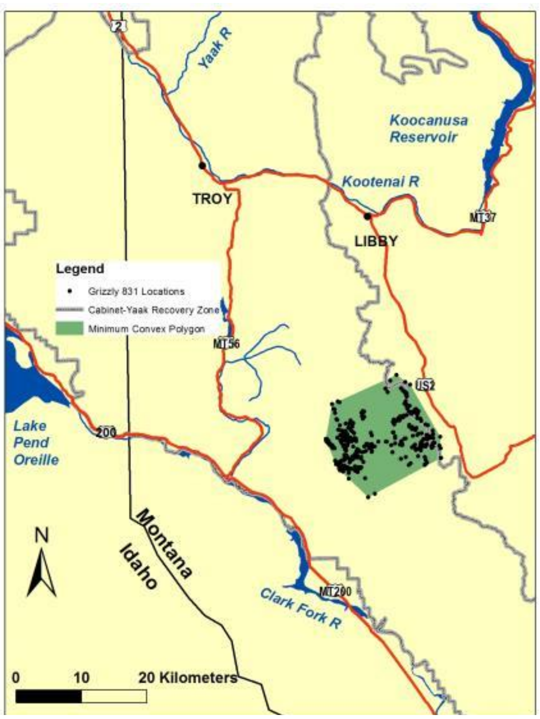

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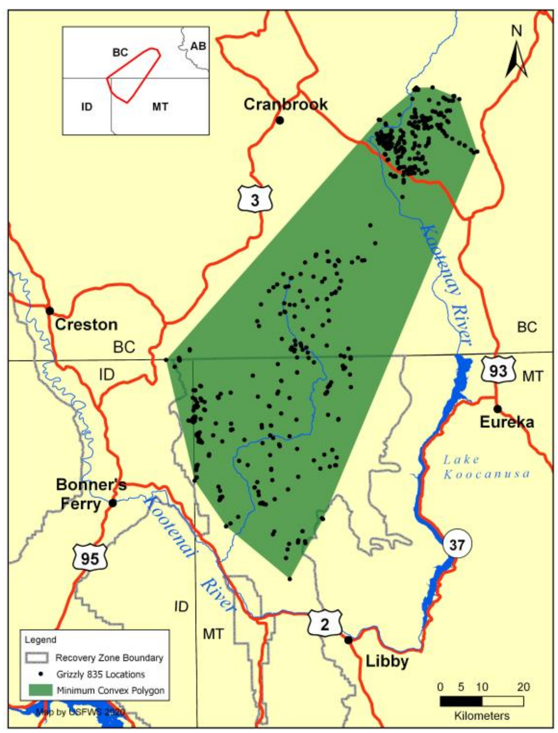
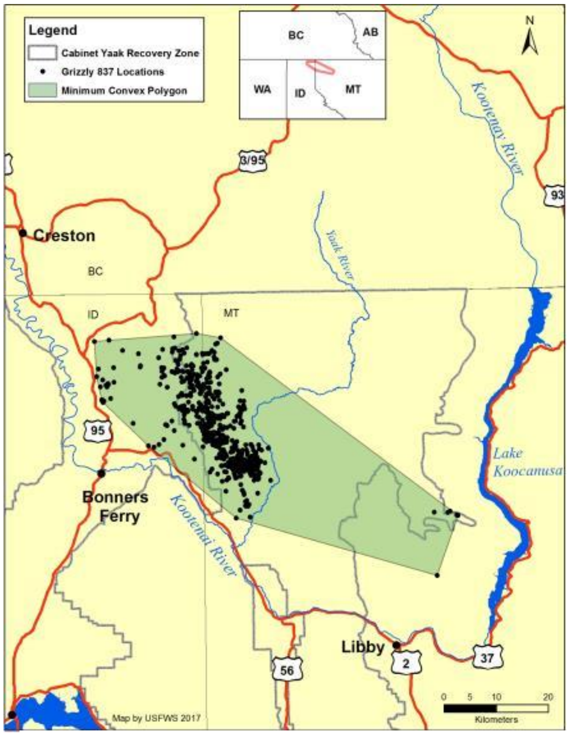


Figure A76. Radio locations and minimum convex (shaded) life range of male grizzly bear 835 in the Yaak River, 2014-16, 2019.



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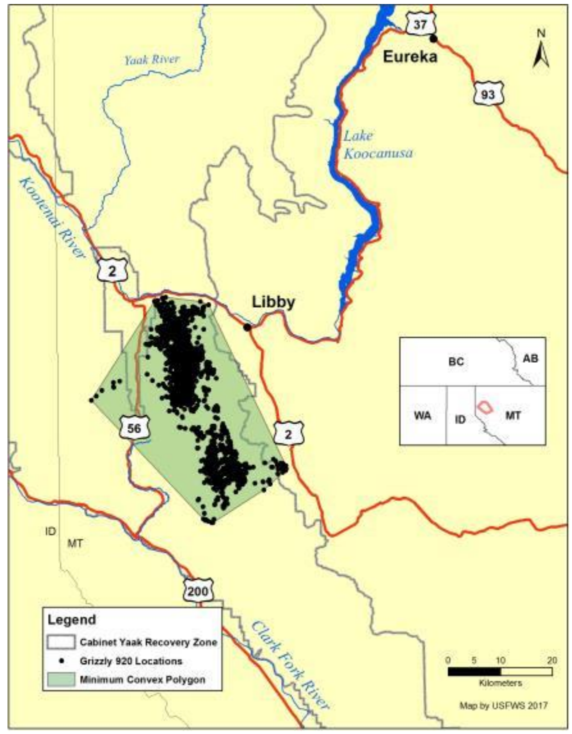

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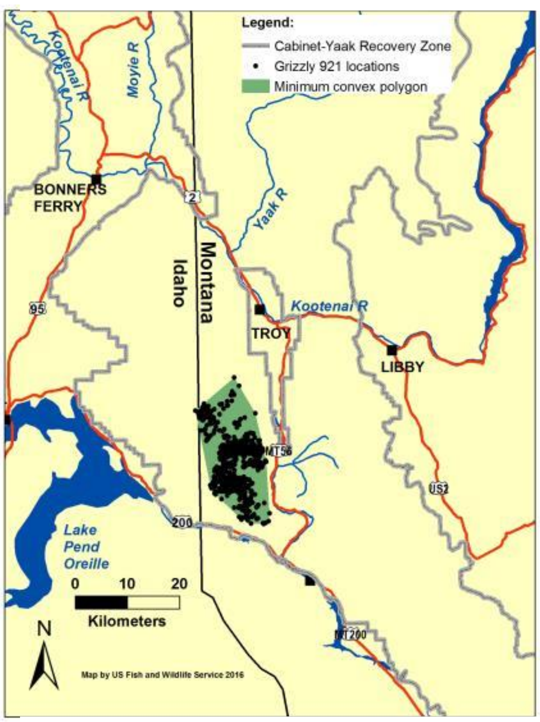

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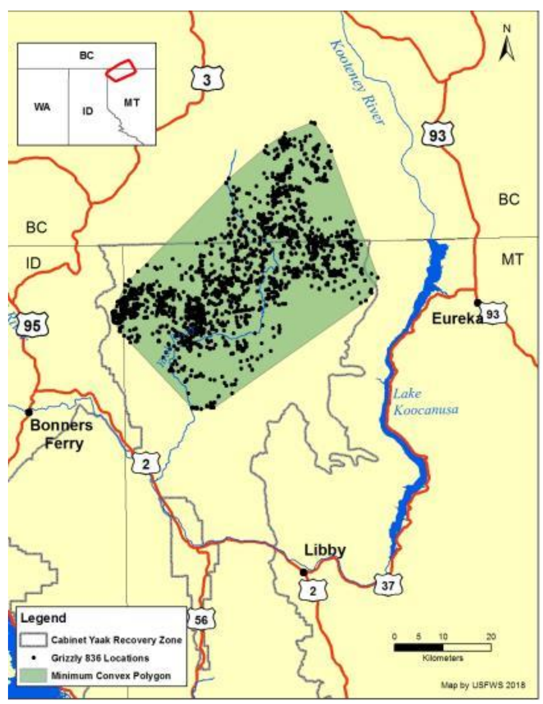

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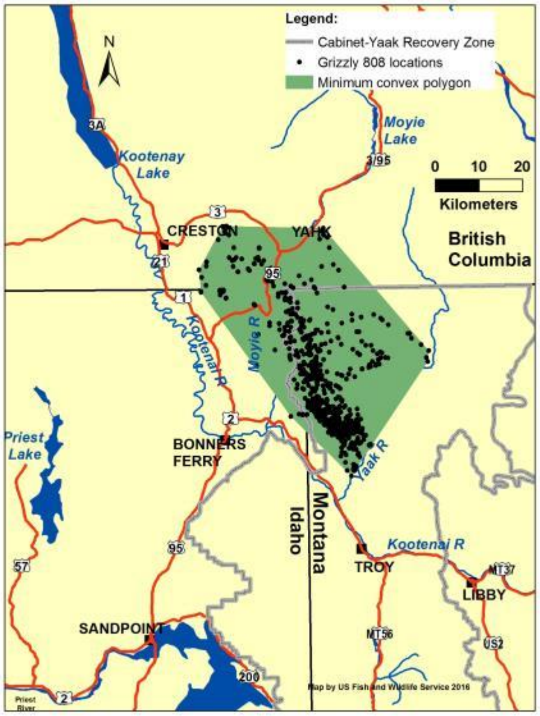

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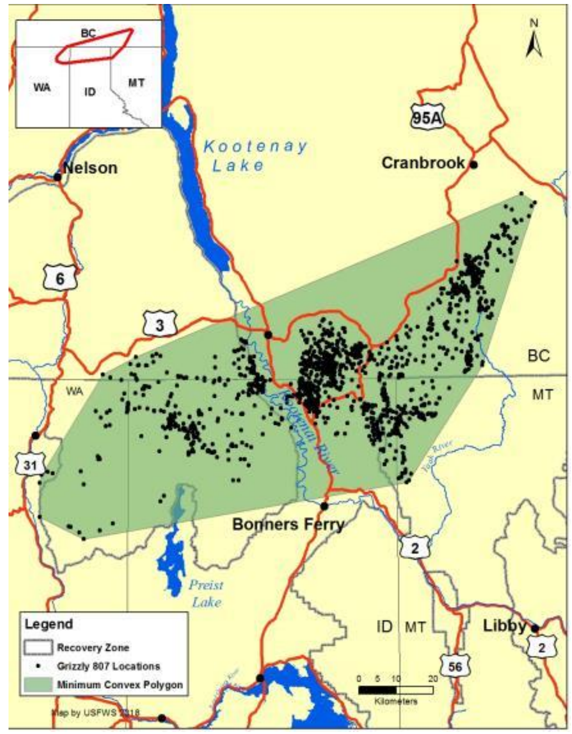
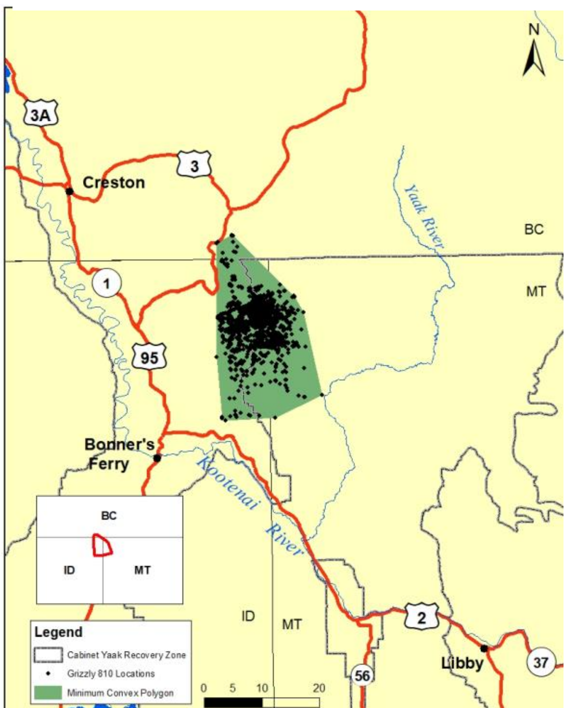


Figure A82. Radio locations and minimum convex (shaded) life range of male grizzly bear 807 in the Yaak River and Selkirk Mountains, 2014-17.



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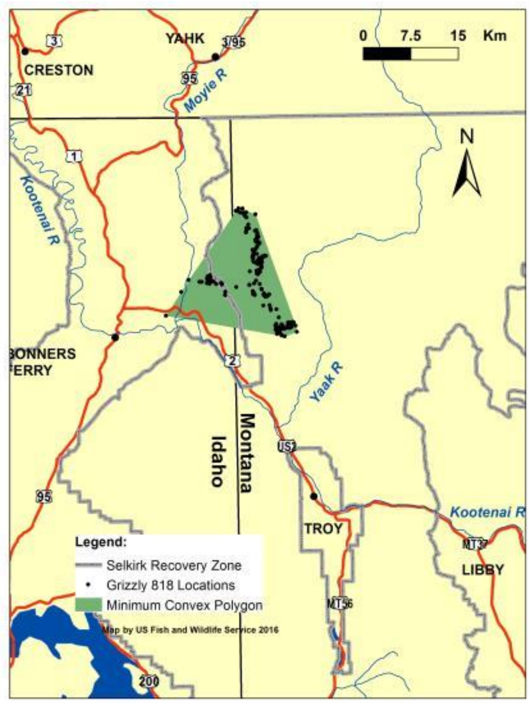

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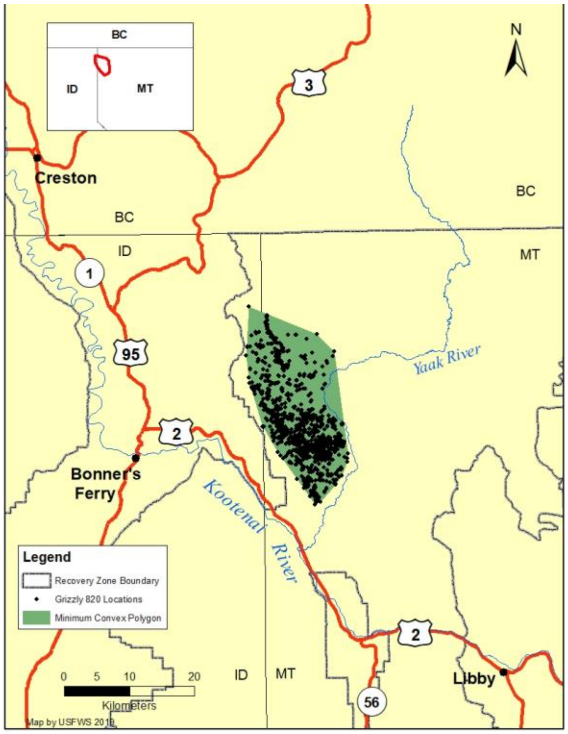

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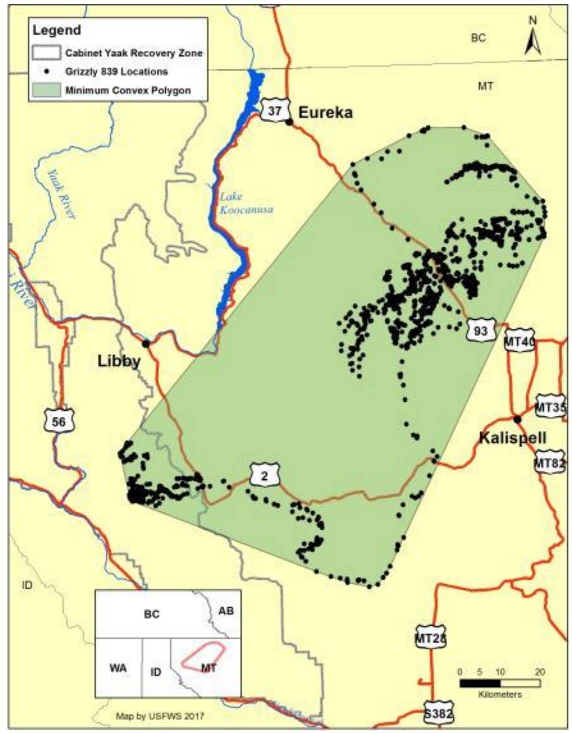


Figure A86. Radio locations and minimum convex (shaded) life range of male grizzly bear 839 in the Cabinet Mountains, 2015-16.

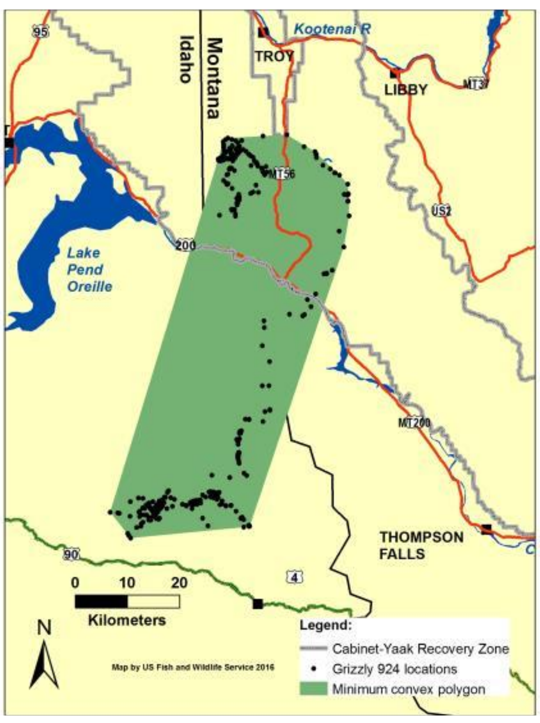


Figure A87. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 924 in the Cabinet Mountains, 2015.

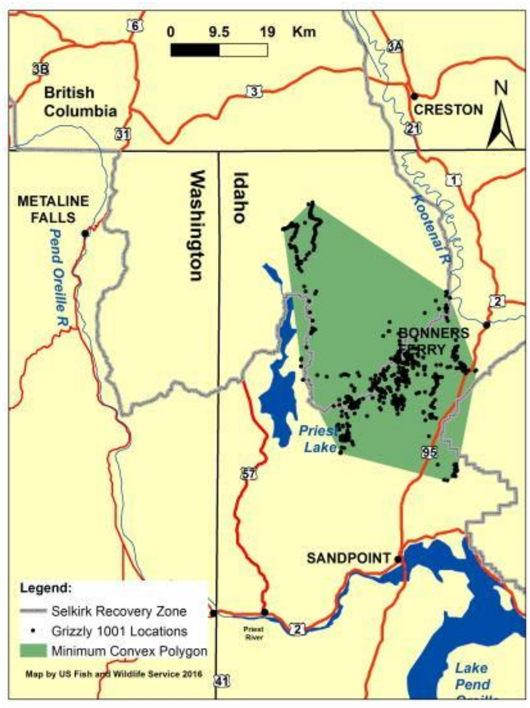


Figure A88. Radio locations and minimum convex (shaded) life range of male grizzly bear 1001 in the Selkirk and Cabinet Mountains, 2015.

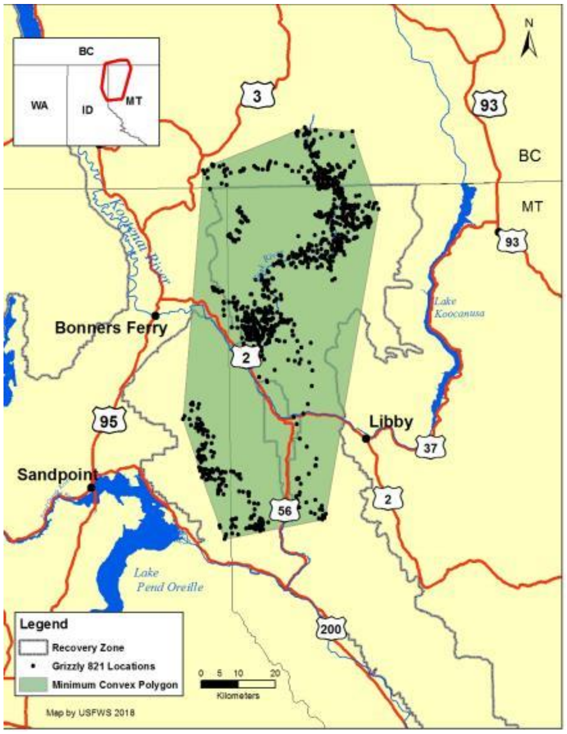


Figure A89. Radio locations and minimum convex (shaded) life range of male grizzly bear 821 in the Yaak River, 2016-17.

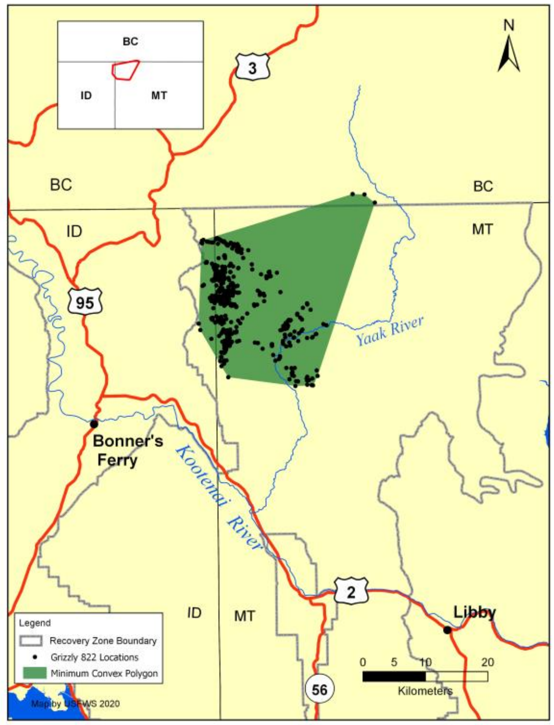
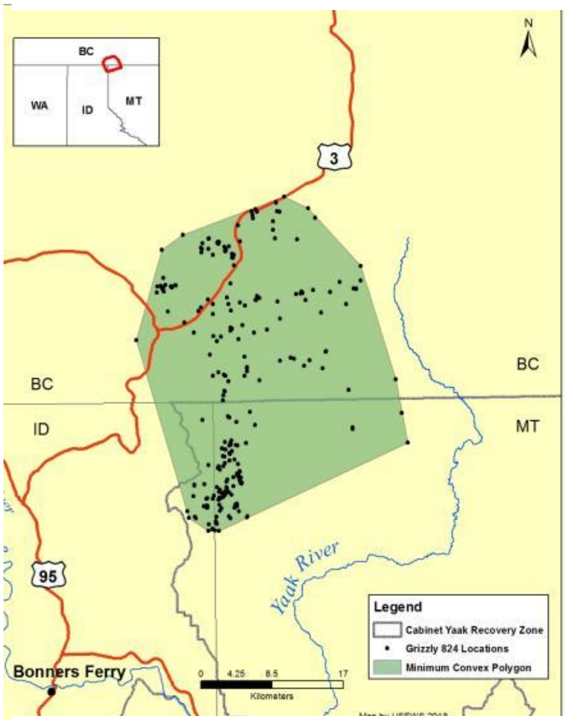


Figure A90. Radio locations and minimum convex (shaded) life range of male grizzly bear 822 in the Yaak River, 2016, 2019.



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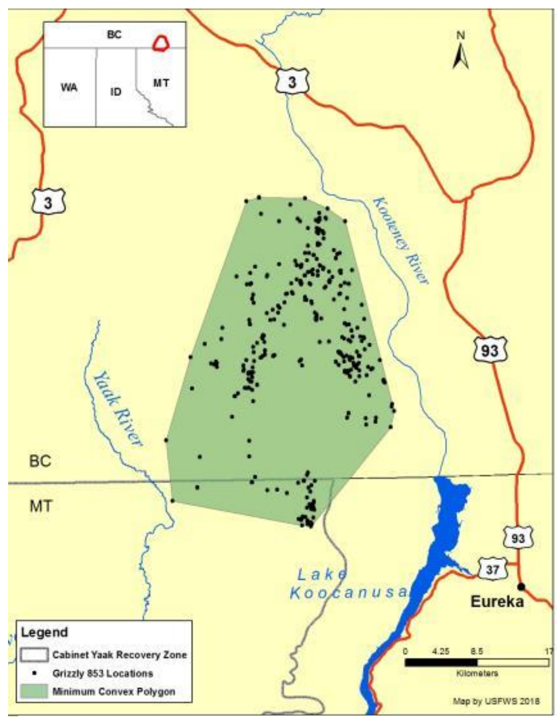


Figure A92. Radio locations and minimum convex (shaded) life range of male grizzly bear 853 in the Yaak River, 2016-17.

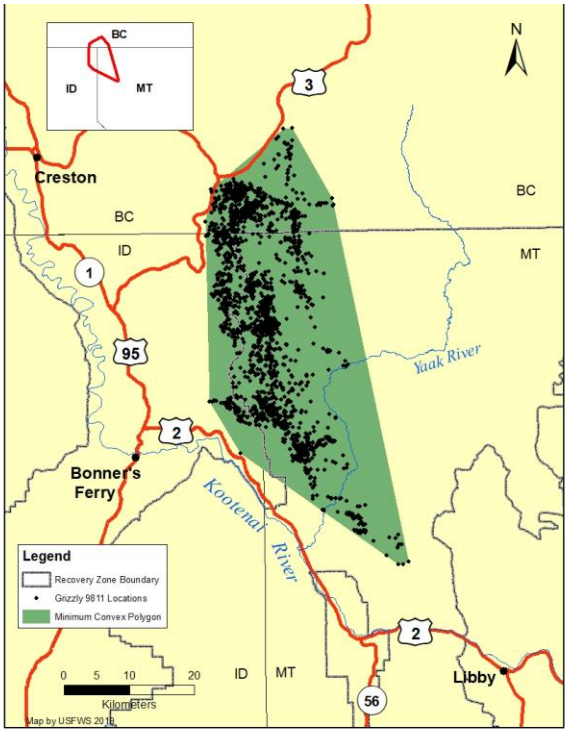


Figure A93. Radio locations and minimum convex (shaded) life range of male grizzly bear 9811 in the Yaak River, 2016-18.

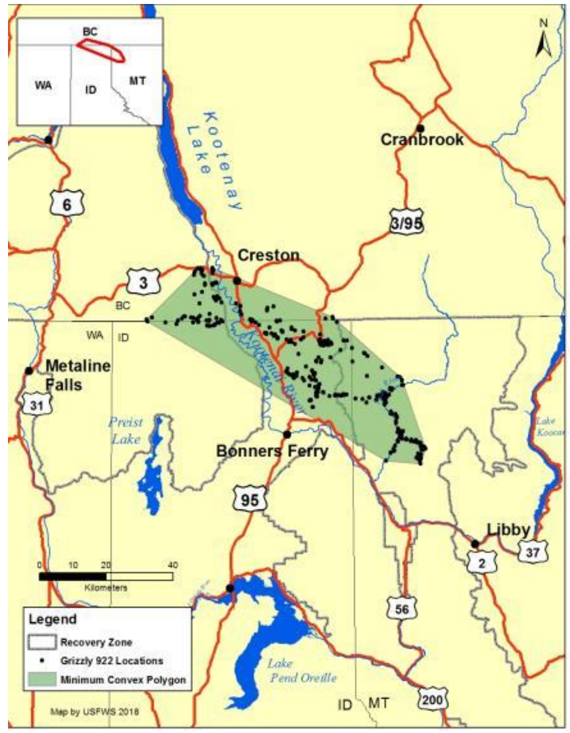


Figure A94. Radio locations and minimum convex (shaded) life range of male grizzly bear 922 in the Yaak River, 2016-17.

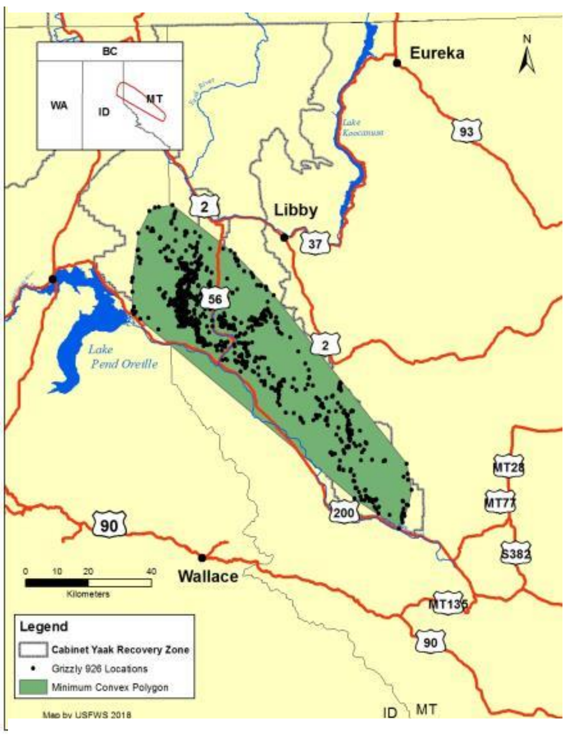


Figure A95. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 926 in the Cabinet Mountains, 2016-17.

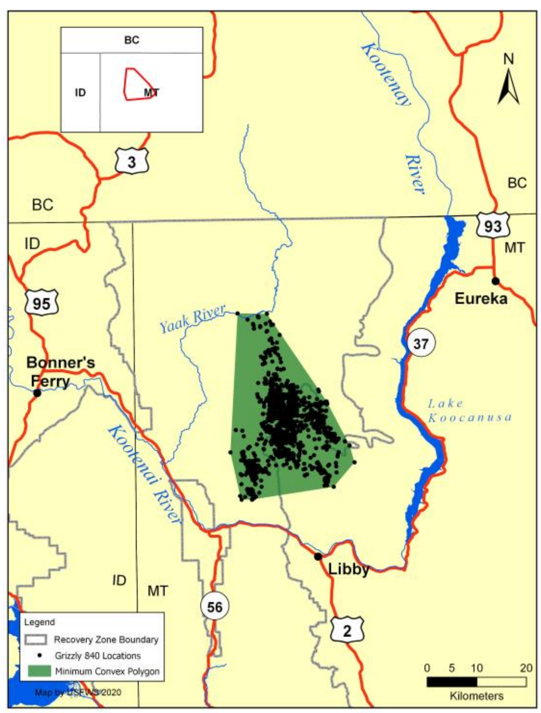


Figure A96. Radio locations and minimum convex (shaded) life range of female grizzly bear 840 in the Yaak River, 2016-19.

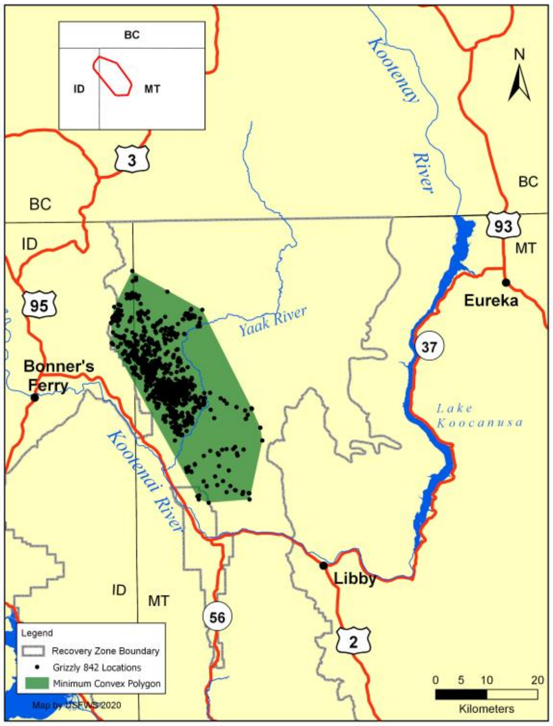


Figure A97. Radio locations and minimum convex (shaded) life range of female grizzly bear 842 in the Yaak River, 2017-19.

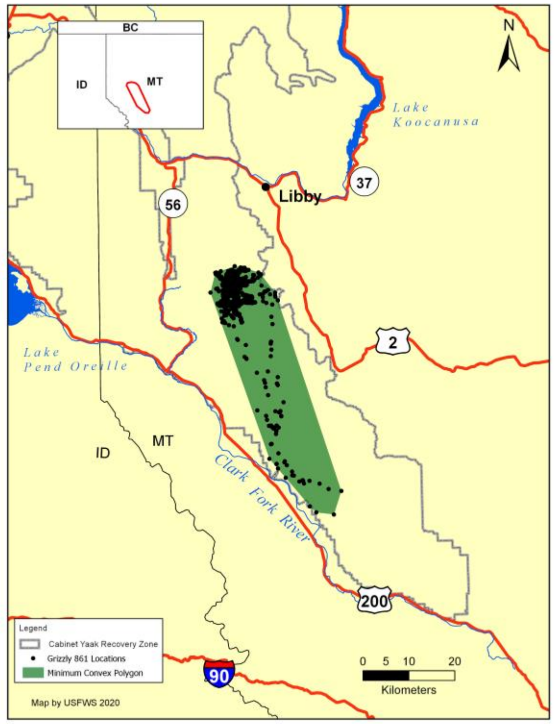


Figure A98. Radio locations and minimum convex (shaded) life range of male grizzly bear 861 in the Cabinet Mountains, 2017-19.

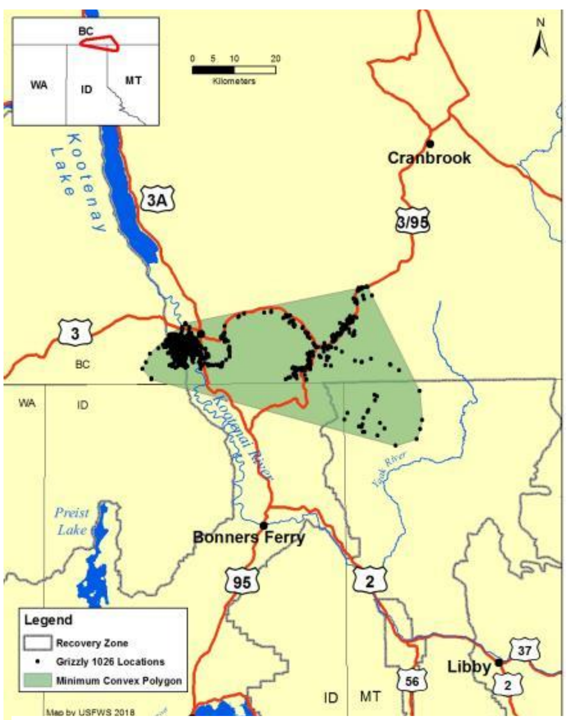


Figure A99. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1026 in the Yaak River, 2017.

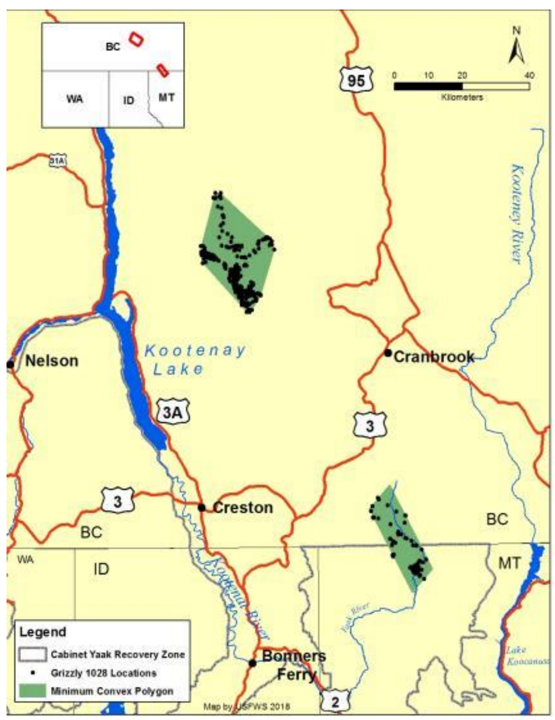


Figure A100. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1028 in the Yaak River, 2017.

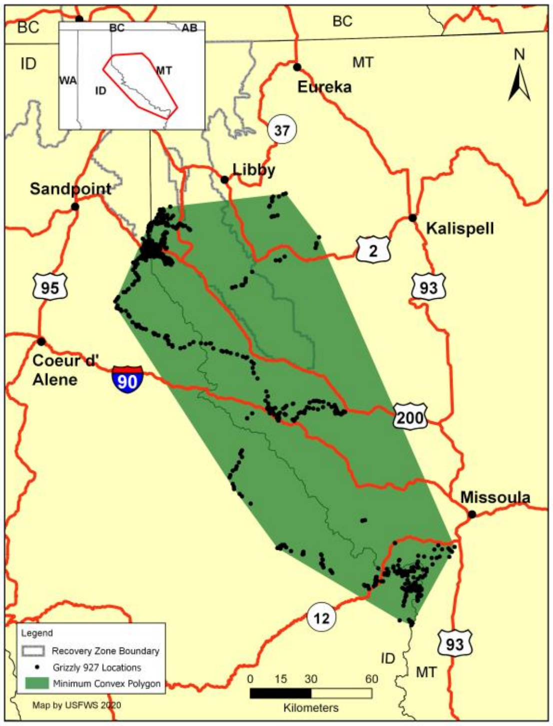


Figure A101. Radio locations and minimum convex (shaded) life range of augmentaiton male grizzly bear 927 in the Cabinet Mountains, 2018-19

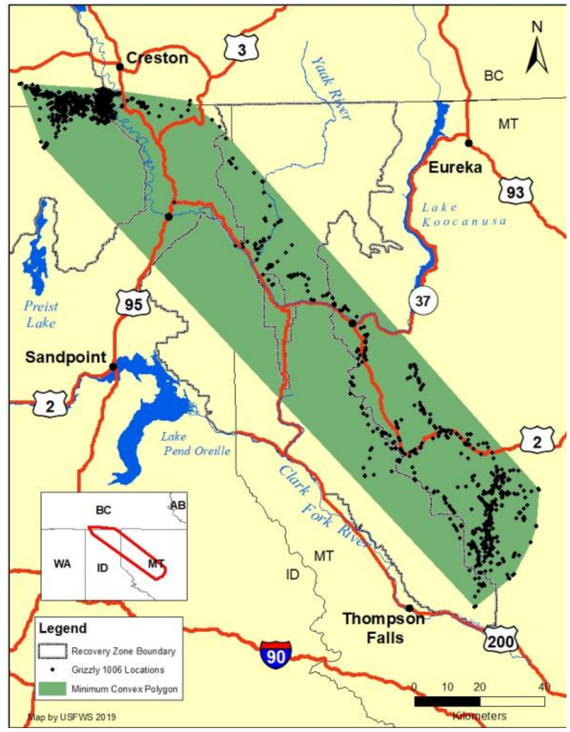


Figure A102. Radio locations and minimum convex (shaded) life range of male grizzly bear 1006 in the Selkirk, Purcell, and Cabinet Mountains, 2017-18.

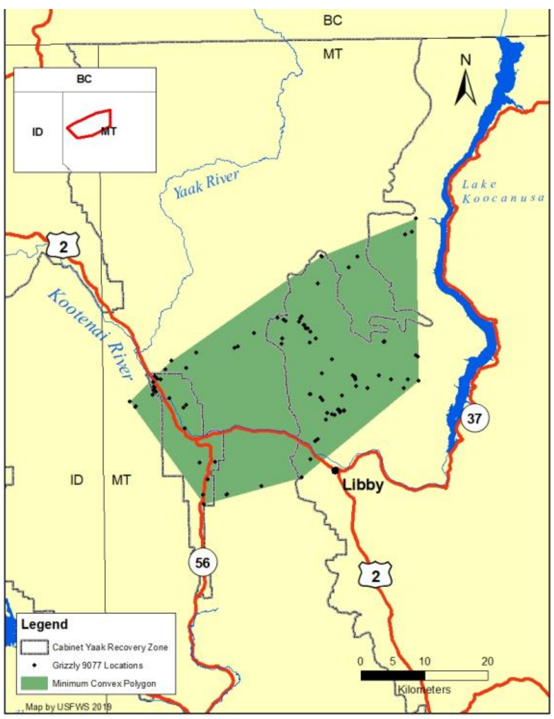


Figure A103. Radio locations and minimum convex (shaded) life range of management male grizzly bear 9077 in the Yaak River, 2018.

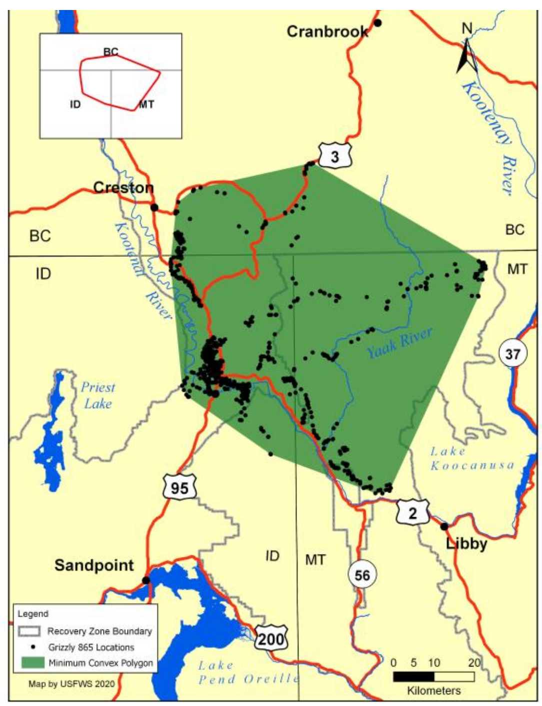


Figure A104. Radio locations and minimum convex (shaded) life range of management male grizzly bear 865 in the Kootenai and Yaak River, 2018-19.

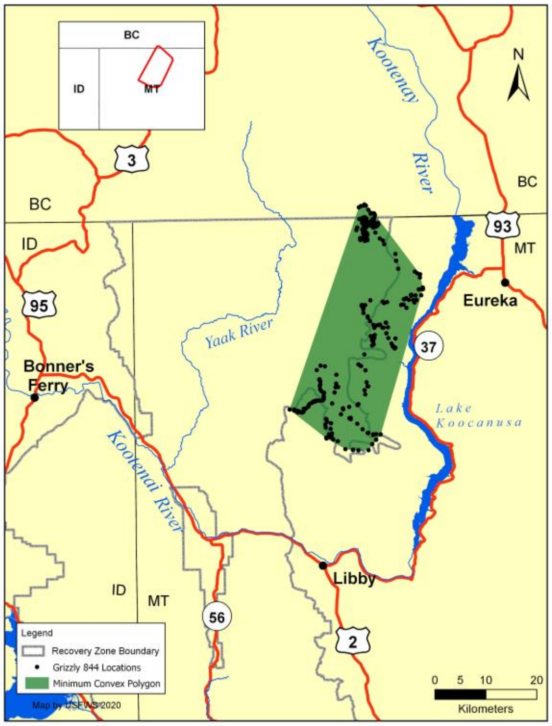


Figure A105. Radio locations and minimum convex (shaded) life range of augmentaiton male grizzly bear 844 in the Yaak River, 2019

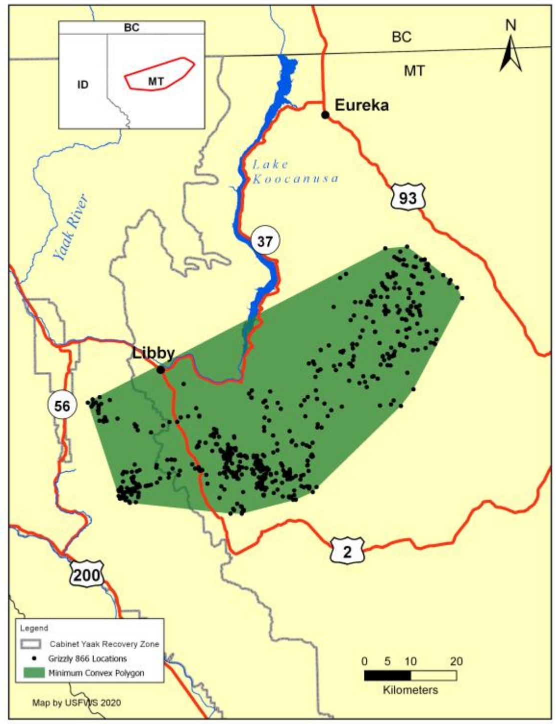


Figure A106. Radio locations and minimum convex (shaded) life range of male grizzly bear 866 in the d Cabinet Mountains, 2019.

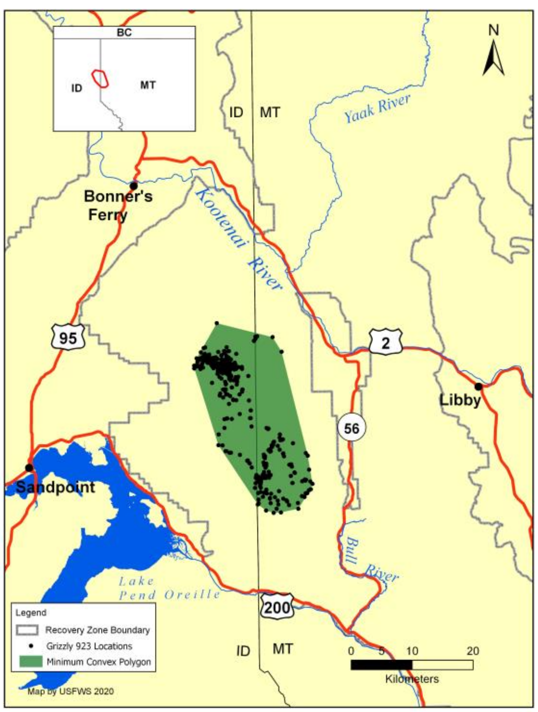


Figure A107. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 923 in the Yaak River, 2019.

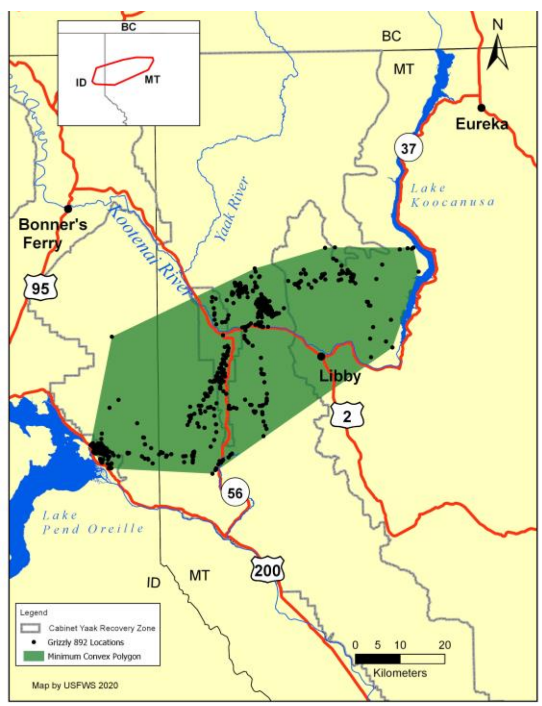


Figure A108. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 892 in the Cabinet Mountains, 2019.

APPENDIX 5 Fine scale habitat modeling for the South Selkirk and Cabinet-Yaak ecosystems

Trans-border Grizzly Bear Project and the US Fish & Wildlife Service
Michael Proctor TBGBP, & Wayne Kasworm USFWS

BACKGROUND

This document describes the methods and appropriate interpretation for fine scale habitat modeling of sex-, season- and ecosystem-specific habitat use modeling for grizzly bears. We modeled habitat use for females and males, in each of 3 seasons (spring, summer, fall) in each of 4 ecosystems, (S Purcells in Canada, the international South Selkirks and Yaak, and the US Cabinets. Here we present the female results. Females receive priority in grizzly bear conservation management because they are the reproductive engine of a population, they tend to have smaller home ranges and move significantly less than males. Management that secures important female habitat and food resources may be most efficient for conservation purposes. Males are important as well and in some instances can dominate the very best of food resources.

METHODS

We assessed habitat use for female and male bears separately at the scale of each of several ecosystems. Including the South Selkirk (international), the Yaak (international), the Cabinets (USA) and the South Purcell (north of Hwy 3 in Canada). We modelled habitat in each of the 3 non-denning seasons (Spring, den emergence – July 14; Summer berry season, July 15 - Sept 15; and Fall, Sept 16 - October 30). Methods below are very similar to those employed by Proctor et al. 2015.

Grizzly bear GPS location data

We deployed GPS-telemetry collars on 38 female grizzly bears in 2004-2015 (22 in the international S Selkirks, 10 in the International Yaak and 6 in the Canadian South Purcells). Bears were captured with Aldrich foot snares and occasionally with culvert traps. We used Telonics Inc. (Mesa, Arizona, USA) Spread Spectrum radio-collars (and occasionally store-on-board collars) and remotely downloaded bear locations on a periodic basis.

Most bears were collared in May or June and were monitored for 1-3 years but usually monitoring spanned at least 2 non-denning periods (i.e., spring summer, fall). Locations were attempted every 1-4 hours depending on collar size (smaller bears carried smaller collars with less battery life), and age of bears (subadult bears carried collars designed to drop off earlier so as to not interfere with neck growth). Because we used only 2D and 3D fixes, overall fix success (the proportion of 2D and 3D fixes relative to fix attempts) was 84%. We also assessed potential location bias for canopy closure, which was the variable with the most potential for low fix success rate (Frair et al. 2004). We placed 13 GPS radio collars at ground level in conifer forest with canopy cover from 0 to 75% canopy and found no relationship between fix rate and canopy closure ($R^2 = 0.07$; regression significance, $P = 0.64$).

Because unequal observations among animals can lead to biased population level estimates (Gillies et al. 2006) and most bears had 1500-2000 locations, we used a maximum of 1600 locations from most bears by removing every n^{th} location from any one bear with > 1600 locations.

Grizzly Bear Habitat Modeling

Female grizzly bear GPS telemetry data were divided into 2 groups for each season and ecosystem. An 80% random sample was used for model training, while the remaining 20% random samples of bear locations were withheld for model evaluation (Boyce et al. 2002, Nielsen et al. 2002). We used the GPS telemetry locations and a similar number of available (random) locations from within the composite home ranges of all grizzly bears to develop a resource selection function (RSF, Boyce and McDonald 1999, Manly et al. 2002, Nielsen et al. 2002). We estimated the parameters of the exponential RSF using logistic regression (Manly et al. 2002) and predictions from the RSF were transformed using the logistic function to normalize the right skewing of exponential RSF values and then mapped at a 100-m scale in ArcGIS 10.1 (ESRI, Redlands, CA). Logistic regression was performed using the statistical software package STATA (Intercooled 9.2, College Station, Texas, USA).

Model building was based on the principles of Hosmer and Lemeshow (1989) and more recently referred to as purposeful selection of variables (Bursac et al. 2008). We did not use an Information Theoretic approach (Burhnam and Anderson 1998) because our goal was predictive ability of grizzly bear habitat use and not testing of broader competing hypotheses (Nielsen et al. 2010). All predictor variables were tested for pairwise correlations (Chatterjee et al. 2000) and only terrain ruggedness and compound topographic index were correlated. All variables and their quadratic relationships were fit individually (uni-variable analyses) and ranked for their significance and explanatory power (pseudo R^2). Multi-variable models were then built by adding non-correlated variables in a forward step-wise fashion starting from higher to lower pseudo R^2. Models were compared sequentially after each variable addition; variable significance and explanatory power (pseudo R^2) were used to compare models and decide if a variable improved model predictability. When a variable increased the pseudo R^2 by at least 5%, we retained that variable in the model; when a variable increased the pseudo R^2 < 5% we did not retain it to favor a parsimonious model.

We used the Huber-White sandwich estimator in the robust cluster option in Stata to calculate standard errors because non-independent locations can lead to biased standard errors and overestimated significance of model parameters (White 1980; Nielsen et al. 2002, 2004b). Because the bears were the unit of replication, they were used to denote the cluster thus avoiding autocorrelation and/or pseudoreplication of locations within individual bears. We assessed the Receiver Operator Characteristic (ROC), a standard technique for summarizing classifier performance (i.e. how well did the model predict habitat and non-habitat correctly) for our most parsimonious models.

Environmental Variables

We used variables that were most consistently measured across the study area and between Canada and the USA including human-use, terrain, forest cover, and other ecological variables (Table 1). Ecosystem characteristics and human uses in the adjacent south Selkirk and south Purcell Mountains are similar (Meidinger and Pojar 1991) allowing development and prediction of models to these areas. Lowlands are dominated by Cedar-Hemlock (*Thuja plicata - Tsuga heterophylla*) forests and upland forests are dominated by Engelmann Spruce - Sub Alpine Fir (*Picea engelmanni – Abies lasiocarpa*). Douglas fir (*Psuedotsuga mensiezii*) forests are somewhat more common in the southern portions of the Purcell range (Meidinger and Pojar 1991). Human uses are relatively similar across the region and include timber harvest, some mining, ungulate hunting, and other forms of recreation.

Baseline Thematic Mapping land-cover variables (recently logged, alpine, avalanche, and riparian), Vegetation Resource Inventory variables (dominant tree species forest cover types, canopy cover), and backcountry resource roads (i.e., associated with timber harvest, mining) were obtained from the BC Ministry of Forests, Lands, and Natural Resource Operations in Canada. Land-cover information for the USA was from the US Forest Service. Alpine, avalanche, burned, and riparian habitats contain a variety of grizzly bear food resources (Mace et al. 1996, McLellan and Hovey 1995, McLellan and Hovey 2001b). Forest cover variables (Table 1) were used because they often have been found to influence grizzly bear habitat selection (Zager et al. 1983, Waller and Mace 1997, Apps et al. 2004, Nielsen et al. 2004a). Greenness, an index of leafy green productivity, correlates with a diverse set of bear food resources and is often found to be a good predictor of grizzly bear habitat use (Mace et al. 1996, Nielsen et al. 2002). Greenness was derived from 2005 Landsat imagery using a Tassled Cap transformation (Crist and Ciccone 1984, Manley et al. 1992). Terrain variables of elevation, compound topographic index (CTI), solar radiation, and terrain ruggedness were derived from a digital elevation model (DEM) in ArcGIS. CTI is an index of soil wetness estimated from a DEM in a GIS using the script from Rho (2002). Solar radiation was estimated for the summer solstice (day 172), again using a DEM, and in this case the ArcInfo AML from Kumar (1997) that was modified by Zimmerman (2000) called shortwavc.aml. Finally, terrain ruggedness was estimated from the DEM based on methods from Riley et al. (1999) and scripted as an ArcInfo AML called TRI.aml (terrain ruggedness index) by Evans (2004). These terrain variables have been shown to influence the distribution of grizzly bear foods (Apps et al. 2004, Nielsen et al. 2004a, 2010) and also affect local human use. We included elevation as a variable because grizzly bears in our region use high country extensively, which may be for a variety of reasons (e.g., high elevation habitat types, thinner forest cover with more edible ground-based vegetation, human avoidance). Highway and human developments were digitized from 1:50,000 topographic maps and ortho-photos. Highway, human developments, and backcountry roads were buffered by 500 m on either side to reflect their influence on grizzly bear habitat use (Mace et al. 1996). The human-use variables have been demonstrated repeatedly to correlate with habitat selection by grizzly bears (Mace et al. 1996, 1999, Nielsen et al. 2002, Apps et al. 2004). Although none of the predictors were direct measures of food resources or human activities, each factor was thought to correlate with resources and behaviors used by bears or activity of humans (Mace et al. 1996, Nielsen et al. 2002, 2006, 2009, Apps et al. 2004).

RESULTS

Best models for each season and ecosystem were dominated by greater than expected use for canopy openness and high level of greenness and less than expected use of high road densities (Table 1). Model predictive ability was greatest in the International South Selkirk area in all 3 seasons, as predictions of habitat use and non-use were all > 0.8 (ROC, Receiver Operator Characteristic measures how well the model predicts habitat use (GPS Locations that were in model predicted use areas vs non-used areas). Because we had very few resident females in the Cabinet population, most were augmented bears from the Rocky Mt region, and the ecology is similar to the S Selkirk region (Proctor et al. 2015), we applied our South Selkirk model to the Cabinet area. These models are similar to the all-season both-sex Resource Selection Function model derived to predict linkage habitat within Proctor et al. (2015). That model was dominated by canopy openness, greenness, riparian, alpine, and elevation.

In the S Selkirk, S Purcell, and Cabinet area, our models were the most predictive with ROC scores usually > 0.75 and even > 0.80 (0.7 is considered a good predictive model). Models for the international Yaak were less predictive, especially in spring and fall (ROC scores were 0.66 and 0.59 respectively).

Where we had a huckleberry patch model available in the South Purcell area of Canada, it dominated the model along with greenness. We have a huckleberry patch model throughout this region within Canada. Therefore we did not include it in international models in the S Selkirk, Yaak, or Cabinet areas. Canopy openness is a powerful predictor of huckleberry patches and in models without huckleberry patches, canopy openness plays a similar predictive role.

DISCUSSION

We envision the usefulness of these habitat models for planning timber harvest, road building, road closing, road decommissioning, and prescribed burns. As canopy openness and greenness are two of the better predictors of female habitat use (Mace et al. 1996, Nielsen et al. 2002), certain timber harvest and prescribed burning practices may have some potential to improve grizzly bear habitat through opening canopy and promoting deciduous and herbaceous bear foods. In contrast, it might be desirable to plan access controls in areas where habitat quality and use is high, to provide security for female grizzly bears. In that regard, these models may be used to decide where roads might be closed, decommissioned, or left open.

It must also be kept in mind that grizzly bear habitat is dynamic spatially and temporally. Some open-canopy habitats that resulted from past timber harvest may change over time as those canopies fill in with forest regrowth. The same applies to habitat created from past burns. Also, some habitat may have a longer-term state of canopy openness (some higher elevation forests) that may remain desirable over longer time periods. Foresters' on-the-ground knowledge may be able to differentiate these types of habitats and their dynamic potential. Future iterations of these models can be run with updated canopy cover and greenness layers as they are derived from remote sensing.

Note that Riparian habitat was a strong predictor in the South Selkirk (and Cabinet) model. This result was driven by the heavy use of female grizzly bears in the Kootenay River Valley just north of the Canada-US border in the Creston Valley in all 3 seasons. If populations continue to grow, the Kootenay River Valley or other main river valleys may see some increased habitat use by female grizzly bears at least seasonally within the US. We also think that the bears in the Creston Valley are getting a measure of agricultural foods that might be holding them in the valley even in the summer. In Canada and the U.S., there are developing programs to secure many of these agricultural products from the bears, but it may never all be secured and there will tend to be some bears spending time in these valley bottoms. On the other hand, this is somewhat desirable from the standpoint of female connectivity between the Selkirk and Purcell and Cabinet ranges (Proctor et al. 2012, 2015). Subadult female dispersal is usually of a short distance (McLellan and Hovey 2001, Proctor et al. 2004) so for female connectivity to develop, it is likely necessary that female grizzly bears spend a portion of their lives in valley bottoms. Conflict reduction efforts become especially important in that regard.

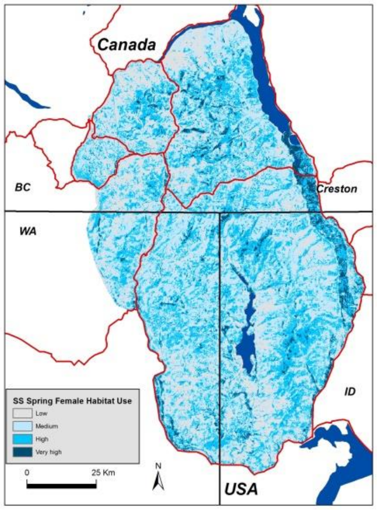
As we modeled each ecosystem separately, thresholds between ecosystems varied. Model outputs have ecosystem-specific thresholds for greater than expected use of specific habitats vs less than expected use built in. For most planning we would expect use of the summer models or occasionally the spring models. Fall modeling probably represents a time when berry feeding has passed and bears may be preparing for denning by looking for protein in the form of wounded animals and gut piles from hunters.

Table 1. Best female grizzly bear seasonal habitat use models for the Selkirk, S Purcell, Yaak, and Cabinet ecosystems. Huckleberry patch models were only available in the S Purcell area.

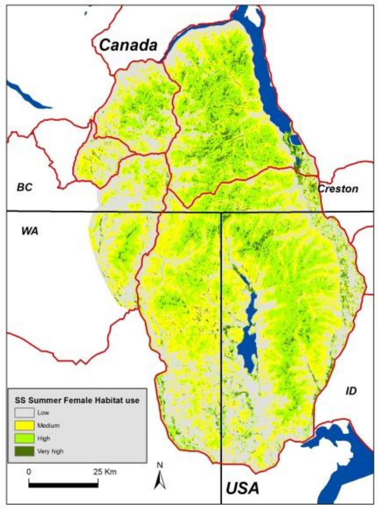
VARIABLES	Female Selkirk Spring	Female Selkirk Summer	Female Selkirk Fall	Female Yaak Spring	Female Yaak Summer	Female Yaak Fall	Female Cabinet Spring	Female Cabinet Summer	Female Cabinet Fall	Female Purcell Spring	Female Purcell Summer	Female Purcell Fall	Female Canada Spring	Female Canada Summer	Female Canada Fall
canopy cover	-	+	+	-	+	+	-	+	+	+			-		
canopy cover^2		-	-		-	-		-	-						
greenness	+	+	+		+		+	+	+	+	+	+	+	+	+
road density	-	-	-	-			-	-	-				-	-	-
riparian	+	+	+				+	+	+					+	
forest age 100-250											-	-			
forest age 1-20					+										
forest age 20-60						-									
forest age 60-80											+				
alpine					+	+						+		+	+
avalanche	+						+						+		
deciduous forest				+	+	+				+					
elevation		+	+	+	+			+	+						
elevation^2			-	-	-				-						
Douglas fir forest			-	+					-						-
distance to road											+				
buildings				-	-										
distance to HuckPatch											-			-	-
HuckPatch X Dist2Road															+
highway			-			-			-						-
mortality risk				-								-			+
recently logged			-						-		-	-			
solar radiation										+		+			
terrain ruggedness										+				-	-
Pseudo R2	0.20	0.25	0.26	0.06	0.18	0.03	0.20	0.25	0.26	0.20	0.32	0.11	0.13	0.25	0.15
ROC AUC	0.80	0.82	0.83	0.66	0.78	0.59	0.80	0.82	0.83	0.79	0.86	0.73	0.75	0.82	0.80
Correct classified	73%	74%	80%	61%	70%	56%	73%	74%	80%	72%	78%	65%	74%	75%	76%

Figure 1a) Spring, b) Summer, & c) Fall female grizzly bear Habitat Use map.

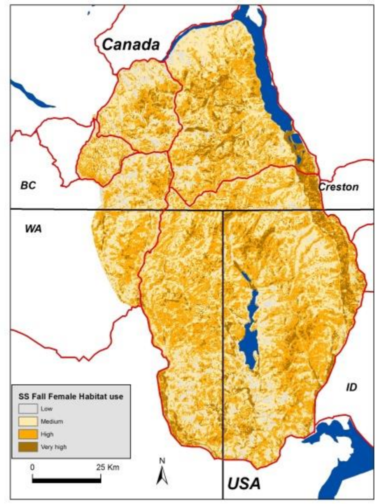
a S Selkirks Spring



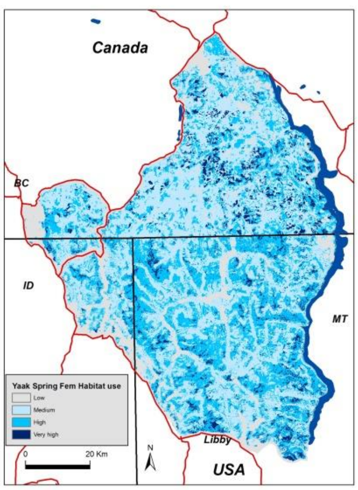
b S Selkirks Summer



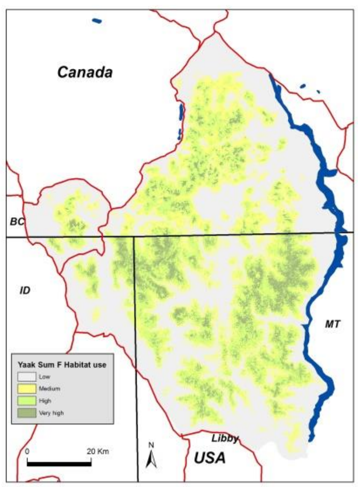
c S Selkirks Fall



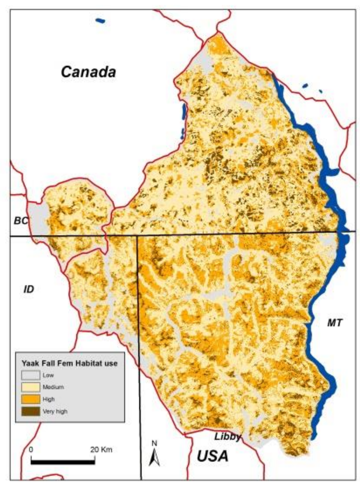
a Yaak Spring



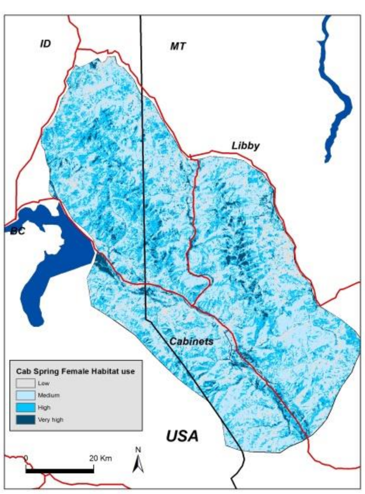
b Yaak Summer



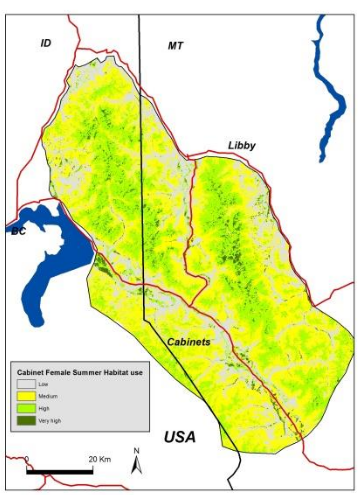
c Yaak Fall



a Cabinets Spring



b Cabinets Summer



c Cabinets Fall

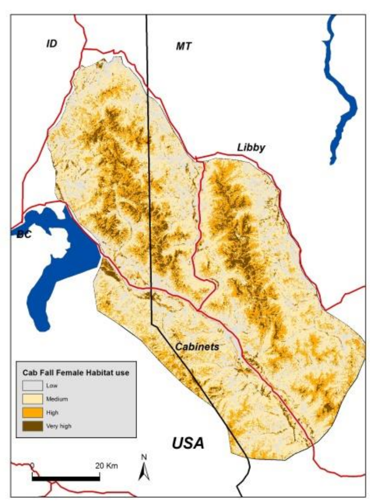
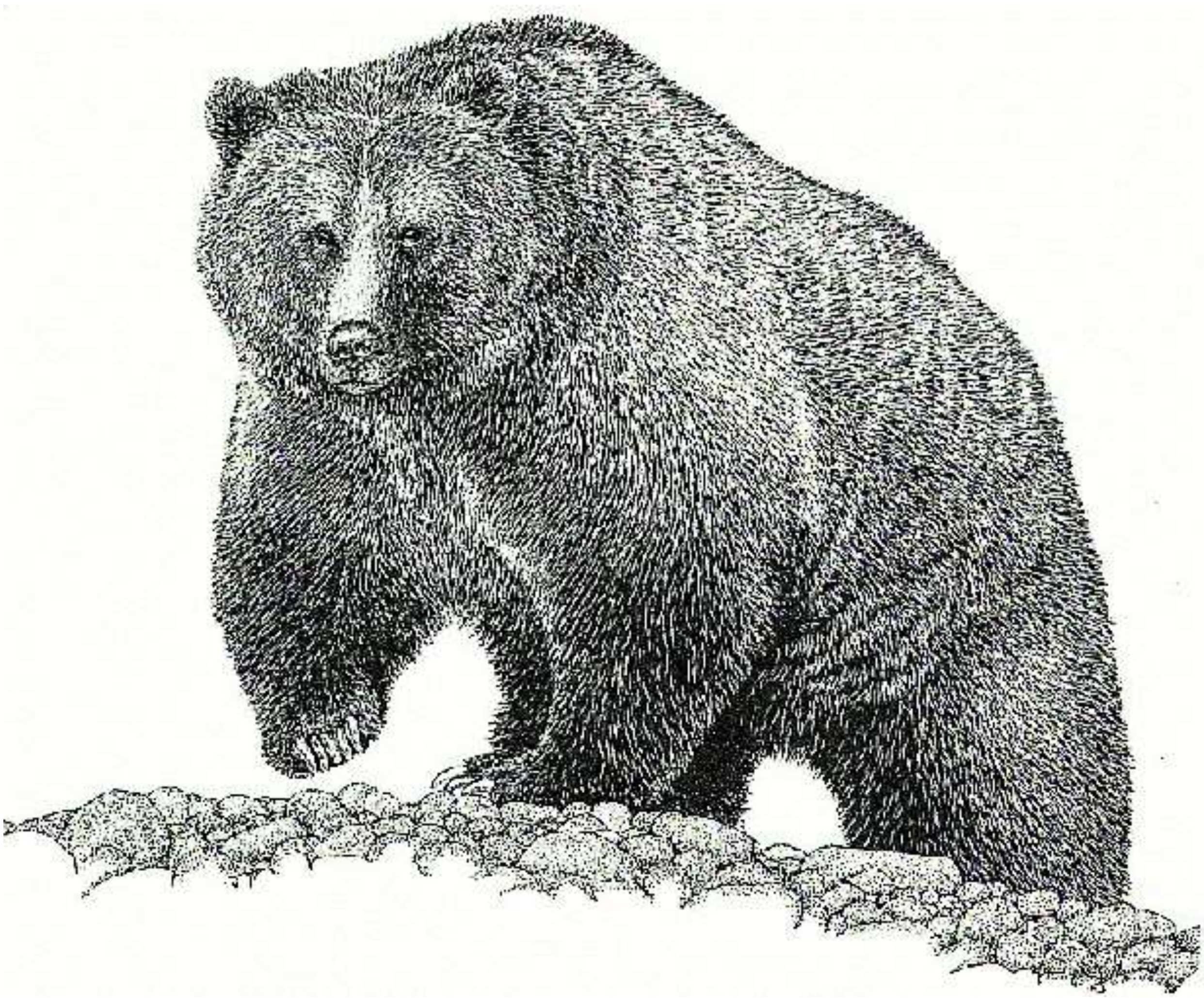


EXHIBIT 3

CABINET-YAAK GRIZZLY BEAR RECOVERY AREA 2020 RESEARCH AND MONITORING PROGRESS REPORT



PREPARED BY
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2021

UNITED STATES FISH AND WILDLIFE SERVICE
GRIZZLY BEAR RECOVERY COORDINATOR'S OFFICE
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This annual report is cumulative and represents data collected, reanalyzed and summarized annually since the inception of this monitoring program in 1983. Information in this report supersedes previous reports. Please obtain permission prior to citation. Cite as follows: **Kasworm, W. F., T. G. Radandt, J. E. Teisberg, T. Vent, A. Welander, M. Proctor, H. Cooley and J. K. Fortin-Noreus. 2021. Cabinet-Yaak grizzly bear recovery area 2020 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 108 pp.**

ABSTRACT

Eleven grizzly bears were monitored with radio-collars during portions of 2020. Research monitoring included four females (three adults and one subadults) and seven males (one adult and six subadults) in the Cabinet-Yaak Ecosystem (CYE). Two subadult males and a subadult female were from the Cabinet Mountains augmentation program. One subadult male bear was collared for conflict management purposes. Grizzly bear monitoring and research has been ongoing in the Cabinet Mountains since 1983 and in the Yaak River since 1986. Eighty-two individual resident bears were captured and monitored through telemetry in the two areas from 1983–2020. Research in the Cabinet Mountains indicated that only a small population remained as of 1988. Concern over persistence of grizzly bear populations within this area resulted in a pilot program in 1990 that tested population augmentation techniques. Four subadult female bears with no history of conflicts with humans were captured in southeast British Columbia for release in the Cabinet Mountains during 1990–1994. Three of four transplanted bears remained within the target area for at least one year. Hair snag sampling and DNA analysis during 2000–2004 identified one of the original transplanted bears. The animal was a 2-year-old female when released in 1993. Genetic analysis conducted in 2005 identified at least three first-generation offspring and two second-generation offspring from this individual. Success of the augmentation test program prompted additional augmentation in cooperation with Montana Fish, Wildlife, and Parks (MFWP). Ten female bears and eight male bears were moved from the Flathead River to the Cabinet Mountains during 2005–2020. Four of these individuals died during their first year from human related causes. Two were illegally shot, one was struck by a train, and one was killed in self-defense. Eight bears left the target area for augmentation, but three returned.

Numbers of females with cubs in the CYE varied from 2–5 per year and averaged 3.3 per year, 2015–2020. Thirteen of 22 bear management units (BMUs) had sightings of females with young. Human caused mortality averaged 1.5 bears per year (0.5 female and 1.0 male), 2015–2020. Nine grizzly bears (3 females and 6 males) died due to known or probable human causes during 2015–2020, including 3 adult females (2 under investigation, 1 self-defense), 2 adult males (1 under investigation and 1 management), 4 subadult males (1 each self-defense, human under investigation, mis-identification, and poaching).

Using all methods (capture, collared individuals, rub tree DNA, corral DNA, opportune DNA sampling, photos, credible observations), we detected a minimum 50 individual grizzly bears alive and in the CYE grizzly bear population at some point during 2019. Five of these bears were known dead. Twenty-three bears were detected in the Cabinets (16 male, 7 female). Twenty-seven bears were detected in the Yaak (16 male, 7 female, 4 unknown sex).

Sex- and age-specific survival and reproductive rates yielded an estimated finite rate of increase (λ) of 1.017 (95% C.I. = 0.935–1.090) for 1983–2020 using Booter software with the unpaired litter size and birth interval option. Finite rate of population change was an annual 1.7% for 1983–2020. The probability that the population was stable or increasing was 60%.

Berry counts indicated above average production for huckleberry, buffaloberry, and mountain ash and average production for serviceberry during 2020.

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INTRODUCTION

Grizzly bear (*Ursus arctos*) populations south of Canada are currently listed as Threatened under the terms of the 1973 Endangered Species Act (16 U.S.C. 1531-1543). In 1993 a revised Recovery Plan for grizzly bears was adopted to aid the recovery of this species within ecosystems that they or their habitat occupy (USFWS 1993). Seven areas were identified in the Recovery Plan, one of which was the Cabinet-Yaak Grizzly Bear Recovery Zone (CYE) of extreme northwestern Montana and northeast Idaho (Fig. 1). This area lies directly south of Canada and encompasses approximately 6800 km^2. The Kootenai River bisects the CYE, with grizzly bear habitat within the Cabinet Mountains to the south and the Yaak River drainage to the north (Fig. 2). The degree of grizzly bear movement between the two portions was believed to be minimal but several movements by males into the Cabinet Mountains from the Yaak River and the Selkirk Mountains have occurred since 2012.

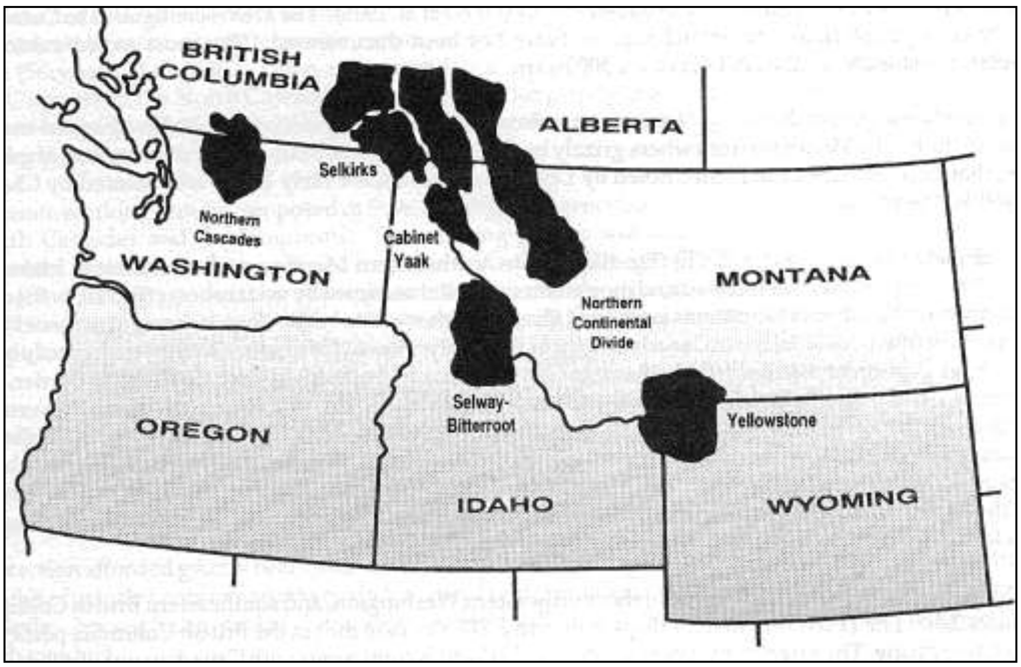

Figure 1. Grizzly bear recovery areas in the U.S., southern British Columbia, and Alberta, Canada.

Research on resident grizzly bears began south of the Kootenai River during the late 1970's. Erickson (1978) reported the results of a survey he conducted for bears and their sign in the Cabinet Mountains and concluded the population consisted of approximately a dozen animals. A trapping effort in 1979 and 1980 in the same area failed to capture a grizzly bear, but a female and yearling were observed (Thier 1981). In 1983 trapping efforts were resumed and intensified (Kasworm and Manley 1988). Three individual grizzly bears were captured and radio-collared during 1983–1987. Minimal reproduction was observed during the period and the population was believed to be declining toward extinction. To reverse this trend, a formal plan was proposed in 1987 to augment the Cabinet Mountains portion of the population with subadult female bears from outside the area (USFWS 1990, Servheen *et al*. 1987).

Two approaches for augmenting grizzly bears were proposed. The first involved transplanting adult or subadult grizzly bears from other areas of similar habitat to the Cabinet

Mountains. Transplants would involve bears from remote areas that would have no history of conflict with humans. The use of subadult females was recommended because of their smaller home ranges and potential reproductive contribution. The second approach relied on the cross fostering of grizzly bear cubs to American black bear (*Ursus americanus*) females. Under this approach, grizzly bear cubs from zoos would be placed in the maternal dens of black bear females during March or April. The fostering of orphaned black bear cubs to surrogate black bear females has been used successfully in several areas (Alt and Beecham 1984, Alt 1984).

During public review of the augmentation program, many concerns were expressed which included human safety, conflicts with other land-uses, and long-term grizzly bear population goals. A citizen's involvement committee was formed to aid information exchange between the public and the agencies. Representatives of several local organizations donated their time to further this purpose. The first product of this group was a question-and-answer brochure regarding grizzly bears in the CYE. This brochure was mailed to all box holders in Lincoln and Sanders counties. In response to concerns expressed by the committee, the augmentation proposal was modified to eliminate cross fostering and to reduce total numbers of transplanted bears to four individuals over five years. The beginning date of augmentation was also postponed for one year to allow additional public information and education programs.

Prior to 1986, little work was conducted on grizzly bears in the Yaak River portion of the CYE. Bears that used the area were thought to be largely transitory from Canada. However, a black bear study in the Yaak River drainage in 1986 and 1987 resulted in the capture and radio-collaring of five individual grizzly bears (Thier 1990). The Yaak River area has traditionally been an important source of timber for area mills, with timber harvesting the dominant use of the area. A pine beetle (*Dendroctonus ponderosae*) epidemic began in the mid 1970's. Large stands of lodgepole pine (*Pinus contorta*) were infected, which resulted in an accelerated timber-harvesting program with clearcutting the dominant silvicultural technique. A concern of environmental degradation, as well as the effects of timber harvesting on the local grizzly bear population, prompted a lawsuit against the Forest Service by a local citizen's group in 1983 (USFS 1989). To obtain additional information on the population status and habitat needs of grizzly bears using the area, the U.S. Forest Service and Montana Fish, Wildlife and Parks (MFWP) cooperated with the U.S. Fish and Wildlife Service (USFWS) initiating a long-term study. Field work began in June of 1989.

A population viability analysis recommended four areas of emphasis in future management for recovery of this population (Proctor *et al*. 2004). Those recommendations included: reducing human caused mortality, implementing population augmentation in the Cabinet Mountains, enhancing population interchange by improving internal and external population linkage, and motorized access management on public lands to reduce mortality risk and habitat displacement. Recovery efforts have and will continue to emphasize these recommendations.

OBJECTIVES

A. Cabinet Mountains Population Augmentation:

Test grizzly bear augmentation techniques in the Cabinet Mountains to determine if transplanted bears will remain in the area of release and ultimately contribute to the population through reproduction.

B. Recovery Zone Research and Monitoring:

1. Document grizzly bear distribution in the CYE.
2. Describe and monitor the grizzly bear population in terms of reproductive success, age structure, mortality causes, population trend, and population estimates and report this

information through the grizzly bear recovery plan monitoring process.

3. Determine habitat use and movement patterns of grizzly bears. Determine habitat preference by season and assess the relationship between human-altered habitats such as logged areas and grizzly bear habitat use. Evaluate grizzly bear movement permeability of the Kootenai River valley between the Cabinet Mountains and the Yaak River drainage and across the Moyie River Valley in British Columbia.
4. Determine the relationship between human activity and grizzly bear habitat use through the identification of areas used more or less than expected in relation to ongoing timber management activities, open and closed roads, and human residences.
5. Identify mortality sources and management techniques to limit human-caused mortality of grizzly bears.
6. Conduct black bear studies incidental to grizzly bear investigations to determine interspecific relations. Data on black bear densities, reproduction, mortality, movements, habitat-use, and food habits relative to grizzly bears will be gathered and analyzed.

STUDY AREA

The CYE (48º N, 116º W) encompasses approximately 6,800 km^2 of northwest Montana and northern Idaho (Fig. 2). The Cabinet Mountains constitute about 58% of the CYE and lie south of the Kootenai River. The Yaak River portion borders Canadian grizzly populations to the north. There are two potential linkage areas between the Yaak and the Cabinets – one between Libby and Troy and one between Troy and the Idaho border. Prior to 2012 we were unable to document any grizzly bear movement between these areas or grizzly bear use within these linkage zones; however, since that time we have documented several instances of male bears moving from the Selkirk Mountains or the Yaak River into the Cabinet Mountains. Approximately 90% of the recovery area is on public land administered by the Kootenai, Lolo, and Panhandle National Forests. Plum Creek Timber Company Inc. and Stimson Corp. are the main corporations holding a significant amount of land in the area. Individual ownership exists primarily along major rivers, and there are numerous patented mining claims along the Cabinet Mountains Wilderness boundary. The Cabinet Mountains

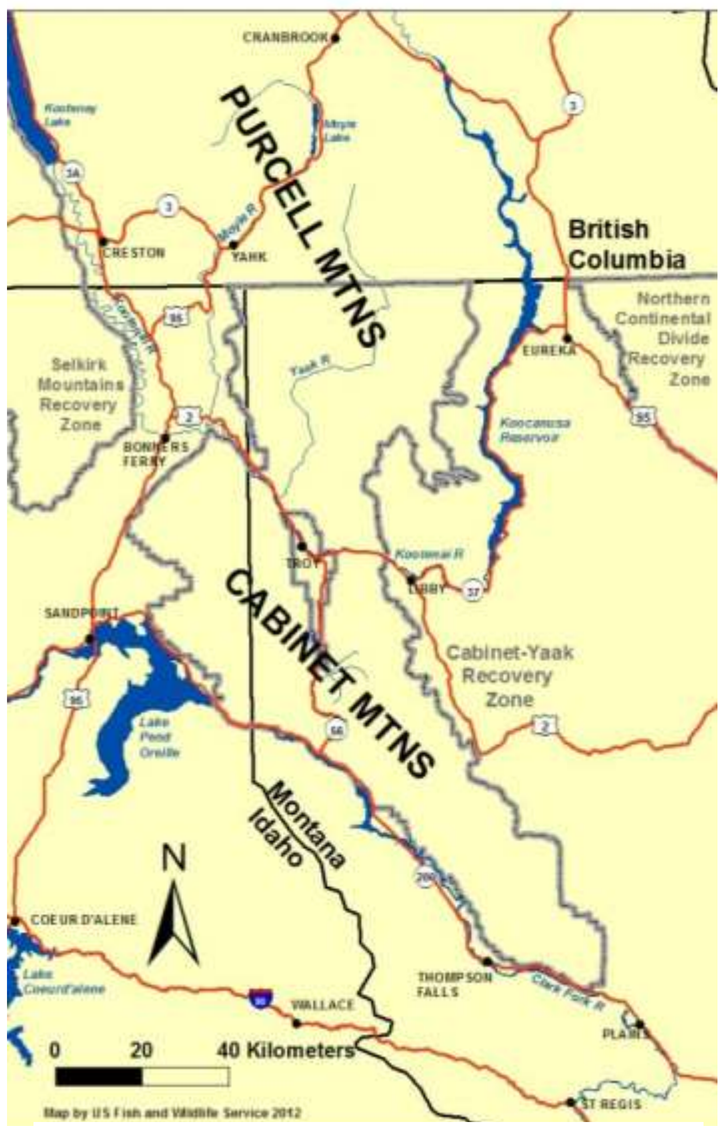

Figure 2. Cabinet-Yaak grizzly bear recovery zone.

Wilderness encompasses 381 km^2 of higher elevations of the study area in the Cabinet Mountains. Bonners Ferry, Libby, Noxon, Sandpoint, Troy, Thompson Falls, and Trout Creek are the primary communities adjacent to the Cabinet Mountains.

Elevations in the Cabinet Mountains range from 610 m along the Kootenai River to 2,664 m at Snowshoe Peak. The area has a Pacific maritime climate characterized by short, warm summers and heavy, wet winter snowfalls. Lower, drier slopes support stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), whereas grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) dominate lower elevation moist sites. Subalpine fir (*Abies lasiocarpa*), spruce (*Picea spp*.), and mountain hemlock (*Tsuga mertensiana*) dominate stands between 1,500 m and timberline. Mixed coniferous and deciduous tree stands are interspersed with riparian shrub fields and wet meadows along major drainages. Huckleberry (*Vaccinium spp*.) and mixed shrub fields are partially a result of wildfires that occurred in 1910 and 1929 and more recent stand replacing fires. Fire suppression has reduced wildfires as a natural force creating or maintaining berry-producing shrub fields.

The Yaak River drainage lies in the extreme northwestern corner of Montana, northeastern Idaho, and southern British Columbia and is bounded on the east and south by Lake Koocanusa and the Kootenai River, to the west by the Moyie River, and to the north by the international boundary. Two north-south trending mountain ranges dominate the landscape - the McGillivray range in the east and the Purcell range to the west. Topography is varied, with rugged, alpine glaciated peaks present in the Northwest Peaks Scenic Area. Rounded peaks and ridges cover most of the remaining area, a result of continental glaciation. Coniferous forests dominate, with cutting units the primary source of diversity. Much of the Yaak River is low gradient and the river tends to meander, creating lush riparian zones and meadows. Elevations range from 550 m at the confluence of the Kootenai and Moyie Rivers to 2348 m atop Northwest Peak. Vegetation is diverse, with an overstory of western hemlock and western red cedar the indicated climax species on much of the study area. Ponderosa pine and Douglas-fir are common at lower elevations on south and west slopes. Subalpine fir and spruce dominate the upper elevations and cirque basins. Large stands of lodgepole pine and western larch (*Larix occidentalis*) occur at mid and upper elevations and are largely the result of extensive wildfires in the past. In recent decades, several stand altering fires have occurred in the Yaak River. Additionally, the Kootenai and Idaho Panhandle National Forests have implemented prescribed fire to promote grizzly bear habitat in recent years.

Understory and non-forested habitats include graminoid parks consisting primarily of fescue (*Festuca* spp.) and bluebunch wheatgrass (*Agropyron spicatum*), which occur at moderate to high elevations. Riparian shrub fields of red-osier dogwood (*Cornus stolonifera*) and hawthorn (*Crataegus douglasii*) are prevalent along major drainages. Buffaloberry (*Shepherdia canadensis*) is common under stands of open lodgepole pine while serviceberry (*Amelanchier alnifolia*) and chokecherry (*Prunus virginiana*) prevail on drier, rockier sites. Huckleberry shrub fields are often found under open timber canopies adjacent to graminoid parks, in old burns, in cutting units, and intermixed with beargrass (*Xerophyllum tenax*). Recent wildfires at upper elevations have had more influence on habitat in the CYE. An outbreak of pine bark beetles resulted in logging large areas at lower elevations during the 1980's. Large portions of upper elevations had been logged earlier in response to a spruce bark beetle (*Dendroctonus obesus*) epidemic.

During 1990–1994, Cabinet Mountains population augmentation trapping was conducted in the upper North Fork of the Flathead River drainage and the Wigwam River drainage in southeast British Columbia, approximately 10–40 km north of the U.S. border. Trapping was also conducted south of the international border in the North Fork of the Flathead River in 1992. Since 2005, augmentation trapping has occurred south of the international border in the Flathead River drainage.

METHODS

This annual report is cumulative and represents almost all data collected since the inception of this monitoring program since 1983. New information collected or made available to this study was incorporated into summaries and may change previous results.

Grizzly Bear Observations and Mortality

All grizzly bear observations and reports of sign (tracks, digs, etc.) by study personnel and the public were recorded. Grizzly bear sighting forms were sent to a variety of field personnel from different agencies to maximize the number of reports received. Sightings of grizzly bears were rated 1–5 with 5 being the best quality and 1 being the poorest. General definitions of categories are presented below, but it was difficult to describe all circumstances under which sightings were reported. Only sightings receiving ratings of 4 or 5 were judged credible for use in reports. Sightings that rate 1 or 2 may not be recorded in the database.

5 - Highest quality reports typically from study personnel or highly qualified observers. Sightings not obtained by highly qualified observers must have physical evidence such as pictures, track measurements, hair, or sightings of marked bears where marks are accurately described.

4 - Good quality reports that provide credible, convincing descriptions of grizzly bears or their sign. Typically, these reports include a physical description of the animal mentioning several characteristics. Observer had sufficient time and was close enough or had binoculars to aid identification. Observer demonstrates sufficient knowledge of characteristics to be regarded as a credible observer. Background or experience of observer may influence credibility.

3 - Moderate quality reports that do not provide convincing descriptions of grizzly bears. Reports may mention one or two characteristics, but the observer does not demonstrate sufficient knowledge of characteristics to make a reliable identification. Observer may have gotten a quick glimpse of the bear or been too far away for a good quality observation.

2 - Lower quality observations that provide little description of the bear other than the observer's judgment that it was a grizzly bear.

1 - Lowest quality observations of animals that may not have been grizzly bears. This category may also involve secondhand reports from someone other than the observer.

Reported grizzly bear mortality includes all bears known to have died within the U.S. and within 16 km of the international border in Canada. Many bears collared in the U.S. have home ranges that extend into Canada. Mortality occurring in this area within Canada can affect calculations for U.S. populations. All radio collared bear mortality was reported regardless of location in the U.S. or Canada.

Survival and Mortality Calculations

Survival rates for all age classes except cubs were calculated by use of the Kaplan-Meier procedure as modified for staggered entry of animals (Pollock *et al*. 1989, Wakkinen and Kasworm 2004). Assumptions of this method include: marked individuals were representative of the population, individuals had independent probabilities of survival, capture and radio collaring did not affect future survival, censoring mechanisms were random, a time origin could be defined, and newly collared animals had the same survival function as previously collared animals. Censoring was defined as radio-collared animals lost due to radio failure, radio loss, or emigration of the animal from the study area. Kaplan-Meier estimates may differ slightly from

Booter survival estimates used in the trend calculation. Survival rates were calculated separately for native, augmentation, and management bears because of biases associated with the unknown proportion of management bears in the population and known differences in survival functions.

Our time origin for each bear began at capture. If a bear changed age classification while radio-collared (i.e., subadult to adult), the change occurred on the first of February (the assigned birth date of all bears). Weekly intervals were used in the Kaplan-Meier procedure during which survival rates were assumed constant. No mortality was observed during the denning season. Animals were intermittently added to the sample over the study. Mortality dates were established based on radio telemetry, collar retrieval, and mortality site inspection. Radio failure dates were estimated using the last radiolocation date when the animal was alive.

Cub recruitment rates to 1 year of age were estimated as: {1 - (cub mortalities / total cubs observed)}, based on observations of radio-collared females (Hovey and McLellan 1996). Mortality was assumed when a cub disappeared or if the mother died. Cubs were defined as bears < 1.0-year-old.

Use of known human-caused mortality counts probably results in under-estimates of total human-caused mortality. Numerous mortalities were reported only because animals wore a radio-collar at the time of death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry *et al*. 2002). The correction factor was not applied to natural mortality, management removals, mortality of radio-collared bears, or bears that died of unknown causes. All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes.

Cabinet Mountains augmentation individuals were counted as mortalities when removed from the Northern Continental Divide Ecosystem and are not counted again as mortalities in the CYE if they die during their first year (Appendix Table T2). Mortalities in Canada are not counted toward recovery goals (USFWS 1993) even though bears initially marked within the CYE have died in Canada. Bears originating in Canada that die in the US are counted.

Reproduction

Reproduction data was gathered through observations of radio-collared females with offspring and genetics data analyzed for maternity relationships. Because of possible undocumented neonatal loss of cubs, no determination of litter size was made if an observation was made in late summer or fall. Inter-birth interval was defined as length of time between subsequent births. Age of first parturition was determined by presence or lack of cubs from observations of aged radio-collared bears and maternity relationships in genetics data from known age individuals.

Population Growth Rate

We used the software program Booter 1.0 (© F. Hovey, Simon Fraser University, Burnaby, B.C.) to estimate the finite rate of increase (λ, or lambda) for the study area's grizzly bear populations. The estimate of λ was based on adult and subadult female survival, yearling and cub survival, age at first parturition, reproductive rate, and maximum age of reproduction.

Booter uses the following revised Lotka equation (Hovey and McLellan 1996), which assumes a stable age distribution:

$$(1) \quad 0 = \lambda^a - S_a \lambda^{a-1} - S_c S_y S_s^{a-2} m[1 - (S_a / \lambda)^{w-a+1}],$$

where S_a, S_s, S_y, and S_c are adult female, subadult female, yearling, and cub survival rates, respectively, a = age of first parturition, m = rate of reproduction, and w = maximum age. Booter calculates annual survival rates with a seasonal hazard function estimated from censored telemetry collected through all years of monitoring in calculation of λ. This technique was used on adults, subadults, and yearlings. Point estimates and confidence intervals may be slightly different from those produced by Kaplan-Meier techniques (differences in Tables 14 and 15). Survival rate for each class was calculated as:

$$(2) \quad S_i = \prod_{j=1}^{k} e^{-L_j(D_{ij} - T_{ij})}$$

where S_i is survival of age class *i*, *k* is the number of seasons, D_{ij} is the number of recorded deaths for age class *i* in season *j*, T_{ij} is the number of days observed by radio telemetry, and L_j is the length of season *j* in days. Cub survival rates were estimated by 1 - (cub mortalities / total cubs born), based on observations of radio-collared females. Intervals were based on the following season definitions: spring (1 April - 31 May), summer (1 June - 31 August), autumn (1 September - 30 November), and winter (1 December - 31 March). Intervals were defined by seasons when survival rates were assumed constant and corresponded with traditional spring and autumn hunting seasons and the denning season.

Booter provides several options to calculate a reproductive rate (*m*) and we selected three to provide a range of variation (McLellan 1989). The default calculation requires a reproductive rate for each bear based upon the number of cubs produced divided by the number of years monitored. We input this number for each adult female for which we had at least one litter size and at least three successive years of radio monitoring, captures, or observations to determine reproductive data. We ran the model with this data and produced a trend calculation. Among other options, Booter allows use of paired or unpaired litter size and birth interval data with sample size restricted to the number of females. If paired data is selected, only those bears with both a known litter size and associated inter-birth interval are used. The unpaired option allows the use of bears from which accurate counts of cubs were not obtained but interval was known, for instances where litter size was known but radio failure or death limited knowledge of intervals. To calculate reproductive rates under both these options, the following formula was used (from Booter 1.0):

$$(3) \quad m = \frac{\sum_{i=1}^{n} \dfrac{\sum_{j=1}^{p} L_{ij}}{\sum_{j=1}^{k} B_{IJ}}}{n}$$

where *n* = number of females; *j* = observations of litter size (*L*) or inter-birth interval (*B*) for female *i*; *p* = number of observations of *L* for female *i*; and *k* = number of observations of *B* for female *i*. Note *k* and *p* may or may not be equal. Cub sex ratio was assumed to be 50:50 and maximum age of female reproduction (*w*) was set at 27 years (Schwartz *et al*. 2003). Average annual exponential rate of increase was calculated as $r = \log_e \lambda$ (Caughley 1977).

Bears captured and relocated to the Cabinet Mountains as part of population augmentation were not included in the population trend calculation (Appendix Table T1). None of these animals had any prior history of nuisance activity. Bears captured initially as objects of conflict captures were not included. Several native bears that were captured as part of a preemptive move to avoid nuisance activity were included. Currently collared bears that became management bears while wearing a collar were included.

Capture and Marking

Capture and handling of bears followed an approved Animal Use Protocol through the University of Montana, Missoula, MT (061-14CSCFC111714 and 040-20HCCFC-092420). Capture of black bears and grizzly bears was performed under state permits 2020-066-W and federal permit TE704930-2. Bears were captured with leg-hold snares following the techniques described by Johnson and Pelton (1980) and Jonkel (1993). Snares were manufactured in house following the Aldrich Snare Co. (Clallam Bay, WA) design and consist of 6.5 mm braided steel aircraft cable. Bears were immobilized with either Telazol (tiletamine hydrochloride and zolazepam hydrochloride), a mixture of Ketaset (ketamine hydrochloride) and Rompun (xylazine hydrochloride), a mixture of Telazol and Dexmedetomidine, or a combination of Telazol and Rompun. Yohimbine and Atipamezole were the primary antagonists for Rompun and Dexmedetomidine. Drugs were administered intramuscularly with a syringe mounted on a pole (jab-stick), homemade blowgun, modified air pistol, or cartridge powered dart gun. Immobilized bears were measured, weighed, and a first premolar tooth was extracted for age determination (Stoneberg and Jonkel 1966). Blood, tissue and/or hair samples were taken from most bears for genetic and food use studies. Immobilized bears were given oxygen at a rate of 2–3 liters per minute. Recovering bears were dosed with Atropine and Diazepam.

All grizzly bears (including management bears captured at conflict sites) and some adult black bears (≥ 4.0 years old) were fitted with radio collars or ear tag transmitters when captured. Some bears were collared with Global Positioning System (GPS) radio collars. Collars were manufactured by Telonics® (Mesa, AZ) and ear tag transmitters were manufactured by Advanced Telemetry Systems® (Isanti, MN). To prevent permanent attachment, a canvas spacer was placed in the collars so that they would drop off in 1–3 years (Hellgren *et al*. 1988).

Trapping efforts were typically conducted from May through September. In 1986–1987, snares were placed in areas where black bear captures were maximized on a defined study area of 214 km^2 (Thier 1990). Snares were placed over a broader area during 1989–1994 to maximize grizzly bear captures. Trap sites were usually located within 200 m of an open road to allow vehicle access. Beginning in 1995, an effort was made to capture and re-collar known grizzly bears in the Yaak River and augmentation bears in the Cabinet Mountains. In 2003, trapping was initiated in the Salish Mountains south of Eureka, Montana to investigate bear movements in the intervening area between the Northern Continental Divide and CYE recovery zones. Trapping was conducted along Highway 2 in northwest Montana and along Highway 3 in southeast British Columbia to collar bears with GPS radio collars during 2004–2010. During 2011, trapping was initiated along Highway 95 near McArthur Lake in northern Idaho and along Interstate 90 near Lookout Pass in Montana and Idaho. All four studies were designed to examine bear population connectivity across river valleys with highways and human habitation. Highway 2, 95, and I-90 studies utilized black bears as surrogates for grizzly bears because of the small number of grizzly bears in the valley. The Highway 3 effort in British Columbia collared grizzly bears and black bears. Much of the trapping effort in the Yaak and Cabinet Mountains areas involved the use of horses on backcountry trails and closed logging roads. Traps were checked daily. Bait consisted primarily of road-killed ungulates.

Trapping for population augmentation was conducted in the North Fork of the Flathead River in British Columbia during 1990–1994. Only female grizzly bears < 6 years old (or prior to first reproduction) and > 35 kg were deemed suitable for transplant. Other captured grizzly bears were released with collaring to aid an ongoing BC bear study. Capture efforts for bears transplanted in 2005–2020 occurred primarily in the North Fork and South Fork of the Flathead River in the US by MFWP. No suitable bears were captured in 1991, 2007, 2017, or 2020.

Hair Sampling for DNA Analysis

This project originally sought evidence of grizzly bears in the Cabinet Mountains using DNA to understand the fates of four bears transplanted during 1990–1994. The program used genetic information from hair-snagging with remote-camera photo verification to identify transplanted bears or their offspring living in the Cabinet Mountains. Since then, sampling has expanded into the Yaak drainage and project objectives now include: observations of females with young, sex ratio of captured bears, relatedness as well as genetic diversity measures of captured bears, and evidence of interpopulation movements of individuals.

Sampling occurred from May–October of 2002–2020 in the CYE in Idaho and Montana following standard hair snagging techniques (Woods *et al.* 1999). Sampling sites were established based on location of previous sightings, sign, and radio telemetry from bears in the CYE. A 5 km x 5 km grid (25 km^2) was used to distribute sample sites across the Cabinet Mountains in 2003 (n =184). Each grid cell contained a single sample point near the center of the cell. Actual site location was modified on the basis of access to the site and habitat quality near the site. Sites were baited with 2 liters of a blood and fish mixture to attract bears across a barbwire perimeter placed to snag hair. Sites were deployed for 2 weeks prior to hair collection. One third of sites were sampled during each of the months of June, July, and August. Sample sites were stratified by elevation with lowest elevation sites sampled in June and highest elevation sites sampled in August. Trail cameras were used at some sites. Hair was collected and labeled to indicate: number and color of hairs, site location, date, and barb number. These data aided sorting hair to minimize lab costs. Solid black hairs were judged to be from black bears and not analyzed further. Samples collected as a part of this effort and other hair samples collected in previous years either from known grizzly bears or samples that outwardly appeared to be grizzly bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Hairs visually identified as black bear hair by technicians at the Laboratory were not processed and hairs processed and determined to be black bear were not genotyped. Dr. Michael Proctor (Birchdale Ecological) is a cooperator on this project and assisted with genetic interpretations. He has previously analyzed genetic samples from the Yaak portion of this recovery zone (Proctor 2003). Hair snag sampling effort during 2012 was altered and reduced to avoid conflicts with a US Geological Survey (USGS) study to estimate CYE grizzly bear population size (Kendall *et al*. 2015). USGS was concerned that our sample sites might influence capture success at their sites.

The USGS study established and sampled 1,373 rub trees across the CYE during 2012. The study made preliminary data available regarding the success of this effort by providing us coordinates of all trees and those trees that produced grizzly bear samples. Sites that produced grizzly bear hair and adjacent sites that were easily sampled in conjunction with successful sites were resampled 2–4 times during 2013–2020. Collected hairs were evaluated by study personnel and samples not judged to be probable black bear were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping.

Movements of radio collared bears, multiple locations of genetically marked bears, and maternity/paternity analysis were typically used to identify migrants between various bear populations. In the absence of this type of data, we used methods as applied in Proctor *et al*. (2005) and further used in Proctor *et al*. (2012) where program GeneClass uses an algorithm to assign a probability of being a migrant by translating log ratio of assignment to each population into probabilities with thresholds using realistic Type I error rates (Piry et al. 2004, Paetkau et al. 2004). The use of TYPE I error rate in this algorithm is important as it allows researchers to differentiate true migrants from those who might appear as migrants by chance. A bear is determined to be a migrant when it has a very high probability of being born in a population other than the one it was captured in, but also when it is beyond the number of ‘putative migrants’ who cross assign by chance (the TYPE I error rate). For more detailed treatment of this process see Proctor *et al*. (2005).

We used bears that were DNA sampled prior to 2006, after which population interchange increased and reduced precision in determining population of origin. More specifically, we used a sample of bears from each population: the South Selkirk (n = 49), Yahk (*n* = 33, south of Highway 3) and South Purcells (*n* = 23, north of BC Highway 3) where we were certain of their origin. This contained 2 sets of bears,

- those captured prior to 2005 as this is when we determined inter-population exchange started to increase (Proctor *et al*. 2018) and
- those whose population of origin was known because the offspring were in a perfectly matched triad: mother – father – offspring where the offspring shared an allele at each of 21 loci with each parent and the parents were captured prior to 2005.

Then we added individual bear suspected of being migrants into the analysis dataset, to assess what their probability of origin was, relative to bears of known origin. Migrants we determined to be real had the highest log ratios, of all 'putative' migrants and they were beyond the number of expected 'chance migrants' (the TYPE I error rate). For example, using an alpha value of 0.01 means that 1 in 100 of samples would appear as a migrant by chance alone, and thus would not be real. So, if our analysis identified 4 migrants in a sample of 100 bears, we could then conclude that 3 were likely real migrants as 1 was a migrant by chance (the TYPE I error rate). We would then take the 3 putative migrants with the greatest log ratio and probability of being a migrant and call them real migrants. In practice, the log ratios of these real migrants typically reflect probabilities that are 100–10000 times higher probabilities being a migrant than a resident.

Radio Monitoring

Attempts were made to obtain aerial radiolocations on all instrumented grizzly bears at least once each week during the 7–8 month period in which they were active. GPS collars attempted a location fix every 1–2 hours. Collar releases were programmed to drop in early October for retrieval. Expected collar life varied from 1–3 field seasons over the course of the study depending upon model of collar and programming. Augmentation bears were monitored daily following release for at least the first two weeks and usually three times per week following. In addition, efforts were made to obtain as many ground locations as possible on all bears, usually by triangulating from a vehicle. Life home ranges (minimum convex polygons; Hayne 1959) were calculated for grizzly bears during the study period. We generated home range polygons using ArcMap 10.

Grizzly and black bears were collared with GPS collars during 2004–2010 to study movements across the Moyie River Valley and Highway 3 in British Columbia. Black bears were tested for their potential to act as surrogates that would predict grizzly bear movements. Collars attempted locations every 1–2 hours depending on configuration and data were stored within the collar. Weekly aircraft radio monitoring was conducted to check for mortality signals and approximate location. From 2004 to 2007, black bears were fitted with similar GPS radio collars to study movements across the Kootenai River Valley and Highway 2 in Montana, as part of linkage monitoring between the Yaak River and Cabinet Mountains. In 2008–2012, black bears were fitted with GPS collars in the Yaak River study area and along the Clark Fork River on the south end of the Cabinet Mountains study area.

Scat analysis

Bear scats were collected, tagged, and either dried or frozen. We only considered scats associated with definite grizzly bear sign (tracks, hair, and radio location of instrumented bear) as from grizzly bears. Food habits analysis was completed by William Callaghan (Florence, MT) and Kevin Frey (Bozeman, MT). Samples were rinsed with hot and cold water over 2 different size mesh screens (0.40 and 0.24 cm). The retained contents were identified to species with the aid of microscopes. We recorded plant part and visually estimated percent volume. We corrected scat volumes with correction factors that incorporate different digestibilities of various food items (Hewitt and Robbins 1996).

Isotope analysis

Hair samples from known age, captured grizzly bears were collected and analyzed for stable isotopic ratios. Stable isotope signatures indicate source of assimilated (i.e., digested) diet of grizzly bears. Nitrogen stable isotope ratios (^{15}N) indicate trophic level of the animal; an increased amount of ingested animal matter yields higher nitrogen isotope ratios while lower values tie to more plant-based diets. In our ecosystem, carbon isotope signatures vary depending on the amount of native C3 vs. C4 plant matter ingested. Corn, a C4 plant, has elevated $^{13}C/^{12}C$ ratios relative to native C3 plants. Because much of the human food stream is composed of corn, carbon stable isotope signatures allow for verification or identification of human food conditioned bears.

Hair samples were rinsed with a 2:1 chloroform:methanol solution to remove surface contaminants. Samples were then ground in a ball mill to homogenize the sample. Powdered hair was then weighed and sealed in tin boats. Isotope ratios of $\delta^{13}C$ and $\delta^{15}N$ were assessed by continuous flow methods using an elemental analyzer (ECS 4010, Costech Analytical, Valencia, California) and a mass spectrometer (Delta PlusXP, Thermofinnigan, Bremen, Germany) (Brenna *et al*. 1997, Qi *et al*. 2003).

Berry Production

Quantitative comparisons of annual fluctuations and site-specific influences on fruit production of huckleberry and buffaloberry were made using methods similar to those established in Glacier National Park (Kendall 1986). Transect line origins were marked by a painted tree or by surveyors' ribbon. A specific azimuth was followed from the origin through homogenous habitat. At 0.5 m intervals, a 0.04 m^2 frame (2 x 2 decimeter) was placed on the ground or held over shrubs and all fruits and pedicels within the perimeter of the frame were counted. If no portion of a plant was intercepted, the frame was advanced at 0.5 m intervals and empty frames were counted. Fifty frames containing the desired species were counted on each transect. Timbered shrub fields and mixed shrub cutting units were the primary sampling areas to examine the influence of timber harvesting on berry production within a variety of aspects and elevations. Notes on berry phenology, berry size, and plant condition were recorded. Service berry, mountain ash, and buffaloberry production was estimated from 10 marked plants at several sites scattered across the recovery area. Since 1989 several sites have been added or relocated to achieve goals for geographic distribution. Some transects were eliminated because plant succession or fire had affected production. Monitoring goals identified an annual trend of berry production and did not include documenting the effects of succession.

Huckleberry sampling began in 1989 at 11 transect sites. Fifteen sites were sampled in 2020. Buffaloberry sampling began in 1990 at 5 sites. Due to the dioecious (separate male and female plants) nature of buffaloberry all frame count transects were dropped in 2007 in favor of marking 10 plants per site and counting the berries on marked plants. Two sites were sampled in 2020. Serviceberry productivity was estimated by counting berries on 10 marked plants at 5 sample sites beginning in 1990. Five sites were sampled in 2020. In 2001, three new plots were established to document berry production of mountain ash (*Sorbus scopulina*). Ten plants were permanently marked at each site for berry counts, similar to the serviceberry plots. Production counts occurred at 3 sites in 2020.

Temperature and relative humidity data recorders (LogTag®, Auckland, New Zealand) were placed at sites beginning in 2011. These devices record conditions at 90 minute intervals and will be retrieved, downloaded, and replaced at annual intervals. We used a berries/plot or berries/plant calculation as an index of berry productivity. Transects were treated as the independent observation unit. For each year observed, mean numbers of berries/plant (berries/plot) were used as our transect productivity indices. For each year, we indicate whether berry productivity is above average (annual 95% confidence interval falls above study-wide mean), average (confidence interval encompasses the study-wide mean), or below average (confidence interval falls below study-wide mean).

Body Condition

Field measurements and bioelectric impedance analysis (BIA) of captured bears allows us to estimate body condition of grizzly bears in the Cabinet-Yaak (Farley and Robbins 1994). More specifically, these methods allow for estimation of body fat content, an important indicator of quality of food resources and a predictor of cub production for adult females. We attempted estimation on captured bears, characterized by sex-age class, reproductive status, area of capture, and management status. ANOVA and post-hoc Tukey-HSD tests were performed to test for differences in body fat content across factors (management status, sex, and month of capture). Body condition (primarily, body fat content) of reproductive-aged females offers an *indirect* metric of whether females were of a physiological condition that supports cub production (Robbins et al. 2012).

RESULTS AND DISCUSSION

Research and monitoring with telemetry and full-time personnel were present since 1983 and therefore this date represents the most intense period of data collection. All tables and calculations are updated when new information becomes available. For instance, genetic analysis determined the sex of a previously unknown mortality (2012) and a bear originally identified as a probable mortality (2003) was removed when genetic evidence later indicated that the bear survived that incident. Covid-19 protocols reduced the monitoring effort substantially during 2020.

Grizzly Bear Observations and Recovery Plan Targets

Grizzly bear observations and mortality from public and agency sightings or records were appended to databases. These databases include information from the U.S. and Canada. The file includes over 1,900 credible sightings, tracks, scats, digs, hair, and trail camera photographs dating from 1960 (Fig. 3) and over 135 mortalities dating from 1949 (Table 1, Appendix Table 2, Fig. 3). Credible sightings were those rating 4 or 5 on the 5-point scale (see page 9). Sixty-three instances of grizzly bear mortality were detected inside or within 16 km of the CYE during 1982–2020 (Table 1). Sixty-three credible sightings were reported to this study that rated 4 or 5 (most credible) during 2020. Forty-five of these sightings occurred in the Yaak portion of the CYE and 18 sightings occurred in the Cabinet Mountains portion of the CYE (Table 2 and Fig. 3). Sightings of females with young or mortalities that occur outside the recovery zone are counted in the closest BMU. Two grizzly bear cubs believed dead in 2018 when their mother was killed were found to be alive in 2019 and were removed from the mortality list.

<u>Recovery Target 1: 6 females with cubs over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone</u>.
Fourteen credible sightings of a female with cubs occurred during 2020 in Bear Management Units (BMUs) 5, 6, 11, 12, 13, 14, and 15 (Tables 2, 3, 4, 5, Fig. 4 and 5). There appeared to be 5 unduplicated females with cubs in the recovery area or within 10 miles during 2020. Thirteen credible sightings of a female with yearlings or 2-year-olds occurred in BMU 6, 11, 13, 14, 15, 16, 17, and 18. Unduplicated sightings of females with cubs (excluding Canada) varied

from 2–5 per year and averaged 3.3 per year from 2015–2020 (Tables 3, 4). This target has not been met.

Recovery Target 2: 18 of 22 BMU's occupied by females with young from a running 6-year sum of verified evidence.

Thirteen of 22 BMUs in the recovery zone had sightings of females with young (cubs, yearlings, or 2-year-olds) during 2015–2020 (Figs. 4, 5, Table 6). Occupied BMUs were: 2, 4, 5, 6, 8, 11, 12, 13, 14, 15, 16, 17, and 18. This target has not been met.

Recovery Target 3: The running 6-year average of known, human-caused mortality should not exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved.

Two known or probable human caused mortalities occurred during 2020. A subadult male was killed by a black bear hunter through mistaken identity. The bear had a neck snare around it's neck that may have ultimately killed the bear had it not been shot. The second bear was an adult female that is under investigation by enforcement authorities. Two grizzly bear cubs believed dead in 2018 when their mother was killed were found to be alive in 2019 and were removed from the mortality list. Nine known or probable human caused mortalities of grizzly bears have occurred in or within 10 miles of the CYE in the U.S. during 2015–2020 (Table 1), including 3 females (BMUs 5, 11, 14) and 6 males (BMUs 2, 12, 13, 17, and 19). These mortalities included three adult females (two under investigation and a self-defense), one adult male (management) and five subadult males (self-defense, poaching, mistaken identity, and two human caused under investigation). We estimated minimum population size by dividing observed females with cubs during 2018–2020 (12) minus any human-caused adult female mortality (3) by 0.6 (sightability correction factor as specified in the recovery plan) then divide the resulting dividend by 0.284 (adult female proportion of population, as specified in the recovery plan) (Tables 3, 4) (USFWS 1993). This resulted in a minimum population of 53 individuals. The recovery plan stated; "any attempt to use this parameter to indicate trends or precise population size would be an invalid use of these data". Applying the 4% mortality limit to the minimum calculated population resulted in a total mortality limit of 2.1 bears per year. The female limit is 0.6 females per year (30% of 2.1). Average annual human caused mortality for 2015–2020 was 1.5 bears/year and 0.5 females/year. The mortality levels for total bears and females were less than the calculated limit during 2015–2020. The recovery plan established a goal of zero human-caused mortality for this recovery zone due to the initial low number of bears, however it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem." Therefore, even if the goal of zero mortality is not met, it is important to evaluate the targets to determine if we are making progress towards recovery. During the 2015–2020 reporting period, total and female mortality met the target. All tables and calculations were updated as new information becomes available.

Table 1. Known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak grizzly bear recovery zone (including Canada). Includes all radio collared bears regardless of location, 1982–2020.

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
October, 1982	None	M	AD	Human, Poaching	Grouse Creek, ID	No	Yes	USFS
October, 1984	None	Unk	Unk	Human, Mistaken Identity, Black bear	Harvey Creek, ID	Yes	Yes	USFS
9/21/1985	14	M	AD	Human, Self Defense	Lyons Gulch, MT	No	Yes	USFS
7/14/1986	106 cub	Unk	Cub	Natural	Burnt Creek, MT	Unk	No	USFS
10/25/1987	None	F	Cub	Human, Mistaken Identity, Elk	Flattail Creek, MT	No	Yes	USFS

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
5/29/1988[1]	134	M	AD	Human, Legal Hunter kill	Moyie River, BC	Yes	Yes	BC
10/31/1988	None	F	AD	Human, Self Defense	Seventeen Mile Creek, MT	No	Yes	USFS
7/6/1989	129	F	3	Human, Research	Burnt Creek, MT	Yes	No	USFS
1990	192	M	2	Human, Poaching	Poverty Creek, MT	Yes	Yes	USFS
1992	678	F	37	Unknown	Trail Creek, MT	No	Yes	USFS
7/22/1993	258[2]	F	7	Natural	Libby Creek, MT	No	No	USFS
7/22/1993	258-cub	Unk	Cub	Natural	Libby Creek, MT	No	No	USFS
10/4/1995[1]	None	M	AD	Human, Management	Ryan Creek, BC	Yes	Yes	PRIV
5/6/1996	302	M	3	Human, Undetermined	Dodge Creek, MT	Yes	No	USFS
October, 1996[1]	355	M	AD	Human, Undetermined	Gold Creek, BC	Yes	No	BC
June? 1997	None	M	AD	Human, Poaching	Libby Creek, MT	Unk	Yes	PRIV
6/4/1999	106	F	21	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	M	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
6/4/1999	106-cub	F	Cub	Natural, Conspecific	Seventeen Mile Creek, MT	No	No	USFS
10/12/1999[1]	596	F	2	Human, Self Defense	Hart Creek, BC	Yes	Yes	BC
11/15/1999	358	M	15	Human, Management	Yaak River, MT	Yes	Yes	PRIV
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
6/1/2000[1]	538-cub	Unk	Cub	Natural	Hawkins Creek, BC	Unk	No	BC
7/1/2000	303-cub	Unk	Cub	Natural	Fowler Creek, MT	Unk	No	USFS
11/15/2000	592	F	3	Human, Undetermined	Pete Creek MT	Yes	No	USFS
5/5/2001	None	F	1	Human, Mistaken Identity, Black Bear	Spread Creek, MT	Yes	Yes	USFS
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
6/18/2001[1]	538-cub	Unk	Cub	Natural	Cold Creek, BC	Unk	No	BC
9/6/2001	128	M	18	Human, Undetermined	Swamp Creek, MT[3]	Yes	No	PRIV
October, 2001	None	F	AD	Human, Train collision	Elk Creek, MT	Yes	Yes	MRL
6/24/2002[1]	None	Unk	Unk	Human, Mistaken Identity, Hounds	Bloom Creek, BC	Yes	Yes	BC
7/1/2002	577	F	1	Natural	Marten Creek, MT	Yes	No	USFS
10/28/2002	None	F	4	Human, Undetermined	Porcupine Creek, MT	Yes	Yes	USFS
11/18/2002	353/584	F	7	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	F	Cub	Human, Poaching	Yaak River, MT	Yes	Yes	PRIV
11/18/2002	None	Unk	Cub	Human, Poaching	Yaak River, MT	Yes	No	PRIV
10/15/2004[1]	None	F	AD	Human, Management	Newgate, BC	Yes	Yes	PRIV
2005?	363	M	14	Human, Undetermined	Curley Creek, MT	Yes	Yes	PRIV
10/9/2005	694	F	2	Human, Undetermined	Pipe Creek, MT	Yes	No	PCT
10/9/2005	None	F	2	Human, Train collision	Government Creek, MT	Yes	Yes	MRL
10/19/2005	668	M	3	Human, Mistaken Identity, Black bear	Yaak River, MT	Yes	Yes	PRIV
5/28/2006[1]	None	F	4	Human, Research	Cold Creek, BC	Yes	No	BC
6/1/2006[1]	292	F	5	Human, Management	Moyie River, BC	Yes	Yes	PRIV
9/22/2007	354	F	11	Human, Self Defense	Canuck Creek, MT	Yes	Yes	USFS
9/24/2008	?	M	3	Human, Under Investigation	Fishtrap Creek, MT	Yes	Yes	PCT
10/20/2008[2]	790	F	3	Human, Poaching	Clark Fork River. MT	Yes	Yes	PRIV
10/20/2008[2]	635	F	4	Human, Train collision	Clark Fork River. MT	Yes	Yes	MRL
11/15/2008[1]	651	M	13	Human, Mistaken Identity, Wolf Trap	NF Yahk River, BC	Yes	Yes	BC
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/5/2009	675-cub	Unk	Cub	Natural	Copper Creek, ID	Unk	No	USFS
6/7/2009[3]	None	M	3-4	Human, Mistaken Identity, Black bear	Bentley Creek, ID[3]	Yes	Yes	PRIV
11/1/2009	286	F	Adult	Human, Self Defense	EF Bull River, MT	No	Yes	USFS
6/25/2010	675-cub	Unk	Cub	Natural	American Creek, MT	Unk	No	USFS
7/7/2010	303-cub	Unk	Cub	Natural	Bearfite Creek, MT	Unk	No	USFS
9/6/2010[1]	1374	M	2	Human, Under Investigation	Hawkins Creek, BC	Yes	No	BC
9/24/2010[1]	None	M	2	Human, Wolf Trap, Selkirk Relocation	Cold Creek, BC	Yes	Yes	BC
10/11/2010	None	M	AD	Human, Under Investigation	Pine Creek, MT	No	Yes	USFS
2011	None	F	1	Unknown	EF Rock Creek, MT	No	Yes	USFS
9/16/2011	None	M	AD	Human, Mistaken Identity	Faro Creek, MT	No	Yes	USFS
11/13/2011	799	M	4	Human, Mistaken Identity	Cherry Creek, MT	Yes	Yes	USFS
11/24/2011	732	M	3	Human, Defense of life	Pipe Creek, MT	Yes	Yes	PRIV
November 2011	342	M	19	Human, Under Investigation	Little Creek, MT	Yes	Yes	PRIV

Mortality Date	Tag #	Sex	Age	Mortality Cause	Location	Open Road <500 m	Public Reported	Owner[1]
5/18/2012	None	F	AD	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
5/18/ 2012	None	M	Cub	Human, Under Investigation	Mission Creek, ID	Yes	Yes	USFS
October 2012[1]	5381	M	8	Human, Management	Duck Creek, BC	Yes	Yes	PRIV
10/26/2014	79575279	M	6	Human, Self defense	Little Thompson River, MT	Yes	Yes	PRIV
5/15/2015[1]	552-ygl	Unk	1	Natural	Linklater Creek, BC	Unk	No	BC
5/23/2015[2]	921	F	3	Natural	NF Ross Creek, MT	No	No	USFS
5/24/2015	None	M	4?	Human, Poaching	Yaak River, MT	Yes	Yes	USFS
8/12/2015	818	M	2	Human, Self Defense	Moyie River, ID	Yes	Yes	PRIV
9/30/2015[2]	924	M	2	Human, Mistaken Identity	Beaver Creek, ID[3]	Yes	Yes	PRIV
10/11/2015	1001	M	6	Human, Under Investigation	Grouse Creek, ID	Yes	No	PRIV
9/1/2017[1]	922	M	5	Human, Self defense	Porthill Creek, BC	Yes	Yes	BC
4/16/2018	821	M	4	Unknown probable	Pine Creek, MT	Yes	Yes	PRIV
5/21/2018	9077	M	3	Human, Under Investigation	Bristow Creek, MT	Yes	No	USFS
9/5/2018	810	F	15	Human, Under Investigation	Spruce Creek, ID	Yes	No	USFS
5/24/2019	None	Unk	Cub	Natural	Skin Creek, MT	No	No	USFS
5/24/2019	None	Unk	Cub	Natural	Skin Creek, MT	No	No	USFS
8/2/2019	None	F	Adult	Human, Self Defense	EF Bull River, MT	No	Yes	USFS
11/10/2019	770	M	25	Human, Management	Libby Creek, MT	Yes	Yes	PRIV
5/22/2020[1]	675	F	18	Human, Self Defense	Cold Creek, BC	Yes	Yes	BC
8/31/2020	BC 4-121	M	3	Human, Mistaken Identity	Deer Creek, ID	No	Yes	USFS
11/19/2020	729	F	10	Human, Under Investigation	Clay Creek, MT	Yes	No	PRIV

[1]The recovery plan (USFWS 1993) specifies that human-caused mortality or female with young sightings from Canada will not be counted toward recovery goals in the CYGBRZ. BC – British Columbia, MRL – Montana Rail Link, PRIV – Individual Private, PCT – Plum Creek Timber Company, USFS – U.S. Forest Service.
[2]Bears transplanted to the Cabinet Mountains under the population augmentation program were counted as mortalities in their place of origin and are not counted toward recovery goals in this recovery zone.
[3]Bear Killed more than 10 miles outside recovery zone in the US and not counted in recovery calculations.

Table 2. Credible grizzly bear sightings, credible female with young sightings, and known human caused mortality by bear management unit (BMU) or area, 2020.

BMU OR AREA	2020 Credible Grizzly Bear Sightings	2020 Sightings of Females with Cubs (Total)	2020 Sightings of Females with Cubs (Unduplicated)	2020 Sightings of Females with Yearlings or 2-year-olds (Total)	2020 Sightings of Females with Yearlings or 2 year-olds (unduplicated)	2020 Human Caused Mortality
1	1	0	0	0	0	0
2	2	0	0	0	0	0
3	0	0	0	0	0	0
4	2	1	1	0	0	0
5	7	1	1	3	1	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	1	0	0	0	0	0
10	0	0	0	0	0	0
11	9	1	0	3	0	1
12	9	2	1	0	0	0
13	10	2	1	1	1	1
14	2	1	0	1	0	0
15	2	1	0	1	0	0
16	4	0	0	1	0	0
17	1	0	0	1	1	0
18	0	0	0	1	0	0
19	1	0	0	0	1	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
BC Yahk GBPU	1	0	0	1	0	1
Cabinet Face	2	2	0	0	0	0
Deer Ridge	2	1	0	0	0	0
Fisher	1	0	0	0	0	0
South Clark Fork	0	0	0	0	0	0
Troy	2	0	0	0	0	0
West Kootenai	4	2	1	0	0	0
2020 TOTAL	63	14	5	13	4	3

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see methods).
[2]Sightings may duplicate the same animal in different locations. Only the first sighting of a duplicated female with cubs is counted toward total females (Table 3), however subsequent sighting contribute toward occupancy (Table 8).
[3]Areas in Canada outside of Cabinet-Yaak recovery zone that do not count toward recovery goals.
[4]Areas with portions <16 km outside the Cabinet-Yaak recovery zone that do not count toward recovery goals.

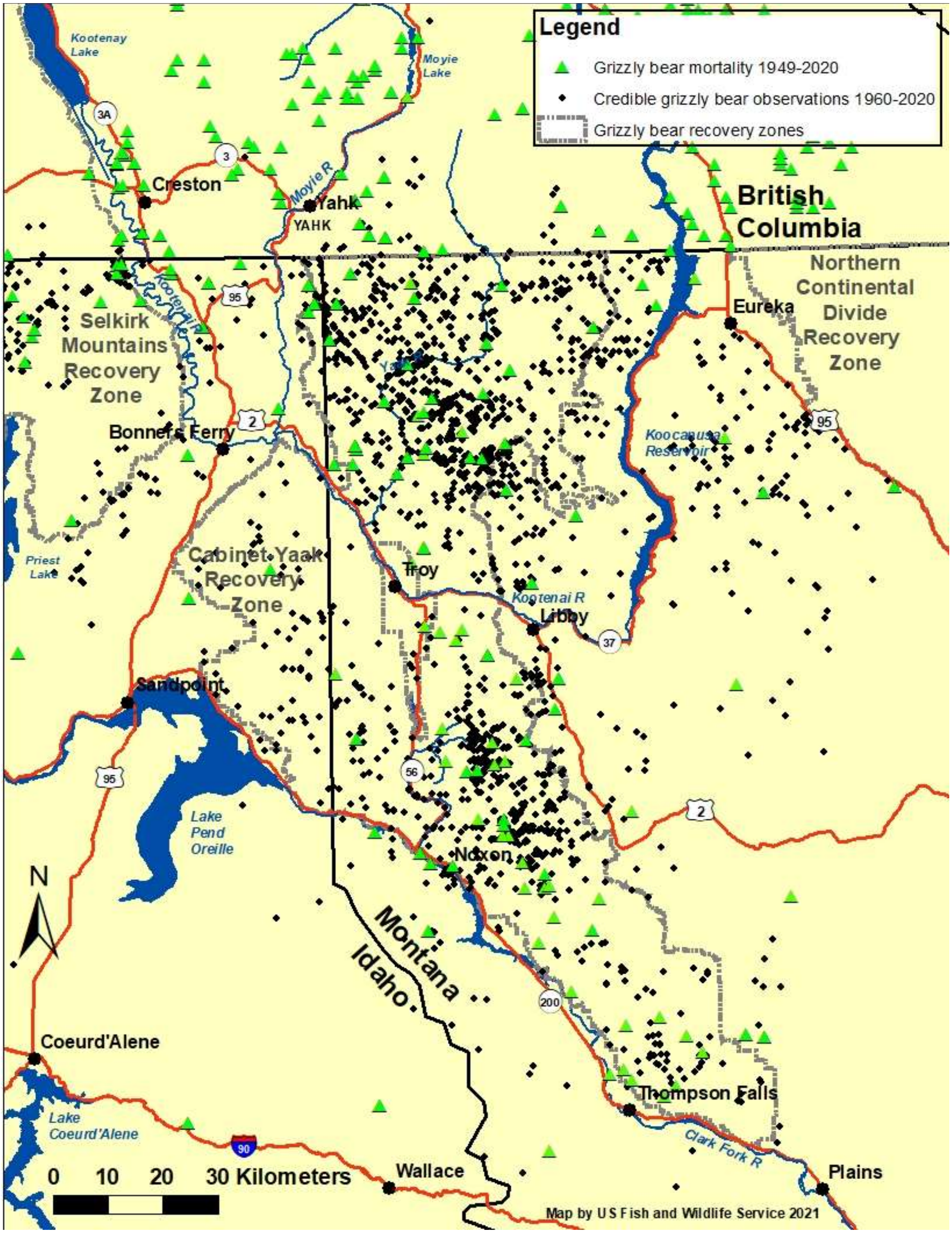

Figure 3. Grizzly bear observations (1959–2020) and known or probable mortalities from all causes (1949–2020) in and around the Cabinet-Yaak recovery area.

Table 3. Status of the Cabinet-Yaak recovery zone during 2015–2020 in relation to the demographic recovery targets from the grizzly bear recovery plan (USFWS 1993).

Recovery Criteria	Target	2015–2020
Females w/cubs (6-yr avg)	6	3.3 (20/6)
Human Caused Mortality limit (4% of minimum estimate)[1]	2.1	1.5 (6 yr avg)
Female Human Caused mortality limit (30% of total mortality)[1]	0.6	0.5 (6 yr avg)
Distribution of females w/young	18 of 22	13 of 22

[1] The grizzly bear recovery plan states "Because of low estimated population and uncertainty in estimates, the current human-caused mortality goal to facilitate recovery of the population is zero. In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem".

Table 4. Annual Cabinet-Yaak recovery zone (excluding Canada) grizzly bear unduplicated counts of females with cubs (FWC's) and known human-caused mortality, 1993–2020.

YEAR	ANNUAL FWC'S	ANNUAL HUMAN CAUSED ADULT FEMALE MORTALITY	ANNUAL HUMAN CAUSED ALL FEMALE MORTALITY	ANNUAL HUMAN CAUSED TOTAL MORTALITY	4% TOTAL HUMAN CAUSED MORTALITY LIMIT[1]	30% ALL FEMALE HUMAN CAUSED MORTALITY LIMIT[1]	TOTAL HUMAN CAUSED MORTALITY 6 YEAR AVERAGE	FEMALE HUMAN CAUSED MORTALITY 6 YEAR AVERAGE
1993	2	0	0	0	0.9	0.3	0.5	0.3
1994	1	0	0	0	0.9	0.3	0.3	0.2
1995	1	0	0	0	0.9	0.3	0.2	0.0
1996	1	0	0	1	0.7	0.2	0.2	0.0
1997	3	0	0	1	1.2	0.4	0.3	0.0
1998	0	0	0	0	0.9	0.3	0.3	0.0
1999	0	0	0	1	0.7	0.2	0.5	0.0
2000	2	0	1	1	0.5	0.1	0.7	0.2
2001	1	1	2	2	0.5	0.1	1.0	0.5
2002	4	1	4	4	1.2	0.4	1.5	1.2
2003	2	0	0	0	1.2	0.4	1.3	1.2
2004	1	0	0	0	1.4	0.4	1.3	1.2
2005	1	0	2	4	0.9	0.3	1.8	1.5
2006	1	0	0	0	0.7	0.2	1.7	1.3
2007	4	1	1	1	1.2	0.4	1.5	1.2
2008	3	0	0	1	1.6	0.5	1.0	0.5
2009	2	1	1	1	1.6	0.5	1.2	0.7
2010	4	0	0	1	1.9	0.6	1.3	0.7
2011	1	0	0	4	1.4	0.4	1.3	0.3
2012	3	1	1	2	1.6	0.5	1.7	0.5
2013	2	0	0	0	1.2	0.4	1.5	0.3
2014	3	0	0	1	1.6	0.5	1.5	0.3
2015	2	0	0	3	1.6	0.5	1.8	0.2
2016	3	0	0	0	1.9	0.6	1.7	0.2
2017	3	0	0	0	1.9	0.6	1.0	0.2
2018	5	1	2	4	2.3	0.7	1.3	0.3
2019	2	1	1	2	1.9	0.6	1.7	0.5
2020	5	1	1	2	2.1	0.6	1.5	0.5

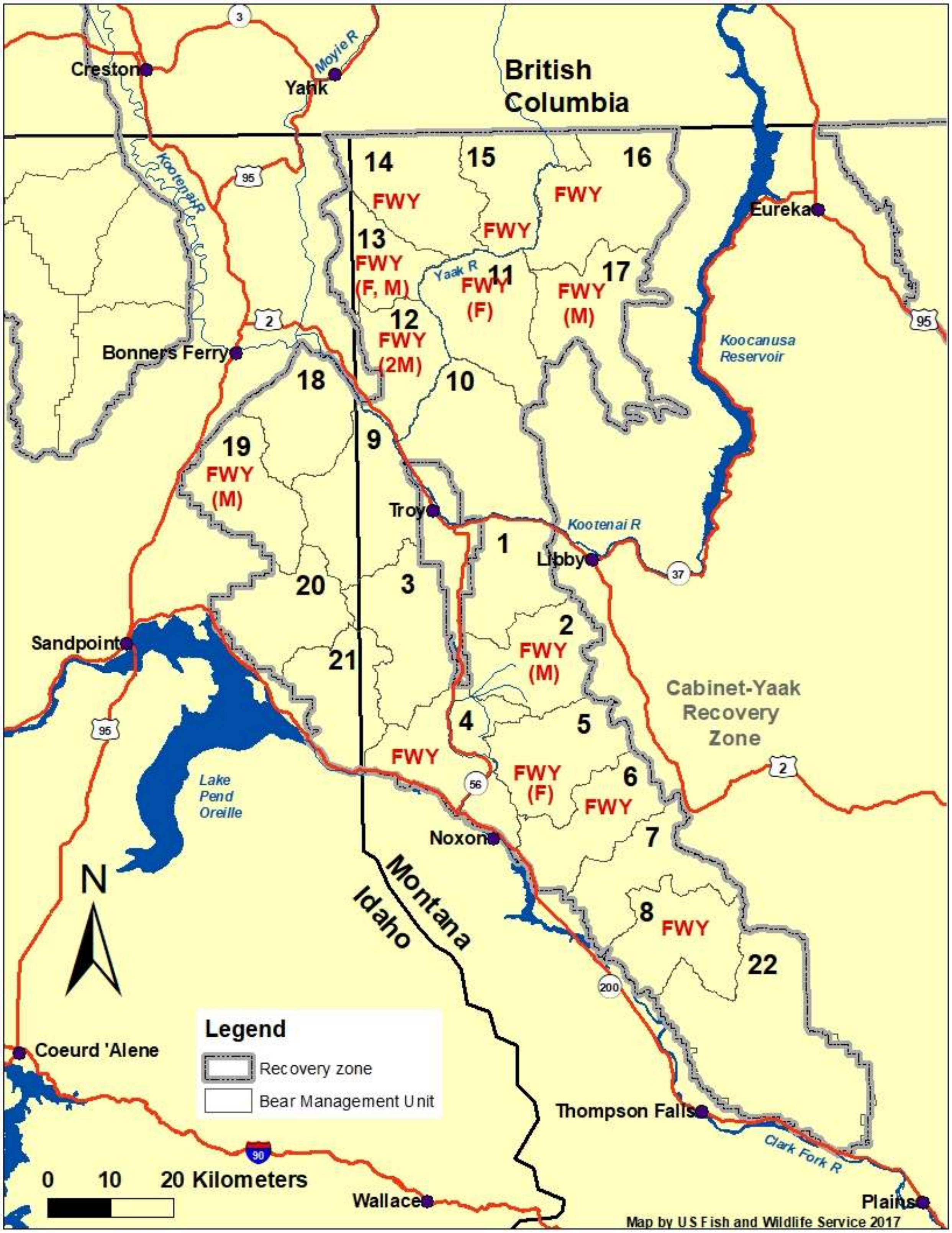

Figure 4. Female with young occupancy and known or probable mortality within Bear Management Units (BMUs) in the Cabinet-Yaak recovery zone 2015–2020. (FWY is occupancy of a female with young and sex of any mortality is in parentheses).

Table 5. Credible observations of females with young in or within 10 miles of the Cabinet-Yaak recovery zone, 1988–2020. Canadian credible observations shown in parentheses.

Year	Total credible[1] sightings females with young	Unduplicated females with cubs	Unduplicated females with yearlings or 2-year-olds	Unduplicated adult females without young	Minimum probable adult females[2]
1990	9	1	2	0	3
1991	4	1	1	1	2
1992	8	1	5	1	6
1993	6	2	1	0	3
1994	5	1	2	0	3
1995	8	1	2	0	3
1996	5	1	1	0	2
1997	14 (1)	3	4	0	7
1998	6 (1)	0	2 (1)	2	2 (1)
1999	2	0	2	3	2
2000	6 (1)	2 (1)	1	0	3 (1)
2001	5 (2)	1 (1)	3	0	4 (1)
2002	10 (1)	4 (1)	1	0	5 (1)
2003	11	2	4	0	6
2004	11	1	4	0	5
2005	10 (1)	1	4 (1)	1	5 (1)
2006	7 (1)	2 (1)	2	1	4 (1)
2007	17	4	2	2	6
2008	7 (1)	3 (1)	3	1	6 (1)
2009	5 (0)	2 (0)	2 (0)	1	4 (0)
2010	14 (0)	4 (0)	2 (0)	1	6 (0)
2011	4 (0)	1 (0)	1 (0)	1	2 (0)
2012	12 (0)	3 (0)	3 (0)	0	6 (0)
2013	9 (0)	2 (0)	5 (0)	0	7 (0)
2014	20 (1)	3 (0)	3 (0)	1	7 (0)
2015	19 (1)	2 (0)	5 (0)	2	9 (0)
2016	11 (0)	3 (0)	3 (0)	2	8 (0)
2017	8 (0)	3 (0)	3 (0)	2	8 (0)
2018	20 (0)	5 (0)	2 (0)	1	8 (0)
2019	10 (0)	2 (0)	5 (0)	1	8 (0)
2020	14 (1)	5 (0)	4 (0)	1	10 (0)

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see page 8).
[2]Minimum does not count females detected by mortality.

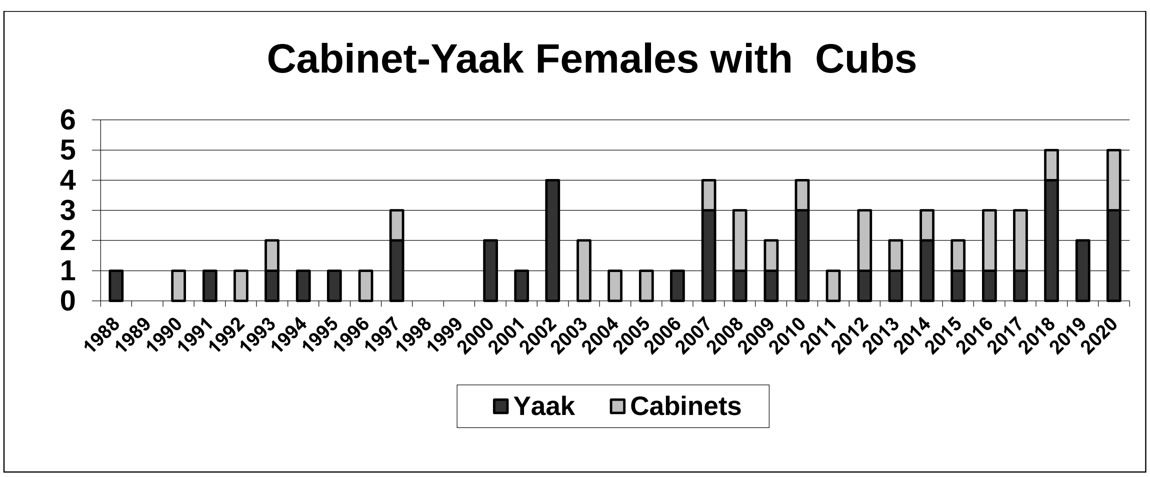

Figure 5. Credible observations of females with cubs in or within 10 miles of the Cabinet-Yaak recovery zone (excluding Canada), 1988–2020. Credible sightings rated 4 or 5 on a 5 point scale.

Table 6. Occupancy of bear management units by grizzly bear females with young in the Cabinet-Yaak recovery zone 1990–2020.

	1 - CEDAR	2 - SNOWSHOE	3 - SPAR	4 - BULL	5 - ST. PAUL	6 - WANLESS	7 - SILVER BUTTE	8 - VERMILION	9 - CALLAHAN	10 - PULPIT	11 - RODERICK	12 - NEWTON	13 - KENO	14 - NW PEAK	15 - GARVER	16 - E FORK YAAK	17 - BIG CREEK	18 - BOULDER	19 - GROUSE	20 - N LIGHTNING	21 - SCOTCHMAN	22 - MT HEADLEY
1988	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
1989	N	N	N	Y	N	N	Y	N	N	N	Y	N	Y	Y	Y	N	N	N	N	N	N	N
1990	N	Y	N	N	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	N	N	N	N	N	Y
1991	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1992	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	Y	N	N
1993	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
1994	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N
1995	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	N
1996	N	N	N	N	N	Y	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N
1997	N	Y	N	Y	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	N	N	N	N	Y	N
1998	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N
1999	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N
2000	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2001	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	Y	N	N	N	N	N
2002	N	Y	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	N	N
2003	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	Y	N
2004	N	Y	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
2005	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
2006	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
2007	N	N	Y	Y	Y	Y	N	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2008	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
2009	N	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
2010	N	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N
2011	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	N	N	N
2012	N	Y	N	N	Y	N	N	N	N	N	Y	N	N	N	N	Y	Y	N	N	N	N	N
2013	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	Y	Y	Y	Y	N	N	N	N	N
2014	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N
2015	N	N	N	N	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N
2016	N	N	N	N	Y	N	N	Y	N	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N
2017	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
2018	N	N	N	N	Y	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N
2019	N	N	N	Y	Y	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N
2020	N	Y	N	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N

Cabinet Mountains Population Augmentation

No bears were transported into the Cabinet Mountains during 2020. None of the bears captured in the Flathead drainage met our criteria for suitable candidate bears. One captured female had a conflict history that made her unsuitable.

Three bears were monitored during 2020, including a two year-old male released in 2018, a two year-old female released in 2019, and a three year-old male also released in 2019.

Bear 927was released in 2018 and monitored through early August of 2020. He was released in the West Cabinet Mountains but moved south of the Clark Fork River in July before being photographed at a black bear bait site on private property in late August of 2018. Landowner concerns prompted Idaho Fish and Game to capture the bear and it was released in the East Cabinet Mountains near the Wilderness. The bear returned to the area south of the Clark Fork River but did not revisit the bait site and spent most of September and October in Montana where black bear baiting is not allowed. The bear moved north of the Clark Fork River in November and denned in the West Cabinet Mountains in 2018. In late March of 2019, he emerged from his den and moved south, crossing the Clark Fork River in late April. He continued south crossing Interstate 90 (I-90) in early June and US Highway 12 in early July. He spent much of July, August, and early September in the Selway Bitterroot Wilderness before returning to the Cabinet Mountains Wilderness where he denned in mid-December (Figure 6). This is the first confirmed instance of a grizzly bear in the Selway-Bitterroot Wilderness in over 50 years. He emerged from his den in April of 2020 and moved northeast into the Whitefish Range east of Eureka, MT where he spent the summer prior to losing his radio collar in early August. The collar was retrieved and downloaded to provide some additional location data that was not transmitted through the Iridium system. One of the major features crossed during his movements south and north was the crossing of I-90. On the southbound leg of his route, he crossed this divided highway about 1 km east of DeBorgia, MT and on the northbound leg crossed approximately 4 km west of St. Regis, MT. Both crossings appeared to occur in an area of the divided highway where vegetation occurred in the median between the two lanes of traffic providing some degree of cover. Both crossings occurred during the hours of darkness.

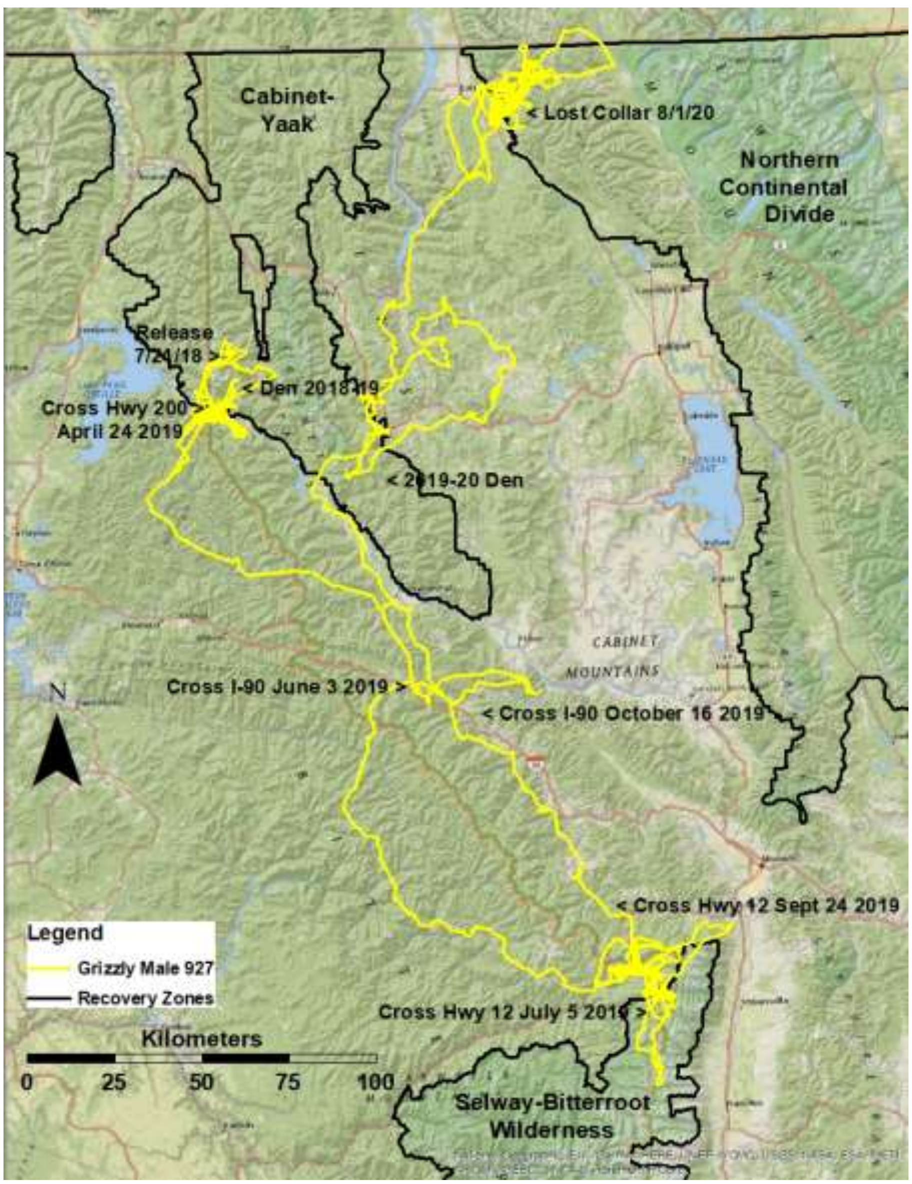

Figure 6. Movements of male augmentation bear 927, 2018-2020.

The female released in 2019 remained in the West Cabinet Mountains prior to denning approximately 4 miles west of her release site. During 2020 she continued her movement patterns in the West Cabinet Mountains on both side of the Idaho and Montana border. The male bear released in 2019 initially moved north and spent much of the summer just north of the Kootenai River before returning to the West Cabinets in early October. The bear was observed numerous times by landowners northwest of Clark Fork, ID, before moving to the Cabinet Mountains Wilderness to den in mid-December of 2019. After his emergence in 2020 he was sighted by several residents in the Lake Creek drainage before moving north and once again crossed the Kootenai River and then Koocanusa Reservoir while moving to the east through the Salish Range. In early June he was shot and killed at a farm northwest of Whitefish, MT. That incident is under investigation.

In summary, four female grizzly bears were captured in the Flathead River of British Columbia and released in the Cabinet Mountains from 1990–1994 (Table 7). Twenty-two different grizzly bears were captured during 840 trap-nights to obtain the 4 subadult females. Capture rates were 1 grizzly bear/38 trap-nights and 1 suitable subadult female/210 trap-nights. One transplanted bear and her cub died of unknown causes one year after release. The remaining three bears were monitored until collars dropped. The program was designed to determine if transplanted bears would remain in the target area and ultimately contribute to the population through reproduction. Three of four transplanted bears remained in the target area for more than one year. One of the transplanted bears produced a cub but had likely bred prior to translocation and did not satisfy our criteria for reproduction with resident males. One other female was known to have reproduced. In 2005 the augmentation program was reinitiated through capture by MFWP personnel and monitoring by this project. During 2005–2020, 10 female and 8 male grizzly bears were released in the Cabinet Mountains (Table 7).

Of 22 bears released through 2020, eight are known to have left the target area (one was recaptured and brought back, two returned in the same year, and one returned a year after leaving), three were killed within 4 months of release, one was killed within 10 months of release, and one was killed 16 years after release. One animal was known to have produced at least 10 first-generation offspring, 16 second-generation offspring, and one third-generation offspring. Another female was known to have produced three offspring and a male was known to have produced one offspring. See the genetic results portion of this report for more details.

Table 7. Sex, age, capture date, capture location, release location, and fate of augmentation grizzly bears moved to the Cabinet Mountains, 1990–2020.

Bear	Sex	Age	Capture date	Capture Location	Cabinet Mtns Release Location	Fate
218	F	5	7/21/1990	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1990, Lost collar Aug. 1991, observed July 1992.
258	F	6	7/21/1992	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1992 Produced 1 cub 1993, Natural mortality July 1993.
286	F	2	7/14/1993	NF Flathead R, BC	EF Bull River	Den Cabinet Mtns 1993–95 Lost collar at den Apr. 1995, hair snag 2004–2009, self-defense mortality November 2009.
311	F	3	7/12/1994	NF Flathead R, BC	EF Bull River	Lost collar July 1994, recaptured Oct. 1995 south of Eureka, MT, released EF Bull River, Signal lost Nov. 1995.
A1	F	7-8	9/30/2005	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2005–06, Lost collar Sept. 2007.
782	F	2	8/17/2006	SF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2006–07, Lost collar Aug. 2008.

Bear	Sex	Age	Capture date	Capture Location	Cabinet Mtns Release Location	Fate
635	F	4	7/23/2008	Stillwater R, MT	EF Bull River	Killed by train near Heron, MT Oct. 2008.
790	F	3	8/7/2008	Swan R, MT	EF Bull River	Illegally killed near Noxon, MT Oct. 2008.
715	F	10	9/17/2009	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2009–10, returned to NF Flathead R, May 2010. Lost collar June 2010.
713	M	5	7/18/2010	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2010, Lost collar Sept. 2011.
714	F	4	7/24/2010	NF Flathead R, MT	Silverbutte Cr	Returned to NF Flathead July 2010. Lost collar Oct. 2013.
725	F	2	7/25/2011	MF Flathead R, MT	Spar Lake	Moved to Glacier National Park, Sept. 2011 den, returned to Cabinet Mtns Aug. 2012 and den, moved to Glacier National Park and returned to Cabinet Mtns, lost collar Oct. 2013
723	M	2	8/18/2011	Whitefish R, MT	Spar Lake	Den Cabinet Mtns 2011. Lost collar June 2012.
918	M	2	7/6/2012	Whitefish R, MT	EF Bull River	Den Cabinet Mtns 2012-–13. Lost collar Oct. 2014.
919	M	4	7/30/2013	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2013. Lost collar Aug. 2014.
920	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2014–15.
921	F	2	6/18/2014	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2014. Died of unknown cause May 2015.
924	M	2	7/25/2015	SF Flathead R, MT	Spar Lake	Mistaken identity mortality Sept. 2015
926	M	3	7/25/2016	SF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2016. Lost collar July 2017
927	M	2	7/20/2018	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2018 and Cabinet Mtns 2019, lost collar August 2020
923	F	2	7/12/2019	NF Flathead R, MT	Spar Lake	Den West Cabinet Mtns 2019 and 2020
892	M	3	7/14/2019	NF Flathead R, MT	Spar Lake	Den Cabinet Mtns 2019, killed June of 2020 near Whitefish, MT

Cabinet-Yaak Hair Sampling and DNA Analysis

Hair snag sampling occurred at barb wire corrals baited with a scent lure during 2000–2020 (Table 8 and Fig. 7). Sampling occurred from May–October but varied within years. Sites were selected based on prior grizzly bear telemetry, sightings, and access. Remote cameras supplemented hair snagging at most sites and were useful in identifying family groups and approximate ages of sampled bears. Genetic analysis from 2020 field collected samples is not yet complete; we will report on these results in the 2021 report. In 2002, study personnel assisted a MFWP black bear population estimate effort that sampled 285 sites in the Yaak River portion of the CYE. During 2003, 184 sites on a 5 km^2 grid were sampled on 4,300 km^2 in the Cabinet Mountains portion of the CYE. In 2009, 98 sites were sampled south of the Clark Fork River. In 2012, United States Geological Survey (USGS) researchers completed an ecosystem-wide mark-recapture population estimate using DNA from hair collected at more than 850 corrals. Other years had much lower numbers of sampled sites. Collectively, USFWS, USGS, and MFWP crews have sampled 2,085 corral traps from 2000–2020 (Table 8 and Fig. 7). Through 2019, corral traps alone were successful during six percent of site visits and provided hair from at least 74 grizzly bears.

Table 8. Hair snagging corrals and success in the Cabinet-Yaak study area, 2000–2020. DNA genetic results not yet complete for 2020 samples.

Year	Number of corral sessions[1]	Sessions with grizzly bear DNA(%[2])	Sessions with grizzly bear photos or DNA(%[2])	Individual grizzly bear genotypes	BMUs with grizzly bear pictures or hair	Comments
2000	1	0	0	0		
2001	3	0	0	0		
2002	319	9 (3)	10 (3)	9	BMUs 2, 5, 6, 12, 14, 16, 17	
2003	184	1 (1)	1 (1)	1	BMUs 5, 6	
2004	14	2 (14)	2 (14)	3	BMU 5	
2005	17	1 (6)	2 (12)	1	BMU 5	
2006	19	3 (16)	3 (16)	3	BMUs 3, 5, 7	
2007	36	4 (11)	5 (14)	9	BMUs 5, 11, 13	Female with young BMU 5
2008	21	1 (5)	1 (5)	1	BMU 5	
2009	125	2 (2)	4 (3)	4	BMUs 5, 6, 9	Female with young BMU 5
2010	27	3 (11)	4 (15)	5	BMUs 3, 5, 6	Female with young BMU 5
2011	72	9 (13)	12 (17)	13	BMUs 3, 4, 5, 6, 11, 13, 14, 15, 16, 17	Female with young BMU 16
2012	854	48 (6)	48 (6)	29	BMUs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20	
2013	5	2 (40)	2 (40)	2	BMUs 2, 3, 5, 6, 7, 11, 13, 14, 15, 16, 17	Female with young BMU 6
2014	41	3 (7)	8 (7)	4	BMUs 1, 2, 3, 5, 6, 11, 12, 13, 14, 15, 16, 17, 19	Female with young BMU 13
2015	72	5 (7)	12 (17)	7	BMUs 2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 15, 16, 17	Female with young BMU 13 Female with cubs BMU 5
2016	39	6 (15)	9 (23)	10	BMUs 2, 3, 5, 6, 7, 10, 11, 13, 14, 15, 16, 17, 19	Female with young BMU 13, 5 Female with cub BMU 16
2017	92	18 (20)	18 (20)	18	BMUs 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17	Female with cubs BMU 5 Female with young BMU 5
2018	55	13 (24)	16 (29)	17	BMUs 1, 2, 3, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17	Female with cubs BMU 5, 13, 14 Female with young BMU 6
2019	49	6(12)	11 (22)	6	BMUs 4, 5, 6, 8, 10, 13	Female with young BMU 13
2020	40	--	13 (33)[3]	--	BMUs 5, 11, 12, 13, 14, 16	Female with cubs BMU 12 Female with young BMU 11,13, 16
Total	2085	136 (7)	181 (9)	74[4]		

[1]Some corral sites were deployed for multiple sessions per year. A "session" is typically 3-4 weeks long and defined as the interval between site set-up and revisits to collect samples and photos.
[2]Percent success at all corral sessions
[3]Sites with photos only. Awaiting 2020 genetic results.
[4]Some individuals captured multiple times among years.

In 2020, we collected 415 samples from 453 visits to 346 individual rub trees (Table 9). Samples were evaluated during cataloging and 269 were judged to be black bears (based on solid black coloration), leaving 146 to be sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Lab analysis on 2020 samples is still in progress, and we will report on results in the 2021 report. From 2013–2019, we genetically identified 79 individual grizzly bears (50 males, 29 females) from 15,803 samples collected via rub effort alone.

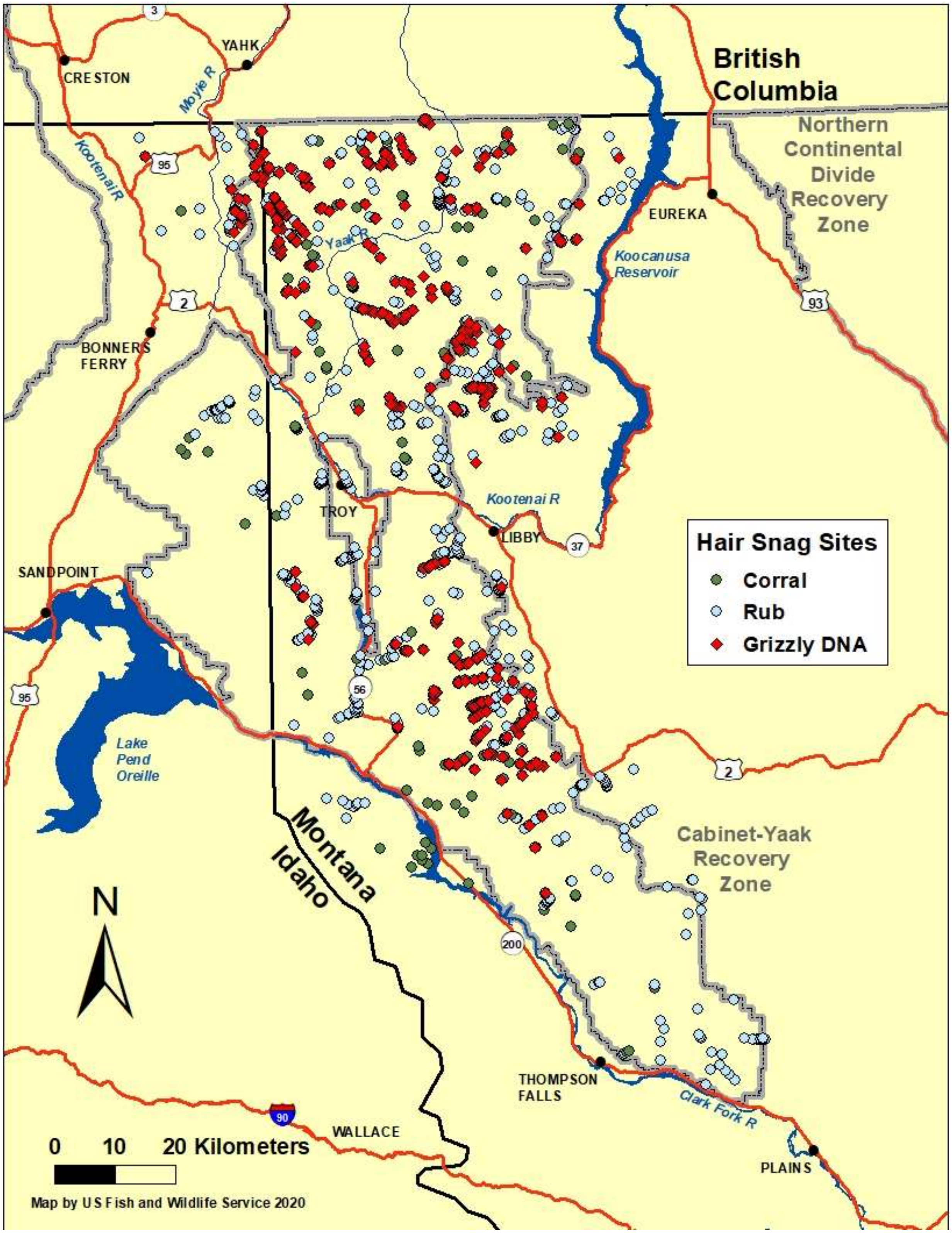

Figure 7. Location of hair snag sample sites in the Cabinet-Yaak Ecosystem study area, 2013–2020. Sites with grizzly bear DNA are identified (2013–2019).

Table 9. Grizzly bear hair rubs and success in the Cabinet-Yaak study area, 2012–2020.

Year	Number of rubs checked[4]	Number of samples collected (%GB[1])	Number of samples sent to Lab (%GB[1])	Number of rubs with grizzly DNA	Individual grizzly bear genotypes	Males	Females
2012[2]	1376	8356 (2)	4639 (3)	85	33	19	14
2013	488	1038 (6)	480 (12)	33	17	9	8
2014	583	1894 (7)	708 (19)	50	24	14	10
2015	693	2258 (6)	617 (22)	76	30	20	10
2016	780	3781 (5)	1049 (19)	90	29	18	11
2017	836	2958 (13)	676 (55)	147	38	24	14
2018	782	2267 (8)	481 (38)	96	37	23	14
2019	845	2167 (7)	440 (33)	85	30	25	5
2020	346	415 (--)	146 (--)	--	--	--	--
Total[3]	1696[4]	24719 (6)	9090 (15)	334[4]	87[5]	57[5]	30[5]

[1] Percentage of samples yielding a grizzly bear DNA genotype.

[2] 2012 results from USGS population estimation study (Kendall et al. 2016). 2013-20 efforts are from USFWS coordinated efforts.

[3]Totals are through 2019. 2020 genetic results from the lab are not yet complete.

[4] Unique rub locations. Some rub locations visited multiple times among years.

[5]Some individuals captured multiple times among years.

Grizzly Bear Genetic Sample Summary

We provide data leading up to and including 2019 as 2020 sample results have not been completed by the laboratory. Using all methods (capture, collared individuals, all sources of DNA sampling, photos, credible observations), we detected a minimum of 50 individual grizzly bears alive and in the CYE grizzly bear population at some point during 2019. Five of these bears were known dead by end of 2019. Twenty-three bears were detected in the Cabinets (16 male, 7 female). Twenty-seven bears were detected in the Yaak (16 male, 7 female, 4 unknown sex).

Captures, genotypes, and observations of grizzly bears by study personnel in the CYE study area were summarized during 1986–2019. Individuals not radio-collared or genotyped were conservatively separated by size, age, location, coloration, or reproductive status. Conservative classification of sightings may result in unique individuals being documented as one individual. Individual status or relationships may change with new information.

Two hundred twenty-one individuals were identified within the CYE study area during 1986–2019 (192 bears captured or genotyped and 29 unmarked individuals observed). Fifty were known to be alive during 2019.

We determined parent-offspring relationships of Yaak grizzly bears using sample genotypes from 1986–2019. A majority of our detected sample in the Yaak descends from female grizzly bear 106 (Figure 8). She produced five known litters, and her matrilines tie to 58 known first, second, and third generation offspring. In 2018, we identified her first fourth generation offspring, male Y38004M, presumed dead in 2019. In 2019, two more fourth generation cubs were detected (cub-of-the-year offspring of female 842). Both died in 2019 (natural mortality). Since 1986, we have genetically detected 41 female grizzly bears in the US Yaak and BC Yahk, 28 (68%) of which are direct maternal descendants of bear 106. Since 2014, all female bears detected in the US Yaak are her maternal descendants. In 2015–2019, we detected 1 daughter, 7 granddaughters, and 5 great-granddaughters of 106.

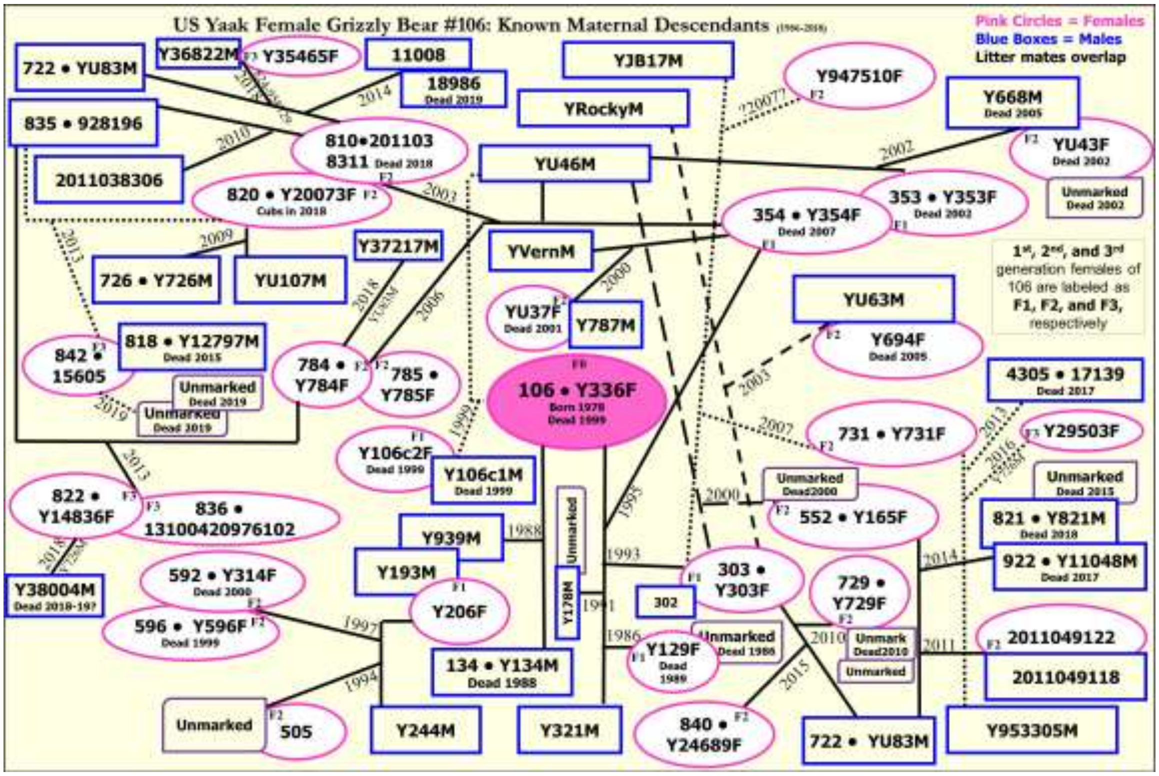

Figure 8. Most likely pedigree displaying matrilineal ancestry of female grizzly bear 106 in the Yaak River, 1986–2019. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 the first generation, F2 the second generation, and F3 the third generation. Numbers along lines indicate when the descendant litter was produced.

Claws from a grizzly bear were discovered in Baree Creek of the Cabinet Mountains in 1993. Analysis of DNA from these claws matched bear 678 originally captured in the Cabinet Mountains in 1983 when 28 years old. Tissue present on the claws suggested that she died no earlier than 1992. Bear 678 would have been at least 37 years old at the estimated time of death. Pedigree analysis also indicated that the three bears captured in the Cabinet Mountains from 1983–1988 were a triad with bear 680 being the offspring of bears 678 and 14.

The Cabinet Mountains population was estimated to be 15 bears or fewer in 1988 on the basis of independent tracks, sightings, and expert opinion (Kasworm and Manley 1988). However, lack of resident bears identified since 1989 suggests the population was well below 15 individuals. Genetic samples from the Cabinet Mountains (1983–2019) were determined to originate from 76 different grizzly bears. Three of these were from captures during 1983–1988, 21 were from augmentation bears during 1990–2019 (1 augmentation bear 218 genetically unmarked), and 54 from captures, mortalities, or hair snagging during 1997–2019.

One of these genotypes identified by hair snagging was from grizzly bear 286. She was released in the Cabinet Mountains as part of population augmentation in 1993 as a 2-year-old (Kasworm *et al*. 2007). She was 13 years old when the first hair sample was obtained during 2004. Pedigree analysis indicates she has produced at least 10 first generation offspring, 22 second generation offspring, and 4 third generation offspring. Six of those first-generation offspring were females, and all 6 are known to have reproduced (Fig. 9). Bear 286 was killed in a self-defense incident with a hunter in November of 2009.

The augmentation effort appears to be the primary reason grizzly bears remain and are increasing in the Cabinet Mountains. Only 15 genotyped bears not known to be augmentation bears or their offspring have been identified in the Cabinet Mountains since 1990 and seven are known dead. The following describes each individual and fate. Two are adult males that bred with 286 to produce first generation of augmentation offspring. Four are a family group (adult female with 3 cubs) identified south of the Clark Fork River in 2002. The adult female and one of the young are known dead. Three are males with past human-bear conflict histories in the Northern Continental Divide population (NCDE) to the northeast and subsequently traveled to the CYE in 2014–2018, including: 1) an adult male killed in self-defense in the Little Thompson River in 2014, 2) a subadult male caught in Flathead Valley in spring of 2016, traveled to Cabinets fall 2016 or spring 2017, and traveled back toward NCDE and died by poaching in May 2017, 3) subadult male caught spring 2018 between the NCDE and Cabinets, relocated into the Yaak and soon thereafter died by human-cause (under investigation) in May 2018. One bear was a subadult male captured near Thompson Falls in 2011 in an incident involving livestock depredation, unknown status thereafter. Two bears were male migrants from the Selkirk Mountains: 1) identified in 2012, who is now known to have moved back to the Selkirks before breeding, has bred and remains in Selkirks in 2018, 2) a collared subadult male with movement in 2018 but lost collar in fall 2018. One bear was a subadult male migrant from the NCDE with no conflict history, caught in 2019 in Cabinets, and spent much time in the Salish range before casting collar, fate unknown. The remaining two bears were adult males born in 2008 and 2009 in the Yaak and identified in the Cabinets in 2016 and 2019.

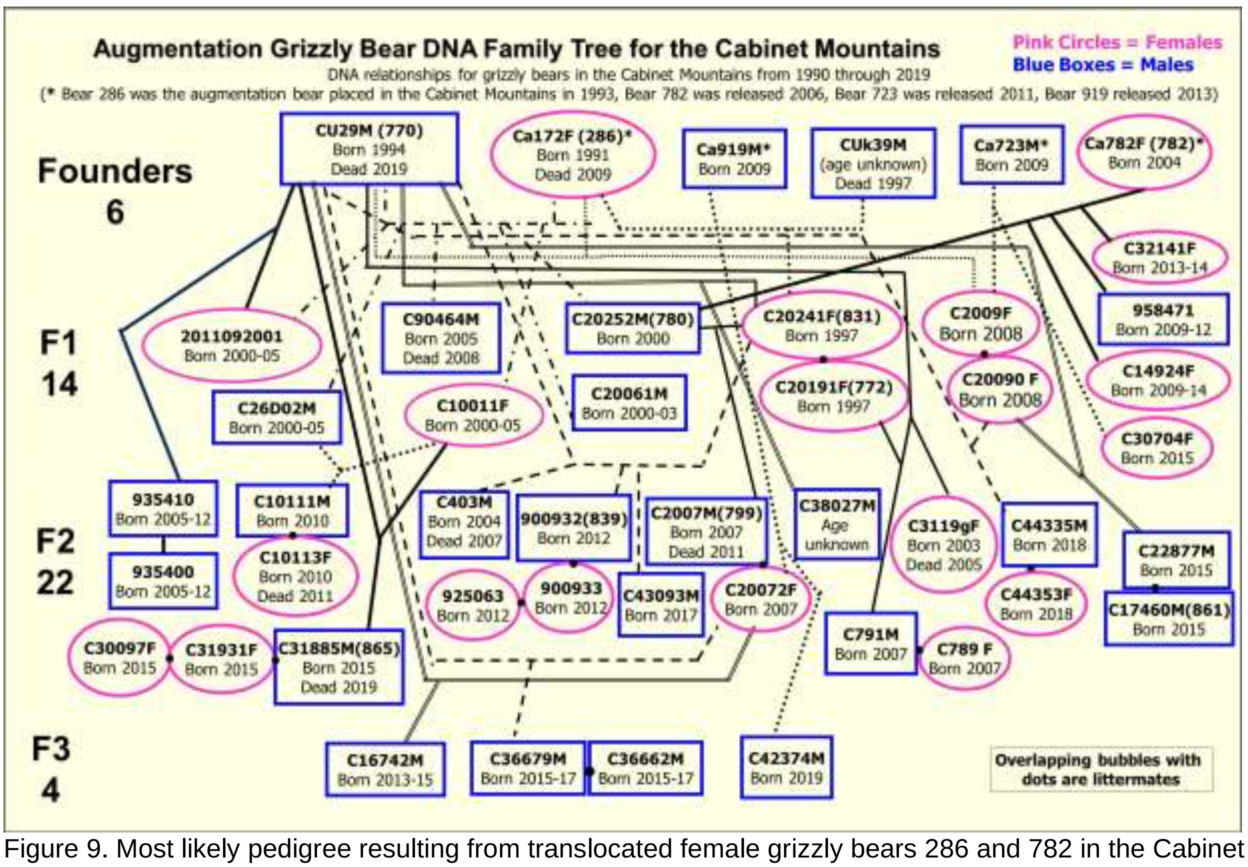

Figure 9. Most likely pedigree resulting from translocated female grizzly bears 286 and 782 in the Cabinet Mountains, 1993–2019. Squares indicate males and circles represent females. Lines indicate a parent-offspring relationship. F0 is the initial generation, F1 is the first generation of offspring for translocated females 286 or 782 and male 723, F2 is the second generation and F3 is the third generation.

Grizzly Bear Movements and Gene Flow Within and Between Recovery Areas

Population linkage is a goal of the CYE recovery plan (USFWS 1993). The population goal of approximately 100 animals requires genetic connectivity to maintain genetic health over time. Movement data from telemetry or genetic methods may be a precursor of linkage, but gene flow through reproduction by immigrant individuals is the best measure of connectivity.

Capture, telemetry, and genetic data were analyzed to evaluate movement and subsequent reproduction resulting in gene flow into and out of the CYE. Forty-one grizzly bears were identified as immigrants, emigrants, or offspring of immigrants to the CYE from 1983–2019 (Appendix Table T4). While movement and gene flow out of the CYE may benefit other populations, gene flow into the CYE is most beneficial to genetic health. Seventeen individuals (14 males and 3 females) are known to have moved into the CYE from adjacent populations; however, eight of these were killed, removed, or emigrated out of the CYE prior to any known gene flow (Figure 10). Ten of these immigrants originated from the North Purcells (3 known mortalities), five from the NCDE (three known mortalities), and two from the South Selkirks (one known mortality). Gene flow has been identified through reproduction by three immigrants from the North Purcells (two males and one female) resulting in 4 offspring in the CYE.

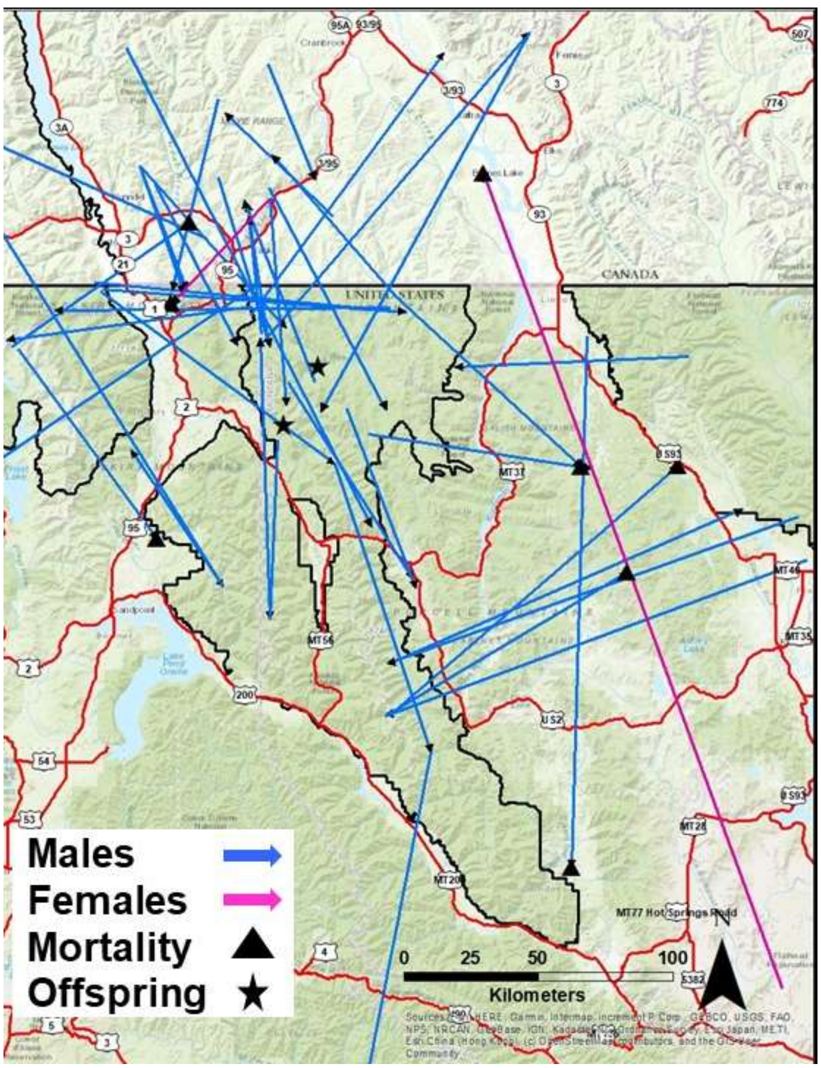

Figure 10. Known immigration or emigration events (blue and pink lines) and gene flow (black stars) in the Cabinet-Yaak, 1988–2020

Known Grizzly Bear Mortality

There were three instances of known or probable grizzly bear mortality in or within 16 km of the CYE (including BC) during 2020 (one subadult male and two adult females). The subadult male mortality was the result of mistaken identity by a black bear hunter. This animal had a wire neck snare around the neck that may have ultimately killed the bear later in life. One adult female died as a result of self-defense (BC) and another is human caused, but under investigation. Two cubs classified as mortalities in 2018 when their mother was killed, were removed from the mortality list after it was determined that they survived into 2019 based on photographic and genetic evidence. Sixty-four instances of known and probable grizzly bear mortality from all causes were detected inside or near the CYE (excluding Canada) during 1982–2020 (Tables 1 and 10, Fig. 11). Forty-six were human caused, 15 were natural mortality, and 3 were unknown cause. There were 19 instances of known grizzly bear mortality in Canada within 16 km of the CYE in the Yahk and South Purcell population units from 1982–2020 (Tables 1 and 10, Fig. 11). Fourteen were human-caused and 5 were natural mortalities.

Table 10. Cause, timing, and location of known and probable grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada), 1982–2020. Radio collared bears included regardless of mortality location.

	Mortality cause											
Country/ age / sex / season / ownership	Defense of life	Legal Hunt	Hound hunting	Management removal	Mistaken identity	Natural	Poaching	Trap predation	Vehicle collision	Unknown, human	Unknown	Total
U.S.												
Age / sex												
Adult female	4					2	1		1	3	1	12
Subadult female						1	1	1	2	3		8
Adult male	2			2	1		2			4		11
Subadult male	2				5		2			4	1	14
Yearling					1	1					1	3
Cub					1	9	2			3		15
Unknown					1							1
Total	7			1	9	13	8	1	3	17	3	64
Season[1]												
Spring					1	3	1			4	1	10
Summer	1				1	10	1	1				14
Autumn	7			2	7		5		3	12		36
Unknown							1			1	2	4
Ownership												
US Private	3			2	2		5		3	6	1	22
US Public	5				7	13	3	1		11	2	42
Canada												
Adult female	1			2								3
Subadult female	1							1				2
Adult male	1	1		2	1					1		6
Subadult male				1						1		2
Yearling						1						1
Cub						4						4
Unknown			1									1
Total	3	1	1	5	1	5		1		2		19
Season[1]												
Spring	1	1		1		1		1				5
Summer			1	1		4						6
Autumn	2			3	1					2		8
Unknown												
Ownership												
BC Private				4								4
BC Public	3	1	1	1	1	5		1		2		15

[1]Spring = April 1 – May 31, Summer = June 1 – August 31, Autumn = September 1 – November 30

Sixty-four percent (16 of 25) of known human-caused mortalities occurring on the US National Forests were <500m of an open road from 1982–2020. Thirty-six percent (9 of 25) of known human-caused mortalities occurring on National Forests were located within core habitat (area greater than 500m from an open or gated road).

Mortality rates were examined by breaking the data into periods of increase (1982–1998, 2007–2020) and decrease (1999–2006) in population trend. From 1982–1998, 16 instances of known mortality occurred in the U.S. and Canada, with 12 (75%) of these mortalities being human-caused (Table 1). The annual rate of known human-caused mortality was 0.71 mortalities per year. Twenty-seven instances of known mortality occurred during 1999–2006 with 18 (67%) of these human-caused. Annual rate of known human-caused mortality was 2.25 per year. Forty instances of known mortality occurred from 2007–2020 with 30 (75%) of these human-caused. Annual rate of known human-caused mortality was 2.073 per year. Though the rate of known human caused mortality was similar between the two most recent time periods, it is important to consider the rate of female mortality. The loss of females is the most critical factor affecting the trend because of their reproductive contribution to current and future growth. The rate of known female mortality was 0.29 and human caused female mortality was 0.18 during 1982–1998. Both total known female and human-caused female mortality rate increased from 1982–1998 to 1999–2006 periods. Total known female mortality rate decreased from 1.88 during 1999–2006 to 0.79 during 2007–2020 and known human-caused female mortality rate decreased from 1.5 to 0.57. This decline of female mortality is largely responsible for the improving population trend from 2007–2020 (Pages 39–42). Efforts to detect mortality were probably lowest during 1982–1998 because of fewer collared bears and less personnel presence in the Yaak portion of the recovery zone. Comparisons involving the two most recent time periods represent more similar amounts of effort to detect mortality.

The increase in total known mortality beginning in 1999 may be linked to poor food production during 1998–2004 (Fig. 11). Huckleberry production during these years was about half the long-term average. Poor berry production years can be expected at various times, but in this case, there were several successive years of poor production. Huckleberries are the major source of late summer food that enables bears to accumulate sufficient fat to survive the denning period and females to produce and nurture cubs. Poor nutrition may not allow females to produce cubs in the following year and cause females to travel further for food, exposing young to greater risk of mortality from conflicts with humans, predators, or accidental deaths. One female bear lost litters of 2 cubs each during spring of 2000 and 2001. Another mortality incident involved a female with 2 cubs that appeared to have been killed by another bear in 1999. The effect of cub mortality may be greatest in succeeding years when some of these animals might have been recruited to the reproductive segment of the population.

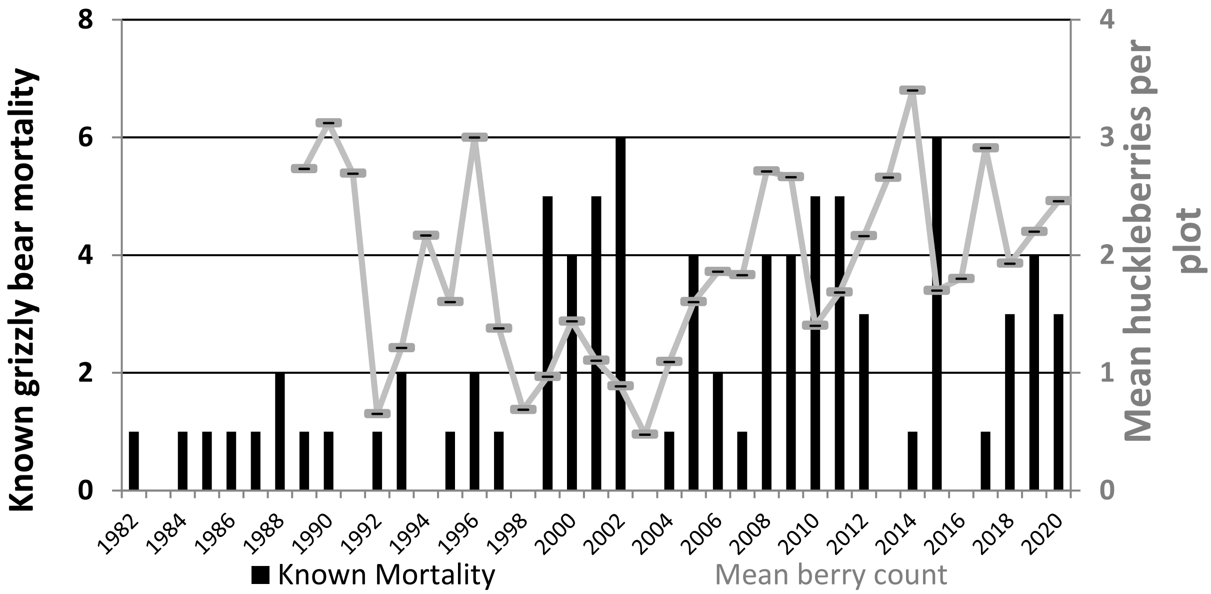

Figure 11. Known grizzly bear annual mortality from all causes in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and all radio-collared bears by cause, 1982–2020 and huckleberry production counts, 1989–2020.

Using counts of known human-caused mortality probably under-estimates total human-caused mortality. Numerous mortalities identified by this study were reported only because animals wore a radio-collar at death. The public reporting rate of bears wearing radio-collars can be used to develop a correction factor to estimate unreported mortality (Cherry *et al*. 2002). Correction factors were not applied to natural mortality, management removals, mortality of radio-collared bears or bears that died of unknown causes (Table 11). All radioed bears used to develop the unreported mortality correction were >2 years-old and died from human related causes. Twenty-three radio-collared bears died from human causes during 1982–2019. Eleven of these were reported by the public (55%) and 9 were unreported (45%). The Bayesian statistical analysis described by Cherry *et al*. (2002) was used to calculate unreported mortality in 3 year running periods in the Yellowstone ecosystem, but samples sizes in the CYE are much smaller, so we grouped data based on the cumulative population trend (ʎ, Fig. 11). The unreported estimate added 24 mortalities to the 83 known mortalities from 1982–2020. The unreported estimate includes bears killed in BC which are not counted in recovery criteria (USFWS 1993).

Table 11. Annual human-caused grizzly bear mortality in or within 16 km of the Cabinet-Yaak recovery zone (including Canada) and estimates of unreported mortality, 1982–2020 (including all radio-collared bears regardless of mortality location).

Years	Population trend	Natural	Management or research	Radio monitored	Unknown cause	Public reported	Unreported estimate	Total
1982-1998	Improving	3	2	4	1	6	5	21
1999-2006	Declining	9	4	7	0	7	6	33
2007-2020	Improving	8	3	11	2	16	13	53
Total		20	9	22	3	29	24	107

Grizzly Bear Survival, Reproduction, Population Trend, and Population Estimate

This report segment updates information on survival rates, cause-specific mortality, and population trend following the methods used in Wakkinen and Kasworm (2004).

Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival and cause-specific mortality rates were calculated for 6 sex and age classes of native grizzly bears from 1983–2019 (Table 12). We calculated survival and mortality rates for augmentation and management bears separately (see below).

Table 12. Survival and cause-specific mortality rates of native grizzly bear sex and age classes based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2020.

	Demographic parameters and mortality rates					
Parameter	Adult female	Adult male	Subadult female	Subadult male	Yearling	Cub
Individuals / bear-years	17 / 50.6	28 / 38.4	20 / 25.3	24 /19.1	33 / 16.4	46 / 46[a]
Survival[b] (95% CI)	0.923 (0.852–0.994)	0.898 (0.804-0.991)	0.849 (0.711–0.987)	0.842 (0.683-01.0)	0.892 (0.748–1.0)	0.652 (0.497–0.787)
Mortality rate by cause						
Legal Hunt Canada	0	0.029	0	0	0	0
Natural	0.020	0	0	0	0.108	0.304
Defense of life	0	0.026	0.037	0.0370	0	0
Mistaken ID	0	0	0	0	0	0
Poaching	0.03619	0	0	0.049	0	0.043
Trap predation	0	0	0.042	0	0	0
Unknown human	0.020	0.047	0.073	0.071	0	

[a]Cub survival based on counts of individuals alive and dead.
[b]Kaplan-Meier survival estimate which may differ from BOOTER survival estimate.

Mortality rates of all sex and age classes of resident non-management radio-collared grizzly bears ≥2 years old were summarized by cause and location of death (Table 13). Rates were categorized by public or private land and human or natural causes. Rates were further stratified by death locations in BC or U.S. and broken into three time periods. The three periods (1983–1998, 1999–2006, and 2007–2020) correspond to a period of population increase followed by a period of decline followed by a period of increase in long term population trend (λ). Grizzly bear survival of all sex and age classes decreased from 0.899 during 1983–1998 to 0.792 during 1999–2006 and then rose to 0.924 during 2007–2020. Some of this decrease in the 1999–2006 period could be attributed to an increase in natural mortality probably related to poor berry production during 1998–2004. Mortality on private lands in the U.S. increased during this period, suggesting that bears were searching more widely for foods to replace the low berry crop. Several mortalities occurring during 1999–2006 were associated with sanitation issues on private lands. Declines in mortality rate on private lands beginning in 2007 correspond to and may be the result of the initiation of the MFWP bear management specialist position. Several deaths of management bears occurred on private lands but were not included in this calculation due to capture biases (traps were set only once a conflict occurred and removed after capture). Point estimates for human-caused mortality occurring on public lands in the U.S. and BC decreased from 1983–1998 to 1999–2006 and again from 1999–2006 to 2007–2020. This apparent decrease in mortality rates on public lands from 1983–1998 to 1999–2006 is particularly noteworthy given the increase in overall mortality rates. Implementation of access management on U.S. public lands could be a factor in this apparent decline.

Table 13. Survival and cause-specific mortality rates of native radio-collared grizzly bears ≥2 years old by location of death based on censored telemetry data in the Cabinet–Yaak recovery zone, 1983–2020.

Parameter	1983–1998	1999–2006	2007–2020
Individuals / bear-years	23 / 48.9	21 / 20.3	44 / 59.6
Survival[b] (95% CI)	0.899 (0.819–0.979)	0.792 (0.634–0.950)	0.924 (0.857–0.991)
Mortality rate by location and cause			
Public / natural	0	0.059	0
U.S. public / human	0.061	0.036	0.031
U.S. private / human	0	0.075	0.045
B.C. public / human	0.040	0.038	0
B.C. private / human	0	0	0

Augmentation Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 22 augmentation grizzly bears from 1990–2020. Fourteen female and eight male bears ranged in age from 2–10. Survival was calculated based on release week for each individual, as the common starting point and progressing by week until death or censor. Bears that left the target area were censored during that week from the survival calculation to obtain survival rates indicative of CYGBE conditions. Four females are known to have left the target area, but one returned while radio collared. Four females are known to have died within the target area. None of the augmentation males died within the target area. Four are known to have left the target area and two are known to have died outside the target area. All known female and male mortality occurred within the first-year post release.

First year annual survival rate for augmentation females was 0.600 (95% CI=0.296–0.904, *n* =14) with a natural mortality, a poaching, a train collision, and an unknown cause. The natural mortality occurred during spring, the unknown mortality occurred during summer, and the poaching, mistaken identity, and train mortality occurred during autumn. The female that died of unknown cause produced a cub before her death and it is assumed the cub died. Female survival for all years radio monitored was 0.746 (95% CI=0.555–0.936, *n* =14. No males died within the target area during their first year though two males were known to have died outside the target area (mistaken identification and a self-defense). Male survival for all years radio monitored was 0.771 (95% CI=0.531–1.0 *n* =8.

Management Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 16 management grizzly bears captured at conflict sites from 2003–2019. Fourteen bears were males and two were females aged 2–25. None of the females died during monitoring. Male survival rate was 0.479 (95% CI=0.265–0.694, *n* =14) with an instance of mistaken identity, a self-defense, two management removals, and one unknown but human-caused mortality among 16 radio-collared bears monitored for 8.3 bear-years. Two mortalities occurred during spring and four occurred during autumn.

Grizzly Bear Reproduction

Reproductive parameters originated from all bears monitored 1983–2020. Mean age of first parturition among native grizzly bears was 6.3 years (95% CI=5.9–6.7, *n* =14, Table 14). Five bears used in the calculation were radio-collared from ages 2–8. One individual was captured with a cub at age 6 years old. We assumed this was a first reproductive event given her age. Eight other first ages of reproduction were established through genetic parentage analysis and known age of offspring. Twenty-nine litters comprised of 62 cubs were observed through both monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation, for a mean litter size of 2.14 (95% CI=1.95–2.33, *n* =29, Table 14).

Twenty-five reproductive intervals were determined through monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation (Table 14). Mean inter-birth interval was calculated as 2.84 years (95% CI=2.41–3.27, *n* =24). Booter software provides several options to calculate reproductive rate (*m*) and we selected unpaired litter size and birth interval data with sample size restricted to the number of females. The unpaired option allows use of bears from which accurate counts of cubs were not obtained but interval was known, or instances where litter size was known but radio failure or death limited knowledge of birth interval. Estimated reproductive rate using the unpaired option was 0.361 female cubs/year/adult female (95% CI=0.286–0.467, *n* =12 adult females, Table 15). Sex ratio of cubs born was assumed to be 1:1. Reproductive rates do not include augmentation bears.

Table 14. Grizzly bear reproductive data from the Cabinet-Yaak 1983–2020.

Bear	Year	Age at first reproduction	Reproductive Interval[1]	Cubs	Cubs (relationship and fate, if known)
106	1986		2	2	1 dead in 1986, ♀ 129 dead in 1989
106	1988		3	3	♂ 192 dead in 1991, ♂ 193, ♀ 206
106	1991		2	2	2 cubs 1 male other unknown sex and fate
106	1993		2	2	♂ 302 dead in 1996, ♀ 303
106	1995		4	2	♀ 353 dead in 2002, ♀ 354 dead in 2007
106	1999			2	♀ 106 and 2 cubs dead in 1999
206	1994	6	3	2	♀ 505
206	1997			2	♀ 596 dead in 1999, ♀ 592 dead in 2000
538	1997	6	3		1 yearling separated from ♀ 538 in 1998
538	2000		1	2	2 cubs dead in 2000
538	2001		1	2	2 cubs dead in 2001
538	2002			2	2 cubs of unknown sex and fate
303	2000	7	3	2	1 cub dead in 2000, ♀ 552
303	2003		4		At least 2 cubs
303	2007		3		
303	2010			3	1 cub dead in 2010
303	2013				Observed with courting male in May 2014
303	2016				1 yearling observed in 2016
354	2000	5	3		Genetic data indicated reproduction of at least two cubs in 2000
354	2003		3		At least 2 cubs
354	2006				At least 2 cubs
353	2002	7		3	♀ 353 dead in 2002, 3 cubs (1 female) all assumed dead in 2002
772	2003	6	4		Genetic data indicated reproduction of at least one cub in 2003
772	2007			2	♀ 789, ♂ 791
675	2009	7	1	2	2 cubs dead in 2009
675	2010			1	1 cub dead in 2010
552	2011		3	2	♀ 2011049122, ♂ 2011049118
552	2014			3	3 cubs, 2 males and one of unknown sex
784	2013	7			At least 2 cubs
784	2018				At least one cub
810	2010	7	4		At least one cub
810	2014			2	2 cubs observed at camera site, August 2014
810	2018			2	2 cubs observed June 2018
820	2009	6	4		At least one cub
820	2013			2	2 cubs ♀ 842, ♂ 818, 818 dead in 2015
820	2018		5	2	2 cubs observed July 2018
831	2004	7	3		At least 1 cub
831	2007			2	2 cubs ♂ 799 and ♀ C20072F

Bear	Year	Age at first reproduction	Reproductive Interval[1]	Cubs	Cubs (relationship and fate, if known)
831	2012			3	3 cubs, ♂ 839, ♀ 900933, ♀ 925063
831	2017			3	Photo with 3 cubs July 2017
731	2013	6	3		At least one cub ♂ 17139
731	2016				At least one cub ♀Y29503F
822	2018	5	2	1	one cub ♂ Y38004M. Photo June 2018
822	2020			2	2 cubs observed July
842	2019	6	1	2	2 cubs dead in 2019
842	2020			2	2 cubs observed October

[1]Number of years from birth to subsequent birth.

Population Trend

Approximately 95% of the survival data and 85% of the reproductive data used in population trend calculations came from bears monitored in the Yaak River portion of this population, hence this result is most indicative of that portion of the recovery area. However, only the Kootenai River divides the Cabinet Mountains from the Yaak River and the trend produced from this data would appear to be applicable to the entire population of native bears in the absence of population augmentation. We have no data to suggest that mortality or reproductive rates are different between the Yaak River and the Cabinet Mountains. The Cabinet Mountains portion of the population was estimated to be <15 in 1988 (Kasworm and Manley 1988) and subsequent lack of identification of resident bears through genetic techniques would suggest the population was possibly 5–10. Population augmentation has added 22 bears into this population since 1990 and a mark recapture population estimate from 2012 indicated the population was 22–24 individuals (Kendall *et al*. 2016). These data indicate the Cabinet Mountains population has increased by 2–4 times since 1988, but this increase is largely a product of the augmentation effort with reproduction from that segment.

The estimated finite rate of increase (λ) for 1983–2020 using Booter software with the unpaired litter size and birth interval data option was 1.017 (95% CI=0.935–1.090, Table 15). Finite rate of change over the same period was an annual 1.7% (Caughley 1977). Subadult female survival and adult female survival accounted for most of the uncertainty in λ, with reproductive rate, yearling survival, cub survival, and age at first parturition contributing much smaller amounts. The sample sizes available to calculate population trend are small and yielded wide confidence intervals around our estimate of trend (i.e., λ). The probability that the population was stable or increasing was 67%. Utilizing the entire survival and reproductive data set from 1983–2020 is partially the product of small sample sizes but also produces the effect of smoothing the data over time and results in a more conservative estimate of population trend.

Finite rates of increase calculated for the period 1983–1998 (λ = 1.067) suggested an increasing population (Wakkinen and Kasworm 2004). Lack of mortality in specific sex-age classes limited calculations for many time periods other than those shown here (Fig. 12). Annual survival rates for adult and subadult females were 0.948 and 0.901 respectively, during 1983–1998, and then declined to 0.926 and 0.740 for the period of 1983–2006, respectively. Cumulative lambda calculations reached the lowest point in 2006 (Fig. 12). Human-caused mortality has accounted for much of this decline in annual survival rates and population trend. Improved adult female survival and subadult female survival rates resulted in an improving population trend estimate since 2006. Improving survival by reducing human-caused mortality is crucial for recovery of this population (Proctor *et al*. 2004).

Table 15. Booter unpaired method estimated annual survival rates, age at first parturition, reproductive rates, and population trend of native grizzly bears in the Cabinet–Yaak recovery zone, 1983–2020.

Parameter	Sample size	Estimate (95% CI)	SE	Variance (%)[a]
Adult female survival[b] (S_a)	17 / 50.2[c]	0.925 (0.833–0.985)	0.040	33.7
Subadult female survival[b] (S_s)	20 / 25.1[c]	0.847 (0.692–0.965)	0.073	51.4
Yearling survival[b] (S_y)	33 / 16.3[c]	0.885 (0.725–1.0)	0.074	2.7
Cub survival[b] (S_c)[d]	46/46	0.652 (0.500–0.783)	0.072	4.6
Age first parturition (*a*)	14	6.3 (5.9–6.6)	0.186	0.5
Maximum age (*w*)	Fixed	27		
Unpaired Reproductive rate (*m*)[e]	16/25/28[f]	0.405360 (0.326–0.536)	0.055	7.1
Unpaired Lambda (λ)	5000 bootstrap runs	1.017 (0.935–1.090)	0.040	

[a] Percent of lambda explained by each parameter
[b]Booter survival calculation which may differ from Kaplan-Meier estimates in Table 13.
[c]individuals / bear-years
[d]Cub survival based on counts of individuals alive and dead
[e]Number of female cubs produced/year/adult female. Sex ratio assumed to be 1:1.
[f]Sample size for individual reproductive adult females / sample size for birth interval / sample size for litter size from Table 14.

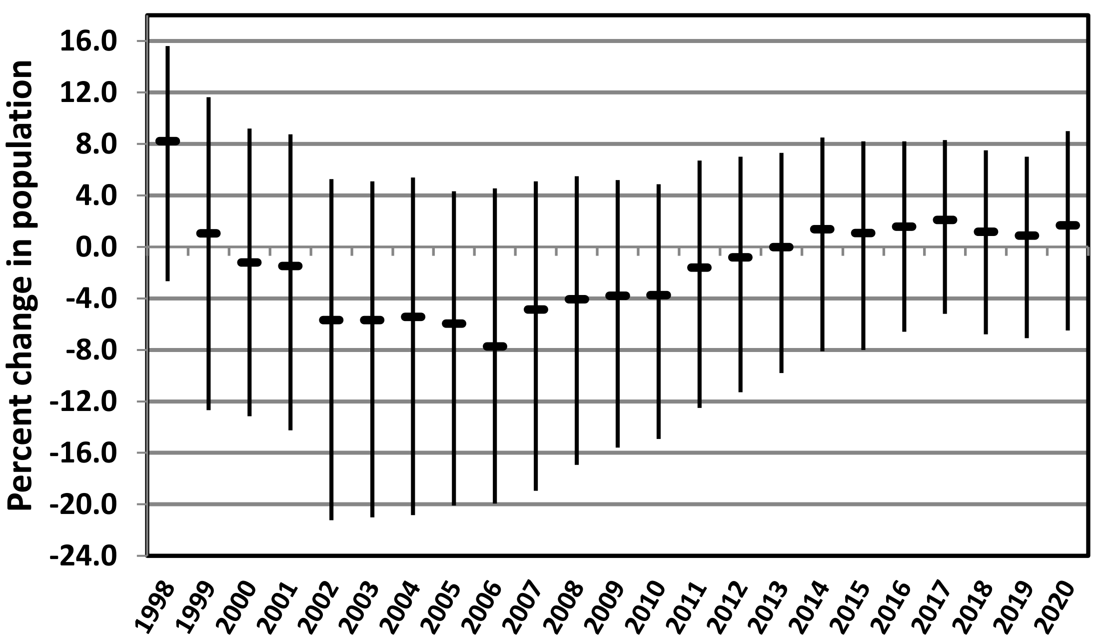

Figure 12. Point estimate and 95% confidence intervals for cumulative annual calculation of population rate of change for native grizzly bears in the Cabinet-Yaak recovery area, 1983–2020. Each entry represents the annual rate of change from 1983 to that date.

Population Estimate

During 2012, USGS used mark-recapture techniques to estimate the CYE grizzly bear population at 48–50 (95% CI = 44–62) (Kendall *et al*. 2016). Using the midpoint of this estimate (49), the calculated rate of increase (1.7%), results in a gain of 7 bears through 2020 to a population of 56. The augmentation program added 8 bears since 2012 but four of those have either left the target area or are known dead. Based on this information, a population estimate of about 60 bears would seem reasonable.

Capture and Marking

Three grizzly bears were captured within the Cabinet and Yaak study area (2 adult females and 1 subadult male) during 2020. All were captured for research monitoring. Ninety-six individual grizzly bears have been captured 148 times as part of this monitoring program since 1983 (Tables 16 and 17). One-hundred twenty-three captures occurred for research purposes and 24 captures occurred for management purposes.

Cabinet Mountains

Research trapping was conducted in the Cabinet Mountains portion of the CYE from 1983–1987. Three adult grizzly bears were captured during this effort (1 female and 2 males). No trapping occurred from 1988–1994 as effort was directed toward the Yaak River. In 1995 an effort was initiated to recapture augmentation bears to determine success of the program and capture any native bears in the Cabinet Mountains. During 1983–2020, 7,715 research trap-nights were expended to capture 13 known individual grizzly bears and 319 individual black bears (Table 16 and 17, Fig. 13). Rates of capture by individual were 1 grizzly bear/593 trap-nights and 1 black bear/24 trap-nights. A trap-night was defined as one site with one or more snares set for one night. One augmentation bear was captured during subsequent trapping efforts

Yaak River, Purcell Mountains South of BC Highway 3

Trapping was conducted in the Yaak portion of the CYE during 1986–1987 as part of a black bear graduate study (Thier 1990). Research trapping was continued from 1989–2020 by USFWS. One-hundred twelve captures of 59 individual grizzly bears and 542 captures of 457 individual black bears were made during 11,738 trap-nights during 1986–2020 (Tables 16 and 17, Fig. 13). Rates of capture by individual were 1 grizzly bear/196 trap-nights and 1 black bear/25 trap-nights. Trapping effort was concentrated in home ranges of known bears during 1995–2020 to recapture adult females with known histories. Much of the effort involved using horses and bicycles in areas inaccessible to vehicles, such as trails and closed roads.

Salish Mountains

Trapping occurred in the Salish Mountains, south of Eureka, Montana, in 2003. An adult female grizzly bear (5 years old), and 5 black bears were captured during 63 trap-nights of effort (Tables 16, 17).

Moyie River and Goat River Valleys North of Highway 3, British Columbia

Eight grizzly bears and 32 black bears were captured in the Moyie and Goat River valleys north of Highway 3 in BC in 2004–2008 (Table 16 and Fig. 13). Trapping was conducted in cooperation with M. Proctor (Birchdale Ecological Consultants, Kaslo, BC) and BC Ministry of Environment. Rates of capture by individual were 1 grizzly bear/32 trap-nights and 1 black bear/8 trap-nights.

Table 16. Research capture effort and success for grizzly bears and black bears within study areas, 1983–2020.

Area / Year(s)	Trap-nights	Grizzly Bear Captures	Black Bear Captures	Trap-nights / Grizzly Bear	Trap-nights / Black Bear
Cabinet Mountains,1983–2020					
Total Captures	7715	16	437	482	18
Individuals[1]	7715	13	319	593	24
Salish Mountains, 2003[1]	63	1	5	63	13
Yaak River South Hwy 3, 1986–20					
Total Captures	11738	112	549	105	21
Individuals[1]	11738	60	463	196	25
Purcells N. Hwy 3, BC 2004–09					
Total Captures	390	10	37	39	11
Individuals[1]	390	9	32	43	12

[1]Only captures of individual bears included. Recaptures are not included in summary.

Table 17. Grizzly bear capture information from the Cabinet-Yaak and Purcell populations, 1983–2020. Multiple captures of a single bear in a single year are not included.

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
678	6/29/83	F	28	86	Bear Cr., MT	Research
680	6/19/84	M	11	(181)	Libby Cr., MT	Research
680	5/12/85	M	12	(181)	Bear Cr., MT	Research
678	6/01/85	F	30	79	Cherry Cr., MT	Research
14	6/19/85	M	27	(159)	Cherry Cr., MT	Research
101	4/30/86	M	(8)	(171)	N Fk 17 Mile Cr., MT	Research
678	5/21/86	F	31	65	Cherry Cr., MT	Research
106	5/23/86	F	8	92	Otis Cr., MT	Research
128	5/10/87	M	4	(114)	Lang Cr., MT	Research
129	5/20/87	F	1	32	Pheasant Cr., MT	Research
106	6/20/87	F	9	(91)	Grizzly Cr., MT	Research
134	6/24/87	M	8	(181)	Otis Cr., MT	Research
129	7/06/89	F	3	(80)	Grizzly Cr., MT	Research
192	10/14/89	M	1	90	Large Cr., MT	Research
193	10/14/89	M	1	79	Large Cr., MT	Research
193	6/03/90	M	2	77	Burnt Cr., MT	Research
206	6/03/90	F	2	70	Burnt Cr., MT	Research
106	9/25/90	F	12	(136)	Burnt Cr., MT	Research
206	5/24/91	F	3	77	Burnt Cr., MT	Research
244	6/17/92	M	6	140	Yaak R., MT	Research
106	9/04/92	F	14	144	Burnt Cr., MT	Research
34	6/26/93	F	(15)	158	Spread Cr., MT	Research
206	10/06/93	F	5	(159)	Pete Cr., MT	Research
505	9/14/94	F	Cub	45	Jungle Cr., MT	Research
302	10/07/94	M	1	95	Cool Cr., MT	Research
303	10/07/94	F	1	113	Cool Cr., MT	Research
106	9/20/95	F	17	(169)	Cool Cr., MT	Research
353	9/20/95	F	Cub	43	Cool Cr., MT	Research
354	9/20/95	F	Cub	47	Cool Cr., MT	Research
302	9/24/95	M	2	113	Cool Cr., MT	Research
342	5/22/96	M	4	(146)	Zulu Cr., MT	Research
363	5/27/96	M	4	(158)	Zulu Cr., MT	Research
303	5/27/96	F	3	(113)	Zulu Cr., MT	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
355	9/12/96	M	(6)	(203)	Rampike Cr., MT	Research
358	9/22/96	M	8	(225)	Pete Cr., MT	Research
353	9/23/96	F	1	83	Cool Cr., MT	Research
354	9/23/96	F	1	88	Cool Cr., MT	Research
384	6/12/97	M	7	(248)	Zulu Cr., MT	Research
128	6/15/97	M	14	(270)	Cool Cr., MT	Research
386	6/20/97	M	5	(180)	Zulu Cr., MT	Research
363	6/26/97	M	5	(180)	Cool Cr., MT	Research
538	9/25/97	F	6	(135)	Rampike Cr., MT	Research
354	9/27/97	F	2	99	Burnt Cr., MT	Research
354	8/20/98	F	3	(90)	Cool Cr., MT	Research
106	8/29/98	F	20	(146)	Burnt Cr., MT	Research
363	8/30/98	M	6	(203)	Burnt Cr., MT	Research
342	9/17/98	M	6	(203)	Clay Cr., MT	Research
303	9/21/98	F	5	(113)	Clay Cr., MT	Research
592	8/17/99	F	2	(91)	Pete Cr., MT	Research
596	8/23/99	F	2	(91)	French Cr., MT	Research
358	11/15/99	M	11	279	Yaak R., MT	Management, open freezer, killed goats
538	7/16/00	F	9	(171)	Moyie River, BC	Research
552	7/16/01	F	1	(36)	Copeland Cr., MT	Research
577	5/22/02	F	1	23	Elk Cr., MT	Management, pre-emptive move
578	5/22/02	M	1	23	Elk Cr., MT	Management, pre-emptive move
579	5/22/02	M	1	30	Elk Cr., MT	Management, pre-emptive move
353	6/15/02	F	7	(136)	Burnt Cr., MT	Research
651	9/25/02	M	7	(227)	Spread Cr., MT	Research
787	5/17/03	M	3	71	Deer Cr. ID	Management, garbage feeding
342	5/23/03	M	11	(227)	Burnt Cr., MT	Research
648	8/18/03	F	5	(159)	McGuire Cr., MT, Salish Mtns.	Research
244	9/25/03	M	17	(205)	N Fk Hellroaring Cr., MT	Research
10	6/17/04	F	11	(159)	Irishman C., BC	Research
11	6/20/04	M	7	(205)	Irishman C., BC	Research
12	7/22/04	F	11	(148)	Irishman C., BC	Research
576	10/21/04	M	2	(114)	Young Cr., MT	Management, garbage feeding
675	10/22/04	F	2	100	Young Cr., MT	Management, pre-emptive move
677	5/13/05	M	6	105	Canuck Cr., BC	Research
688	6/13/05	M	3	93	EF Kidd Cr., BC	Research
576	6/17/05	M	3	133	Teepee Cr., BC	Research
690	6/17/05	F	1	52	EF Kidd Cr., BC	Research
17	6/18/05	M	8	175	Norge Pass, BC	Research
2	6/20/05	M	7+	209	EF Kidd Cr., BC	Research
292	7/6/05	F	4	(114)	Mission Cr., ID	Research
694	7/15/05	F	2	73	Kelsey Cr., MT	Research
770	9/20/05	M	11	(250)	Chippewa Cr., MT	Research
M1	10/4/05	M	(2)	(80)	Pipe Cr., MT	Management, garbage feeding
668	10/11/05	M	3	120	Yaak R., MT	Management, garbage feeding
103	5/23/06	M	3	125	Canuck Cr., BC	Research
---	5/28/06	F	4	(125)	Cold Cr., BC (Trap predation)	Research
5381	6/6/06	M	4	(200)	Hellroaring Cr., ID	Research
651	6/28/06	M	11	198	Cold Cr., BC	Research
780	9/22/06	M	6	(250)	S Fk Callahan Cr., MT	Research
130	6/18/07	F	26	113	Arrow Cr., BC	Research
131	6/28/07	F	(5)	(80)	Arrow Cr., BC	Research
784	9/23/07	F	1	(80)	Spread Cr., MT	Research
772	9/18/07	F	10	116	Pilgrim Cr., MT	Management, fruit trees
789	9/18/07	F	Cub	36	Pilgrim Cr., MT	Management, fruit trees
791	9/18/07	M	Cub	39	Pilgrim Cr., MT	Management, fruit trees
785	10/15/07	F	1	75	Pete Cr., MT	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg (Est.)	Location	Capture Type
675	5/23/09	F	7	89	Elmer Cr. BC	Research
784	7/24/09	F	3	(136)	Hensley Cr., MT	Research
731	9/17/09	F	2	(125)	Fowler Cr., MT	Research
5381	11/21/09	M	4	(273)	Kidd Cr., BC	Research
799	5/21/10	M	3	(102)	Rock Cr., MT	Research
737	7/21/10	M	4	129	Messler Cr., MT	Research
1374	8/30/10	M	2	98	Young Cr., MT	Management, garbage feeding
726	5/24/11	M	2	77	Meadow Cr., MT	Research
722	5/31/11	M	12	261	Otis Cr., MT	Research
729	6/18/11	F	1	33	Beulah Cr., MT	Research
724	7/13/11	M	2	159	Graves Cr., MT	Management, killed pigs
732	10/27/11	M	5	139	Otis Cr., MT	Management, killed chickens
729	6/26/12	F	2	(80)	Pipe Cr., MT	Research
737	9/19/12	M	6	(159)	Basin Cr., MT	Research
552	9/24/12	F	12	(136)	Basin Cr., MT	Research
826	6/28/13	M	(5)	(136)	Pipe Cr., MT	Research
303	7/23/13	F	20	132	Pipe Cr., MT	Research
831	6/21/14	F	14	81	Libby Cr., MT	Research
807	6/24/14	M	4	111	Canuck Cr., ID	Research
808	6/27/14	M	4	130	Spruce Cr., ID	Research
722	8/21/14	M	15	(182)	Hellroaring Cr., MT	Research
835	8/24/14	M	19	185	Hellroaring Cr., MT	Research
836	9/19/14	F	1	75	Hellroaring Cr., MT	Research
837	9/29/14	M	6	(227)	Hellroaring Cr., MT	Research
729	5/19/15	F	5	107	Cool Cr., MT	Research
839	6/19/15	M	4	78	Bear Cr., MT	Research
810	7/16/15	F	12	120	Hellroaring Cr., MT	Research
818	7/18/15	M	2	82	Meadow Cr., MT	Research
820	8/20/15	F	12	149	Hellroaring Cr., MT	Research
726	10/5/15	M	6	227	Libby Cr., MT	Management, beehives
836	7/18/16	F	3	87	Hellroaring Cr., MT	Research
822	8/15/16	F	3	92	Hellroaring Cr., MT	Research
824	8/18/16	M	(12)	197	Hellroaring Cr., MT	Research
9811	8/19/16	M	(2)	(91)	Hellroaring Cr., MT	Research
821	8/27/16	M	2	127	Hellroaring Cr., MT	Research
853	9/21/16	M	5	120	Boulder Cr., MT	Research
722	9/29/16	M	17	238	17 Mile Cr., MT	Management, pigs and chickens
922	10/10/16	M	2	130	Upper Yaak R., MT	Management, chicken feed
726	6/18/17	M	8	(195+)	Beulah Cr., MT	Research
1026	6/21/17	F	2	63	Upper Yaak R., MT	Management, habituated
1028	6/21/17	F	2	64	Upper Yaak R., MT	Management, habituated
861	6/25/17	M	2	55	Bear Cr., MT	Research
840	6/26/17	F	2	53	Cruien Cr., MT	Research
842	7/25/17	F	4	93	Fourth of July Cr., MT	Research
810	9/18/17	F	14	150	Hellroaring Cr., MT	Research
9077	4/30/18	M	(3)	112	Thompson R., MT	Management
927	9/5/18	M	(2)	92	Dry Cr., ID	Management, Black Bear Bait Station
722	9/23/18	M	19	238	Hellroaring Cr., MT	Research
844	6/22/19	M	(3)	122	Pipe Cr, MT	Research
866	6/25/19	M	(3)	134	Bear Cr, MT	Research
835	7/23/19	M	24	175	Canuck Cr, MT	Research
822	7/25/19	F	6	109	Canuck Cr, MT	Research
770	10/11/19	M	25	207	Bear Cr,MT	Management, Livestock feed
930	6/23/20	M	2	78	Whitetail Cr.,MT	Research
784	7/24/20	F	14	115	Hellroaring Cr.,MT	Research
729	9/21/20	F	10	158	Burnt Cr.,MT	Research

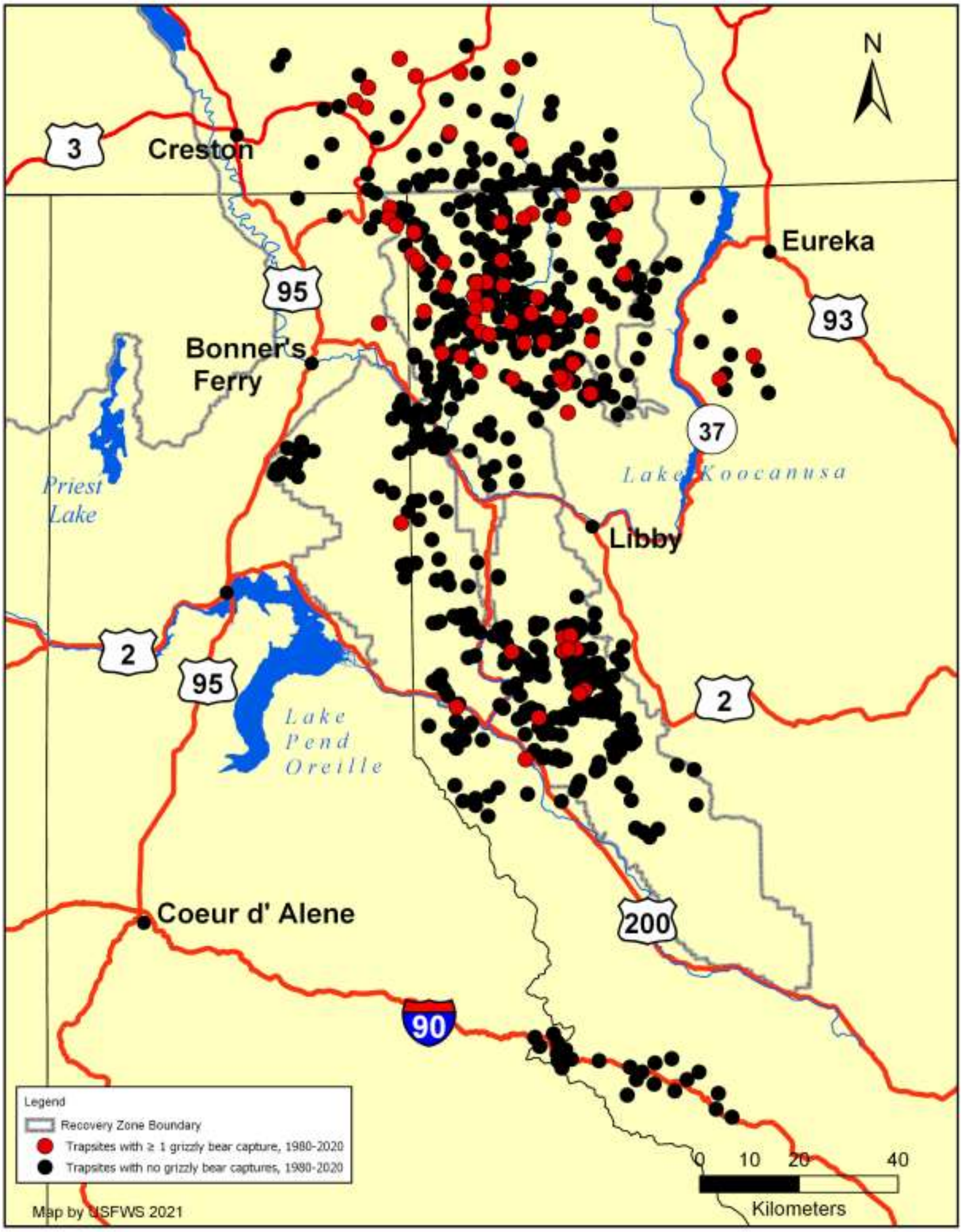

Figure 13. Trap site locations in the Cabinet-Yaak study areas 1983–2020. Red dots represent sites with ≥ one grizzly bear capture.

Grizzly Bear Monitoring and Home Ranges

Ten grizzly bears were monitored with radio-collars during portions of 2020. Research monitoring included three females (two adults and one subadult) and four males (three adult and two subadults) in the CYE. Two subadult males and a subadult female were from the Cabinet Mountains augmentation program. One adult male bear was collared for conflict management purposes.

Aerial telemetry locations and GPS collar locations were used to calculate home ranges. The convex polygon life ranges were computed for bears monitored during 1983–2020 (Table 18 and Appendix 4 Figs. A1-A108). Resident, non-augmentation bears with life range estimates for bears with ≥ 5 months of telemetry were used to calculate basic statistics. Adult male life range averaged 2,105 km^2 (95% CI ± 507, n = 35) and adult female life range averaged 687 km^2 (95% CI ± 186, n = 21) using the minimum convex polygon estimator.

Young female bears typically utilize home ranges adjacent to or a part of their mother's home range. The minimum convex polygon estimator for bear 106 was 852 km^2 during her 1986–1999 lifetime (Fig. 14). Her home range was smallest during the five years that she had cubs. Four known female offspring of bear 106 established home ranges around their maternal range (Fig. 14). Bear 206 has established a home range adjacent to and north of her mother's home range. Bear 303 has established a home range east of her mother's home range and female 354 may have established her home range west of her mothers. Bear 353 lived within her mother's old range, before her death. Second-generation female offspring of 106 occupied habitats east and west of first-generation offspring. In recent years, third-generation females have established home ranges south of second-generation females (Fig. 14).

Home ranges of collared grizzly bears overlap extensively on a yearly and lifetime basis. However, bears typically utilize the same space at different times. Male home ranges overlap several females to increase breeding potential, but males and females consort only during the brief period of courtship and breeding. Adult male bears, whose home ranges overlap, seldom use the same habitat at the same time to avoid conflict.

Table 18. Home range sizes of native (independent or family groups) and transplanted grizzly bears in the Cabinet-Yaak recovery zone, Purcell Mountains and Salish Mountains 1983–2020.

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
678	F	28-34	1983-89	VHF	173	658	Cabinet Mtns, MT
680	M	11-12	1984-85	VHF	75	1,947	Cabinet Mtns, MT
14	M	27	1985	VHF	23	589	Cabinet Mtns, MT
101	M	8	1986	VHF	38	787	Yaak River, MT
106	F	8-20	1986-99	VHF	379	852	Yaak River, MT
128	M	4-14	1987-97	VHF	204	2,895	Yaak River, MT
129	F	1-3	1987-89	VHF	42	60	Yaak River, MT
134	M	8-9	1987-88	VHF	20	594	Yaak River, MT
192	M	2	1990	VHF	10	574	Yaak River, MT
193	M	2	1990	VHF	34	642	Yaak River, MT
206	F	2-7	1990-95	VHF	208	1,332	Yaak River, MT
218[1]	F	5-6	1990-91	VHF	95	541	Cabinet Mtns, MT
244	M	6-18	1992-04	VHF	158	1,406	Yaak River, MT
258[1]	F	6-7	1992-93	VHF	54	400	Cabinet Mtns, MT
286[1]	F	2-3	1993-94	VHF	82	266	Cabinet Mtns, MT
311[1]	F	3-4	1994-95	VHF	16	209	Cabinet Mtns, MT
302	M	1-3	1994-96	VHF	60	514	Yaak River, MT

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km²)	Area of use
303	F	1-22	1994-01, 2011-16	GPS & VHF	12,177	605	Yaak River, MT
342	M	4-12	1996-04	VHF	134	1,653	Yaak River, MT
355	M	(6)	1996	VHF	5	N/A	Yaak River, MT & BC
358	M	8-10	1996-98	VHF	55	1,442	Yaak River, MT & BC
363	M	4-7	1996-99	VHF	120	538	Yaak River, MT
386	M	5-6	1997-98	VHF	29	1,895	Yaak River, MT
354	F	2-4	1997-99	VHF	70	537	Yaak River, MT
538	F	6-11	1997-02	VHF	232	835	Yaak River, MT & BC
592	F	2-3	1999-00	VHF	59	471	Yaak River, MT & BC
596	F	2	1999	VHF	10	283	Yaak River, MT & BC
552	F	1-15	2001, 2012-15	GPS & VHF	1,431	1,210	Yaak River, MT
577	F	1	2002	VHF	11	2	Cabinet Mtns, MT
578	M	1	2002	VHF	3	N/A	Cabinet Mtns, MT
579	M	1	2002	VHF	10	5	Cabinet Mtns, MT
353	F	7	2002	VHF	37	119	Yaak River, MT
651	M	7-11	2002-03,06	GPS & VHF	1,827	1,004	Yaak River, MT & BC
787[2]	M	3-4	2003-04	VHF	84	1,862	Yaak River, MT
648	F	5-7	2003-05	VHF	85	948	Salish Mtns, MT
576[2]	M	3-4	2005-06	GPS & VHF	2,290	1,320	Yaak River, MT & BC
675	F	2-8	2004-10	GPS & VHF	1,827	714	Yaak River, MT & BC
10	F	11	2004	GPS	1,977	176	Moyie River, BC
11	M	7	2004	GPS	894	1,453	Moyie River, BC
12	F	11	2004	GPS	1,612	333	Moyie River, BC
17	M	8	2005	GPS	1,903	3,074	Yaak River, MT & BC
677	M	6	2005	GPS	519	3,361	Yaak River, MT & BC
688	M	3-4	2005-06	GPS	3,421	1,544	Moyie & Goat River, BC
694	F	2	2005	VHF	11	89	Yaak River, MT
292	F	4	2005	GPS	7,062	253	Moyie & Goat River, BC & ID
770	M	11-12,25	2005-06,19	VHF & GPS	1039	524	Cabinet Mtns, MT
2	M	(7-9)	2005-06	GPS	1,337	2,860	Moyie / Yahk, BC
A1[1]	F	(8-10)	2005-07	VHF	73	725	Cabinet Mtns, MT
782[1]	F	2-5	2006-08	GPS	1,126	1,932	Cabinet Mtns, MT
780	M	6-8	2006-08	VHF	56	1,374	Cabinet Mtns, MT
103	M	2-4	2006-07	GPS	4,872	6,545	Kootenai, & Pend Oreille River, BC, ID, & WA
5381	M	4-5	2006-07	GPS	11,491	1,949	Moyie & Goat River, BC & ID
130	F	26-27	2007-08	GPS	3,986	281	Goat River, BC
131	F	(5)	2007-08	GPS	3,270	276	Goat River, BC
784	F	1-3,16	2007-09,20	GPS	2311	611	Yaak River, MT
785	F	1-2	2007-08	GPS	362	207	Yaak River, MT
772	F	10	2007	VHF	14	446	Cabinet Mtns, MT
635[1]	F	4	2008	GPS	285	451	Cabinet Mtns, MT
790[1]	F	3	2008	GPS	227	423	Cabinet Mtns, MT
715[1]	F	(10-11)	2009-10	GPS	437	6,666	Cabinet Mtns, MT
731	F	2-4	2009-11	GPS	1,652	852	Yaak River, MT
799	M	2-4	2010-11	GPS	1,422	805	Cabinet Mtns, MT
713[1]	M	5-6	2010-11	GPS & VHF	562	5,999	Cabinet Mtns, MT
714[1]	F	5-6	2010-12	GPS	1,684	2,389	Cabinet Mtns & Flathead, MT
737	M	4-7	2010-13	GPS & VHF	1,626	2,667	Yaak River, MT & BC
1374	M	2	2010	GPS	14	381	Yaak River, MT & BC
722[2]	M	12-19	2011-19	GPS	3523	4,282	Yaak River, MT & BC
723[1]	M	1-3	2011-12	GPS	430	1,063	Cabinet Mtns, MT

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km²)	Area of use
724[2]	M	1-3	2011-12	VHF	29	873	Cabinet Mtns, MT
725[1]	F	2-4	2011-13	GPS	3,194	3,314	Cabinet Mtns & Flathead, MT
726	M	2-3,6-8	2011-12,15-17	GPS	6,335	3,751	Kootenai & Yaak River, MT
729	F	1-7,10	2011-13, 15-17,20	GPS	17,952	560	Yaak River, MT
732[2]	M	5	2011	GPS	875	458	Yaak River, MT
918[1]	M	2-4	2012-14	GPS	1,192	587	Cabinet Mtns, MT
826	M	-5	2013	GPS	164	1,820	Yaak& Kootenai River, MT & BC
919[1]	M	4-5	2013-14	GPS	792	2974	Cabinet Mtns, MT
808	M	4-5	2014-15	GPS	1,273	1,722	Yaak River, MT
831	F	14	2014	GPS	434	218	Cabinet Mtns, MT
835	M	12-14,17-18	2014-16,19-20	GPS	3361	4,4298	Yaak River, MT
836	F	1-4	2014--17	GPS	3,772	1,816	Yaak River, MT
837	M	6-8	2014-16	GPS	1,173	1,553	Yaak River, MT
920[1]	F	3-5	2014-16	GPS	5,108	913	Cabinet Mtns, MT
921[1]	F	2-3	2014-15	GPS	2,033	259	Cabinet Mtns, MT
810	F	12,14-15	2015,2017-18	GPS	3,150	413	Yaak River, MT
818	M	2	2015	GPS	461	225	Yaak River, MT
839	M	3-4	2015-16	GPS & VHF	2,595	6,819	Cabinet & Whitefish Mtns, MT
820	F	12-14	2015-18	GPS	2,537	295	Yaak River, MT
924[1]	M	2	2015	GPS	741	2,068	Cabinet Mtns, MT
1001	M	6	2015	GPS	1,352	1,357	Selkirk Mtns, BC
807	M	4-7	2014-17	GPS	2,568	3,319	Selkirk Mtns, ID&Yaak River, MT
821	M	2-3	2016-17	GPS	2,467	4,405	Yaak River, MT
822	F	3,6-7	2016,19-20	GPS	2930	1144	Yaak River, MT
824	M	(12-13)	2016-14	GPS	455	884	Yaak River, MT & BC
853	M	5-6	2016-17	GPS	938	736	Kootenay River, BC
9811	M	(2-4)	2016-18	GPS	3,135	1,210	Moyie River, MT,ID,BC
922[2]	M	4-5	2016-17	GPS	938	2,148	Kootenai Rr., ID Yaak Rr, MT
926[1]	M	4-5	2016-17	GPS	2,834	3,328	Cabinet Mtns, MT
840	F	2-4	2017-19	GPS	2987	627	Pipe Cr., MT
842	F	4-6	2017-19	GPS	2776	753	Yaak River, MT
861	M	2-4	2017-19	GPS	2,376	669	Cabinet Mtns, MT
1026[2]	F	2	2017	GPS	3,435	1,556	Creston Valley, BC Yaak Rr., MT
1028[2]	F	2	2017	GPS	1,639	708	Yaak Rr.,MT St. Mary's Rr. ,BC
927[1]	M	2-4	2018-20	GPS	9011	29583	Cabinet & Bitterroot Mtns, MT, ID
9077[2]	M	(3)	2018	GPS	193	1,155	Cabinet Mtns, Yaak River, MT
1006	M	2-3	2017-18	GPS	1,921	8,092	Selkirk & Cabinet Mtns, Yaak River MT
844	M	4-5)	2019-20	GPS	4082	5448	Yaak and Kootenai Rr.,MT
866	M	4-5	2019-20	GPS	3038	3758	Salish & Cabinet Mtns, MT
892[1]	M	(3)	2019-20	GPS	1845	5127	Cabinet Mtns ID, MT & Kootenai Rv., MT
923[1]	F	2	2019-20	GPS	1781	681	Cabinet Mtns ID & MT
930	M	2	2020	GPS	1004	583	Yaak River, MT

[1]Augmentation bears.

[2]Management bears.

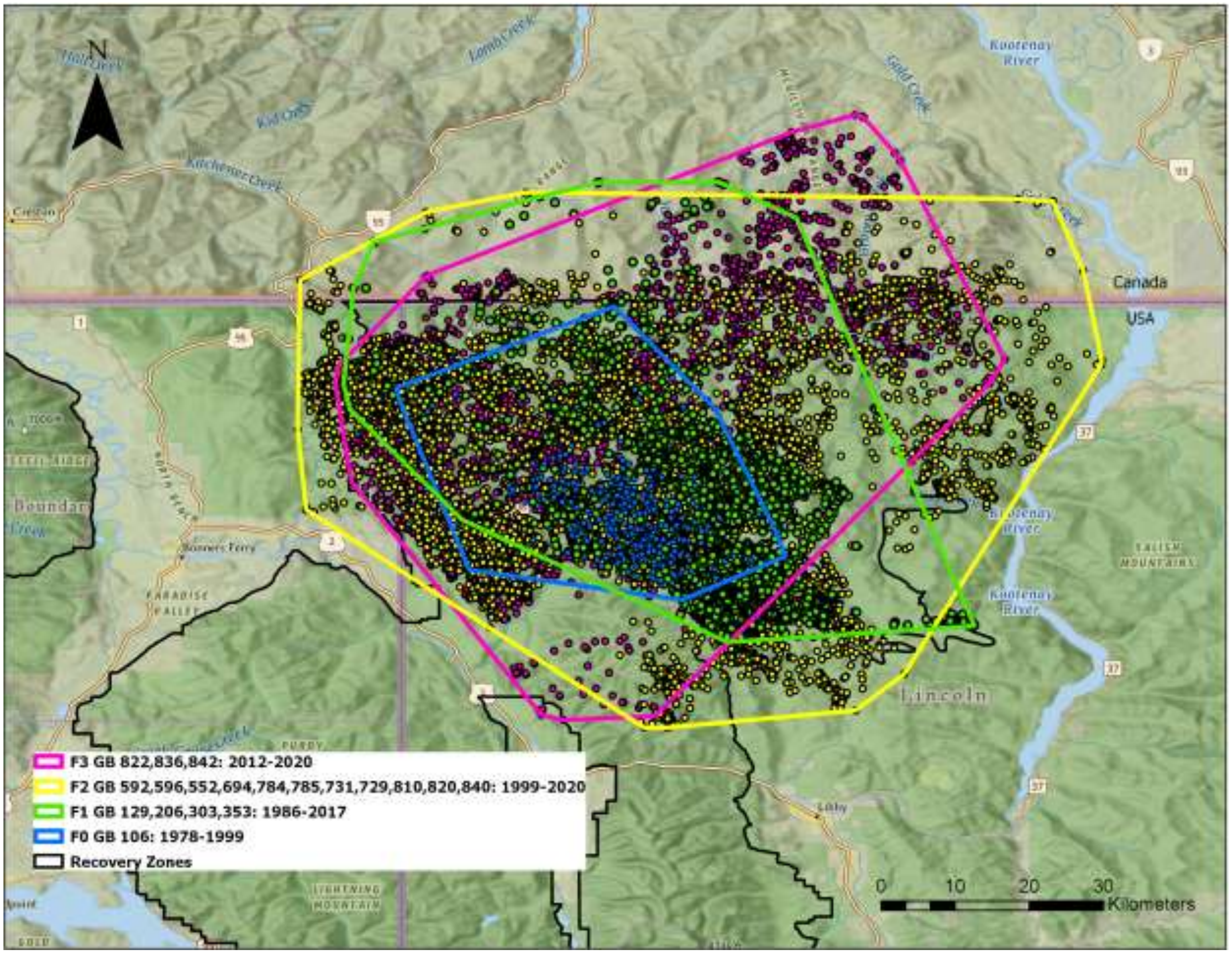

Figure 14. Generational home ranges of female grizzly bears in the Yaak River descended from bear 106, 1986–2020.

Grizzly Bear Denning Chronology

We summarized den entry and exit dates of radio-collared grizzly bears using primarily VHF and GPS location data (1983–2020). Radio-collars deployed since the late 2000s include an activity monitoring device (i.e., accelerometer), which allows an additional, more detailed assessment of den entrance and exit and activity during the denning period.

Den entry dates (n = 129) ranged from the third week of October to the last week of December. Ninety-five percent (122) of entries occurred between the 4th week of October and the 3rd week of December (Fig. 15). Grizzly bears in the Cabinet Mountains (median entry in 2nd week of November) entered dens 2 weeks earlier than bears in the Yaak River drainage (median entry during 4th week of November). Males generally entered dens later than females. Female-offspring family groups tended to enter dens later than independent adult females (Fig. 16). By December 1, 39% of Cabinet and Yaak grizzly bears had not yet entered winter dens (22% females and 61% of males, Fig. 17).

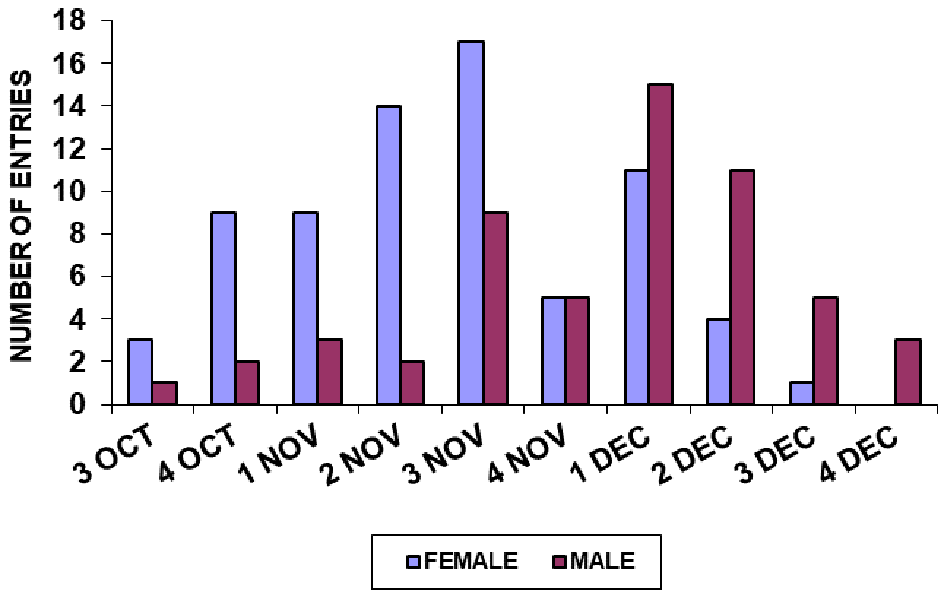

Figure 15. Month and week of den entry for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2020.

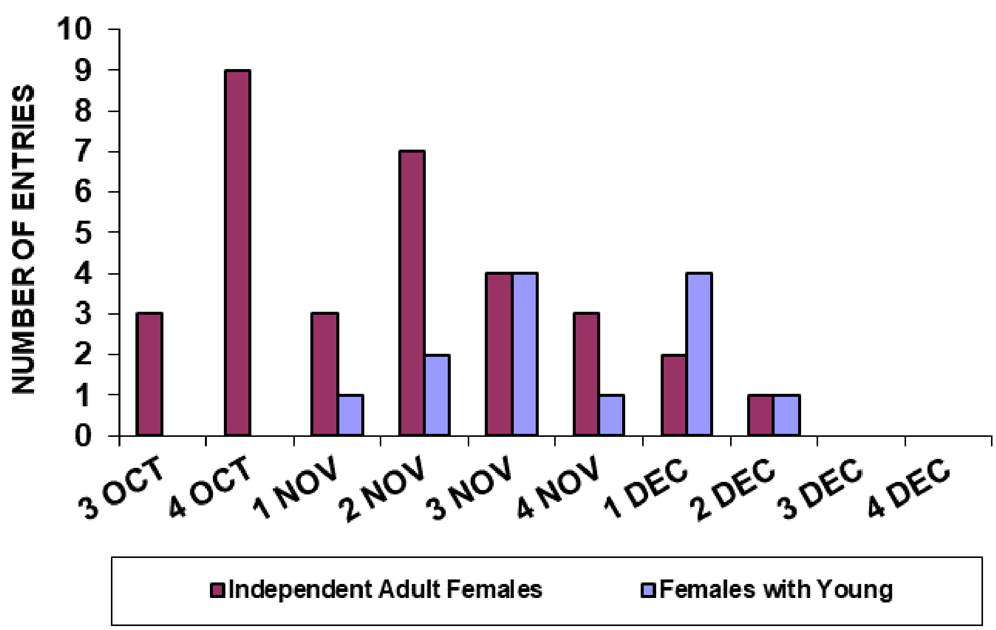

Figure 16. Month and week of den entry for adult female, radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2020.

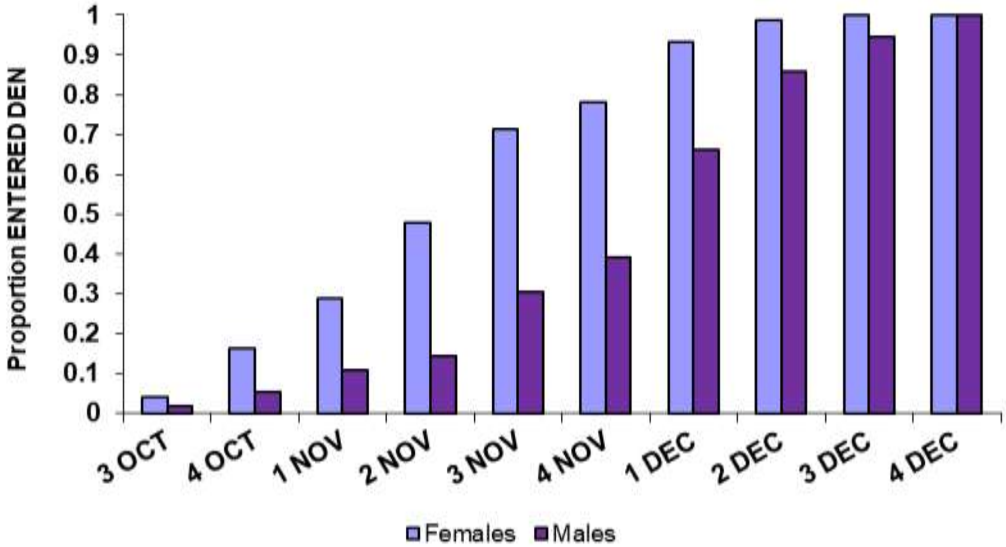

Figure 17. Cumulative proportion of den entries for female and male, radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, by month and week, 1983–2020.

Den exit dates (n = 121) ranged from the first week of March to the third week of May (Fig. 18). Ninety-six percent (116) of exit dates occurred from the 2nd week of March through the 2nd week of May. Grizzly bears in the Cabinet Mountains generally exited dens one week later than bears in the Yaak river drainage. Males tended to exit dens two weeks earlier than females. Sixty-nine percent of den exits occurred during the month of April. By May 1, 13% of Cabinet and Yaak grizzly bears were still in dens, well over half of which were females with cubs. Females with cubs generally exit dens later than other adult females (median exit during 1st week of May; Fig. 19). All adult females with cubs remained at dens until at least April 15.

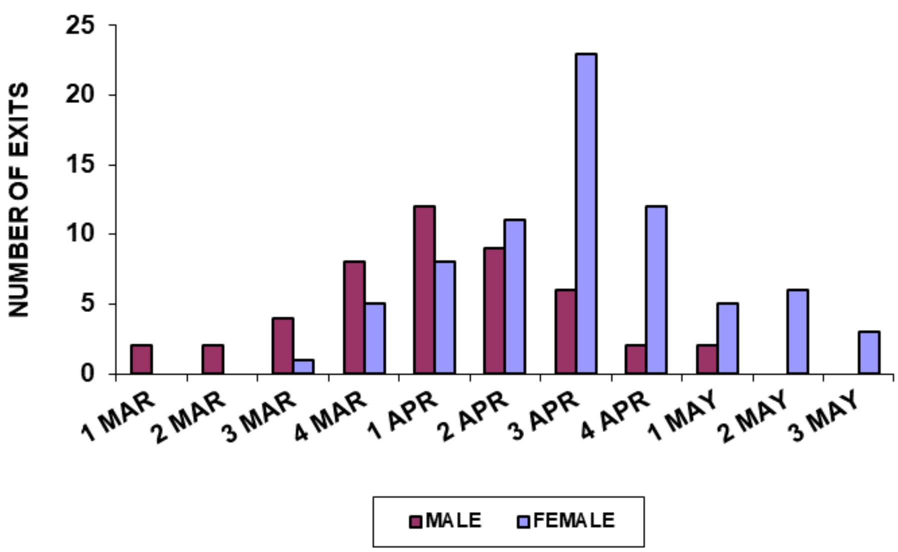

Figure 18. Month and week of den exit for male and female radio-collared grizzly bears in the Cabinet-Yaak grizzly bear recovery zone, 1983–2020.

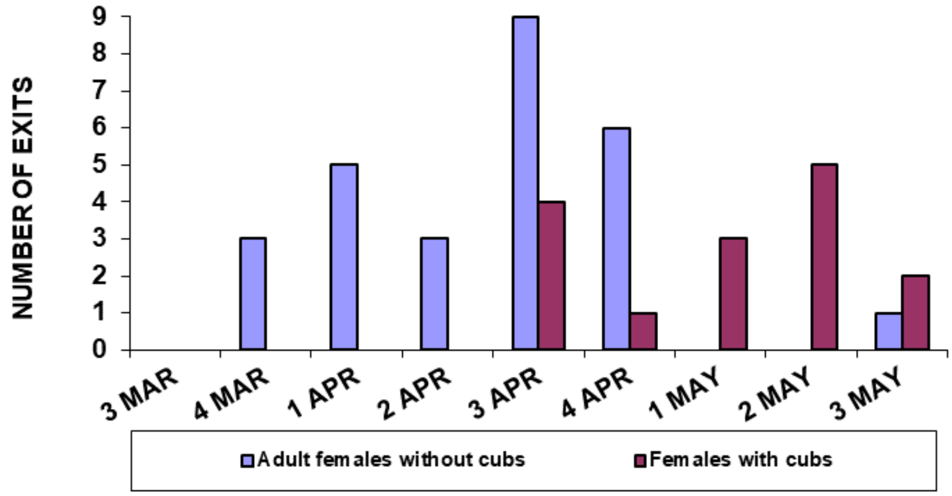

Figure 19. Month and week of den exit for adult female, radio-collared grizzly bears (with and without cubs) in the Cabinet-Yaak grizzly bear recovery zone, 1983–2020.

Grizzly Bear Habitat Analysis

Resource selection functions were utilized to develop seasonal habitat use maps for the Cabinet-Yaak and Selkirk Mountains recovery area zones and surrounding area based on telemetry locations collected from 2004–2015. See Appendix 5 for methodology and maps. The following habitat analysis will discuss both recovery areas.

Grizzly Bear Use by Elevation

Differences in elevation between the Cabinet-Yaak and Selkirk Mountains are reflected in individual bear's radio location data (GPS &VHF) from both areas. To account for differences in sample size between VHF and GPS collared bears, monthly mean elevation for each bear was first calculated. These means were then averaged. Only bears with at least four locations per month were utilized. Grizzly bears in all three study areas exhibited the same general pattern of elevation use (Figure 20). In spring, bears are at lower elevations accessing early green vegetation. As the year progresses, bears move to higher elevations to utilize a variety of berry species. Yaak River bear's decrease in elevation during October and November correspond to the Montana general hunting season. Bears may be utilizing wounded animals and gut piles. Selkirk bears do show an increase in meat consumption later in the year, but by the first week of November 50% of bears have entered dens and may not have the ability to respond to the presence of this protein source. The difference in Idaho and Montana's hunt season structure may account for some of the differences in fall elevation use.

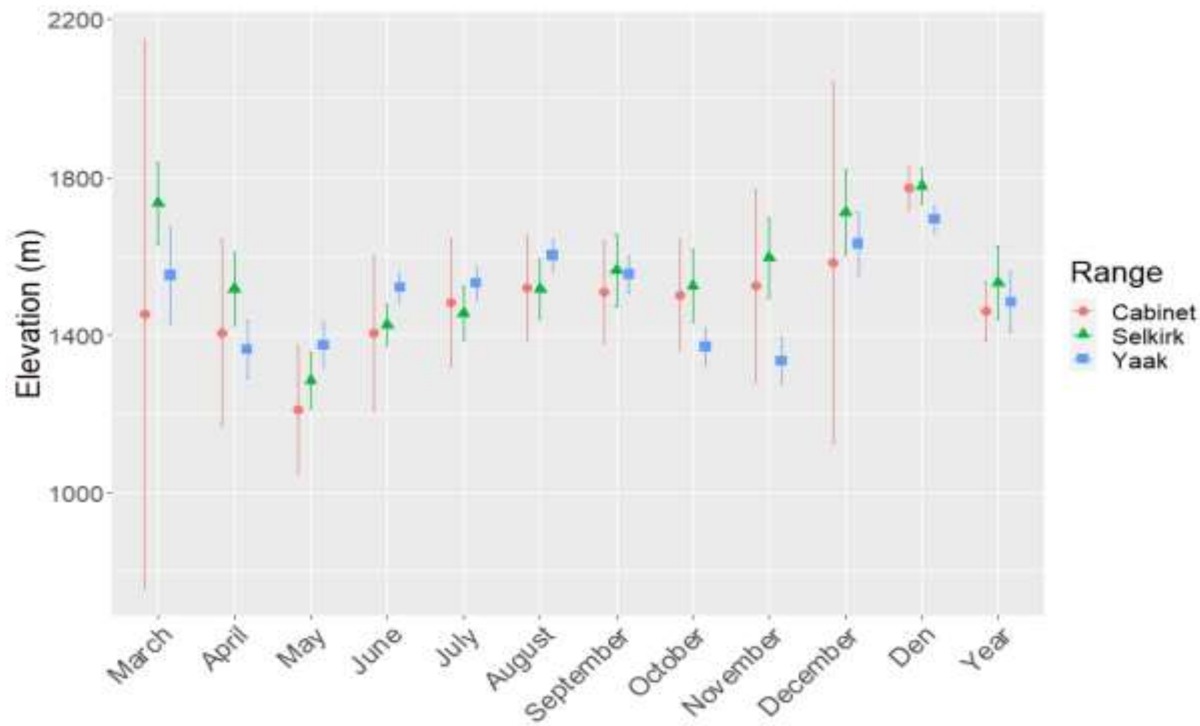

Figure 20. Mean monthly use of elevation for bears in the Cabinet Mountains (*n* = 9) from 1983–2020, the Yaak River (*n* = 58) from 1986–2020, and the Selkirk Mountains (*n* = 93) from 1986–2020 for VHF and GPS collared bears. Error bars represent 95% CI.

Grizzly Bear Use by Aspect

Annual grizzly bear VHF and GPS location summary indicates that Cabinet bears (*n* = 9,801) utilize north facing slopes more so than bears in other study areas (Figure 21). Bears in the Yaak River (*n* = 121,676) and Selkirk (*n* = 84,640) exhibit similar use of aspect, using east the most and north the least.

Bear dens in the Yaak River (*n* = 97) and Selkirk study area (*n* = 93) occurred on east facing slopes more than other aspects (Figure 22). Yaak River bear dens occurred on north slopes more than other study areas. Cabinet bear dens (*n* = 40) utilized east and south facing slopes to the same degree and north facing slopes the least. These differences may be a result of varying topography among study areas and where snowpack is present.

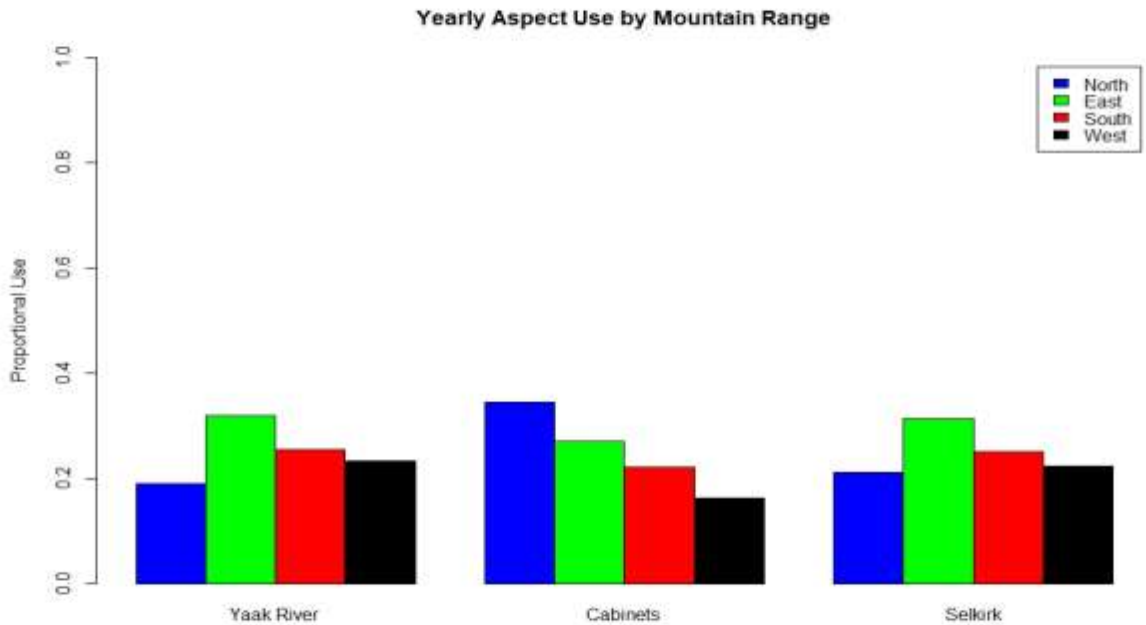

Figure 21. Yearly proportional use of aspect for grizzly bear VHF and GPS locations in the Yaak River from 1986–2020, the Cabinet Mountains from 1986–2020, and the Selkirk Mountains from 1986–2020.

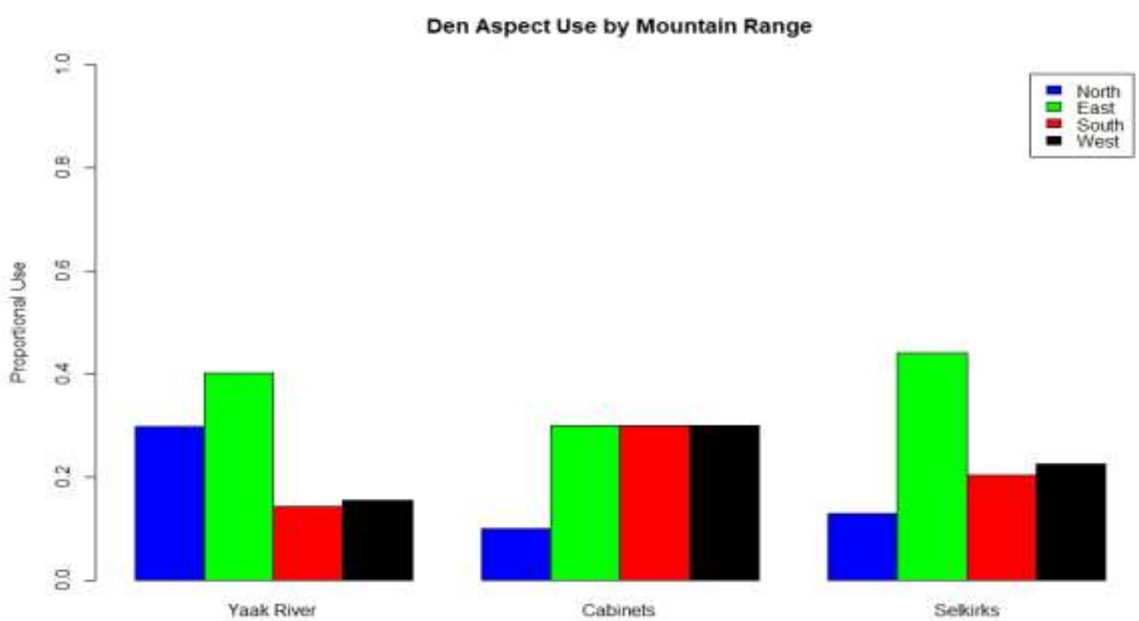

Figure 23. Aspect of grizzly bear dens in the Yaak River from 1986–2020, the Cabinet Mountains from 1983–2020, and the Selkirk Mountains from 1986–2020.

Grizzly Bear Spring Habitat Description

After den emergence in spring, bears seek sites that melt snow early and produce green vegetation. These sites can often overlap with ungulate winter range and provide winterkill carrion. Spring habitat use in both study areas (April and May) indicated use of low elevation sites. Cabinet Mountain radio locations indicated most use below 1,600 m with primary use of southerly facing snow chutes, alder shrub fields, grassy sidehill parks, and closed timber. Yaak River radio locations indicated most use below 1,400 m with primary use of closed timber, timbered shrub fields, cutting units, and grassy sidehill parks on virtually all aspects. Lower elevation of the Yaak River area may allow snow to melt and vegetation to green-up earlier.

Inter-ecosystem Isotope Analysis

We are using isotope analysis to compare grizzly bear food use (plant vs. animal matter) between ecosystems, among sex-age classes, and across management status. Samples currently analyzed are only from grizzly bears of known sex and age. The majority of samples come from capture events; future analysis will include samples from known grizzly bears at hair rub and hair corral sites. To date, we have obtained carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios from 237 grizzly bear hair and blood samples between 1984 and 2015 from the CYE and Selkirk ecosystems. Across the Selkirk and CYE ecosystems, adult males consume slightly more animal matter (22%) than adult females (14%) and subadults (13%). Adult females in the Yaak River consume higher proportions of animal matter (22%) than do adult females in the Cabinets (10%) and the Selkirks (6%).

We estimate that 14% of the annual diet of Cabinet Mountain grizzly bears (n =19 hair samples from non-management bears) is derived from animal matter. Adult males had slightly higher $\delta^{15}N$ stable isotope signatures (4.2‰) than adult females (3.1‰), indicating greater use of available animal matter (24% vs. 10% animal matter, respectively).

Yaak grizzly bear diets contained nearly 22% animal matter (n = 84 hair samples). Adult female use of animal matter varied widely; $\delta^{15}N$ and diet values ranged as low as 2.3‰ (~6% animal matter) to as high as 7.2‰ (~80% animal matter).

Sampled grizzly bears in the Selkirk ecosystem consumed less animal matter than Cabinet and Yaak bears (12%; n =36 hair samples). Diets of non-management, adult female bears include only 7% animal matter. However, one adult female captured in a management incident in the Creston Valley fed on animal matter at a rate of 82%. We suspect bears such as her likely gain meat from bone piles or dead livestock at nearby dairy operations.

Across ecosystems, management bears had slightly higher proportions of meat (26%) in assimilated diets than research bears (17%). Management bears did not necessarily have higher $\delta^{13}C$ signatures as would indicate a more corn-based or anthropogenic food source (-23‰ for both research and management bears). In fact, highest $\delta^{13}C$ in our dataset came from a research female caught in Corn Creek of the Creston Valley, BC in 2008. By all indications, she likely fed extensively on corn from nearby fields without human conflict.

By analyzing different hair types that initiate growth at different times of the year, we have observed increases in proportion of animal matter in bear diets as they transition from summer months (diet estimated from guard hairs) to fall months (diet from underfur). Previous studies have emphasized the importance of splitting these hair types due to temporal differences in growing period (Jones *et al*. 2006). We currently have 45 bear capture events with paired guard hair and underfur samples collected at capture. In all cases, grizzly bears have either 1) the same dietary meat proportion in summer vs. fall or 2) have higher amounts of meat in their fall diet. On average, grizzly bears meat consumption nearly doubles from summer to fall (10.7% summer to 17.6% fall). Fall shifts toward meat use were not isolated to a specific sex-age class. Larger shifts include: an adult male (4327) shifting from 31% meat in summer to 82% meat in fall, an adult female (mortality 5/18/2012) consuming 14% in spring, then 38% in the fall, and a subadult female grizzly (675) with a summer diet consisting of 6% meat and fall diet of 16% meat. We suspect that wounding loss and gut piles from hunted ungulates contribute to observed increases in meat use by grizzly bears in fall months.

Food Habits from Scat Analysis

Grizzly bear scats (*n* =180) were collected in the Cabinet Mountains between 1981 and 1992. Graminoids (grasses and sedges) were consumed frequently (43% of scats) by grizzly bears in May. Additionally, meat, presumably from winter-killed deer and moose, accounted for 40% of all dry matter consumed in April and May (Fig. 24). In June, the use of forbs increased markedly, yet grasses and sedges were still a dominant food category. Cow parsnip (*Heracleum lanatum*), clover (*Trifolium spp.*), and dandelion (*Taraxacum officinale*) were commonly used in June; over half (52%) of scats in June included parts of at least one of these three forbs. By July, forbs (mainly *Heracleum*) comprised 32% of dry matter consumed by grizzly bears. Only 8% of dry matter consumed in July came from grasses and sedges; graminoids begin to cure in July and provide far less digestible nutrition. Grizzly bears began to feed upon berries (huckleberry and whortleberry [*Vaccinium spp.*], serviceberry [*Amelanchier alnifolia*]) and insects (mainly ants) in July. Food habits during August and September were dominated by use of berries (*Vaccinium* spp., in particular), yet September habits include an increased use of animal matter. Unlike black bears, grizzly bears targeted animal matter (deer, elk, moose) in October. We suspect hunter-discarded gut piles or other remains account for a fair amount of the available animal meat. Fall regrowth of forbs (mainly clover) and graminoids contributed 25% of dry matter consumed by sampled grizzly bears in October. Mammal and berries (i.e., the most calorie-dense foods available) in fall constitute 64% of total dry matter consumed annually by grizzly bears.

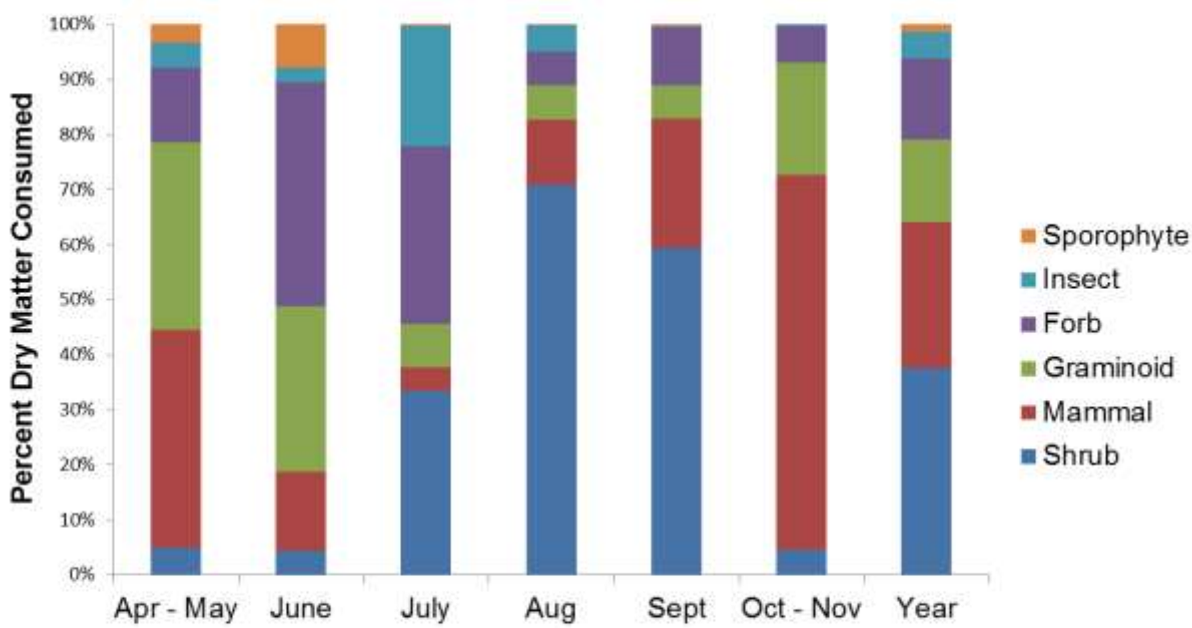

Figure 24. Monthly percent of total dry matter of foods consumed by grizzly bears in the Cabinet Mountains and Yaak River, 1981–1992.

Black bear scats (*n* =618) were collected between 1984 and 1992. Relative use of foods was quite similar to that of grizzly bears between April and August (Fig. 25). However, black bear food habits in September and October were quite different from grizzly bears. Black bears tend to use berries (*Vaccinium* spp., *Sorbus* spp. [mountain-ash], *Amelanchier alnifolia,* and *Arctostaphylos* spp. [bear berry]) more frequently as fall progresses (percent dry matter consumed, August = 74%; September = 82%; October = 91%). In October, black bears fed heavily on mountain-ash. In contrast, grizzly bears increase relative dry matter consumption of animal meat in fall months (August = 12%, September = 24%; October = 68%). We suggest this difference in food use may be explained by either 1) early den entrance dates for black bears (i.e., den entrance before open of big game hunting season), 2) higher energetic demand of larger grizzly bears (i.e., consumption of calorie-dense foods is metabolically preferred by larger bears; Welch *et al*. 1997), 3) interspecific exclusion of black bears by grizzly bears (i.e., exploitative competition), and/or 4) differences in risk behavior between the two species. On an annual basis, black bears consumed less high-quality, calorie-dense foods (meat and berries; 42%) relative to lower-quality foods such as graminoids and forbs (46%).

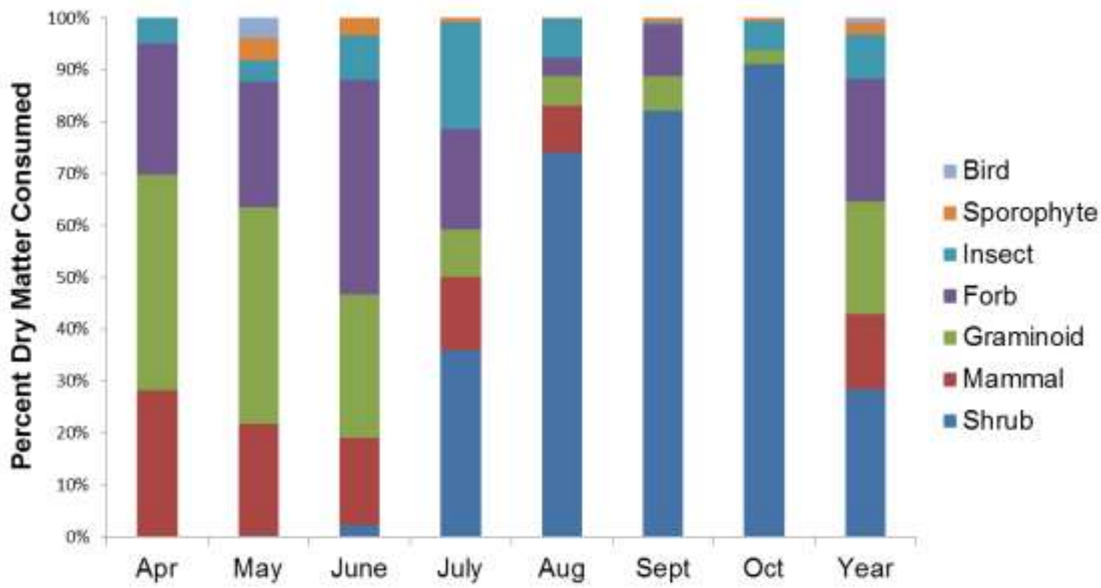

Figure 25. Monthly percent of total dry matter of foods consumed by black bears in the Cabinet Mountains and Yaak River, 1984–1992.

Berry Production

Huckleberry, Buffaloberry, and mountain ash production during 2020 was greater than the long-term average. Serviceberry production was similar to the long-term average. Because of its relatively far-ranging distribution in the CYE and life history of inhabiting larger areas (e.g., shrub fields) when compared with other berry-producing plants, huckleberries appear to provide a greater amount of food for bears in the CYE. However, serviceberry and mountain ash may provide significant secondary food sources in some years when huckleberry crops have failed (e.g., 2001 and 2003). Mountain ash may be particularly valuable to bears in years of low food production because the berries persist and remain on the plants until after frost and leaf drop. Low berry counts for all three of these species would prove most detrimental for bears attempting to store fat for winter denning (e.g., 2002, 2004, and 2015). Because of its sparse distribution, buffalo berries appear to be the least-available berry food for grizzly bears in the CYE. Below-average production among all species surveyed occurred in 1992, 1998–2000, 2002, 2004, and 2015. The 2015 berry season marked the first time we have observed below average counts for all four berry species in one year. Sampling sites for each species were selected to best represent landscape level variation of geography, elevation, aspect, and overstory canopy (Fig. 26).

Fluctuations in berry production in the CYE may be influenced by climatic variables. Holden *et al*. (2012) found huckleberry production in the CYE to be highest in years with cool springs and high July diurnal temperature ranges. Serviceberry production was also highest in years with cool springs and high winter snowpack. Future changes in climate may influence the availability of these foods to CYE grizzly bears.

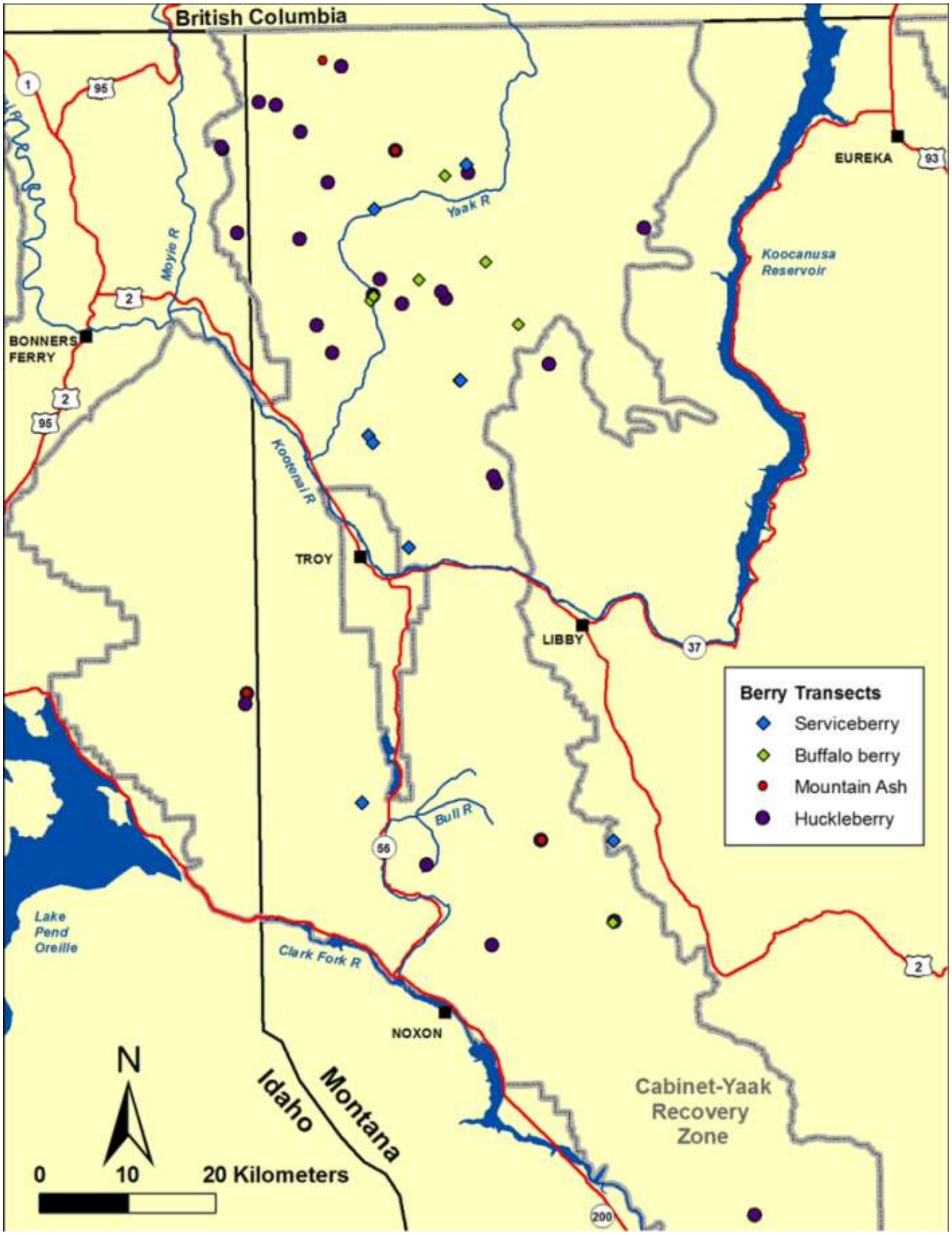

Figure 26. Locations of all serviceberry, buffaloberry, mountain ash, and huckleberry sampling sites within the CYE study area, 1989–2020. Some locations show multiple berry species sites in close proximity.

Huckleberry

We evaluated berry production at a median number of 18 (range=11–23) huckleberry transects per year within the CYE study area from 1989–2020 (Fig. 27). During this study period, the mean number of berries per plot was 1.8 (95% CI ± 0.12). Mean annual berry counts between 1989 and 2020 ranged from 0.5–3.4. Statistically below-average berry counts occurred in 11 years while above average counts occurred in eight years. Highest mean annual counts occurred in 2014. Based upon these production indices at sampled sites, the 9-year period from 1997–2005 was a prolonged stretch of years without above average annual huckleberry production; more recent mean annual counts since 2006 average 108% higher than during the 1997–2005 period (1.1 berries per plot higher). Of interest is whether lower- and higher-than-average production influences population reproduction and survival.

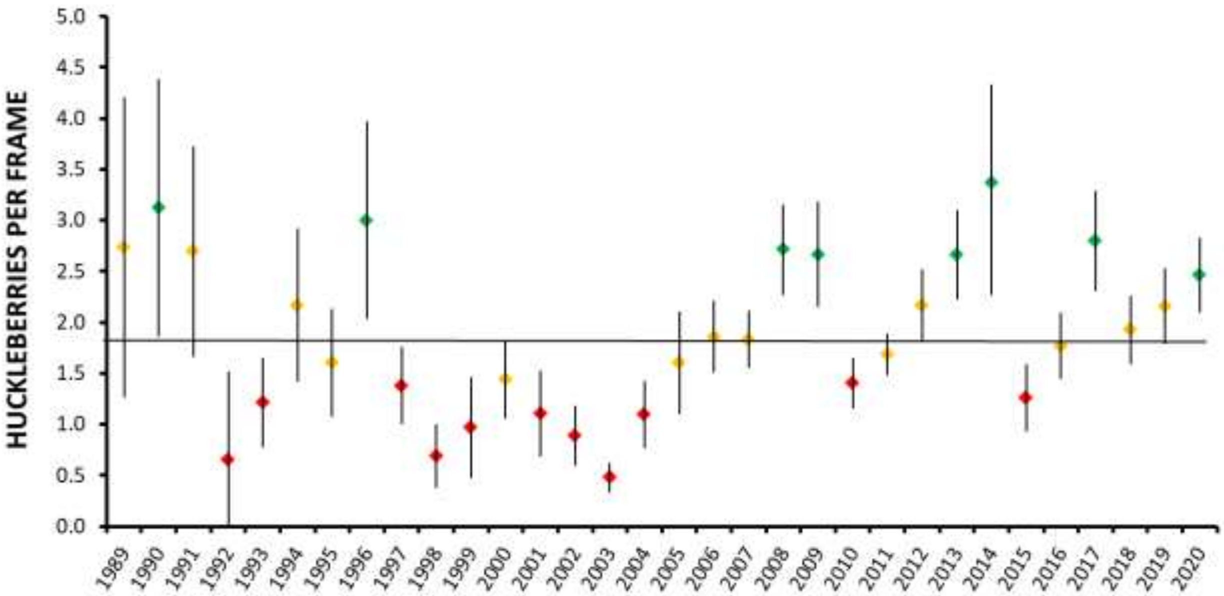

Figure 27. Mean berries per plant (± 95% confidence interval) for huckleberry transects in the Cabinet-Yaak, 1989–2020. Horizontal line indicates study-wide mean production, 1989–2020.

Serviceberry

We evaluated berry production at a median number of six (range = 5–7) serviceberry transects per year from 1990 to 2020 (Fig. 28). The overall mean berry count per plant was 107 (95% CI ± 22) during the study. Mean berry counts per plant ranged from 12 to 355 during the 25+ year index. Statistically below-average counts occurred during 13 years and above average counts occurred only in a single year, 1997. Considering the entirety of the data, the past sixteen years have been particularly less productive (2005–2020; 72 berries per plant) when compared to the first 15 (150 berries per plant from 1990–2004).

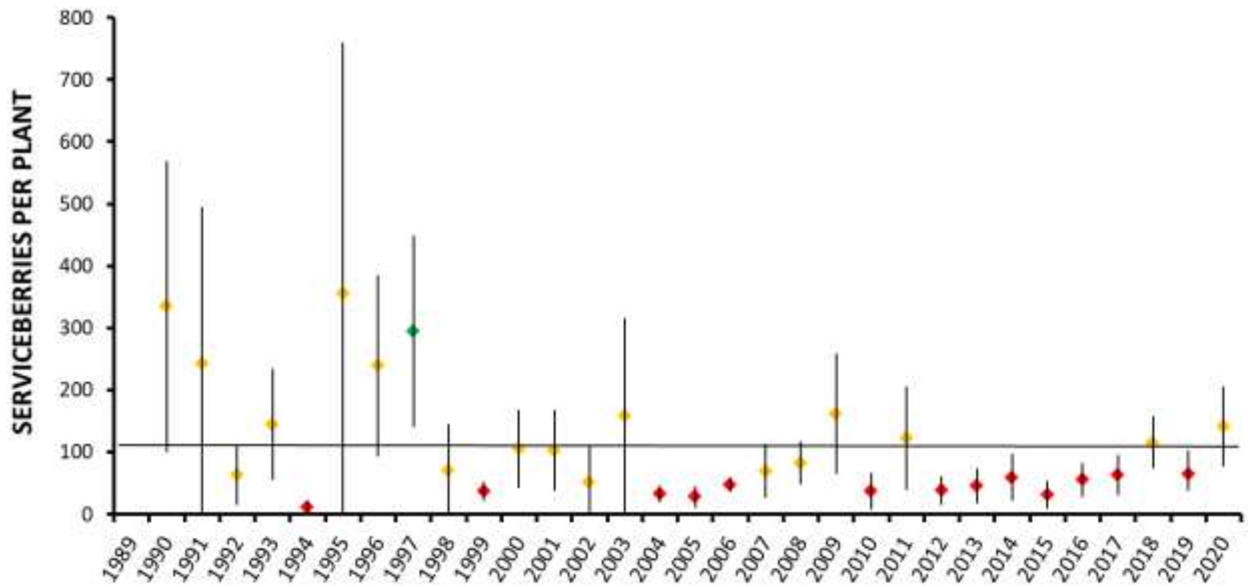

Figure 28. Mean berries per plant (± 95% confidence interval) for serviceberry transects in the Cabinet-Yaak, 1990–2020. Horizontal line indicates study-wide mean production, 1990–20120.

Mountain Ash

Three sites were evaluated for mountain ash production each year, from 2001 to 2020 (Fig. 29). Total mean berry count was 168 berries per plant (95% CI ± 48). Statistically below-average production occurred in six years while above average production occurred in 2 years.

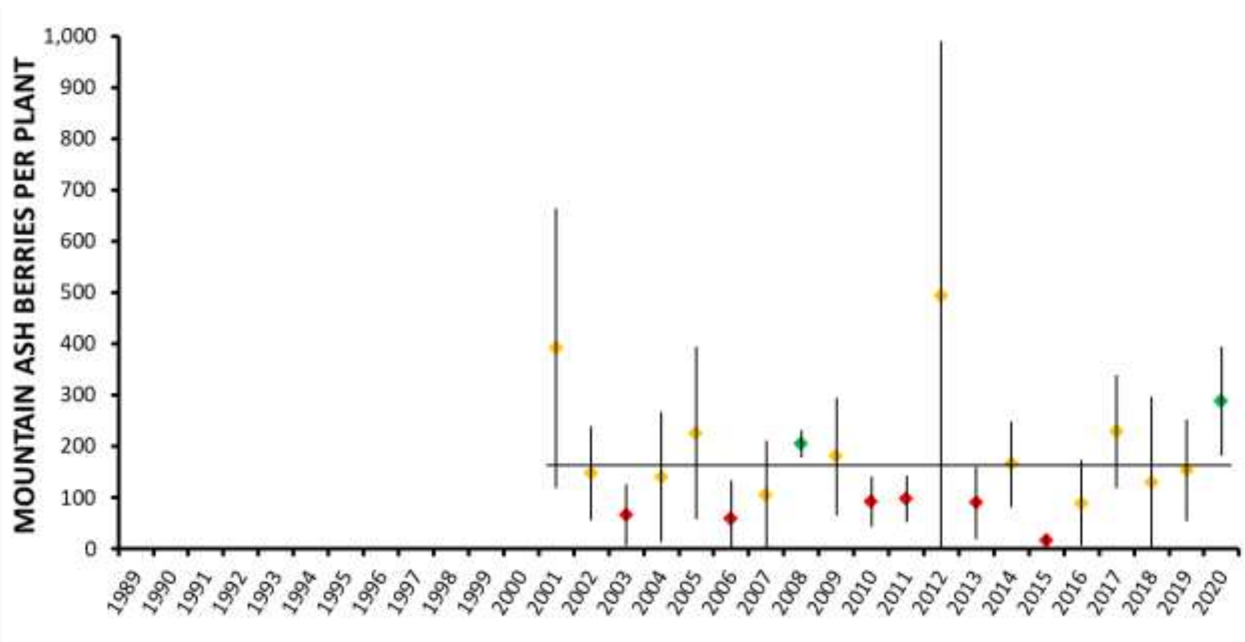

Figure 29. Mean berries per plant (± 95% confidence interval) for mountain ash transects in the Cabinet-Yaak, 2001–2020. Horizontal line indicates study-wide mean production, 2001–2020.

Buffaloberry

Five buffaloberry transects (5 plants at each transect) were evaluated during 1990–1999 and 2002–2003. No sites were sampled during 2004–2006. One new transect (10 plants) was established in 2007 and was the only transect sampled. Another transect (10 plants) was added in 2008. These two transects were evaluated in 2008–2020. A median of 2.5 sites were evaluated annually (range 1–5) between 1990 and 2020. Mean berry count per plant from all transects was 181 (95% CI ± 45) during the study period. Mean berry counts ranged between 15 to 627 berries per plant from 1990 to 2020 (Fig. 30), with statistically below-average counts in nine years and above-average counts occurred in four years.

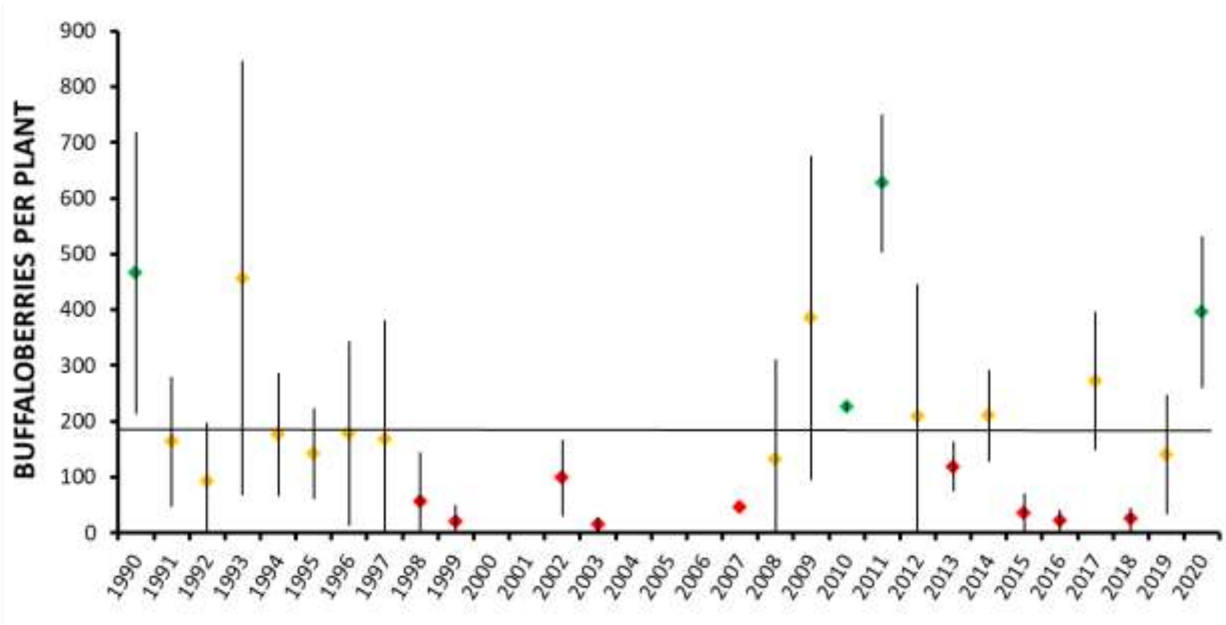

Figure 30. Mean berries per plant (± 95% confidence interval) for buffaloberry transects in the Cabinet-Yaak, 1990–2020. Horizontal line indicates study-wide mean production, 1990–2020.

Body Condition

We estimated body fat content of Cabinet-Yaak and Selkirk (CYS) grizzly bears at 99 independent capture instances, May through November 2010–19. We assessed whether body fat content of CYS grizzly bears differed by sex (56 males, 43 females), capture type (76 research, 23 management captures), and month of capture. Researchers in the Greater Yellowstone and Northern Continental Divide Ecosystems have noted that body fat content of grizzly bears varies by month, exhibiting a trend that is presumably dependent on denning (i.e., inactive) season and availability and quality of foods consumed during the active season (Schwartz *et al*. 2014; Teisberg et al. *in prep*). We similarly partitioned our seasonal data into categorical bins by month, as follows: May (n = 17), June (n = 39), July (n = 16), August (n = 16), and September–November (n = 1).

Body fat content of male and female grizzly bears did not differ (P = 0.077; Table 19). Body fat content of research-captured vs. management-captured grizzly bears also did not differ (P = 0.525; Table 19), suggesting that management bears do not necessarily obtain a more nutritionally rich diet than research-captured bears. However, body fat content of CYS grizzly bears did differ by month (P < 0.0001; Fig. 31). Body fat content in September–November was significantly higher than those in all other months, and August fat contents were higher than those in June (Tukey-HSD contrasts; P<0.05). With all other months, fat content did not differ. CYS grizzly bears appear to start gaining fat as early as July. These results suggest habitat and foods available to CYS grizzly bears allow for body fat gain, such that bears can attain above-average body fat contents in the months preceding den entrance. Reproductive-aged, female grizzly bears experience 1) delayed implantation of already-fertilized eggs in November and 2) cub birth in the den (Jan–Feb). Studies suggest adult females must reach a pre-denning body fat content more than ~20% to support implantation and winter cub production (Robbins et al. 2012).

Table 19. Mean estimates of percent body fat content (kg fat / kg body mass) and effect size (+/- standard error, SE) of Cabinet-Yaak and Selkirk grizzly bears, by factors of interest, 2010–2019.

Factor / Level	Mean	SE
Capture Type		
Research	17.1	+/-0.8
Management	18.1	+/-1.3
Sex		
Female	16.4	+/-1.1
Male	18.8	+/-0.9
Month		
May	17.1	+/-1.6
June	12.7	+/-1.1
July	15.3	+/-1.7
August	18.1	+/-1.6
Sept-Nov	24.7	+/-1.9

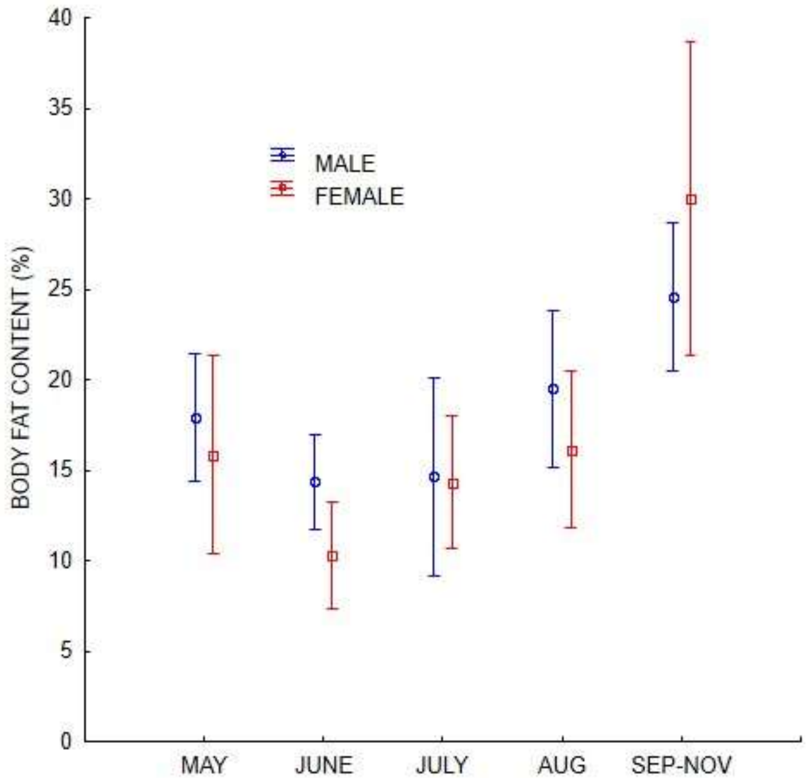

Figure 31. Mean percent body fat content (kg fat / kg body mass) of captured female and male grizzly bears in the Cabinet-Yaak and Selkirk mountains 2010–2019, by month. Error bars represent 95% confidence intervals.

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LITERATURE CITED

Alt, G. L. 1984. Cub adoption in the black bear. Journal of Mammalogy 65:511-512.

Alt, G. L. and J. J. Beecham. 1984. Reintroduction of orphaned black bear cubs into the wild. Wildlife Society Bulletin 12:169-174.

Brenna, J. T., T.N. Corso, H.J. Tobias, and R.J. Caimi. 1997. High-precision continuous-flow isotope ratio mass spectrometry. Mass Spectrometry Reviews. 16:227–258.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York.

Cherry, S., M.A. Haroldson, J. Robison-Cox, and C.C. Schwartz. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175-184.

Erickson, A. W. 1978. Grizzly bear management in the Cabinet Mountains of western Montana. U.S. Forest Service Contract 242-46, Kootenai National Forest.

Farley, S.D., and C.T. Robbins. 1994. Development of two methods to estimate body composition of bears. Canadian Journal of Zoology 72:220–226.

Hayne, D. W. 1959. Calculation of size of home range. Journal of Mammalogy 30:1-18.

Hellgren, E. C., D. W. Carney, N. P. Garner, and M. R. Vaughn. 1988. Use of breakaway cotton spacers on radio collars. Wildlife Society Bulletin 16:216-218.

Hewitt, D. G., and C. T. Robbins. 1996. Estimating grizzly bear food habits from fecal analysis. Wildlife Society Bulletin 24:547–550.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Hovey, F. W. and B. N. McLellan. 1996. Estimating growth of grizzly bears from the Flathead River drainage using computer simulations of reproductive and survival rates. Canadian Journal of Zoology 74:1409-1416.

Johnson, K. G. and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildlife Society Bulletin 8:46-54.

Jones, E. S., D. C. Heard, and M. P. Gillingham. 2006.Temporal variation in stable carbon and nitrogen isotopes of grizzly bear guardhair and underfur. Wildlife Society Bulletin 34:1320–1325.

Jonkel, J. J. 1993. A manual for handling bears for managers and researchers. Edited by T.J. Thier, U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F. and T. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of northwest Montana. Montana Department of Fish, Wildlife, and Parks, Helena.

Kasworm, W. F. and T. J. Thier. 1993. Cabinet-Yaak ecosystem grizzly bear and black bear research, 1992 progress report. U.S. Fish and Wildlife Service, Missoula, Montana.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana. National Park Service Progress Report. 42 pp.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Lewis, J. S. 2007. Effects of human influences on black bear habitat selection and movement patterns within a highway corridor. MS Thesis University of Idaho, Moscow. 152 pp

McLellan, B. N. 1989. Dynamics of a grizzly bear population during a period of industrial resource extraction. III Natality and rate of increase. Canadian Journal of Zoology 67:1861-1864.

Paetkau, D., R. Slade, M. Burden, and A. Estoup. 2004. Genetic assignment methods for the direct, real-time estimation of migration rate: a simulation-based exploration of accuracy and power. *Molecular Ecology* **13**, 55-65.

Piry, S., A. Alapetite, J.-M. Cornuet, D. Paetkau, L. Baudouin, and A. Estoup. 2004. GeneClass2: A software for genetic assignment and first-generation migrant detection. Journal of Heredity 95:536-539.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7-15.

Proctor, M.F., 2003. Genetic analysis of movement, dispersal, and population fragmentation of grizzly bears in southwestern Canada. PhD Thesis. University of Calgary. 147 pp.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Proctor, M., B.N. McLellan, C. Strobeck, and R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society, London 272:2409-2416.

Proctor, M.F., D. Paetkau, B.N. McLellan, G.B. Stenhouse, K.C. Kendall, R.D. Mace, W.F. Kasworm, C. Servheen, C.L. Lausen, M.L. Gibeau, W.L. Wakkinen, M.A. Haroldson, G. Mowat, C.D. Apps, L.M. Ciarniello, R.M.R. Barclay, M.S. Boyce, C.C. Schwartz, and C. Strobeck. 2012. Population Fragmentation and Inter-Ecosystem Movements of Grizzly Bears in Western Canada and the Northern United States. Wildlife Monographs 180:1-46.

Proctor, M. F., W. F. Kasworm, K. M. Annis, A. G. MacHutchon, J. E. Teisberg, T. G. Radandt, C. Servheen. 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human Wildlife Interactions 12:248-272.

Qi, H., Coplen, T.B., Geilmann, H., Brand, W.A. and Böhlke, J.K. 2003. Two new organic reference materials for δ13C and δ15N measurements and a new value for the δ13C of NBS 22 oil. Rapid Communications in Mass Spectrometry. 17:2483–2487.

Robbins, C. T., M. Ben-David, J. K. Fortin, and O. L. Nelson. 2012. Maternal condition determines birth date and growth of newborn bear cubs. Journal of Mammalogy 93:540–546.

Schwartz, C. C., J. K. Fortin, J. E. Teisberg, M. A. Haroldson, C. Servheen, C. T. Robbins, and F. T. van Manen. 2014. Body and diet composition of sympatric black and grizzly bears in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 78:68–78.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr., R. A. Sellars, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. Kasworm, R. Smith, and S. Herrero. 2003. Reproductive maturation and senescence in the female brown/grizzly bear. Ursus. 14:109-119.

Stoneberg, R. and C. Jonkel. 1966. Age determination in black bears by cementum layers. Journal of Wildlife Management 30:411-414.

Thier, T. J. 1981. Cabinet Mountains grizzly bear studies, 1979-1980. Border Grizzly Project Special Report 50. University of Montana, Missoula.

Thier, T. J. 1990. Population characteristics and the effects of hunting on black bears in a portion of northwestern Montana. M.S. Thesis. University of Montana, Missoula.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana.

U.S. Forest Service. 1989. Upper Yaak draft environmental impact statement. U.S. Forest Service, Kootenai National Forest.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

Welch, C.A., J. Keay, K.C. Kendall, and C.T. Robbins. 1997. Constraints on frugivory by bears. Ecology 78:1105–1119.

Woods, J.G., D. Paetkau, D. Lewis, B.N. McLellan, M. Proctor, and C. Strobeck. 1999. Genetic tagging of free-ranging black and brown bears. Wildlife Society Bulletin. 27:616-627.

PUBLICATIONS OR REPORTS INVOLVING THIS RESEARCH PROGRAM

Canepa, S., K. Annis, and W. Kasworm. 2008. Public opinion and knowledge survey of grizzly bears in the Cabinet-Yaak Ecosystem. Cabinet-Yaak and Selkirk Mountains Subcommittee of the Interagency Grizzly bear Committee, Missoula, Montana. 88 pp.

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231.

Jansen, H.T., T. Leise, G. Stenhouse, K. Pigeon, W. Kasworm, J. Teisberg, T. Radandt, R. Dallmann, S. Brown and C T. Robbins. 2016. The bear circadian clock doesn’t ‘sleep’ during winter dormancy. Frontiers in Zoology 13:42 15 pages.

Kasworm, W. F. and T. L. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of Northwest Montana. Montana Department Fish, Wildlife, Parks, Helena.

Kasworm, W. F. 1989. Telling the difference. Wyoming Wildlife. Volume 53, No. 8, pages 28-33.

Kasworm, W. F. and T. L. Manley. 1990. Influences of roads and trails on grizzly bears and black bears in Northwest Montana. International Conference on Bear Research and Management 8:79-84.

Kasworm, W. F. and T. J. Thier. 1994. Adult black bear reproduction, survival, and mortality sources in northwest Montana. International Conference on Bear Research and Management 9:223-230.

Kasworm, W. F., T. J. Thier, and C. Servheen. 1998. Grizzly bear recovery efforts in the Cabinet-Yaak ecosystem. Ursus 10:147-153.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261-1266.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, W. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak ecosystem. Journal of Wildlife Management. 80:314-331.

Knick, S. T. and W. Kasworm. 1989. Shooting mortality in small populations of grizzly bears. Wildlife Society Bulletin 17:11-15.

Mace, R., K. Aune, W. Kasworm, R. Klaver, and J. Claar. 1987. Incidence of Human Conflicts by Research Grizzly Bears. Wildlife Society Bulletin 15:170-173.

McCall, B. S., M.S. Mitchell, M.K. Schwartz, J. Hayden, S.A. Cushman, P. Zager, W.F. Kasworm. 2013. Combined use of mark-recapture and genetic analyses reveals response of a black bear population to changes in food productivity. Journal of Wildlife Management 77:1572-1582.

McLellan, B. N., F. W. Hovey, R. D. Mace, J. G. Woods, D. W. Carney, M. L. Gibeau, W. L. Wakkinen, and W. F. Kasworm. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, Washington, and Idaho. Journal of Wildlife Management 63:911-920.

Proctor, M.F., C. Servheen, S.D. Miller, W.F. Kasworm, and W.L. Wakkinen. 2004. A comparative analysis of management options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145-160.

Proctor, M. P., D. Paetkau, B. N. Mclellan, G. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in Western Canada and Northern United States. Wildlife Monographs 180:1-46.

Proctor, M. P., Nielson, S. E., W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. Machutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada–United States trans-border region. Journal of Wildlife Management 79:544-558.

Proctor, M. P., W. F. Kasworm, K. M. Annis, A. G. Machutchon , J. E. Teisberg, T. G. Radandt, , and C. Servheen. 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human–Wildlife Interactions 12(3):348–372.

Romain-Bondi, K.A., R. B. Wielgus, L. Waits, W.F. Kasworm, M. Austin, and W. Wakkinen. 2004. Density and population size estimates for North Cascade grizzly bears using DNA hair-sampling techniques. Biological Conservation 117:417-428.

Schwartz, C. C., K. A. Keating, H. V. Reynolds III, V. G. Barnes, Jr., R. A. Sellers, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. L. Wakkinen, R. D. Mace, W. F. Kasworm, R. Smith and S. Herrero. 2003. Reproductive maturation and senescence in the female brown bear. Ursus 14:109-119.

Servheen, C., W. Kasworm, and A. Christensen. 1987. Approaches to augmenting grizzly bear populations in the Cabinet Mountains of Montana. International Conference on Bear Research and Management 7:363-367.

Servheen, C., W. F. Kasworm, and T. J. Thier. 1995. Transplanting grizzly bears *Ursus arctos horribilis* as a management tool - results from the Cabinet Mountains, Montana, USA. Biological Conservation 71:261-268.

Servheen, C., J. Waller and W. Kasworm. 1998. Fragmentation effects of high-speed highways on grizzly bear populations shared between the United States and Canada. 1998 International Conference on Wildlife Ecology and Transportation, Pages 97-103.

Swensen, J. E., W. F. Kasworm, S. T. Stewart, C. A. Simmons, and K. Aune. 1987. Interpopulation applicability of equations to predict live weight in black bears. International Conference on Bear Research and Management 7:359-362.

Thier, T. J. and W. F. Kasworm. 1992. Recovery of a Grizzly Bear from a Serious Gunshot Wound. The Montana Game Warden 4(1):24-25.

U.S. Fish and Wildlife Service. 1990. Final environmental assessment - grizzly bear population augmentation test, Cabinet-Yaak ecosystem. U.S. Fish and Wildlife Service, Missoula.

Wakkinen, W. L. and W. F. Kasworm. 1997. Grizzly bear and road density relationships in the Selkirk and Cabinet-Yaak recovery zones. U.S. Fish and Wildlife Service, Missoula, MT.

Wakkinen, W. L. and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 65-75.

APPENDIX Table 1. Mortality assignment of augmentation bears removed from one recovery area and released in another target recovery area.

#	Scenario	Where Mortality Credited and Year [1]	
		Source	**Target**
1	Bear stays in Target recovery area[2] past Year 1.	Mortality removal year	No mortality
2	Bear dies in Target recovery area[2] during Year 1.	Mortality removal year	No mortality
3	Bear dies in Target recovery area[2] after Year 1.	Mortality removal year	Mortality, Year 2 or later
4	Bear returns to Source area[2] and dies within Year 1.	Mortality year of death	No mortality
5	Bear returns to Source area[2] and is alive in Year 1.	No mortality	No mortality
6	Bear returns to Source area[2] and is alive after Year 1.	No mortality	No mortality
7	Bear returns to Source area[2] and dies there after Year 1.	Mortality year of death	No mortality
8	Bear dies outside both Target and Source areas[2] within Year 1.	Mortality removal year	No mortality
9	Bear dies outside both Target and Source areas[2] after Year 1.	Mortality removal year	No mortality
10	Collar failure/lost bear in Target area[2] within Year 1.	Mortality removal year	No mortality
11	Collar failure/lost bear in Target area[2] after Year 1.	Mortality removal year	No mortality
12	Collar failure/lost bear outside both Target and Source areas[2] within Year 1.	Mortality removal year	No mortality
13	Collar failure/lost bear outside both Target and Source areas[2] after Year 1.	Mortality removal year	No mortality

[1] Year 1 begins on the day the bear is released in the target area and ends after 365 days. One year was chosen to give the animal an opportunity to locate and use all seasonal habitats. This rule set may conditionally require a bookkeeping correction to remove the mortality in the source area in the year of removal.

[2] Target and Source areas include 10-mile buffer around Recovery Zones. Bears dying in Canada only count against mortality limits in the Selkirk Mountains, where the Recovery Plan defines a Recovery Zone that includes Canada. If an augmentation bear leaves the target recovery area and dies, it counts as source area mortality in the removal year, but it does not count as target area mortality. If an augmentation bear leaves the target recovery area in year 2 or later, it counts as source area mortality in year 1 and target area mortality in year 2 or later if the mortality was human caused. While this approach counts a bear as dead twice, the second mortality represents a human caused mortality issue outside of a bear learning a new area and should be counted in the target area. (Mortalities in Canada only count inside the Selkirk recovery zone inside Canada and the 10-mile buffer will not apply to that portion of the Selkirk recovery area in Canada. Areas adjacent to the Canadian Selkirks have more robust, contiguous populations, several of which are hunted, and mortality should not be counted against the Selkirk recovery area. The 10-mile buffer was promoted inside the US because this area was believed to contain animals that spent a portion of their time outside the recovery area but were believed to be part of that recovery area population.)

APPENDIX Table 2. Known historic grizzly bear mortality pre-dating project monitoring, in or near the Cabinet-Yaak recovery zone and the Yahk grizzly bear population unit in British Columbia, 1949–1978.

YEAR	LOCATION	TOTAL	SEX / AGE	MORTALITY CAUSE
1949	COPPER CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1950	SQUAW CR, MT	1	SUBADULT	UNKNOWN
1951	PETE CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1951	PAPOOSE CR, MT	2	SUBADULTS	UNKNOWN
1951	GOAT CR, MT	1	SUBADULT MALE	UNKNOWN
1952	FELIX CR, MT	6	2 ADULT FEMALES, 4 YEARLINGS	HUMAN, MANAGEMENT REMOVAL
1953	OBRIEN CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1953	KENELTY MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	20-ODD MT, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	BURNT CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1953	17-MILE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	N F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	S F BULL R, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	CEDAR LK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	TAYLOR PK, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBUTTE CR, MT	1	UNKNOWN	HUMAN, LEGAL HUNTER KILL
1954	SILVERBOW CR, MT	1	ADULT FEMALE	HUMAN, LEGAL HUNTER KILL
1955	WOLF CR, MT	1	ADULT MALE	HUMAN, MANAGEMENT REMOVAL
1955	MT HEADLEY, MT	1	SUBADULT	HUMAN, MANAGEMENT REMOVAL
1955	BAREE LK, MT	1	ADULT MALE	UNKNOWN
1955	BAREE LK, MT	1	ADULT FEMALE	UNKNOWN
1955	BEAR CR, MT	1	SUBADULT MALE	HUMAN, LEGAL HUNTER KILL
1958	SQUAW CR, MT	1	ADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1959	E F ROCK CR, MT	2	ADULT FEMALE, 1 CUB	HUMAN, LEGAL HUNTER KILL
1959	W F THOMPSON R, MT	4	ADULT FEMALE, 3 CUBS	UNKNOWN
1959	CLIFF CR, MT	1	UNKNOWN	UNKNOWN
1960	PROSPECT CR, MT	2	ADULT FEMALE, 1 CUB	UNKNOWN
1964	GRAVES CR, MT	2	SUBADULTS	UNKNOWN
1964	WANLESS LK, MT	3	SUBADULTS (ADULT WOUNDED)	UNKNOWN
1965	SNOWSHOE CR, MT	2	SUBADULTS	UNKNOWN
1965	PINKHAM CR, MT	1	UNKNOWN	UNKNOWN
1967	SOPHIE LK, MT	1	UNKNOWN	UNKNOWN
1968	BEAR CR, MT	1	ADULT FEMALE	HUMAN, ILLEGAL KILL
1968	GRANITE CR, MT	1	SUBADULT MALE	HUMAN, MANAGEMENT REMOVAL
1969	PRISCILLA PK, MT	1	ADULT FEMALE	UNKNOWN
1970	THOMPSON R, MT	1	UNKNOWN	UNKNOWN
1970	CAMERON CR, MT	1	SUBADULT MALE	UNKNOWN
1970	SQUAW CR, MT	2	ADULT FEMALE, SUBADULT FEMALE	HUMAN, MANAGEMENT REMOVAL
1971	MURR CR, MT	1	ADULT FEMALE	UNKNOWN
1972	ROCK CR, MT	1	SUBADULT	HUMAN, MISTAKEN IDENTITY (Black Bear)
1974	SWAMP CR, MT	1	ADULT MALE	HUMAN, LEGAL HUNTER KILL
1977	RABBIT CR, MT	1	ADULT MALE	HUMAN, DEFENSE OF LIFE BY HUNTER
1978	MOYIE LAKE, BC	1	SUBADULT MALE	HUMAN, MANAGEMENT

APPENDIX Table 3. Movement and gene flow to or from the Cabinet-Yaak recovery area.

Area[1] Start / Finish	Action	Bear ID	Sex	Age	Year	Basis	Comments
Cabs / NCDE	Movement	C403M	M	2-3	2007	Telemetry, Genetics	Captured Marion, MT 2006 NCDE, traveled to Whitefish, relocated to Whitefish Range. Train kill 2007
NCDE / SPur	Movement	YGB737M	M	4	2010	Genetics	Captured and monitored 2010-15. Parentage in NCDE by USGS.
NCDE / SPur	Movement	43-44	F	3	2013	Capture, Mortality	Management bear relocated at least twice in NCDE. Traveld to SPur, shot after Killing chickens by landowner.
NPur / SPur	Movement	P9183M	M	Unk	2004-05	Genetics	DNA captured NPur and SPur.
NPur / SPur	Movement	PKiddM	M	7	2004	Telemetry	Radio collared June 2004, Travels from NPur to SPur, offspring in SPur.
NPur / SPur	Movement	YMarilF	F	4-5	2005-06	Telemetry, Genetic assignment	Radio collared July 2005 in SPur, Genetic assignment to the NPur. Management removal 2006.
NPur / SPur	Movement	Y732M	M	3	2011	Genetics	Born in NPur and Traveled to SPur. Mortality 2011.
NPur / SPur	Movement	10569F	F	6	2005, 2012	Genetics, Mortality	Father SPur YVernM, Mother NPur PIrishF, DNA capture NPur 2005, Mortality with cub SPur 2012
NPur / SPur	Gene flow	Y90479M	M	0.5	2012	Genetics, Mortality	Father Y576M Mother 10569F Mortality 2012
SPur / NCDE	Movement	N323M	M	Unk	1999	Genetics	Hair snagged 1999 in SPur. Hair snagged NCDE USGS 1998-2006. USGS assigned to SPur.
SPur / Salish	Movement	Y128M	M	18	2001	Mortality	Capture 1987. Monitored 1987-92 and 1997 SPur. Recaptured August 2001 in Salish, Mortality 2001.
SPur / NPur	Movement	Y128M	M	4-14	1987-92, 1997	Telemetry	Capture May 1987 SPur. Monitored 1987-92 and 1997. Monitored NPur and produced offspring.
SPur / NPur	Movement	YVernM	M	7-12	1997, 2002	Telemetry, Genetics	Radio collared SPur 1997. Hair snag NPur 2002.Sired offspring NPur and SPur.
SPur / NPur	Movement	YRockyM	M	8-12	2002-06	Telemetry	Captured and collared SPur 2002. Recapture 2006. Traveled NPur in 2006.
SPur / NPur	Movement	134	M	8-9	1987-88	Telemetry	Radio collar in SPur 1987. Hunter kill 1988 NPur
SPur / NPur	Movement	P9190M	M	4-5	2006-07	Telemetry	Radio collared June 2006 SPur. Traveled to NPur
SPur / NPur	Movement	PTerryM	M	3	2005	Telemetry, Genetics	Father SPS Y178M, Mother SPS Y538F Travel to NPur from SPur.
SPur / SSelK	Movement	YHydeM	M	3	2006-07	Telemetry	Captured in SPur Yaak 2006. Bear traveled to SSelk 2006-07
SPur / SSelK	Gene flow	SOsoM	M	Unk	2009	Genetics	Hair snagged 2001 SPur. Captured SSelk 2009.
SSelk / Cabs / SSelk	Movement	928442	M	5	2012	Genetics	Father SSelk S9058aM, Mother SSelk SBettyF, Hair snagged USGS 2012 Cabs and in SSelk 2015
SSelk / SPur	Movement	S31M	M	6	2004-05	Telemetry, Mortality	Father SSelk SS3KM, Mother SSelk S1MF, Management capture 2003 and Relocated. Hunter kill 2005 SPur
SPur / Cabs / SPur	Movement	Y726M	M	6	2015-16	Telemetry	Travel from SPur to Cabs and back
SPur / SRock	Movement	922947	M	5	2013	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SPur / SRock	Movement	928196	M	20	2015-16	Telemetry	Travel north from SPur across Kootenay in BC to SRock and return
SSelk / Cabs	Movement	S1001M	M	6	2015	Telemetry, Mortality	Travel from SSelk to Cabs. Mortality 2015
Cabs / NCDE	Movement	900932	M	4	2015-16	Telemetry	Travel east from Cabs to NCDE

Area[1] Start / Finish	Action	Bear ID	Sex	Age	Year	Basis	Comments
SPur / NPur	Movement	958729	M	12	2016	Telemetry	Travel north from SPur to NPur
SPur / SSelk	Movement	Y11048M	M	4	2017	Telemetry, Mortality	Travel west from SPur to SSelk. Mortality 2017
SPur / SSelk	Movement	YGB807M	M	5	2015-17	Telemetry	Travel west from SPur to SSelk.
SPur / Cabs	Movement	Y821M	M	3	2017	Telemetry	Travel from SPur to Cabs
NPur / SPur	Gene flow	YGB837M	M	6	2014	Genetics	Parents both NPur, Father NPur PKiddM, Mother NPur PIrishF
SPur / NPur	Gene flow	P9194F	F	Unk	2004-05	Genetics	Father SPur Y128M, Mother NPur P9127F, Origin of father probably NPur
NPur / SPur	Gene flow	Y787M	M	3	2003	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
NPur / SPur	Gene flow	YU37F	F	1	2001	Genetics	Father SPurYVernM, Mother SPur Y354F, Origin of father probably NPur
SSelk / SPur	Movement	16749	M	Unk	2015	Genetics	Father C134B2V2, Mother JillS226F Both SSelk. Male offspring 16749 SPur
NCDE / Cabs	Movement	C90467M	M	6	2014	Genetics, Mortality	Management bear from NCDE traveled to Cabs, mortality 2014
NCDE / Cabs	Movement	C30604M	M	4	2017	Genetics, Mortality	NCDE Management bear traveled to Cabs 2017 and returned to NCDE mortality 2017
NCDE / Cabs	Movement	C866M	M	3	2019	Genetics	Genetics identified parents in NCDE, captured in Cabinets
NPur / SPur	Movement	P1374M	M	2	2010	Genetics, Mortality	Hair snag as cub in 2008 NPur? Management capture SPur 2010, relocated, Mortality 2010
NPur / SSelk / Cabs / Bitt	Gene flow, Movement	S21285M	M	0.5-2	2016-18	Genetics, Telemetry	Father NPur SCptHM, Mother SSelk S11675F, S21285M traveled to Cabs in 2018, then dropped collar, hair snagged in Bitterroot
SPur / SRock	Movement	18986	M	4	2018	Genetics, Telemetry	Travel north from SPur across Kootenay in BC to SRock (BC mgmt. capture)
NPur / SPur	Movement	Y29761M	M	Unk	2017	Genetics	Father P9101M, Mother PMaeveF, both NPur. Male offspring Y29761M SPur

[1]Cabs – Cabinet Mountains, NCDE – Northern Continental Divide, NPur – Purcell Mountains north of Highway 3, SPur – Purcell Mountains south of Highway 3, SSelk – South Selkirk Mountains south of Nelson, BC

APPENDIX 4. Grizzly Bear Home Ranges

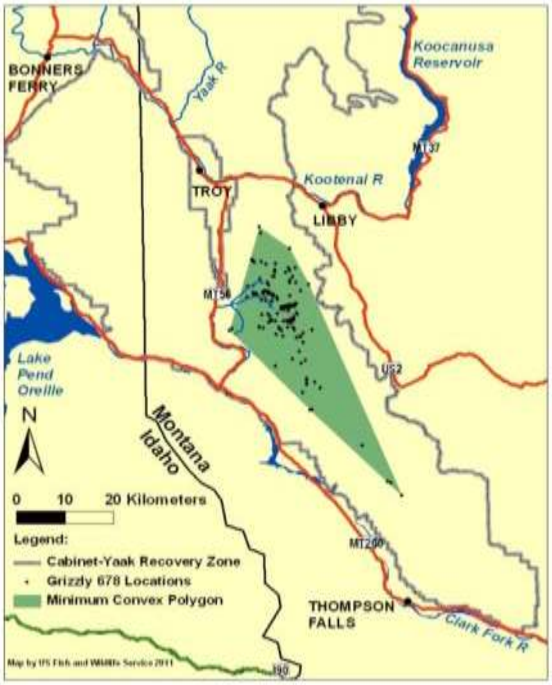


Figure A1. Radio locations and minimum convex (shaded) life range of female grizzly bear 678 in the Cabinet Mountains, 1983–1989.

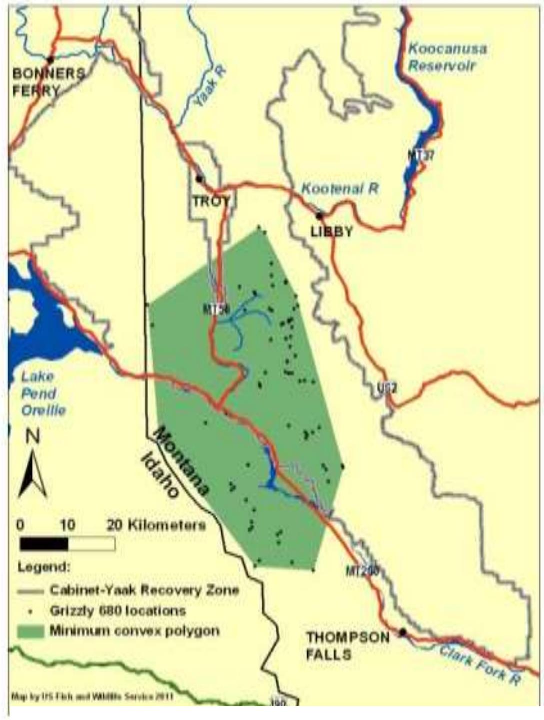


Figure A2. Radio locations and minimum convex (shaded) life range of male grizzly bear 680 in the Cabinet Mountains, 1984–1985.

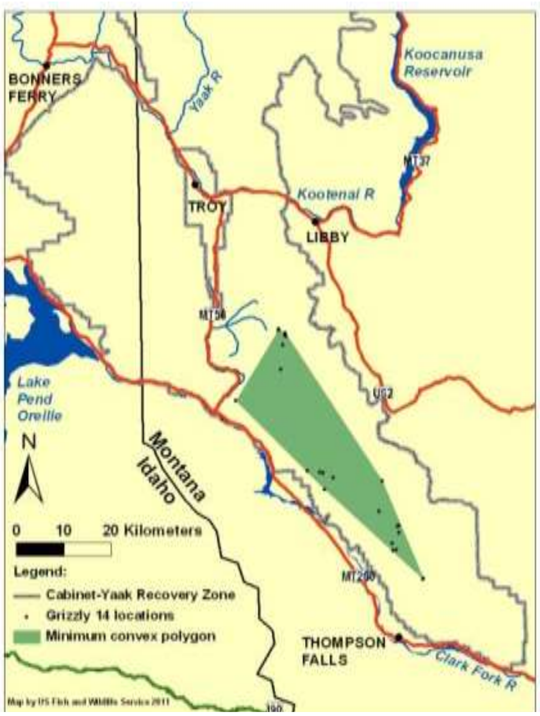


Figure A3. Radio locations and minimum convex (shaded) life range of male grizzly bear 14 in the Cabinet Mountains, 1985.

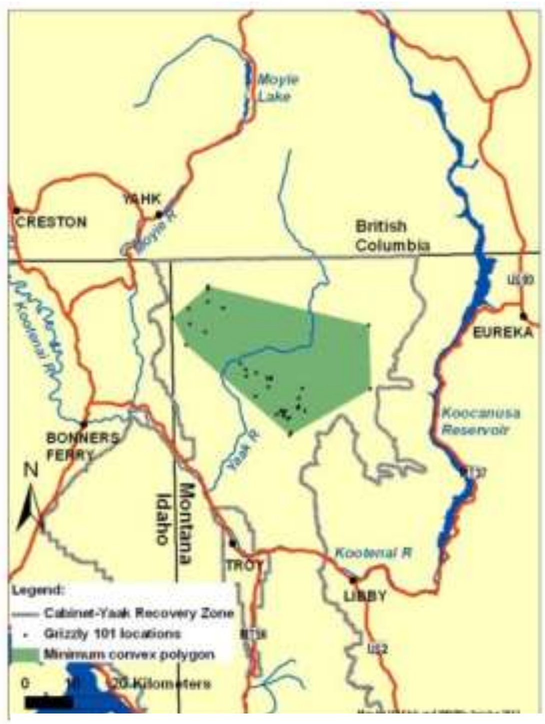


Figure A4. Radio locations and minimum convex (shaded) life range of male grizzly bear 101 in the Yaak River, 1986–1987.

Figure A5. Radio locations and minimum convex (shaded) life range of female grizzly bear 106 in the Yaak River, 1986–1999.

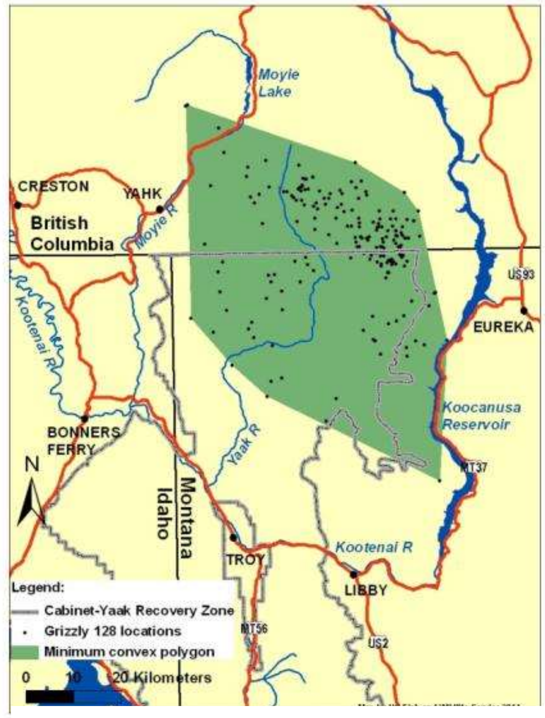


Figure A6. Radio locations and minimum convex (shaded) life range of male grizzly bear 128 in the Yaak River, 1987–1997.

Figure A7. Radio locations and minimum convex (shaded) life range of female grizzly bear 129 in the Yaak River, 1987–1989.

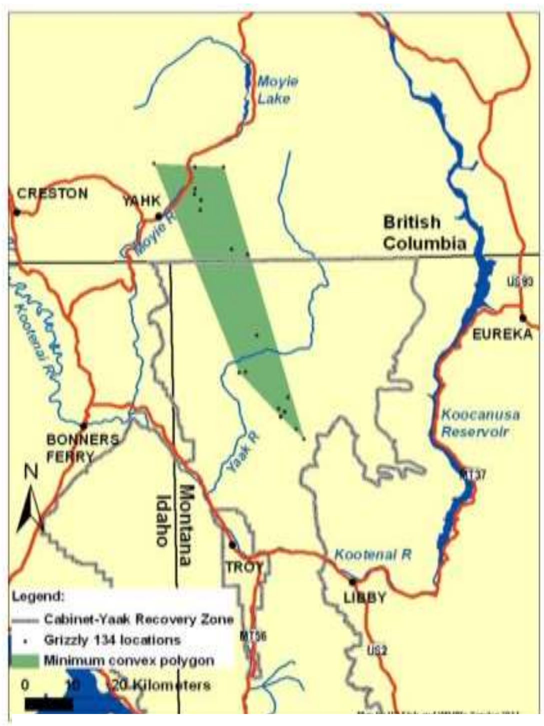


Figure A8. Radio locations and minimum convex (shaded) life range of male grizzly bear 134 in the Yaak River, 1987–1988.

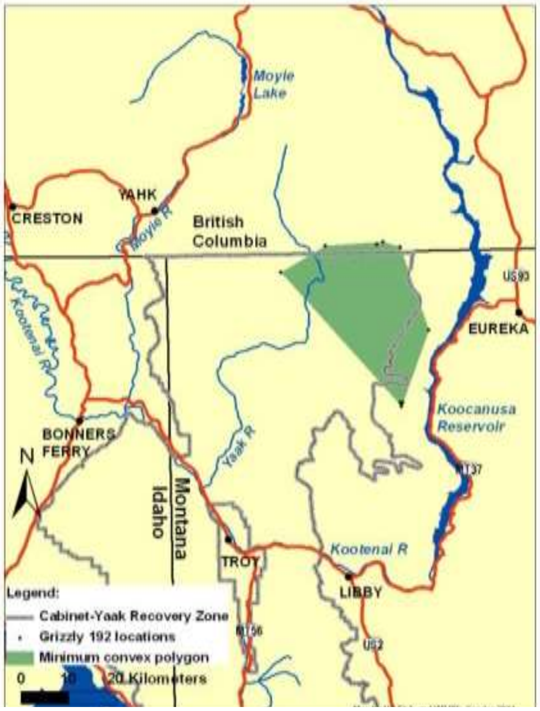


Figure A9. Radio locations and minimum convex (shaded) life range of male grizzly bear 192 in the Yaak River, 1990.

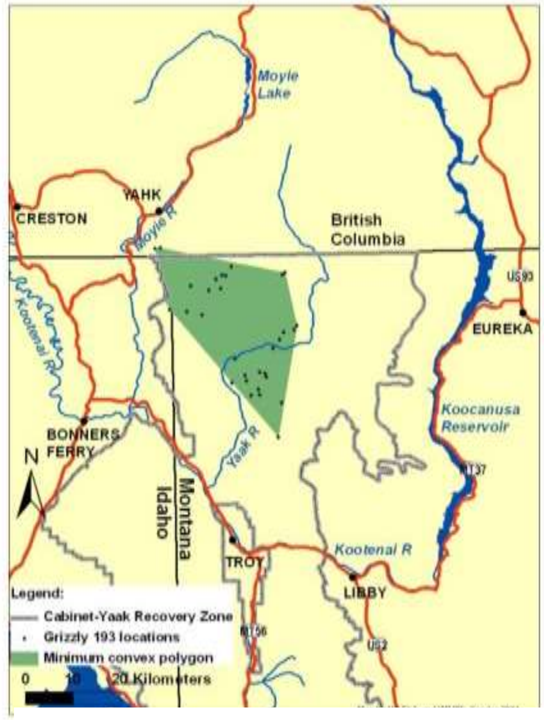


Figure A10. Radio locations and minimum convex (shaded) life range of male grizzly bear 193 in the Yaak River, 1990.

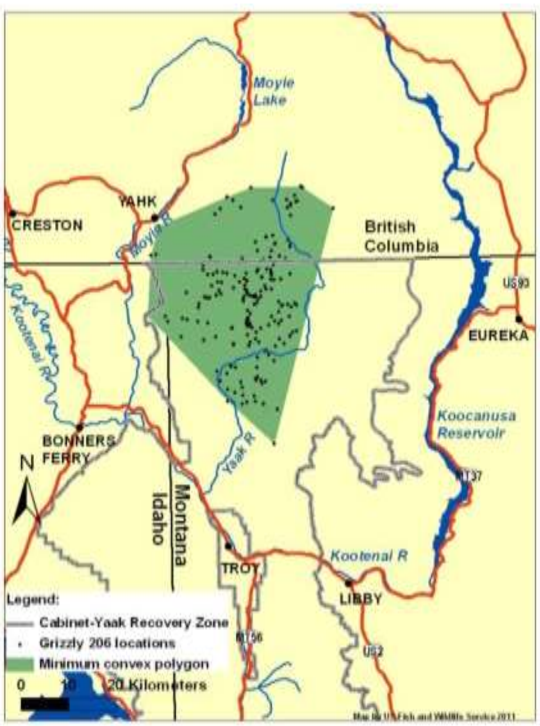


Figure A11. Radio locations and minimum convex (shaded) life range of female grizzly bear 206 in the Yaak River, 1991–1994.

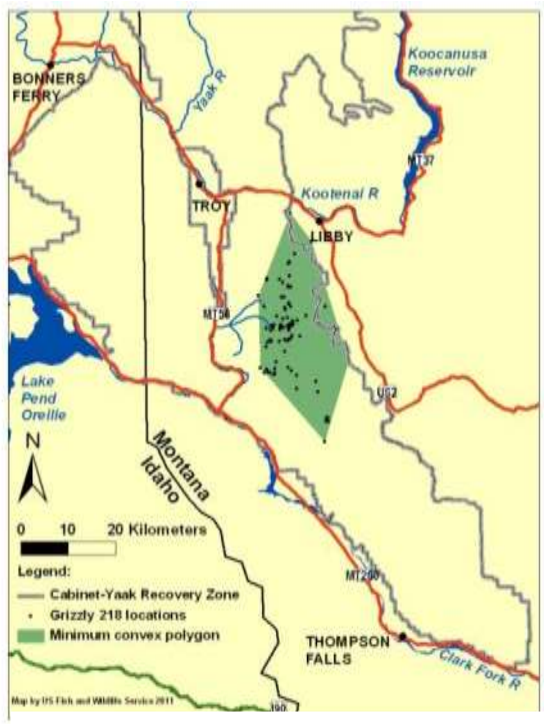


Figure A12. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 218 in the Cabinet Mountains, 1990–1991.

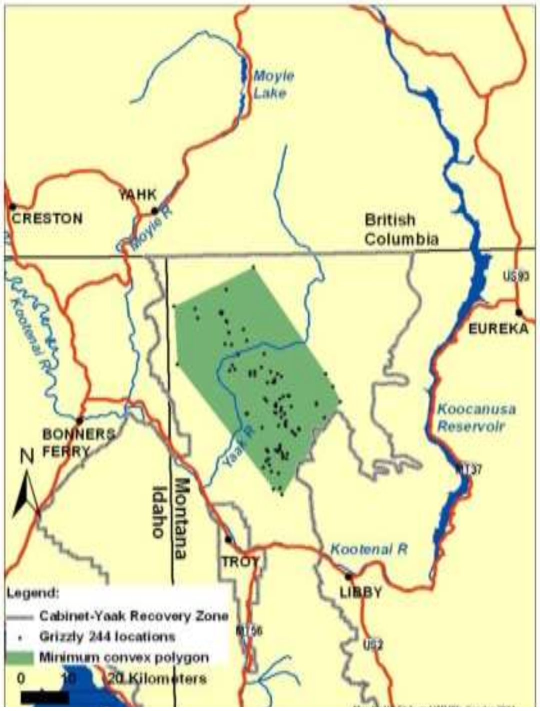


Figure A13. Radio locations and minimum convex (shaded) life range of male grizzly bear 244 in the Yaak River, 1992–2003.

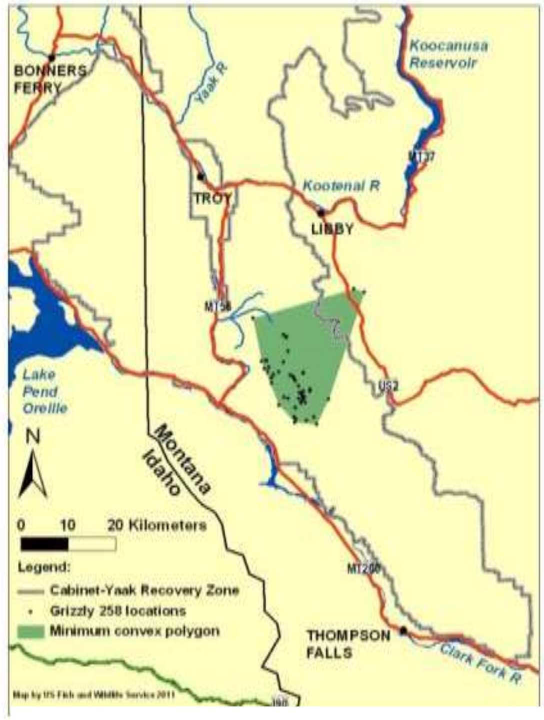


Figure A14. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 258 in the Cabinet Mountains, 1992–1993.

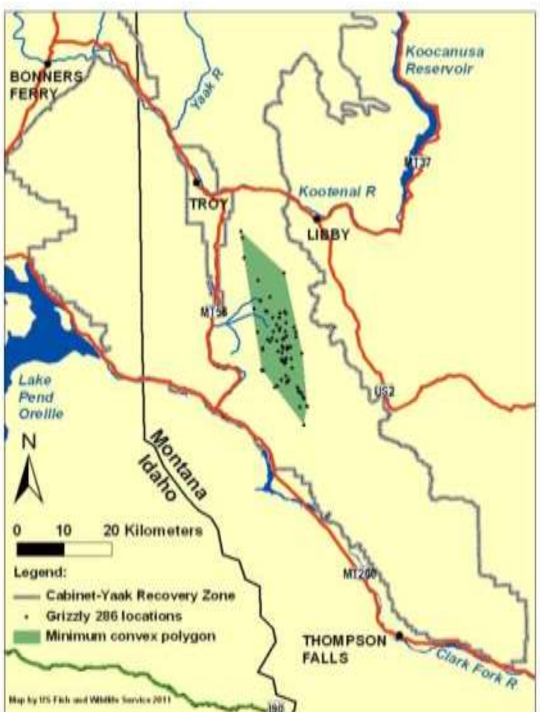


Figure A15. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 286 in the Cabinet Mountains, 1993–1995.

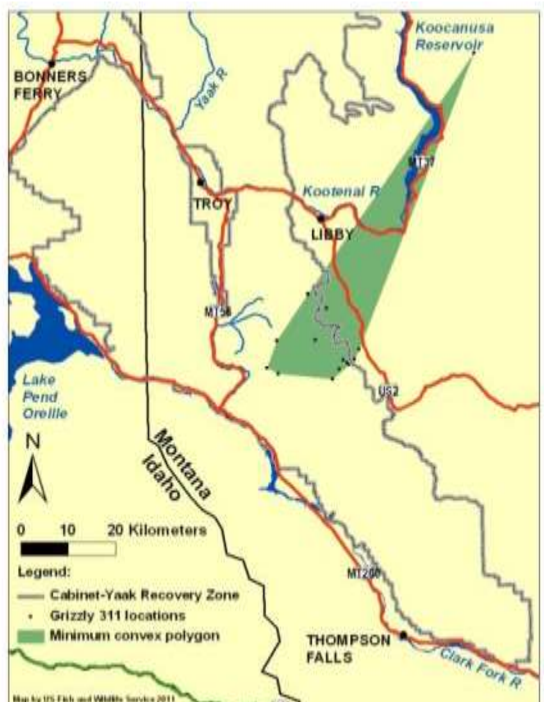


Figure A16. Radio locations and minimum convex (shaded) life range of female augmentation grizzly bear 311 in the Cabinet Mountains, 1994–1995.

Figure A17. Radio locations and minimum convex (shaded) life range of male grizzly bear 302 in the Yaak River, 1994–1996.

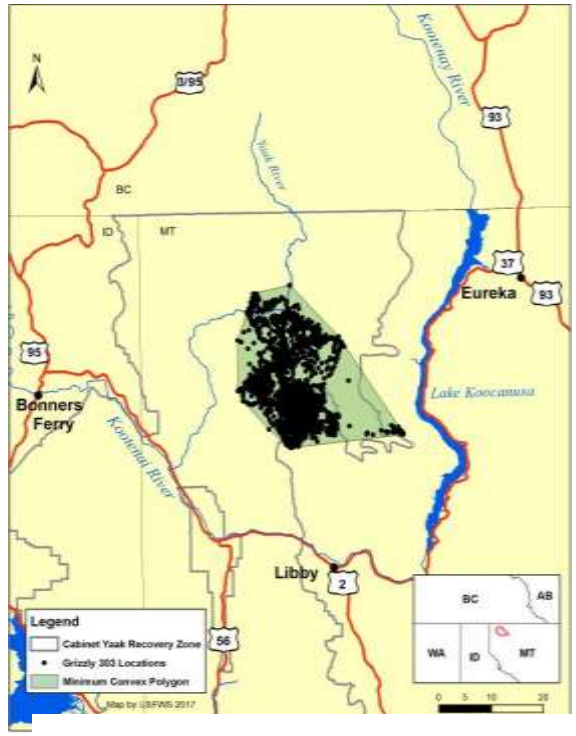


Figure A18. Radio locations and minimum convex (shaded) life range of female grizzly bear 303 in the Yaak River, 1994–2001 and 2011–2016.

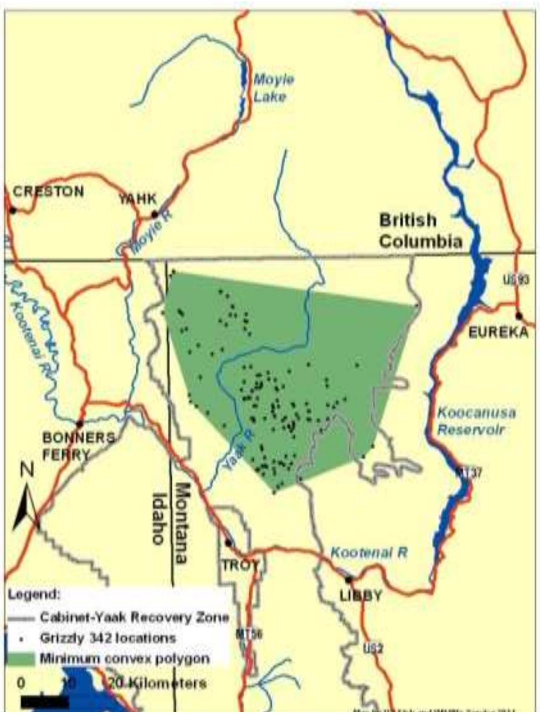


Figure A19. Radio locations and minimum convex (shaded) life range of male grizzly bear 342 in the Yaak River, 1995–2001.

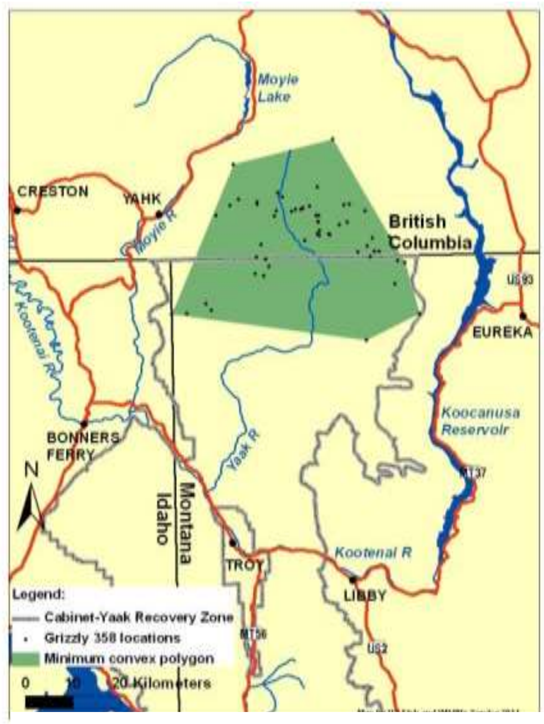


Figure A20. Radio locations and minimum convex (shaded) life range of male grizzly bear 358 in the Yaak River, 1996–1998.

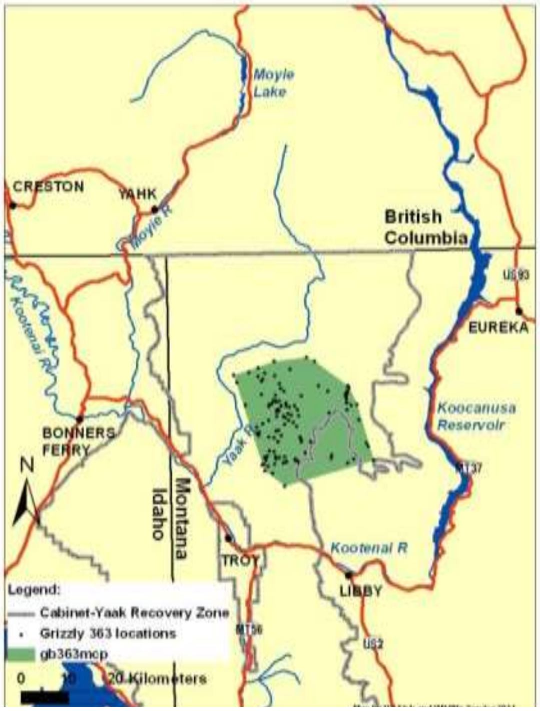


Figure A21. Radio locations and minimum convex (shaded) life range of male grizzly bear 363 in the Yaak River, 1996–1999.

Figure A22. Radio locations and minimum convex (shaded) life range of male grizzly bear 386 in the Yaak River, 1997–1999.

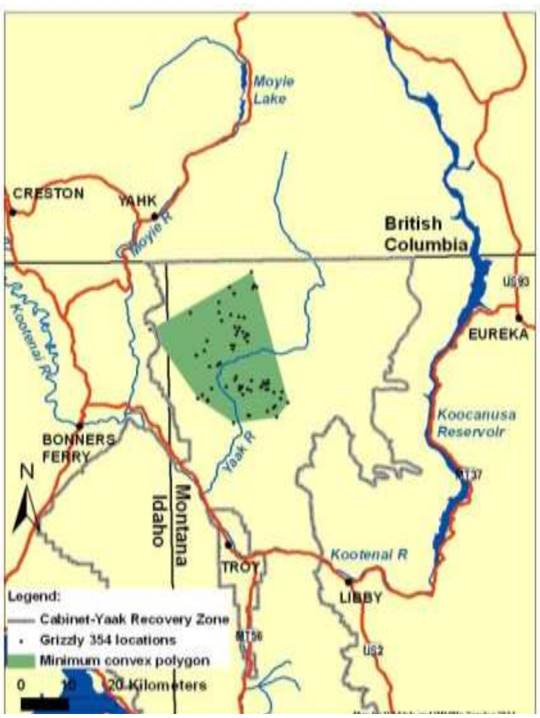


Figure A23. Radio locations and minimum convex (shaded) life range of female grizzly bear 354 in the Yaak River, 1997–1999.

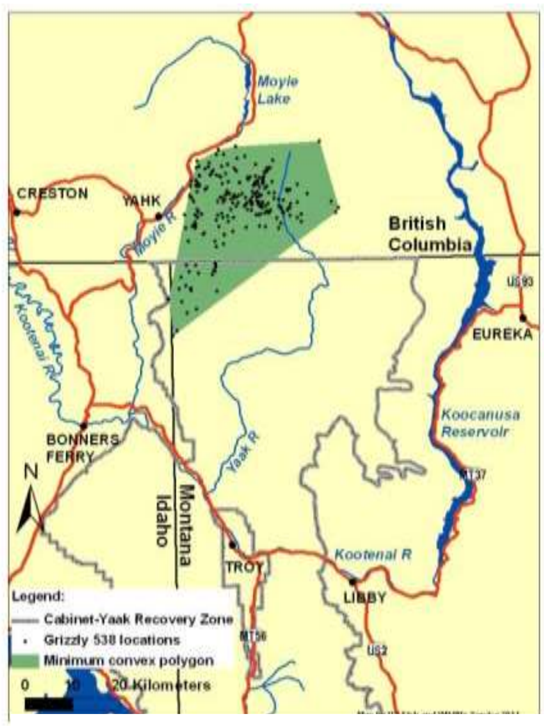


Figure A24. Radio locations and minimum convex (shaded) life range of female grizzly bear 538 in the Yaak River, 1997–2002.

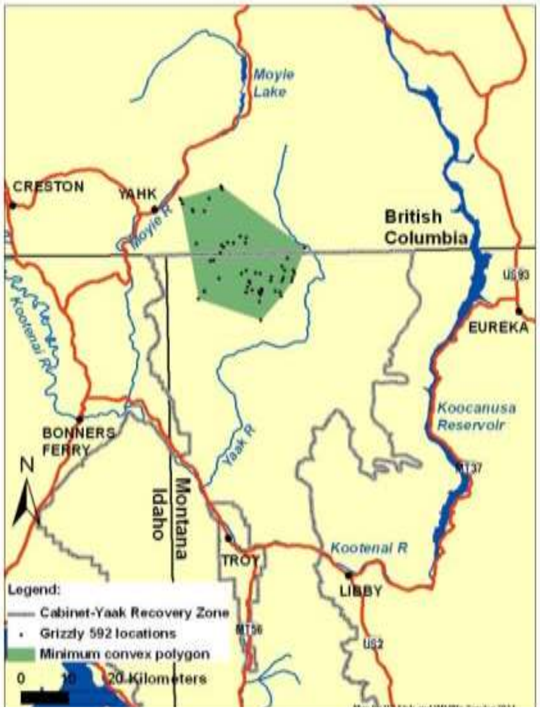


Figure A25. Radio locations and minimum convex (shaded) life range of female grizzly bear 592 in the Yaak River, 1999–2000.

Figure A26. Radio locations and minimum convex (shaded) life range of female grizzly bear 596 in the Yaak River, 1999.

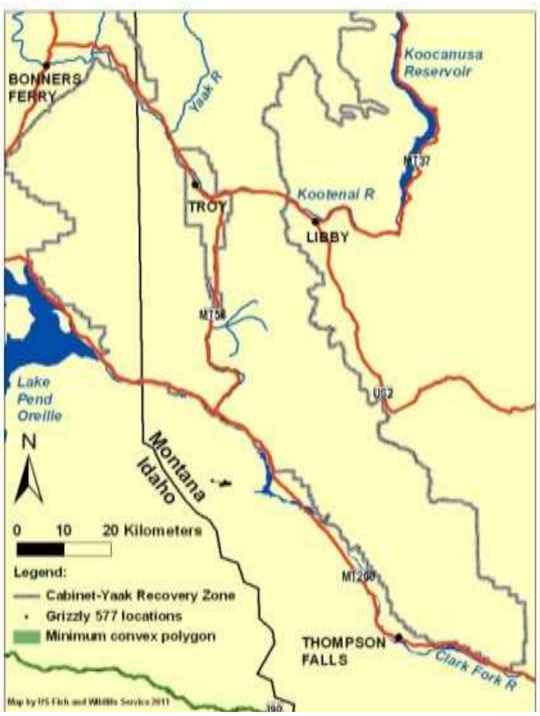


Figure A27. Radio locations and minimum convex (shaded) life range of female grizzly bear 577 in the Cabinet Mountains, 2002.

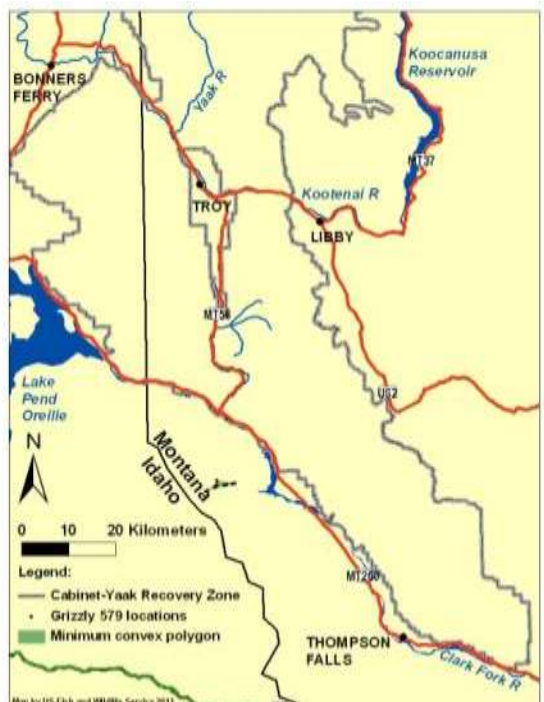


Figure A28. Radio locations and minimum convex (shaded) life range of male grizzly bear 579 in the Cabinet Mountains, 2002.

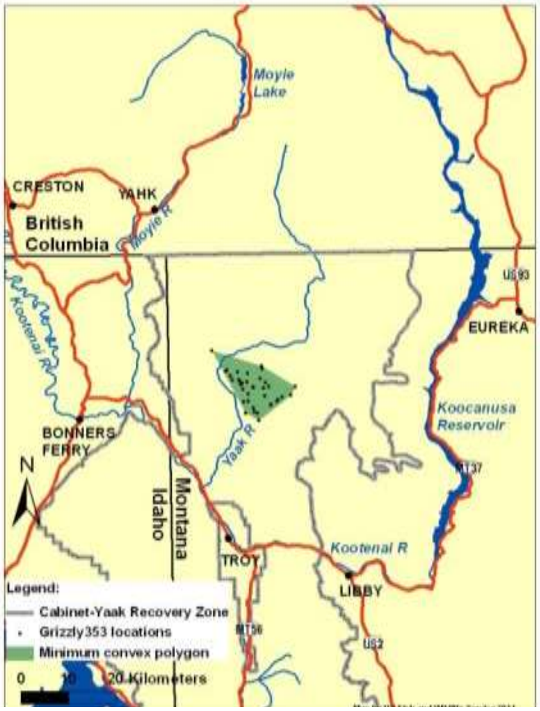


Figure A29. Radio locations and minimum convex (shaded) life range of female grizzly bear 353 in the Yaak River, 2002.

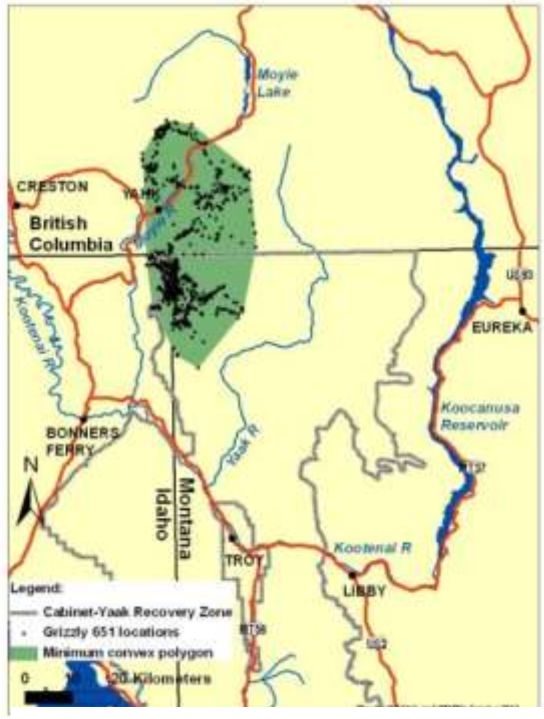


Figure A30. Radio locations and minimum convex (shaded) life range of male grizzly bear 651 in the Yaak River, 2002–2006.

Figure A31. Radio locations and minimum convex (shaded) life range of male grizzly bear 787 in the Yaak River, 2003–2004.

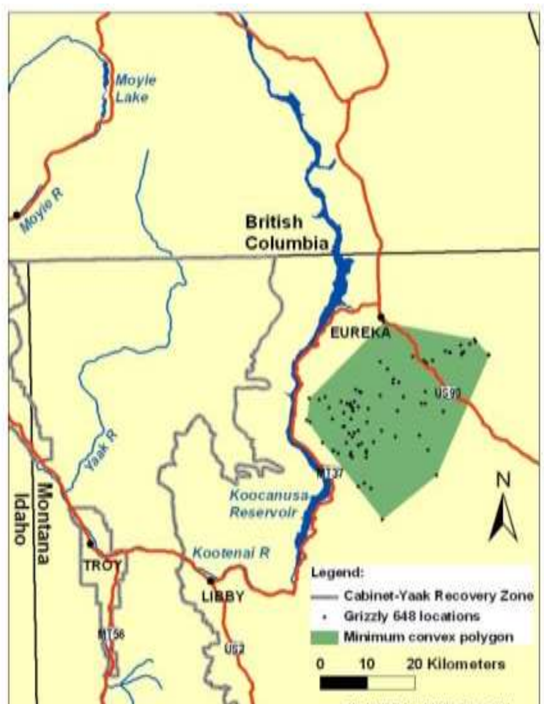


Figure A32. Radio locations and minimum convex (shaded) life range of female grizzly bear 648 in the Salish Mountains, 2003–2005.

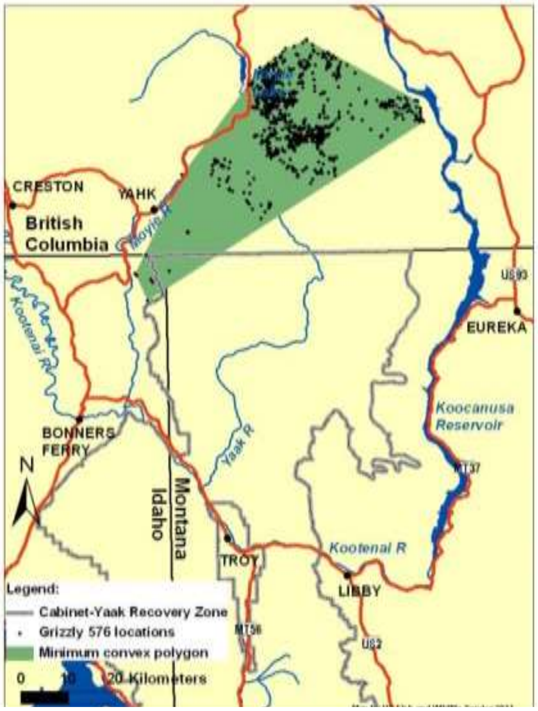


Figure A33. Radio locations and minimum convex (shaded) life range of male grizzly bear 576 in the Yaak River, 2004–2006.

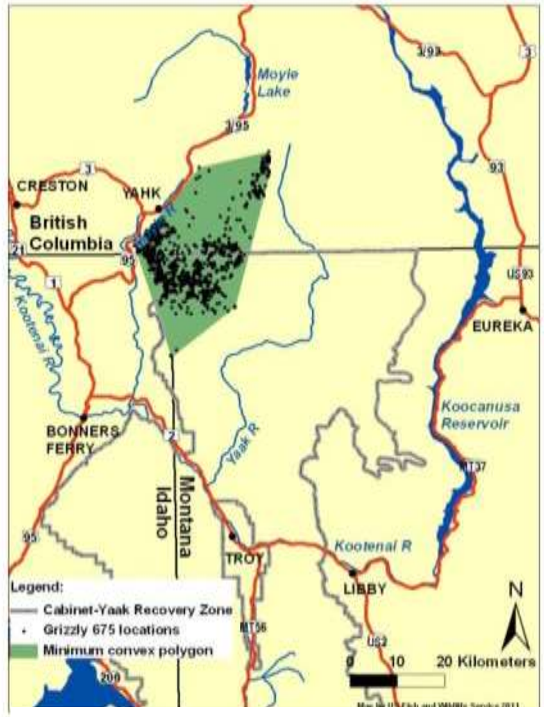


Figure A34. Radio locations and minimum convex (shaded) life range of female grizzly bear 675 in the Yaak River, 2004–2010.

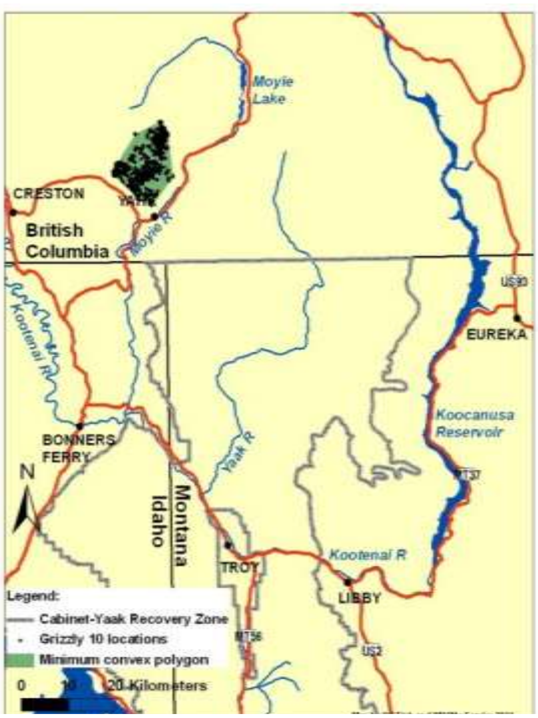


Figure A35. Radio locations and minimum convex (shaded) life range of female grizzly bear 10 in the Purcell Mountains, 2004.

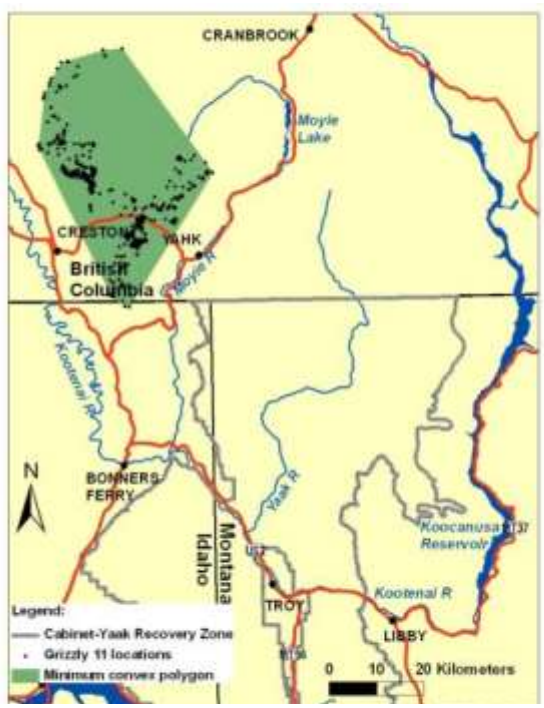


Figure A36. Radio locations and minimum convex (shaded) life range of male grizzly bear 11 in the Purcell Mountains, 2004.

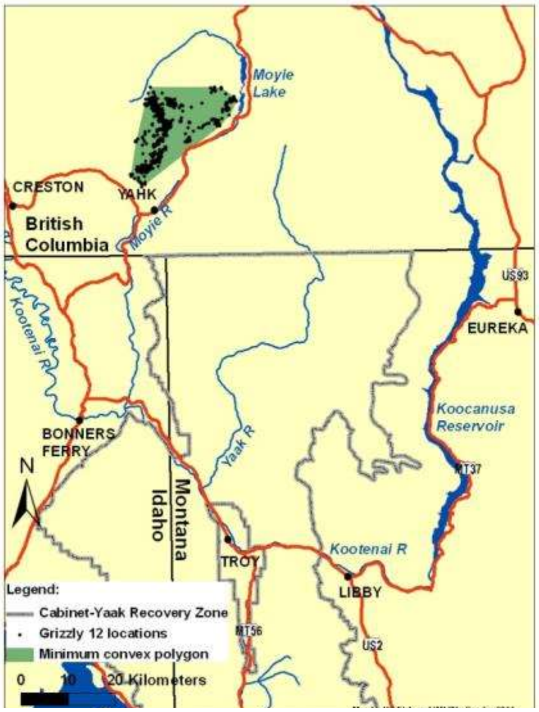


Figure A37. Radio locations and minimum convex (shaded) life range of female grizzly bear 12 in the Purcell Mountains, 2004.

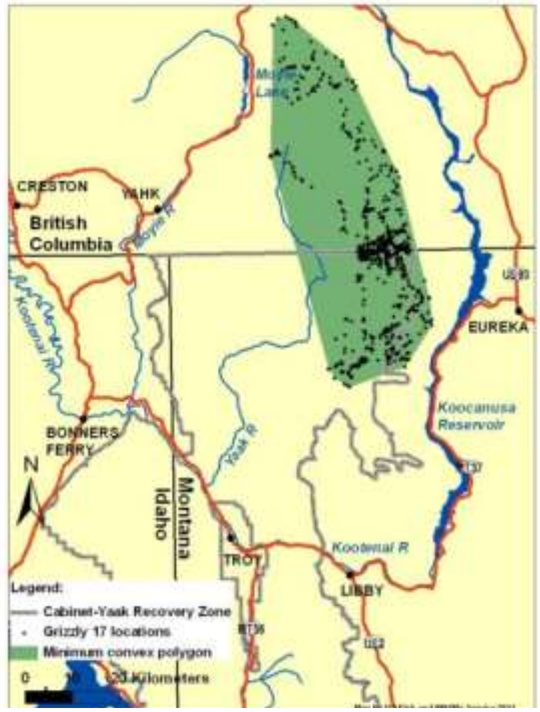


Figure A38. Radio locations and minimum convex (shaded) life range of male grizzly bear 17 in the Purcell Mountains, 2004.

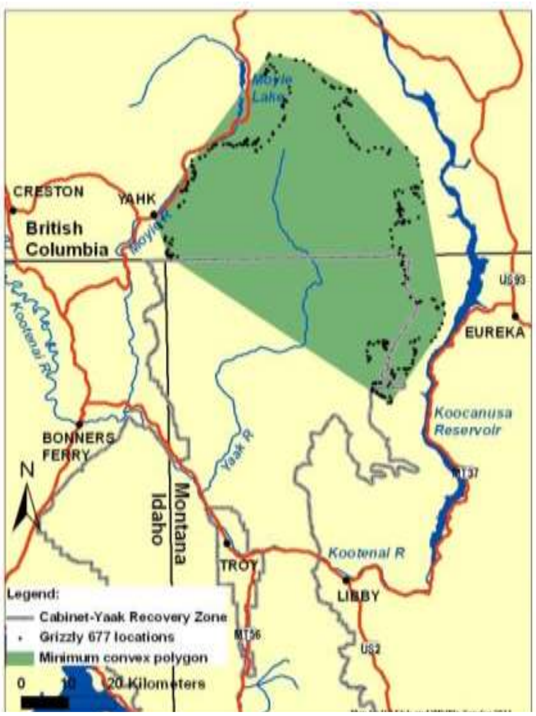


Figure A39. Radio locations and minimum convex (shaded) life range of male grizzly bear 677 in the Purcell Mountains, 2005.

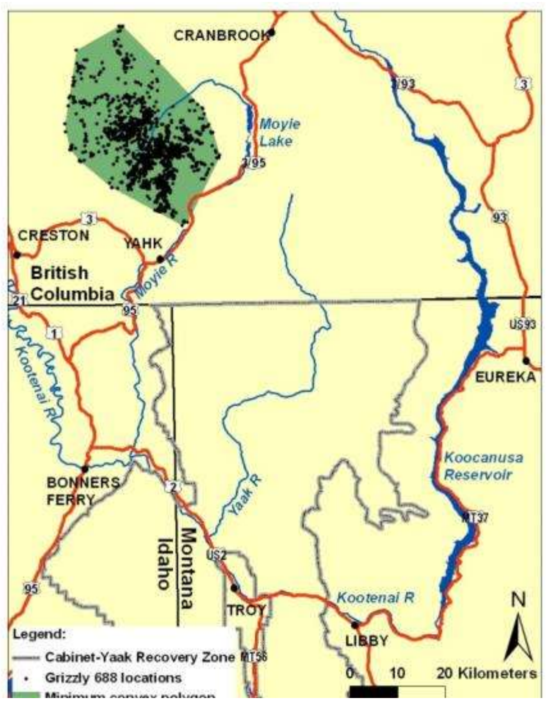


Figure A40. Radio locations and minimum convex (shaded) life range of male grizzly bear 688 in the Purcell Mountains, 2005–2006.

Figure A41. Radio locations and minimum convex (shaded) life range of female grizzly bear 694 in the Yaak River, 2005.

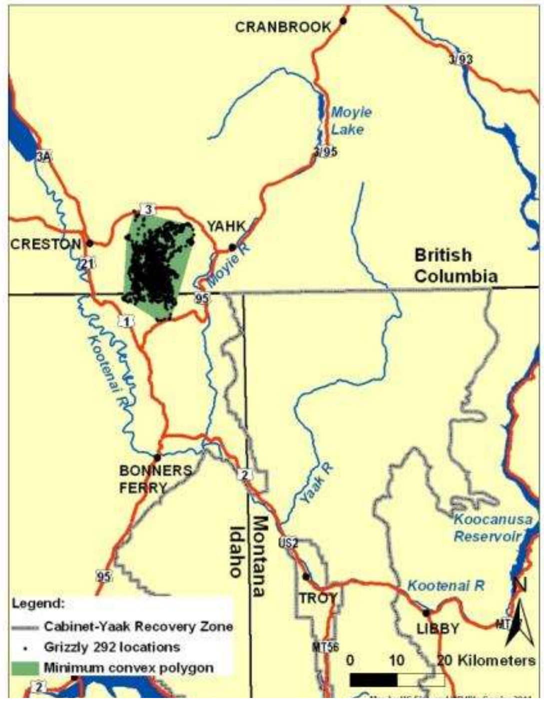


Figure A42. Radio locations and minimum convex (shaded) life range of female grizzly bear 292 in the Purcell Mountains, 2005.

Figure A43. Radio locations and minimum convex (shaded) life range of male grizzly bear 770 in the Cabinet Mountains, 2005–2006, 2019.

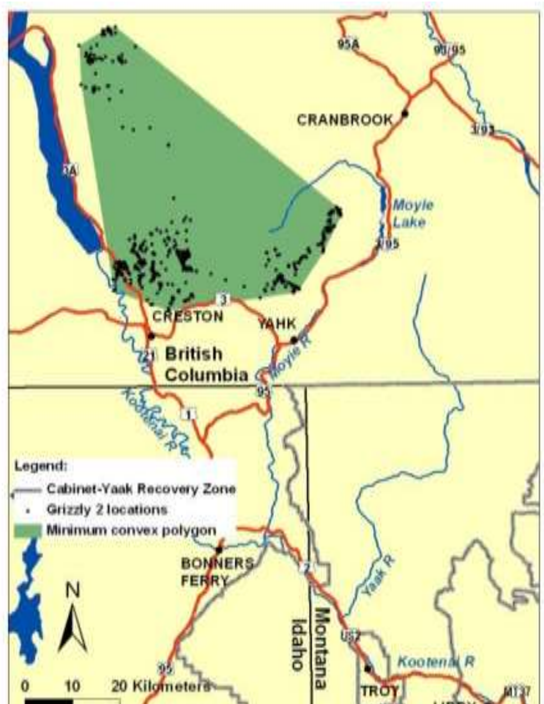


Figure A44. Radio locations and minimum convex (shaded) life ranges of male grizzly bear 2 in the Purcell Mountains, 2005.

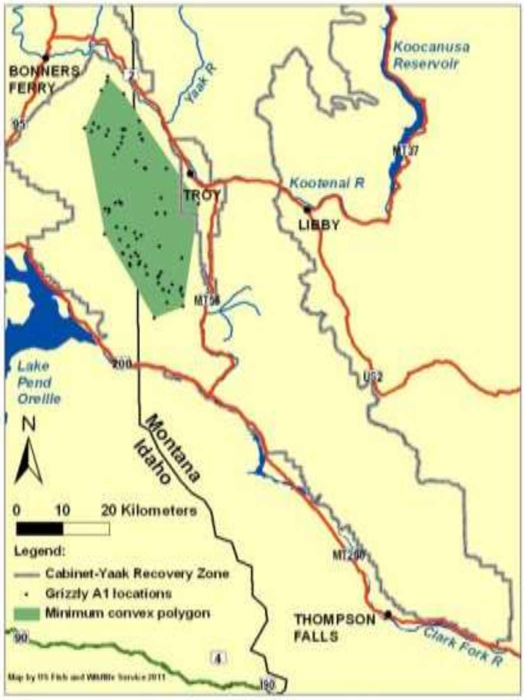


Figure A45. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear A1 in the Cabinet Mountains, 2005–2007.

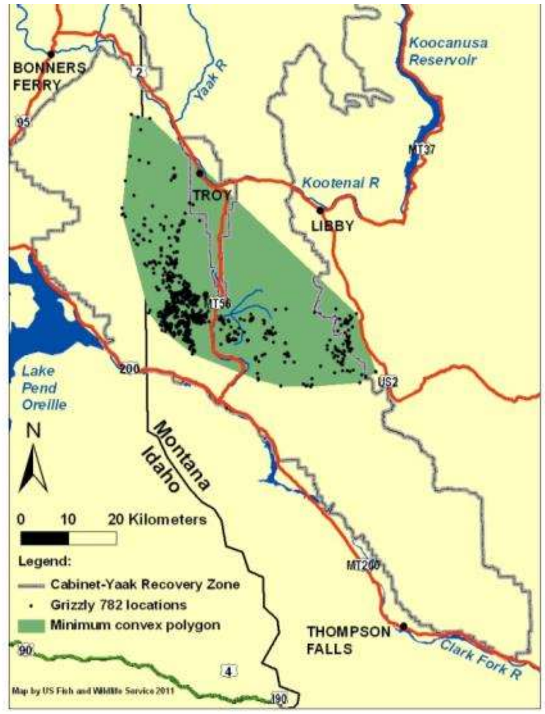


Figure A46. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 782 in the Cabinet Mountains, 2006–2007.

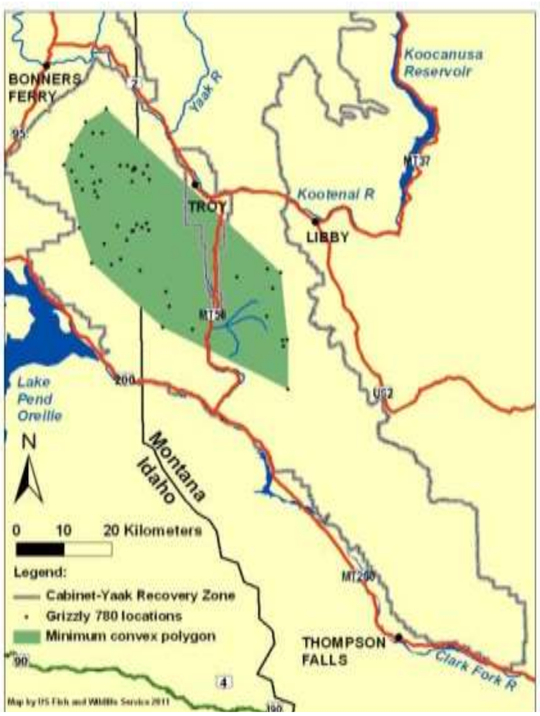


Figure A47. Radio locations and minimum convex (shaded) life range of male grizzly bear 780 in the Cabinet Mountains, 2006–2008.

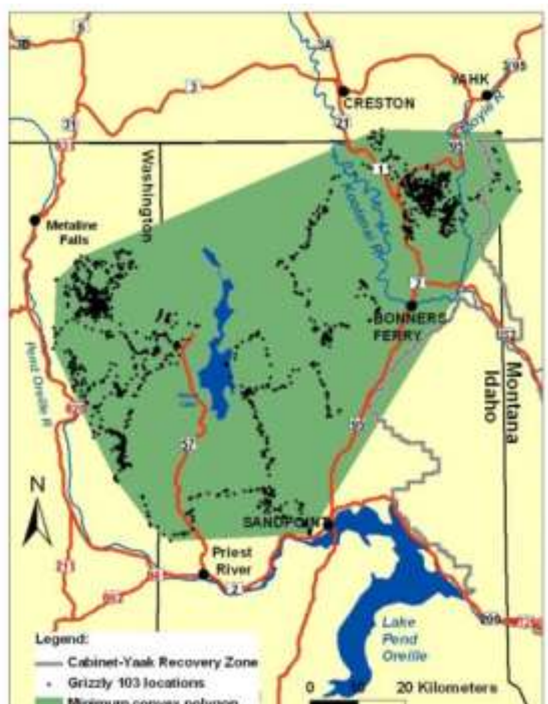


Figure A48. Radio locations and minimum convex (shaded) life range of male grizzly bear 103 in the Yaak River, 2006–2007.

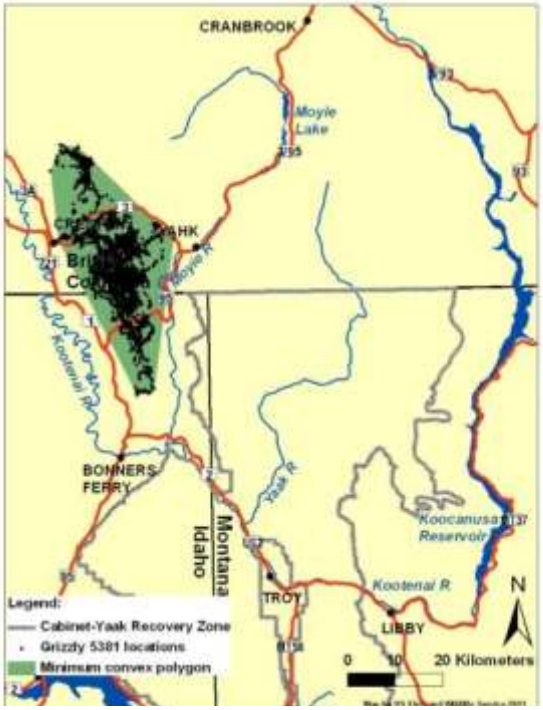


Figure A49. Radio locations and minimum convex (shaded) life range of male grizzly bear 5381 in the Purcell Mountains, 2006–2007.

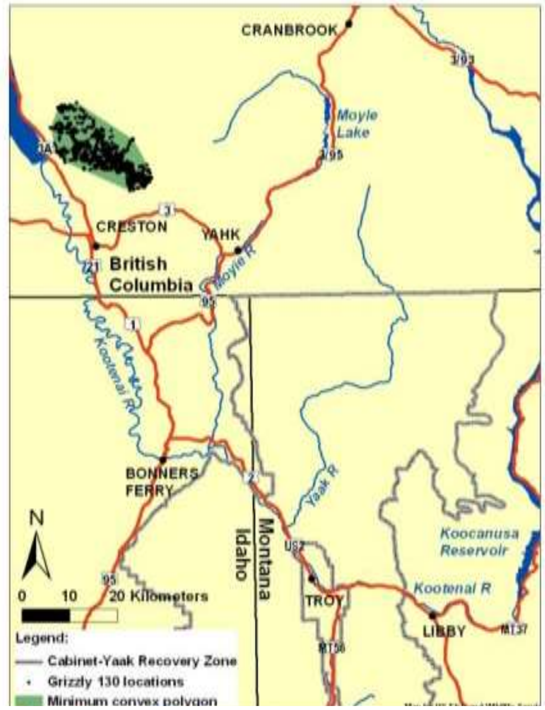


Figure A50. Radio locations and minimum convex (shaded) life range of female grizzly bear 130 in the Purcell Mountains, 2007–2008.

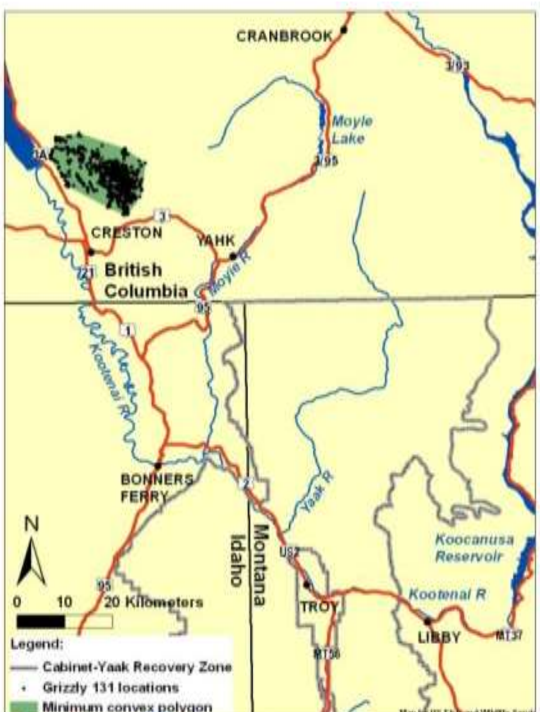


Figure A51. Radio locations and minimum convex (shaded) life range of female grizzly bear 131 in the Purcell Mountains, 2007–2008.

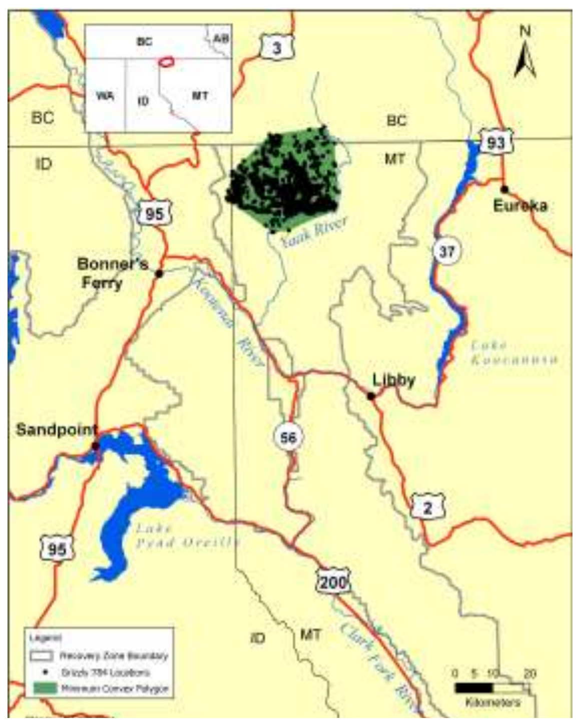


Figure A52. Radio locations and minimum convex (shaded) life range of female grizzly bear 784 in the Yaak River, 2007–2009, 2020.

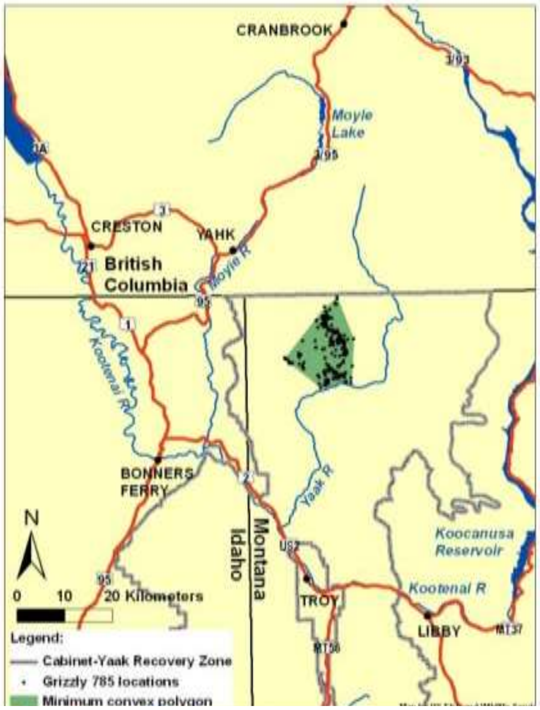


Figure A53. Radio locations and minimum convex (shaded) life range of female grizzly bear 785 in the Yaak River, 2007–2008.

Figure A54. Radio locations and minimum convex (shaded) life range of female grizzly bear 772 in the Cabinet Mountains, 2007.

Figure A55. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 635 in the Cabinet Mountains, 2008.

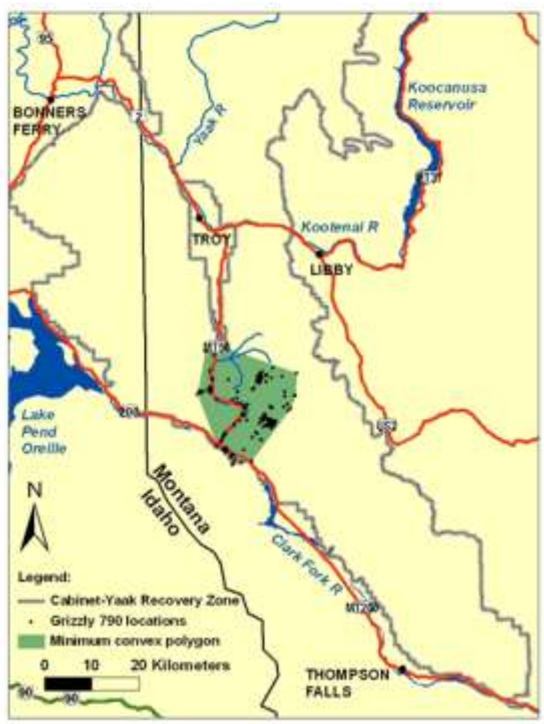


Figure A56. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 790 in the Cabinet Mountains, 2008.

Figure A57. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 715 in the Cabinet Mountains, 2009–2010.

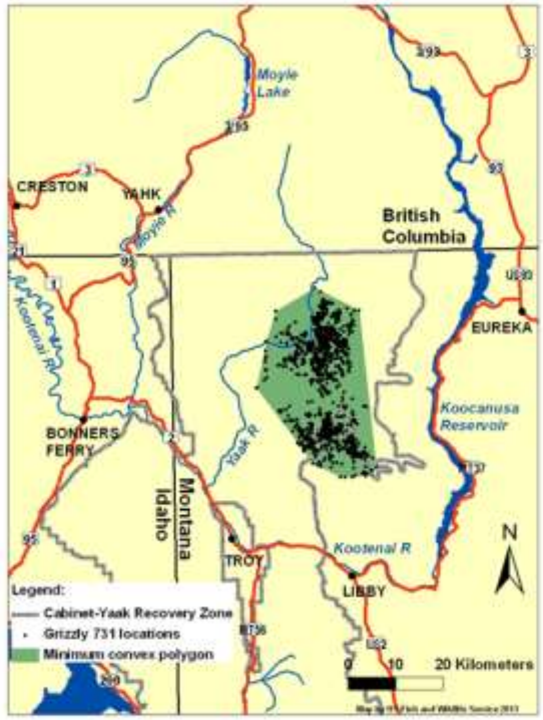


Figure A58. Radio locations and minimum convex (shaded) life range of female grizzly bear 731 in the Yaak River, 2009–2011.

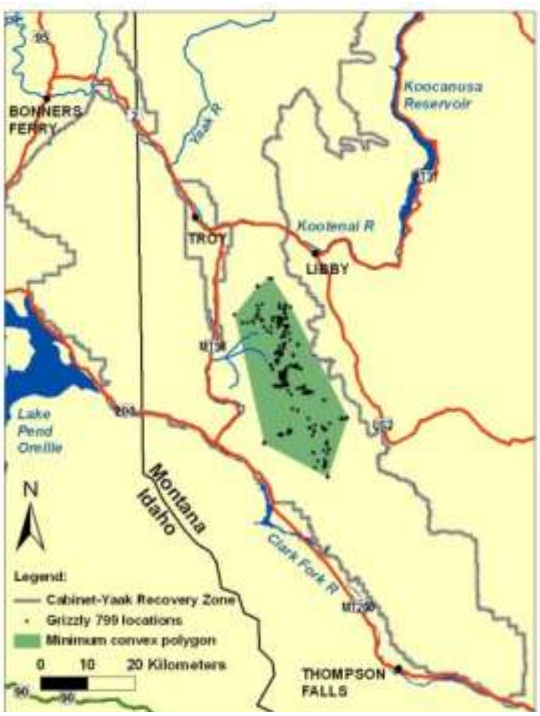


Figure A59. Radio locations and minimum convex (shaded) life range of male grizzly bear 799 in the Cabinet Mountains, 2009–2010.

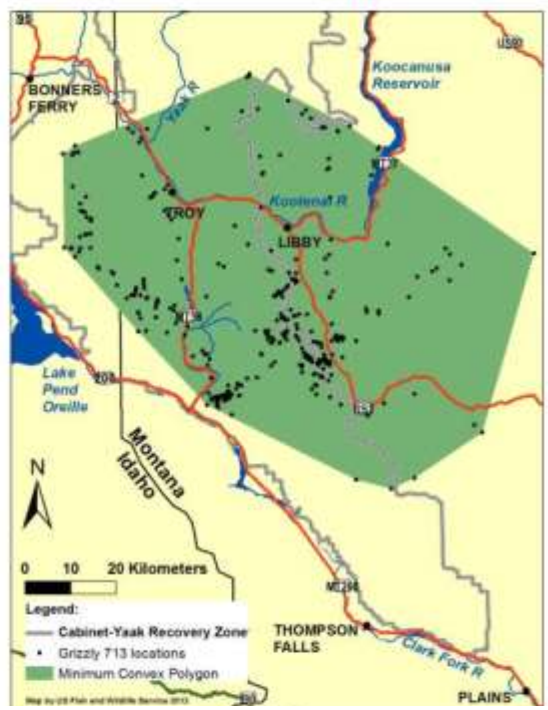


Figure A60. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 713 in the Cabinet Mountains, 2010–2011.

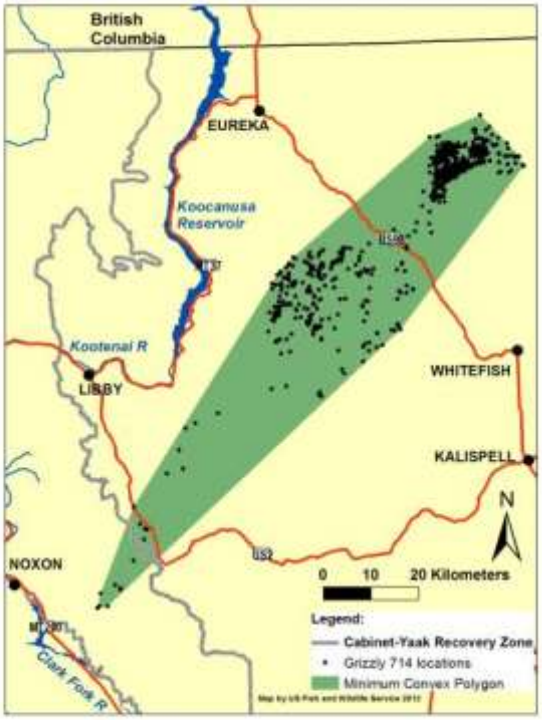


Figure A61. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 714 in the Cabinet Mountains, 2010–2012.

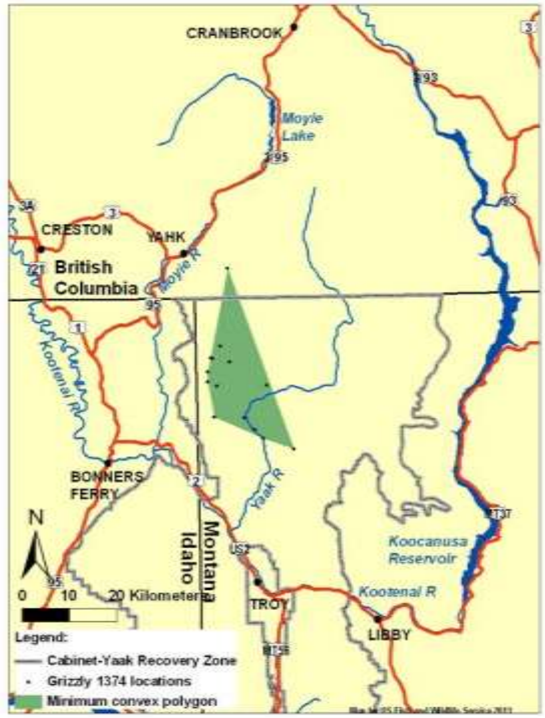


Figure A62. Radio locations and minimum convex (shaded) life range of male grizzly bear 1374 in the Yaak River, 2010.

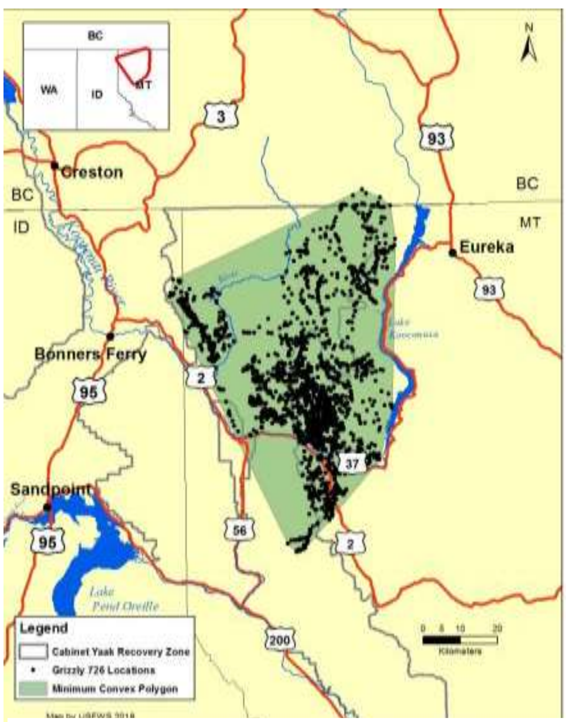


Figure A63. Radio locations and minimum convex (shaded) life range of male grizzly bear 726 in the Yaak River, 2011–2012, 2015–2017.

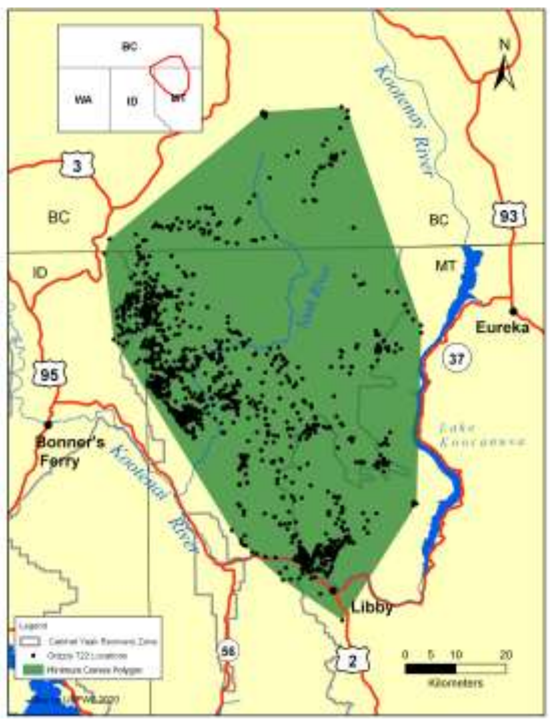


Figure A64. Radio locations and minimum convex (shaded) life range of male grizzly bear 722 in the Yaak River, 2011–2012, 2014, 2016–2019.

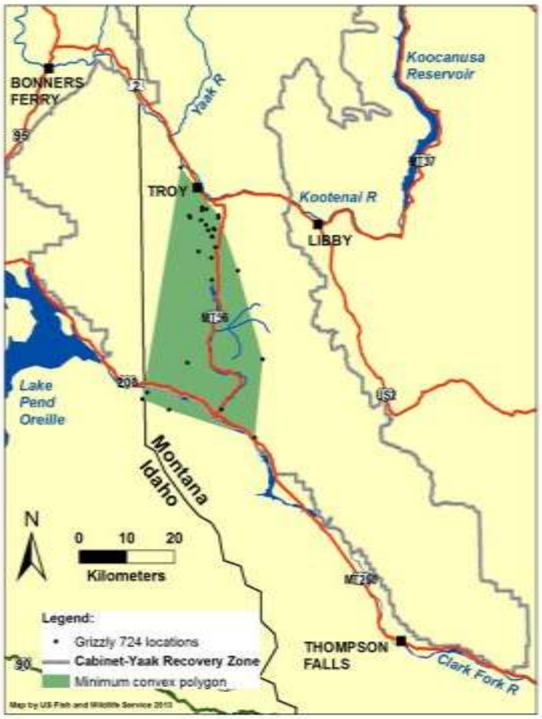


Figure A65. Radio locations and minimum convex (shaded) life range of management male grizzly bear 724 in the Cabinet Mountains, 2011–2012.

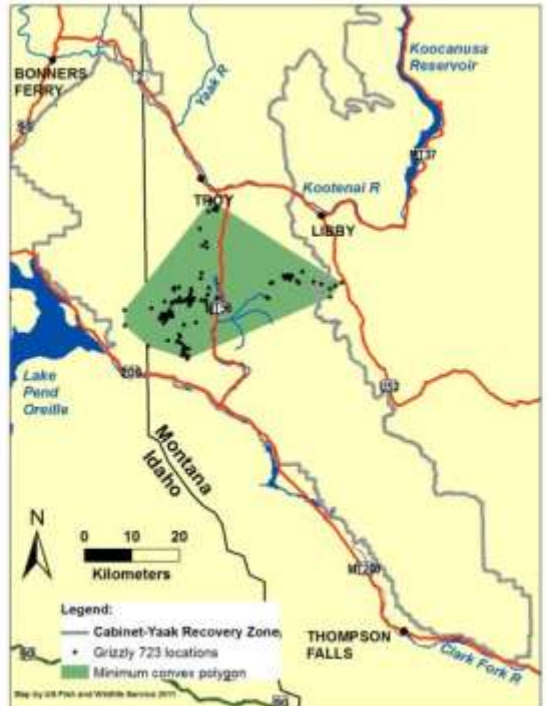


Figure A66. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 723 in the Cabinet Mountains, 2011–2012.

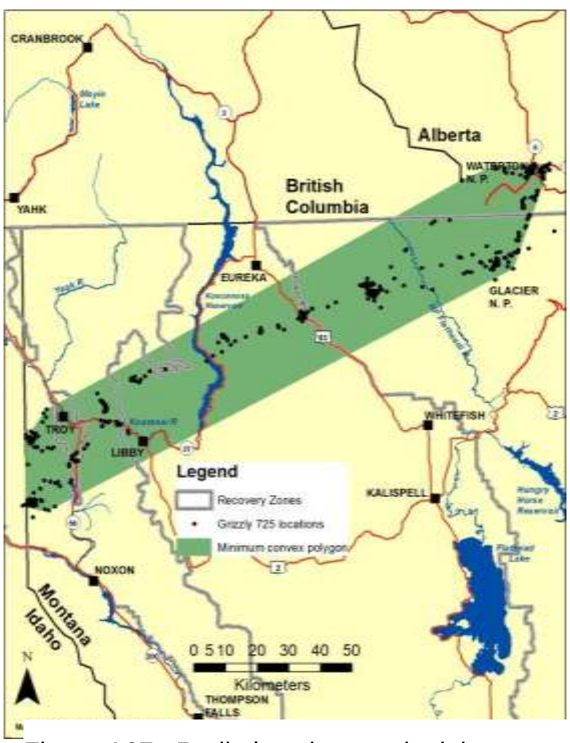


Figure A67. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 725 in the Cabinet Mountains, 2011–2013.

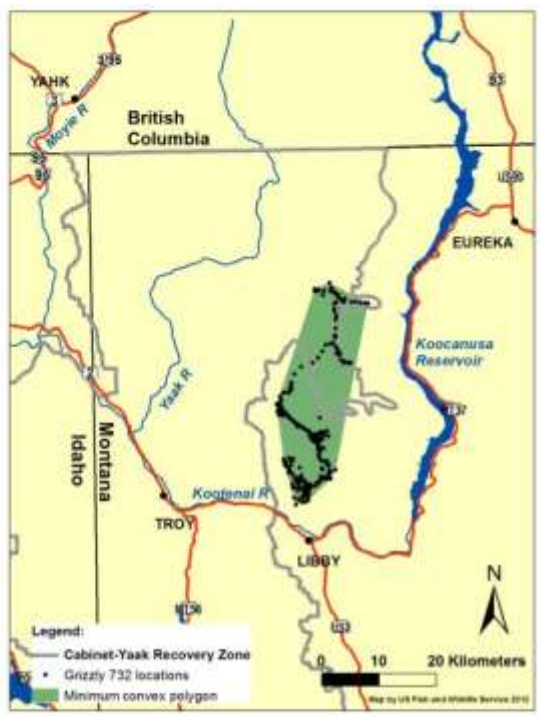


Figure A68. Radio locations and minimum convex (shaded) life range of management male grizzly bear 732 in the Yaak River, 2011.

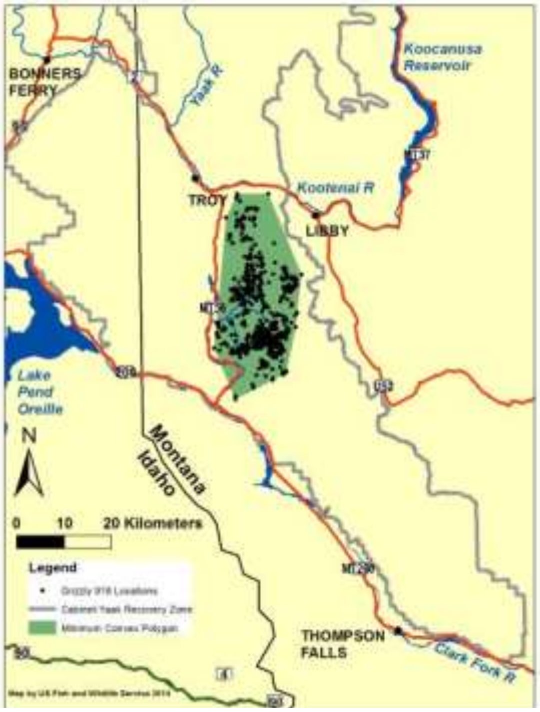


Figure A69. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 918 in the Cabinet Mountains, 2012–2014.

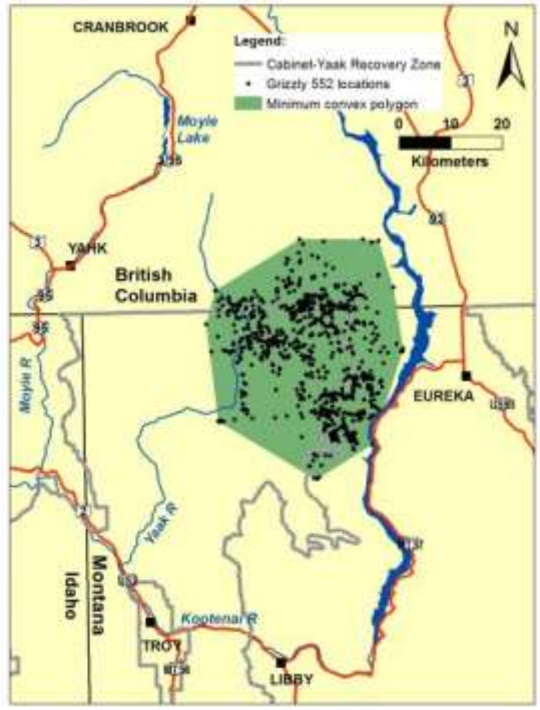


Figure A70. Radio locations and minimum convex (shaded) life range of female grizzly bear 552 in the Yaak River, 2012–2015.

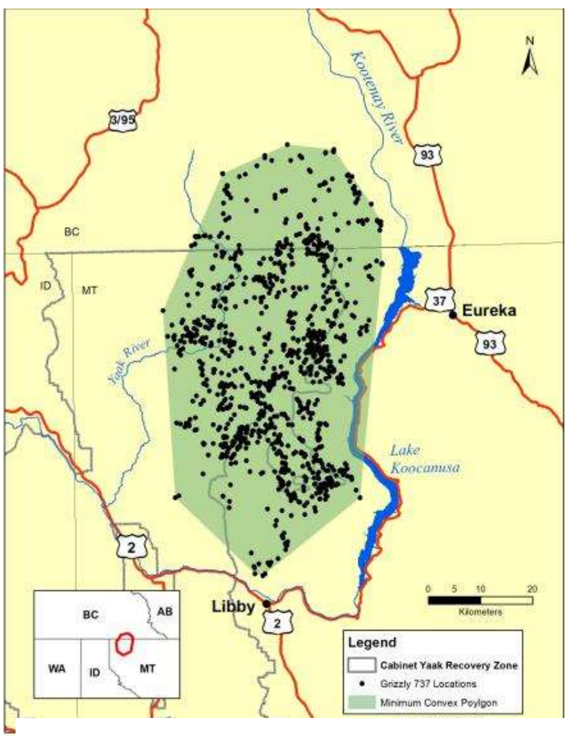


Figure A71. Radio locations and minimum convex (shaded) life range of male grizzly bear 737 in the Yaak River, 2010–2013.

Figure A72. Radio locations and minimum convex (shaded) life range of female grizzly bear 729 in the Yaak River, 2013–2017, 2020.

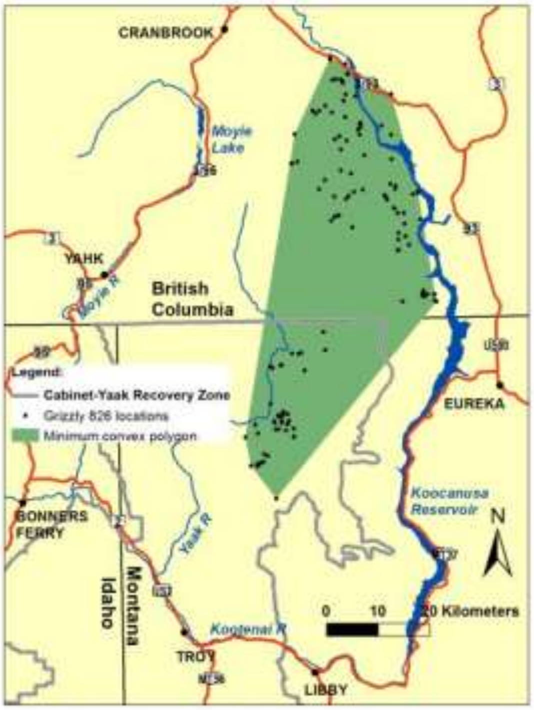


Figure A73. Radio locations and minimum convex (shaded) life range of male grizzly bear 826 in the Yaak River, 2013.

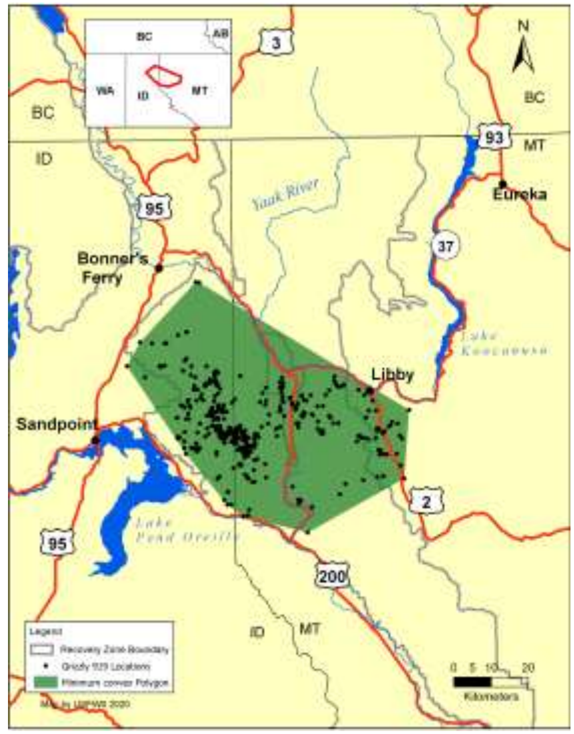


Figure A74. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 919 in the Cabinet Mountains, 2013–2014.

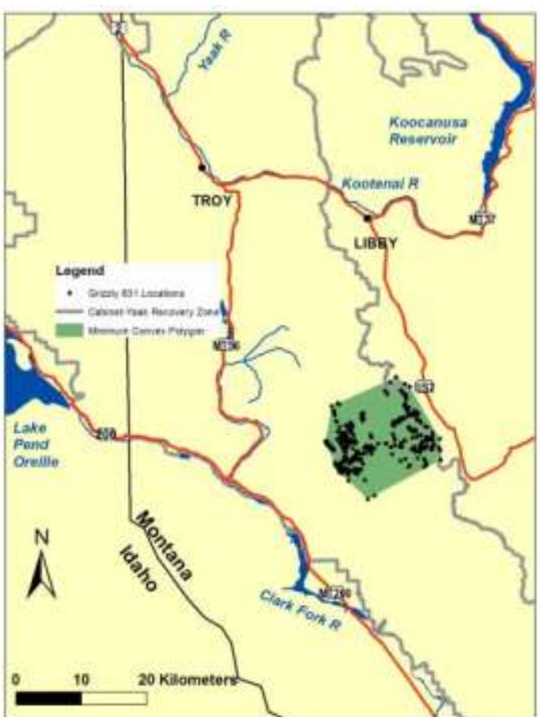


Figure A75. Radio locations and minimum convex (shaded) life range of female grizzly bear 831 in the Cabinet Mountains, 2014.

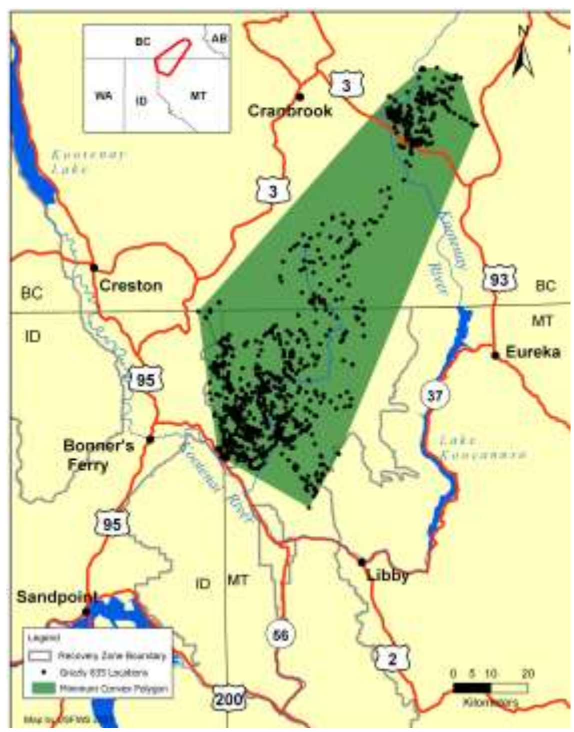


Figure A76. Radio locations and minimum convex (shaded) life range of male grizzly bear 835 in the Yaak River, 2014–2016, 2019–2020.

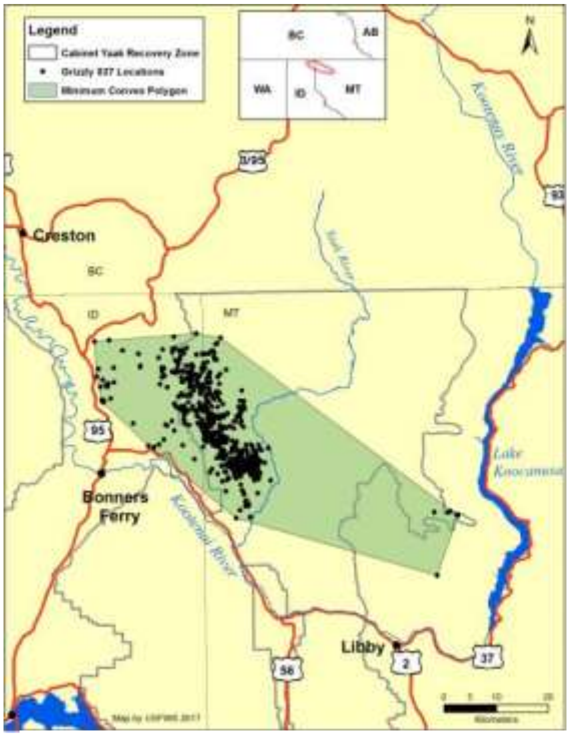


Figure A77. Radio locations and minimum convex (shaded) life range of male grizzly bear 837 in the Cabinet Mountains, 2014–2016.

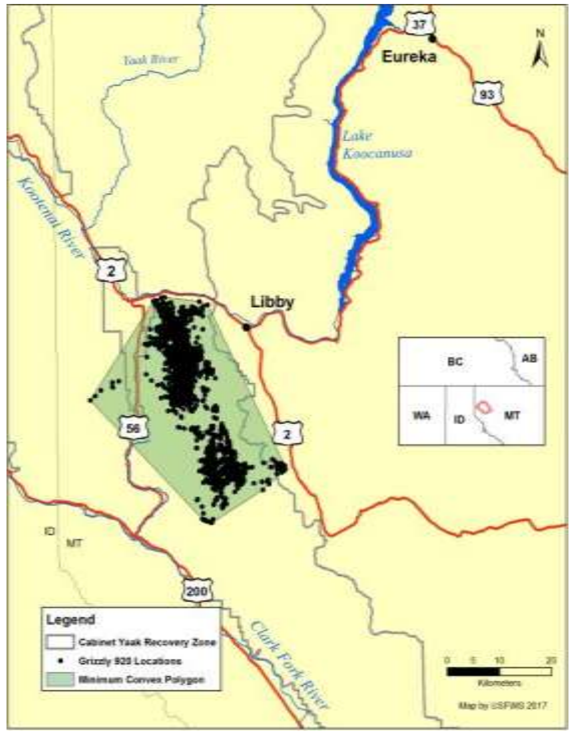


Figure A78. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 920 in the Cabinet Mountains, 2014–2016.

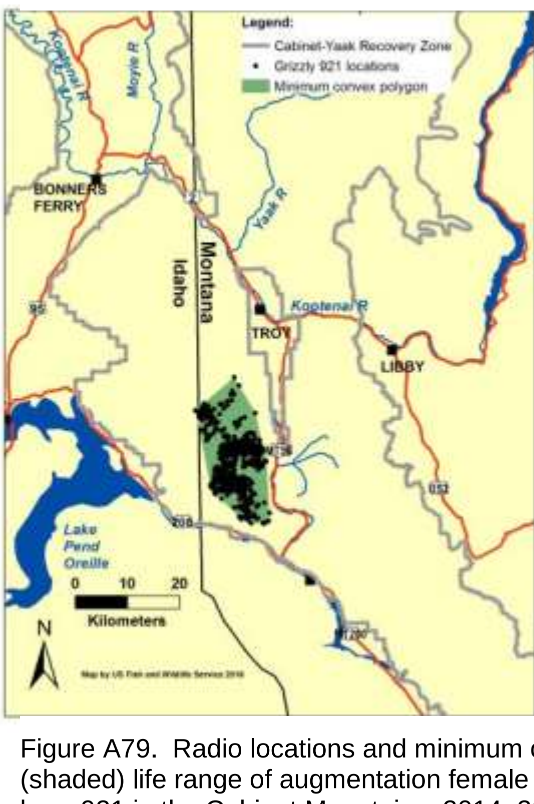


Figure A79. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 921 in the Cabinet Mountains, 2014–2015.

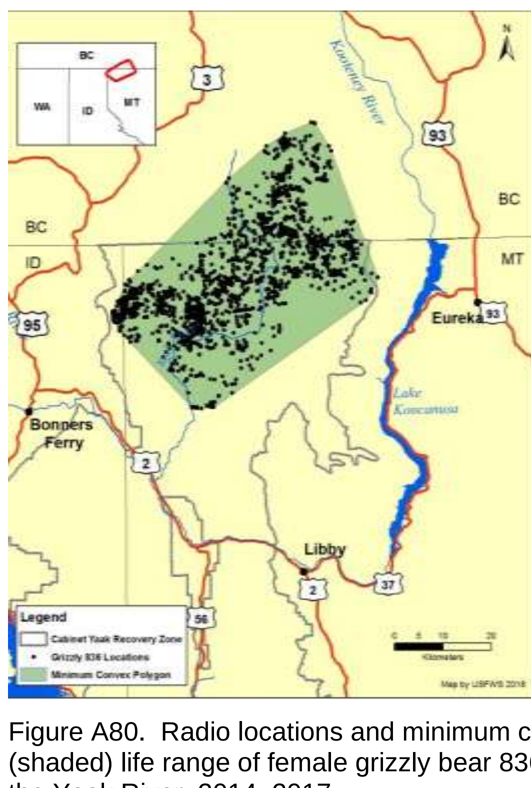


Figure A80. Radio locations and minimum convex (shaded) life range of female grizzly bear 836 in the Yaak River, 2014–2017.

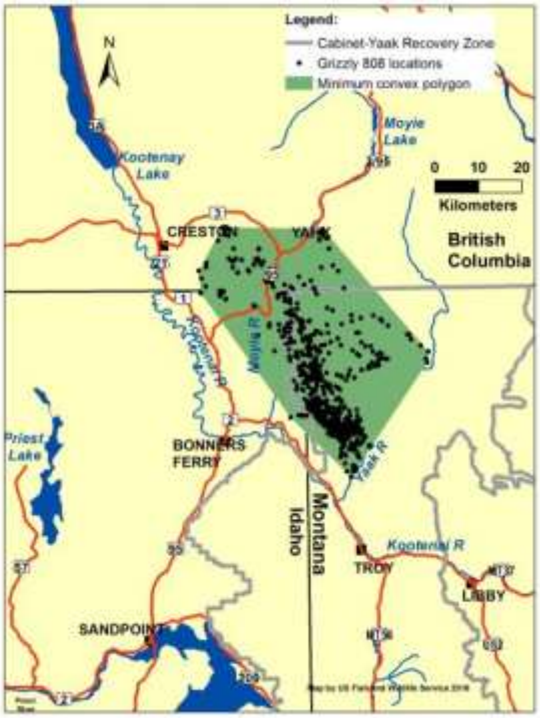


Figure A81. Radio locations and minimum convex (shaded) life range of male grizzly bear 808 in the Yaak River, 2014–2015.

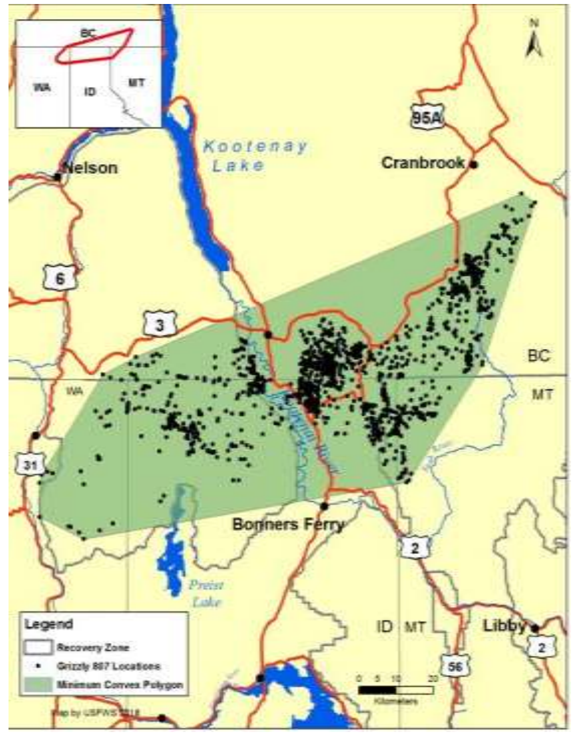


Figure A82. Radio locations and minimum convex (shaded) life range of male grizzly bear 807 in the Yaak River and Selkirk Mountains, 2014–2017.

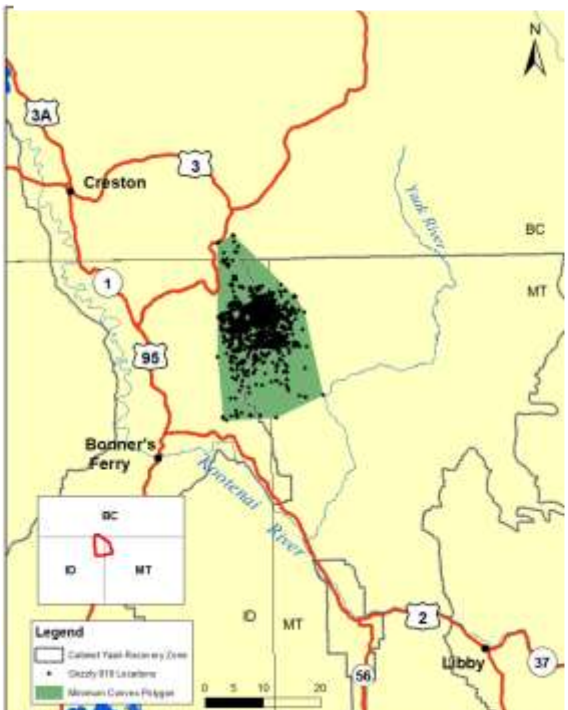


Figure A83. Radio locations and minimum convex (shaded) life range of female grizzly bear 810 in the Yaak River, 2015–2018.

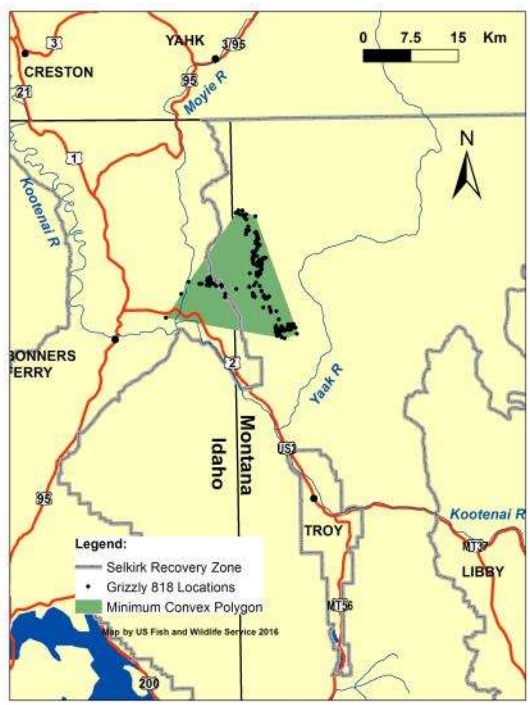


Figure A84. Radio locations and minimum convex (shaded) life range of male grizzly bear 818 in the Yaak River, 2015.

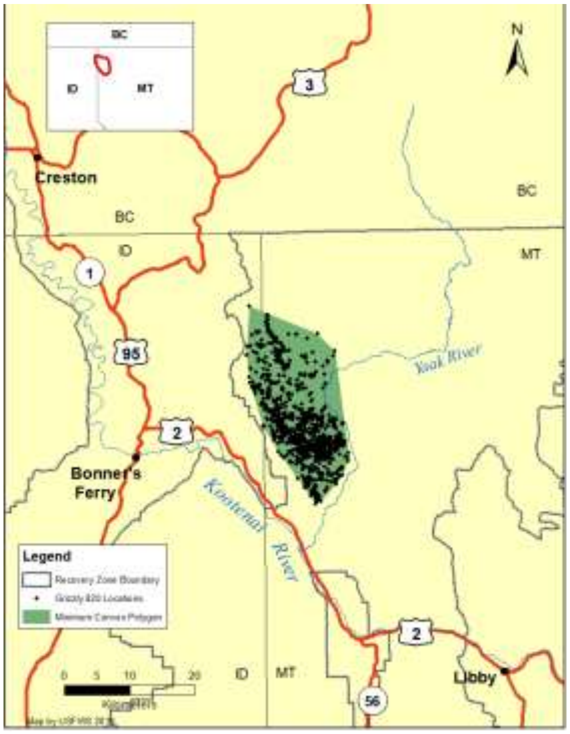


Figure A85. Radio locations and minimum convex (shaded) life range of female grizzly bear 820 in the Yaak River, 2015–2018.

Figure A86. Radio locations and minimum convex (shaded) life range of male grizzly bear 839 in the Cabinet Mountains, 2015–2016.

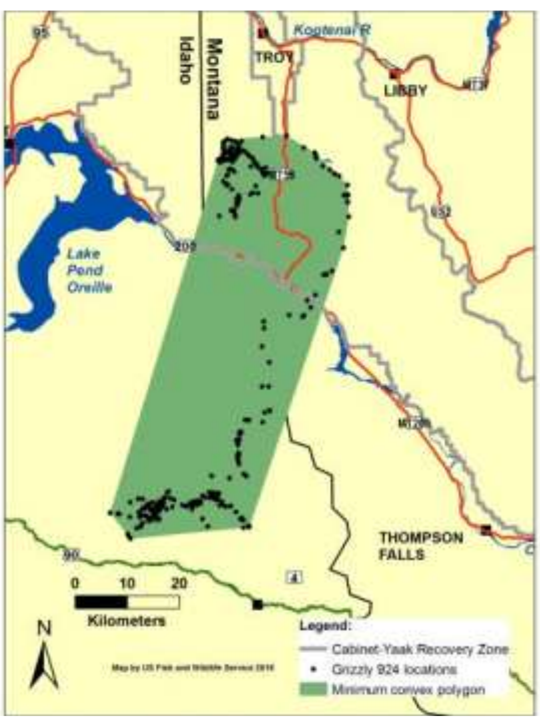


Figure A87. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 924 in the Cabinet Mountains, 2015.

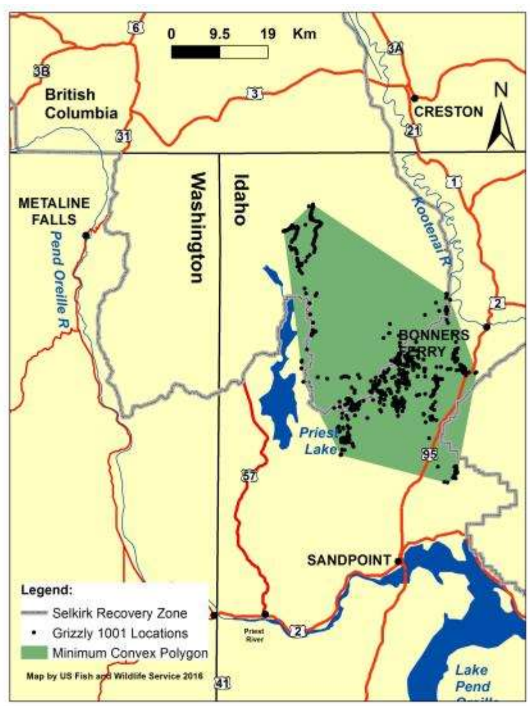


Figure A88. Radio locations and minimum convex (shaded) life range of male grizzly bear 1001 in the Selkirk and Cabinet Mountains, 2015.

Figure A89. Radio locations and minimum convex (shaded) life range of male grizzly bear 821 in the Yaak River, 2016–2017.

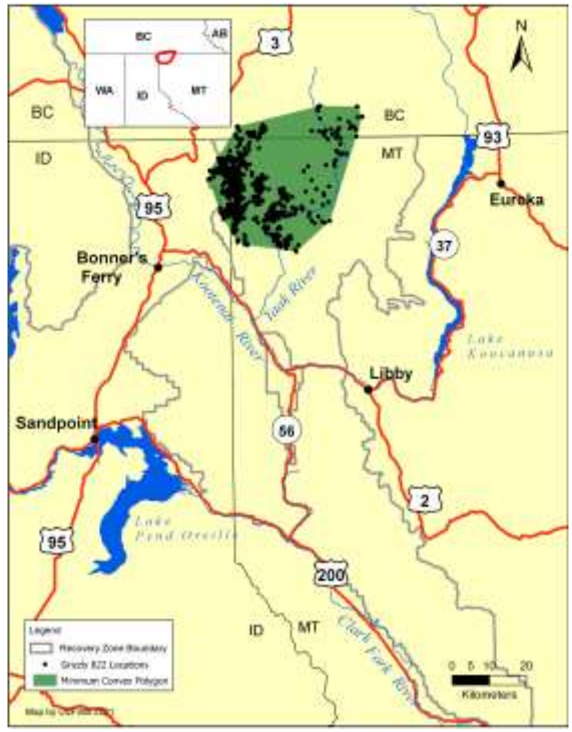


Figure A90. Radio locations and minimum convex (shaded) life range of male grizzly bear 822 in the Yaak River, 2016, 2019–2020.

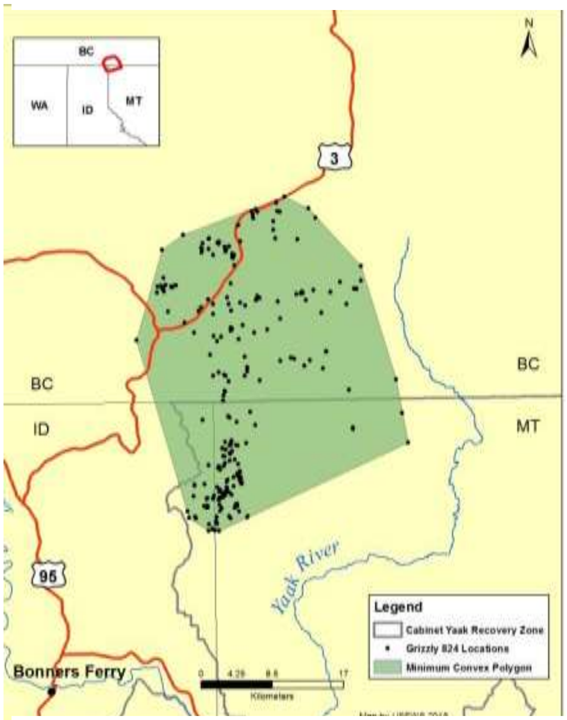


Figure A91. Radio locations and minimum convex (shaded) life range of male grizzly bear 824 in the Yaak River, 2016–2017.

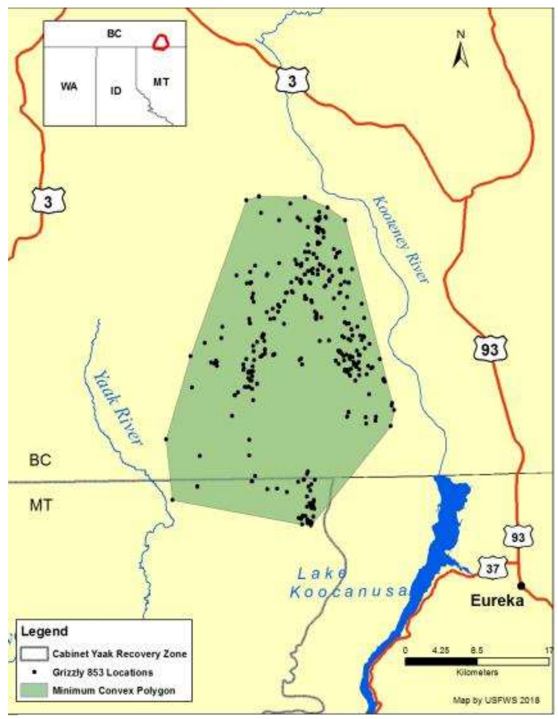


Figure A92. Radio locations and minimum convex (shaded) life range of male grizzly bear 853 in the Yaak River, 2016–2017.

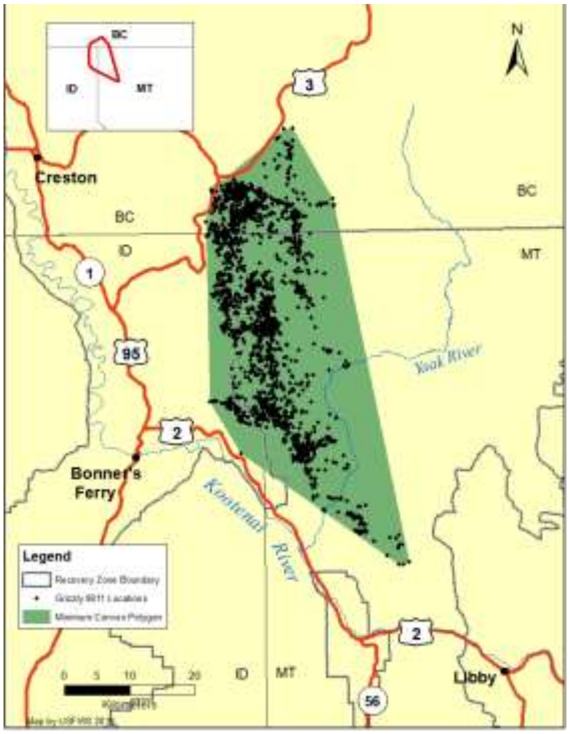


Figure A93. Radio locations and minimum convex (shaded) life range of male grizzly bear 9811 in the Yaak River, 2016–2018.

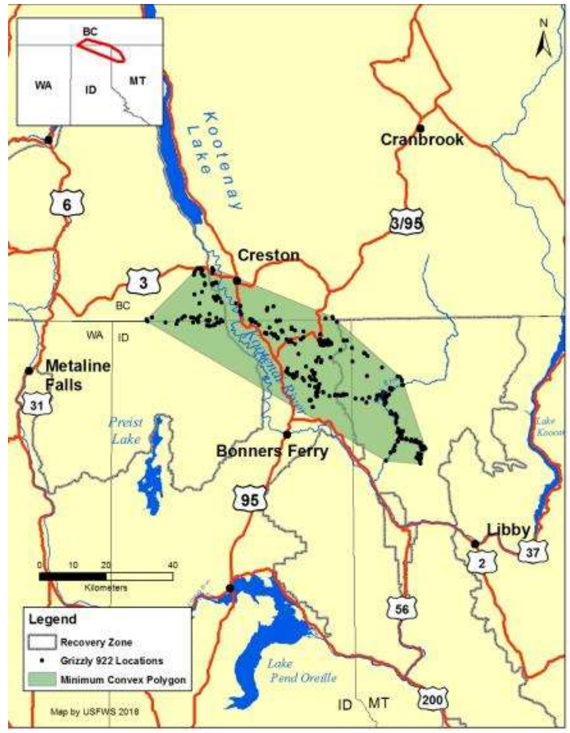


Figure A94. Radio locations and minimum convex (shaded) life range of male grizzly bear 922 in the Yaak River, 2016–2017.

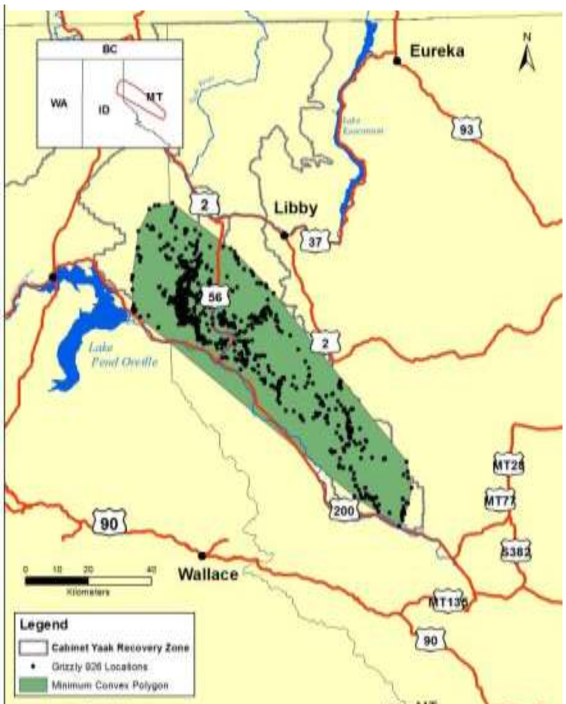


Figure A95. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 926 in the Cabinet Mountains, 2016–2017.

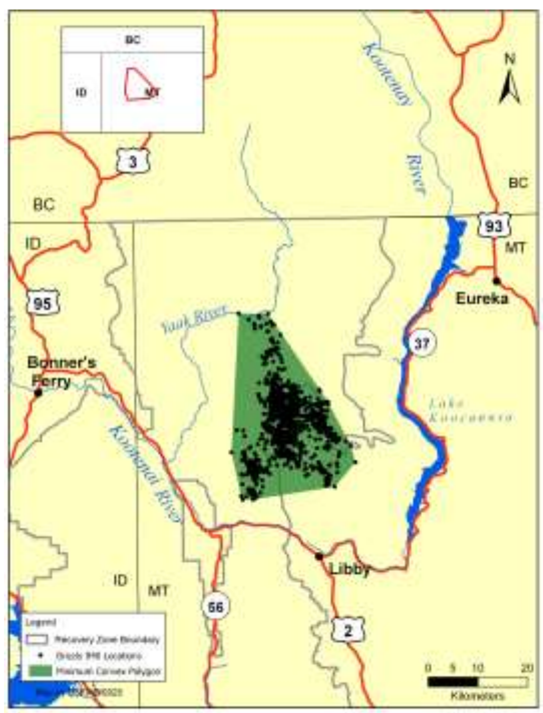


Figure A96. Radio locations and minimum convex (shaded) life range of female grizzly bear 840 in the Yaak River, 2016–2019.

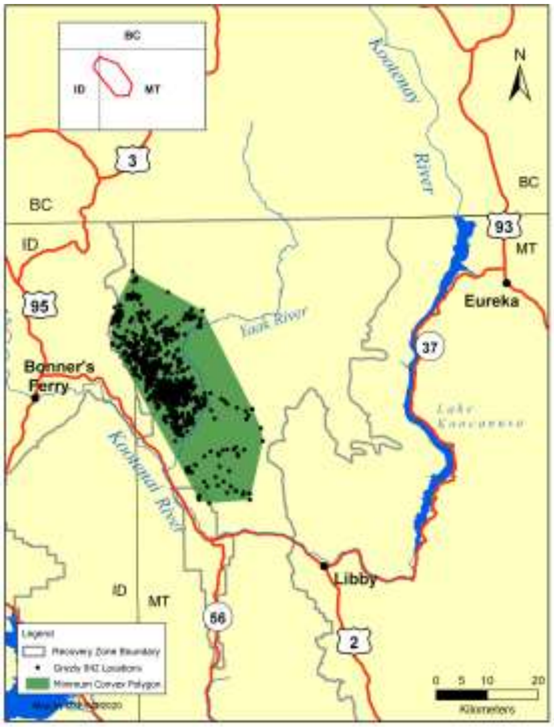


Figure A97. Radio locations and minimum convex (shaded) life range of female grizzly bear 842 in the Yaak River, 2017–2019.

Figure A98. Radio locations and minimum convex (shaded) life range of male grizzly bear 861 in the Cabinet Mountains, 2017–2019.

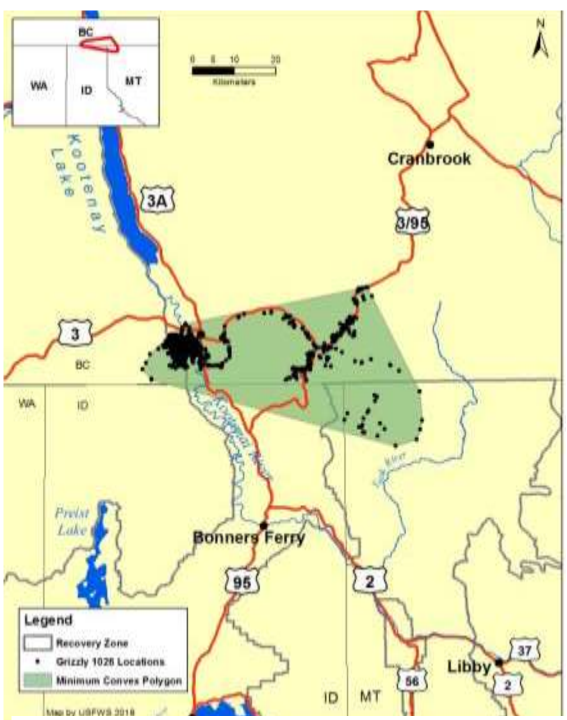


Figure A99. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1026 in the Yaak River, 2017.

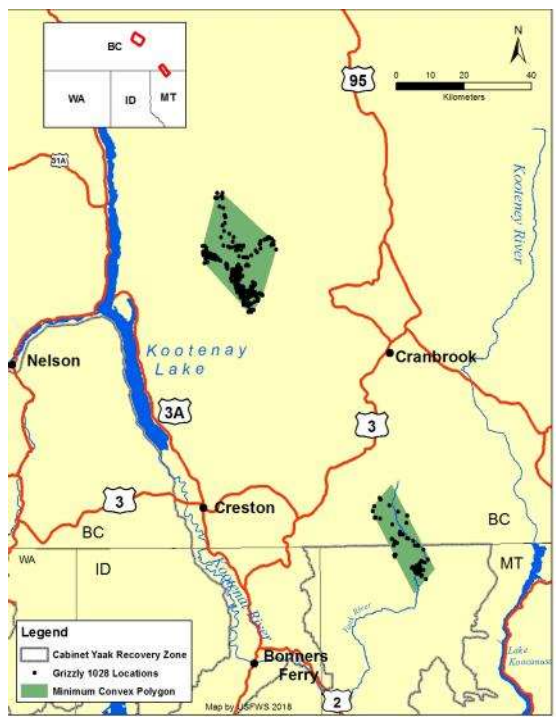


Figure A100. Radio locations and minimum convex (shaded) life range of management female grizzly bear 1028 in the Yaak River, 2017.

Figure A101. Radio locations and minimum convex (shaded) life range of augmentaiton male grizzly bear 927 in the Cabinet Mountains, 2018–2020

Figure A102. Radio locations and minimum convex (shaded) life range of male grizzly bear 1006 in the Selkirk, Purcell, and Cabinet Mountains, 2017–2018.

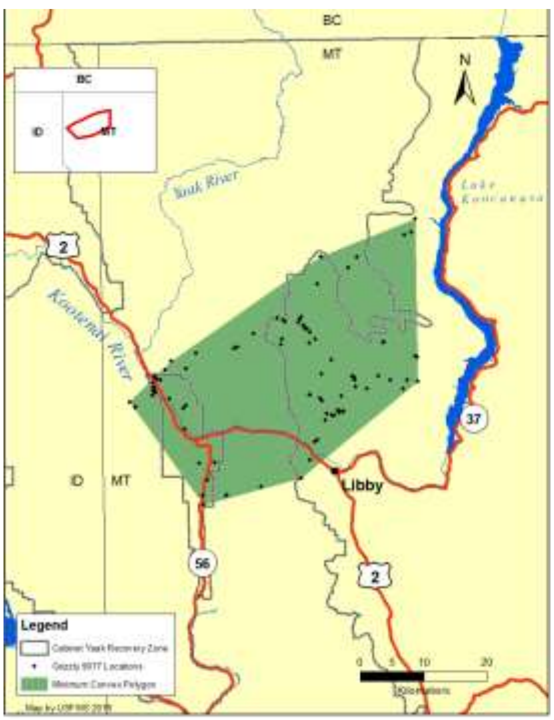


Figure A103. Radio locations and minimum convex (shaded) life range of management male grizzly bear 9077 in the Yaak River, 2018.

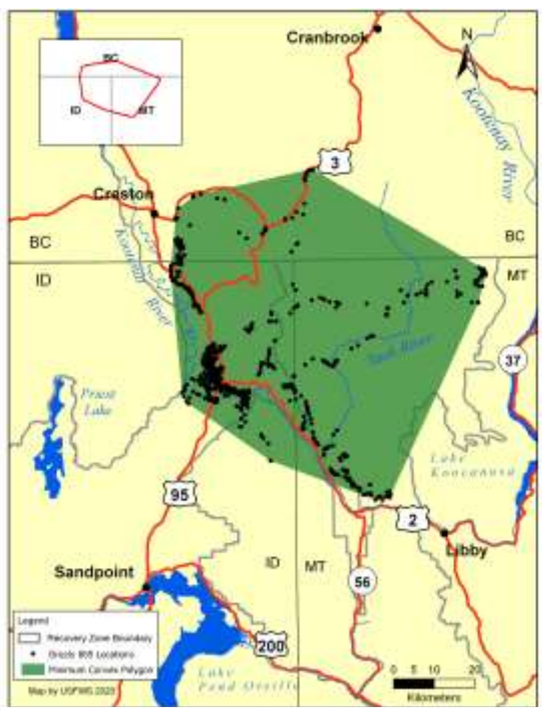


Figure A104. Radio locations and minimum convex (shaded) life range of management male grizzly bear 865 in the Kootenai and Yaak River, 2018–2019.

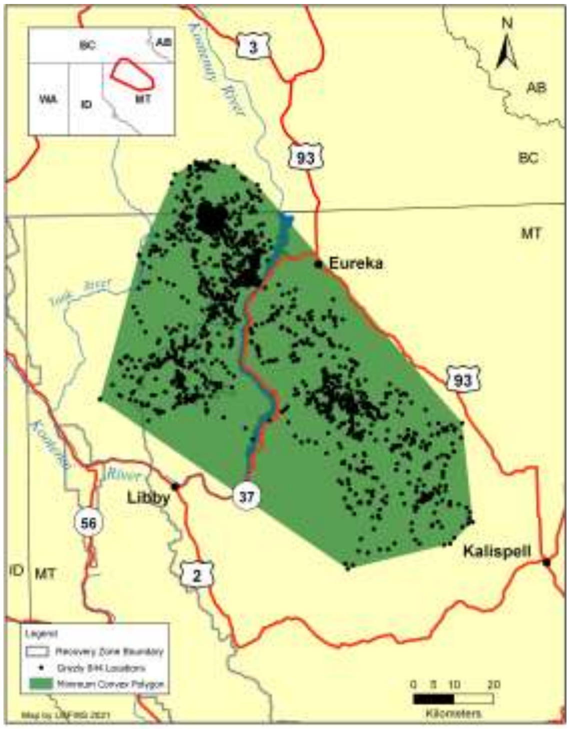


Figure A105. Radio locations and minimum convex (shaded) life range of augmentaiton male grizzly bear 844 in the Yaak River, 2019–2020.

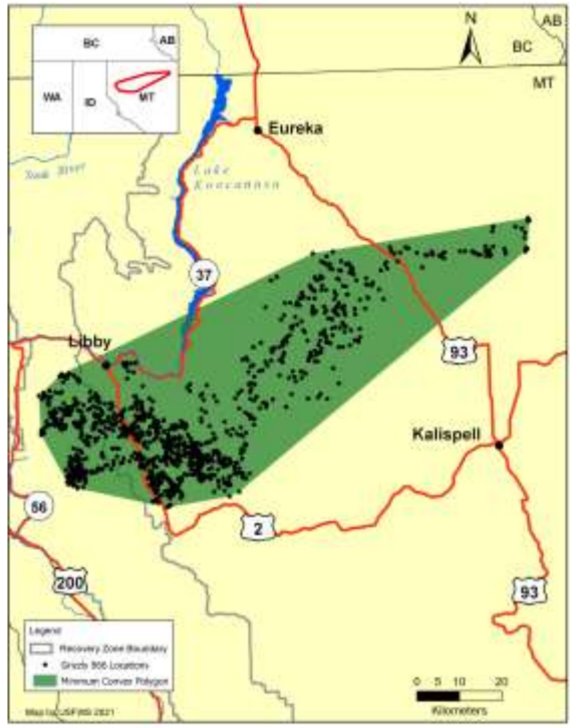


Figure A106. Radio locations and minimum convex (shaded) life range of male grizzly bear 866 in the Cabinet Mountains, 2019–2020.

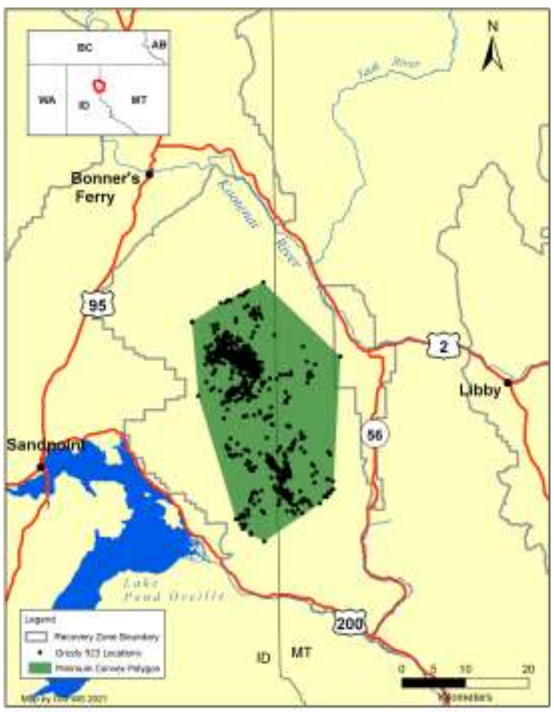


Figure A107. Radio locations and minimum convex (shaded) life range of augmentation female grizzly bear 923 in the Cabinet Mountains, 2019–2020.

Figure A108. Radio locations and minimum convex (shaded) life range of augmentation male grizzly bear 892 in the Cabinet Mountains, 2019–2020.

APPENDIX 5. Fine scale habitat modeling for the South Selkirk and Cabinet-Yaak ecosystems

Trans-border Grizzly Bear Project and the US Fish & Wildlife Service
Michael Proctor TBGBP and Wayne Kasworm USFWS

BACKGROUND

This document describes the methods and appropriate interpretation for fine scale habitat modeling of sex-, season- and ecosystem-specific habitat use modeling for grizzly bears. We modeled habitat use for females and males, in each of 3 seasons (spring, summer, fall) in each of 4 ecosystems, S Purcells in Canada, the international South Selkirks and Yaak, and the US Cabinets. Here we present the female results. Females receive priority in grizzly bear conservation management because they are the reproductive engine of a population, they tend to have smaller home ranges and move significantly less than males. Management that secures important female habitat and food resources may be most efficient for conservation purposes. Males are important as well and, in some instances, can dominate the very best of food resources.

METHODS

We assessed habitat use for female and male bears separately at the scale of each of several ecosystems, including the South Selkirk (international), the Yaak (international), the Cabinets (USA) and the South Purcell (north of Hwy 3 in Canada). We modelled habitat in each of the 3 non-denning seasons (Spring, den emergence – July 14; Summer berry season, July 15 – Sept 15; and Fall, Sept 16 – October 30). Methods below are very similar to those employed by Proctor *et al*. 2015.

Grizzly bear GPS location data

We deployed GPS-telemetry collars on 38 female grizzly bears in 2004–2015 (22 in the international S Selkirks, 10 in the International Yaak and 6 in the Canadian South Purcells). Bears were captured with Aldrich foot snares and occasionally with culvert traps. We used Telonics Inc. (Mesa, Arizona, USA) Spread Spectrum radio-collars (and occasionally store-on-board collars) and remotely downloaded bear locations on a periodic basis.

Most bears were collared in May or June and were monitored for 1–3 years but usually monitoring spanned at least 2 non-denning periods (i.e., spring summer, fall). Locations were attempted every 1–4 hours depending on collar size (smaller bears carried smaller collars with less battery life), and age of bears (subadult bears carried collars designed to drop off earlier so as to not interfere with neck growth). Because we used only 2D and 3D fixes, overall fix success (the proportion of 2D and 3D fixes relative to fix attempts) was 84%. We also assessed potential location bias for canopy closure, which was the variable with the most potential for low fix success rate (Frair *et al*. 2004). We placed 13 GPS radio collars at ground level in conifer forest with canopy cover from 0 to 75% canopy and found no relationship between fix rate and canopy closure ($R^2 = 0.07$; regression significance, $P = 0.64$).

Because unequal observations among animals can lead to biased population level estimates (Gillies *et al*. 2006) and most bears had 1500–2000 locations, we used a maximum of 1600 locations from most bears by removing every n^{th} location from any one bear with > 1600 locations.

Grizzly Bear Habitat Modeling

Female grizzly bear GPS telemetry data were divided into 2 groups for each season and ecosystem. An 80% random sample was used for model training, while the remaining 20% random samples of bear locations were withheld for model evaluation (Boyce *et al*. 2002, Nielsen *et al*. 2002). We used the GPS telemetry locations and a similar number of available (random) locations from within the composite home ranges of all grizzly bears to develop a resource selection function (RSF, Boyce and McDonald 1999, Manly *et al*. 2002, Nielsen *et al*. 2002). We estimated the parameters of the exponential RSF using logistic regression (Manly *et al*. 2002) and predictions from the RSF were transformed using the logistic function to normalize the right skewing of exponential RSF values and then mapped at a 100-m scale in ArcGIS 10.1 (ESRI, Redlands, CA). Logistic regression was performed using the statistical software package STATA (Intercooled 9.2, College Station, Texas, USA).

Model building was based on the principles of Hosmer and Lemeshow (1989) and more recently referred to as purposeful selection of variables (Bursac *et al*. 2008). We did not use an Information Theoretic approach (Burhnam and Anderson 1998) because our goal was predictive ability of grizzly bear habitat use and not testing of broader competing hypotheses (Nielsen *et al*. 2010). All predictor variables were tested for pairwise correlations (Chatterjee *et al*. 2000) and only terrain ruggedness and compound topographic index were correlated. All variables and their quadratic relationships were fit individually (uni-variable analyses) and ranked for their significance and explanatory power (pseudo R^2). Multi-variable models were then built by adding non-correlated variables in a forward stepwise fashion starting from higher to lower pseudo R^2. Models were compared sequentially after each variable addition; variable significance and explanatory power (pseudo R^2) were used to compare models and decide if a variable improved model predictability. When a variable increased the pseudo R^2 by at least 5%, we retained that variable in the model; when a variable increased the pseudo $R^2 < 5\%$ we did not retain it to favor a parsimonious model.

We used the Huber-White sandwich estimator in the robust cluster option in Stata to calculate standard errors because non-independent locations can lead to biased standard errors and overestimated significance of model parameters (White 1980, Nielsen *et al*. 2002, 2004b). Because the bears were the unit of replication, they were used to denote the cluster thus avoiding autocorrelation and/or pseudoreplication of locations within individual bears. We assessed the Receiver Operator Characteristic (ROC), a standard technique for summarizing classifier performance (i.e., how well did the model predict habitat and non-habitat correctly) for our most parsimonious models.

Environmental Variables

We used variables that were most consistently measured across the study area and between Canada and the USA including human-use, terrain, forest cover, and other ecological variables (Table 1). Ecosystem characteristics and human uses in the adjacent south Selkirk and south Purcell Mountains are similar (Meidinger and Pojar 1991) allowing development and prediction of models to these areas. Lowlands are dominated by Cedar-Hemlock (*Thuja plicata - Tsuga heterophylla*) forests and upland forests are dominated by Engelmann Spruce - Sub Alpine Fir (*Picea engelmanni – Abies lasiocarpa*). Douglas fir (*Psuedotsuga mensiezii*) forests are somewhat more common in the southern portions of the Purcell range (Meidinger and Pojar 1991). Human uses are relatively similar across the region and include timber harvest, some mining, ungulate hunting, and other forms of recreation.

Baseline Thematic Mapping land-cover variables (recently logged, alpine, avalanche, and riparian), Vegetation Resource Inventory variables (dominant tree species forest cover types, canopy cover), and backcountry resource roads (i.e., associated with timber harvest, mining) were obtained from the BC Ministry of Forests, Lands, and Natural Resource Operations in Canada. Land-cover information for the USA was from the US Forest Service. Alpine, avalanche, burned, and riparian habitats contain a variety of grizzly bear food resources (Mace *et al*. 1996, McLellan and Hovey 1995, McLellan and Hovey 2001b). Forest cover variables (Table 1) were used because they often have been found to influence grizzly bear habitat selection (Zager *et al*. 1983, Waller and Mace 1997, Apps *et al*. 2004, Nielsen *et al*.

2004a). Greenness, an index of leafy green productivity, correlates with a diverse set of bear food resources and is often found to be a good predictor of grizzly bear habitat use (Mace *et al*. 1996, Nielsen *et al*. 2002). Greenness was derived from 2005 Landsat imagery using a Tassled Cap transformation (Crist and Ciccone 1984, Manley *et al*. 1992). Terrain variables of elevation, compound topographic index (CTI), solar radiation, and terrain ruggedness were derived from a digital elevation model (DEM) in ArcGIS. CTI is an index of soil wetness estimated from a DEM in a GIS using the script from Rho (2002). Solar radiation was estimated for the summer solstice (day 172), again using a DEM, and in this case the ArcInfo AML from Kumar (1997) that was modified by Zimmerman (2000) called shortwavc.aml. Finally, terrain ruggedness was estimated from the DEM based on methods from Riley *et al*. (1999) and scripted as an ArcInfo AML called TRI.aml (terrain ruggedness index) by Evans (2004). These terrain variables have been shown to influence the distribution of grizzly bear foods (Apps *et al*. 2004, Nielsen *et al*. 2004a, 2010) and also affect local human use. We included elevation as a variable because grizzly bears in our region use high country extensively, which may be for a variety of reasons (e.g., high elevation habitat types, thinner forest cover with more edible ground-based vegetation, human avoidance). Highway and human developments were digitized from 1:50,000 topographic maps and ortho-photos. Highway, human developments, and backcountry roads were buffered by 500 m on either side to reflect their influence on grizzly bear habitat use (Mace *et al*. 1996). The human-use variables have been demonstrated repeatedly to correlate with habitat selection by grizzly bears (Mace *et al*. 1996, 1999, Nielsen *et al*. 2002, Apps *et al*. 2004). Although none of the predictors were direct measures of food resources or human activities, each factor was thought to correlate with resources and behaviors used by bears or activity of humans (Mace *et al*. 1996, Nielsen *et al*. 2002, 2006, 2009, Apps *et al*. 2004).

RESULTS

Best models for each season and ecosystem were dominated by greater than expected use for canopy openness and high level of greenness and less than expected use of high road densities (Table 1). Model predictive ability was greatest in the International South Selkirk area in all 3 seasons, as predictions of habitat use and non-use were all > 0.8 (ROC, Receiver Operator Characteristic measures how well the model predicts habitat use (GPS Locations that were in model predicted use areas vs non-used areas). Because we had very few resident females in the Cabinet population, most were augmented bears from the Rocky Mt region, and the ecology is similar to the S Selkirk region (Proctor *et al*. 2015), we applied our South Selkirk model to the Cabinet area. These models are similar to the all-season both-sex Resource Selection Function model derived to predict linkage habitat within Proctor *et al*. (2015). That model was dominated by canopy openness, greenness, riparian, alpine, and elevation.

In the S Selkirk, S Purcell, and Cabinet area, our models were the most predictive with ROC scores usually > 0.75 and even > 0.80 (0.7 is considered a good predictive model). Models for the international Yaak were less predictive, especially in spring and fall (ROC scores were 0.66 and 0.59 respectively).

Where we had a huckleberry patch model available in the South Purcell area of Canada, it dominated the model along with greenness. We have a huckleberry patch model throughout this region within Canada. Therefore, we did not include it in international models in the S Selkirk, Yaak, or Cabinet areas. Canopy openness is a powerful predictor of huckleberry patches and in models without huckleberry patches, canopy openness plays a similar predictive role.

DISCUSSION

We envision the usefulness of these habitat models for planning timber harvest, road building, road closing, road decommissioning, and prescribed burns. As canopy openness and greenness are two of the better predictors of female habitat use (Mace *et al*. 1996, Nielsen et al. 2002), certain timber harvest and prescribed burning practices may have some potential to improve grizzly bear habitat through opening canopy and promoting deciduous and herbaceous bear foods. In contrast, it might be desirable to plan access controls in areas where habitat quality and use is high, to provide security for female grizzly bears. In that regard, these models may be used to decide where roads might be closed, decommissioned, or left open.

It must also be kept in mind that grizzly bear habitat is dynamic spatially and temporally. Some open-canopy habitats that resulted from past timber harvest may change over time as those canopies fill in with forest regrowth. The same applies to habitat created from past burns. Also, some habitat may have a longer-term state of canopy openness (some higher elevation forests) that may remain desirable over longer time periods. Foresters' on-the-ground knowledge may be able to differentiate these types of habitats and their dynamic potential. Future iterations of these models can be run with updated canopy cover and greenness layers as they are derived from remote sensing.

Note that Riparian habitat was a strong predictor in the South Selkirk (and Cabinet) model. This result was driven by the heavy use of female grizzly bears in the Kootenay River Valley just north of the Canada-US border in the Creston Valley in all 3 seasons. If populations continue to grow, the Kootenay River Valley or other main river valleys may see some increased habitat use by female grizzly bears at least seasonally within the US. We also think that the bears in the Creston Valley are getting a measure of agricultural foods that might be holding them in the valley even in the summer. In Canada and the US, there are developing programs to secure many of these agricultural products from the bears, but it may never all be secured and there will tend to be some bears spending time in these valley bottoms. On the other hand, this is somewhat desirable from the standpoint of female connectivity between the Selkirk and Purcell and Cabinet ranges (Proctor *et al*. 2012, 2015). Subadult female dispersal is usually of a short distance (McLellan and Hovey 2001, Proctor *et al*. 2004) so for female connectivity to develop, it is likely necessary that female grizzly bears spend a portion of their lives in valley bottoms. Conflict reduction efforts become especially important in that regard.

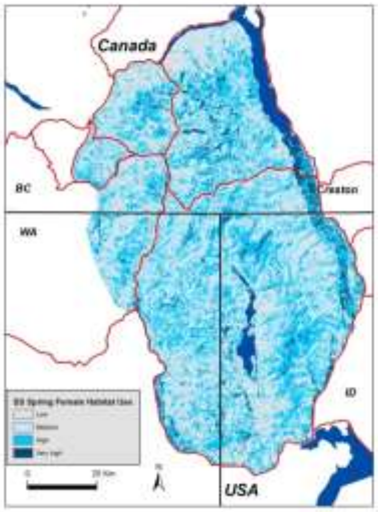
As we modeled each ecosystem separately, thresholds between ecosystems varied. Model outputs have ecosystem-specific thresholds for greater than expected use of specific habitats vs. less than expected use built in. For most planning we would expect use of the summer models or occasionally the spring models. Fall modeling probably represents a time when berry feeding has passed, and bears may be preparing for denning by looking for protein in the form of wounded animals and gut piles from hunters.

Table 1. Best female grizzly bear seasonal habitat use models for the Selkirk, S Purcell, Yaak, and Cabinet ecosystems. Huckleberry patch models were only available in the S Purcell area.

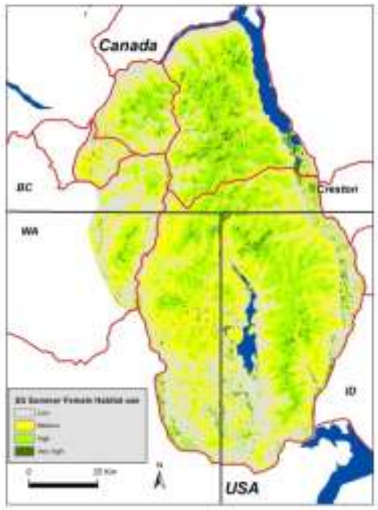
VARIABLES	Female Selkirk Spring	Female Selkirk Summer	Female Selkirk Fall	Female Yaak Spring	Female Yaak Summer	Female Yaak Fall	Female Cabinet Spring	Female Cabinet Summer	Female Cabinet Fall	Female Purcell Spring	Female Purcell Summer	Female Purcell Fall	Female Canada Spring	Female Canada Summer	Female Canada Fall
canopy cover	-	+	+	-	+	+	-	+	+	+			-		
canopy cover^2		-	-		-	-		-	-						
greenness	+	+	+		+		+	+	+	+	+	+	+	+	+
road density	-	-	-	-			-	-	-				-	-	-
riparian	+	+	+				+	+	+					+	
forest age 100-250											-	-			
forest age 1-20					+										
forest age 20-60						-									
forest age 60-80											+				
alpine					+	+						+		+	+
avalanche	+						+						+		
deciduous forest				+	+	+				+					
elevation		+	+	+	+			+	+						
elevation^2			-	-	-				-						
Douglas fir forest			-	+					-						-
distance to road											+				
buildings				-	-										
distance to HuckPatch											-			-	-
HuckPatch X Dist2Road															+
highway			-			-			-						-
mortality risk				-								-			+
recently logged			-						-		-	-			
solar radiation										+		+			
terrain ruggedness										+				-	-
Pseudo R2	0.20	0.25	0.26	0.06	0.18	0.03	0.20	0.25	0.26	0.20	0.32	0.11	0.13	0.25	0.15
ROC AUC	0.80	0.82	0.83	0.66	0.78	0.59	0.80	0.82	0.83	0.79	0.86	0.73	0.75	0.82	0.80
Correct classified	73%	74%	80%	61%	70%	56%	73%	74%	80%	72%	78%	65%	74%	75%	76%

Figure 1a) Spring, b) Summer, and c) Fall female grizzly bear Habitat Use map.

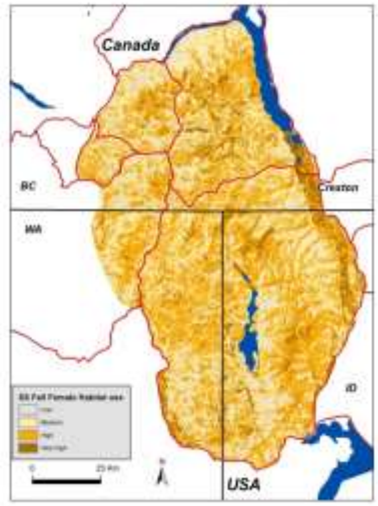
a) S Selkirks Spring



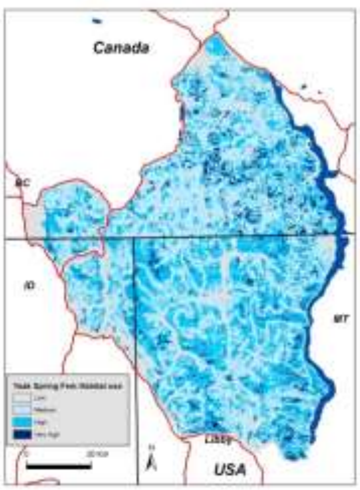
b) S Selkirks Summer



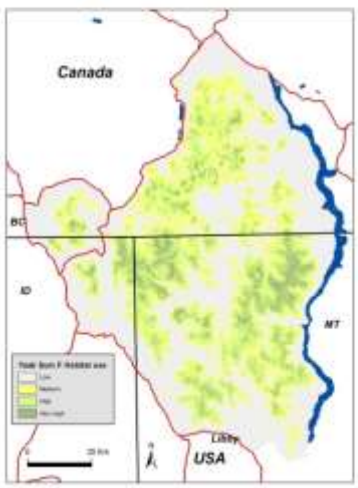
c) S Selkirks Fall



a) Yaak Spring

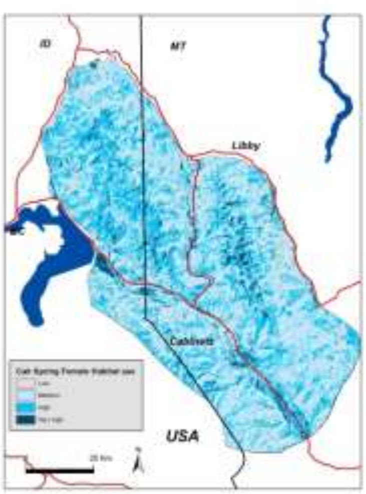


b) Yaak Summer

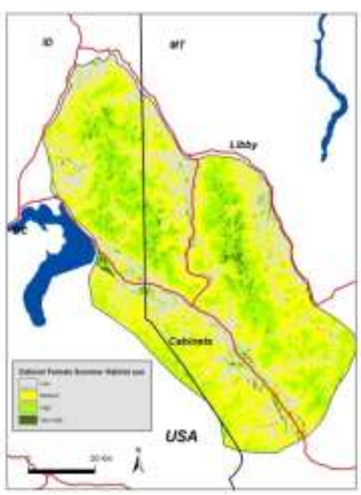


c) Yaak Fall

a) Cabinets Spring



b) Cabinets Summer



c) Cabinets Fall

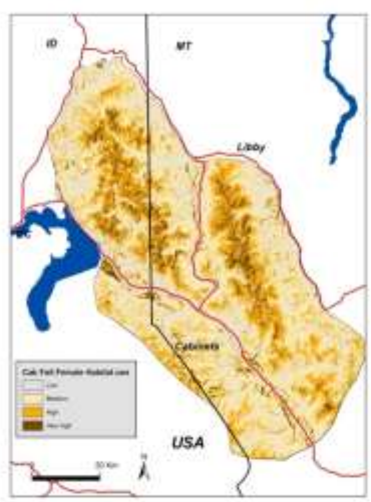


EXHIBIT 4

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Research Article

Density, Distribution, and Genetic Structure of Grizzly Bears in the Cabinet-Yaak Ecosystem

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ABSTRACT The conservation status of the 2 threatened grizzly bear (*Ursus arctos*) populations in the Cabinet-Yaak Ecosystem (CYE) of northern Montana and Idaho had remained unchanged since designation in 1975; however, the current demographic status of these populations was uncertain. No rigorous data on population density and distribution or analysis of recent population genetic structure were available to measure the effectiveness of conservation efforts. We used genetic detection data from hair corral, bear rub, and opportunistic sampling in traditional and spatial capture–recapture models to generate estimates of abundance and density of grizzly bears in the CYE. We calculated mean bear residency on our sampling grid from telemetry data using Huggins and Pledger models to estimate the average number of bears present and to correct our superpopulation estimates for lack of geographic closure. Estimated grizzly bear abundance (all sex and age classes) in the CYE in 2012 was 48–50 bears, approximately half the population recovery goal. Grizzly bear density in the CYE (4.3–4.5 grizzly bears/1,000 km^2) was among the lowest of interior North American populations. The sizes of the Cabinet ($n = 22$–24) and Yaak ($n = 18$–22) populations were similar. Spatial models produced similar estimates of abundance and density with comparable precision without requiring radio-telemetry data to address assumptions of geographic closure. The 2 populations in the CYE were demographically and reproductively isolated from each other and the Cabinet population was highly inbred. With parentage analysis, we documented natural migrants to the Cabinet and Yaak populations by bears born to parents in the Selkirk and Northern Continental Divide populations. These events supported data from other sources suggesting that the expansion of neighboring populations may eventually help sustain the CYE populations. However, the small size, isolation, and inbreeding documented by this study demonstrate the need for comprehensive management designed to support CYE population growth and increased connectivity and gene flow with other populations. Published 2015. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS bear rub, Cabinet-Yaak Ecosystem, density estimation, genetic detection, grizzly bear, hair corral, Huggins–Pledger capture–recapture models, pedigree, spatially explicit capture–recapture models, *Ursus arctos*.

The 2 grizzly bear (*Ursus arctos*) populations in the Cabinet-Yaak Ecosystem (CYE) in northwestern Montana and northern Idaho were designated threatened under the Endangered Species Act in 1975. In 1993, these populations qualified for endangered designation, but a status change was precluded because listing other species had higher priority (U.S. Fish and Wildlife Service 1993). Between 1983 and 2006, the CYE populations declined at an annual rate of 8% ($\lambda = 0.920$ [95% CI: 0.790–1.020]; Kasworm et al. 2007*a*). Research conducted on the CYE populations since the late 1970s (Kasworm et al. 2014) reported that the grizzly bears in the Cabinet Mountains and the Yaak region were demographically independent groups split along U.S.

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Highway 2 (Fig. 1). The bears in the Yaak were part of a larger population that contained an estimated 24 grizzly in the Canadian Yahk to the north, in the Purcell Mountains, British Columbia (Proctor et al. 2007, 2012*b*), making that population more genetically diverse than the Cabinet population. Fragmented from the Yaak and other grizzly bear populations, the Cabinet Mountain population was estimated to be ≤15 individuals in the 1980s and 1990s (Kasworm and Manley 1988, Kasworm et al. 2005). Concern over persistence of the critically small and isolated Cabinet population prompted the establishment of a population augmentation program. From 1990 to 1994, 4 subadult female bears were moved from southeastern British Columbia to the Cabinet Mountains (Kasworm et al. 2007*b*). Seven more females and 3 male grizzly bears were translocated to the Cabinet Mountains from the Whitefish Range in Montana between 2007 and 2012 (Kasworm et al. 2014). Prior to the beginning of our research in 2012, all bears recently documented to be present in the Cabinets were augmentation bears or progeny of 1 augmentation female and 2 male bears of unknown origin with which she bred (Kasworm et al. 2007*b*). The few bears sampled in earlier efforts thought to be native bears from the Cabinet appeared to be genetically similar to bears from the Northern Continental Divide Ecosystem (NCDE; Proctor et al. 2012*b*). Demographic data available on the populations in the CYE included the locations and causes of mortalities, population trend, and survival and reproductive rates (Kasworm et al. 2014).

Agencies need statistically rigorous data on population demography and population genetic structure to develop and assess policies and practices designed to promote the recovery of grizzly bears in the CYE. Our demographic objectives were to obtain statistical estimates of abundance, density, and distribution. Our genetic objectives were to comprehensively assess the degree of inbreeding within the CYE populations and the amount of gene flow with neighboring populations.

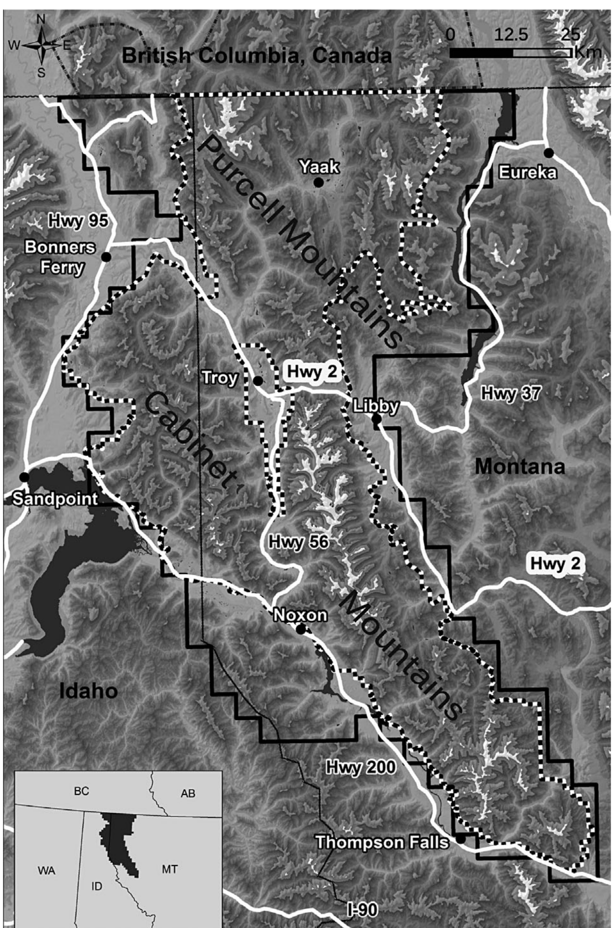

Figure 1. Study area in northwestern Montana and northern Idaho, USA where we estimated grizzly bear abundance and density in 2012. Areas outside the recovery zone were locations with recent confirmed presence of grizzly bears outside the recovery zone boundary specified by the Grizzly Bear Recovery Plan (US Fish and Wildlife Service 1993).

STUDY AREA

The study area (48°30′N, 115°45′W) covered 9,875 km^2 of northwestern Montana and northern Idaho considered to be occupied by grizzly bears. This encompassed the 6,765-km^2 Cabinet-Yaak Grizzly Bear Recovery Zone (U.S. Fish and Wildlife Service 1993) plus 3,110 km^2 of range that fell outside its periphery (Fig. 1). Our sampling area encompassed the known extent of occupied habitat of the native grizzly bear populations in CYE and, therefore, the boundary was essentially closed to movements of native bears. The primary exception was the northern border where occupied range continued into the Purcell Mountains, British Columbia, Canada. The second exception was the Cabinet Mountains that contained bears translocated there to augment the small population. The source population was the NCDE approximately 70 km east of the northeastern edge of the CYE and 150 km from the Cabinet Mountains.

The CYE was a region of diverse land use with rugged mountains surrounded by multiple-use forests. It contained portions of 3 national forests (Kootenai, Idaho Panhandle, and Lolo) that included 1 wilderness area, Cabinet Mountains (382 km^2), and 1 proposed wilderness area, Scotchman Peaks (356 km^2). There were 2,175 km of maintained trails, 6,530 km of open roads, and 8,330 km of gated, closed, and private roads in the CYE study area. National forests and corporate timber lands had active timber harvest and forest management programs. The study area also included an active silver and copper mine, 2 proposed silver and copper mines, and a closed vermiculite mine area (14.5 km^2) that was not available for sampling because of asbestos contamination. The major valley bottoms, primarily private lands, were a mix of forested and open parcels and variable densities of towns, rural residences, small farms, and ranches.

Climate in the CYE was characterized by Pacific Maritime weather patterns of short, warm summers, wet winters, and 100–150 cm of annual precipitation, mostly falling as snow (Kasworm et al. 1998). Stands of subalpine fir (*Abies lasiocarpa*), spruce (*Picea* spp.), and mountain hemlock

(*Tsuga mertensiana*) predominated between 1,500 m and timberline (Kasworm et al. 1998). Lower slopes were dominated by stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) on drier sites and by grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) on moister sites. Thick understory dominated by alder (*Alnus viridis*), fool's huckleberry (*Menziesia ferruginea*), and other leafy shrubs and forbs limited sight distances in much of the CYE. Valley bottoms of major drainages were mosaics of wet meadows, riparian shrub fields, and mixed stands of coniferous and deciduous trees.

METHODS

Field Methods

We used a multiple data source approach to assess the status of the bear populations. Because the study area was heavily vegetated, direct observation techniques for estimating bear population abundance were not appropriate. We used 2 concurrent hair collection methods to systematically sample our study area during 9-day sessions conducted at 14-day intervals starting 7 June 2012: barbed wire hair corrals with scent lure attractants and natural bear rubs (no scent lure). We also recorded opportunistic detections of bears during the period of time we conducted our structured hair sampling. Hair corrals consisted of 30 m of lightweight, 4-pronged barbed wire stapled 50 cm above the ground around ≥3 trees (Woods et al. 1999, Mowat and Strobeck 2000, Kendall et al. 2009). We used a 5-km × 5-km grid superimposed on the study area (Fig. 2a) to systematically distribute hair corrals. We placed corrals in the highest-quality bear habitat available during early and late summer, in travel routes, or in sites that promoted dispersion of attractant odor based on expert opinion of experienced bear researchers. We used habitat quality maps developed using resource selection function models applied to global positioning system (GPS) telemetry locations of grizzly bears in the CYE region (Proctor et al. 2015). For human safety and to minimize human disturbance of bears, corrals were located ≥500 m from developed areas (i.e., homes, campgrounds) and ≥100 m from roads and trails. We established 1 corral in each of 395 grid cells during sampling occasion 1 (early season locations), rebaited corrals during occasions 2 and 3, moved corrals to a new site within each cell during occasion 4 (late season locations), and rebaited corrals during occasion 5. The scent lure was a 2:1 mixture of aged cattle blood and liquid from decayed fish. We poured lure on forest debris piled approximately 1 m high in the center of the enclosure and on a cloth that we suspended over the corral.

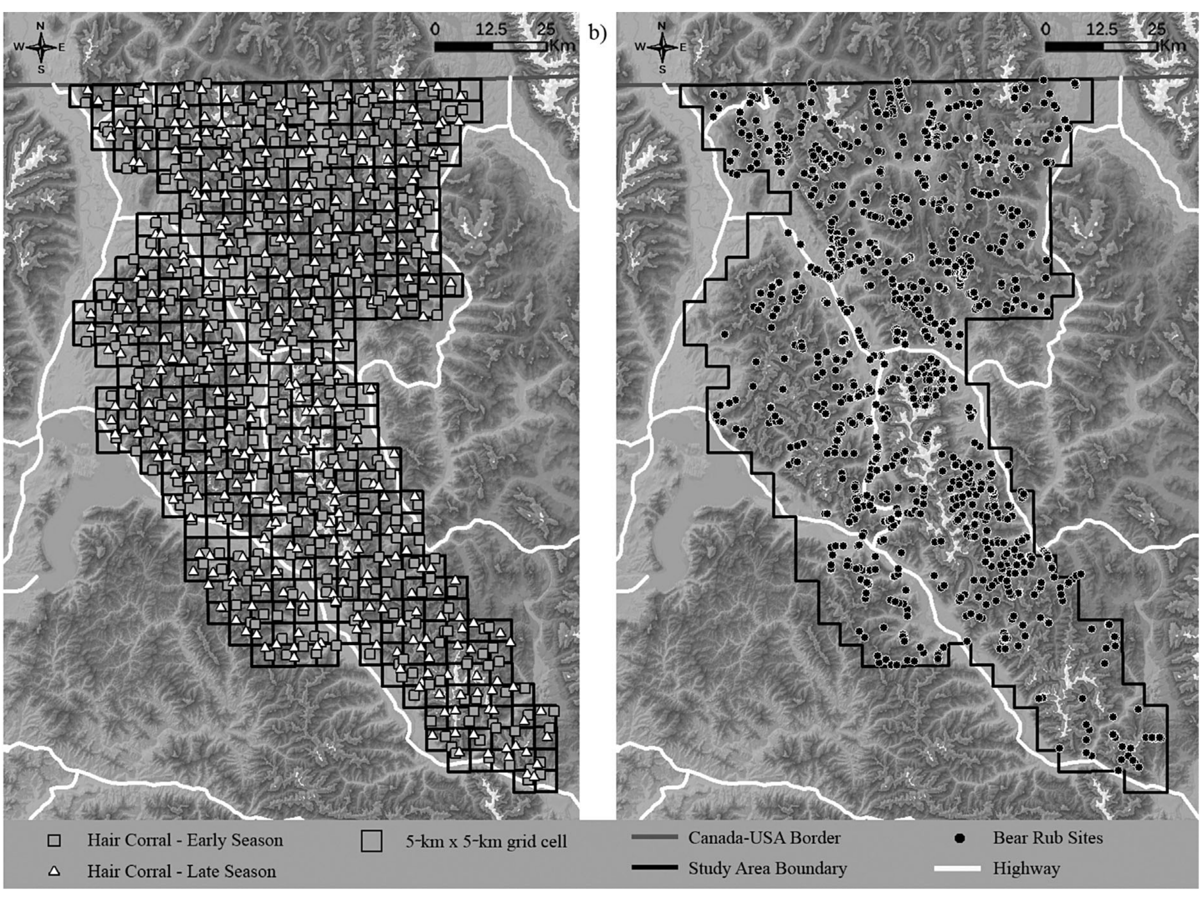

Figure 2. Locations of hair corral ($n = 790$) and bear rub sites ($n = 1{,}374$) sampled in 2012 in the Cabinet-Yaak Ecosystem in northern Montana and Idaho, USA. (a) Corrals were systematically distributed in 395 5-km × 5-km grid cells and were operational 7 June–13 July (early season: squares) and 14 July–24 August (late season: triangles). (b) Rubs (black dots) were surveyed 7 June–21 September.

We treated corrals with 4 L of scent lure for each 14-day sampling session. To increase detection probability, field crews created scent trails by dragging conifer boughs splashed with lure along the ground from corrals to natural and man-made travel routes. To counteract possible waning response to the lure, we applied a secondary lure to another suspended cloth when we rebaited corrals. We used anise, skunk, and cherry oil as secondary scents during sampling occasions 2, 3, and 5, respectively. Where cattle are present, they often trample hair corrals, tearing down the wire or fouling it with their hair (Kendall et al. 2009). For corrals located in areas with cattle, we erected 3-strand barbed wire exclusion fences around the corrals, creating a 1- to 2-m buffer that prevented livestock from contacting the corral wire.

Our secondary hair sampling approach collected hair at trees and other objects that bears had naturally rubbed against. We identified bear rubs during surveys of trails, roads, power lines, and fence lines. We visited rubs at 14-day intervals for 8 sampling visits from 7 June to 21 September. Because 72% of rubs were set up in 2011 and could have accumulated hair during 2011 or before our sampling season began in 2012, we did not include bears detected from samples collected during the initial visit to each rub in our estimates of 2012 population abundance and density. However, because it was possible that hair collected during initial visits was deposited during 2012, we explored the sensitivity of our estimates to the additional detections from the first pass samples by fitting models that included these individuals (see non-spatial capture–recapture modeling methods for details). Bear rub sampling continued 4 weeks beyond the end of hair corral sampling to target the period in which female detection rates peak at rub sites (Kendall et al. 2008, 2009). To facilitate hair collection, we attached 4 42-cm lengths of barbed wire to each rub object. We positioned wire to cover as much of the rubbed surface as possible and placed the lowest piece 0.45 m above ground level to enhance sampling of juvenile bears. Each piece of wire had 3 4-pronged barbs. We did not use lure to attract bears to these sites or to promote rubbing.

We collected all hair deposited on corral and rub wire during each visit to ensure that the period of deposition was known for hair found on subsequent visits. We considered hair from each set of barbs a separate sample. Because bears often leave hair on adjacent barbs when they cross the corral wire, we recorded the relative location of the sample so we could identify which samples were likely to have been left by the same bear. Bar-coded sample handling techniques followed those used by Kendall et al. (2009).

The third sampling method, opportunistic, also took place 7 June–21 September 2012. Opportunistic sampling included individuals known to be present on the sampling grid through telemetry data, remote photography, and hair sampling not part of our structured hair corral or bear rub network. The telemetry and photography data were available from a separate project that equipped grizzly bears with GPS collars and deployed remote cameras in the CYE for research and management purposes (Kasworm et al. 2014). Capture and handling of bears followed an approved Animal Use Protocol through the University of Montana, Missoula (067-11CSCFC-121311). We also used Kasworm et al. (2014) telemetry data to calculate residency time in our non-spatial capture–recapture density estimates. For this, we used data from 20 grizzly bears radio-collared in the CYE 2008–2012 (Kasworm et al. 2014). We included data from years immediately prior to our study to increase our sample because only 7 bears were radio collared and present on the sampling grid 7 June–21 September 2012.

Genetic Analysis

To reduce genotyping costs while attempting to maximize detections of different bears, we strategically selected only a portion of hair samples for genetic analysis. Hair corral sample selection was based on previous work (Mowat et al. 2005; Kendall et al. 2008, 2009) that found that when bears pass over or under the corral wire, they often leave hair on several adjacent barbs. In the simplest application of our adjacency rule for hair corrals, we took the 1 best sample from each cluster of adjacent samples. The best hair samples were the ones with the largest number of guard (preferred) or underfur hairs with follicles. We selected increasing numbers of samples as the number of clusters increased at an individual site within a sampling occasion or as clusters increased in size (e.g., cluster of 6 samples = 2 selected, 9 samples = 3 selected). When selecting samples from rubs, we chose the 2 best samples from each rub during each visit. When possible, we selected samples from different quadrants on the rub surface to increase the chance of detecting multiple bears. If, based on color difference, >1 bear appeared to have deposited hair at a corral or rub; we chose the 2 best samples for each hair color.

We used microsatellite genotyping analysis to determine species, sex, and individual identity of the bear hair samples generally following the procedures applied by Kendall et al. (2009). Because there was a large sympatric population of black bears (*U. americanus*) in the CYE, we designed our genetic analysis process to efficiently identify and set aside the black bear hair that made up the majority of our samples. Additional information on our genotyping methods and approach to culling black bear samples is available (Fig. S1, other Supporting Information, available online at www.wildlifejournals.org).

We used data from 21 microsatellite markers and principal component analysis in Program GENETIX (Belkhir et al. 1996–2004) to assess geographic origins of the individuals detected in this project. To represent 2 potential source populations, we used 30 and 16 randomly drawn individuals from the NCDE (Kendall et al. 2009) and Selkirk (Proctor et al. 2012*b*) populations, respectively. To conduct parentage analysis, we used program PARENTE (Cercueil et al. 2002) to search the regional dataset for evidence of family relationships. Given the low variability in the region, searches for a single parent would not reliably differentiate between sibling and parent–offspring relationships, so we limited ourselves to simultaneous searches for both parents to identify matches. Our first pass at parentage analysis was to check potential parent–offspring pairs and mother–father–offspring triads for genotyping errors by reanalyzing the mismatching markers in cases where alleles were shared at all but 1 or 2 markers, and where PARENTE indicated $P > 0.5$ for the indicated pair or triad. This process uncovered a single genotyping error (possibly a false amplification of a sample from the region collected and genotyped by M. Proctor, Birchdale Ecological, unpublished data), which we corrected. In addition to genetic analysis by this study, we constructed a pedigree for the Cabinet population using parentage data from Kasworm et al. (2007*b*, 2014), Kendall et al. (2008, 2009), K. Kendall (U.S. Geological Survey, unpublished data), and M. Proctor (unpublished data).

Abundance and Density Estimation

Non-spatial capture–recapture modeling.—We jointly analyzed 3 data sources: corrals, rubs, and opportunistic detections (Boulanger et al. 2008*a*; Kendall et al. 2008, 2009) to estimate population abundance. Our procedure closely followed previous modeling for the NCDE population where a stepwise a priori approach to mark-recapture model development was used (Kendall et al. 2009). We initially modeled hair corral, bear rub, and telemetry (for residency analysis) data sets separately to define optimal models for each data source (see detailed methods in Supporting Information, available online at www.wildlifejournals.org). We constructed our candidate corral- and rub-only models based on our knowledge of bear behavior and detection patterns at corrals and rubs. We used the Huggins closed capture model (Huggins 1991) and the heterogeneity mixture model (Pledger 2000) in Program MARK (White and Burnham 1999) for our single-source analyses and joint analysis of our 3 data sources. An a priori hypothesis approach was not practical for developing models for our joint dataset given the complexity of 2 populations, 3 sampling methods, and 11 covariates. Once we completed method-specific analyses, we combined the models with the most support into a joint model with the opportunistic data. Because we modeled opportunistic detections as a single session, within-method modeling was not required.

For our joint analysis, we entered female and male bears in the Cabinet and Yaak as separate groups in MARK to allow sex-specific estimates for both regions. In most analyses, we pooled Cabinet and Yaak data given that our separate corral and rub analyses suggested minimal differences in detection rates between the areas. We tested area-specific detection probabilities for each data source (corral, rub, and opportunistic) as a final step in the model-selection analysis to further test the assumption that the geographic area (Cabinet or Yaak) did not influence detection probabilities for each of the data sources. The rationale behind this retesting was that the power to detect differences in detection rates would be higher when all data sources were considered in a joint model compared to the method-specific analyses.

Because it was possible that the assumption of geographic closure was violated along the northern border and by augmentation bears, we used the Ivan density estimator (Ivan 2011; Ivan et al. 2013*a*,*b*) in Program MARK to estimate density and average number of bears on the sampling grid at any one time. The density estimation module uses information from DNA bears and bears that were radio collared to estimate density. The general estimator of population abundance using mark-recapture methods is the count of individuals detected (M_{t+1}) divided by the capture probability of individuals across all sampling occasions (P^*; Huggins 1991)

$$\left(\widehat{N} = \frac{M_{t+1}}{P^*}\right) \text{or} \left(\widehat{N} = \sum_{i=1}^{M_{t+1}} \left(\frac{1}{P^*}\right)\right) \quad (1)$$

The key assumption with this estimator is that each bear spends all of its time during the sampling period on the grid so that each bear counts fully toward the population estimate (the 1 in the numerator for each bear). If closure violation occurred, a bear may have spent a portion of time off the sampling grid. The MARK Ivan module uses estimates of residency approximated by the proportion of points that radioed bears were on the sampling grid to correct estimates of residency for DNA bears (symbolized as $\tilde{p}$). So, $\tilde{p}$ replaces the 1 in Equation 1 to estimate N_{avg} or the average number of bears on the sampling grid at any one time (Ivan 2011):

$$(N_{ave}){:}\ \widehat{N}_{avg} = \sum_{i=1}^{M_{t+1}} \left(\frac{\tilde{p}}{P^*}\right) \quad (2)$$

We then obtained estimates of density by dividing N_{avg} by the area of the sampling grid: 9,875 km^2 (CYE), 5,800 km^2 (Cabinet Mountains), 4,075 km^2 (Yaak). We derived superpopulation (N_{super} = no. of full- and part-time bears in the study area) estimates from the Ivan estimator by fixing residency ($\tilde{p}$) to 1. We ran the same set of models for this analysis that we used for the telemetry-based residency estimator (Supporting Information available online at www.wildlifejournals.org).

We used individual and temporal covariates (Table 1) to define groups for our analysis and further model variation in detection probabilities and bear residency. In most cases, covariates were binary, allowing specific modeling based on geographic location of detection (Cabinet or Yaak), previous live capture (Boulanger et al. 2008*b*, Kendall et al. 2009), whether a bear was an augmentation bear, was native to the CYE (included DNA detections and radio-collared bears), or was a bear that had been radio-collared for research or management but was not an augmentation bear. A bear's residency time and, thus, its detection probability often is a function of its distance from the sampling grid edge (Boulanger and McLellan 2001). Bears that occurred near the edge were more likely to be part-time residents than bears in the middle of the grid. Therefore, we used distance-from-edge (the shortest distance of radioed and DNA bears) from the northern edge (dN) and from all edges (dAll) of the sampling grid as covariates to model detection probability and residency variation. We selected the distance to the northern edge because it was known to be open to bear movements. We included the distance to the nearest grid edge to account for augmentation bears being more likely to spend a portion of their time in their natal range and to look for evidence of

Table 1. Individual and temporal covariates used for mark-recapture analysis of grizzly bear abundance and density in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, 2012. We calculated distance from edge using mean detection locations of DNA bears in hair corrals, bear rubs, and opportunistic samples, and mean collar locations for the radio-collared bears. We used only radio-collared bear locations that fell within the DNA sampling grid to estimate mean locations and distance from edge to ensure equivalency of DNA and radio-collared bear mean locations.

Name	Values	Description
Sex	M or F	Sex of bear
Cab	0 or 1	Bear detected in Cabinets
Yaak	0 or 1	Bear detected in Yaak
Pcap	0 or 1	Bear previously live captured
Aug	0 or 1	Augmentation bear (translocated) from other area
Nat	0 or 1	Native bear (not augmented)
Res	0 or 1	Radio-collared bear (not augmented)
dN	Continuous	Distance of mean location to north edge of grid
dAll	Continuous	Distance of mean location to closest edge of grid
Season	Early or late	Early, sessions 1–3; late, sessions 4–5
Rubeffort	Continuous	Bear rub effort = the no. bear rub days (no. of rubs surveyed × the no. of days the rubs were available) that rubs were available to sample bears during each sampling session

unknown movements that were beyond our understanding of occupied range. We modeled residency for male and female bears, and augmented and native bears, separately. We used temporal covariates, such as bear rub effort, to describe temporal variation in detection probabilities.

We used the sample size-adjusted Akaike's Information Criterion (AIC_c) and AIC_c weights (Burnham and Anderson 2002) to evaluate relative support for each of our method-specific and joint candidate models. We obtained estimates of population size as derived parameters of Huggins–Pledger closed mixture models in Program MARK (White and Burnham 1999, White et al. 2001). We estimated log-based confidence intervals that incorporated the minimal number of bears detected (M_{t+1}) using the formulas of White et al. (2002). We calculated model-averaged population estimates based on their support by the data as estimated by AIC_c weights to account for model selection uncertainty (Burnham and Anderson 2002). We generated estimates of total abundance for the populations as the sum of male and female estimates. We obtained the standard errors of pooled estimates as the sum of the variance–covariance matrix for sex- or area-specific estimates. We used simulated annealing to check model convergence for all of the MARK analyses.

Using the pooled Huggins estimator, we explored the sensitivity of our estimates to the inclusion of 4 additional bears: 3 that were not conclusively detected on the sampling grid in 2012 (uncertain status) and 1 bear that was of unknown sex. We detected 2 of the bears of uncertain status only during the first visit to rubs in 2012, therefore, the hair could have been deposited during 2011. The third bear of uncertain status was radio-collared and on the study grid in late May 2012, but no signal was received from the collar during our 7 June to 21 September 2012 sampling period and we did not identify it in any hair samples. We could not include the bear of unknown sex in our sex-specific models; therefore, we ran estimates with this bear categorized as a female in 1 analysis and a male in the other. We designated these 4 bears as opportunistic detections for our sensitivity analysis. Distances to the grid edge were unknown for the 3 unknown-status bears. To mitigate this issue, we assigned mean distances from edge to these bears based upon the mean values for bears in the Cabinets or the Yaak (dependent on what area they were last observed in). This allowed these bears to be in the analysis but minimized the effect of their locations on the distance to edge model coefficients.

Spatial capture–recapture modeling.—Spatial capture–recapture (SCR) models specify a spatially explicit link between a summary of each individual's spatial location, henceforth their activity center, and locations where they may be detected. For our analyses, the possible detection locations were hair corrals and bear rub locations, (henceforth collectively referred to as snares). We denoted the coordinates of snares by the vector x_j for $j = 1, 2, \ldots,$ 2,150 snares and the activity center for individual i as s_i, a 2-dimensional coordinate. SCR models parameterize the probability of detection, $p(x_j, s_i)$, of an individual at some snare by a function of distance between the snare and the activity center. The model that we used was the hazard function model:

$$p(x_j, s_i) = 1 - \exp\left(-\lambda_0 \exp\left(-\text{dist}(x_j, s_i)^2 / (2\sigma^2)\right)\right) \quad (3)$$

The parameters we estimated were baseline detection rate λ_0 and the distance scale parameter σ related to home-range radius.

We fit 4 main a priori models based on our knowledge of bear behavior at hair corrals and rubs: 1) simple (no covariates), 2) snare type effect on λ_0, 3) snare-specific behavioral response, and 4) behavioral response + snare type effect. We investigated additional models that extended our main models to allow for the individual behavioral response to differ by bear rub and hair corral (i.e., snare type × behavior interaction) and a time trend in detection probability (see detailed methods in Supporting Information, available online at www.wildlifejournals.org). Models with a covariate for snare type allowed different baseline detection rates (λ_0) for detections at hair corrals and bear rubs (our 2 snare types). We modeled the covariate snare type on the logarithm of baseline detection rate according to:

$$\log(\lambda_0) = \beta 0 + \beta 1 * \text{type} \quad (4)$$

We parameterized snare type as a dummy variable taking on the value 0 for hair corrals and 1 for bear rubs, so the estimated effect was the change in baseline detection rate (on the log scale) of an individual at a rub. Behavioral models allowed for a snare-level behavioral response so that detection at a hair corral or bear rub could change the subsequent probability of detection in that corral or rub. We fit models separately for females and males to accommodate complete sex-specificity of model parameters and generated posterior summaries of abundance, density, and model parameters for both sexes. SCR models regard the activity center s_i as a latent variable that is estimated along with other parameters. We used the posterior samples of each individual's activity center to produce a map of local density for each sex.

For SCR models, a state space must be specified, which identifies potential locations of estimated activity centers of individuals that could possibly be detected during the sampling. We defined our state space as the known grizzly bear range in the CYE plus a 2-km buffer within the United States. To ensure all potential activity centers were included, we extended the grid 15 km into Canada because non-spatial modeling found no effect on detection probability beyond that distance (Fig. S2, available online at www.wildlifejournals.org). We produced population size and density estimates for the state space stratified by Cabinet (5,996 km^2), Yaak (3,920 km^2), and Canadian (1,428 km^2) regions.

We used a Bayesian approach for analyzing the SCR model using Markov chain Monte Carlo (MCMC) methods (Royle et al. 2009) that has been incorporated in the R package SCRbayes (Russell et al. 2012). The MCMC algorithm ran for 32,000 iterations; we discarded the first 2,000 as burn-in with a thinning rate of 2. We assessed convergence using the Gelman–Rubin diagnostic (Brooks and Gelman 1998) based on 2 independent chains, which produced a potential scale reduction factor of less than 1.01 for the main structural parameters of the model.

Our abundance and, therefore, density estimates derived from spatial and non-spatial models incorporated all sex–age classes. We based this assumption on the findings of a grizzly bear study that used similar sampling methods and occurred in habitat comparable to the CYE (Kendall et al. 2009). Kendall et al. (2009) demonstrated that their corral and rub sampling detected substantial proportions of all cubs and yearlings in the population. They also reported at least partial independence of capture probabilities within family groups, a key assumption in capture–recapture models.

RESULTS

Field Sampling and Genotyping

During 7 June–24 August 2012, we operated 392–396 hair corrals during each of our 5 14-day sampling occasions (Table 2). All corrals were moved within our 5-km × 5-km grid cells ≥1 km from the early locations during occasion 4, yielding 790 hair corral sites (Fig. 2a). Of the 10,405 hair samples collected at hair corrals, 6,663 were selected for analysis, identifying 28 individual grizzly bears (11 F, 17 M).

Table 2. Grizzly bears detected during 9-day sampling sessions conducted at 14-day intervals at hair corrals 7 June–29 August 2012 in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, USA.

	Hair corral sampling session				
	1	2	3	4	5
F					
No. detected	6	2	1	5	4
Newly detected	6	1	1	2	1
Cumulative total detected	6	7	8	10	11
M					
No. detected	6	2	1	7	6
Newly detected	6	1	1	4	5
Cumulative total detected	6	7	8	12	17
No. corrals	392	395	395	396	395
Session start date	7 Jun	21 Jun	5 Jul	2 Aug	16 Aug

We visited bear rubs 8 times from 7 June to 21 September 2012 (Table 3). This included 1 visit to clear wire of hair that had accumulated between set up and the start of the 2012 sampling season and 7 standard collection visits. Exceptions to this were rubs that were inaccessible during early sampling sessions because of persistent snow at high elevations or high water at critical access points. We monitored 1,374 rubs (Fig. 2b): 785 trees, 285 sign posts, 277 power poles, and 27 bridges and other types of posts and structures. Because hair collected from rubs that were only sampled once in 2012 could have been deposited in 2011, we used only detections from the 1,362 rubs sampled ≥2 times in our abundance and density estimates. Because 2 pairs of trees were located immediately next to one another, there were 1,360 bear rub sampling locations. We collected 8,356 bear hair samples from rubs. Genotyping identified 28 individual grizzly bears (13 F, 15 M) from the 4,617 samples selected for genetic analysis.

We documented the presence of 13 grizzly bears through opportunistic sampling with 3 of those bears detected only through opportunistic sampling (Table S1, available online at www.wildlifejournals.org). We detected 11 of those bears (6 F, 5 M) through telemetry. One yearling was observed via remote photography at a site where the mother and sibling were live captured. Because we did not handle or obtain a DNA sample from the yearling, we could not determine its sex or genotype. We used genotypes from the photographed yearling's mother and littermate to identify its likely father, and then to ascertain that the yearling was not detected through any of our other sampling. Finally, we detected 1 female with hair found on hair corral wire at an early season location that was not taken down after the last sampling occasion for that site. When the field crew returned to this site to remove the wire, they found hair that had been deposited since their last visit.

When we combined results from all sampling methods, we detected 42 grizzly bears: 20 females, 21 males, and 1 bear of unknown sex (Fig. 3a; Table S2, available online at www.wildlifejournals.org). Principal component analysis (PCA; Belkhir et al. 1996–2004) confirmed that all 41 individuals for which we had genotypes were grizzly bears (Fig. S3; available online at www.wildlifejournals.org). Mean observed heterozygosity across the 8 markers used to identify individuals was

Table 3. Grizzly bears detected at bear rubs and rub sampling effort 7 June–21 September 2012 in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, USA.

	Bear rub sampling session						
	1	2	3	4	5	6	7
F							
No. detected	2	0	2	5	4	4	6
Newly detected	2	0	2	4	2	1	2
Cumulative total detected	2	2	4	8	10	11	13
M							
No. detected	7	6	2	4	3	5	6
Newly detected	7	2	1	1	1	0	3
Cumulative total detected	7	9	10	11	12	12	15
Session start date	7 Jun	21 Jun	5 Jul	2 Aug	16 Aug	30 Aug	13 Sep
Sampling effort							
No. of rubs	1,086	1,188	1,263	1,298	1,322	1,317	1,333
Bear rub days	15,212	16,712	17,832	18,355	18,621	18,693	19,011
Mean duration	14.0	14.1	14.1	14.1	14.1	14.2	14.3
SD	1.8	2.0	2.5	2.6	1.4	2.9	3.0
5th percentile	12	12	12	14	14	12	13
95th percentile	16	15	15	14	14	15	14

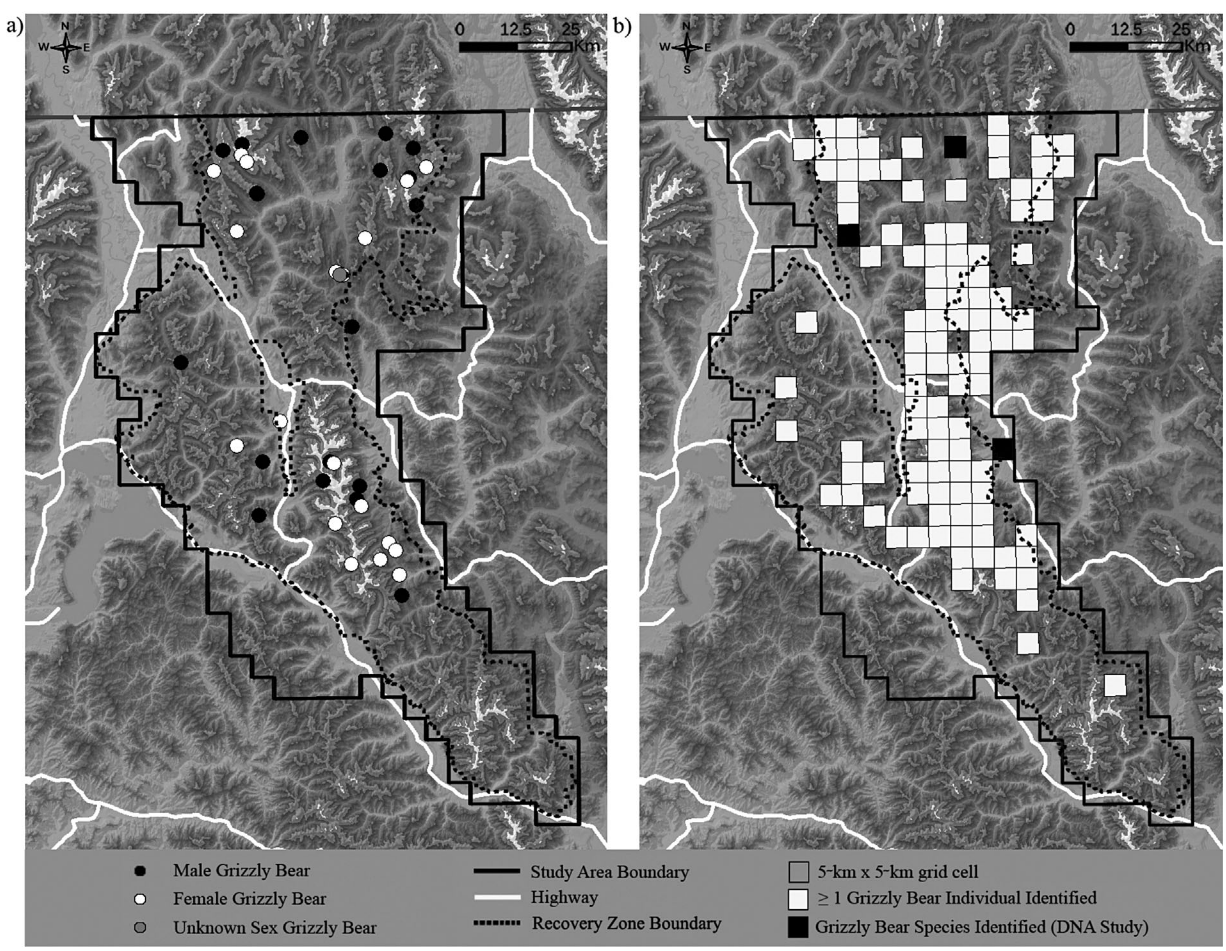

Figure 3. Mean locations and distribution of grizzly bears detected by corral, rub, and opportunistic sampling methods in the Cabinet-Yaak Ecosystem 7 June–21 September 2012. (a) Mean detection locations of 20 females (white circles), 21 males (black circles), and 1 bear of unknown sex (gray circle). (b) Grizzly bear presence in 395 5-km × 5-km sample grid cells. White cells ($n = 103$) indicate presence of individual grizzly bears detected by nuclear genotyping of hair samples by this study and telemetry monitoring (Kasworm et al. 2013). Black cells ($n = 3$) indicate where grizzly bear presence (species only) was verified by mitochondrial 16S gene partial sequence analysis of hair collected by this study.

0.77 and 0.73 for the Cabinet and Yaak bears, respectively (Table S3, available online at www.wildlifejournals.org). The probability that 2 randomly drawn, unrelated individuals from the Cabinet and Yaak populations would share the same genotype (P_{ID}) was 6.9E-07 and 5.0E-08, respectively. The probability that full siblings would have identical genotypes (P_{SIB}) was 0.0021 for the Cabinet population and 0.0012 for the Yaak population. Because our abundance and density analyses required bears of known sex, we did not include the unknown sex bear in mark-recapture analyses except in the formulation of the lower confidence limits for total abundance and density. Therefore, our non-spatial abundance and density estimates were based on the detection of 28 (11 F, 17 M) bears at hair corrals, 28 (13 F, 15 M) at rubs, and 12 (7 F, 5 M) bears with opportunistic sampling. Spatial models used only corral and rub detections.

During our 7 June–21 September 2012 sampling period, we documented grizzly bear presence in 27% of our study area (Fig. 3b). We identified individual grizzly bears in 103 of 395 grid cells through hair sampling with nuclear species identification and telemetry monitoring. We confirmed the presence of grizzly bears in 3 additional cells via mitochondrial sequencing (species identification only).

Non-Spatial Abundance and Density Estimation

Joint model analysis.—For joint model selection, we used the most-supported model for each data source (Tables S4, S5, and S6, available online at www.wildlifejournals.org) to provide density estimates that used all data sources (Table 4). The main additional model selection steps that we pursued for this analysis were fitting opportunistic data-source models and modeling the detection probability of all DNA bears (bears detected via corrals and rubs) as a function of distance from grid edge. Our distance-to-edge analysis was guided by the results of our telemetry modeling, which found that native bear residency was most related to distance from the northern border, whereas augmentation bear residency was more related to distance from all borders. None of the locations of the 20 DNA females were within 10 km of the northern edge. One of 21 DNA males was detected <6 km from the northern border and only 5 were <10 km. Distance-to-edge candidate models ranged from simple covariate to threshold models (Kendall et al. 2009). We considered distance-to-edge thresholds for non-augmentation bears at 5-km intervals with various distances for male and female bears.

The base model for our joint analysis combined the most supported hair corral, bear rub, and telemetry models. For

Table 4. Model selection results for hair corral, bear rub, and telemetry (joint), and opportunistic (opp) mark-recapture analysis of grizzly bear abundance in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, 2012. Each a priori model is described by its 3 components: 1) joint (corral, rub, and telemetry), 2) opportunistic sampling (Opp), and 3) detection variation caused by distance from the sampling grid edge (Dist to edge).

No	Joint model[a]	Opp	Dist to edge (DNA bears)[b]	AIC_c[c]	ΔAIC_c[d]	w_i[e]	K[f]	Deviance
1	Base (aug: dAll) + Rub(CY(sex))		nat: dN MF_{15}	1,109.7	0.00	0.169	20	1,068.7
2	Base (aug: dAll) + Rub(CY)		nat: dN MF_{15}	1,110.8	1.02	0.102	19	1,071.8
3	Base (aug: dAll)	.	nat: dN MF_{15}	1,110.8	1.04	0.101	18	1,073.9
4	Base	.	nat: dN MF_{15}	1,110.9	1.13	0.096	19	1,071.9
5	Base (aug: dAll)	CY	nat: dN MF_{15}	1,111.2	1.45	0.082	19	1,072.2
6	Base (aug: dAll)	.	aug: dALL nat: dN MF_{15}	1,111.2	1.48	0.081	19	1,072.3
7	Base	.	aug: dALL nat: dN MF_{15}	1,111.3	1.57	0.077	20	1,070.3
8	Base	.		1,111.6	1.86	0.067	18	1,074.7
9	Base	.	aug: dALL nat: dN M_{15},F_{10}	1,112.6	2.86	0.040	21	1,069.4
10	Base (aug: dAll) + Corral(CY)		nat: dN MF_{15}	1,112.9	3.14	0.035	19	1,073.9
11	Base	.	aug: dALL nat: dN MF_{20}	1,113.3	3.51	0.029	20	1,072.2
12	Base	Sex		1,113.3	3.55	0.029	19	1,074.3
13	Base		aug: dALL nat: dN M_{20},F_{10}	1,113.8	4.02	0.023	21	1,070.6
14	Base	.	aug: dALL nat: sex*dN	1,114.5	4.73	0.016	21	1,071.3
15	Base	.	aug: dALL nat: dN M_{25},F_{15}	1,114.5	4.80	0.015	21	1,071.4
16	Base	.	aug: dALL nat: dN	1,114.7	4.94	0.014	20	1,073.6
17	Base	.	aug: dALL nat: dN M_{30},F_{20}	1,115.4	5.67	0.010	21	1,072.2
18	Base	.	aug: dALL nat: sex* log(dN)	1,115.5	5.77	0.009	21	1,072.3
19	Base	.	aug:dALL nat: sex*dAll	1,117.3	7.55	0.004	21	1,074.1
20	Base (no Rub mixture model)			1,125.2	15.48	0.000	14	1,096.7
21	Base (no t covariates)	.		1,130.5	20.72	0.000	15	1,099.9
22	Base (constant $\tilde{p}$)			1,512.9	403.15	0.000	13	1,486.4

[a] Base model was Corral: P(sex+prevcap + t_{23}) Rub: π(sex) $\theta_{1\&2}$ ((*sex) + t_{123F}) Telemetry:($\tilde{p}$) (sex + res: sex*dN aug: sex*dAll): P, detection probability; prevcap, history of previous live capture; t, session-specific variation in detection rates with applicable sessions and F for female listed as subscripts; π, mixture model probabilities of mixture; $\theta_{1\&2}$, 2 mixture detection probabilities; $\tilde{p}$, detection probability corrected for residency time (proportion of radioed bears telemetry points that were on the sampling grid); res, bear radio-collared for research but not an augmentation bear; dN, shortest distance of average location of each bear to the northern study area boundary;aug, bear transplanted from a different population to augment the Cabinet population; dAll, shortest distance of the average location of each bear from all of the study area boundary. Any terms added to or subtracted from the base model are noted in the joint model column. CY, separate parameters for the Cabinet and Yaak regions.

[b] Distance to edge models for bears detected at corrals and rubs (DNA bears): nat, native bears; threshold models are indicated by sex (M or F) and subscript distances (km).

[c] AIC_c, Akaike Information Criteria.

[d] ΔAIC_c, difference in AIC_c values between the ith model and the model with lowest AIC_c value.

[e] w_i, Akaike weights.

[f] K, no. of parameters.

the bear rub portion of the base model, we used sex-specific mixture probabilities as long as the mixture model provided stable estimates. We obtained the most robust estimates from sex-specific mixtures. A candidate model with sex-specific detection probabilities for augmented bears as a function of distance to edge did not converge (because of low sample sizes of augmented bears in the analysis), so we pooled sexes for the augmentation bear detection rates. The most-supported distance-to-edge threshold model (Table 4, model 4) pooled detection curves for native DNA female and male bears as a function of a distance of 15 km to the northern border.

As our last step, we introduced models that tested whether there were differences in overall detection rates between the Cabinet and Yaak regions for each of the data sources. Models that assumed different rub detection probabilities (models 1 and 2) for the Cabinets and Yaak were more supported than models with specific Cabinet and Yaak detection probabilities for corrals (model 10) or opportunistic samples (model 5). A model with sex-specific detection probabilities for rub trees in the Cabinet and Yaak was most supported (model 1).

Estimates of detection probability from the joint analysis indicated reasonable detection probabilities across all our data sources (Table 5). The cumulative detection probabilities for all data sources combined (i.e., rub, corral, and opportunistic) were >0.9 for all sex and area combinations indicating that we sampled a very high proportion of the bear populations in the Cabinet and Yaak regions, although confidence intervals around those estimates were high.

Density and abundance.—Estimated grizzly bear density in the CYE was 4.48 bears/1,000 km^2 (95% CI = 3.69–5.26; Table 6). The average number of grizzly bears present, N_{avg} (abundance corrected for part-time residency) was 44 (95% CI = 42–65) with population size split almost evenly between the Cabinet and Yaak regions and between females and males (49:51 F:M ratio). Superpopulation size (N_{super}), the number of full- and part-time grizzly bears using the CYE, was 48 (95% CI = 44–62; Table S7, available online at www.wildlifejournals.org). Our exploratory analysis of the sensitivity of our models to the inclusion of 3 bears of unknown status (their presence on the grid during the 2012 sampling period could not be verified) and 1 bear of unknown sex increased the pooled superpopulation estimate for the CYE to 54 bears (95% CI = 49–70; Table S8, available online at www.wildlifejournals.org).

Estimates of density and average population size from the joint model analysis for both study areas were precise with coefficients of variation <15% even for sex- or area-specific estimates (Table 6). Sex-specific estimates for the Cabinet or Yaak areas were less precise, but coefficients of variation were still <20%. Our non-spatial estimate of the average number of grizzly bears on the grid (N_{avg}: 44), was only 2 bears greater than the number of bears detected in the area during sampling (including 1 bear of unknown sex not used in the analysis).

Spatial Abundance and Density Estimation

For SCR models, we used detection histories for 38 individuals from 2,150 sampling sites (Fig. S2): 1,360 bear rub locations surveyed ≥2 times and 790 hair corral locations. We did not include the 4 additional individuals detected by opportunistic sampling that were included in our non-spatial modeling because we could not explicitly quantify opportunistic sampling effort. We detected the 17 female individuals 50 times and the 21 males 77 times.

Estimated grizzly bear density in the CYE using spatial models was 4.28 bears/1,000km^2 (95% Bayesian Credible Interval [BCI] = 3.63–5.14; Table 6). The average number of bears present in the CYE was 43 (95% BCI = 36–51) with 24 (95% BCI = 20–30) bears in the Cabinet and 18 (95% BCI = 15–23) bears in the Yaak population. Spatial models estimated 7 bear activity centers (95% BCI = 3–12) in the state space in Canada (1,428 km^2 or 15 km beyond the northern study area boundary; Table 6). The female:male ratio from spatial models was 51:49. Estimates of

Table 5. Model-averaged estimates of average detection probabilities per sample session (P) and cumulative detection probability (P^*) across all sampling sessions from mark-recapture analysis of grizzly bear abundance in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, 2012. Average detection probabilities were calculated using Akaike Information Criteria weights for all models from joint analysis of detection data from 3 sources (hair corral, bear rub, and opportunistic).

				Per-session detection probabilities (P)					Cumulative (P^*)			
Data type	Area	Sex	No. of sessions	Average	95% CI		Min.[a]	Max.	P^*	95% CI		CI width
Bear rub	Cabinet	F	7	0.24	0.03	0.80	0.11	0.33	0.86	0.21	1.00	0.79
		M	7	0.25	0.04	0.74	0.25	0.25	0.87	0.25	1.00	0.75
	Yaak	F	7	0.23	0.03	0.80	0.11	0.33	0.86	0.21	1.00	0.79
		M	7	0.28	0.05	0.75	0.28	0.28	0.90	0.30	1.00	0.70
Hair corral	Cabinet/Yaak	F	5	0.15	0.09	0.26	0.05	0.21	0.57	0.37	0.78	0.41
		M	5	0.20	0.12	0.31	0.08	0.28	0.68	0.48	0.86	0.38
Opportunistic	Cabinet/Yaak	F	1	0.26	0.14	0.41	0.26	0.26	0.26	0.14	0.41	0.27
		M	1	0.24	0.13	0.43	0.24	0.24	0.24	0.13	0.43	0.30
All data sources	Cabinet	F	13	0.21	0.06	0.56	0.05	0.33	0.96	0.57	1.00	0.43
		M	13	0.23	0.08	0.55	0.08	0.28	0.97	0.66	1.00	0.34
	Yaak	F	13	0.21	0.06	0.56	0.11	0.33	0.95	0.57	1.00	0.43
		M	13	0.23	0.08	0.55	0.24	0.28	0.98	0.68	1.00	0.32

[a] Min. and max. correspond to minimum and maximum per-session detection probabilities. Min. and max. will be equal if there was no time variation in detection probabilities for the most supported data source models.

Table 6. Abundance and density estimates of the grizzly bear populations in the Cabinet-Yaak Ecosystem, northern Montana and Idaho, 2012 produced using spatial and non-spatial capture-recapture models. We present the average number of bears present in the population at any one time (N_{avg}) and the estimated bears/1,000 km^2 (D_{1000}) with error terms including the Bayesian credible interval (BCI). Non-spatial models cannot provide estimates for the state space in Canada.

	Non-spatial modeling						Spatial modeling					
	N_{avg}	95% CI	CV (%)	D_{1000}	95% CI	CV (%)	N_{avg}	95% BCI	CV (%)	D_{1000}	95% BCI	CV (%)
Cabinet												
F	10.8	10.0–22.9	18.7	1.85	1.17–2.53	18.9	12.7	9–18	18.4	2.12	1.50–3.00	18.4
M	11.2	10.2–18.8	14.5	1.93	1.39–2.48	14.5	11.6	10–15	12.1	1.94	1.67–2.50	12.1
Total	22.0	20.2–35.5	12.8	3.79	2.84–4.73	12.7	24.3	20–30	11.2	4.06	3.34–5.00	7.6
Yaak												
F	11.0	10.1–20.4	16.2	2.69	1.84–3.54	16.4	9.3	7–13	15.7	2.37	1.79–3.32	15.6
M	11.3	11.0–23.0	15.4	2.77	1.93–3.60	15.2	8.8	6–12	16.2	2.25	1.53–3.06	16.3
Total	22.3	22.0–38.8	11.3	5.46	4.25–6.66	11.4	18.2	15–23	11.2	4.63	3.86–5.87	11.2
Cabinet + Yaak												
F	21.7	20.2–36.9	13.5	2.20	1.62–2.78	13.6	22.0	17–29	13.9	2.22	1.71–2.92	13.9
M	22.5	21.1–36.5	11.8	2.28	1.75–2.80	11.8	20.5	17–25	10.4	2.06	1.71–2.52	10.4
Total	44.2	42.2–65.1	8.9	4.48	3.69–5.26	8.9	42.5	36–51	8.7	4.28	3.63–5.14	8.7
Canada												
F							2.8	0–7	65.7	1.94	0.00–2.10	66.0
M							4.3	1–8	39.5	3.03	0.70–5.60	39.6
Total							7.1	3–12	35.2	4.97	2.10–8.40	35.2

superpopulation size and density were nearly identical for females and males although credible intervals were narrower for males (95% BCI = 21.00–30.00) than females (95% BCI = 19.00–34.00; Table S9, available online at www.wildlifejournals.org). The posteriors indicated about 7.8 females and 3.8 males were undetected by hair corral and bear rub sampling (these analyses did not use opportunistic detections). Behavioral models received overwhelming support and there was no evidence of differences in baseline detection probability between hair corrals and bear rubs for either sex. Results of our more complex models that allowed for the individual behavioral response to differ by sampling type and time trend in detection probability indicated those factors had a negligible effect on our estimates (see detailed results in Supporting Information, available online at www.wildlifejournals.org). Both sexes showed positive behavioral responses suggesting that snare-specific encounter probability was larger after initial detection for both hair corrals and rubs (Table S9, available online at www.wildlifejournals.org). This response was stronger for females than for males: 95% posterior BCI = 0.61–3.10 (F) and 1.10–2.33 (M). The parameter σ, related to the amount of space used by individuals, suggests that males used approximately twice as much space as females ($\sigma = 10.37$ km vs. 4.79 km). Female and male densities in the Cabinet population were highest in the east-central Cabinet

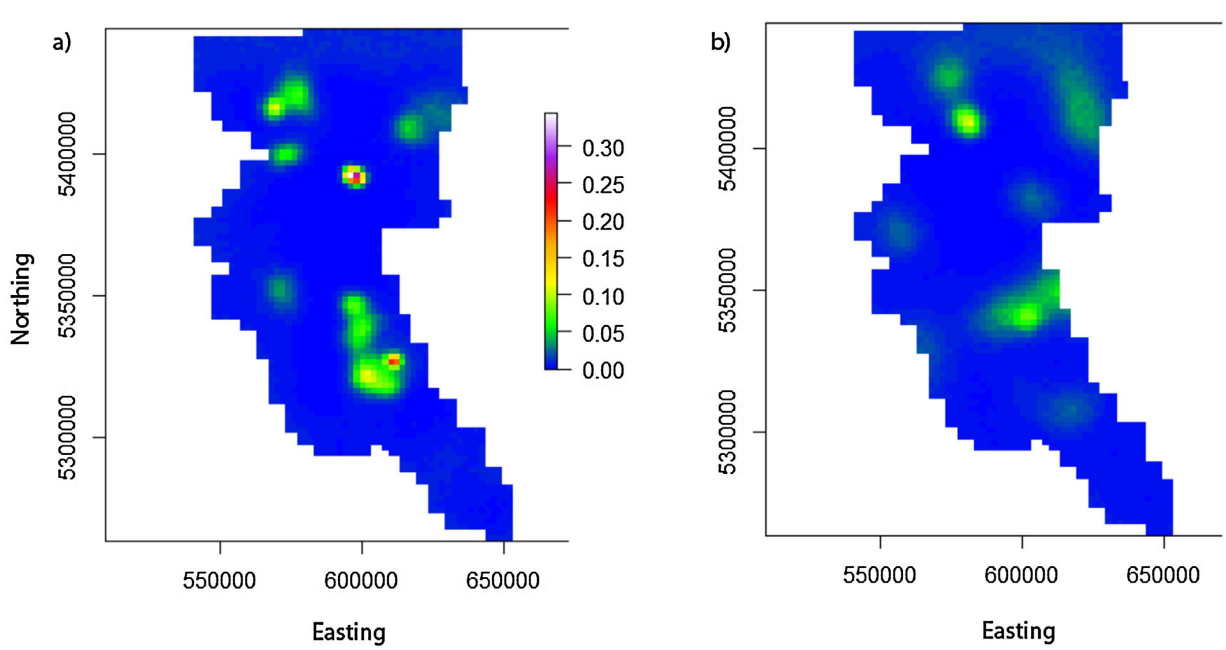

Figure 4. Density maps for (a) female and (b) male grizzly bears in the Cabinet-Yaak Ecosystem in 2012 derived from summaries of posterior simulated values of activity centers produced using Bayesian spatial mark-recapture modeling. The plotted values are the expected number of activity centers (individuals) in each 2-km × 2-km cell.

Mountains (Fig. 4). In the Yaak population, female density was greatest in the center of the Yaak region and male density was highest in the west-central Yaak.

Genetic Origins, Interchange, and Parentage

Of the 42 individual grizzly bears we identified, 26 were known from previous studies (Kasworm et al. 2014) and had been genotyped at 22-locus genotypes (21 microsatellite markers plus sex). For the 15 new individuals, we created extended genotypes by adding the same 13 additional loci used by Kasworm et al. (2014). Each individual that we identified in the initial 9-locus analysis also had a unique genotype based on the 13 extra loci, which would not be expected if genotyping errors had led to the identification of spurious individuals.

Our results indicated the grizzly bears in the Cabinet and Yaak regions were separate populations split along the Hwy 2 corridor. Only 1 of the 42 individuals we detected in this study were found on both sides of the highway, an augmentation female translocated from the NCDE to the Cabinets in August 2011. Telemetry data from this bear revealed her return to her natal range from her transplant site and subsequent return to the Cabinet Mountains in 2012. There was perfect resolution of native bears in the Cabinet and Yaak mountains in the first (Fig. 5) and second (not shown) dimensions of the PCA analysis, suggesting complete spatial and reproductive isolation between these 2 populations, at least in recent generations. Also consistent with existing knowledge, the 4 augmentation bears from the NCDE that were detected in the Cabinets grouped separately from the other 16 bears in the Cabinet Mountains, grouped instead with the reference genotypes from the northern NCDE.

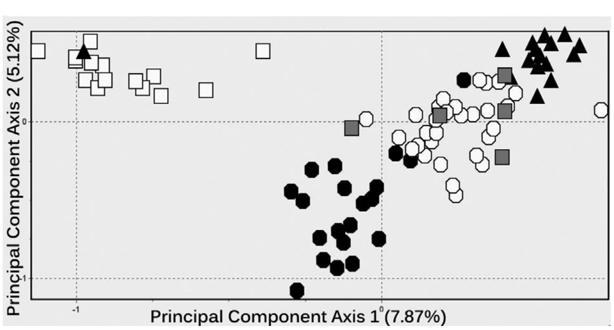

Figure 5. First and second principal components (and percentage of variance explained) from a genotype-based principal component analysis (program GENETIX; Belkhir et al. 1996–2004) undertaken to assess population genetic structure among the individuals detected 7 June–21 September 2012 in the Cabinet-Yaak Ecosystem in northern Montana and Idaho, USA. The graph is based on 21 microsatellite locus genotypes for 41 of the 42 individuals detected by this project (1 yearling was detected by remote camera and we did not obtain a sample to genotype): 20 Yaak (black octagons), 16 native Cabinet (black triangles), and 5 Cabinet augmentation bears (gray squares) as well as reference genotypes from the Northern Continental Divide Ecosystem (white octagons; Kendall et al. 2009) and Selkirk (white squares; Proctor et al. 2012*b*) grizzly bear populations. Probable immigrants are male bear number 737 detected in the Yaak (black octagon amid white octagons) and male bear number 928442 detected in the western Cabinet Mountains (black triangle amid white squares). Augmentation bears were transplanted from the NCDE to the Cabinet Mountains (Kasworm et al. 2013).

Although the clustering supported the existing understanding of fragmentation in the regional metapopulation (Proctor et al. 2012*b*), we found 2 male immigrants in the CYE (Fig. S4a,b, available online at www.wildlifejournals.org) that clustered with populations outside the study area. Bear number 737 in the Yaak Mountains clustered with NCDE bears and bear number 928442 in the Cabinet Mountains had the distinctive genetic signature of the Selkirk Mountains subpopulation of northern Idaho and southern British Columbia. A third male bear, number 323, was detected in the Yaak during our study grouped by PCA with the genotypes in the Yaak, but had been detected in the NCDE multiple times between 1998 and 2006 (Fig. S4c, available online at www.wildlifejournals.org).

To summarize the Cabinet parentage results, 23 individuals descended from 4 founders (Fig. 6). Ancestry of 22 of those descendants is 100% from 3 of the founders and the 23rd individual is 50% derived from the founders. The 2 founding males and female bear number 286 gave rise to 9 F1 individuals. Nine other F1.5 individuals descended from 2 F1 females mating with one of the founding males, including a father–daughter mating. The F2 generation consists of 4 offspring from matings of F1 siblings or half-siblings, plus 1 offspring from an F1 male mating with the fourth founding augmentation female. Were it not for the 50% contribution of female number 782 to the genotype of male bear number 958471, and the male immigrant number 928442 from the Selkirk Mountains, the grizzly bear population in the Cabinet Mountains would be reduced to permutations on the genotypes of 1 female (no. 286) and 2 males (nos. 770 and 39).

Parentage analysis was less successful in the Yaak where previous sampling intensity had not been high enough to include most new individuals' parents. Of the 7 new individuals identified by corral and rub sampling by this project in 2012, only 3 were placed into triads; 2 as offspring and 1 as the likely father of a bear first identified in the Purcell Mountains, British Columbia, Canada by M. F. Proctor (unpublished data). Additional information on genetic origins, interchange, and parentage of the CYE populations can be found in Supporting Information (available online at www.wildlifejournals.org).

DISCUSSION

Our results provide the first statistically rigorous estimates of grizzly bear abundance and density for the threatened grizzly bear populations in the Cabinet and Yaak mountains and establish baselines that can be used to assess the effectiveness of efforts to recover these populations. During our 15-week sampling period, we documented grizzly bears in 27% of our sampling grid cells. Although occupied cells were well distributed throughout the recovery zone (Fig. 3b), population size in the CYE was approximately half of the recovery goal of 100 bears (U.S. Fish and Wildlife Service 1993). Estimates of the number of bears in the CYE derived from the United States Fish and Wildlife Service's 30-year

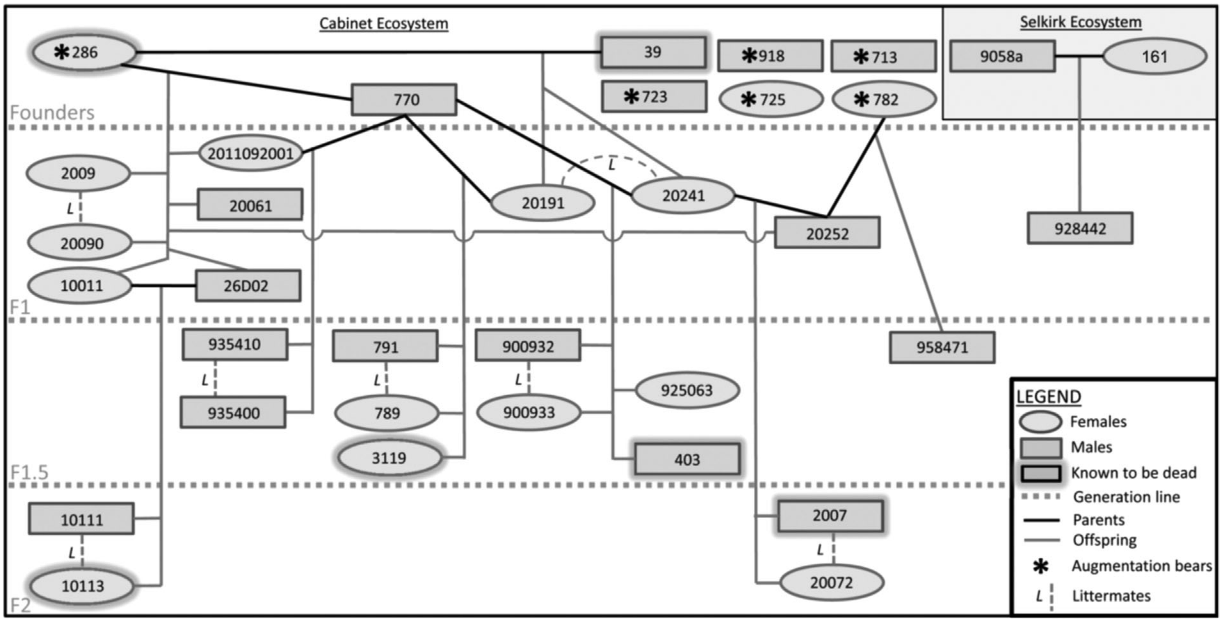

Figure 6. Pedigree of grizzly bears detected in the Cabinet Mountain region of the Cabinet-Yaak Ecosystem (1 of 6 grizzly bear recovery zones in the U.S. south of Canada) in Montana and Idaho during 2012. Augmentation bears were individuals translocated from the Northern Continental Divide Ecosystem (a grizzly bear recovery zone east of the CYE) population to the Cabinet Mountains to bolster that population. Bears known to be dead prior to 2012 (gray halo) do not necessarily include all bears that were dead; the status of any bear not detected during 2012 was unknown. We assigned offspring from a mating between a founder and offspring of a founder to generation F1.5 (a mixture of F1 and F2). The Selkirk Ecosystem is a grizzly bear recovery zone west of the CYE. We derived parentage data from Kasworm et al. 2007*b*, 2014; Kendall et al. 2008, 2009; K. Kendall (NCDE, unpublished data); M. Proctor (Selkirk Ecosystem, unpublished data), and genetic analysis from this study.

monitoring program ranged from 30 to 40 (Kasworm et al. 2007*b*) for an unspecified time period prior to 2007 to a minimum of 47 for 2000–2008 (Kasworm et al. 2009). Although these estimates are not true annual minimums and lack measures of precision, their similarity to our estimates of population abundance indicates that intensive, long-term monitoring can acquire knowledge of general population status useful in planning conservation actions.

Confidence intervals for the average number of bears on the sampling grid were estimated assuming an asymmetric confidence limit with the lower bound being determined by the minimum number of bears detected on the sampling grid (M_{t+1}; Table 6). In theory, if closure violation is high, it is possible that there would be fewer than the minimum number of bears detected on the grid during the course of sampling and, therefore, use of M_{t+1} as a lower bound on the confidence limit would lead to a biased interval. However, in the case of the Cabinet and Yaak, closure violation was minimal and, therefore, the use of M_{t+1} as a lower bound should not have caused excessive bias in the confidence limit. Use of this limit assumes that there were always M_{t+1} bears present on the grid during sampling.

At 4.28–4.48 bears/1,000 km^2, grizzly bear density in the CYE fell among the lower values of interior grizzly bear populations in North America (e.g., Miller et al. 1997, Schwartz et al. 2003, Proctor et al. 2012*b*). In general, the highest grizzly bear densities occur in areas with abundant and uniformly distributed food with little human disturbance, whereas low densities are found where food is patchy and widely spaced, or where the human-caused mortality rate is high (Schwartz et al. 2003). Some of the populations with the lowest densities occur in northern North America including the Alaska Range, along the Beaufort Sea and northern Yukon, Northwest Territories, and Nunavut (Kingsley et al. 1988, Schwartz et al. 2003) where human impacts are slight and food abundance or quality controls bear density (Miller et al. 1997). In contrast, high rates of human-caused mortality are primarily responsible for the low densities reported in a number of grizzly bear populations in the southern part of current grizzly bear range (Proctor et al. 2012*b*). There, grizzly bear density ranges from 4.79–18.1/1,000 km^2 in Alberta Management Units 3, 3B, 4, 4B, 6, and 6B (Boulanger et al. 2005*a*,*b*; Grizzly Bear Inventory Team 2008), and from 7.5–18.9/1,000 km^2 in the Purcell and south Selkirk Mountains of southeastern British Columbia (Proctor et al. 2007). Excessive human-caused mortality has been identified as the primary agent responsible for reducing the CYE population to small numbers initially and for impeding recovery (Kasworm et al. 2014, U.S. Fish and Wildlife Service 1993).

Measures designed to prevent conflicts are focused inside the 6,765-km^2 recovery zone. Although the home range centers of almost all grizzly bears in our CYE study area lay within the recovery zone, nearly 75% of radio-collared bears had home ranges that included areas outside it (Kasworm et al. 2014). This is, in part, because the CYE recovery area is relatively narrow in relation to the average home range size of grizzly bears. Compared to more compact recovery zones, this configuration places bears at greater risk of coming into contact with people and intentional or accidental killing by humans. Areas bordering protected areas have the greatest influence on population dynamics in small reserves with high perimeter:area ratios and in species that range widely (Woodroffe and Ginsberg 1998), characteristics exemplified by the CYE and grizzly bears. An additional challenge to human–bear conflict prevention is the relatively high density of roads and diversity of human activities in the CYE compared with other recovery zones.

Although cumulative detection probabilities for each data source alone were variable (Table 5), sampling using multiple methods and a high level of sampling effort (13 occasions) was highly effective. Detection probabilities by sampling type indicated our use of 3 sampling methods gave us much better sample coverage than any single data source. The large confidence intervals around our detection probability estimates were caused primarily by variation among data sources. However, the high level of sampling effort and coverage minimized the effect on our abundance estimates. When we computed the cumulative detection probability across all data sources, we sampled 95–96% (95% CI = 0.57–1.00) of the females and 97–98% (95% CI = 0.66–1.00) of the males present in the Cabinet and Yaak populations (Table 5). Bear rubs generated the highest but most variable detection probabilities. Prior studies of other grizzly bear and black bear populations that sampled at bear rubs had lower detection rates for females than males because most rub sampling was done in spring and mid-summer when female use of rubs is lower than males (Boulanger et al. 2008*a*; Kendall et al. 2008, 2009; Stetz et al. 2014). Our female and male detection rates at rubs were similar because we extended the rub surveys into late August and September when female use of rubs peaks. Our thorough sample coverage resulted in minimal differences in density and average abundance estimates regardless of the underlying detection probability model used (see Table S10, available online at www.wildlifejournals.org).

This study demonstrates the advantages of using multiple sampling methods when working with small populations. Each of the model-averaged single-source estimates of N_{avg} were imprecise with coefficients of variation >20%. However, when we combined data sources, the joint N_{avg} estimate coefficient of variation was 9% (Table 6). We were also able to generate sex-specific estimates with reasonable precision for the Yaak and Cabinet regions separately using this approach. These improvements in estimate precision are similar to a study that used multiple data sources to get precise estimates of an equally small population of bears in Italy (Gervasi et al. 2012).

Our non-spatial estimates of average and superpopulation sizes were quite similar. That is reasonable based on the residency model which indicated the only study area boundary that was open for native bears was the northern border and their residency was high when more than 15 km from that edge. Translocated bears had larger, less centralized home ranges and were more likely than native bears to move in or out of the study area during our sampling period (Kasworm et al. 2014). However, augmentation bears comprised a small portion of the CYE populations. When this is considered together with the distribution of native bears and large size of the study area (9,875 km^2), it is clear that the majority of bears in the CYE were full-time residents of our study area.

There is some evidence that SCR models, whether using inference frameworks based on Bayesian (Royle et al. 2009) or integrated likelihood (Borchers and Efford 2008), produce lower and, perhaps, more accurate density estimates than non-spatial models. This is especially true for species with large home ranges, such as bears and felids (Obbard et al. 2010, Reppucci et al. 2011), and when study areas and sample sizes are small. The values and precision of our estimates from spatial (SCRbayes) and non-spatial (Huggins–Pledger) capture–recapture models differed by <5% (Table 6). We saw no evidence that estimates from either approach were consistently biased higher or lower than the other. This congruence of estimates from spatial and non-spatial capture–recapture models is consistent with an American black bear study (Stetz et al. 2014) that, like ours, had relatively intense sampling and a study area that was large with respect to the study animals' home ranges. A study of grizzly bears in the barren grounds of northern Canada that compared spatially explicit and mark-recapture estimators also found similar estimates but higher precision of SCR models (Dumond et al. 2015).

Several properties of SCR modeling made it a good fit for our study. In SCR models, every individual is associated with a specific part of the study area and maps of density are a direct output from the SCR model. The main use of density maps, besides providing a depiction of the spatial pattern of density, is that they can be used to produce local estimates of *N* and *D* over any defined subregion. For example, we obtained the stratum-specific estimates of population size and density (Table 6) by summing cell values (Fig. 4) over the desired geographic strata. Additionally, our non-spatial estimates of average population size relied on radio-collar data to calculate grizzly bear residency and correct our superpopulation estimate for bears that moved across study area boundaries during our study period. However, the area to which the Huggins–Pledger estimates of superpopulation size apply cannot be precisely defined (Efford and Fewster 2013). Our SCR model estimate had an explicit area, the state space, associated with it from which we computed density. We defined our state space to include animals with activity centers on the northern boundary.

Grizzly bears share the CYE with a much larger population of black bears. We designed our laboratory process to efficiently identify and set aside the black bear samples, which comprised the majority of our hair samples, and weak and mixed samples unlikely to produce clear results. The system we developed efficiently culled the 18,761 bear hair samples we collected to 382 worthy of multilocus genotyping through subsampling, visual inspection, quality screening, and selective application of a direct-to-polymerase chain reaction (PCR) approach. With the DTP technique, we clipped hair roots straight into a tube of PCR mix, thus bypassing the purification of DNA through spin columns (Qiagen, Valencia, CA). The direct-to-PCR step alone eliminated 2,478 samples from DNA extraction and genotyping at the G10J microsatellite marker (at which alleles with an odd number of base pairs are diagnostic of black bears; Kendall et al. 2009) at significant savings of time and cost. We recommend its use by anyone considering a project where samples from non-target species greatly out number samples from the study species.

Black bear density in the Cabinet area (Montana Fish, Wildlife, and Parks Hunting Unit 104) was estimated at 210 black bears/1,000 km^2 (90% CI: 170–250) and in the Yaak area (Hunting Unit 100) at 150 black bears/1,000 km^2 (90% CI: 130–170; Mace and Chilton-Radandt 2011). Mattson et al. (2005) postulated that black bears may affect grizzly bear reproduction and recruitment by exploitation competition where there is dietary overlap, especially where grizzly bear populations have been substantially reduced and black bear populations are robust. Where berries and succulent forbs are the primary high-quality bear foods, as in the CYE, dietary overlap between grizzly bears and black bears is almost complete (Hilderbrand et al. 1999, Jacoby et al. 1999). Furthermore, black bears can sustain their smaller body mass better than grizzly bears when feeding on dispersed food sources such as low densities of berries (Welch et al. 1997). However, vital rates for grizzly bear populations in the CYE are similar to recovering grizzly populations with sympatric black bear populations in the NCDE and greater Yellowstone ecosystem (GYE). In the NCDE where black bear density ranged from 104 to 230 black bears/1,000 km^2 (Mace and Chilton-Radandt 2011), the grizzly bear population grew 3% annually with mean litter size of 2.27 and age of primiparity of 5.4 years (Mace et al. 2012). During 1983–2001, when the GYE grizzly population was expanding at an annual rate of 4.2–7.6%, and its conservation status was first considered recovered (U.S. Fish and Wildlife Service 2007), average litter size was 2.0, age of first reproduction was 5.81 years, and birth interval was 2.78 years (Schwartz et al. 2006). For grizzly bears in the CYE, average litter size was 2.1, age of first reproduction was 6.5 years, and birth interval was 2.71 years (Kasworm et al. 2014). The similarity of CYE vital rates to populations with robust growth rates and large populations of black bears is inconsistent with the hypothesis that black bears create resistance to grizzly bear recovery by reducing reproduction and recruitment. The mean annual rate of change of the Cabinet-Yaak populations has steadily increased since its low point (1983–2006, $\lambda = 0.946$; 95% CI $= 0.822$–1.041; Kasworm et al. 2007*a*) as a result of increasing female survival rates. The resulting mean annual rate of change for 1983–2013 was 1.000 (95% CI $= 0.907$–1.076; Kasworm et al. 2014).

Grizzly bear population genetics in the CYE have been affected by a number of factors. Consistent with existing knowledge of this region (Proctor et al. 2012*b*, Kasworm et al. 2014), our results indicated the grizzly bears in the Cabinet and Yaak regions were separate populations split along the Hwy 2 corridor. Population size and genetic diversity in the Cabinet Mountains were low prior to the augmentation program that has transplanted bears to the Cabinets since 1990 (Kasworm et al. 2005). The Cabinet population is essentially demographically and reproductively isolated. Currently, the majority of bears in the Cabinets are descendants of just 4 bears, 2 augmentation females and 2 males of unknown ancestry (Kasworm et al. 2014; this study). The Yaak grizzly bear population in the United States, although the same size as the Cabinet population, has the advantage that it is fully connected to a larger gene pool of grizzly bears in the Purcell Mountains, British Columbia (Proctor et al. 2012*a*,*b*). However, density is relatively low in British Columbia's Yahk Grizzly Bear Population Unit (GBPU) adjacent to the population of bears in the YaakMountains in the United States. A study conducted in 2004–2005 estimated grizzly bear density was 7.5 bears/1,000 km^2 in the 2,719-km^2 Yahk GBPU (Proctor et al. 2007). This population is considered threatened by British Columbia because it was estimated to be below the 50% habitat capability threshold for threatened status (Hamilton et al. 2004).

Before the augmentation program began, there may have been ≤ 15 grizzly bears remaining in the Cabinet Mountains (Kasworm et al. 2014). With all but a few bears we detected in the Cabinets related to augmentation bears, it is clear that the augmentation program likely rescued this population from extirpation. Proctor et al. (2004) used population viability analysis to evaluate the demographic impact of several management actions on the Cabinet population. They concluded that augmentation had the largest effect in the short term to increase population growth rate and that reducing mortality had the largest influence in the long term to decrease extirpation probability.

As in our study, prior efforts have documented minimal natural grizzly bear movement between the CYE and other populations. Although Proctor et al. (2012*b*) reported 1 subadult male who migrated into the Selkirk Mountains in the United States from the Yahk (the Canadian part of the international Yaak/Yahk population), the direction of most migration was into the Yahk (Proctor et al. 2005). For example, Proctor et al. (2012*b*) reported 4 males and 1 female that moved from the southern Purcell Mountains, British Columbia to the Yahk. No grizzly bear movements had been documented into the Cabinets from other populations. Excluding bears transplanted from the NCDE to the CYE that returned to the NCDE, prior to this study only 1 male grizzly bear had been documented to move from the CYE into the NCDE (Proctor et al. 2012*b*, Kasworm et al. 2014). In recent years, grizzly bears from the NCDE have begun to reoccupy the Salish Mountains, located between the northwestern edge of the NCDE and the east side of the Yaak (Mace and Roberts 2012). The Selkirk grizzly bear population has also expanded in numbers and distribution in recent years (Wakkinen and Kasworm 2004; W. L. Wakkinen, Idaho Fish and Game, and W. F. Kasworm, U. S. Fish and Wildlife Service, unpublished data). The movement of a bear from the Selkirks to the Cabinets documented in this study was the first evidence of natural migration into the small, isolated, and inbred Cabinet population Further evidence of re-establishing connections between the CYE and NCDE was the male grizzly bear of Yaak origin that made multiple temporary forays to the Whitefish Range in the NCDE. Detections of this bear in the NCDE multiple times during 1998–2006 and discovery of 4 of his offspring with 2 NCDE females suggest that the intervening habitat, the Salish Mountains, was permeable to and reasonably secure for bear travel.

The migratory and breeding events documented in this study and data from other sources (C. Servheen and W. F. Kasworm, U.S. Fish and Wildlife Service, unpublished data; Mace and Roberts 2012) suggest nascent reconnection of the CYE with adjacent populations and that expansion of neighboring populations may eventually help recover and sustain the Cabinet and Yaak populations. However, we did not detect natural immigration by females to the CYE populations. Although movement and reproduction by males can increase genetic variability and fitness, movement by female bears is most important for demographic rescue of populations (Proctor et al. 2012*a*). Previous studies have concluded that increasing the number and survival rate of female bears will provide the greatest potential for population growth and recovery (Proctor et al. 2004, Kasworm et al. 2014). The small population sizes, genetic isolation, and high level of inbreeding documented in our study demonstrate that the Cabinet and Yaak grizzly bear populations continue to need comprehensive management designed to support population growth and increased connectivity and gene flow with other populations.

MANAGEMENT IMPLICATIONS

In the small Cabinet and Yaak populations, the difference between growth and decline is 1 or 2 adult females being killed annually or not. A decrease in human-caused mortality during the past decade reversed a severe population decline (3.7% decline 1983–2002; Wakkinen and Kasworm 2004). The public education, reduction of bear attractants, and nonlethal management of potential problem grizzly bears accomplished by state and provincial bear managers have been effective in reducing human-bear conflicts and mortality. The Cabinet population was essentially rescued from extirpation through the successful augmentation program that began in the early 1990s. Population recovery will require continuation of these programs. Equally important for recovery is achieving functional connectivity of the Yaak and Cabinet populations to each other and larger, genetically diverse populations. Interbreeding between adjacent populations will buffer a recovered Cabinet-Yaak population from future threats. Connectivity for the transboundary Yaak/Yahk population may be established across Highway 3 in the Purcell Mountains of southern British Columbia, the Selkirk population in Idaho, Washington, and British Columbia, and to the NCDE in western Montana. The Cabinet population could be reconnected to the Yaak, Selkirks, or the NCDE. Efforts to identify and establish linkage zones and manage for connectivity are underway (Proctor et al. 2015). They include strategic private land purchases, conservation easements, measures to preserve and restore habitat, livestock protection techniques such as electric fencing, public information and education programs, and wildlife crossing structures in future highway and rail line infrastructure improvements. Continuing commitment to this work will be essential for long-term persistence of the Cabinet and Yaak populations.

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LITERATURE CITED

Belkhir K., P. Borsa, L. Chikhi, N. Raufaste N., and F. Bonhomme. 1996–2004. GENETIX 4.05, Windows TM software for population genetics. Laboratoire Génome, Populations, Interactions, CNRS UMR 5000, Université de Montpellier II, Montpellier (France). Accessed 11 Apr 2007.

Borchers, D. L., and M. G. Efford. 2008. Spatially explicit maximum likelihood methods for capture-recapture studies. Biometrics 64:377–385.

Boulanger, J., K. C. Kendall, J. B. Stetz, D. A. Roon, L. P. Waits, and D. Paetkau. 2008*a*. Multiple data sources improve DNA-based mark-recapture population estimates of grizzly bears. Ecological Applications 18:577–589.

Boulanger, J., and B. McLellan. 2001. Closure violation in DNA-based mark-recapture estimation of grizzly bear populations. Canadian Journal of Zoology 79:642–651.

Boulanger, J., G. Stenhouse, G. MacHutcheon, M. Proctor, S. Himmer, D. Paetkau, and J. Cranston. 2005*a*. Grizzly bear population and density estimates for the 2005 Alberta Unit management area inventory. Alberta Sustainable Resource Development, Hinton, Alberta, Canada.

Boulanger, J., G. Stenhouse, M. Proctor, S. Himmer, D. Paetkau, and J. Cranston. 2005*b*. 2004 population inventory and density estimates for the

Alberta 3B and 4B Grizzly bear Management Area. Alberta Sustainable Resource Development, Hinton, Alberta, Canada.

Boulanger, J., G. C. White, M. Proctor, G. Stenhouse, G. MacHutchon, and S. Himmer. 2008*b*. Use of occupancy models to estimate the influence of past live captures on detection probabilities of grizzly bears using DNA hair snagging methods. Journal of Wildlife Management 72:589–595.

Brooks, S. P., and A. Gelman. 1998. General methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics 7:434–455.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

Cercueil, A., E. Bellemain, and S. Manel. 2002. PARENTE: Computer program for parentage analysis. Journal of Heredity 93:458–459.

Dumond, M., J. Boulanger, and D. Paetkau. 2015. The estimation of grizzly bear density through hair-snagging techniques above the tree line. Wildlife Society Bulletin 39:390–402.

Efford, M. G., and R. M. Fewster. 2013. Estimating population size by spatially explicit capture-recapture. Oikos 122:918–928.

Gervasi, V., P. Ciucci, J. Boulanger, E. Randi, and L. Boitani. 2012. A multiple data source approach to improve abundance estimates of small populations: the brown bear in Apennines, Italy. Biological Conservation 152:10–20.

Grizzly Bear Inventory Team. 2008. Grizzly bear population and density estimates for Alberta bear management unit 6 and British Columbia management units 4-1, 4-2, and 4-23 (2007). Alberta Sustainable Resource Development, Fish and Wildlife Division, British Columbia Ministry of Forests and Range, British Columbia Ministry of Enviroment, and Parks Canada, Edmonton, Alberta, Canada.

Hamilton, A. N., D. C. Heard, and M. A. Austin. 2004. British Columbia grizzly bear (*Ursus arctos*) population estimate 2004. British Columbia Ministry of Water, Land, and Air Protection, Biodiversity Branch, Victoria, British Columbia, Canada.

Hilderbrand, G. V., C. C. Schwartz, C. T. Robbins, M. E. Jacoby, T. A. Hanley, S. M. Arthur, and C. Servheen. 1999. The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. Canadian Journal of Zoology 77:132–138.

Huggins, R. M. 1991. Some practical aspects of a conditional likelihood approach to capture experiments. Biometrics 47:725–732.

Ivan, J. S. 2011. Density, demography, and seasonal movements of snowshoe hares in central Colorado. Dissertation, Colorado State University, Ft. Collins, USA.

Ivan, J. S., G. C. White, and T. M. Shenk. 2013*a*. Using auxiliary telemetry information to estimate animal density from capture-recapture data. Ecology 94:809–816.

Ivan, J. S., G. C. White, and T. M. Shenk. 2013*b*. Using simulation to compare methods for estimating density from capture-recapture data. Ecology 94:817–826.

Jacoby, M. E., G. V. Hilderbrand, C. Servheen, C. C. Schwartz, S. M. Arthur, T. A. Hanley, C. T. Robbins, and R. Michner. 1999. Trophic relations of brown and black bears in several western North American ecosystems. Journal of Wildlife Management 63:921–929.

Kasworm, W. F., H. Carriles, T. G. Radandt, M. Proctor, and C. Servheen. 2009. Cabinet-Yaak grizzly bear recovery area 2008 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F., H. Carriles, T. G. Radandt, and C. Servheen. 2005. Cabinet-Yaak grizzly bear recovery area 2004 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F., H Carriles, T. G. Radandt, and C. Servheen. 2007*a*. Cabinet-Yaak grizzly bear recovery area 2006 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W., and T. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet mountains of northwest Montana. Montana Department of Fish, Wildlife, and Parks, Kalispell, Montana, USA.

Kasworm, W. F., M. F. Proctor, C. Servheen, and D. Paetkau. 2007*b*. Success of grizzly bear population augmentation in northwest Montana. Journal of Wildlife Management 71:1261–1266.

Kasworm, W. F., T. G. Radandt, J. E. Teisberg, M. Proctor, and C. Servheen. 2014. Cabinet-Yaak grizzly bear recovery area 2013 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F., T. J. Their, and C. Servheen. 1998. Grizzly bear recovery efforts in the Cabinet/Yaak ecosystem. Ursus 10:147–153.

Kendall, K. C., J. B. Stetz, J. Boulanger, A. C. Macleod, D. Paetkau, and G. C. White. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73:3–17.

Kendall, K. C., J. B. Stetz, D. A. Roon, L. P. Waits, J. Boulanger, and D. Paetkau. 2008. Grizzly bear density in Glacier National Park, Montana. Journal of Wildlife Management 72:1693–1705.

Kingsley, M. C. S., J. A. Nagy, and H. V. Reynolds. 1988. Growth in length and weight of northern brown bears: differences between sexes and populations. Canadian Journal of Zoology 66:981–986.

Mace, R. D., D. W., Carney, T. Chilton-Radandt, S. A. Courville, M. A. Haroldson, R. B. Harris, J. Jonkel, B. McLellan, M. Madel, T. L. Manley, C. C. Schwartz, C. Servheen, G. Stenhouse, J. S. Waller, and E. Wenum. 2012. Grizzly bear population vital rates and trend in the Northern Continental Divide Ecosystem, Montana. Journal of Wildlife Management 76:119–128.

Mace, R. D., and T. Chilton-Radandt. 2011. Black bear harvest research and management in Montana. 2011. Final Report. Montana Fish, Wildlife and Parks. Helena, USA.

Mace, R., and L. Roberts. 2012. Northern Continental Divide Ecosystem Grizzly Bear Monitoring Team annual report, 2012. Montana Fish, Wildlife and Parks, Kalispell, USA.

Mattson, D. J., S. Herrero, and T. Merrill. 2005. Are black bears a factor in the restoration of North American grizzly bear populations? Ursus 16:11–30.

Miller, S. D., G. C. White, R. A. Sellers, H. V. Reynolds, J. W. Schoen, K. Titus, V. G. Barns Jr., R. B. Smith, R. R. Nelson, W. B. Ballard, and C. C. Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133:1–55.

Mowat, G., D. C. Heard, D. R. Seip, K. G. Poole, G. Stenhouse, and D. Paetkau. 2005. Grizzly *Ursus arctos* and black bear *U. americanus* densities in the interior mountains of North America. Wildlife Biology 11:31–48.

Mowat, G., and C. Strobeck. 2000. Estimating population size of grizzly bears using hair capture, DNA profiling, and mark-recapture analysis. Journal of Wildlife Management 64:183–193.

Obbard, M. E., E. J. Howe, and C. J. Kyle. 2010. Empirical comparison of density estimators for large carnivores. Journal of Applied Ecology 47:76–84.

Pledger, S. 2000. Unified maximum likelihood estimates for closed models using mixtures. Biometrics 56:434–442.

Proctor, M., J. Boulanger, S. Nielsen, C. Servheen, W. Kasworm, T. Radandt, and D. Paetkau. 2007. Abundance and density of Central Purcell, South Purcell, Yahk, and South Selkirk Grizzly Bear Population Units in southeast British Columbia. British Columbia Ministry of Environment, Nelson and Victoria, British Columbia, Canada.

Proctor, M., W. Kasworm, W. Wakkinen, and C. Servheen. 2012*a*. Pedigree analysis to assess and monitor functional connectivity of grizzly bears in the trans-border region of northern Montana, Idaho, Washington, and southern British Columbia. Birchdale Ecological, Kaslo, British Columbia, Canada.

Proctor, M., B. N. McLellan, C. Strobeck, and R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society, London 272:2409–2416.

Proctor, M. F., S. E. Nielsen, W. F. Kasworm, C. Servheen, T. G. Radandt, A. G. MacHutchon, and M. S. Boyce. 2015. Grizzly bear connectivity mapping in the Canada-US trans-border region. Journal of Wildlife Management 79:544–558.

Proctor, M. F., D. Paetkau, B. N. McLellan, G. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. D. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Scwartz, and C. Strobeck. 2012*b*. Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs 180:1–46.

Proctor, M. F., C. Servheen, S. D. Miller, W. F. Kasworm, and W. L. Wakkinen. 2004. A comparative analysis of mangement options for grizzly bear conservation in the U.S.-Canada trans-border area. Ursus 15:145–160.

Reppucci, J., B. Gardner, and M. Lucherini. 2011. Estimating detection and density of the Andean cat in the high Andes. Journal of Mammalogy 92:140–147.

Royle, J. A., K. U. Karanth, A. M. Gopalaswamy, and N. S. Kumar. 2009. Bayesian inference in camera trap studies using a class of spatial capture-recapture models. Ecology 90:3233–3244.

Russell, R. E., J. A. Royle, R. Desimone, M. K. Schwartz, V. L. Edwards, K. P. Pilgrim, and K. S. McKelvey. 2012. Estimating abundance of mountain lions from unstructured spatial sampling. Journal of Wildlife Management 76:1551–1561.

Schwartz, C. C., M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the greater Yellowstone ecosystem. Wildlife Monographs 161:1–68.

Schwartz, C. C., S. D. Miller, and M. A. Haroldson. 2003. Grizzly bear. Pages 556–586 *in* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Second edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Stetz, J. B., K. C. Kendall, and A. C. Macleod. 2014. Black bear density in Glacier National Park, Montana. Wildlife Society Bulletin 38:60–70.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service Missoula, Montana, USA.

U.S. Fish and Wildlife Service 2007. Final rule designating the GYA population of grizzly bears as a distinct population segment and removing the Yellowstone distinct population segment of grizzly bears from the federal list of endangered and threatened wildlife. 72 Federal Register 14866.

Wakkinen, W. L., and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk Ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15 Workshop Supplement:65–75.

Welch, C. A., J. Keay, K. C. Kendall, and C. T. Robbins. 1997. Constraints on frugivory by bears. Ecology 78:1105–1119.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study Supplement 46:120–138.

White, G. C., K. P. Burnham, and D. R. Anderson. 2001. Advanced features of Program MARK. Pages 368–377 *in* R. Field, R. J. Warren, H. Okarma, and P. R. Sievert, editors. Wildlife, land, and people: priorities for the 21st century. Proceedings of the second international wildlife management congress. The Wildlife Society, Bethesda, Maryland, USA.

White, G. C., K. P. Burnham, and D. R. Anderson. 2002. Advanced features of Program MARK. Pages 368–377 *in* R. Fields, R. J. Warren, H. Okarma, and P. R. Seivert, editors. Integrating people and wildlife for a sustainable future: Proceedings of the Second International Wildlife Management Congress, Gödölló, Hungary. The Wildlife Society, Bethesda, Maryland, USA.

Woodroffe, R., and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126–2128.

Woods, J. G., D. Paetkau, D. Lewis, B. McLellan, M. Proctor, and C. Strobeck. 1999. Genetic tagging of free-ranging black and brown bears. Wildlife Society Bulletin 27:616–627.

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