SELKIRK MOUNTAINS GRIZZLY BEAR RECOVERY AREA 2020 RESEARCH AND MONITORING PROGRESS REPORT

PREPARED BY
WAYNE F. KASWORM, THOMAS G. RADANDT, JUSTIN E. TEISBERG, ALEX WELANDER, TYLER VENT, MICHAEL PROCTOR, HILARY COOLEY, AND JENNIFER K. FORTIN-NOREUS
2021

UNITED STATES FISH AND WILDLIFE SERVICE
GRIZZLY BEAR RECOVERY COORDINATOR'S OFFICE
UNIVERSITY OF MONTANA, MAIN HALL ROOM 309
MISSOULA, MONTANA 59812
(406) 243-4903

This annual report is cumulative and represents data collected since inception of this monitoring program. 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. Please cite this report as following:
Kasworm, W. F., T. G. Radandt, J. E. Teisberg, A. Welander, T. Vent, M. Proctor, H. Cooley, and J. K. Fortin-Noreus. 2021. Selkirk Mountains grizzly bear recovery area 2020 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 69 pp.

ABSTRACT

The U.S. Fish and Wildlife Service (USFWS) has been leading a grizzly bear monitoring and research program in the Selkirk Mountains Ecosystem (SE) since 2012. Key research and funding cooperators include Idaho Department of Fish and Game (IDFG), Colville and Idaho Panhandle National Forests (USFS), Idaho Department of Lands, Kalispel Tribe, Kootenai Tribe of Idaho, and Washington Department of Fish and Wildlife. The British Columbia (BC) effort was led by Michael Proctor with key funding provided by BC Habitat Conservation Trust Fund and BC Fish and Wildlife Compensation Fund. Fieldwork was limited by COVID-19 during 2020.

Numbers of females with cubs in the SE varied from 2–6 per year and averaged 3.83 per year from 2015–2020. Eight of 10 U.S. bear management units and two of six BC units had sightings of females with young during 2015–2020. Human-caused mortality averaged 2.2 bears per year (1.4 males and 0.8 females per year). Thirteen known or probable human-caused grizzly bear mortalities occurred in or within 10 miles of the SE in the U.S. or inside the South Selkirk GBPU during 2015–2020, including five females and eight males. Mortality included three adult females (two management removal, one mistaken identity), two adult males (one vehicle collision, one self-defense), one subadult female (one vehicle collision), five subadult males (two management removal, one defense, one train collision, one under investigation), and two cubs (management removals).

Eighty-nine instances of known and probable grizzly bear mortality were detected inside or within 16 km of the U.S. SE and the BC South Selkirk grizzly bear population unit during 1980–2020. Seventy-three were human caused, 11 were natural mortality, and 5 were unknown cause. Fifty-four occurred in BC, 27 in Idaho, and 8 in Washington.

The estimated finite rate of increase (λ) for 1983–2020 using Booter software with the unpaired litter size and birth interval data option was 1.029 (95% CI=0.959–1.086). Finite rate of change over the same period was an annual 2.9%. The probability that the population was stable or increasing was 81%.

All combined efforts (hair collection, photos, captures) identified a minimum 44 individual grizzly bears (21 female, 19 male, 4 unknown) alive and within the U.S. portion of the SE grizzly bear population at some point during 2019. Genetic DNA results are not yet complete for sampling in 2020 and we will provide those results in the 2021 report. Many bears were known to have home ranges extending into BC and this estimate includes some bears on both sides of the international boundary. Remote cameras and corrals were deployed at 93 sites and checked for pictures and hair collection 154 times during 2020. Grizzly bears were detected by cameras at 28 sites. During 2019, 415 rub sites were checked a total of 1,760 times. Since 2013, interagency personnel have identified and installed 462 bear rub locations in the SE.

Fifty-nine grizzly bears were radio collared for research purposes from 2007 to 2020, the most recent period of active bear research in BC (2007–2016) and the U.S. (2012–2020). Twenty-one of these occurred in the U.S. and 37 occurred in BC. Home range summary calculations and maps were provided. Den entrance and exit dates were summarized.

TABLE OF CONTENTS PAGE

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 Selkirk Mountains Grizzly Bear Recovery Zone (SE) of northern Idaho, northeast Washington, and southeast British Columbia (BC) (Fig. 1). The recovery area includes the South Selkirks BC grizzly bear population unit and encompasses approximately 5,070 km^2.

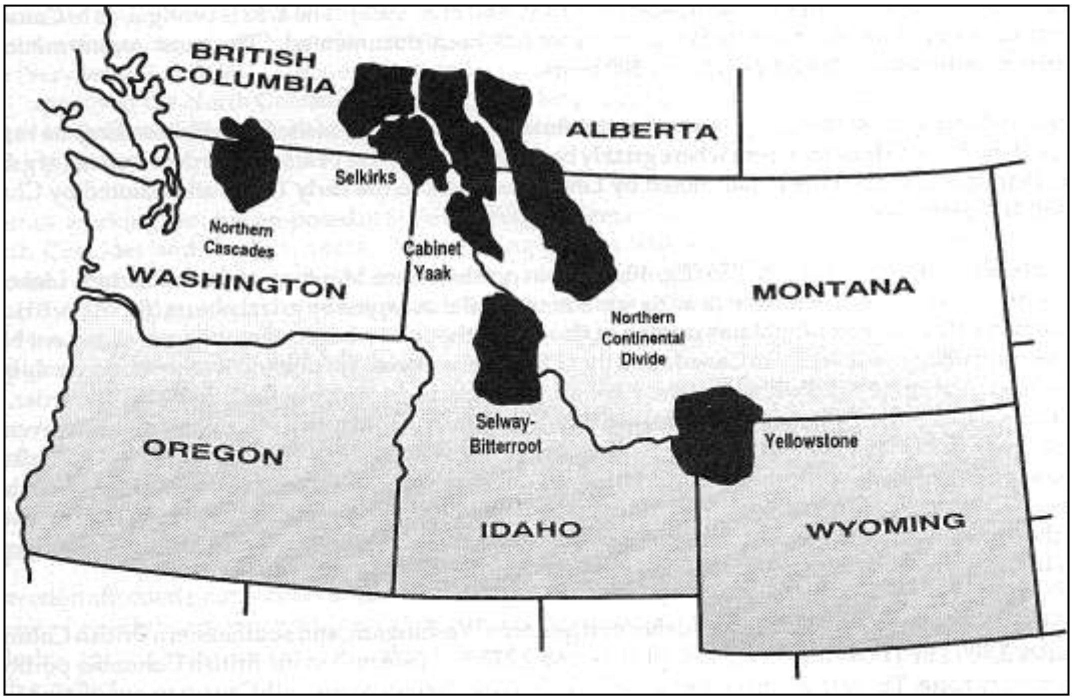

Figure 1. Grizzly bear recovery areas in the U.S., southern British Columbia, and Alberta, Canada.

Surveys of sightings, sign, and mortality have been documented by Layser (1978) and Zager (1983). Idaho Department of Fish and Game (IDFG) captured and monitored a radio-collared sample of grizzly bears in the SE from 1983 until 2002 to determine distribution, home ranges, cause specific mortality, reproductive rates, and population trend (Almack 1985, Wakkinen and Johnson 2004, Wakkinen and Kasworm 2004). This effort was suspended in 2003 due to funding constraints and management decisions. In cooperation with IDFG and the Panhandle National Forest (USFS) this effort was reinitiated during 2012 with personnel from the U.S. Fish and Wildlife Service (USFWS). During 2013, the program was expanded with funding from IDFG, USFS, several sources in BC, and USFWS. This cooperative research and monitoring effort was further expanded to involve Idaho Department of Lands, the Kalispel Tribe, the Kootenai Tribe of Idaho, and Washington Department of Fish and Wildlife in 2014. USFWS began a trapping and monitoring effort to collect and update known-fate population vital rates of radio-collared grizzly bears within the SE. In 2013–2020, we also collected camera and hair samples at DNA hair corral, camera, and rub post locations, adding to similar efforts conducted by IDFG and USFS personnel.

OBJECTIVES

1. Document grizzly bear distribution in the SE.
2. Describe and monitor the grizzly bear population in terms of reproductive success, age structure, mortality causes, population trend, and population estimates and monitor the targets for recovery as described in the grizzly bear recovery plan (USFWS 1993).
3. Determine habitat use and movement patterns of grizzly bears. Determine habitat preference by season and assess the relationship between habitats affected by man such as logged areas and grizzly bear habitat use. Evaluate permeability of the Kootenai River valley between the SE and adjacent grizzly bear populations.
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.

STUDY AREA

The SE encompasses 5,700 km^2 of the Selkirk Mountains of northeastern Washington, northern Idaho, and southern BC (Figure 2). Approximately 53% lies in the U.S. with the remainder in BC. Land ownership in BC is approximately 65% crown (public) land and 35% private. Land ownership in the U.S. portion is about 80% federal, 15% state, and 5% private.

Elevation on the study area ranges from 540 to 2,375 m. Weather patterns are characterized as Pacific maritime-continental climate, with long winters and short summers. Most of the precipitation falls during winter as snow, with a second peak in spring rainfall.

SE vegetation is dominated by various forested types. Dominant tree species include subalpine fir (*Abies lasiocarpa*), Englemann spruce (*Picea engelmannii*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*). Major shrub species include alder (*Alnus* spp.), fool's huckleberry (*Menziesia ferruginea*), mountain ash (*Sorbus scopulina*), and huckleberry (*Vaccinium* spp.).

Historically, wildfire was the primary disturbance factor in the SE. The 1967 Trapper Peak (6,000 ha) and Sundance (9,000 ha) fires produced large seral huckleberry shrubfields. Timber management and recreation are currently the principal land uses.

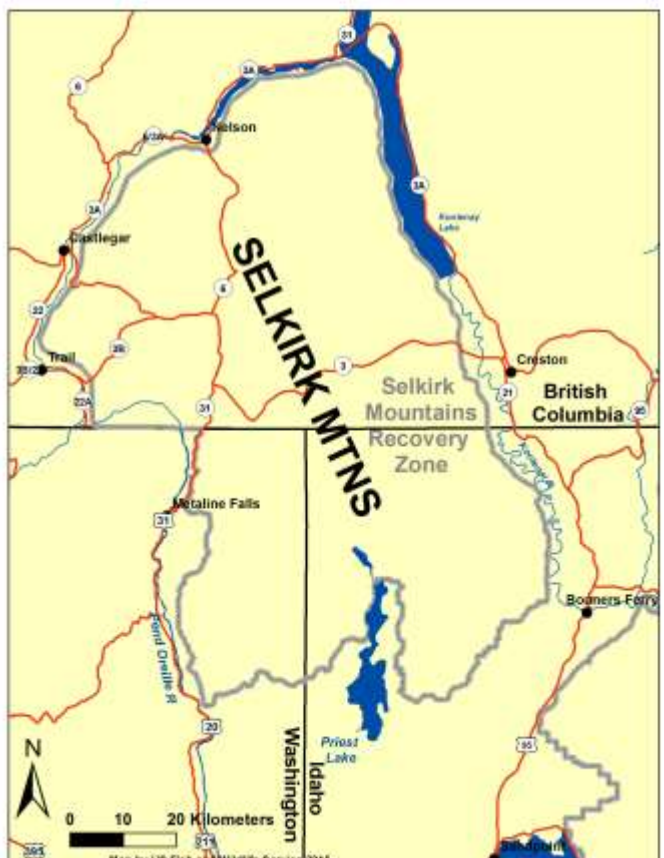

Figure 2. Selkirk Mountains grizzly bear recovery area.

METHODS

Grizzly Bear Observations

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 these 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 and used in reports. Sightings that rate 1 or 2 may not always 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 were 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 other than the observer.

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 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.

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

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):

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

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). Lack of mortality in specific sex-age classes limited calculations for many time periods other than those shown here.

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 Idaho and Washington state collection permits (ID 140226 and WA20-074) and a 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. All bears were immobilized with Telazol (tiletamine hydrochloride and zolazepam hydrochloride), a mixture of Ketaset (ketamine hydrochloride) and Rompun (xylazine hydrochloride), or a combination of Telazol and Rompun. Yohimbine and Atipamezole were the primary antagonists for Rompun. 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) 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). 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 August. Trap sites were usually located within 500 m of an open road to allow vehicle access. In a few instances, trap sites were accessed behind restricted roads within the administrative motorized access provisions of the land management agency. Further, some remote trap sites were accessed with pack livestock. Traps were checked daily or in some cases twice daily. Bait consisted primarily of road-killed ungulates and a liquid lure composed of fish and livestock blood.

Hair Sampling for DNA Analysis

Genetic information from hair-snagging with remote-camera photo verification allows us to document the number of individual grizzly bears occupying the study area and understand the level of relatedness within this population and between this and adjacent populations. Project objectives include: observations of females with young, sex ratio of sampled bears, and relatedness as well as genetic diversity measures of captured bears and source population and assessment of movement or gene flow in and out of the population.

Sampling occurred from May–September in the SE following standard hair snagging techniques with barbed wire hair corrals (Woods *et al.* 1999). Sampling sites were established based on location of previous sightings, sign, habitat quality, and radio telemetry from bears. Sites were baited with 2 liters of a blood and fish mixture to attract bears across a barb wire perimeter placed to snag hair. Sites were deployed for 2–3 weeks prior to hair collection. Hair sampling also occurred at sites where personnel observed bear hair and "rubbing" on a tree, artificial signpost, or similar object. When observed, personnel formally established these sites by attaching barbed wire at the spot of rubbing and designating the location with a unique site number. Crews then subsequently revisited these locations to collect hair. Hair was collected and labeled to indicate number and color of hairs collected, location, date, and barb number. Solid black hairs were judged to be from black bears and not analyzed further. Samples collected 1) as part of this formal hair sampling effort, 2) from captured and handled bears, and 3) opportunistically (i.e., not from established sampling sites, such as tree staubs along trail, within identified daybeds, etc.) were sent to Wildlife Genetics International Laboratory in Nelson, British Columbia for DNA extraction and genotyping. Only samples from known grizzly bears or that outwardly appeared to be grizzly bear were sent to the lab. Hairs visually identified as black bear hair by technicians on our project or 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.

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: South Selkirk (n = 49), Yahk (*n* = 33, south of Highway3) 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 offspring were in a perfectly matched triad: mother – father – offspring where offspring shared an allele at each of 21 loci with each parent and 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 determined to be real had 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. 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, log ratios of these real migrants typically reflect probabilities 100-10000 times higher of 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 not in dens. Global Positioning System (GPS) collars were programmed to attempt locations every 1–2 hours depending on configuration, and data were stored within the collar and then downloaded to a lap top computer in an aircraft (Telonics Inc., Mesa AZ). Beginning in 2016, we have used iridium collars on select males to enable remote download. All collars were equipped with a release mechanism to allow them to drop off and be retrieved prior to denning. Expected collar life varied from 1–3 field seasons over the course of the study depending upon model of collar and programming. Weekly aircraft radio monitoring was conducted to check for mortality signals and approximate location. Life home ranges (minimum convex polygons; Hayne 1959) were calculated for grizzly bears during the study period. We generated home range polygons using ArcGIS.

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 the SE, 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 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 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. Berry phenology, berry size, and plant condition were recorded. Monitoring goals identified annual trend of berry production and did not include documenting forest succession.

Temperature and relative humidity data recorders (LogTag®, Auckland, New Zealand) were placed at berry monitoring sites. These devices record conditions at 90 minute intervals and will be retrieved, downloaded, and replaced at annual intervals. We used a berries/plot 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 transect productivity indices.

Body Condition

Field measurements and bioelectric impedance analysis (BIA) of captured bears allows us to estimate body condition of grizzly bears (Farley and Robbins 1994). More specifically, these methods allow 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

Grizzly Bear Observations, Mortality, and Recovery Plan Criteria

One hundred twenty-two reported sightings rated 4 or 5 (most credible) during 2020 (Table 1). Sightings occurred in all Bear Management Units (BMUs) except Lakeshore. Two known human-caused mortalities of a subadult female and a subadult male occurred during 2020 (Table 2, Figure 3). Sightings of females with young or mortalities that occur outside the recovery zone are counted in the closest BMU.

<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 US portion of the recovery zone</u>.

Cubs are offspring in the first 12 months of life and yearlings are offspring in their second 12 months. The recovery plan (USFWS 1993) indicates that female with cub sightings within 10 miles of the US portion of the recovery zone count toward recovery goals. Eleven credible sightings of a female with cubs occurred during 2020 in Blue-Grass and Long-Smith, Myrtle, and State Lands BMUs or Bears Outside Recovery Zone (BORZ) units (Tables 1, 3, 4, 5 and Fig. 4). There appeared to be 4 unduplicated females with cubs in the recovery area during 2020. Seven credible sightings of a female with yearlings or 2-year-olds occurred in Blue-Grass and Myrtle BMUs in 2020. Unduplicated sightings of females with cubs (including Canada) varied from 2–6 per year and averaged 3.83 per year from 2015–2020 (Tables 3, 4). Recovery plan targets require a running 6-year average of 6.0 females with cubs per year and therefore this target has not been met.

Recovery Target 2: 7 of 10 BMU's occupied by females with young from a running 6-year sum of verified evidence.

Eight of 10 BMUs in the U.S. portion of the recovery zone and two of six BC BMUs had sightings of females with young (cubs, yearlings, or 2-year-olds) during 2015–2020 (Fig. 4 and Table 5). Occupied U.S. BMUs were: Ball-Trout, Blue-Grass, LeClerc, Long-Smith, Myrtle, Salmo-Priest, State Lands, and Sullivan-Hughes BMUs. Occupied BC BMUs included Boundary and Three Sisters. Recovery plan criteria indicate the need for 7 of 10 U.S. BMUs to be occupied. This target has been met.

Recovery Target3: 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 human caused mortalities occurred in 2020 consisting of a subadult female and a subadult male. The male was killed by a neck snare and the female was struck by a vehicle.

Thirteen known or probable human caused grizzly bear mortalities occurred in or within 10 miles of the SE in the U.S. or inside the South Selkirk GBPU during 2015–2020, including five females (one Long-Smith and four BC BMUs) and eight males (two Myrtle, two Ball-Trout, and four BC BMUs) (Table 1). Mortality included three adult females (two management removal and one mistaken identity), two adult males (one vehicle collision and one self-defense), one subadult females (vehicle collision), five subadult males (two management removal, one self-defense, one train collision, and one under investigation), and two cubs (management removals). We estimated minimum population size by dividing observed females with cubs (10), minus any human-caused adult female mortality (2) from 2018–2020, by 0.6 (sightability correction factor as specified in the recovery plan) then divide the resulting dividend by 0.333 (adult female proportion of population as specified in the recovery plan) (Tables 3, 4) (USFWS 1993). This resulted in a minimum population of 40 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 1.6 bears per year. The female limit is 0.5 females per year (30% of 1.6). Average annual human caused mortality for 2015–2020 was 2.2 bears/year and 0.8 females/year. Mortality levels for total bears and females were more than the calculated limits 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." All tables and calculations were updated when new information became available.

Table 1. Credible grizzly bear sightings, credible female with young sightings, and known human caused mortality by Selkirk Mountain bear management unit (BMU) or area, 2020.

BMU OR AREA	2020 Credible[1] Grizzly Bear Sightings	2020 Sightings of Females with Cubs (Total)	2020 Sightings of Females with Cubs (Unduplicated[2])	2020 Sightings of Females with Yearlings or 2-year-olds (Total)	2020 Sightings of Females with Yearlings or 2 year-olds (Unduplicated[2])	2020 Human Caused Mortality
Ball-Trout	0	0	0	0	0	1
Blue Grass	49	3	1	6	3	0
Kalispel-Granite	1	0	0	0	0	0
Lakeshore	0	0	0	0	0	0
LeClerc	2	0	0	0	0	0
Long-Smith	33	2	1	0	0	1
Myrtle	5	1	0	1	1	0
Salmo-Priest	2	0	0	0	0	0
State Idaho	5	1	1	0	0	0
Sullivan-Hughes	3	0	0	0	0	0
Pack River	16	3	1	0	0	0
Priest River	0	0	0	0	0	0
Kootenai Valley	5	0	0	0	0	0
BC	1	1	0	0	0	0
TOTAL	122	11	4	7	4	2

[1]Credible sightings are those rated 4 or 5 on a 5 point scale (see methods).
[2]Sightings may duplicate the same bear in different locations. Only the first sighting of a duplicated female with cubs was counted toward total females (Table 3), however subsequent sightings contribute toward occupancy (Table 5).

Table 2. Known and probable grizzly bear mortality in the Selkirk Mountains recovery area, 1980–2020.

Mortality Date	Tag Number	Sex	Age	Mortality Cause	Location	<500m from open road	Owner[1]
11-May-80	None	F	5.0	Human, Hunting	Barrett Creek, BC	Unk	BC
2-May-82	None	M	AD	Human, Poaching	Priest River, ID	Yes	USFS
Sept 1982	None	U	Unk	Human, Undetermined	LeClerc Creek, WA	Yes	USFS
1-Jul-85	949	M	4.5	Human, Undetermined	NF Granite Creek, WA	Yes	USFS
Autumn, 1985	867-85a	U	Cub	Natural	Cow Creek, ID	Unk	USFS
1-Sep-86	898	F	1.5	Human, Undetermined	Grass Creek, ID	Unk	USFS
10-Sep-86	None	M	7.0	Human, Management	Curtis Lake, BC	Yes	BC
June 1987	1005	M	10.5	Human, Poaching	Wall Mtn, BC	Unk	BC
8-Sep-87	962	M	7.5	Human, Poaching	Trapper Creek, ID	No	IDL
30-May-88	None	M	5.0	Human, Hunting	Monk Creek, BC	Unk	BC
Sept 1988	1050	M	1.5	Natural	Porcupine Creek, BC	No	BC
Sept 1988	1085	F	3.5	Human, Mistaken Identity	Cow Creek, ID	No	USFS
14-Aug-89	1044	F	20+	Natural	Laib Creek, BC	No	Private
22-Sep-89	None	M	2.0	Human, Management	49 Mile Creek, BC	Yes	Private
22-Sep-89	None	U	Unk	Human, Management	49 Mile Creek, BC	Yes	Private
6-Aug-90	None	M	Unk	Human, Management	Ymir Area, BC	Yes	Private
16-Sep-90	1042	F	3.5	Human, poaching	Maryland Creek, BC	Yes	BC
1-Aug-91	1076	F	20+	Natural	Next Creek, BC	No	BC
23-Apr-91	867-92a	U	1.5	Natural	Trapper Creek, ID	Unk	IDL
11-Apr-92	None	M	Unk	Unknown	Atbara, BC	Yes	BC
22-May-92	None	M	4.0	Human, Hunting	Cottonwood, BC	Unk	BC
July 1992	None	M	Unk	Human, Management	Lost Creek, BC	Yes	BC
7-Sep-92	1090	M	5.5	Unknown	Laib Creek, BC	Yes	BC
25-Sep-92	1015	F	12.5	Human, Self Defense	Monk Creek, BC	No	BC
2-Jun-93	None	M	4.0	Human, Management	Lost Creek, BC	Yes	BC
5-Jun-93	None	M	4.0	Human, Hunting	Elmo Creek, BC	Unk	BC
2-Nov-93	867	F	15.5	Human, Poaching	Willow Creek, WA	No	USFS
2-Nov-93	867-93a	U	0.5	Human, Poaching	Willow Creek, WA	No	USFS
2-Nov-93	867-93b	U	0.5	Human, Poaching	Willow Creek, WA	No	USFS
23-May-94	None	M	12.0	Human, Hunting	Wall Mountain, BC	Unk	BC
10-May-95	None	F	1.5	Human, Undetermined	Boundary Creek, ID	Yes	USFS
31-Oct-95	1100	M	2.5	Human, Mistaken Identity	Granite Pass, WA	Yes	USFS
Autumn, 1995	None	M	AD	Human, Mistaken Identity	Mill Creek, WA[2]	Yes	USFS
Autumn, 1996	1027-96b	U	Cub	Natural	Cedar Creek, ID	Unk	USFS

Mortality Date	Tag Number	Sex	Age	Mortality Cause	Location	<500m from open road	Owner[1]
10-Oct-1996	1022	M	2.5	Human, Management	Boswell, BC[2]	Yes	Private
Sept 1997	None	M	1.5	Human, Management	Salmo, BC	Yes	Private
29-May-98	1023	M	4.5	Human, Hunting	Findlay Creek, BC[2]	Yes	BC
Aug 1998	None	M	3.5	Human, Undetermined	Usk, WA	Yes	Private
Oct 1999	1032	M	18.0	Human, Management	Procter, BC	Yes	Private
Oct 1999	9810	M	10.0	Human, Undetermined	Smith Creek, ID	Unk	USFS
Autumn 2000	None	U	Unk	Unknown	Hughes Meadows, ID	Yes	USFS
29-Aug-01	7	F	13.0	Natural	Porcupine Creek, BC	Yes	BC
25-Oct-01	None	F	2.0	Human, Management	49 Mile Creek, BC	Yes	Private
Oct 2001	None	M	Unk	Human, Management	Cottonwood Creek, BC	Yes	Private
12-May-02	17	M	6.0	Human, Management	Nelway, BC	Yes	Private
15-Sep-02	None	F	10+	Human, Management	Blewett, BC	Yes	Private
15-Sep-02	None	U	0.5	Human, Management	Blewett, BC	Yes	Private
15-Sep-02	None	U	0.5	Human, Management	Blewett, BC	Yes	Private
15-Sep-02	None	U	0.5	Human, Management	Blewett, BC	Yes	Private
4-Oct-02	19	M	3.5	Human, Undetermined	Lamb Creek, ID	Yes	USFS
May 2003	None	U	1.5	Human, Mistaken Identity	Smith Creek, ID	Yes	Private
2-Sep-03	None	F	AD	Human, Management	Blewett, BC	Yes	Private
23-Sep-03	None	F	5.0	Human, Management	Blewett, BC	Yes	Private
23-Sep-03	None	F	0.5	Human, Management	Blewett, BC	Yes	Private
3-Oct-03	30	F	2.5	Human, Management	Erie Creek, BC	Yes	Private
May 2004	None	M	AD	Human, Undetermined	Hughes Meadows, ID	Yes	USFS
Autumn 2004	32	M	7.0	Human, Undetermined	Bismark Meadows, ID	Unk	Private
Spring 2005	None	U	Unk	Human, Undetermined	E F Priest River, ID	Unk	IDL
10-May-2005	31	M	6	Human, Hunting	Russell Creek, BC[2]	Yes	BC
May 2006	None	M	AD	Human, Management	Procter, BC	Yes	Private
23-Oct-06	None	F	1.0	Human, Management	Blewett Ski Hill, BC	Yes	Private
23-Oct-06	None	M	1.0	Human, Management	Blewett Ski Hill, BC	Yes	Private
1-Aug-07	29	F	AD	Vehicle Collision	Kootenay Pass, BC	Yes	BC
1-Oct-07	1000	F	AD	Human, Mistaken Identity	Pass Creek Pass, WA	Yes	USFS
4-Oct-07	5393	M	SA	Human, Management	Priest River, ID	Yes	Private
29-Sep-08	119	M	13.0	Human, Management	Salmo, BC	Yes	Private
18-Aug-10	8005	F	5	Vehicle Collision	Summit Creek, BC	Yes	BC
5-May-11	None	M	2.5	Human, Management	Porthill, ID	Yes	Private
25-May-11	0012	M	2.5	Human, Management	Nelson, BC	Yes	Private
25-May-11	None	M	2.5	Human, Management	Nelson, BC	Yes	Private
28-Aug-2011	002	M	20	Human, Management	Kootenay River, BC	Yes	Private
7-Oct-12	None	M	3.0	Human, Mistaken Identity	Beaverdale Creek, BC	Yes	BC
16-Oct-12	170	F	6.0	Human, Under investigation	Salmo River, BC	Yes	Private
6-Jun-14	12006	F	4	Human, Under investigation	Boundary Creek, BC	Yes	BC
27-Sep-14	None	F	AD?	Human, Management	Ootishenia Creek, BC	Unk	BC
Summer 2014	3023a	U	Cub	Natural	Malcolm Creek, ID	Unk	USFS
Summer 2014	3023a	U	Cub	Natural	Malcolm Creek, ID	Unk	USFS
7-May-15	None	M	AD	Vehicle Collision	Summit Creek, BC	Yes	BC
27-Aug-16	None	M	2.5?	Train Collision	Deep Creek, ID	Yes	Private
25-Jun-17	226	F	10	Human, Management	Kootenay River, BC	Yes	BC
25-Jun-17	None	M	0.5	Human, Management	Kootenay River, BC	Yes	BC
25-Jun-17	None	F	0.5	Human, Management	Kootenay River, BC	Yes	BC
1-Sep-17	922	M	5	Human, Self Defense	Porthill Creek, BC	Yes	BC
4-Oct-17	None	M	4	Human, Mistaken Identity	McCormick Creek, ID	No	IUSFS
Summer 2018	None	U	1	Natural	Bugle Creek, ID	Unk	USFS
Autumn 2018	None	U	1	Natural	Smith Creek, ID	Unk	USFS
1-Jun-19	865	M	3	Human, Management	Brush Creek, ID	Yes	Private
2-Jun-19	None	F	AD	Human, Management	Cottonwood Creek, BC	Yes	Private
2-Jun-19	None	M	SA	Human, Management	Cottonwood Creek, BC	Yes	Private
17-Sep-19	2003	F	15	Human, Mistaken Identity	Beaver Creek, ID	No	USFS
Spring 2020	None	M	3	Human, neck snare Under investigation	Parker Creek, ID	Yes	USFS
10-Jun-20	None	F	3	Vehicle Collision	Olds Creek, ID	Yes	IDOT

[1]BC – British Columbia Crown Lands, IDL – Idaho Department of Lands, and USFS – U.S. Forest Service.
[2]More than 10 miles outside recovery zone in the U.S or outside the BC South Selkirk grizzly bear population unit

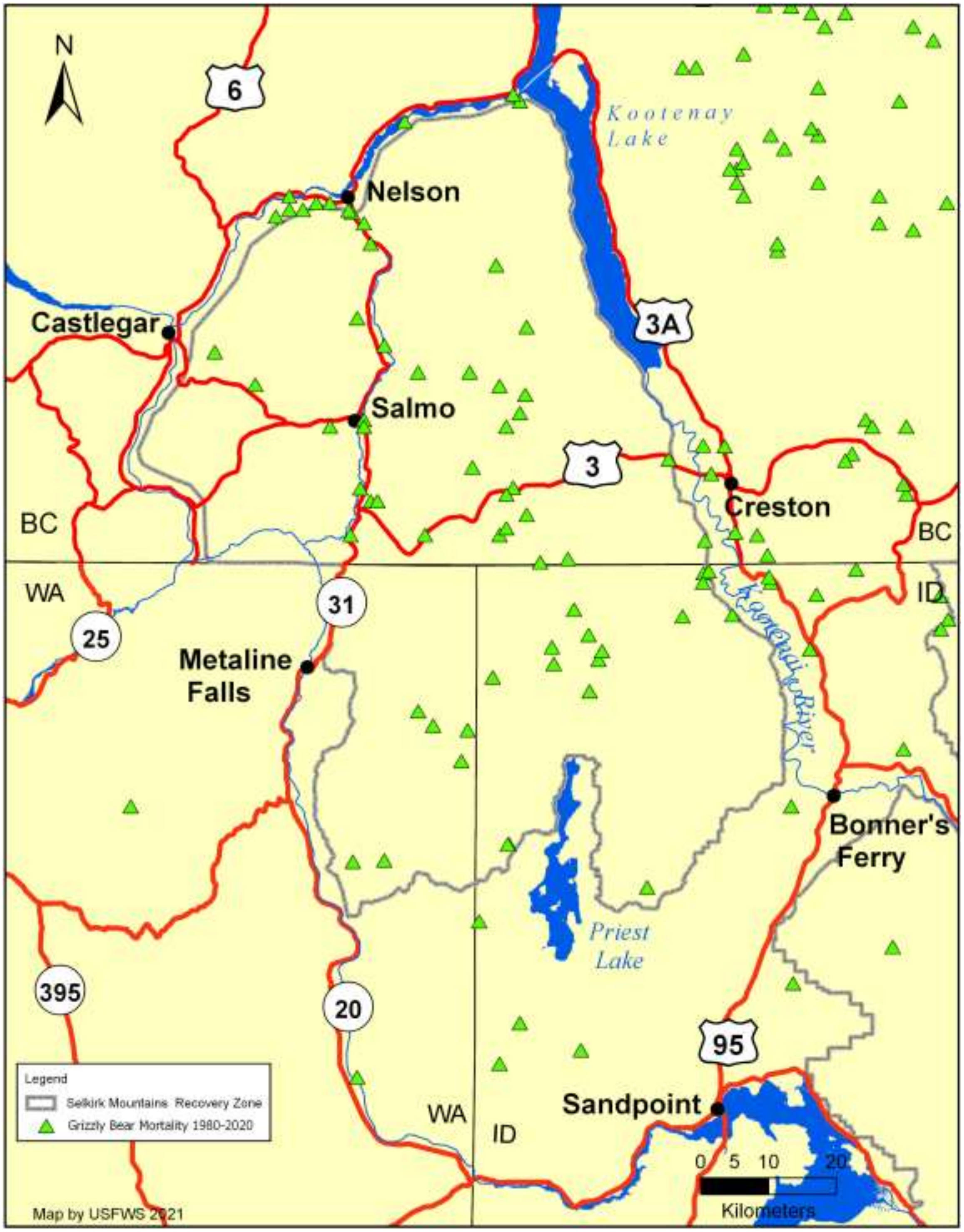

Figure 3. Grizzly bear known or probable mortalities from all causes (1980–2020) in the Selkirk Mountains recovery area.

Table 3. Status of the Selkirk Mountains recovery zone during 2015–2020 in relation to the demographic recovery targets from the grizzly bear recovery plan (USFWS 1993).

Recovery Criteria	Target	2020
Females w/cubs (6-yr avg)	6	3.83 (23/6)
Human Caused Mortality limit [1] (4% of minimum population estimate)	1.6	2.2 (6 yr avg)
Female Human Caused mortality limit [1] (30% of total mortality)	0.5	0.8 (6 yr avg)
Distribution of females w/young in the most recent 6 years [2]	7 of 10 US BMUs	8 of 10 US BMUs

[1] Includes both U.S. and B.C. mortalities.
[2] Includes only U.S. BMUs.

Table 4. Annual Selkirk Mountains recovery zone grizzly bear unduplicated counts of females with cubs (FWC's) and known human-caused mortality, 1988–2020. The grizzly bear recovery plan (USFWS 1993) states that the goal for human caused mortality shall be zero.

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	0	0	1	2				
1989	4	0	0	2				
1990	1	0	1	2				
1991	1	0	0	0				
1992	1	1	1	3				
1993	1	1	2	5	0.0	0.0	0.8	0.3
1994	1	0	0	1	0.2	0.1	0.2	0.0
1995	1	0	1	3	0.2	0.1	0.5	0.2
1996	1	0	0	0	0.4	0.1	0.5	0.2
1997	1	0	0	1	0.6	0.2	0.7	0.2
1998	1	0	0	1	0.6	0.2	0.8	0.2
1999	1	0	0	2	0.6	0.2	1.2	0.2
2000	2	0	0	0	0.8	0.2	1.2	0.2
2001	2	0	1	2	1.0	0.3	1.0	0.2
2002	0	1	3	6	0.6	0.2	2.0	0.7
2003	1	2	4	5	0.0	0.0	2.7	1.3
2004	1	0	0	2	0.0	0.0	2.8	1.3
2005	1	0	0	1	0.2	0.1	2.7	1.3
2006	0	0	1	3	0.4	0.1	3.2	1.5
2007	0	2	2	3	0.0	0.0	3.3	1.7
2008	0	0	0	1	0.0	0.0	2.5	1.2
2009	0	0	0	0	0.0	0.0	1.7	0.5
2010	0	1	1	1	0.0	0.0	1.5	0.7
2011	0	0	0	4	0.0	0.0	2.0	0.7
2012	1	1	1	2	0.0	0.0	1.8	0.7
2013	1	0	0	0	0.2	0.1	1.3	0.3
2014	3	2	2	2	0.4	0.1	1.5	0.7
2015	4	0	0	1	1.2	0.4	1.7	0.7
2016	3	0	0	1	1.6	0.5	1.7	0.5
2017	6	1	2	5	2.4	0.7	1.8	0.8
2018	4	0	0	0	2.4	0.7	1.5	0.7
2019	2	2	2	4	1.8	0.5	2.2	1.0
2020	4	0	1	2	1.6	0.5	2.2	0.8

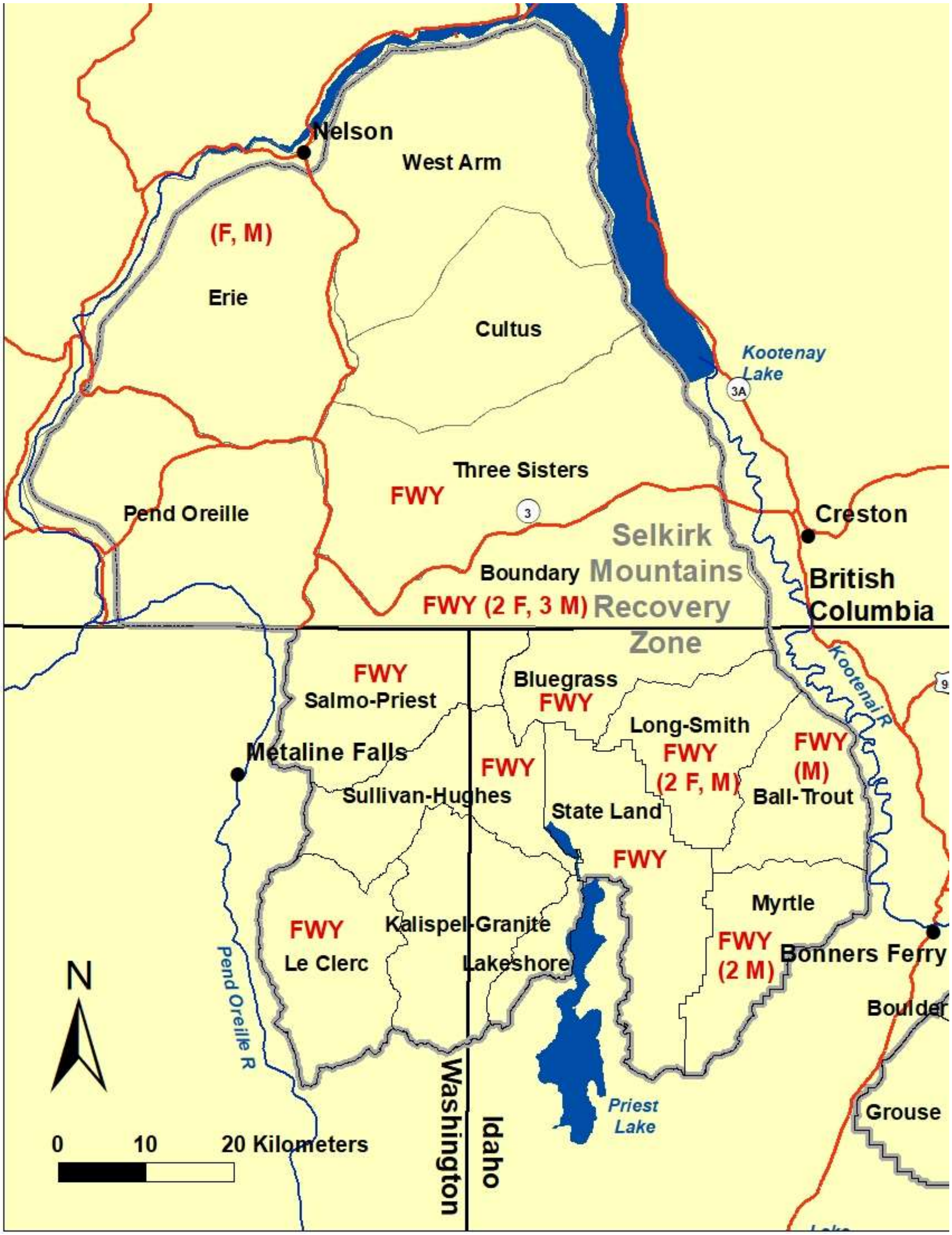

Figure 4. Female with young occupancy and known or probable mortality within Bear Management Units (BMUs) in the Selkirk Mountains recovery zone 2015–2020. FWY indicates occupancy of a BMU by a female with young, and sex of any mortality is in parentheses.

Table 5. Occupancy of bear management units by grizzly bear females with young in the Selkirk Mountains recovery zone 1996–2020.

YEAR	Ball-Trout	Blue Grass	Kalispell-Granite	Lakeshore	LeClerc	Long-Smith	Myrtle	Salmo-Priest	State Idaho	Sullivan-Hughes	BC Boundary	BC Cultus[1]	BC Erie[1]	BC Pend Oreille[1]	BC Three Sisters[1]	BC West Arm[1]
1996	Y	Y	N	N	N	Y	Y	N	N	N	N					
1997	Y	Y	N	N	N	Y	Y	N	Y	N	N					
1998	Y	Y	N	N	N	Y	N	Y	Y	N	N					
1999	N	Y	N	N	N	Y	N	Y	Y	N	N					
2000	N	N	N	N	N	N	N	N	N	N	N					
2001	N	Y	Y	N	N	Y	Y	N	Y	N	N					
2002	N	Y	Y	N	N	Y	Y	N	Y	N	N					
2003	N	Y	Y	N	N	Y	N	N	Y	N	N					
2004	N	Y	Y	N	N	Y	N	N	Y	N	N					
2005	N	Y	Y	N	N	Y	N	N	Y	N	N					
2006	N	N	Y	N	N	Y	Y	N	N	Y	N					
2007	N	N	Y	N	N	Y	Y	N	N	Y	N					
2008	N	N	Y	N	N	Y	Y	N	N	Y	N					
2009	N	N	N	N	N	N	N	N	N	N	N					
2010	N	N	N	N	N	N	N	N	N	N	N					
2011	N	Y	N	N	N	Y	N	N	N	N	N					
2012	N	Y	N	N	N	Y	N	N	Y	N	N					
2013	N	Y	N	N	N	Y	N	N	Y	N	N					
2014	N	Y	N	N	N	Y	Y	Y	Y	Y	Y					
2015	N	Y	N	N	Y	Y	Y	Y	Y	N	Y					
2016	N	Y	N	N	Y	Y	N	N	Y	Y	Y					
2017	N	Y	N	N	Y	Y	Y	N	Y	Y	Y					
2018	N	Y	N	N	Y	Y	Y	N	Y	N	Y					
2019	Y	Y	N	N	N	Y	N	N	Y	N	N					
2020	N	Y	N	N	N	Y	Y	N	Y	N	Y	N	N	N	Y	N

[1] Monitoring of females with young in these BC units was not conducted until 2020.

Hair Collection, Remote Camera, and Genetics

Remote cameras and corrals were deployed at 93 sites and were checked for pictures and hair collection 154 times during 2020 (Tables 6 and 7, Figure 5). Grizzly bears were detected by cameras at 21 sites. Genetic DNA results are not yet complete from collected hair at sites in 2020 and we will report 2020 genetic results in the 2021 report. Cameras detected females with cubs at 4 corral sites (Blue-Grass, Long-Smith, and Myrtle BMUs) and one female with yearlings at one site within Long-Smith BMU. In addition, crews set up cameras at some rub sites and opportunistically along roadways and trails presumed to be on grizzly bear travel routes. This extended effort documented presence of two additional female grizzly bears with young in upper reaches of Blue-Grass BMU (Malcom, Bog, Blue Joe, and Grass Creeks), one of which was an unduplicated female with a single cub. Several other single individuals were photographed at trail camera sites. Hair samples were collected from signposts, bridges, and rub trees, as observed opportunistically by study personnel. Since 2013, interagency personnel have identified and installed 514 bear rub locations in the SE. During 2020, 442 rub sites were checked a total of 1,800 times.

In total from corral, rub, or opportune methods, 2,141 samples were collected in the SE in 2020 (27% corral, 68% rub, 4% opportune). All hair samples were visually examined by study personnel to screen out hair that appeared to be black bear and the remaining 791 samples collected were sent to Wildlife Genetics International for analysis. Lab analysis for 2020 samples has not yet been completed.

In 2019, 114 rub sites (28% of checked) yielded grizzly bear hair. The rub effort alone identified 26 individual grizzly bears. Hair collection efforts via corral and rub sites genetically detected 35 individual grizzly bears within the U.S. in 2019. One additional bear was genetically detected from an opportunistic hair collection (i.e., collections along trails, at trapsites, on cattle fencing or tree staubs). Nine other bears were detected via opportunistic means, yet all nine were also detected with corral or rub methods. Six of the 8 bears collared or captured for research monitoring in 2019 were also detected via rub, corral, or opportune DNA collections.

In total, all combined efforts (hair collection, photos, captures) identified a minimum 44 individual grizzly bears (21 female, 19 male, 4 unknown) alive and within the U.S. portion of the SE grizzly bear population at some point during 2019. Two of these bears were known dead at the end of 2019 (adult female #2003, human-caused; subadult male #865, management removal). We were able to assign sex-age class to all 44 individuals detected. Pre-census sex-age class distribution consisted of 32% adult females, 27% adult males, 18% subadults, and 23% dependents in 2019. New genotypes from individuals detected in 2019 were added to the grizzly bear genetic database from the South Selkirk Mountains that now contains 192 individuals, 1983–2019.

Table 6. Grizzly bear hair rubs and success in the Selkirk study area, 2014–2020.

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
2014	8	11 (9)	9 (11)	1	1	1	0
2015	31	267 (1)	14 (21)	1	1	0	1
2016	166	529 (10)	155 (35)	40	13	9	4
2017	292	1035 (15)	275 (58)	76	20	15	5
2018	372	1575 (18)	482 (58)	103	26	15	11
2019	413	1535 (14)	417 (52)	114	26	14	12
2020	442	1460 (--)	549 (--)	--	--	--	--
Total[2]	459[3]	4952 (14)	1352 (53)	178[3]	40[4]	22[4]	18[4]

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

[2]Totals are through 2019. 2020 genetic results from the lab are not yet complete.

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

[4]Some individuals captured multiple times among years.

Table 7. Grizzly bear hair snagging corrals and success in the Selkirk Mountains study area, 2013–2020. DNA genetic results not yet complete for 2020 samples.

Year	Number of sites	Sites with grizzly bear DNA(%[1])	Sites with grizzly bear photos or DNA(%[1])	Individual grizzly bear genotypes	BMUs with grizzly bear pictures or hair	Comments
2013	29	0(3)	4(17)	0	Blue-Grass, Long-Smith, State Land, Sullivan-Hughes, Kalispel-Granite	
2014	47	4(9)	13(28)	4	Blue-Grass, Long-Smith, State Land, Sullivan-Hughes, Kalispel-Granite, Le Clerc, Myrtle	Female with cubs Blue-Grass, Long-Smith, Myrtle
2015	189	20(11)	28(15)	20	Blue-Grass, Long-Smith, State Land, Sullivan-Hughes, Le Clerc, Myrtle	Female with cubs Blue-Grass, Le Clerc
2016	181	12(7)	19(10)	14	Blue-Grass, Long-Smith, State Land, Sullivan-Hughes, Kalispel-Granite, Le Clerc, Myrtle	Female with young Long-Smith Female with cubs Blue-Grass
2017	121	21(17)	32(26)	26	Blue-Grass, Long-Smith, State Land, Sullivan-Hughes, Le Clerc, Myrtle	Female with young Blue-Grass, Long-Smith, Le ClercFemale with cubs Blue-Grass, Long-Smith, State Lands, Myrtle
2018	129	23(18)	31(24)	28	Blue-Grass, Long-Smith, State Lands, Sullivan-Hughes, Le Clerc, Myrtle, Trout-Ball	Female with young Blue-Grass, Long-Smith, Le Clerc, MyrtleFemale with cubs Blue-Grass, State Lands, Le Clerc
2019	118	23(19)	28(24)	23	Blue-Grass, Long-Smith, State Lands, Sullivan-Hughes, Le Clerc, Myrtle	Female with young Blue-Grass, Long-Smith, State Lands Female with cubs Blue-Grass, Long-Smith
2020	93	--	21(23)[2]	--	Blue-Grass, Long-Smith, Le Clerc, Myrtle	Female with young Blue-Grass. Female with cubs Blue-Grass, Long-Smith, Myrtle
Total	907	103	176	60 [3]		

[1]Percent success out of total number of sites deployed within the year

[2]Numbers represent sites with photos only. Awaiting 2020 genetic results.

[3]Some individuals captured multiple times among years.

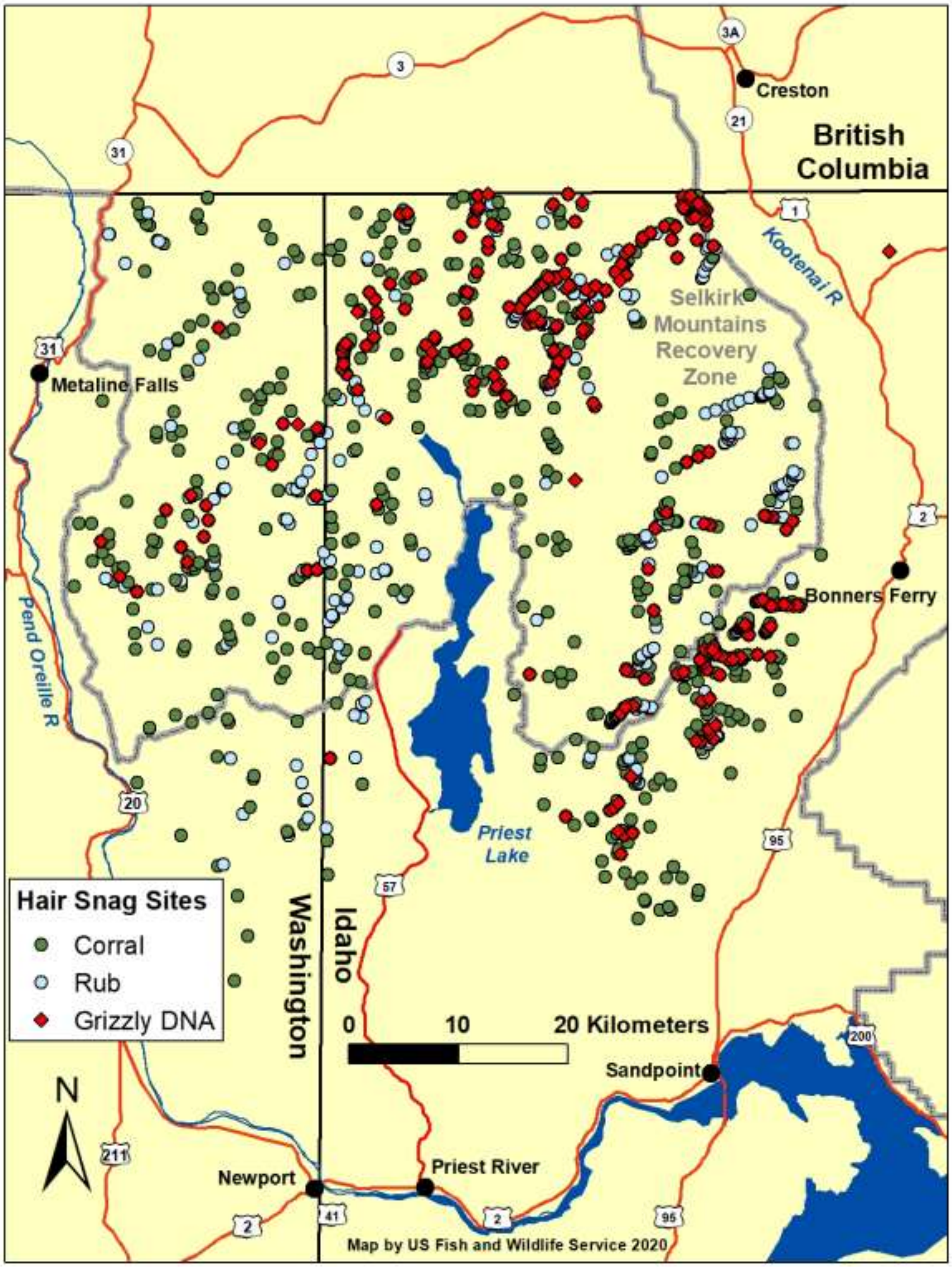

Figure 5. Location of hair snag corral and rub sampling sites in the U.S. Selkirk Mountains, 2007–2020. "Grizzly DNA" represents a site where collected hair was genetically identified as grizzly bear.

Movements and Gene Flow

The SE population was previously identified as having low genetic diversity as determined by heterozygosity calculations (*H*=0.54, Proctor *et al*. 2012). This 2007 level was among the lowest of all interior North American grizzly bear populations. Low heterozygosity was believed to be the result of a small remnant population that has grown by reproduction with little emigration and gene flow from adjacent populations. Capture, telemetry, and genetic data were analyzed to evaluate movement and subsequent reproduction resulting in gene flow into and out of the SE from 1983–2020. Twenty grizzly bears were identified as immigrants or emigrants. While movement and gene flow out of the SE may benefit other populations, gene flow into the SE is most beneficial to genetic health. Nine individuals (7 males and 2 females) are known to have moved into the SE from adjacent populations; however, two males and one female were killed or removed (Figure 6). Known gene flow has been identified through reproduction by two immigrants (two males) resulting in 9 offspring in the SE (Appendix Table T1). Additional analysis of changes in heterozygosity and other genetic measures is planned.

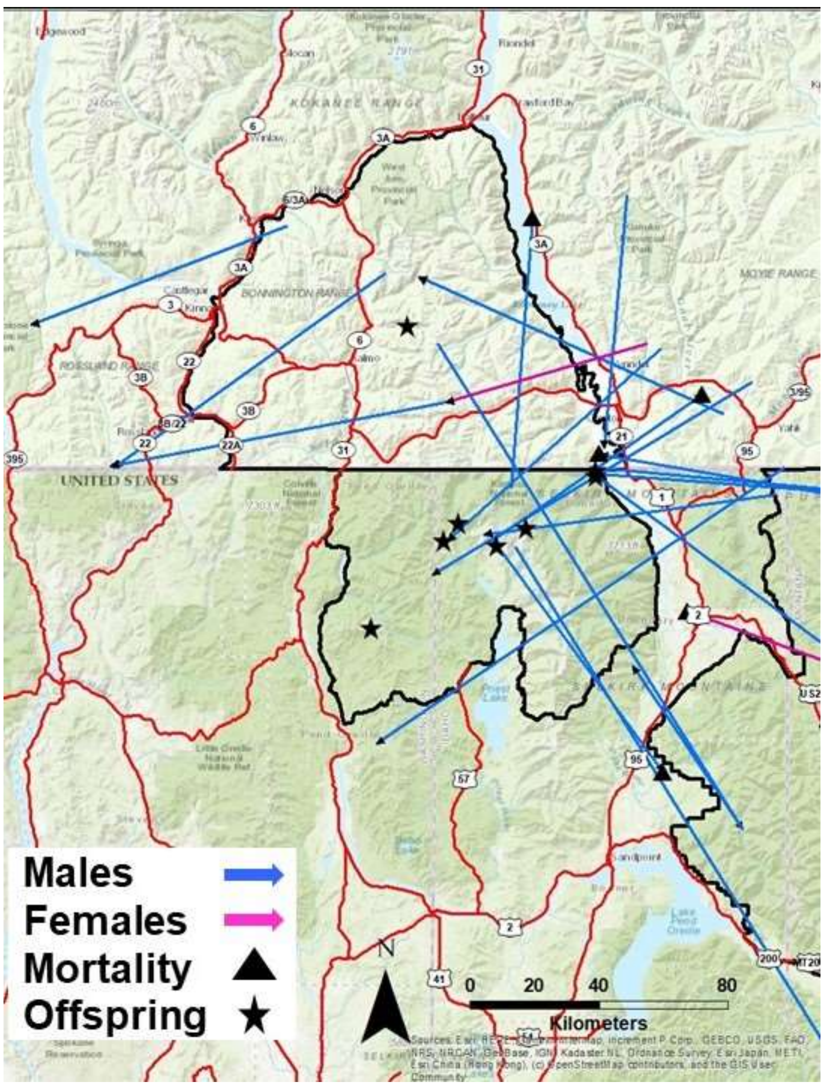

Figure 6. Known immigration and gene flow into the Selkirk Mountains, 2000–2020.

Known Grizzly Bear Mortality

In 2020 there were two known human-caused grizzly bear mortalities (one female and one male) and no known natural mortalities (2 US and 0 BC). Eighty-nine instances of known and probable grizzly bear mortality were detected inside or within 16 km of the U.S. SE and the BC South Selkirk grizzly bear population unit during 1980–2020 (Tables 2 and 8, Figure 3 and 7). Seventy-three were human caused, 11 were natural mortality, and 5 were unknown cause. Fifty-four occurred in BC, 27 in Idaho, and 8 in Washington. Seventy-nine individuals were of known sex and age (Table 8). Seventeen were adult females, 18 adult males, 6 subadult females, 18 subadult males, 10 yearlings, and 12 cubs. Mortality causes (frequency) were management removal (36), natural (11), unknown but human-caused (10), poaching (7), mistaken identity (7), BC legal hunting (5), unknown (5), vehicle/train collision (5), and defense of life (3). Nineteen mortalities occurred in spring (April 1 to May 31), 22 in summer (June 1 to August 31), 44 in autumn (September 1 to November 30), and 4 on unknown dates.

Table 8. Cause, timing, and location of known or probable grizzly bear mortality in or within 16 km of the Selkirk Mountains recovery zone (with South Selkirk Population Unit), 1980–2020.

	Mortality cause									
Age / sex / season / ownership	Defense of life	Legal Hunt	Management removal	Mistaken identity	Natural	Poaching	Vehicle/Train Collision	Unknown, human	Unknown	Total
BC Adult female	1	1	6		3		2	1		14
US Adult female				2		1				3
BC Subadult female			2			1		1		4
US Subadult female				1			1			2
BC Adult male	1	2	6			1	1	1		12
US Adult male				1		2		3		6
BC Subadult male		2	6	1						9
US Subadult male	1		3	1			1	3		9
BC Yearling			3		1					4
US Yearling				1	3				2	6
BC Cub			6							6
US Cub					4	2				6
BC Unknown			4						1	5
US Unknown								1	2	3
Total	3	5	36	7	9	7	5	10	5	89
Season[1]										
Spring		4	8	1		1	1	2	2	19
Summer		1	7		7	1	4	2		22
Autumn	3		21	6	3	5		4	2	44
Unknown					1			2	1	4
Ownership										
BC Private			30		1			1		32
BC Public	2	5	3	1	3	2	3	2	1	22
US Private			3	1			1	2		7
US Public	1			5	7	5		4	4	28

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

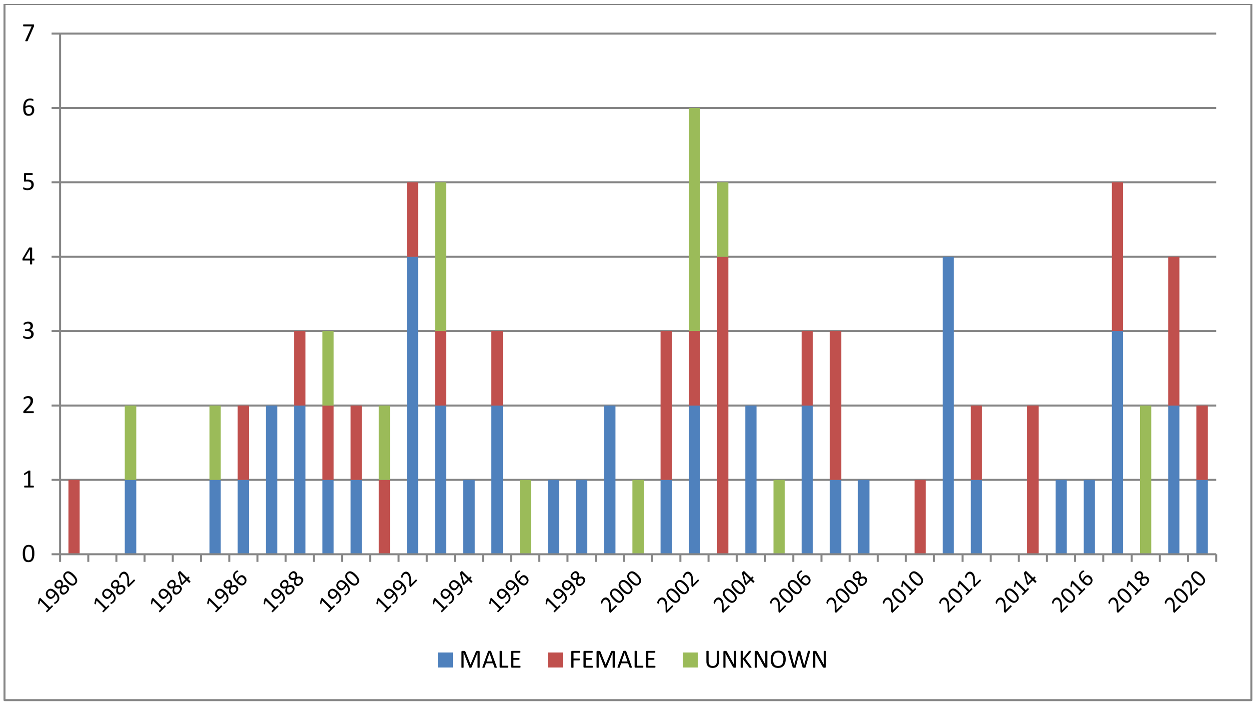

Figure 7. Known grizzly bear annual mortality from all causes in Selkirk Mountains recovery area (including Canada), 1980–2020.

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 six sex and age classes of native grizzly bears from 1983–2020 (Table 9). We calculated survival and mortality rates for management bears separately (see below).

Table 9. Survival and cause-specific mortality rates of native grizzly bear sex and age classes based on censored telemetry data in the Selkirk Mountains recovery zone, 1983–2020.

	Demographic parameters and mortality rates					
Parameter	Adult female	Adult male	Subadult female	Subadult male	Yearling	Cub
Individuals / bear-years	46 / 102.4	39 / 47.7	20 / 17.3	25 /23.3	37 / 22.8	44 / 44
Survival[b] (95% CI)	0.912 (0.857–0.967)	0.941 (0.872-1.0)	0.907 (0.782–1.0)	0.923 (0.818-1.0)	0.833 (0.680–0.986)	0.886 (0.754-0.962)
Mortality rate by cause						
Natural	0.024	0	0	0	0.131	0.091
Defense of life	0.008	0	0	0	0	0
Mis-ID	0.008	0	.046	0.039	0	0
Management	0	0	0.048	0	0	0
Poaching	0.010	0041	0	0	0	0.023
Unknown human	0.011	0.018	0	0.038	0	0
Unknown	0.009	0	0	0.	0	0
Unknown probable	0.017	0	0	0	0.036	0

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

Management Grizzly Bear Survival and Cause-Specific Mortality

Kaplan-Meier survival rates were calculated for 18 adult or subadult management grizzly bears from 1983–2019. Fourteen bears were males aged 2–16 and four were females aged 6–13. Four dependent cubs of unknown sex were not included in the analysis. Survival rate for males was 0.410 (95% CI=0.177–0.643) with three instances of management removal, two unknown but human-caused mortality, one legal hunt mortality, and one probable mortality among 14 radio-collared bears monitored for 7.1 bear-years. Survival rate for females was 0.857 (95% CI=0.598–1.0) with one instance of management removal among 4 radio-collared bears monitored for 6.3 bear-years.

Grizzly Bear Reproduction

Reproductive parameters originated from all bears monitored from 1983–2020. Mean age of first parturition among 12 female grizzly bears was 6.3 years (95% CI=5.9–6.6, Table 10). First age of parturition was determined by observation of radio-collared bears and genetic parentage analysis and known age of offspring. Twenty-nine litters comprised of 63 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=1.97–2.37, Table 10). Nineteen reproductive intervals were determined through both monitoring radio-collared bears and known genetic parentage analysis paired with remote camera observation (Table 10). Mean inter-birth interval was calculated as 3.42 years (95% CI=3.11–3.73). 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 0.307 female cubs/year/adult female (95% CI=0.265–0.357, *n* = 27 adult females, Table 11). In all calculations, the sex ratio of cubs born was assumed 1:1.

Table 10. Grizzly bear reproductive data from the Selkirk Mountains 1985–2020.

Bear	Year	Age	Age at first reproduction	Reproductive Interval[1]	Cubs	Cubs (relationship and fate, if known)
867	1985	7	7	2	2	♀ 898
867	1987	9		3	2	♀ 1042, ♂ 1077
867	1990	12		3		
867	1993	15			2	♀ 867 killed
1000	1995	5	5		2	
1000	2001	11			3	♂ 28 one of 3 cubs
1015	1987	7	7	3	2	♂ 1090, ♂ 1091
1015	1990	10			2	
1024	1997	6	6		2	
1029	1998	6	6	3	2	cubs became ♀ 4 and ♂ 10
1029	2001	9		3	2	2 cubs
1029	2004	12		3		At least 2 cubs ♀ 4208, ♀ 2003
1029	2007	15		3		At least 2 cubs ♂ 4327, ♀ S11649F
1029	2010	18		3	3	1029C, 1029D, ♂ S20918M
1029	2013	21		3		At least 2 cubs ♂ S11514M, ♀ S21947F
1029	2016	24		5		At least 2 cubs
1027	1996	6	6		2	2 cubs

Bear	Year	Age	Age at first reproduction	Reproductive Interval[1]	Cubs	Cubs (relationship and fate, if known)
1045	1989	9			2	
1047	1989	11			2	2 cubs
1056	1987	7		4	3	3 cubs
1076	1989	20+			2	2 cubs
1084	1985	16		4	2	2 cubs
1087	1989	9			3	
1089	1992	7	7		3	3 cubs
9809	2000	12			1	
2003	2010	6	6	4		At least ♀ S3021F
2003	2014	10		3		2 cubs ♀ 19021F, ♂ 16521M
2003	2017	13			3	3 cubs at capture 7/24/17
2008	2003	6	6			At least ♀ S2016
2008	2007	10				At least ♀ S796F
2008	2011	14		4		At least one cub
2016	2011	8		4		At least 2 cubs
2016	2015	12		4	2	At least 2 cubs
3017	2017	6	6		3	photo 3 cubs 8/8/17
3021	2017	7	7		2	photo 2 cubs 8/9/17
3023	2014	10			2	observe with 2 cubs 5/15/14
3023	2018	14			2	
1003	2016	6	6	4	1	♂ 1006 at capture
1003	2020				2	
9037	2018	14			2	

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

Population Trend

The estimated finite rate of increase (λ) for 1983–2020 using Booter software with the unpaired litter size and birth interval data option was 1.029 (95% CI=0.959–1.086, Table 11). Finite rate of change over the same period was an annual 2.9% (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 81%.

Finite rates of increase calculated for the period 1983–2002 (λ = 1.019) 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. Annual survival rates for adult and subadult females were 0.935 and 0.878 for the period of 1983–2002, respectively with adult female survival slightly higher and subadult female survival slightly lower than 1983–2020 rates (Table 11). Maintaining or improving survival by reducing human-caused mortality is crucial for recovery of this population (Proctor *et al*. 2004).

Table 11. Booter unpaired method estimated annual survival rates, age at first parturition, reproductive rates, and population trend of native grizzly bears in the Selkirk recovery zone, 1983–2020.

Parameter	Sample size	Estimate (95% CI)	Std Error	Variance (%)[a]
Adult female survival[b] (S_a)	46 / 104.0[c]	0.913 (0.860–0.960)	0.026	19.3
Subadult female survival[b] (S_s)	20 / 16.4[c]	0.901 (0.747–1.0)	0.069	68.8
Yearling survival[b] (S_y)	37 / 22.3[c]	0.834 (0.671–0.961)	0.077	5.6
Cub survival[b] (S_c)[d]	44/44	0.886 (0.796–0.977)	0.047	1.9
Age first parturition (*a*)	12	6.3 (5.9–6.6)	0.172	0.4
Maximum age (*w*)	Fixed	27		
Unpaired Reproductive rate (*m*)[e]	27/19/29[f]	0.306 (0.265–0.357)	0.024	4.0
Unpaired Lambda (λ)	5000 bootstrap runs	1.029 (0.959–1.086)	0.033	

[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.

Capture and Marking

One subadult male, four adult males, and one adult female grizzly bear were captured during research trapping in 2020 (all in the U.S.). Fifty-eight grizzly bears were captured during 1,720 trap-nights in BC and the U.S. during 2007–2020 (Table 12, 13). Sixty-seven individual black bears were captured during these efforts (Appendix Table T2). Largely, we base our trapsite selection, effort, and distribution on known or suspected grizzly bear spatial density, occupancy, DNA monitoring success, and past trap success (Figure 8). There was no research trapping in BC during 2018–2020.

Rates of grizzly bear capture were higher in BC than the U.S. Thirty-seven individual grizzly bears have been captured in BC at a rate of 1 new individual every 16 trap-nights. Rates of capture of grizzly bears in the U.S. were 1 new individual every 62 trap-nights. Rates of capture for black bears were similar in BC and the U.S. at 1 new individual every 25 and 29 trap-nights, respectively. Black bear data are provided for comparison purposes.

Table 12. Research capture effort and success for grizzly bears and black bears within the Selkirk Mountains study areas, 2007–2020.

Area / Year(s)	Trap-nights	Grizzly Bear Captures	Black Bear Captures	Trap-nights / Grizzly Bear	Trap-nights / Black Bear
Selkirks, US, 2012–2020					
ID Total Captures	969	27	34	36	29
WA Total Captures	327	3	11	109	30
US Individual bears[1]	1296	21	44	62	29
Selkirks, BC, 2007–2017					
Total Captures	579	42	28	14	21
BC Individual bears[1]	579	37	23	16	25

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

Table 13. Grizzly bear capture information from the Selkirk Mountain study area, 2007–2020. Multiple captures of a single bear during a given year are not included.

Bear	Capture Date	Sex	Age (Est.)	Mass kg	Location	Capture Type
119	4/21/07	M	19	205	Duck Lake, BC	Research
138	5/20/08	F	2	100	Corn Cr., BC	Research
144	6/16/08	M	12	(205)	Next Cr., BC	Research
150	6/21/08	F	7	71	Elmo Cr., BC	Research
151	6/23/08	F	20	82	Cultus Cr., BC	Research
155	6/27/08	M	11	(170)	Next Cr., BC	Research
149	6/12/09	M	10	216	Wildhorse Cr., BC	Research
161	6/15/09	F	18	82	Wildhorse Cr., BC	Research
163	6/16/09	F	7	(102)	Wildhorse Cr., BC	Research
8005	6/16/09	F	4	(90)	Salmo River, BC	Management, pig feed
165	6/19/09	F	14	(80)	Apex Cr., BC	Research
169	6/23/09	F	20	(80)	Wildhorse Cr., BC	Research
171	6/25/09	F	14	91	Seaman Cr,, BC	Research
177	6/22/10	F	9	84	Hidden Cr., BC	Research
183	6/29/10	F	11	102	Sheep Cr., BC	Research
17	9/17/10	M	3	100	Nelson Golf Course, BC	Management, non-target capture
154	9/18/10	M	(4)	(91)	Summit Cr., BC	Research
7	9/25/10	F	13	132	Nelson Golf Course, BC	Management, grease bin
152	5/26/11	M	10	148	Cottonwood Cr., BC	Research
149	5/31/11	M	12	(205)	Cottonwood Cr., BC	Research
2	8/19/11	M	26	178	Creston Valley, BC	Management, animal feed
174	5/25/12	M	6	84	Cottonwood Cr., BC	Research
166	5/30/12	M	3	56	Cottonwood Cr., BC	Research
170	6/5/12	F	6	130	Salmo River, BC	Management, cat food
183	6/8/12	F	11	--	Lost Cr., BC	Research
156	8/17/12	M	2	125	Creston Valley, BC	Management, fruit trees
12003	8/15/12	F	8	111	Trapper Cr., ID	Research
12008	8/26/12	F	15	114	Trapper Cr. ID	Research
12006	8/29/12	F	2	60	Trapper Cr. ID	Research
221	8/29/12	M	6	149	Creston Valley, BC	Research
226	6/6/13	F	6	115	Creston Valley, BC	Management, frequenting dump
9037	6/11/13	F	(9)	(91)	Creston Valley, BC	Management, animal feed
13017	7/22/13	F	2	58	Trapper Cr., ID	Research
13021	7/30/13	F	3	76	Bugle Cr., ID	Research
13023	7/30/13	F	9	94	Trapper Cr., ID	Research
12016	8/23/13	F	10	104	Grass Cr., ID	Research
232	5/17/14	M	5	130	Apex Cr., BC	Research
174	5/22/14	M	8	116	Apex Cr., BC	Research
234	5/23/14	M	7	75	Ymir Cr., BC	Research
240	5/26/14	M	22	>245	Cottonwood Cr., BC	Research
150	6/14/14	F	14	70	Hidden Cr., BC	Research
248	6/19/14	M	4	93	Apex Cr., BC	Research
250	6/21/14	M	7	123	Wildhorse Cr., BC	Research
14327	6/21/14	M	7	195	Jackson Cr., ID	Research
227	6/24/14	M	8	112	Hidden Cr., BC	Research
229	6/26/14	F	4	72	Apex Cr., BC	Research
4250	10/6/14	F	(6)	(145)	Creston Valley, BC	Research
1019	5/30/15	F	2	100	Creston Valley, BC	Research
1020	6/7/15	F	6	144	Cultus Cr., BC	Research
150	6/13/15	F	14	182	Next Cr., BC	Research
1001	6/20/15	M	6	215	Trapper Cr., ID	Research
247	5/29/16	M	3	79	Creston Valley, BC	Research
1019	5/29/16	F	3	115	Creston Valley, BC	Research
1021	5/31/16	M	11	242	Creston Valley, BC	Research
1024	6/1/16	M	3	74	Creston Valley, BC	Research

Bear	Capture Date	Sex	Age (Est.)	Mass kg	Location	Capture Type
1002	6/29/16	M	8	166	Willow Cr., WA	Research
4-070	8/6/16	F	(10)	(182)	Creston Valley, BC	Research
1003	8/14/16	F	6	128	Boundary Cr., ID	Research
4-011	8/15/16	F	>5	(68)	Kootenay R., BC	Management; fruit trees
4-002	8/15/16	F	(0.5)	(34)	Kootenay R., BC	Management; captured with mother 4-011
4-004	8/15/16	F	(0.5)	(34)	Kootenay R., BC	Management; captured with mother 4-011
1006	5/26/17	M	1	46	Boundary Cr., ID	Research
1028	6/5/17	F	2	58	Corn Cr., BC	Management; garbage
1026	6/5/17	F	2	60	Corn Cr., BC	Management; garbage
1030	6/10/17	F	4	110	Kootenay R., BC	Research
1031	6/14/17	F	(1)	40	Kootenay R., BC	Research
166	6/19/17	M	8	170	Cow Cr., ID	Research
1008	6/21/17	M	1	86	Boundary Cr., ID	Research
1009	6/21/17	M	3	151	Cow Cr., ID	Research
1029	6/25/17	F	25	123	Cow Cr., ID	Research
12008	7/23/17	F	20	113	Trapper Cr., ID	Research
12003	7/24/17	F	13	97	Bugle Cr., ID	Research
1002	6/21/18	M	10	178	W. Branch LeClerc, WA	Research
14327	6/26/18	M	11	216	W. Branch LeClerc, WA	Research
865	8/16/18	M	3	80	Rathdrum, ID	Management
12003	5/30/19	F	15	110	Cow Crk, ID	Research
9037	6/26/19	F	(12)	169	Boundary Crk, ID	Research
1003	7/25/19	F	9	127	Boundary Crk., ID	Research
1017	7/28/19	M	(4)	118	Boundary Crk., ID	Research
1036	6/18/20	M	(14)	191	Cow Crk, ID	Research
1037	6/20/20	M	(7)	193	Cow Crk, ID	Research
1038	6/28/20	M	(9)	227	Cow Crk, ID	Research
1017	6/30/20	M	6	121	Boundary Crk, ID	Research
1039	6/30/20	M	(4)	162	Boundary Crk, ID	Research
1029	7/26/20	F	28	127	Boundary Crk, ID	Research

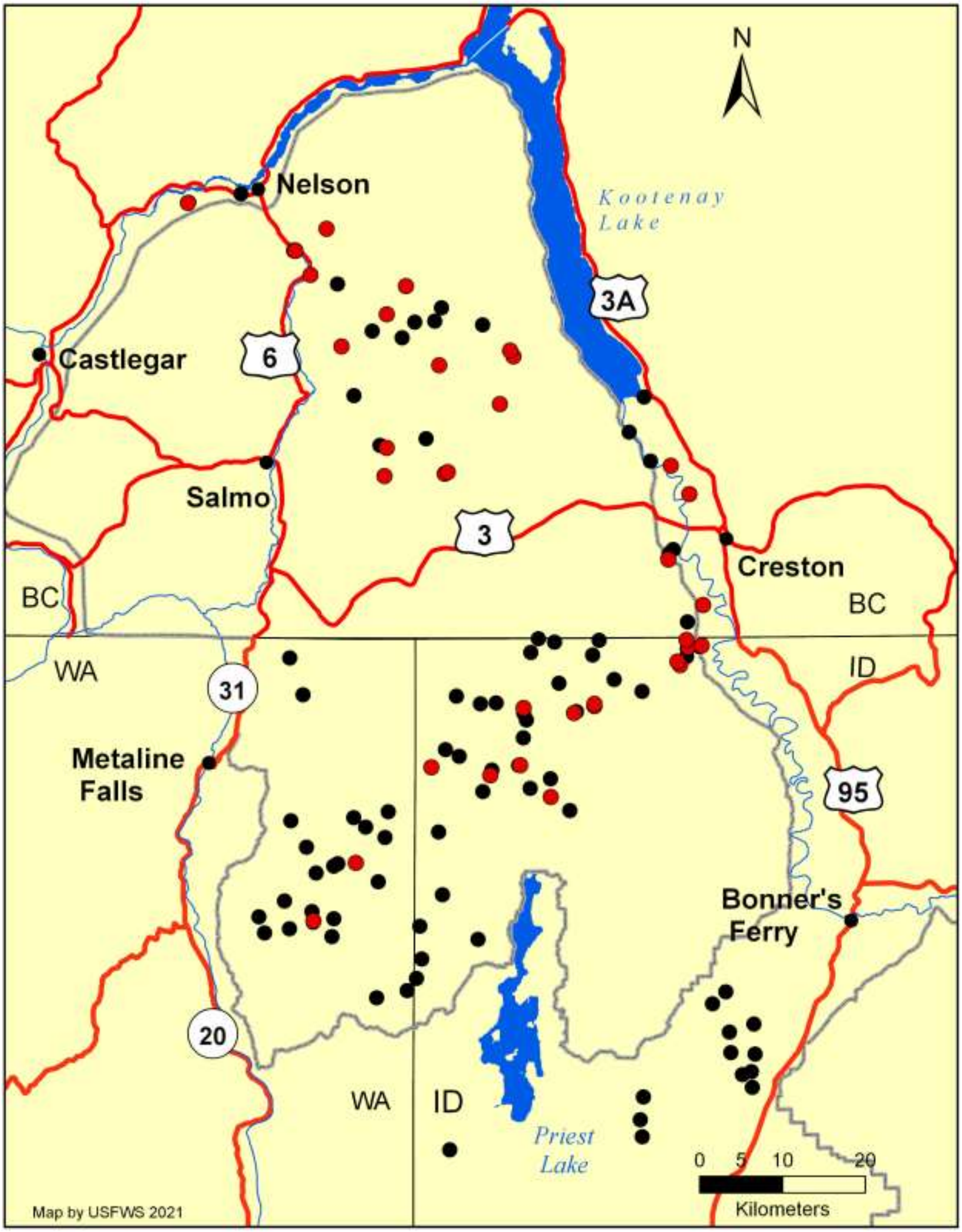

Figure 8. Research trapsite locations in the Selkirk Mountains study area 2007–2020. Red dots represent sites with ≥ 1 grizzly bear capture.

Grizzly Bear Monitoring and Home Ranges

Seven grizzly bears were monitored by GPS radio collars during portions of 2020 in the SE study area. Monitoring included three females (all adults) and four males (2 adults and 2 subadults).

Specific and general locations were obtained on collared bears, but only aerial, specific locations and GPS collar locations were used to calculate home ranges. Convex polygon life ranges were computed for bears monitored during 2007–2020 (Table 14, Appendix, Figs. A1-A48). Multiannual home range estimates and basic statistics were calculated for bears with ≥ 5 months of telemetry. Adult male life range averaged 1,425 km^2 (95% CI ± 1,266, n = 16) using the minimum convex polygon. Adult female life range averaged 422 km^2 (95% CI ± 310, n = 17) using the minimum convex polygon estimator.

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 14. Grizzly bear capture information from the Selkirk Mountain study area, 2007–2020. Multiple captures of a single bear during a given year are not included.

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km^2)	Area of use
103	M	3-4	2006-07	GPS	4,872	6,545	Kootenai, & Pend Oreille River, BC, ID, & WA
119	M	19-20	2008-09	GPS	2,115	1,830	Selkirk Mtns., BC
138	F	2-3	2008-09	GPS	3,232	750	Kootenay River, BC
144	M	9	2008	GPS	1,648	883	Selkirk Mtns., BC
7005	M	4	2008	GPS	229	1,144	Selkirk Mtns., BC
150	F	6-14	2008-09, 2014-16	GPS	5,919	1,354	Selkirk Mtns., BC
155	M	11-13	2008-10	GPS	2,175	1,479	Selkirk Mtns., BC
161	F	6-7	2009-10	GPS	2,008	126	Selkirk Mtns., BC
163	F	6-7	2009-10	GPS	4,144	271	Selkirk Mtns., BC
165	F	15-16	2009-10	GPS	416	169	Selkirk Mtns., BC
171	F	15-16	2009-10	GPS	2,740	227	Selkirk Mtns., BC
8005	F	4-5	2009-10	GPS	1,649	4,511	Selkirk Mtns., BC
177	F	9	2010	GPS	486	72	Selkirk Mtns., BC
154	M	4	2010	GPS	396	178	Selkirk Mtns., BC
183	F	9-12	2010, 12-13	GPS	616	362	Selkirk Mtns., BC
7	F	9	2010	GPS	35	75	Selkirk Mtns., BC
17	M	3	2010	GPS	255	106	Selkirk Mtns., BC
152	M	6-7	2011-12	GPS	1,189	340	Selkirk Mtns., BC
149	M	11	2011	GPS	737	2,114	Selkirk Mtns., BC
12003	F	5-7,13-15	2012-13,17-19	GPS	4183	526	Selkirk Mtns, ID
12006	F	2-4	2012-14	GPS	626	532	Selkirk Mtns, ID
12008	F	15-17,20-22	2012-14,17-19	GPS	3,317	849	Selkirk Mtns, ID
221	M	6-7	2012-13	GPS	47	140	Selkirk Mtns., BC
174	M	4-6	2012-14	GPS	972	621	Selkirk Mtns., BC
12016	F	10-13	2013-16	GPS	742	216	Selkirk Mtns, ID
13017	F	2-5	2013-16	GPS	1,707	859	Selkirk Mtns, ID
13021	F	3-5	2013-15	GPS	1,187	1,801	Selkirk Mtns, ID
13023	F	9-11	2013-15	GPS	1,109	472	Selkirk Mtns, ID
226	F	6-9	2013-16	GPS	2,578	482	Selkirk Mtns, Creston Valley, BC

Bear	Sex	Age (Est)	Years	Collar Type	Number of fixes	100% Convex polygon (km²)	Area of use
229	F	3-5	2014-16	GPS	489	71	Selkirk Mtns, BC
232	M	5	2014	GPS	1,354	353	Selkirk Mtns, BC
234	M	7-9	2014-16	GPS	3,560	446	Selkirk Mtns, BC
248	M	4-6	2014-16	GPS	4,418	2,321	Selkirk Mtns, BC
250	M	7-8	2014-15	GPS	3,224	829	Selkirk Mtns, BC
4250	F	(6-7)	2014	GPS	1,722	395	Selkirk Mtns, BC
227	M	8-9	2014-15	GPS	2,227	771	Selkirk Mtns, BC
14327	M	7-12	2014-19	GPS	2,283	3,416	Selkirk Mtns, BC, ID&WA
807	M	4-7	2014-17	GPS	2,568	3,319	Selkirk Mtns, ID&Yaak River, MT
1001	M	6	2015	GPS	1,352	1,357	Selkirk Mtns, BC
1019	F	3-4	2015-16	GPS	894	187	Selkirk Mtns, Creston Valley
1020	F	5-6	2015-16	GPS	3,366	196	Selkirk Mtns, BC
1002	M	9-12	2016,18-19	GPS	5,455	4,321	Selkirk Mtns, BC, ID&WA
1003	F	6-10	2016-20	GPS	8100	678	Selkirk Mtns, ID& Creston Valley BC
1024	M	(2)	2016	GPS	594	80	Selkirk Mtns, Creston Valley, BC
4011	F	(10-12)	2016-18	GPS	2,729	312	Selkirk Mtns, BC
4070	F	(10)	2016	GPS	600	60	Selkirk Mtns, Creston Valley, BC
247	M	3	2016	GPS	601	129	Selkirk Mtns, Creston Valley, BC
1021	M	11	2016	GPS	139	945	Selkirk Mtns, Creston Valley, BC
922[2]	M	4-5	2016-17	GPS	938	2,148	Kootenai Rr., ID Yaak Rr, MT
1006	M	1-2	2017-19	GPS	2,968	8,158	Selkirk Mtns, ID&BC, Yaak & Cabinets, MT
1007	M	8	2017	GPS	118	74	Selkirk Mtns, ID&BC
1008	M	1	2017	GPS	152	52	Selkirk Mtns, ID& Creston Valley BC
1009	M	3	2017	GPS	180	216	Selkirk Mtns, ID&BC
1029	F	25-28	2017-20	GPS	1326	404	Selkirk Mtns, ID
23	M	(3)	2017	GPS	427	114	Selkirk Mtns, BC
865	M	(2)	2018-19	GPS	5.121	4,428	Kootenai Rr., ID Yaak Rr, MT
1017	M	5-6	2019-20	GPS	2492	269	KooteniaRr., ID
9037	F	(12)	2019	GPS	859	138	Selkirk Mtns, Creston Valley, BC
1037	M	(7)	2020	GPS	1025	857	Selkirk Mtns, ID
1038	M	(9)	2020	GPS	3483	741	Selkirk Mtns, & Kootenia Rr, ID&BC
1039	M	(4)	2020	GPS	4639	200	Kootenai Rr., ID Creston Valley, BC

Grizzly Bear Denning Chronology

We used VHF and GPS location data from radio-collared grizzly bears during 1986–2020 to summarize den entry and exit dates by month and week. Den entry dates (*n* = 90) ranged from the first week of October to the second week of December. Ninety-four percent (85) of entries occurred between the 2nd week of October and the 4th week of November (Fig. 9). SE grizzly bears (median entry during 1st week of November) entered dens 1 and 3 weeks earlier than bears in the Cabinet Mountains and Yaak River drainage (Kasworm *et al.* 2021), respectively (median entry during 2nd week of November for Cabinet bears and 4th week of November for Yaak bears). Males typically enter dens one week later than females (Fig. 9). By December 1, 97% of monitored SE grizzly bears had entered winter dens (100% of females, 90% of males; Fig. 10). By this same date, only 61% of Cabinet and Yaak grizzly bears had entered dens (78% of females, 39% of males; Kasworm et al. 2021).

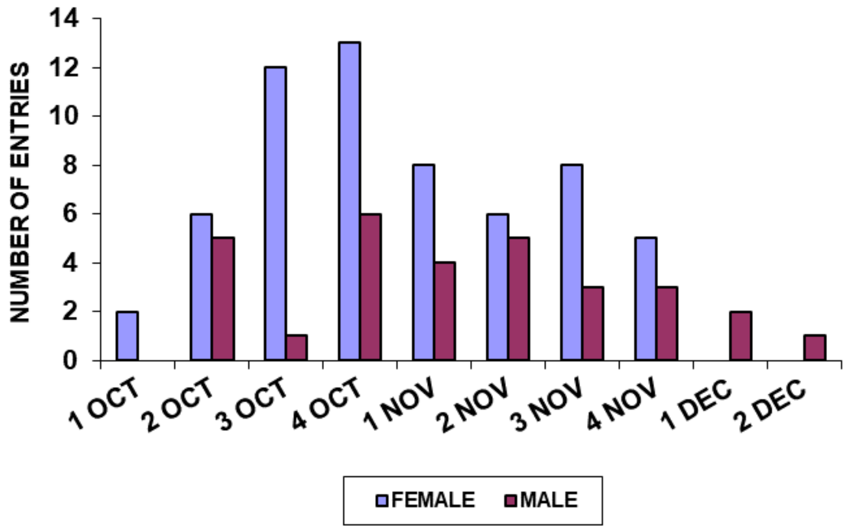

Figure 9. Month and week of den entry for male and female radio-collared grizzly bears in the Selkirk Ecosystem, 1998–2020.

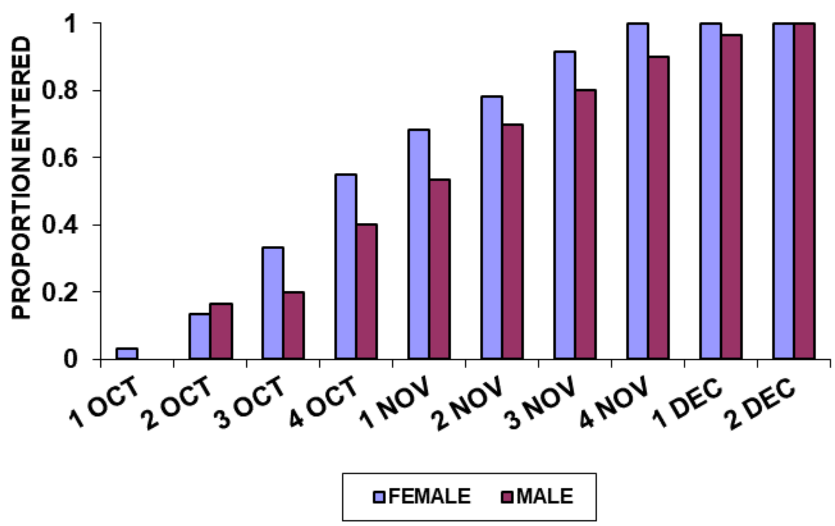

Figure 10. Cumulative proportion of den entries for female and male, radio-collared grizzly bears in the Selkirk Ecosystem, by month and week, 1986–2020.

We have fewer den exit dates for SE radio-collared grizzly bears (*n* = 65), and a majority of emergence data is from female grizzly bears (72%). Exit dates for female SE grizzly bears ranged from the third week of March to the third week of May (median of 4th week in April) (Fig. 11). Exit dates for SE females are typically 1 week later than that of females in the Cabinet Mountains and Yaak drainage (Kasworm *et al*. 2021). Females with cubs exit dens much later than adult females without cubs, with all females with cubs remaining in dens until April 15 (Fig. 12). In fact, 85% of female SE grizzly bears are still in their dens on April 15; less than half (44%) of males are still in dens on that same date (Fig. 13).

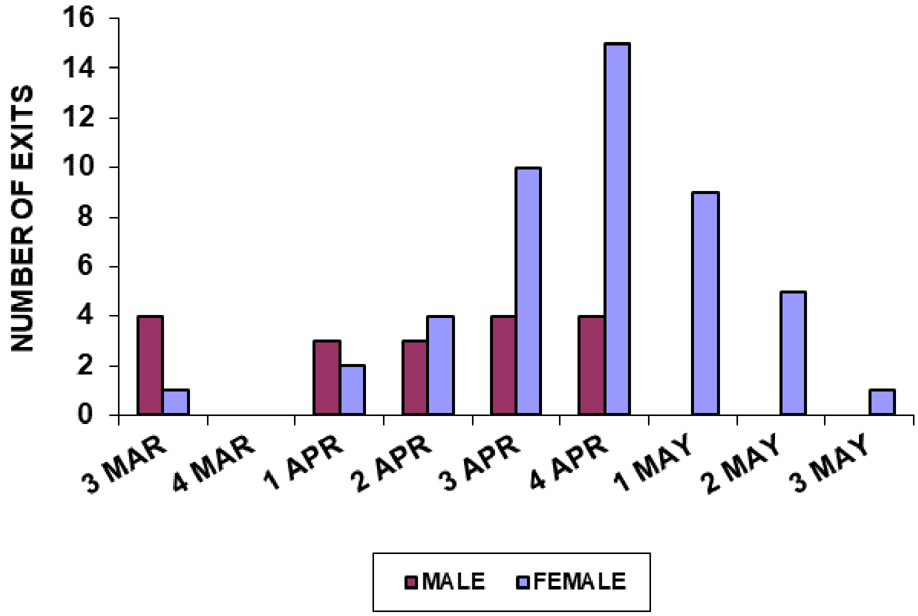

Figure 11. Month and week of den exit for male and female radio-collared grizzly bears in the Selkirk Ecosystem, 2013-2020.

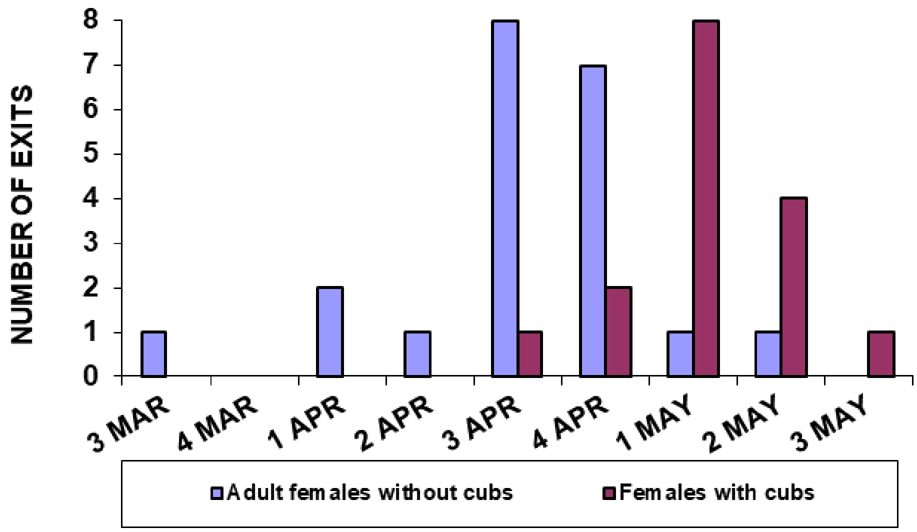

Figure 12. Month and week of den exit for adult female, radio-collared grizzly bears (with and without cubs) in the Selkirk Ecosystem, 1986–2020.

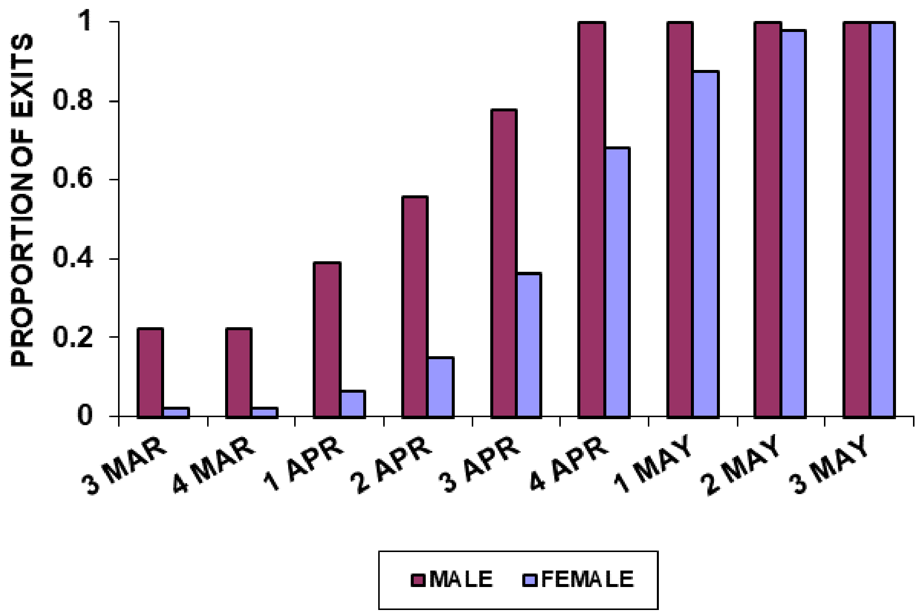

Figure 13. Cumulative proportion of den exits for female and male, radio-collared grizzly bears in the Selkirk Ecosystem, by month and week, 1986–2020.

Grizzly Bear Habitat Analysis

Resource selection functions were utilized to develop seasonal habitat use maps for the Cabinet-Yaak (CYE) and SE 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 and all telemetry data from 1983–2020.

Grizzly Bear Use by Elevation

Differences in elevation between the CYE and SE 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 14). 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.

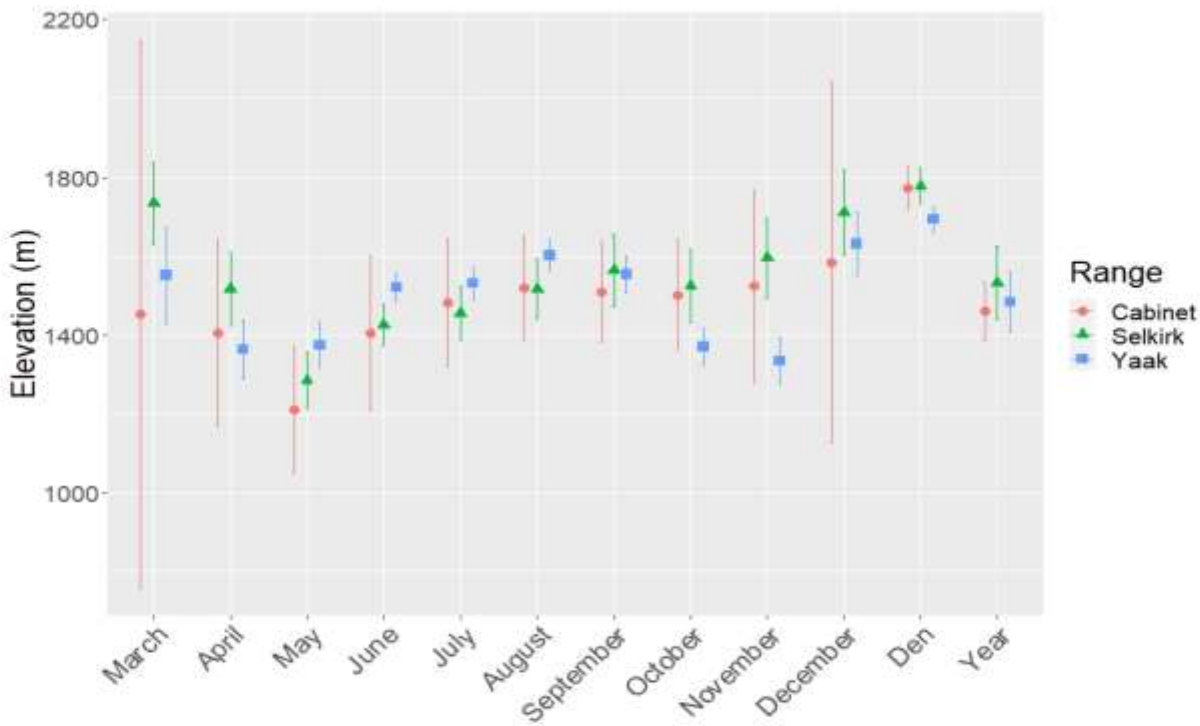

Figure 14. Mean monthly use of elevation for bears in the Cabinet Mountains (*n* = 9) from 1983–2020, the Yaak River (*n* = 58) from 1986–2020, and the Selkirk Mountains (*n* = 93) from 1986–2020 for VHF and GPS collared bears. Error bars represent 95% CI.

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 15). Bears in the Yaak River (*n* = 121,676) and Selkirk (*n* = 99,886) 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 16). 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.

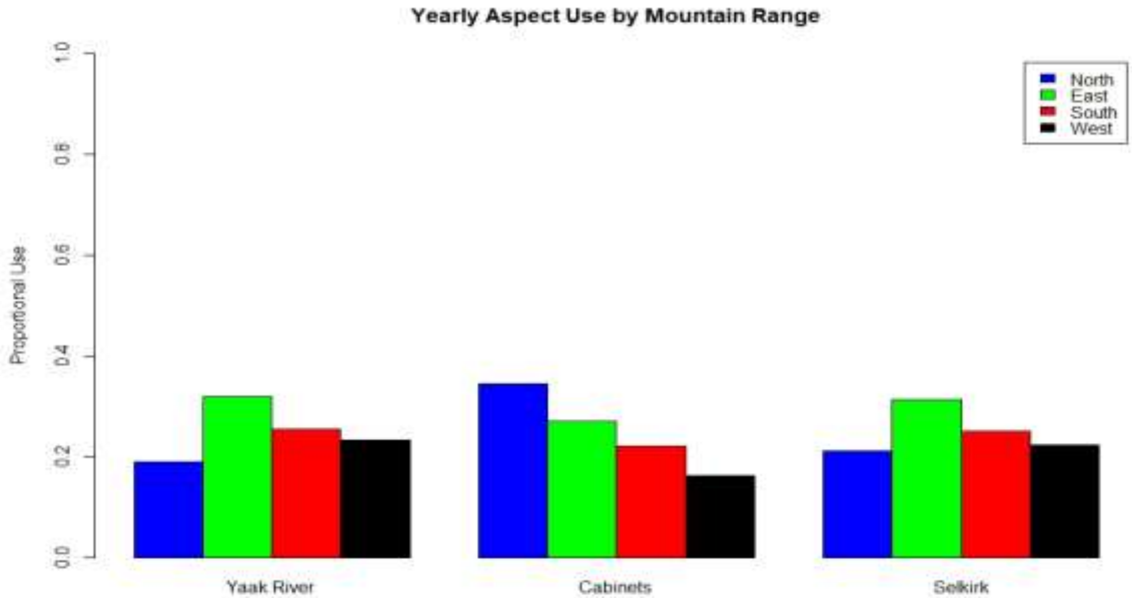

Figure 15. Yearly proportional use of aspect for grizzly bear VHF and GPS locations in the Yaak River from 1986–2020, the Cabinet Mountains from 1986–2020, and the Selkirk Mountains from 1986–2020.

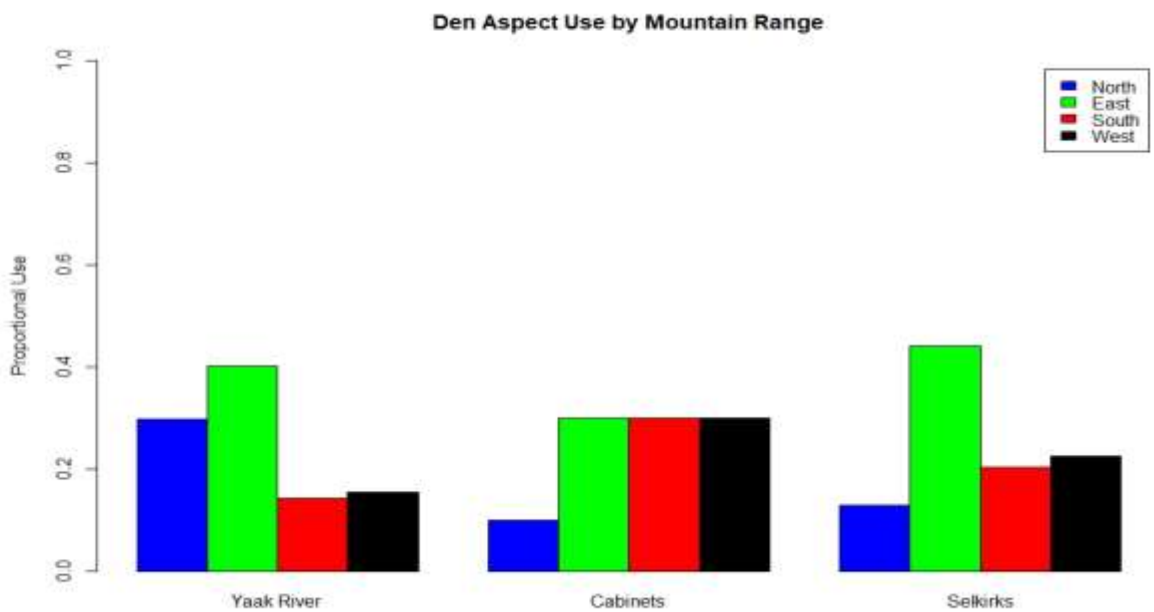

Figure 16. Aspect of grizzly bear dens in the Yaak River from 1986–2020, the Cabinet Mountains from 1983–2020, and the Selkirk Mountains from 1986–2020.

Inter-ecosystem Isotope Analysis

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 in the CYE and SE. Across the SE and CYE, 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 SE (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 contain nearly 22% animal matter (n = 84 hair samples). Adult female use of animal matter varies 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 SE consumed less animal matter than CYE 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, conflict and 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 indication, 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 on 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.

Berry Production

In 2020, SE transect counts were slightly higher than the 2014–2020 average, at 2.3 berries per frame (range = 1.4–3.2; 95% CI = 0.62) (Table 15). Huckleberries are an important summer and early-fall food for SE grizzly bears, as they are high in sugar content and effective in contributing to necessary fat gains for winter denning and reproduction. In an effort to index year-to-year production of huckleberries, we established and evaluated one huckleberry transect in the SE in 2014. In 2015, we established and evaluated four additional transects in the SE. Surveys were repeated on these five sites in 2016–2020 (Fig. 16). In comparison, huckleberry indices in the CYE were strikingly similar as those for the SE in 2020, at 2.5 berries per plot (n = 15 transects; range = 1.3–4.4; Table 15), with both ecosystem indices tracking one another year-to-year (i.e., estimate confidence intervals overlap every year, 2015–2020) (Kasworm *et al*. 2021).

Table 15. Berry production indices (berries per plot) at transect locations within the Selkirk Mountains study area, 2014–2020. At bottom, yearly mean indices and 95% confidence intervals (CI), with comparison to Cabinet-Yaak transects. Selkirk grand average across all transects is 2.2 berries per plot.

	Berries per plot						
Huckleberry transect	2014	2015	2016	2017	2018	2019	2020
Cow Creek	2.2	1.0	1.0	2.9	1.4	2.1	2.6
Caribou Creek	–	1.8	2.4	3.1	1.4	3.0	1.9
East Ruby Creek	–	2.2	3.0	3.7	3.0	2.3	3.2
Pass Creek Pass	–	2.0	1.3	3.6	1.0	1.8	1.4
Bunchgrass Meadows	–	1.5	2.0	2.9	1.9	1.8	2.4
Selkirk Annual Mean (CI)	2.2 (–)	1.7 (0.45)	1.9 (0.79)	3.3 (0.35)	1.7 (0.65)	2.2 (0.47)	2.3 (0.62)
Cabinet-Yaak Annual Mean (CI)	3.4 (1.09)	1.3 (0.33)	1.8 (0.33)	2.8 (0.49)	1.9 (0.32)	2.2 (0.37)	2.5 (0.37)

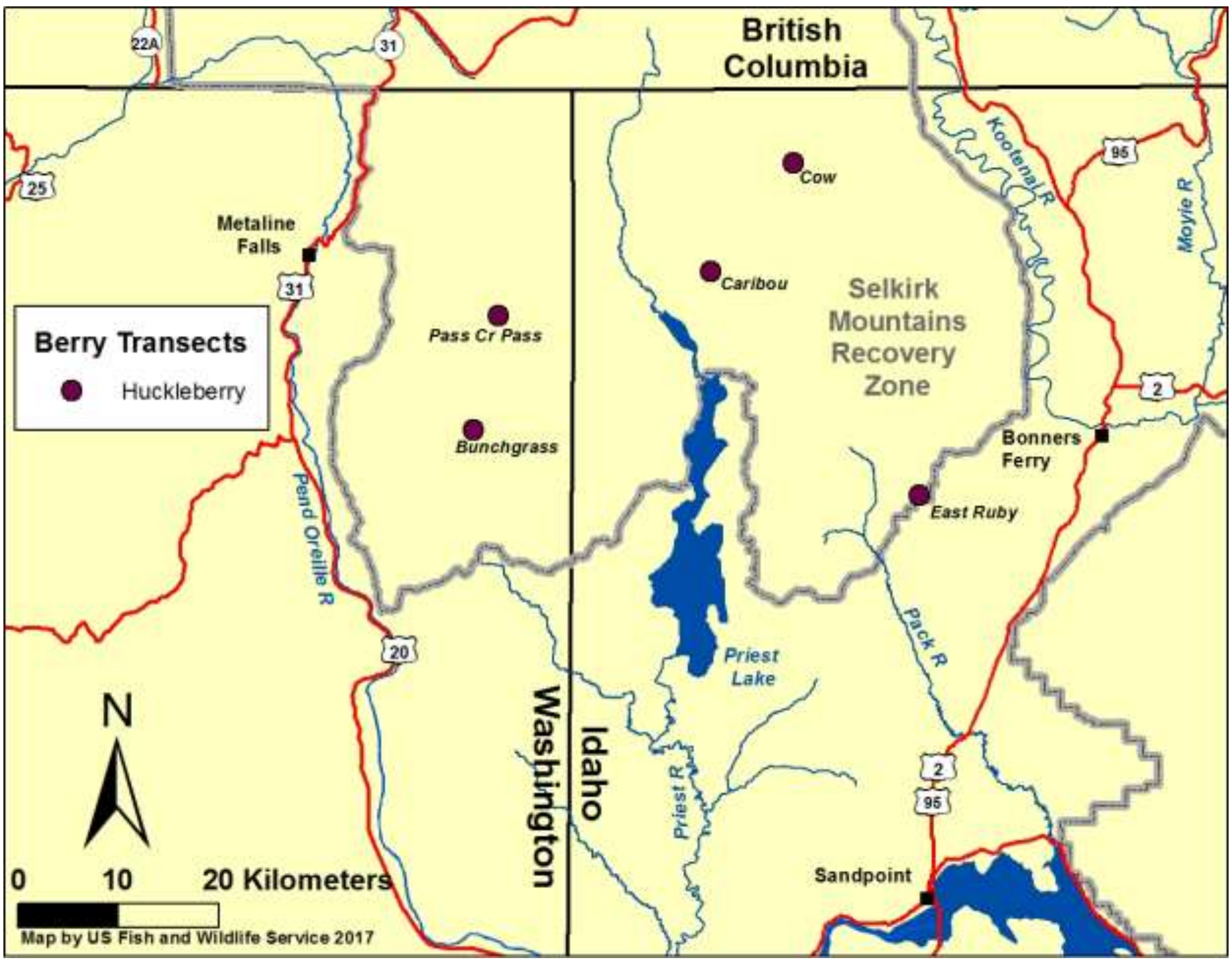

Figure 16. Locations of huckleberry transects surveyed within the Selkirk Mountain study area, 2014–2020.

Body Condition

We estimated body fat content of Cabinet-Yaak and Selkirk (CYS) grizzly bears at 99 independent capture instances, May through November 2010–2019. 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 16). Body fat content of research-captured vs. management-captured grizzly bears also did not differ (P = 0.525; Table 16), 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. 17). Body fat contents 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 more than ~20% to support implantation and winter cub production (Robbins *et al*. 2012).

Table 16. 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

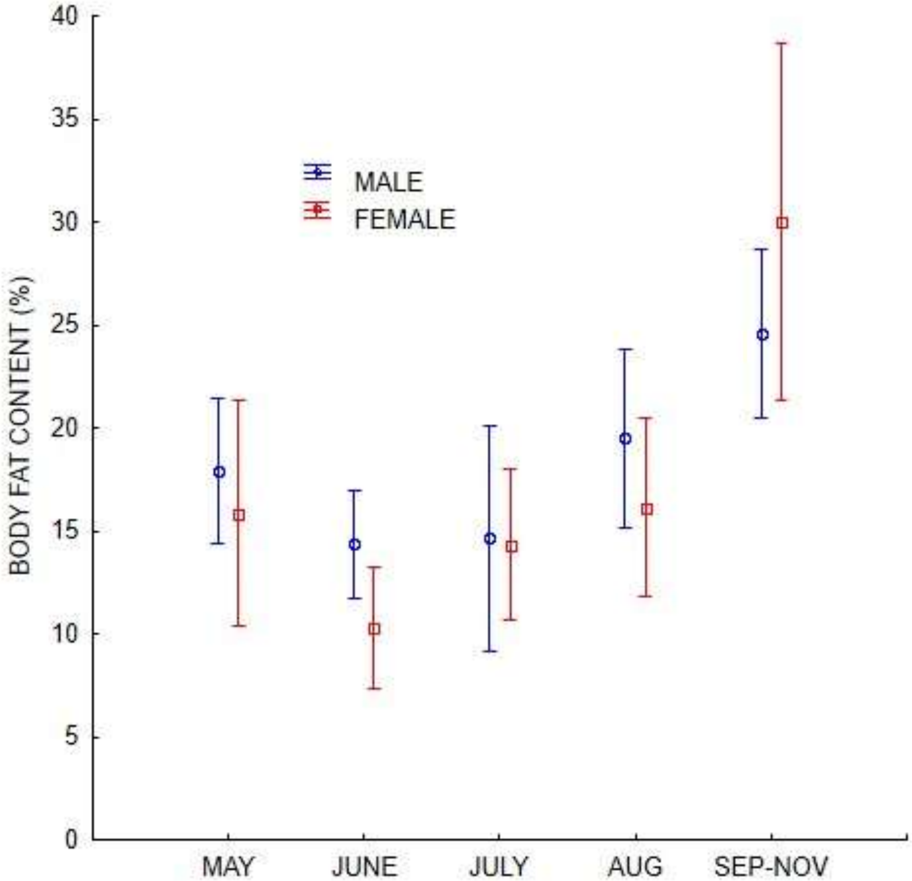

Figure 17. Mean percent body fat content (kg fat / kg body mass) of captured female and male grizzly bears in the Cabinet-Yaak and Selkirk mountains 2010–2019, by month. Error bars represent 95% confidence intervals.

ACKNOWLEDGMENTS

Numerous individuals and agencies have contributed to bear research in the SE since 2012. We are indebted to all of the following that have assisted this study. This study has been aided with administrative assistance from K. Smith and K. Marks. We thank field biologists J. Adams, T. Allen-Johnson, J. Ashley, T. Baldwin, J. Berg, R. Bicandi, A. Crow, K. Dekome, B. Diller, J. Durbin, A. Faircloth, T. Garwood, D. Gatchell, D. Gay, M. Gray, B. George, M. Grode, T. Harrison, J. Harvey, K. Hayes, K. Hennings, K. Hunter, S. Kina, C. Kristovich, T. Larkowski, M. Lucid, M. McKay, N. Merz, D. Misciagna, E. Morrison, W. Parker, A. Prince, S. Sater, M. Sterner, B. Turnock, T. Vent, K. Voll, J. Ware, K. Wasner, and M. Wright for bear capture, photo, and hair collection efforts. C. Harris, L. Harris, D. Paetkau, M. Proctor, and S. Waterhouse provided genetic analysis and interpretation.

Idaho Department of Fish and Game personnel W. Wakkinen, B. Johnson, and B. Moore provided funding, administrative support, field equipment, and previously collected data. Kalispel Tribe Wildlife personnel B. George and Kootenai Tribe of Idaho Wildlife personnel S. Soults provided funding and field support. Washington Department of Fish and Wildlife personnel D. Base and A. Prince provided field and administrative support. Numerous individuals from the U.S. Forest Service have provided agency support and contributed their assistance to this project. These include: L. Allen, L. Bernhardt, M. Borysewicz, J. Durbin, and

B. Lyndaker. N. Cheshire, D. Parker, and T. Wisberg provided exceptional services as aircraft pilots.

The BC Fish Wildlife Compensation Program, BC Habitat Trust Foundation, Columbia Basin Trust, Colville National Forest, Great Northern Landscape Conservation Cooperative, Idaho Department of Fish and Game, Idaho Panhandle National Forest, Kalispel Tribe, Kootenai Tribe of Idaho, Liz Claiborne Art Ortenberg Foundation, National Fish and Wildlife Foundation, Nature Conservancy Canada, Wilburforce Foundation, Yellowstone to Yukon Conservation Initiative, Northern Lights Incorporated, and the U.S. Fish and Wildlife Service provided funding and support for this project.

LITERATURE CITED

Almack, J. A. 1985. An evaluation of grizzly bear habitat in the Selkirk Mountains of north Idaho. M.S. Thesis University of Idaho, Moscow. 87 pp.

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.

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.

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.

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., T. G. Radandt, J.E. Teisberg, A. Welander, M. Proctor, and C. Servheen. 2015. Cabinet-Yaak grizzly bear recovery area 2014 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana. 109 pp.

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

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.

Layser, E. F. 1978. Grizzly bears in the southern Selkirk Mountains. Northwest Science 52:77-91.

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.

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

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

Wakkinen, W. L. and B. K..Johnson. 2004. Selkirk ecosystem project January 2003-December 2003. Idaho Department of Fish and Game, Boise. 24 pp.

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.

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.

Zager, P. 1983. Grizzly bears in Idaho's Selkirk Mountains: an update. Northwest Science 57:299-309.

APPENDIX Table 1. Movement and gene flow to or from Selkirk Mountains recovery area.

Area Start / Finish[1]	Action	Bear ID	Sex	Age	Year	Basis	Comments
NCDE / SSelk	Movement	N14	F	2	2000	Telemetry, capture	Relocated several times in NCDE. Recaptured north of Bonners Ferry, ID relocated to NCDE.
Spur / SSelk	Movement	SOsoM	M	2	2001	Capture, Genetics	Born in SPur but traveled to SSelk. Genetics determine parents in SPur
NPur / SSelk	Movement	S10739F	F	Unk	2005	Genetics	Born in NPur but traveled to SSelk. Genetics determine parents in NPur
NPur / SSelk	Movement	SCptHM	M	19	2008	Telemetry, Genetics	Born in NPur but traveled to SSelk and captured. Genetics determine parents in NPur
SPur / SSelk	Movement	YHydeM	M	3	2006-07	Telemetry	Captured in SPur 2006. Bear traveled to SSelk 2006, denned then lost collar 2007.
KG / NPur	Movement	Wilf(156)	M	4	2012	Capture, Genetics	Traveled from KG in WA to NPur. Management removal 2012
SSelk / Bitt	Movement	B90307M	M	?	2007	Genetic assignment	Killed in Bitterroot September 2007. Genetic analysis indicates origin in SSelk
SSelk / Cabs / SSelk	Movement	928442	M	5	2012	Genetics	Father SSelk S9058aM, Mother SSelk SBettyF, Hair snagged 2012 in Cabs and in SSelk 2015
SSelk / NPur	Movement	S1022M	M	1	1994, 1996	Telemetry, Mortality	Captured in SSelk 1994, Management removal 1996 Boswell, BC NPur.
SSelk / SPur	Movement	S31M	M	6	2004-05	Telemetry, Mortality	Father SSelk SS3KM, Mother SSelk S1MF, Collared 2003 SSelk. Hunter kill 2005 SPur
NPur / SSelk	Movement	PBobM	M	26	2011	Telemetry, Mortality	Collared in NPurs, but recaptured later in SSelk and Management removal 2011
SSelk / KG	Movement	ApexS248M	M	4	2014-15	Telemetry	Radio collared and traveled west to KG from SSelk 2015
SSelk / Cabs	Movement	S1001M	M	6	2015	Telemetry, Mortality	Travel east from SSelk to Cabs. Mortality 2015
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.
NPur / SSelk	Movement	S14151M	M	6	2014	Genetics	Parents both NPur, Father NPur PKiddM, Mother NPur PKellyF
NPur / SSelk	Gene flow	SFoccacia170F	F	6	2012	Genetics	Father NPur SCptHM, Mother SSelk SCulveF
NPur / SSelk	Gene flow	S92231M	M	1	2016	Genetics	Father NPur SCptHM, Mother SSelk JillS226F
NPur / SSelk	Gene flow	S25793M	M	0.5	2016	Genetics	Father NPur SCptHM, Mother SSelk S1029F
NPur / SSelk / Cabs	Gene flow Movement	S21285M	M	0.5-2	2016-18	Genetics, Telemetry	Father NPur SCptHM, Mother SSelk S11675F, S21285M moved to Cabs 2018, dropped collar
NPur / SSelk	Gene flow	S21690M	M	0.5	2016	Genetics	Father NPur SCptHM , Mother SSelk SMaya4208F
NPur / SSelk	Gene flow	S21698M	M	0.5	2016	Genetics	Father NPur SCptHM , Mother SSelk SMaya4208F
SSelk / KG	Movement	9305a	?	Unk	Unk	Genetics	Father SKirkM, Mother SSelk S10991F, Origin of father probably SSelk
SSelk / KG	Movement	JC12-23	M?	Unk	2012	Genetics, Mortality	Father Sunk1M, Mother S10739F both SSelk, Male offspring JC12-23 in KG
SSelk / SPur	Movement	16749	M	2	2015	Genetics	Father C134B2V2, Mother JillS226F both SSelk. Male offspring 16749 in SPur
NPur / SSelk	Gene flow	S28776M	M	Unk	2017	Genetics	Father NPur S14151M, Mother SSelk S2008F
NPur / SSelk	Gene flow	S25506M	M	0.5	2015	Genetics	Father NPur S14151M, Mother SSelk S252F
NPur / SSelk	Gene flow	15124	F	0.5	2015	Genetics	Father NPur S14151M, Mother SSelk S252F

[1]Cabs – Cabinet Mountains, KG - Kettle Granby, 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 Table 2. Black bears captured by study personnel in the Selkirk Ecosystem, 2007–2020.

Bear	Tag Color	Capture Date	Sex	Age (Est.)	Mass kg (Est)	Location	Capture Type
116	BLACK	4/24/2007	M	13	(125)	Corn Cr., BC	Research
118	BLACK	4/26/2007	M	3	(57)	Corn Cr., BC	Research
120	BLACK	4/28/2007	M	UNK	163	Corn Cr., BC	Research
120	BLACK	4/30/2008	M	UNK	(136)	Corn Cr., BC	Research
118	BLACK	4/30/2008	M	(4)	(73)	Duck Lake, BC	Research
136	BLACK	5/17/2008	M	(6)	(79)	Leach Cr., BC	Research
146	BLACK	6/17/2008	M	UNK	(59)	Cultus Cr., BC	Research
148	BLACK	6/20/2008	M	UNK	76	Laib Cr., BC	Research
142	BLACK	6/21/2008	M	UNK	(68)	Cultus Cr., BC	Research
153	BLACK	6/24/2008	M	UNK	67	Elmo Cr., BC	Research
143	BLACK	5/17/2009	M	20	(109)	Corn Cr., BC	Research
145	BLACK	5/24/2009	UNK	UNK	(79)	Corn Cr., BC	Research
143	BLACK	5/27/2009	M	20	(109)	Dodge Cr., ID	Research
401	GREEN	6/22/2011	F	5	56	Fall Cr., ID	Research
403	GREEN	6/26/2011	F	9	79	Fall Cr., ID	Research
405	GREEN	6/29/2011	M	4	58	Fall Cr., ID	Research
407	GREEN	7/13/2011	M	2	47	Dodge Cr., ID	Research
409	GREEN	7/15/2011	M	3	54	Trail Cr., ID	Research
411	GREEN	7/18/2011	M	2	52	Fall Cr., ID	Research
417	GREEN	7/21/2011	M	UNK	37	Fall Cr., ID	Research
8006	GREEN	8/18/2011	F	2	41	Roman Nose Cr., ID	Research
155	GREEN	9/19/2011	F	8	(73)	Dodge Cr., ID	Research
165	GREEN	9/25/2011	M	11	139	SF Dodge Cr., ID	Research
160	BLACK	5/26/2012	M	4	(68)	Blewett Cr., BC	Research
2001	GREEN	5/29/2012	M	11	95	Fedar Cr., ID	Research
162	BLACK	5/29/2012	M	3	60	Blewett Cr., BC	Research
2005	GREEN	8/23/2012	M	3	61	Abandon Cr., ID	Research
3016	GREEN	7/21/2013	M	10	74	Hughes Meadows, ID	Research
3019	GREEN	7/22/2013	M	4	49	Upper Priest Rv., ID	Research
3020	GREEN	7/29/2013	M	3	49	Bugle Cr., ID	Research
3013	GREEN	8/20/2013	F	16	75	Silver Cr., ID	Research
238	BLACK	5/25/2014	M	9	58	Porcupine Cr., BC	Research
236	BLACK	5/25/2014	M	8	90	Clearwater Cr., BC	Research
236	BLACK	6/12/2014	M	6	93	Apex Cr., BC	Research
4326	GREEN	6/13/2014	M	6	61	Jackson Cr., ID	Research
246	BLACK	6/17/2014	M	8	102	Wildhorse Cr., BC	Research
244	BLACK	6/17/2014	M	15	76	Wildhorse Cr., BC	Research
392	RED	6/28/2014	M	(4)	72	Hemlock Cr., WA	Research
388	RED	7/19/2014	M	(6)	96	LeClerc Cr., WA	Research
389	RED	7/25/2014	F	(9)	57	Le Clerc Cr., WA	Research
391	RED	7/26/2014	M	(5)	63	Jungle Cr., WA	Research
390	RED	7/26/2014	F	(4)	61	Sema Meadows, WA	Research
4330	GREEN	8/22/2014	M	8	103	Trapper Cr., ID	Research

Bear	Tag Color	Capture Date	Sex	Age (Est.)	Mass kg (Est)	Location	Capture Type
4331	GREEN	8/24/2014	F	(8)	(79)	Bugle Cr., ID	Research
4332	GREEN	8/26/2014	M	16	105	Trapper Cr., ID	Research
4333	GREEN	8/28/2014	M	3	53	Trapper Cr., ID	Research
4305	GREEN	6/24/2015	F	6	47	Lime Cr., ID	Research
4306	GREEN	7/18/2015	M	(12)	113	Bugle Cr.,ID	Research
4307	GREEN	8/23/2015	M	(7)	(125)	Grass Cr., ID	Research
601	RED	5/27/2016	M	7	88	SF Granite, WA	Research
602	RED	6/9/2016	M	6	74	NF Harvey, WA	Research
603	RED	6/27/2016	M	6	74	Willow Cr., WA	Research
---	---	8/23/2016	---	(1)	(18)	Boundary Cr., ID	Research culvert, not tagged
4308	GREEN	7/17/2017	M	5	62	Bugle Cr., ID	Research
4309	GREEN	7/19/2017	M	4	52	Trapper Cr., ID	Research
4310	GREEN	7/19/2017	M	14	65	Bugle Cr., ID	Research
4329	GREEN	7/21/2017	M	8	63	Trapper Cr., ID	Research
4334	GREEN	7/23/2017	M	3	(68)	Trapper Cr., ID	Research
4335	GREEN	8/1/2017	M	9	96	Trapper Cr., ID	Research
4336	GREEN	8/24/2017	M	(3)	61	Caribou Cr., ID	Research
9050	---	6/18/2018	---	(---)	---	Harvey Cr., WA	Research, grizzly predation
604	RED	6/20/2018	M	(8)	(113)	White Man Cr., WA	Research
605	RED	6/24/2018	M	(10)	101	WB Le Clerc Cr., WA	Research
1014	WHITE	6/19/2019	M	(4)	51	Boundary Cr., ID	Research
4337	GREEN	6/23/2019	M	(3)	68	Grass Cr., ID	Research
4338	GREEN	6/24/2019	M	(4)	72	Boundary Cr., ID	Research
4339	GREEN	7/12/2019	M	(1)	43	Boundary Cr., ID	Research
4340	GREEN	7/14/2019	M	(10)	98	Grass Cr., ID	Research
4341	GREEN	7/16/2019	M	(6)	78	Boundary Cr., ID	Research
4342	GREEN	7/18/2019	M	(14)	80	Grass Cr., ID	Research
4343	GREEN	6/25/2020	M	(10)	90	Saddle Cr.	Research
4344	GREEN	7/21/2020	M	(3)	70	Smith Cr.	Research
4338	GREEN	7/22/2020	M	(6)	88	Boundary	Research

APPENDIX 3. Grizzly Bear Home Ranges

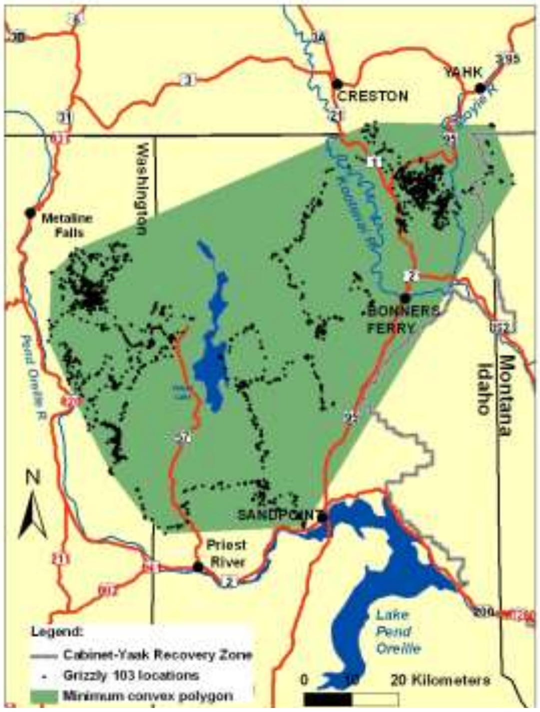

Figure A1. Radio locations and minimum convex (shaded) life range of male grizzly bear 103 in the Yaak River and Selkirk Mountains, 2006–2007.

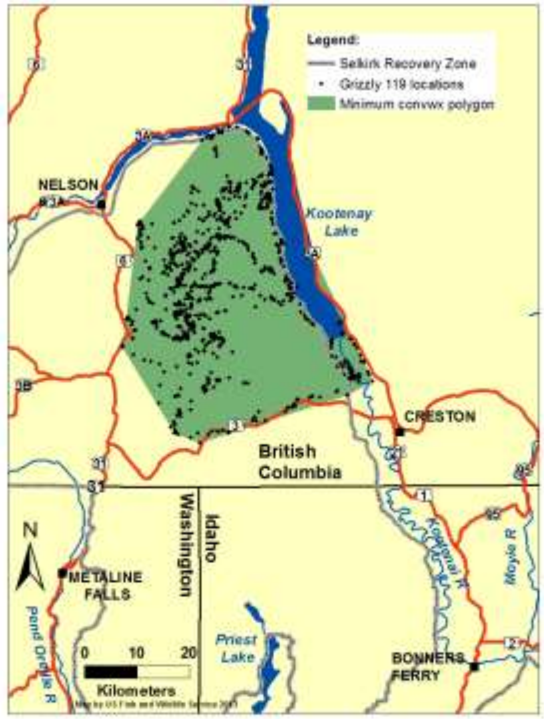

Figure A2. Radio locations and minimum convex (shaded) life range of male grizzly bear 119 in the Selkirk Mountains, 2008–2009.

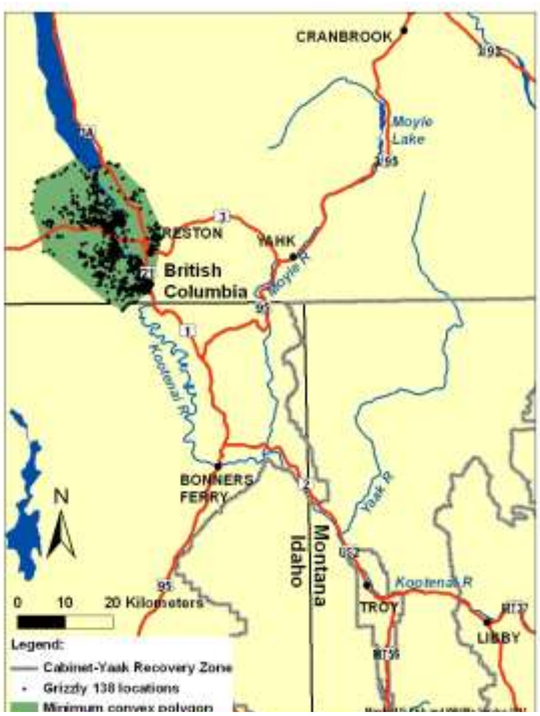

Figure A3. Radio locations and minimum convex (shaded) life range of female grizzly bear 138 in the Selkirk Mountains, 2008–2009.

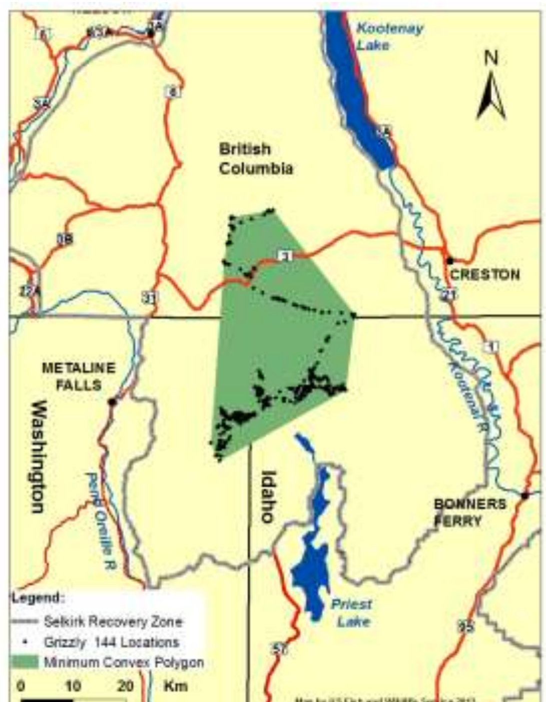

Figure A4. Radio locations and minimum convex (shaded) life range of male grizzly bear 144 in the Selkirk Mountains, 2008.

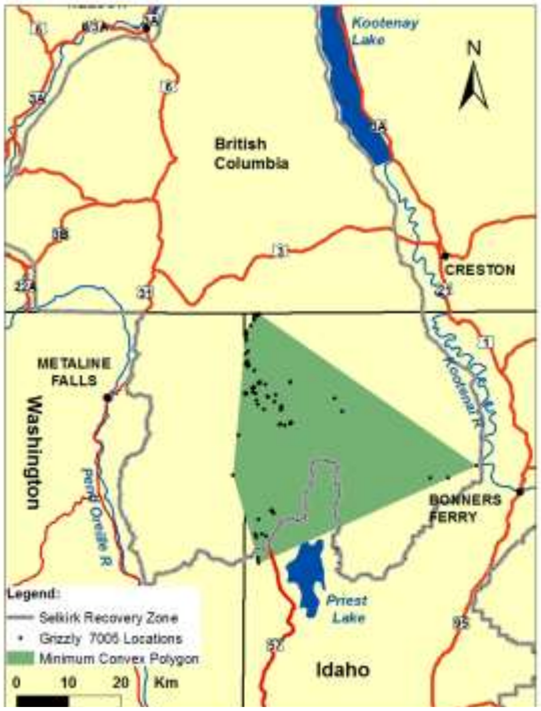

Figure A5. Radio locations and minimum convex (shaded) life range of management male grizzly bear 7005 in the Selkirk Mountains, 2008.

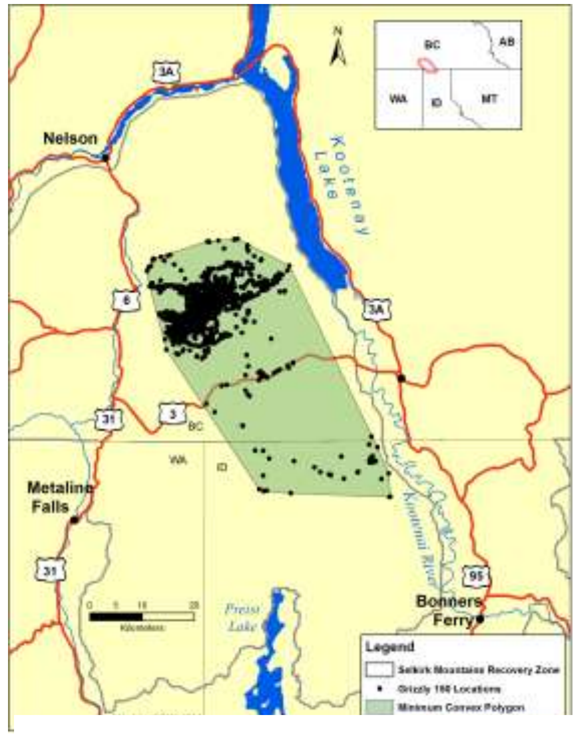

Figure A6. Radio locations and minimum convex (shaded) life range of female grizzly bear 150 in the Selkirk Mountains, 2008–2009, 2014–2016.

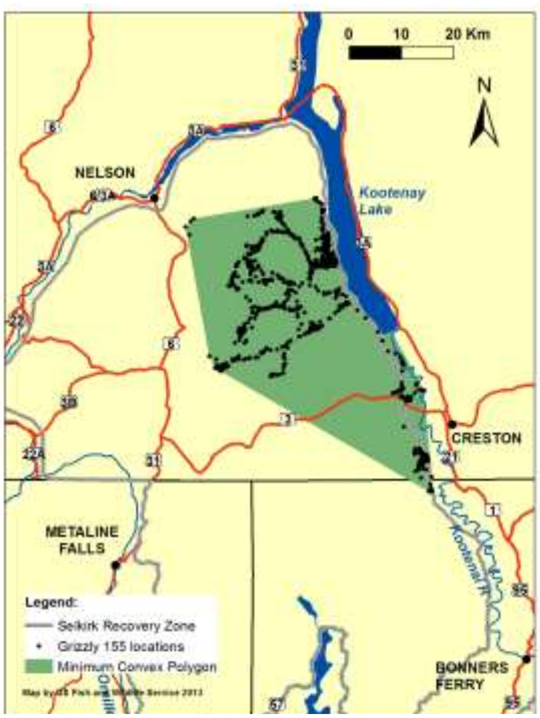

Figure A7. Radio locations and minimum convex (shaded) life range of male grizzly bear 155 in the Selkirk Mountains, 2008–2010.

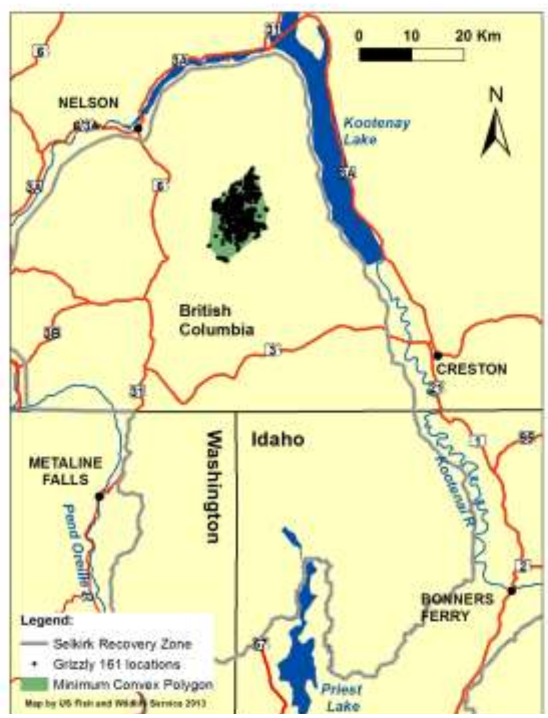

Figure A8. Radio locations and minimum convex (shaded) life range of female grizzly bear 161 in the Selkirk Mountains, 2009–2010.

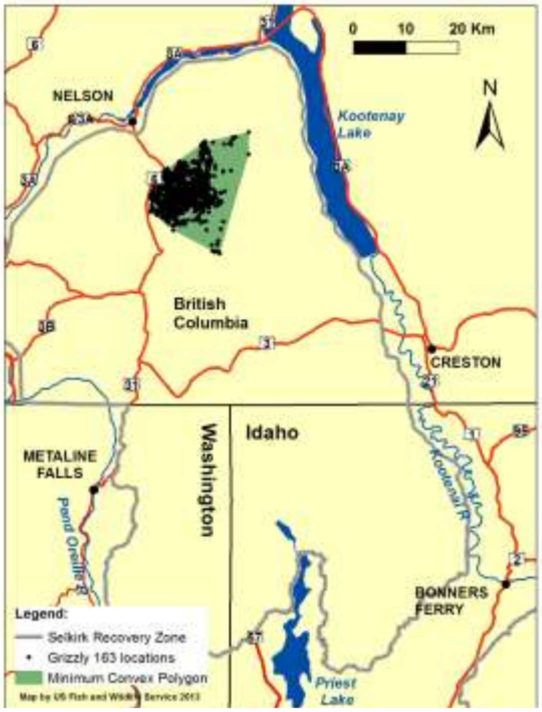

Figure A9. Radio locations and minimum convex (shaded) life range of female grizzly bear 163 in the Selkirk Mountains, 2009–2010.

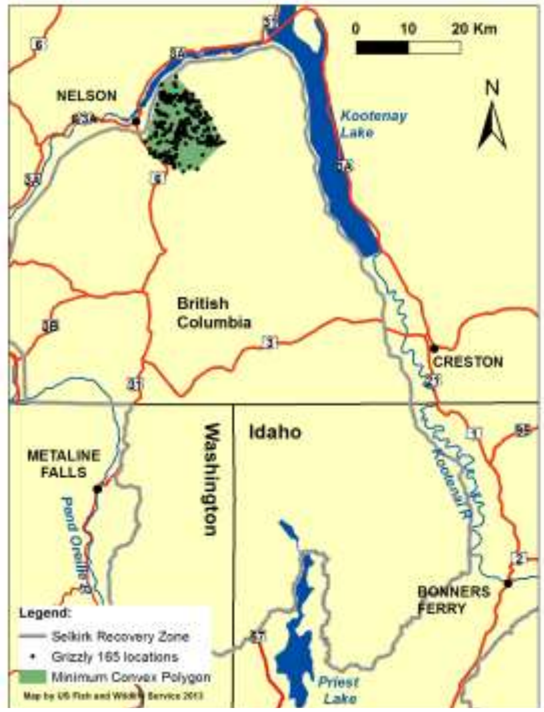

Figure A10. Radio locations and minimum convex (shaded) life range of female grizzly bear 165 in the Selkirk Mountains, 2009–2010.

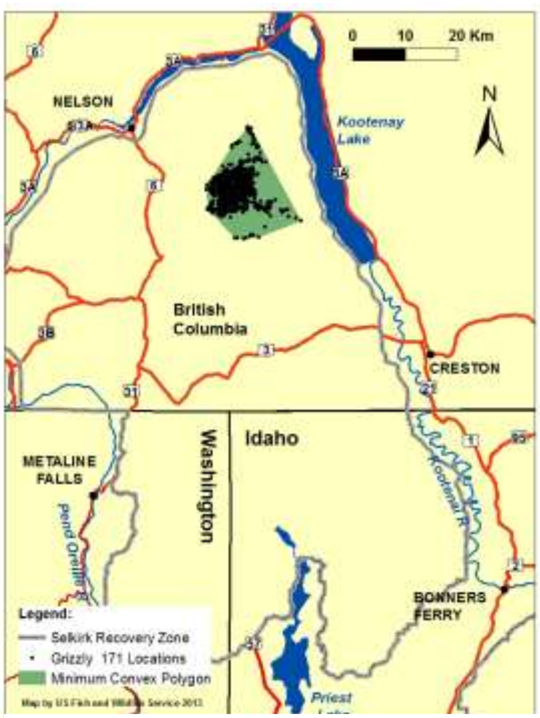

Figure A11. Radio locations and minimum convex (shaded) life range of female grizzly bear 171 in the Selkirk Mountains, 2009–2010.

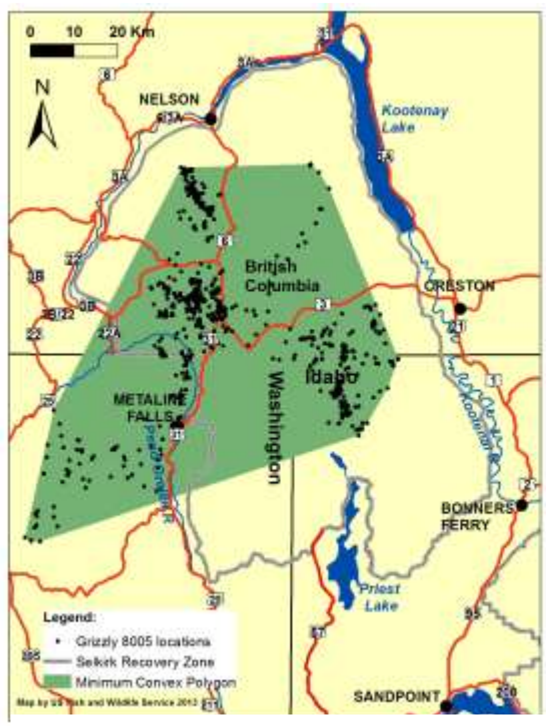

Figure A12. Radio locations and minimum convex (shaded) life range of female grizzly bear 8005 in the Selkirk Mountains, 2009–2010.

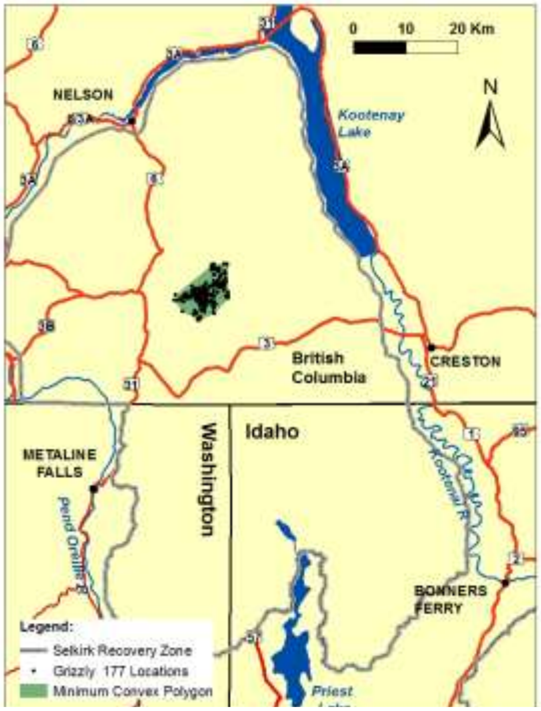

Figure A13. Radio locations and minimum convex (shaded) life range of female grizzly bear 177 in the Selkirk Mountains, 2010.

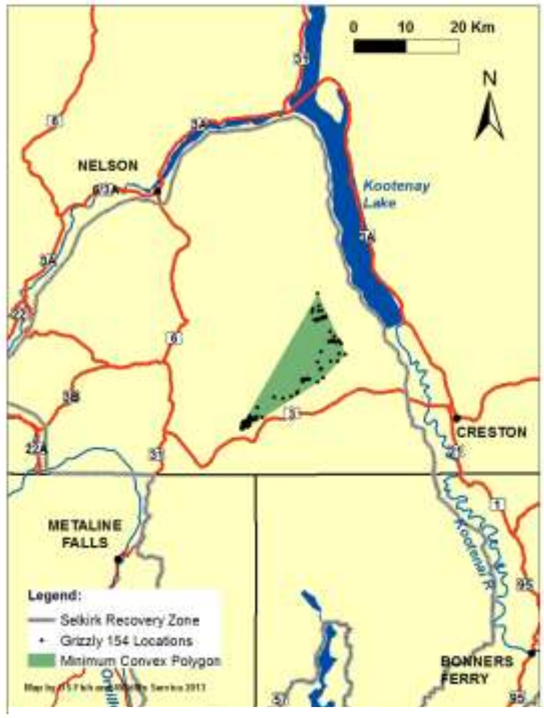

Figure A14. Radio locations and minimum convex (shaded) life range of male grizzly bear 154 in the Selkirk Mountains, 2010.

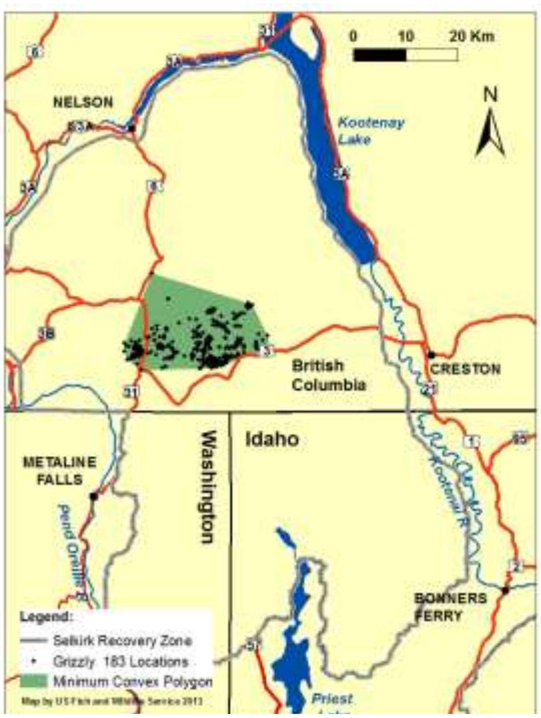

Figure A15. Radio locations and minimum convex (shaded) life range of female grizzly bear 183 in the Selkirk Mountains, 2010 and 2012–2013.

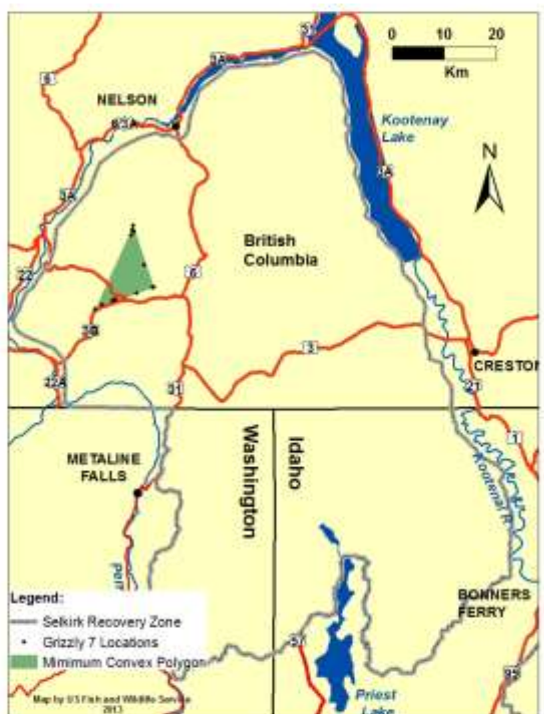

Figure A16. Radio locations and minimum convex (shaded) life range of management female grizzly bear 7 in the Selkirk Mountains, 2010.

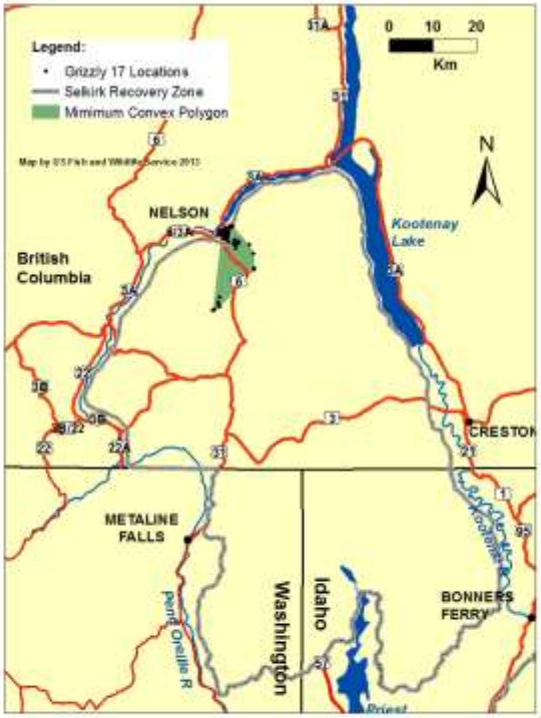

Figure A17. Radio locations and minimum convex (shaded) life range of management male grizzly bear 17 in the Selkirk Mountains, 2010.

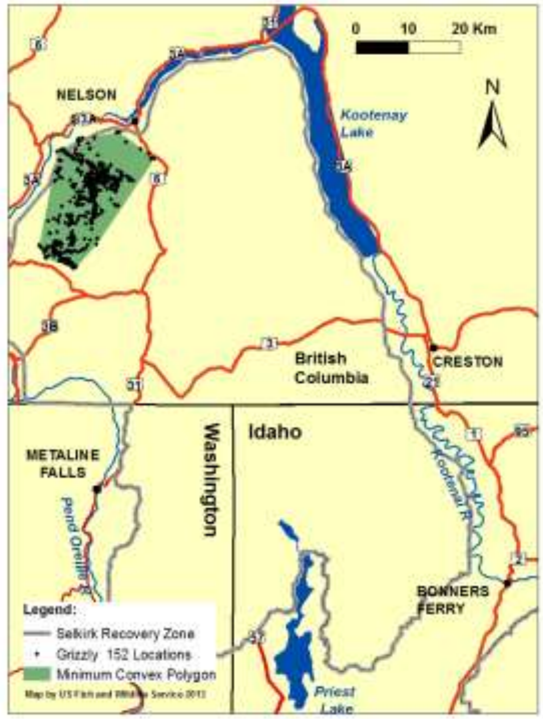

Figure A18. Radio locations and minimum convex (shaded) life range of male grizzly bear 152 in the Selkirk Mountains, 2011–2012.

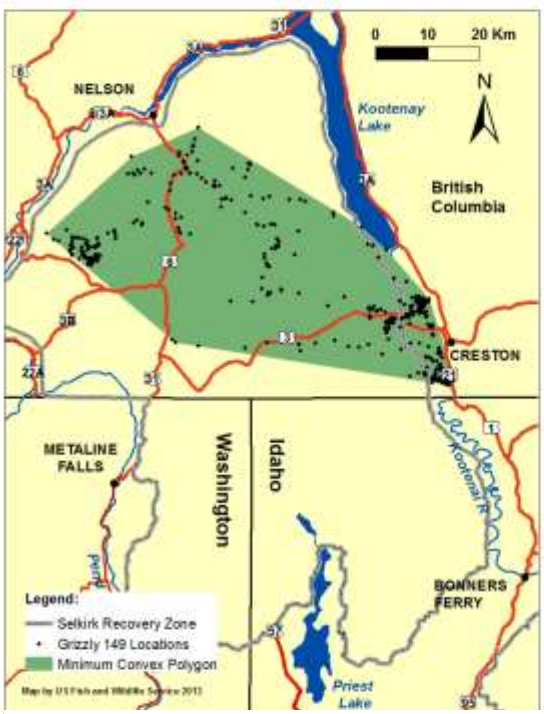

Figure A19. Radio locations and minimum convex (shaded) life range of male grizzly bear 149 in the Selkirk Mountains, 2011.

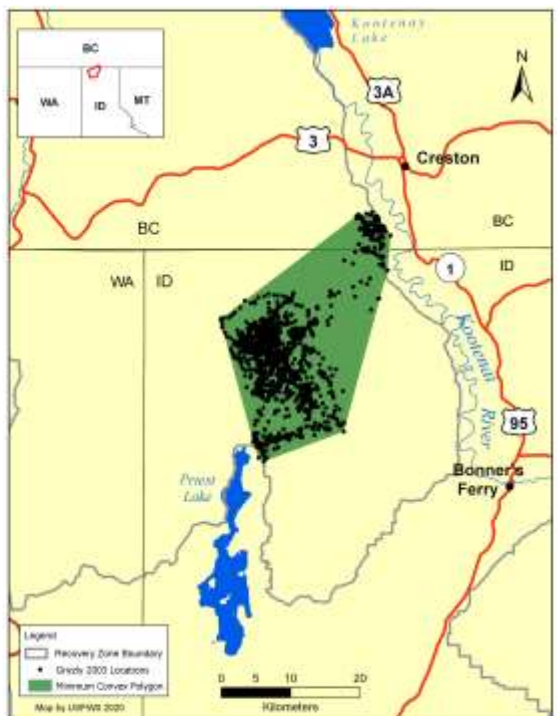

Figure A20. Radio locations and minimum convex (shaded) life range of female grizzly bear 12003 in the Selkirk Mountains, 2012–2014, 2017–2019.

Figure A21. Radio locations and minimum convex (shaded) life range of female grizzly bear 12006 in the Selkirk Mountains, 2012–2014.

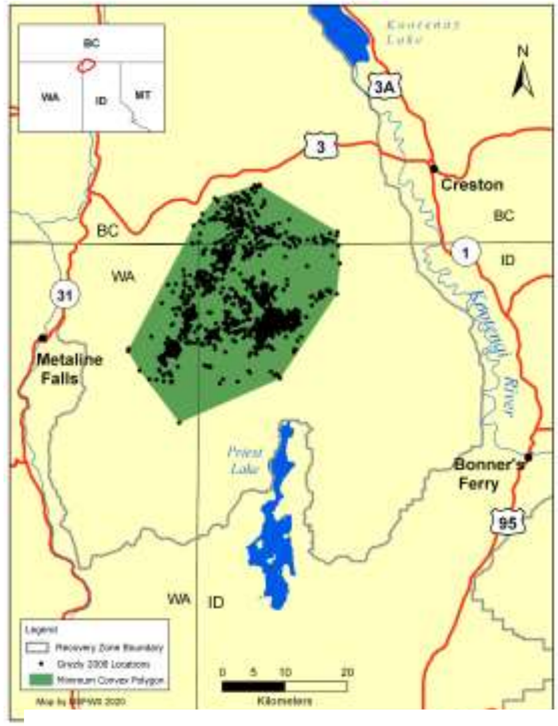

Figure A22. Radio locations and minimum convex (shaded) life range of female grizzly bear 12008 in the Selkirk Mountains, 2012–2014, 2017–2019.

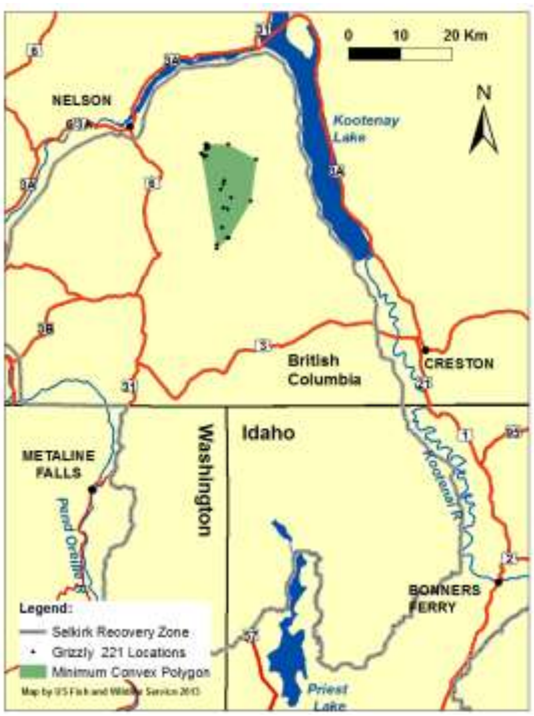

Figure A23. Radio locations and minimum convex (shaded) life range of male grizzly bear 221 in the Selkirk Mountains, 2012–2013.

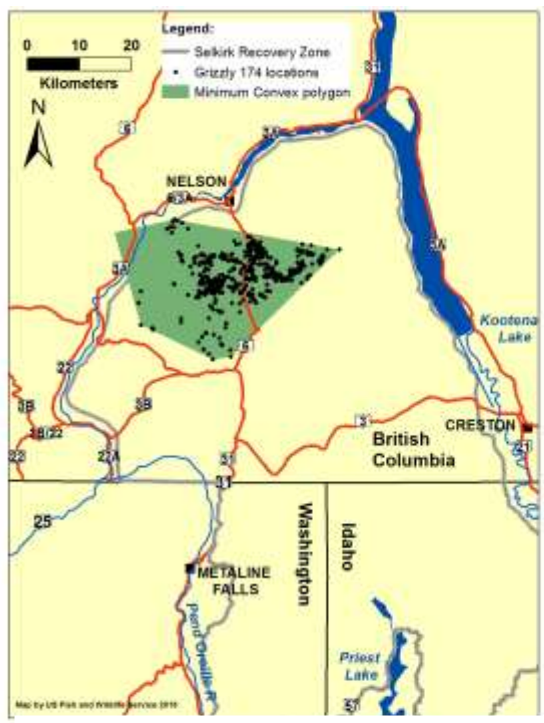

Figure A24. Radio locations and minimum convex (shaded) life range of male grizzly bear 174 in the Selkirk Mountains, 2012–2013, 2015.

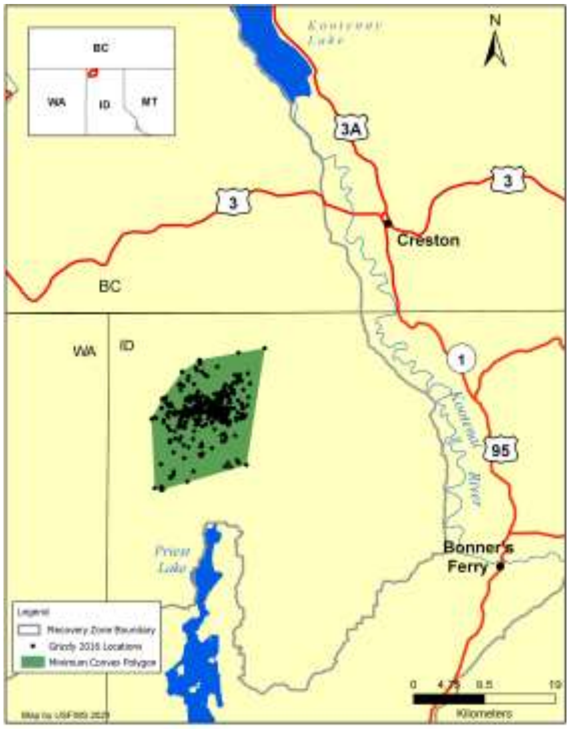

Figure A25. Radio locations and minimum convex (shaded) life range of female grizzly bear 12016 in the Selkirk Mountains, 2013–2016.

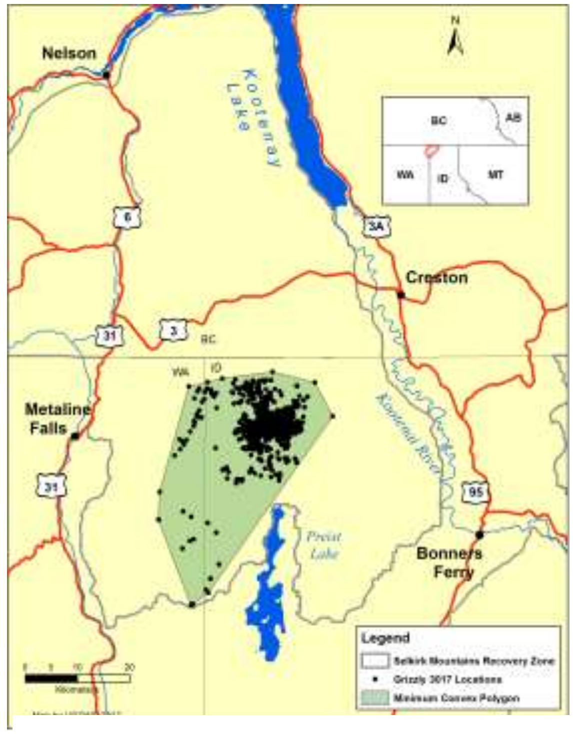

Figure A26. Radio locations and minimum convex (shaded) life range of female grizzly bear 13017 in the Selkirk Mountains, 2013–2016.

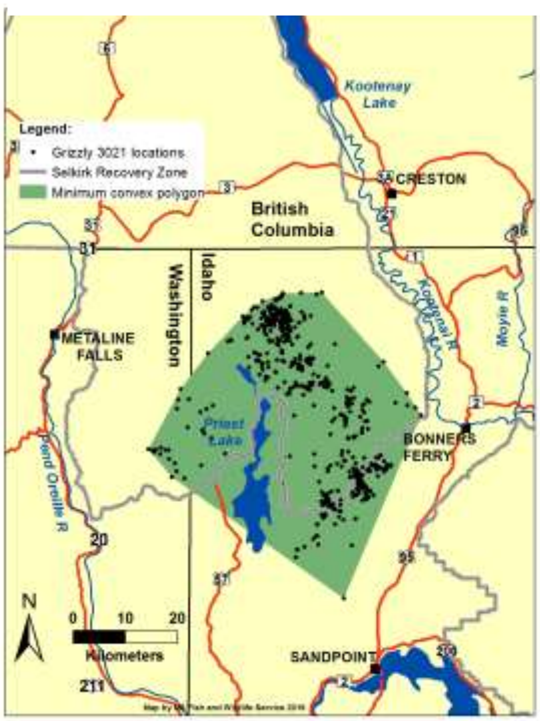

Figure A27. Radio locations and minimum convex (shaded) life range of female grizzly bear 13021 in the Selkirk Mountains, 2013–2015.

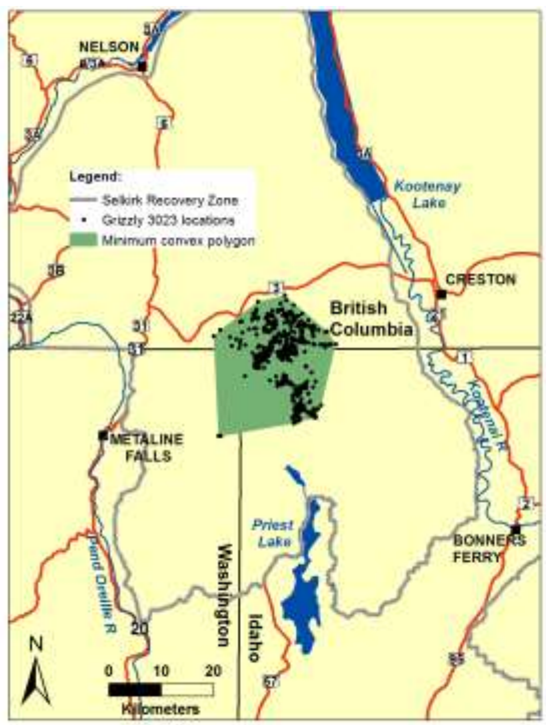

Figure A28. Radio locations and minimum convex (shaded) life range of female grizzly bear 13023 in the Selkirk Mountains, 2013–2015.

Figure A29. Radio locations and minimum convex (shaded) life range of female grizzly bear 226 in the Selkirk Mountains, 2013–2018.

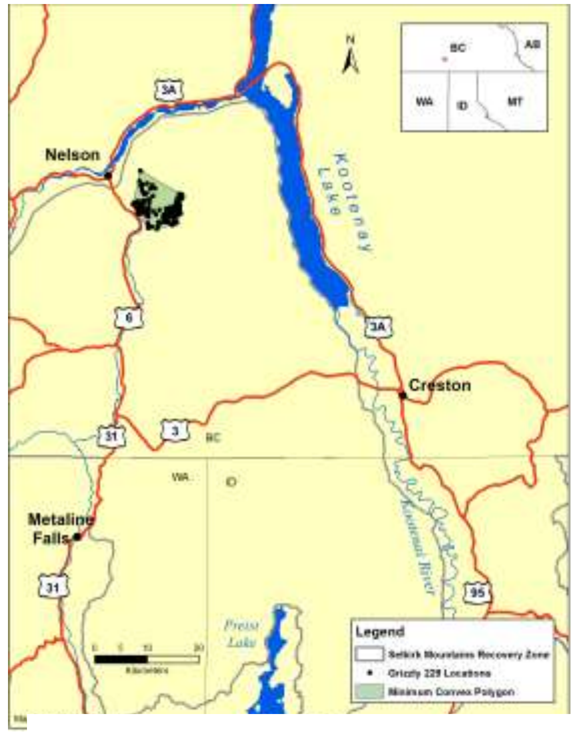

Figure A30. Radio locations and minimum convex (shaded) life range of female grizzly bear 229 in the Selkirk Mountains, 2014–2016.

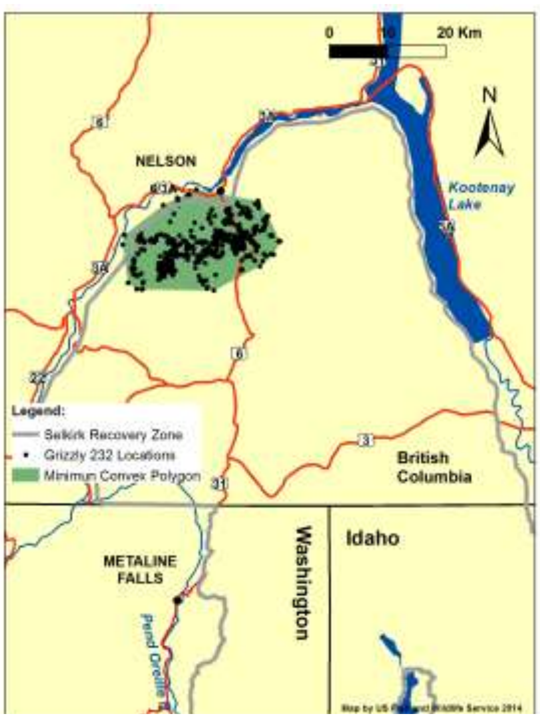

Figure A31. Radio locations and minimum convex (shaded) life range of male grizzly bear 232 in the Selkirk Mountains, 2014.

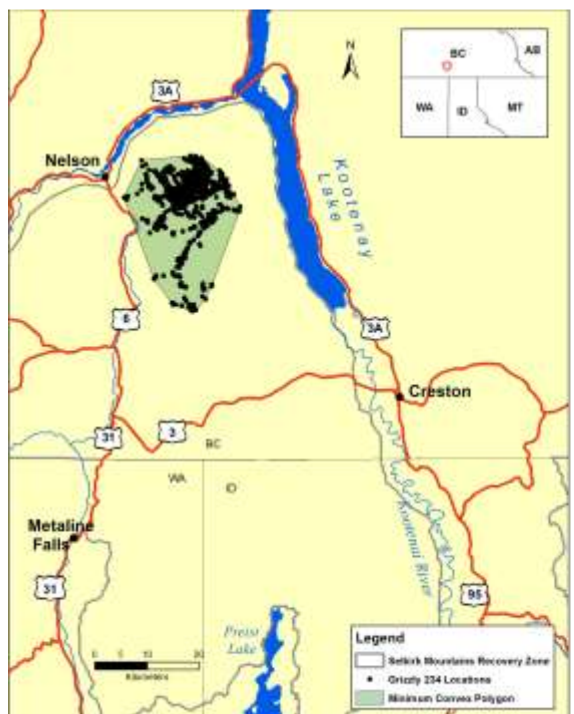

Figure A32. Radio locations and minimum convex (shaded) life range of male grizzly bear 234 in the Selkirk Mountains, 2014–2016.

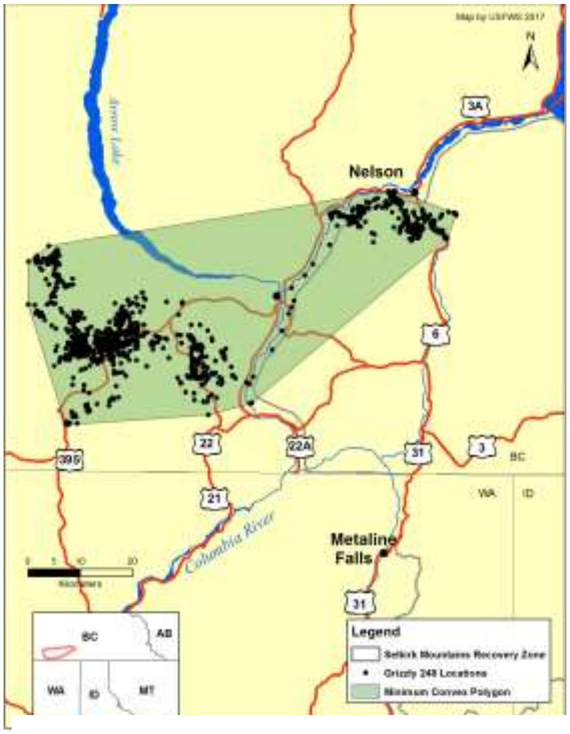

Figure A33. Radio locations and minimum convex (shaded) life range of male grizzly bear 248 in the Selkirk Mountains, 2014–2016.

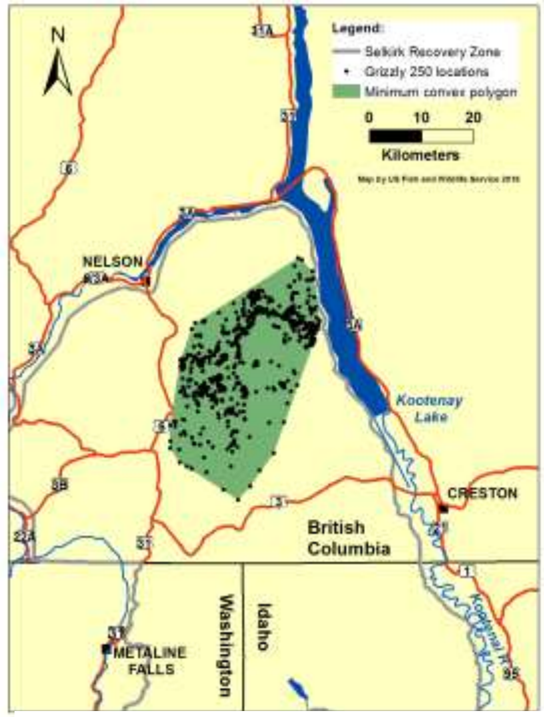

Figure A34. Radio locations and minimum convex (shaded) life range of male grizzly bear 250 in the Selkirk Mountains, 2014–2015.

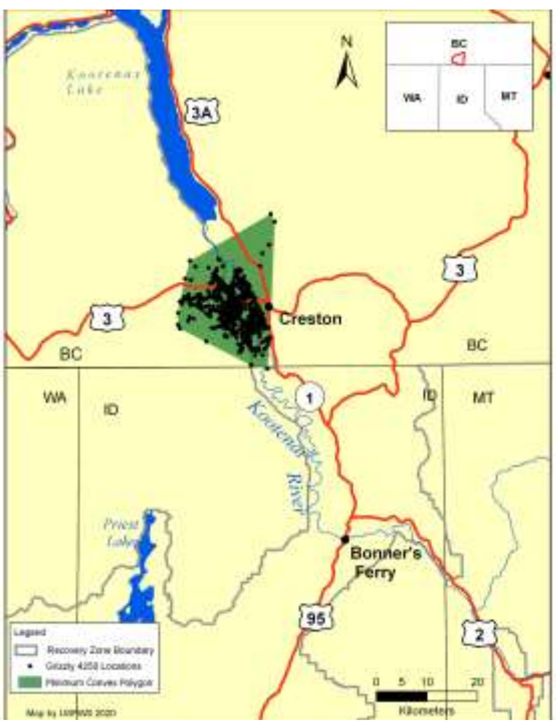

Figure A35. Radio locations and minimum convex (shaded) life range of male grizzly bear 4250 in the Selkirk Mountains, 2014–2015.

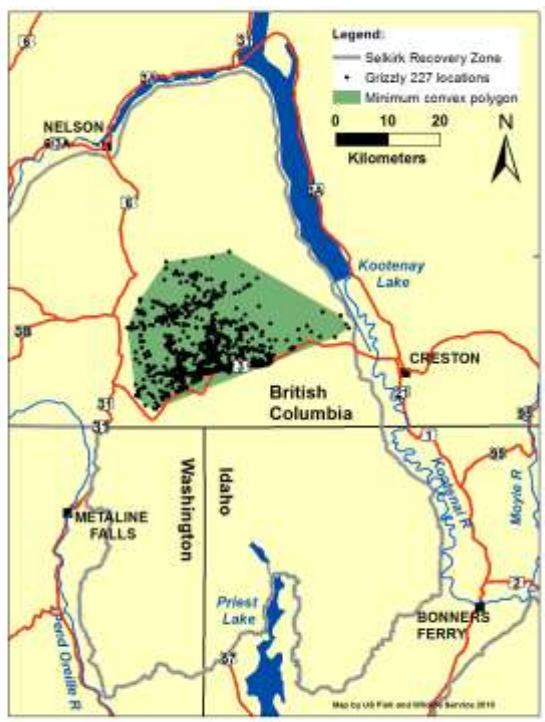

Figure A36. Radio locations and minimum convex (shaded) life range of male grizzly bear 227 in the Selkirk Mountains, 2014–2015.

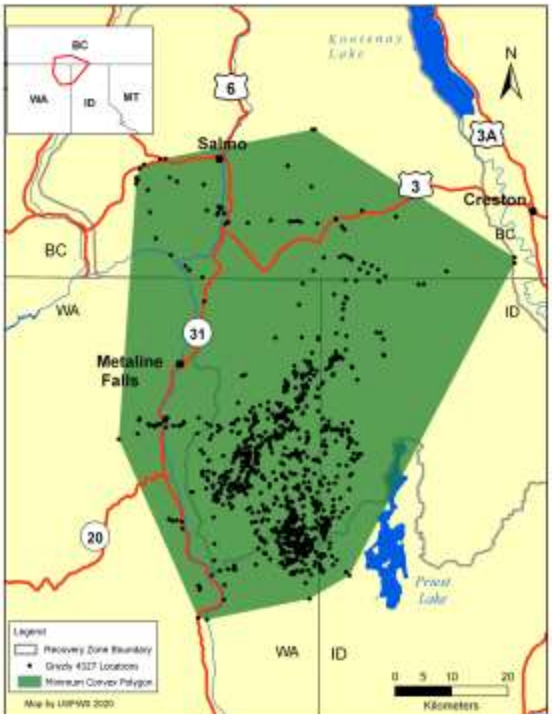

Figure A37. Radio locations and minimum convex (shaded) life range of male grizzly bear 4327 in the Selkirk Mountains, 2014–2016, 2018–2019.

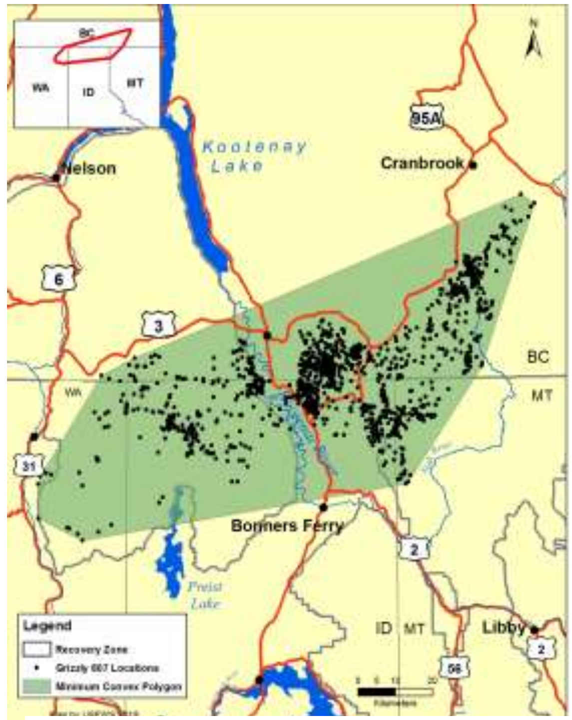

Figure A38. Radio locations and minimum convex (shaded) life range of male grizzly bear 807 in the Yaak River and Selkirk Mountains, 2014–2017.

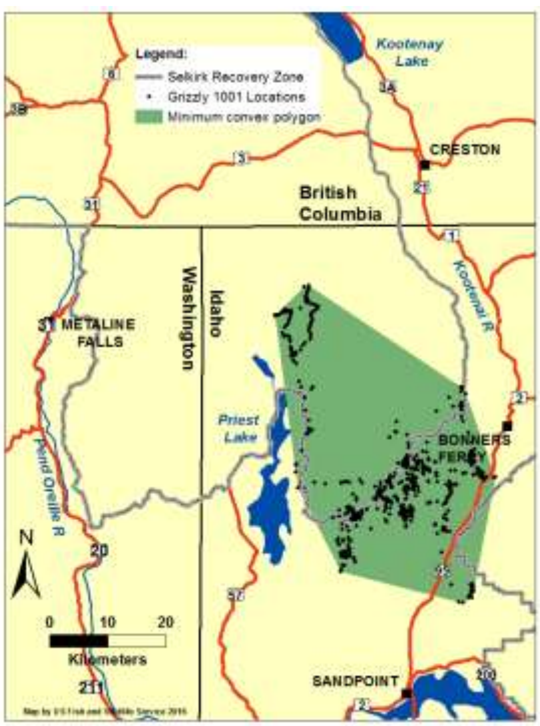

Figure A39. Radio locations and minimum convex (shaded) life range of male grizzly bear 1001 in the Selkirk and Cabinet Mountains, 2015–2016.

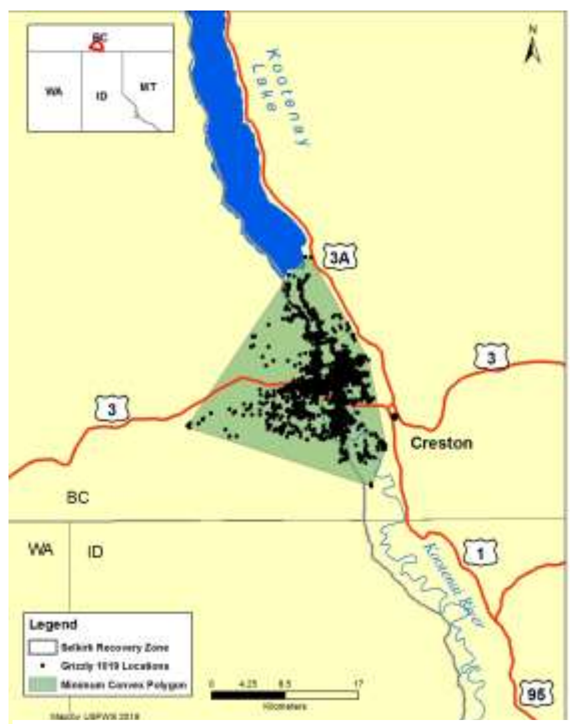

Figure A40. Radio locations and minimum convex (shaded) life range of female grizzly bear 1019 in the Selkirk Mountains, 2015–2017.

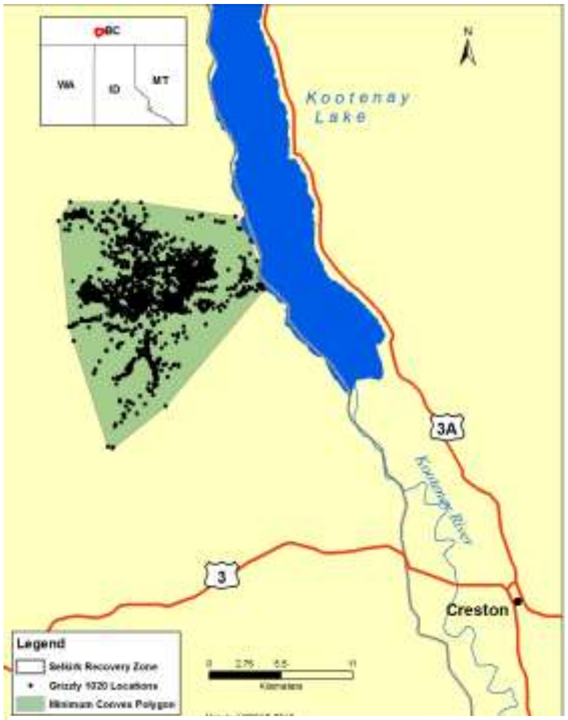

Figure A37. Radio locations and minimum convex (shaded) life range of female grizzly bear 1020 in the Selkirk Mountains, 2014–2017.

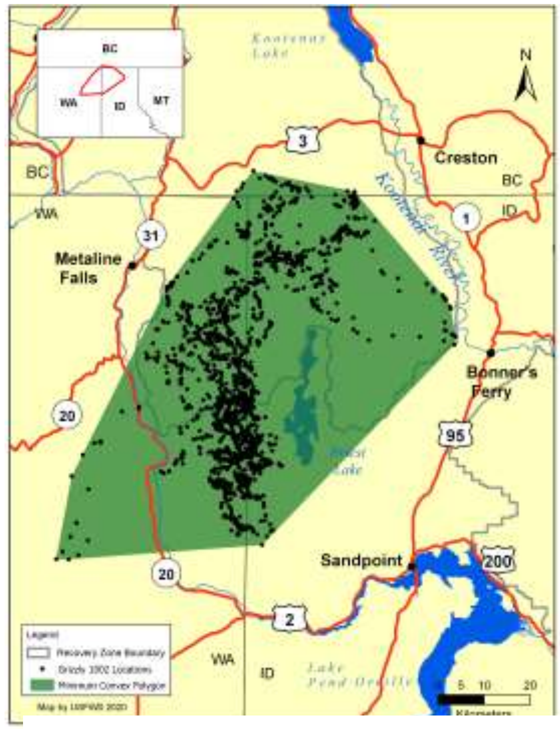

Figure A38. Radio locations and minimum convex (shaded) life range of male grizzly bear 1002 in the Selkirk Mountains, 2016–2019.

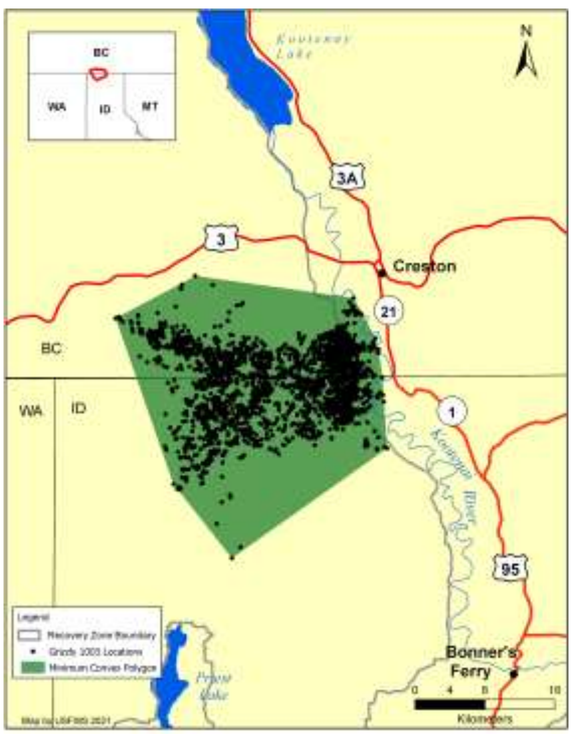

Figure A39. Radio locations and minimum convex (shaded) life range of female grizzly bear 1003 in the Selkirk Mountains, 2016–2020.

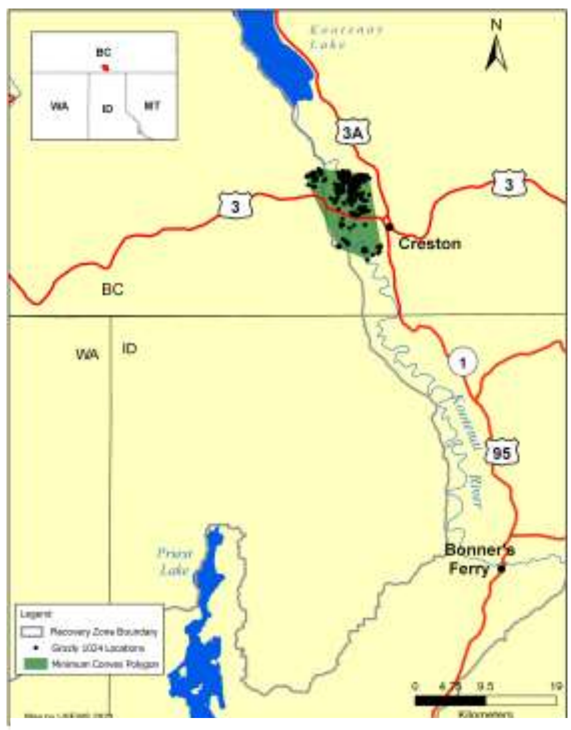

Figure A40. Radio locations and minimum convex (shaded) life range of male grizzly bear 1024 in the Selkirk Mountains, 2016.

Figure A41. Radio locations and minimum convex (shaded) life range of male grizzly bear 4011 in the Selkirk Mountains, 2016–2018.

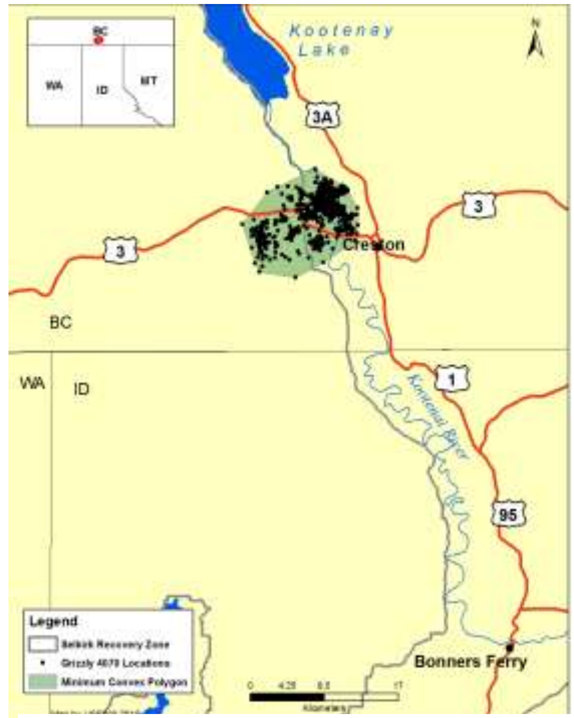

Figure A42. Radio locations and minimum convex (shaded) life range of female grizzly bear 4070 in the Selkirk Mountains, 2016–2017.

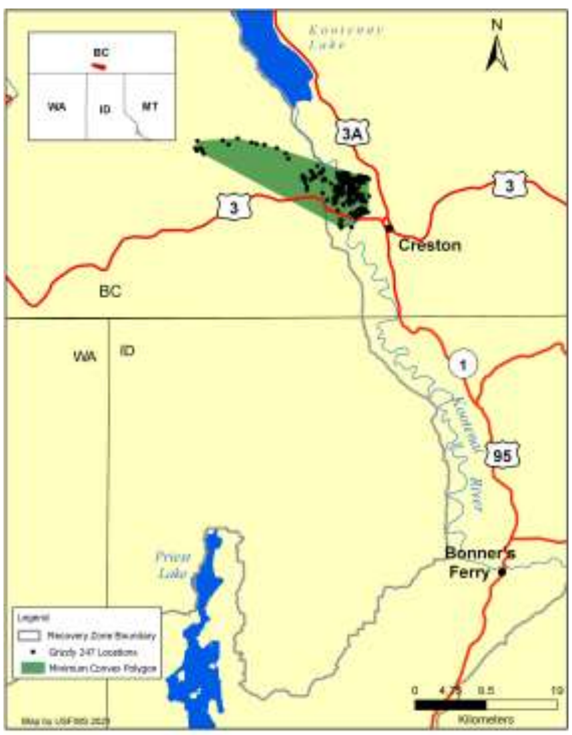

Figure A43. Radio locations and minimum convex (shaded) life range of male grizzly bear 247 in the Selkirk Mountains, 2016.

Figure A44. Radio locations and minimum convex (shaded) life range of male grizzly bear 1021 in the Selkirk Mountains, 2016.

Figure A45. Radio locations and minimum convex (shaded) life range of management male grizzly bear 922 in the Yaak River and Selkirk Mountains,

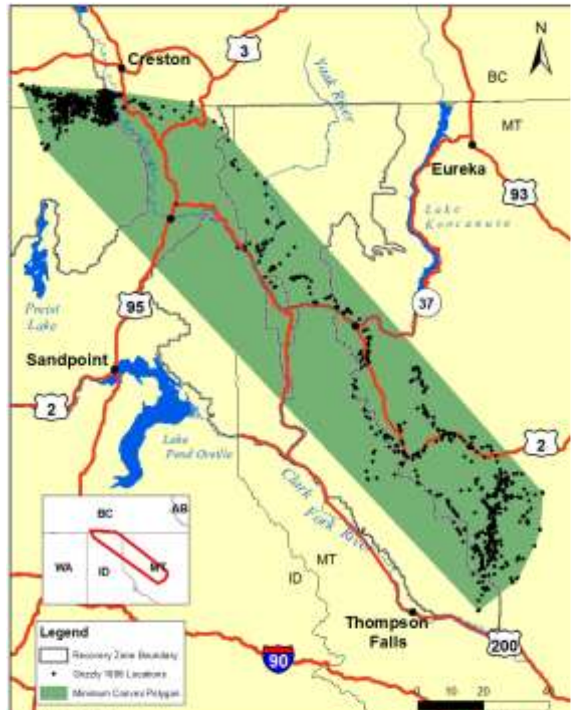

Figure A46. Radio locations and minimum convex (shaded) life range of male grizzly bear 1006 in the Selkirk Mountains, 2017–2018.

Figure A47. Radio locations and minimum convex (shaded) life range of male grizzly bear 1007 in the Selkirk Mountains, 2017.

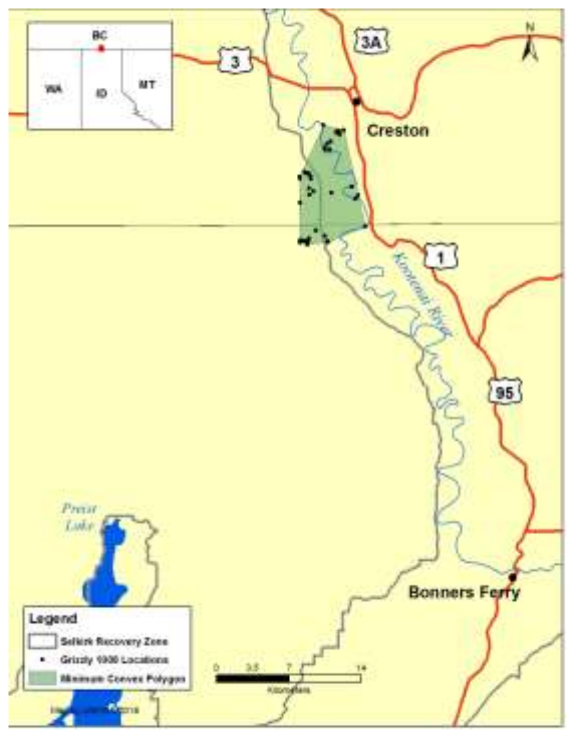

Figure A44. Radio locations and minimum convex (shaded) life range of male grizzly bear 1008 in the Selkirk Mountains, 2017.

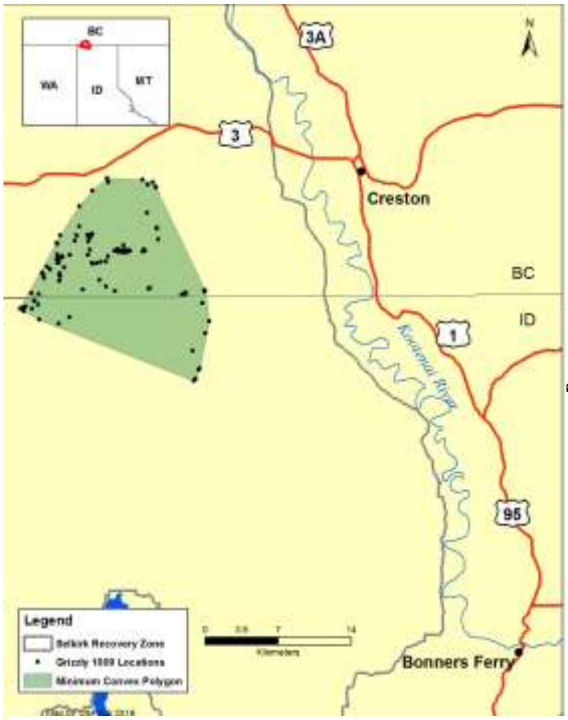

Figure A45. Radio locations and minimum convex (shaded) life range of male grizzly bear 1009 in the Selkirk Mountains, 2017.

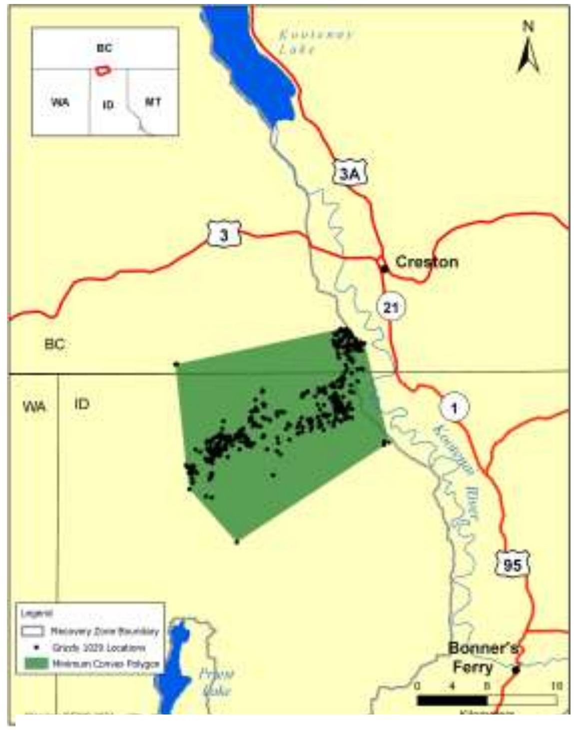

Figure A46. Radio locations and minimum convex (shaded) life range of female grizzly bear 1029 in the Selkirk Mountains, 2017–2020.

Figure A47. Radio locations and minimum convex (shaded) life range of male grizzly bear 23 in the Selkirk Mountains, 2017.

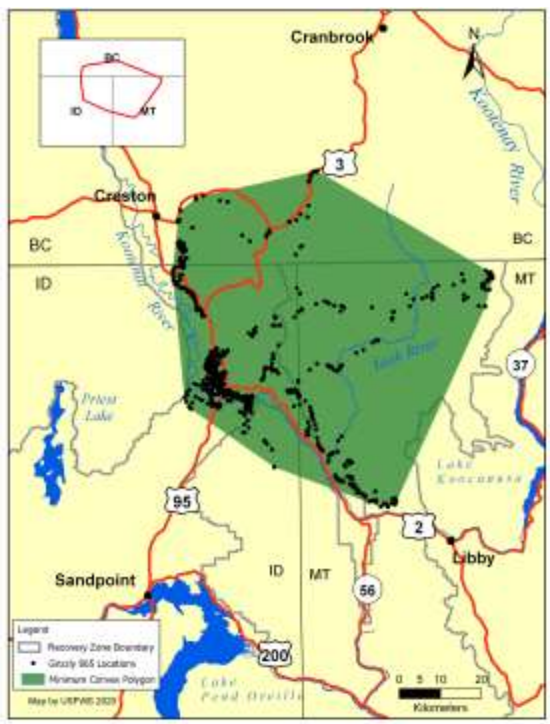

Figure A48. Radio locations and minimum convex (shaded) life range of management male grizzly bear 865 in the Kootenai and Yaak River, 2018–2019.

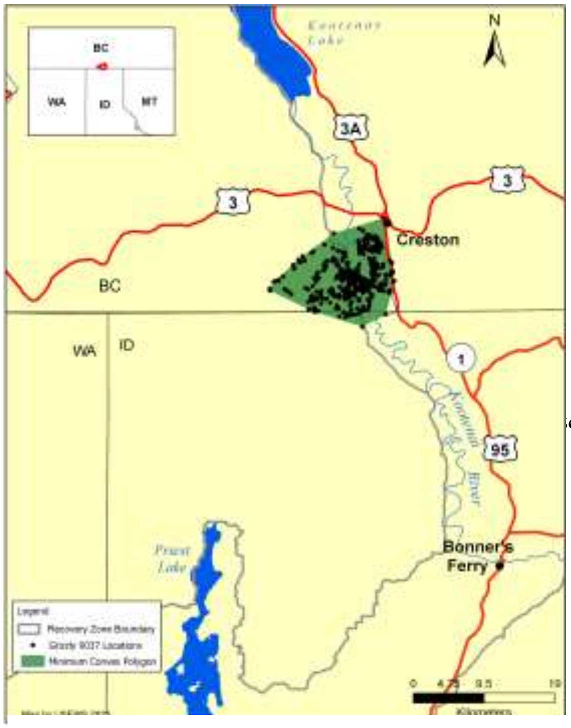

Figure A49. Radio locations and minimum convex (shaded) life range of female grizzly bear 9037 in the Selkirk Mountains, 2019–2020.

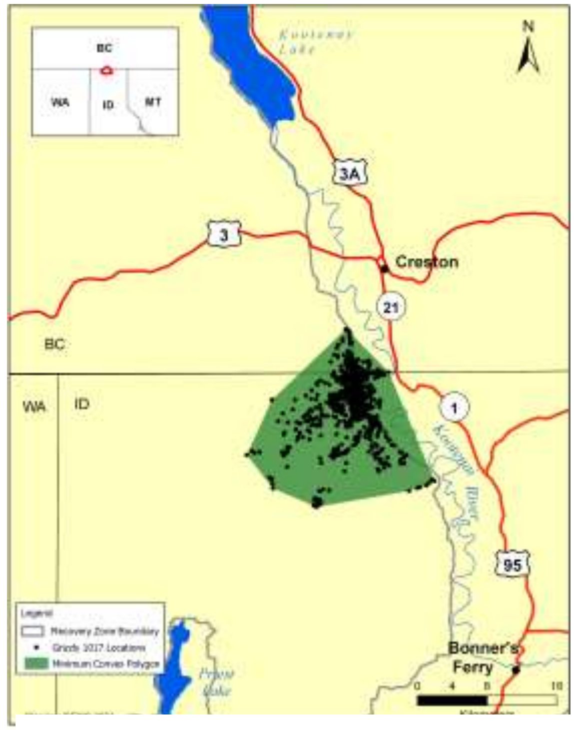

Figure A50. Radio locations and minimum convex (shaded) life range of male grizzly bear 1017 in the Selkirk Mountains, 2019–2020.

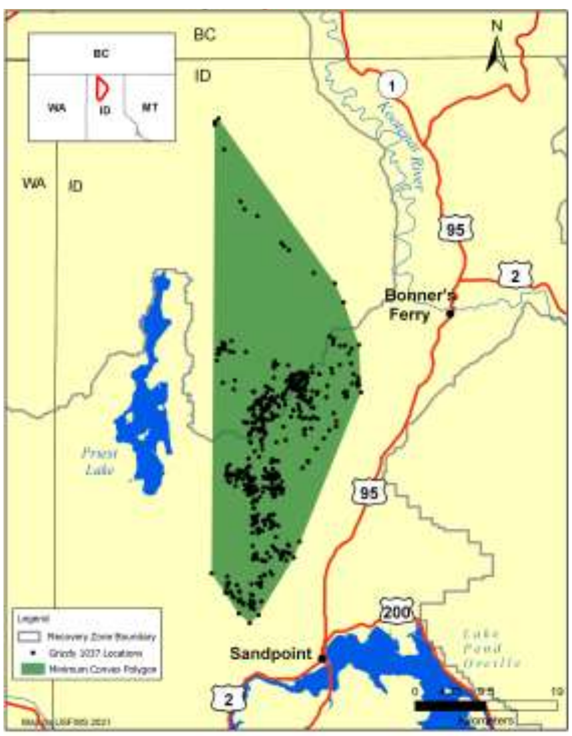

Figure A51. Radio locations and minimum convex (shaded) life range of male grizzly bear 1037 in the Selkirk Mountains, 2020.

Figure A52. Radio locations and minimum convex (shaded) life range of male grizzly 1038 in the Selkirk Mountains, 2020.

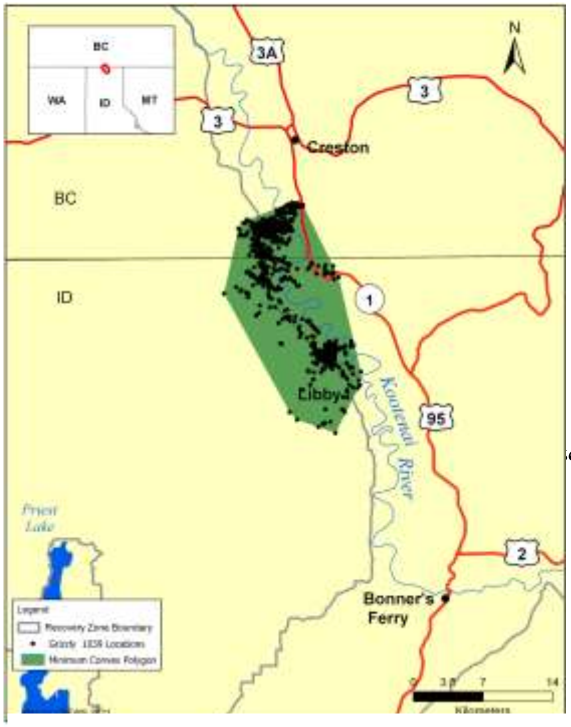

Figure A49. Radio locations and minimum convex (shaded) life range of male grizzly bear 1039 in the Selkirk Mountains, 2020.

APPENDIX 4. 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 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 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.