COLUMBIA BASIN FISH & WILDLIFE COMPENSATION PROGRAM

CHARACTERISTICS OF A HUNTED POPULATION OF COUGAR IN THE SOUTH SELKIRK MOUNTAINS OF BRITISH COLUMBIA

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November 2003

www.cbfishwildlife.org

Executive Summary

Nineteen cougars (*Puma concolor*) were captured and fitted with radiocollars on the British Columbia portion (3045 km^2) of the South Selkirk Mountains (SSM) between November 1998 and March 2002. The goal was to determine the impact of cougar predation on the endangered South Selkirk Caribou herd as well as collect information on the characteristics of a hunted population of cougars. Captured cougars were examined, aged, and morphological measurements were recorded. Using capture-recapture techniques, tracks, hunter harvest, and radio telemetry we estimated that the annual cougar population on the study area ranged from 14 to 22 cougars and estimated an average population density of 0.55 cougars/100 km^2 over the course of 4 years. Home ranges were delineated for 7 female and 5 male cougars. Annual home ranges (100% minimum convex polygon) for adult females cougars (628 km^2) were similar to adult males (782 km^2; $P = 0.57$). Seasonal home ranges (100% minimum convex polygon) were also similar for adult males and adult females ($P = 0.59$) and ($P = 0.88$) for summer and winter home ranges respectively. Individual female summer and winter home ranges overlapped extensively whereas the male's seasonal home ranges were more distinct. All cougars displayed some elevational movements in the summer. Only two cougars moved to higher elevations in the summer where there was overlap with the caribou summer range. Home range overlap between females was extensive as well as between male and female. Home range overlap between males was only observed once and the younger of the two died possibly due to interaction with the older cougar. Observed and deduced cougar litters (n=7) indicated a mean litter size of 2.4 (*SD*=0.25). Litters were born during the spring to early fall period with no litters being born in the winter. The sex ratio of kittens (N=12) was 1.4M: 2F. Mean age of dispersal was 24.7 months. Most cougars dispersed after independence, but 2 females established home ranges that overlapped with their mother's home ranges. Dispersal of juveniles ranged from 60 to 177 km from their natal area. Annual mortality from all sources increased from 12% in 1999 to 53% in 2002 of the estimated population. Hunting accounted for 7 of the 12 collared cougar mortalities. Natural mortality of all age groups accounted for 3 of the 12 collared cougar mortalities. The cougar population in the British Columbia portion of the SSM was limited by high mortality rates of both male and female cougars. The immigration of subadults from Washington State is helping to maintain the cougar population within the BC portion of the study area.

Acknowledgements

Special thanks go to Dave Lewis, Stuart Hawes, and Dave Basaraba for the time spent searching and collaring cougars. Dave Mairs of Silvertip Aviation and John Gwilliam for assisting with the collection of aerial telemetry location data. John Krebs and Guy Woods for technical assistance. Thomas Hill, Tasha Kirby, and Ian Parfitt for assisting with the creation the Arcview maps from the telemetry data. Beth Woodbridge for administrative support throughout the project. Don Katnik and Hugh Robinson for their contribution with telemetry data collection and cougar capture respectively. Thanks to Darkwoods Forestry, Beaumount Timber, Stagleap Ranch, Jerry Nellestijn, and Kevin Maloney for permission to access their property during the course of the three winters. Thanks to the houndsmen - Mike Dawson, Gerry Brown, and Rob Kuny who participated in and supported the project.

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Introduction

In 1998, the Columbia Basin Fish & Wildlife Compensation Program (CBFWCP) in partnership with the Columbia Basin Trust (CBT), Ministry of Water, Land, and Air Protection (MWLAP), and Washington State University (WSU) initiated a cougar (*Puma concolor*) ecology and predation study in the British Columbia, Washington and Idaho portion of the South Selkirk Mountains (SSM) (Woods 1998, Katnik 1998). Caribou (*Rangifer tarandus caribou*) in the SSM had a high rate of mortality during the summers of 1995 to 1997 and it was hypothesised that predation from cougars may be accelerating the decline of the South Selkirk mountain caribou however there was a lack of direct evidence of cougars killing caribou (Katnik 2002). Mule deer (*Odocoileus hemionus*) in the same study area had also experienced a significant decline during the mid 1990's (Robinson et al. 2002). If cougar predation was a significant cause of caribou mortality we needed to know whether it was specific individual cougars (caribou specialists) or cougars (generalists) opportunistically killing caribou. The results of cougar predation on caribou in the SSM and management strategy recommendations to minimize the predation can be found in Katnik (2002). Specifically, he investigated seasonal patterns of elevation use and home ranges by cougars, overlap with caribou, as well as estimated survival and growth rates for the cougar population in the SSM.

Concurrent with the research on cougar predation of caribou in the SSM was the opportunity to investigate densities, home ranges, movements as well as other factors that may affect population size of a hunted population of cougars in southeastern BC. In the British Columbia and Idaho portion of the SSM study area hounds can be used to hunt cougars whereas in Washington State hounds are not allowed except for "Public Safety hunts". Differences in hunting regulations in the three jurisdictions may have implications on home range sizes, movement rates, and population parameters such as reproduction and recruitment. The characteristics of hunted cougar populations have been described in other studies in Idaho (Hornocker 1969, 1970; Seidensticker et al. 1973), Wyoming (Logan et al. 1985) and Alberta (Ross and Jalkotzy 1992). However cougar research in southeastern British Columbia has been limited to the Elk and Fording River valley's in the Rocky Mountains (Spreadbury et al. 1996).

In this report, emphasis was placed on the basic factors affecting cougar populations which include: reproductive rate, mortality rates of different age groups, juvenile dispersal rates, immigration, densities, and home range size. Knowledge of these factors affecting the cougar population in the British Columbia portion of the SSM study area will contribute to the status of the cougar population and cougar management.

Study Area

The 3045 km^2 study area was located in the South Selkirk Mountains of southern British Columbia. It includes the area south of the west arm of Kootenay Lake to the Canada/USA border between the Pend d'Oreille River on the west side of Kootenay Pass east to the Kootenay River (Fig. 1). Mountain ridges characterized the area with broad to narrow valley bottoms with elevations ranging from 525 m to 2145 m. The average annual precipitation is approximately 50 cm in the valley bottom and up to 125 cm in the mountains with the majority of the precipitation occurring in the winter and spring. Total snowfall at Kootenay Pass averaged 15.1 m from 1965 – 1975 (Johnson 1976). Mean (1961-1990) temperatures range from –3.0^{o}C (January) to 19.3^{o}C (July) in Creston on the east side of the study area to 3.2^{o}C (January) to 19.9^{o}C (July) in

Castlegar on the west side of the study area (Environment Canada, Vancouver, British Columbia).

The area was within the Southern Columbia Mountains Ecosection and included the western portion of Fish & Wildlife Management Unit 4-08 and all of 4-07. Biogeoclimatic zones include Interior Cedar hemlock (ICH; xw, dw, mw2), Engelmann Spruce-Subalpine Fir (ESSFwc4) and Alpine Tundra/Engelmann Spruce-Subalpine Fir (AT/ESSFwcp) (Braumandl & Curran 1992). The ICH zone extends from the lowest elevations of the study area to approximately 1200 m. Western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) are the dominant tree species on the moist forest sites. The dry forest sites on southeast to west aspects were dominated by Douglas-fir (*Psuedotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) interspersed with shrub dominated openings. The ESSF zone extends from approximately 1200m to 2100m. Engelmann spruce (*Picea engelmanii*) and subalpine fir (*Abies lasiocarpa*) are the dominant tree species to treeline. At low elevations common shrubs include mallow ninebark (*Physocarpus malvaceus*), snowberry (*Symphoricarpus albus*), willow (*Salix* spp.), Douglas maple (*Acer glabrum*), saskatoon (*Amelanchier alnifolia*), falsebox (*Pachistima myrsinites*), and hazelnut (*Corylus cornuta*). At higher elevations white-flowered rhododendron (*Rhododendron albiflorum*) and false azalea (*Menziesia ferruginea*) are the dominant shrub species (Parish et al. 1996).

Timber harvesting is presently the major source of disturbance. Fire suppression in the last 50 years has impacted wildfires, which was historically the main source of natural disturbance. The last major fires in the area occurred in the 1930's and the forests have now regenerated to mixed coniferous stands (Woods 1984).

The study area contained a complex community of predators and prey. White-tailed deer (*Odocoileus virginianus*) and mule deer (*O.hemionus*) were the most common ungulates. Elk (*Cervus elaphus*), moose (*Alces alces*), and mountain caribou (*Rangifer tarandus caribou*) were also present but in lower numbers. Small numbers of bighorn sheep (*Ovis canadensis*) were found in the rugged portion of the study area during the summer and at a feeder maintained by the Trail Wildlife Club and the Nelson Rod and Gun Club in the winter. Large predators other than cougars included black bears (*Ursus americanus*) which were the most abundant large predator in the ecosystem (Katnik 2002). Grizzly bears (*U. arctos*) were less common (Wielgus and Bunnell 1994). Coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) were common. Lynx (*Lynx lynx)* and wolverine (*Gulo gulo*) were present in low numbers. Wolf (*Canus lupus*) tracks were observed during the winter of 2000/2001 on two occasions but did not remain within the study area.

The study area encompassed two Provincial Parks, three Forest Licenses, Darkwoods Forestry private land, and Small Business Forest Enterprise Program cutting areas. The southern portion of the study area was bisected by Highway 3.

Cougar hunting was permitted each year in Management Unit (MU) 4-07 and 4-08, within which the study area was located, from September 10 – to March 31. The annual bag limit was 1 for the first two years of the study and was increased to 2 during the last two years of the study. An annual female quota of 25 animals was in effect for the West Kootenay Region from 1975 to 2002 within MU 4-07 and 4-08 a total of 163 cougars were killed, 56 cougars (30M, 26F) were killed from non hunting activity (animal control) and 107 cougars (66M, 41F) were legally harvested (B.C. Ministry of Water, Land, and Air Protection, unpubl data).

Figure 1 – Study Area

Methods

Capture activities within the study area were conducted annually, December 1998 – March 2002. Snow covered roads and trails were systematically searched by truck, snowmobile, and on foot. Known cougar travel corridors and watercourses were also searched. Roads were well distributed throughout the majority of the study area. Search intensity was dependent upon snow conditions and priority was directed to areas with evidence of unmarked cougars.

Trained hounds were used to tree cougars following a "houndsmen protocol" designed for the project. Sixty-nine cougars were treed over the course of the study. Treed cougars were immobilized with Telezol at a concentration of 7mg/kg using a 3cc dart with a ½" barbless needle. Delivery of the drug was carried out using a "Cap Chur" gun (Palmer Chem. and Equip. Co., Douglasville, GA.) with a brown powder charge. All darts were injected into the hindquarter musculature. Small kittens (<2 months) were captured by hand and not administered any drug. Provisions were made to lower immobilized cougars out of a tree if necessary with the use of climbing spurs and ropes. Once immobilized the cougars were ear-tagged in both ears with numbered rototags (NASCO; Modesto, Calif., USA), sexed, measured, and examined for reproductive status and general condition. All females were examined for evidence of recent lactation. Cougars were aged according to tooth replacement, wear and coloration (Ashman et al. 1983) and morphological characteristics of known aged cougars in the study. We placed each cougar into one of the following age classes: kitten (0 - 0.5 yr.), juvenile (0.6 – 1.5 yr.), subadult (1.6 – 2.5 yr.) and adult (>2.5yr.) (Ross and Jalkotzy 1992). DNA samples were collected. Between 1998 and 2002 nineteen cougars (10F, 9M) were fitted with radiocollars with a four hour mortality delay (Lotek Engineering, Inc. Newmarket, Ontario LMRT-4). The collars were modified to include a canvas insert designed to rot through after ~ 2 years to free the cougar of the collar. The rot-off strip consisted of two layers of canvas fire hose strips sewn into the collar. The collars could be reused simply by inserting another rot-off strip.

Efforts to collect habitat and movement data were co-ordinated with parallel efforts in Washington State. Attempts were made to locate the cougars from the air in the winter using a Cessna 337 with an average of one flight per month from November through May during the same flight used to track the radiocollared mule deer within the Salmo/Creston Study Area. Summer flights were shared with Washington Department of Fish & Wildlife staff and a Washington State University Ph.D. student with an average of three flights per month from June to October. A total of 1108 radiolocations were recorded over the course of the study. Radiolocation data was collected using aircraft mounted Global Positioning System (GPS; Garmin Corp., Olathe, KS). All radio location data collected was projected into the Universal Transverse Mercator (UTM) system, North American Datum (NAD) 1983 to the nearest 0.1 km. Having the pilot and observer locate hidden test collars location data precision was determined to be ± 100m (Katnik 2002). Ground telemetry locations were conducted frequently to get general locations and movements and to classify kills of radiocollared cougars where possible. CBFWCP staff did ground telemetry on an opportunistic basis.

Home range analysis for individual cougar home ranges was determined using the minimum convex polygon method (MCP) (Mohr 1947) and adaptive kernels (ADK; Worton 1989). The minimum number of radio locations used for home range calculations was 25. Cougars were considered residents once the areas in which they moved became predictable over ≥ 4 months (Ross and Jalkotzy 1992). Annual, winter (Nov. 1 – May 31), and summer (June 1 – Oct. 31) home ranges were calculated for cougars that had enough telemetry points. Seasonal periods (winter and summer) were delineated on the basis of a shift in prey selection within the study area as described by Katnik (2002) and Servheen et al. (1989). Home range overlap was the percentage of 1 cougar's home range area included within another's.

Terminology regarding cougar social organization is based upon Seidensticker et al. (1973), Shaw (1983), and Hemker et al. (1984). Resident cougars were adults that restricted their movements to a specific area. Transient cougars included subdults and mature animals that did not restrict their movements to a specific home range (Shaw 1983).

Population estimates were made for the study area at the end of each capture season (March 31) based on winter density when snow cover and reduced home range size allowed for a more accurate estimate. These estimates were based on radiocollared individuals, their offspring and uncollared individuals detected. The proportion of the population that was unmarked was estimated by comparing location and size of tracks with known location of collared study animals. Compulsory inspection records of cougars harvested within the study area were also used in the estimate. Track size was only used to differentiate sex. Multiple observations of tracks within an area that were not associated with collared individuals were assumed to indicate uncollared animals. In some cases these unmarked individuals were treed but not collared because they were not in a safe position to immobilize. Densities were calculated by dividing the total population estimate by the study area size. Student's *t*-tests were used to evaluate difference between means (Sokal and Rohlf 1987). Differences were considered significant when $P \leq 0.05$.

Rub pads to collect hair samples for DNA analysis were set up during the winter of 2001/2002 to test their effectiveness to get estimates of relative abundance of the cougar population in the South Selkirk Mountains. Twenty eight rub pads were placed throughout the Pend d'Oreille valley in December 2001 baited with a mixture of beaver castoreum and catnip oil that was used successfully for lynx in the Yukon by Garth Mowat (pers com.). We also attached strips with a glue-like substance to snag hairs (available commercially as glue traps used to entangle mice and insects). The hair grabbers were rebaited in February 2002 with a lure formulated and purchased from John Weaver (Wildlife Conservation Society) for lynx. Visual attractants were placed near the rub pads and consisted of one half of an aluminium pie plate hanging from a tree branch. The rub pads were placed at shoulder level of a cougar (~60 to 80 cm) along known cougar travel routes where possible.


Typical Rub Pad Set-up (Photo by R. Clarke)

Results

Capture Record

Cougars were treed 69 times over the course of the study. This includes cougars that were already collared, cougars that were not in a safe place for immobilization, cougars that were too young to collar, and cougars that were treed outside the study area. Of those treed nineteen different cougars were immobilized and collared during the study period (Table 1). One cougar initially collared as a juvenile was treed the following capture season and recollared. Two kittens (≤ 2 months) were captured by hand but were not tagged. We had one capture related mortality during the second year of the project. A female cougar vomited while immobilized and all attempts to clear her airway were unsuccessful. A necropsy of the cougar was carried out at Washington State University and she appeared to be in good condition at the time of capture.

Table 1. Summary of cougar trapping efforts in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Year	Trapping Effort (days)	Number Collared	Capture Rate (days/collar)
Dec. 1998-March 1999	64	5	12.8
Dec. 1999-March 2000	51	6	8.5
Dec. 2000-March 2001	67	6[a]	11.2
Dec. 2001-March 2002	32	3	10.7
Total	214	20	Av. 10.8

[a]Includes 1 recapture of a young female that had dropped her collar.

Population Characteristics

The estimated number of cougars in the study area ranged from 14 to 22 (Table 2). Radio collared cougars comprised 37, 43, 36, and 27 % of the of the total estimated population, and adults/subadults were 50, 64, 64, and 73 % of the estimated population for 1999, 2000, 2001, and 2002, respectively.

Through intensive searching, capture and radio telemetry data, harvest data, and reproductive status of females we could account for all the resident cougars in the study area by the end of March for each year of the study. The population estimates however are most likely overestimates due to some cougars only having partial home ranges within the study area and some of the harvested animals may have been transients rather than resident cougars. Hunter harvest played an important role impacting population size as the area was intensively hunted each year of the study. An example of this is cougar F10 who was killed less than 24 hours after she was collared. Also included in the estimate were two radiocollared cougars that moved into the study area in 2000 that were collared in Washington State as part of the Washington State University South Selkirk Cougar Predation Study (M10, F11). M10 moved in and partially occupied a portion of M1's home range after M1 was killed in March 2000 for having killed 2 endangered South Selkirk Mountain Caribou during the summer of 1999.

Population density estimates of 0.52, 0.46, 0.72, and 0.49/100km^2 was determined for the South Selkirk Mountain study area in 1999, 2000, 2001, and 2002 respectively (range = 0.46 – 0.72, x = 0.55, SD = 0.12) (Table 2).

Table 2. Estimated density (No./100 km^2) of radiocollared and non-radiocollared cougars in the South Selkirk Mountains, B.C., January 1999 - March 2002.

	Adult/Subadult					Juvenile						
	Radio		Nonradio			Radio		Nonradio			Cougar	
Year	F	M	F	M	U[a]	F	M	F	M	U[a]	n[b]	Density
1999	2	2	2	2	0	2	0	0	0	6	16	0.52
2000	2	0	4	1	2	2	2	0	1	0	14	0.46
2001	4	3	4	3	0	0	1	1	4	2	22	0.72
2002[c]	2	2	3	3	1	0	0	0	2	2	15	0.49

[a] U = unknown sex
[b] n = total number of cougars
[c] January to March 2002

Home-Range Characteristics

Between 1998 and 2002, 1108 radiolocations were recorded from 21individual cougars (Figure 2). This includes a collared male and a collared female that moved into the study area from Washington and established their home ranges partially in British Columbia. We were able to determine annual home ranges for 6 females and 4 males and seasonal home ranges for 7 females and 5 males using the minimum convex polygon (MCP) method. The mean number of radio locations used for summer, winter, and annual home-range calculations was 50 (range =18-106), 34 (range = 15-58), and 96 (range = 36-152) (Table 3).

Figure 2 – South Selkirk Cougar Telemetry Locations

Table 3. Seasonal home ranges, and annual home ranges (100% minimum convex polygon) from aerial telemetry locations for female (F) and male (M) cougars in the South Selkirk Mountains, B.C. December 1998 – March 2002.

Cougar ID	Annual Home Range km^2	No. of Locations	Summer Home Range km^2	No. of Locations	Winter Home Range km^2	No. of Locations
F1 (Bonnie)	-		296	35	-	
F2 (Claire)	994	114	739	56	293	58
F3 (Gidgit)	919	152	659	106	698	46
F4 (Linda)	128	140	105	85	98	55
F6 (Ginger)	510	56	478	36	190	20
F7 (Trouper)	1041	115	956	75	558	40
F11[a] (Katie)	177	108	124	83	127	25
M1 (Mr. Nasty)	1231	96	650	58	569	38
M4 (Muffin)	-		593	40	-	
M5 (Matt)	280	36	96	18	80	18
M6 (George)	909	42	852	27	492	15
M10[a] (Sleepy)	709	100	706	76	259	24

[a] F11 and M10 were two cougars collared in Washington State that established home ranges within the study area.

Home range size varied widely among individual cougars of both sexes (Table 3). Annual adult female home areas ranged from 128 to 1041 km^2 for 6 female cougars (x = 628 km^2, SE = 413). Adult male home areas ranged from 280 to 1231 km^2 for 4 male cougars (x = 782 km^2, SE = 398). The average seasonal home range size for adult females was 466 (N = 7, SE = 288, range = 105 – 956) and 327 (N = 6, SE = 246, range = 98 – 698) during the summer and winter seasons, respectively. The average seasonal home range size for adult males was 579 (N = 5, SE = 287, range = 96 – 852) and 350 (N = 4, SE = 223, range = 80 – 569) during the summer and winter seasons, respectively.

Mean annual home ranges were similar for resident males and resident females (t = -0.6, 6.8*df*, *P =0.574*). Seasonal home ranges were also similar for resident males and resident females (*t*=-

0.6, 9.4*df*, *P*=0.586) and (*t*=-0.15, 7.1*df*, *P*=0.884) for summer and winter home ranges respectively.

Individual female summer and winter home ranges overlapped extensively whereas male home ranges were more distinct. Cougar F4 was the only cougar with the same summer and winter home range (Figure 3). Two adult cougars whose home ranges included higher elevations (M1, F2) concentrated their activities but not exclusively, to higher elevations during the summer period. Two adult cougars (M5, F7) passed through higher elevations but did not concentrate their activities there. Restriction to relatively small home ranges at low elevations during the winter period was common for most individuals. Movement off the winter home range corresponded to the movement of white-tailed deer and mule deer to their corresponding summer ranges.

Home range overlap between adult females was extensive (Table 4). Three of the six adult females annual home ranges overlapped. F2 and F4 had an 88 km^2 overlap, which was 9% and 69% of these females home ranges respectively (Figure 4). F11 home range was totally within F2's home range (Figure 5). F4 and F11 had an overlap of 40 km^2, which was 31% and 22% of these female home ranges respectively. Adult male and female annual home range overlap was also common. M10 completely overlapped F11's home range. M10 also overlapped F4 and F2 after M4 was killed. Prior to M1 being killed, F4's home range was completely within M1's home range. M5 and F6 had a 166km^2 overlap, which represents 32 % of F6's home range. M6 and F7 had a 652km^2 overlap, which represents 63% of F7's home range. Home range overlap between adult males was restricted to M5 and M6 in which M5's home range was completely with M6's home range. M5 was a subadult when collared and his home range was extremely small. Within eight months of being collared, M5 died of starvation.

Table 4. Area and percent overlap of annual home ranges (100% Minimum convex polygon) for adult female (F-F), adult female and male (F-M), and adult male (M-M) cougars in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Cougars	km^2	% Overlap by Individual	
F2 – F4	88	F2 – 9	F4 – 69
F2 – F11			F11 – 100
F4 – F11	40	F4 – 31	F11 – 22
F11 – M10		F4 – 100	
F4 – M10	125	F4 – 98	M10 – 18
F2 – M10	617	F2 – 62	M10 – 87
F4 – M1		F4 – 100	
F6 – M5	166	F6 – 32	M5 – 59
F7 – M6	652	F7 – 63	M6 – 72
M5 – M6		M5 – 100	

Figure 3 – F4 Home Range

Figure 3 – Home Range

Figure 4 – Overlap F2:F4

Figure 5 – Overlap F2:F11

Annual home ranges of 6 females and 4 males were also calculated using the adaptive kernel (ADK) method (Table 5).

Table 5. Annual home ranges (95%,50% ADK) from aerial telemetry locations for female (F) and male (M) cougars in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Cougar ID	Annual Home Range km^2		No. of Locations
	95%	50%	
F2	757	142	114
F3	788	89	152
F4	132	19	140
F6	843	80	56
F7	609	46	115
F11[a]	147	10	108
M1	856	112	96
M5	418	68	36
M6	1616	295	42
M10[a]	683	148	100

[a] F11 and M10 were two cougars collared in Washington State that established home ranges within the study area.

Sex and Age

The sex ratio (M:F) of 12 cougar kittens was 7 males to 5 females (1.4:1). The sex ratios for 5 litters of kittens were 0:2, 2:1, 1:1, 2:1, 2:0.

The sex ratio for 12 adult and subadult cougars (6M and 6F) radiocollared on the study area was (1:1).

The age structure showed that kittens made up 50% of the cougar population in 1999, 36% in 2000, 36% in 2001, and 27% in 2002. Resident females ranged in age from 2 years to 8 years. F4 was collared at an approximate age of 4 in 1999 and was still alive in the January 2003 when the project houndsman treed her and positively identified her from her ear tags. She successfully raised 2 litters during the course of the study. Resident males ranged in age from 2 years to 4 years. Heavy hunting pressure apparently prevented the males from reaching older age classes.

Reproduction

Six adult females produced 7 litters over the course of the study (Table 6). These 7 litters produced 17 kittens. Litters had 2-3 kittens each. Mean litter size was 2.4 (n=7, SD= 0.25). Litter size was determined from capture, repeated visual observations when treed, and photos from a remote camera set up at a kill site. Litter size was usually determined when litters were < 5 months old. The reproductive rate (# kittens/adult female/year) varied between 0.33 and 1 (Table 7).

Table 6. Cougar reproductive characteristics in the South Selkirk Mountains, B.C., December 1998 – March 2002, determined from visuals (treed), capture, and photos from a remote camera set up at a kill site.

Litter Reference No.	Litter Size	Sex[a]	Year	Method	Maternal ID No.
1	2	F1,F2	1998	capture	U[b]
2	3	F5,M3,M4	1999	capture	F4
3	3	U	1999	visual	U[b]
4	2	F6,M	2000	capture/ visual	U[b]
5	3	F10,M8,M9	2000	capture	F11
6	2	U	2001	visual	F1
7	2	2M	2001	capture	F4

[a] Sexes are female (F), male (M) and unknown (U)
Cougar ID numbers are listed when possible
[b] Unknown

Table 7. Reproductive Rate for Adult Female Cougars in the South Selkirk Mountains.

Female Reference No.	1998	1999	2000	2001	Total
F1	0	0	0	2	2
F4	0	3	0	2	5
F11	0	0	3	0	3
U[a]	2	0	0	0	2
U[a]	0	3	0	0	3
U[a]	0	0	2	0	2
Av. #kittens/Adult Female/Year	0.33	1	0.83	0.67	0.71

We were able to assign birth months for 5 of the litters. One litter was born in May, 2 in June, 1 in August and 1 in September. The age interval between breeding was not determined however one female had kittens 17 months after her first kittens dispersed. Only one known-age cougar had her first litter after she was radiocollared. She had her first litter at 30 months of age. Based on a gestation period of 92 days (Anderson 1983), this cougar was bred for the first time when she was 27 months of age. F7 was at least 3 years old when she was collared. She appeared to be pregnant at the time of collaring but there was no evidence of kittens over the course of the following winter.


Known cougar den (Photo by R Clarke)

Dispersal

We documented juvenile emigration from the study area from compulsory inspection of harvested cougars and radio telemetry activity. Six of the 8 (75%) radiocollared juveniles and subadults (3F, 3M) dispersed during the study. Dispersal of juveniles from the maternal home range varied from 3 months to 8 months after independence. The average dispersal age was 24.7 months (range = 22– 26 months). Three siblings (2M,1F) were 23 – 24 months old when they emigrated. One male was shot in northern Idaho, 65 km from his capture location. The female was radio located 177 km from her capture location. The other male was 60 km from his capture site when we lost his signal. Two sibling females that were collared at the same location were 26 months old when one of them emigrated. She set up a home range in northern Idaho 84 km from where she was captured. A young 24 - 25 month old female emigrated and set up a home range in northern Idaho 62 km from her capture site. One juvenile male cougar that was collared moved out of the study area and attempts to relocate him were unsuccessful. Dispersal ranged from 60 – 177 km (x = 89.6 km, SE = 44, n = 5).
Two radiocollared juvenile females did not disperse upon reaching independence. We did not get the opportunity to collar the mothers of these cougars, however both cougars remained in the same general geographic area as their capture site (Figure 6). No marked males born in the study area that survived to independence (n=3) remained in the study area. Four juveniles (2M, 2F) died shortly after becoming independent prior to dispersal.

Mortality

We documented the deaths of 12 of the 19 cougars we radiocollared over the course of the study (Table 8). Adult cougars sustained the highest losses; 5 males and 3 females died. Seven of the documented mortalities were attributed to cougar hunters. No collared juveniles were killed by hunters during the study. However by the end of the study 5 of the 15 kittens observed and/or handled had been killed as subadults by hunters. Three collared cougars died of natural causes. These included succumbing to an injury sustained while attacking prey aggravated by extremely poor condition, skeletal remains of a adult female found with a puncture wound through the skull (tracks of a larger cougar in vicinity), and starvation. Other mortalities include one collared adult male that was killed after it was documented killing two endangered South Selkirk Mountain Caribou and a mortality signal of collared subadult in Pend d'Oreille reservoir. Mortalities associated with capture activities include an adult female having an adverse reaction to Telezol and an adult tom being shot by a houndsmen when it attacked one of his hounds.

Figure 6 – F6 Juvenile – Adult Home Ranges

Table 8. Life Span of radiocollared cougars that died in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Cougar ID	Capture Date	Mortality Date	Cause of Mortality	No. of months with live signal
F5	Jan. 10, 2000	Jan. 2, 2001	Hunter Kill	12
F6	Jan. 19, 2000	Feb. 25, 2002	Hunter Kill	26
F7	Jan. 27, 2000	Dec.21 2002	Unknown	35
F8	Jan. 21,2001	Feb. 3, 2001	Unknown	<1
F10	Jan.31, 2002	Feb. 1, 2002	Hunter Kill	1 day
M1	Dec. 10, 1998	March 7,2000	Animal Control	15
M2	Dec. 27, 1998	Feb. 15,1999	Hunter Kill	2
M4	Feb. 3, 2000	Dec. 22, 2000	Hunter Kill	11
M5	Jan.3, 2001	Aug. 7, 2001	Starvation	7
M6	Jan. 10, 2001	Dec. 16, 2001	Hunter Kill	11
M7	Jan 17, 2001	Feb. 11, 2001	Hunting Death	1
M9	Jan. 21, 2002	March 20, 2002	Hunter Kill	2

Annual survival rates were calculated for radiocollared cougars in the South Selkirk Mountains (Table 9) using the Kaplan-Meier method (Pollock et al. 1989). This approach centers on the time of death of each individual in the sample and allows for the staggered entry of collared individuals to maintain a large sample size.

Table 9. South Selkirk Collared Cougar Survival Rates, 95% Confidence Intervals, December 1998 – March 2002[a].

Period	Survival Rate	Standard Error
Dec. 1998 – Mar. 1999	0.42188	0.216506
Apr.1999 – July 1999	0.64952	0.216506
Aug. 1999 – Nov. 1999	0.75000	0.216506
Dec. 1999 – Mar.2000	0.73779	0.207870
Apr. 2000 – July 2000	0.78405	0.207870
Aug. 2000 – Nov. 2000	0.81650	0.207870
Dec. 2000 – March 2001	0.64200	0.161203
Apr. 2001 – July 2001	0.67856	0.161203
Aug. 2001 – Nov. 2001	0.67760	0.147051
Dec. 2001 – March 2002	0.40655	0.045169

[a] Includes F11 and M10 that were collared in Washington State.

Seasonal survivorship for cougars was lowest during the winter months (Figure 7). Cougar sport hunting was the predominant cause of mortality during this season. There was only one mortality that did not occur during the winter months (M5 died of starvation in August).

Recorded cougar mortality, from MWLAP harvest data (B.C. Ministry of Water, Land, and Air Protection, unpubl data) was summarized for the period 1977 to 1999 for Management Units 4-07 and 4-08. Of the 140 mortalities in the 22 years, 78 (56%) were males, 60 (43%) were females, and 2 (0.01%) were unclassified. These figures represent cougars that were killed by hunters, animal control, illegal kills and animals that were picked up (found dead). One hundred of the mortalities (71%) were attributed to hunting (54M, 36F). Since 1977, an average of 4.5 cougars were harvested each year in the study area and the immediate vicinity. During-1999 – 2002, hunters within the study area killed 11 uncollared cougars (7M, 4F).

Known annual mortality of both collared and uncollared cougars within the study area was 12% in 1999, 29% in 2000, 41% in 2001, and 53% in 2002 based on the population estimates for those years. Mortality of females increased from 0% in 1999 to 50% in 2002 based on the yearly estimated population. Sport hunting accounted for 79% of male mortality and 78% of the female mortality (both collared and uncollared cougars) in the study area over the course of the study.

Relative Abundance Trial

Twenty-eight cougar rub pads were set up in the Pend d'Oreille valley for a total of 113 days from December 13, 2001 to April 4, 2002. They were checked every two weeks during that time. The effort yielded only one visitation by a bobcat. One cougar walked within 3 m of a rub pad based on track observations. A bobcat track was observed within 10 m of a rub pad along an old trail and there was no sign of the tracks moving in the direction of the rub pad.

Rot-Off Collars

All of the radiocollars used (n=20) were equipped with rot-off strips inserted into the collar. The collars rotted off four adult cougars (0M, 4F). One female cougar was initially collared as a juvenile so we cut the rot-off so as only 2 cm was intact and she dropped her collar 9 months after collaring. She was recollared the following winter. The average life span of the collars that rotted off was 26 months (range 18 to 37 months).

Discussion

Cougar density on the BC portion of the South Selkirk Mountain study area was $0.55/100km^2$ and remained relatively stable during the course of the 4 year study. This stability was most likely due to the immigration of subadult and transient cougars from northeastern Washington State where there is no hunting season. The density estimate were considerably lower than densities in studies in British Columbia (Spreadbury et al. 1996) and in Alberta (Ross and Jalkotzy, 1992) but were similar to those found in Utah (Hemker et al., 1984) and in Texas (Harveson, 1997 and Pittman et al., 2000). Over the course of the study the juvenile component of the population steadily decreased. As well, that the majority of cougars captured were in the subadult category indicates that the average age of the population was decreasing resulting in fewer females of breeding age.

Figure 7 – South Selkirk Collared Cougar Survival Rates December 1998 – March 2002.

Seasonal and annual home ranges for male and female cougars in the BC portion of the South Selkirk Mountains were considerably larger in size compared with other studies in South-western Canada and Western United States with the exception of Hemker et al. (1984) who had similar results as this study (Table 10).

Table 10. Summary of female and male cougar mean home ranges (100% minimum convex polygon) from studies in Southwestern Canada and Western United States.

Area	Population Man. Status	Female		Male		Reference
		km^2	*n*	km^2	*n*	
Southeastern B.C.	Not Hunted	55	4	152	2	Spreadbury et al. 1996
Southeastern B.C.	Hunted	628	6	782	4	This study
South-western Alberta	Hunted	140	21	334	6	Ross & Jalkotzy 1992
Utah	Not Hunted	685	4	826	1	Hemker et al. 1984
Wyoming	Hunted	67	4	320	2	Logan et al. 1986
Central Idaho	Hunted	106.6	9	125.5	4	Seidensticker et al. 1973

The variability in home range size was quite evident and the reasons are varied and still poorly understood. However the major factors determining home range size in different areas are habitat quality for prey and the availability of stalking cover (Seidensticker et al. 1973, Ross and Jalkotzy 1992). Logan et al. (1996) observed that larger home ranges are needed when prey densities are low, and home range size tends to increase when the habitat of the cougars prey becomes fragmented. When cougar densities are not limited by prey availability, social interactions may limit their numbers (Hornocker 1970). However, hunting pressure also needs to be considered in analyzing home range size. The removal of both resident males and females created unoccupied habitat resulting in home range shifts. This was most evident with M10 and F11. Both cougars were collared in Washington State and both shifted their home ranges with the removal of cougars of both sexes on the British Columbia side of the border. This finding is consistent with other cougar studies (Seidensticker et al. 1973). One also needs to consider different techniques used to determine home range size (Seidensticker et al. 1973, Hopkins et al. 1986, Neal et al. 1987), different sample sizes, and duration of study (Ross and Jalkotzy 1992) when comparing results between studies.

Considerable annual home range overlap of female cougars was noted. This is consistent with previous studies (Smith et al. 1986, Sweanor 1990, Cunningham et al. 1995, and Logan 1996). In one case, annual home ranges of females overlapped completely. F11's home range was 100% within F4's home range. This is consistent with Seidensticker et al. (1973) and Neal et al. (1987). As noted in Ross and Jalkotzy (1992) and Honocker (1969) areas home range overlap were usually avoided temporally thereby reducing the frequency of direct conflict between individuals.

Considerable overlap of female and male annual home ranges also occurred throughout the study area, and this is also consistent with other studies (Smith et al. 1986, Sweanor 1990, Harveson 1997). M10 overlapped with as many as 3 females in the BC portion of the study area. Over the course of two years, F11's annual home range was completely within M10's home range. Before M1 was killed F4's annual home range was within M1's home range. With the removal of M1, M10 shifted his home range and occupied 98% of F4's home range and remained to represent the male segment of the radiocollared cougars on the western portion of the study area.

There was only one overlap of male home ranges. M5's home range was completely within M6's home range. M5 was a subadult when captured and his home range was extremely small. He died of starvation after being radiocollared for only eight months, which was probably brought on by a complicating factor. One of his canines had been freshly broken off which may have occurred from a fight with M6. Radio telemetry indicated that they were within 6 km of each other three weeks before his death (Figure 8). The intervening period between his death and the possible conflict with M6, M5 remained relatively stationary along Midge Creek, which provides further evidence that he had been injured in a fight. Although male's home ranges cover a large geographical area, there was no evidence of males crossing the boundaries of other male home ranges other than noted above.

The majority of resident cougars exhibited seasonal home range shifts. Mule deer, white-tailed deer, elk and to a lesser extent moose were typically present throughout the year. Caribou were present during the late spring, summer and early fall. Elevational migrations of prey were largely a function of snow depth within the study area (Robinson et al. 2002). This resulted in seasonal cougar shifts corresponding to seasonal prey movements. Generally during the summer months the cougars extended their home ranges to include higher elevations but they did not use the higher elevations exclusively. Only two cougars summer home ranges (M1 and F2) overlapped extensively with the summer home range of the caribou. M1's home range overlapped significantly with the caribou (Figure 9). In 1999 there were two collared caribou mortalities and possibly a third that was attributed to M1. There were no confirmed caribou mortalities attributed to cougars in 2000, 2001, or 2002 (Jon Almack pers. comm.). From 1995 to March 2000 twenty-nine radiocollared caribou mortalities have been recorded. Seven of those were attributed to cougars (Almack 2000). There was considerably more cougar overlap with mule deer year-round on the Creston side of the study area. On the Salmo side of the study area, mule deer cougar overlap was predominantly during early spring through early winter.

The sex ratio of known litters of kittens within the study area had more males than females. More males than females were also noted in Southeastern BC (Spreadbury 1996) however the opposite was observed in other studies (Robinnette et al. 1961, Hornocker 1970, Hemker 1982, Logan et al. 1986). However Anderson (1992) observed that sex ratios in smaller samples might be a function of sample size. Adult and subadult sex ratio was 1:1 in the study area.

At the start of the study, kittens made up half of the population and by the end of the study they only represented a quarter of the population. Resident females were relatively young but generally appeared to be longer lived that the males. However there was an increase in hunting pressure on females towards the end of the study as male numbers decreased. Generally, the majority of cougar hunters are interested in large males as opposed to the smaller females.

The mean litter size in this study was similar to other studies (Hornocker 1970, Anderson 1983, Hemker e al. 1986, Logan et al. 1986). All of the birth months for litters observed were from early spring to early fall. The birth interval between litters was only determined for one cougar (35 months) and it was similar to that noted in other studies (Robinette et al. 1961, Ashman et al. 1983, Logan et al 1986, Pall et al. 1988, Spreadbury et al. 1996). Survival of known kittens and

Figure 8 – M5 and M6 Interactions – Summer 2001

juveniles to independence was 71%. This was similar to that observed in other studies (Robinette et al. 1961, Hornocker 1970, Hemker et al. 1986).

Dispersal of juveniles from the study area was similar to that noted in other studies. Logan et al. (1986) noted dispersal distances of 9-274 km. Hemker et al. (1984) reported juvenile dispersal distances of 35-120 km. Pall et al. (1988) observed juvenile dispersal distances of 25-150 km. Spreadbury et al. (1996) observed juvenile dispersal distances of 12-163 km. There were no dispersals into Washington State, which indicates that home ranges availability was limited. Two females and one male did disperse into northern Idaho where cougar hunting is allowed. Two females did not disperse upon reaching independence. Both cougars set up home ranges that overlapped with their mothers. This has been observed in other studies (Murphy 1983, Maehr et al. 1989, Ross and Jalkotzy 1992) however some researchers (Seidensticker et al. 1973, Logan et al. 1986, Spreadbury et al. 1996) observed no non-dispersing juveniles. No collared males remained in the study area, however one male that was collared as a subadult and believed to be a sibling of F6 set up a home range just outside his mothers home range but within another males home range.

It was noted by Logan et al (1986) that losses to the resident adult population must be compensated for by the immigration of transients from outside the study area.

Cougar hunting for sport was the largest cause of mortality in the study and has also been noted in other hunted populations of cougars (Hornocker 1970, Currier et al. 1977, Shaw 1980, Murphy 1983, Logan et al. 1986, Ross and Jalkotzy 1992). Provincial cougar harvest data for the area (MWLAP 2000) recorded 71% of all mortalities from 1977 to 1999 attributed to hunting. Collared adult and subadult cougars were targeted by hunters with more males than females being killed. Similar numbers were recorded for non collared cougars in the study area. No collared juveniles were killed by hunters however 33% of kittens observed and/or handled had been killed as subadults by hunters. Within the West Kootenay region in which the study area is part of, a maximum of 25 females are allowed to be harvested. When the limit is reached, the Regional MWLAP Wildlife Biologist will shut the season down. During the study the annual female limit was only reached during the 2001/2002 hunting season.

One fifth of all collared cougar mortalities were natural. In the 4 years of study there were 4 non hunting mortalities out of a population of 19 collared cougars which is similar to other studies of hunted cougar populations (Hornocker 1970, Currier et al. 1977, Ashman et al. 1983, Ross and Jalkotzy 1992).

Determining relative abundance on wide-ranging carnivores is difficult. The use of rub pads does not appear to be an effective way of determining relative abundance for cougars in the study area. Researchers (Garth Mowat and John Weaver pers. comm.) suggest that the use of rub pads may be more successful in desert climates where high temperatures heat the lure resulting in the scent being dispersed more effectively. Low cougar density was also a factor that influenced the success. Low cougar density also precluded the use of systematic track counts within the study area. This method would also have a high cost due to the low densities. The one method that may have been effective would be a mark – recapture technique using hounds.

Rot off strips inserted into the collars are effective for short-term studies freeing the cougars of the collars after roughly a two-year period. However if the research is for a term longer than two years then rot off strips would not be effective unless the goal is to recapture the animals more than once during the study.

Figure 9 – Overlap of South Selkirk Caribou and M1

Management Implications

The management goal within the recovery area for the South Selkirk Mountain Caribou is to minimize predation on caribou. As described in Katnik (2002) only two cougar home ranges overlapped significantly with that of the caribou and the best management would be to remove individual cougars that are knowingly preying on caribou. However this management technique would be costly and labour intensive over the long term. Also not enough is known about the implications of the removal of resident males and how their home ranges are reoccupied by other males. The sex hypothesis of sexual segregation (Weilgus et al. 1995) where the mortality of older males results in the influx of younger, potentially infanticidal immigrant males and adult female avoidance of these males could be tested. To study this would require a longer study under more controlled conditions. Robinson et al (2002) proposed that limiting alternate prey could control the cougar population in the South Selkirk Mountains. He suggests that by maintaining a heavy hunter harvest on white-tailed deer, cougar populations would not be allowed to grow. The present management of cougars in the study area has been successful in reducing the cougar population but there is the potential of reducing the cougar numbers to a level where a certain segment of cougar hunters stop hunting them. Over time cougar numbers would start to increase which will result in more hunters returning to hunt cougars but there is a time lag whereby the cougars could have a negative impact on caribou numbers during the interim. It would be advantageous to measure cougar abundance over time to help managers set cougar seasons and /or quotas in the caribou recovery area. The most accurate method would be to do a mark recapture survey every five years but would be expensive and time consuming. Lower cost ideas could include the hunter harvest trends. We compared the hunter harvest data (B.C. Ministry of Water, Land, and Air Protection, unpubl data) in Management units 4-07 and 4-08 with the estimated cougar population within the study area (Figure 10) to see if there was any correlation between hunter harvest and population trends. Based on this data over the course of the 3.5-year study there appears to be a good correlation between the two. Whether or not this is representative over a longer time frame is unknown. Other ideas include analysing the age/sex of harvested animals over time or trends in problem cougar reports.

The immigration of subadults from Washington State is helping to maintain the population within the BC portion of the study area. The age of harvested cougars is relatively young which indicates that the cougars are not establishing home ranges over a long term. Cougars have the ability to increase in numbers as long as a core population of breeding age animals is maintained as well as a sufficient prey base.

Figure 10 – Hunter Harvest vs. Study Area Population Estimates

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Appendices

Appendix 1. Capture dates and status of females (F) cougars collared in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Cougar ID	Capture Date	Age Class[a] at Capture	Est. Weight (kg)	Condition Class	Capture Location	Capture Method	Status March 2002
F1 (Bonnie)	Dec. 5 1998	J	36	Good	Lost Cr.	Hounds	Alive
F2 (Claire)	Dec. 5 1998	J	36	Good	Lost Cr.	Hounds	Alive
F3 (Gidgit)	March 5 1999	S	39	Good	Pend d'Oreille	Hounds	Alive
F4 (Linda)	Dec. 20 1999	A	55	Good	Nelway	Hounds	Alive
F5 (Anna)	Jan. 10 2000	J	36	Good	Remac	Hounds	Mortality[b]
F6 (Ginger)	Jan. 19 2000	J	23	Good	Summit Cr.	Hounds	Mortality[c]
F7 (Trouper)	Jan. 27 2000	A	41	Good	Five Mile Cr.	Hounds	Unknown[d]
F8 (Beau)	Jan. 21 2001	S	36	Fair	Limpid cr.	Hounds	Unknown[e]
F9 (Stephenie)	March 5 2001	A	55	Good	Corn Cr.	Hounds	Unknown[f]
F10 (Oreo)	Jan. 31 2002	S	41	Good	McCormick Cr.	Hounds	Mortality[g]

[a] as per Ross and Jalkotzy (1992) A-Adult, S-Subadult, J-Juvenile
[b] Killed by cougar hunter on December 29, 2000 – Sugar Lake
[c] Killed by cougar hunter on Feb. 25, 2002 – Topaz Cr.
[d] Only remains found Dec. 2001
[e] Mortality signal located in Pend d'Oreille Reservoir Feb. 3, 2001 – Collar not recovered
[f] Dropped Collar May 6, 2001
[g] Killed by cougar hunter on Feb. 1, 2002 – McCormick Cr.

Appendix 2. Capture dates and status of male (M) cougars collared in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Cougar ID	Capture Date	Age Class[a] at Capture	Est. Weight (kg)	Condition Class	Capture Location	Capture Method	Status March 2002
M1 (Mr. Nasty)	Dec. 10 1998	A	73	Good	Porto Rico	Hounds	Mortality[b]
M2 (Dodgey)	Dec. 27 1998	A	68	Good	Dodge Cr.	Hounds	Mortality[c]
M3 (Tommy Hunter)	Jan. 7 2000	J	57	Good	McCormick Cr.	Hounds	Unknown[d]
M4 (Muffin)	Feb. 3 2000	J	54	Good	McCormick Cr.	Hounds	Mortality[e]
M5 (Matt)	Jan. 3 2001	A	73	Good	Newington Cr.	Hounds	Mortality[f]
M6 (George)	Jan. 10 2001	S	54	Good	Lasca Cr.	Hounds	Mortality[g]
M7 (Lewy)	Jan. 17 2001	J	36	Poor	Charbonneau Cr.	Hounds	Mortality[h]
M8 (Slim)	Jan. 17 2002	S	54	Good	Grouse Cr.	Hounds	Unknown[i]
M9 (Skidder)	Jan. 21 2002	S	45	Fair	Limpid Cr.	Hounds	Mortality[j]

[a] as per Ross and Jalkotzy (1992) A-Adult, S-Subadult, J-Juvenile
[b] Killed for animal control purposes on March 7, 2000 – Remac (had killed two South Selkirk Caribou)
[c] Killed by cougar hunter on Feb. 15, 1999 – Trout Cr. Idaho
[d] Moved out of study area
[e] Killed by cougar hunter on Dec. 22, 2000 – Fisher Cr. Idaho
[f] Died of starvation – investigated Aug. 7, 2001- Kutetl Cr.
[g] Killed by a cougar hunter on Dec. 16, 2001 – Topaz Cr.
[h] Natural mortality from an injury sustained while attacking prey aggravated by extremely poor condition on Feb. 11, 2001 – Nine Mile Cr.
[I] Moved out of study area
[j] Killed by cougar hunter on March 20, 2002 – Four Mile Cr.

Appendix 3. Summary of cougar kill site investigations in the South Selkirk Mountains, B.C., December 1998 – March 2002.

Species	Male	Female	Fawn/Calf	Unknown
White-tailed Deer	0	2	5	3
Mule Deer	0	1	0	0
Elk	2 (spikes)	0	0	0
Caribou	0	2	0	0

Appendix 4 – Individual Cougar Home Range Maps

Appendix 5 – Annual Home Range Overlap Maps

Appendix 6 – 95% and 50% Adaptive Kernel Home Range Maps