HABITAT USE, SEASONAL MOVEMENTS, AND POPULATION DYNAMICS OF BIGHORN SHEEP IN THE ELK VALLEY

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ABSTRACT

The Elk Valley, in south-eastern BC, supports important industrial activities such as coal mining and timber harvesting, and supports a provincially significant population of approximately 600 Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*). The Ewin Ridge sheep range to the north of Line Ridge has been considered to be the most important bighorn sheep winter range in BC.

In 1997 BC Environment staff, industrial resource users, residents, and other stakeholders organized the Elk Valley Bighorn Sheep Committee (EVBSC). The groups goals are: "*To employ the principle of sustainable development with a sheep management strategy that maintains a determined sheep population in perpetuity, and allow for orderly development of resources that will benefit mankind*".

In 2007 the EVBSC approved a plan to evaluate sheep habitat use, quality and distribution within the east Elk Valley in light of the potential for future industrial development. The results of the study are expected to provide recommendations to sustainably manage bighorn sheep and their habitats.

To date 39 sheep of both sexes have been fitted with global positioning system (GPS) collars, 62 vegetation enclosures have been placed across 8 winter range units and seasonal fecal pellet collections have occurred.

INTRODUCTION

The Elk Valley in southeastern British Columbia (BC) is home to a population of approximately 600 Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*). Bighorn sheep occupy high elevation winter ranges on both the east and west side of the Elk Valley. The majority (80%) of the Elk Valley bighorn sheep utilize high elevation grasslands on the east side. Bighorn sheep in this area are comparatively unique in BC, as they winter at high elevation where high winds and sun maintain relatively snow free grasslands on south-facing slopes. The bighorn sheep winter along high elevation, windswept grassland ridges as snow depths in the valley bottom are approximately 60 cm at 1600 m. The sheep population in the area is of provincial significance; the Ewin Ridge sheep range to the north of Line Ridge has been considered to be the most important bighorn sheep winter range in BC (Demarchi 1968).

The bighorn sheep within the Elk Valley are sought after by both resident and non-resident hunters. Since 1998, the average annual harvest from the Elk Valley is 11 full curl rams, which is the most heavily harvested area in the Kootenay Region. In addition, since 2000, 11 trophy bighorn rams have been harvested from the east side of the Elk Valley through the Premier's Special Sheep Permit.

In 1997 a process was begun among BC Environment staff, industrial resource users, residents, and other stakeholders to coordinate bighorn sheep management in the east side of the Elk Valley in southeastern BC (Adams et al. 2001). The goal of this group, the Elk Valley Bighorn Sheep Committee (EVBSC), was: "*To employ the principle of sustainable development with a bighorn sheep management strategy that maintains a determined sheep population in perpetuity, and allow for orderly development of resources that will benefit mankind*".

The Elk Valley supports important industrial activities, primarily coal mining and timber harvesting. Even though the four coal mines have been in existence since the late 1960s, important high elevation winter ranges have not been significantly impacted by development. However, with increasing demand for coal, future expansion is proposed to occur within important winter ranges. Winter range is likely the single most important factor controlling bighorn sheep populations in the area (Schuerholz 1984). Incomplete knowledge about bighorn sheep ecology in the area of interest, including important winter use areas, habitat use and migration corridors, was identified as one obstacle to coordinating sheep management activities. Identification of high value areas can be used to assess and manage the potential impacts of industrial activities. Previous radio-telemetry studies of bighorn sheep have been carried out (Schuerholz 1984), but collaring was limited primarily to the Line Creek area, and was sporadic and incomplete; e.g., lambing grounds could not be determined from the data. Data on numbers and distribution of sheep are available. Independent winter wildlife surveys by the five coal mines in the region were begun in the early 1980s and are conducted annually. Also, since 2002, BC Environment conducts a valley-wide sheep survey in the Elk Valley East area every 2 years (generally funded by Habitat Conservation Trust Fund; I. Teske, BC Environment, pers. comm.).

In 2008 a report was developed that reviewed existing data and proposed a study design and work plan to augment existing knowledge of bighorn sheep in the Elk Valley (Poole and MacCallum 2008). The report and proposed study design were reviewed by the EVBSC. In large part with funding from Teck Coal, this study was initiated during winter 2008–09. The overall goal of this research project is to provide information to improve the management and conservation of bighorn sheep within the east side of the Elk Valley. Specific objectives include:

- Describe and document seasonal habitats of bighorn sheep occupying ranges along the east side of the Elk Valley from the northern boundary of Fording River Operations to southern boundary of Elkview Operations;
- Describe and map important habitats such as movement corridors, lambing areas, mineral licks, rutting areas, seasonal ranges, etc.;
- Assess bighorn sheep seasonal use of reclaimed mine sites vs. natural habitats;
- Estimate survival rates of collared ewes and rams;
- Develop a model of winter habitat capability for sheep within the study area;

- Compare forage quality and quantity between summer and winter ranges and between reclaimed and natural sites;
- Use radio-collared sheep to quantify animal sightability using high elevation habitats during annual winter surveys; and
- Provide recommendations regarding maintaining or improving the health and size of bighorn populations and habitats.

Objectives related to high elevation habitat condition are being addressed in a companion study headed by Clint Smyth (Matrix Solutions Inc., Calgary), and include:

- Describe and classify winter range plant communities according to accepted phytosociological methods as well as site series coding;
- Measure standing crop production of graminoids (grasses, sedges and rushes), forbs, and shrubs on bighorn sheep winter ranges;
- Evaluate estimates of bighorn sheep winter diet through faecal analyses; and
- Measure the nutritional composition of forage plants.

STUDY AREA

This study focuses on bighorn sheep populations wintering east of the Elk River from Highway 3 in the south to the upper reaches of the Fording River drainage in the north. Alberta border herds near Crowsnest Pass and Deadman Pass will not be examined. The study area is entirely within BC Environment Management Unit 4-23, and covers approximately 800 km^2. A number of sheep wintering areas (some of which may be combined into "herds") occur within the study area (Fig. 1). The most recent count of sheep in the study area was 362 (February 2008; I. Teske, BC Environment, unpubl. data). Given less than full sightability, it is likely that a minimum of 400 sheep reside within the study area. Additional sheep occur within the Elk Valley north and south of the study area (Aldridge, Tobermory, Crowsnest, Deadman's Pass), and in scattered herds west of the Elk River.

Biogeoclimatic zones within the study area grade from Montane Spruce dry cool (MSdk) in valley bottoms, Engelmann Spruce–Subalpine Fir dry cool (ESSFdk, including subalpine parkland) at higher elevations, to small amounts of Alpine Tundra (AT) on ridge and mountain tops (Meidinger and Pojar 1991, Braumandl and Curran 1992). Approximately 92 km^2 of the study area (12%) is taken up with mine-related infrastructure, pits, dumpsites, etc.

Snow depths in the valley bottom (1600 m) average approximately 60 cm (Environment Canada Climate Data and Information Archive). Snow depths on high elevation grasslands are much less due to south facing aspects and wind conditions.

There are 7 major winter ranges grouped spatially (i.e., Erickson Ridge, Sheep Mountain, Ewin Ridge, Todhunter Ridge / Imperial Ridge, Chauncey, Greenhills Range, and Turnbull Mountain / Brownie Ridge / Henretta Ridge). The telemetry data collected will be correlated with winter range habitat.

STUDY DESIGN AND METHODOLOGY

Full rationale for the study is provided in Poole and MacCallum (2008). The methodology regarding the accompanying habitat condition component of this research is outlined in Smyth (2008). A summary is provided below.

Bighorn Sheep Capture and Collaring

In February 2009, we deployed global positioning system (GPS) collars on bighorn sheep within the study area, spreading capture effort throughout our areas of interest. Equal numbers of rams and ewes were collared. We attempted to deploy about 4 collars on each winter range (equal numbers of each sex if possible), with a greater emphasis on Ewin Ridge and Greenhills, and a slightly reduced emphasis on Elkview/Erickson Ridge. Sheep were captured by helicopter net-gunning (Barrett et al. 1982) using an experienced crew, as this was the most efficient and practical method. A second helicopter was used to transport additional workers to assist in handling sheep. Once netted, we restrained the sheep using hobbles and blindfolds, and attached a GPS radio collar. A number of measurements were obtained in most cases: horn measurements (length and base), estimated age (using annuli on the horns and tooth eruption), total length, chest girth, and neck girth. In addition, we sampled blood for pregnancy (progesterone levels), selenium analysis, and parasites, hair and a biopsy sample (ear punch) for DNA archives and genetic studies, and faecal pellets (for dietary analysis and parasites). To facilitate observation and identification from the ground, we generally placed a numbered, orange ear-tag on each animal.

Processing was accomplished as quickly as possible, and the animals were released immediately, generally within 15–20 minutes of netting. We avoided capturing rams with greater than ⅔ to ¾ curl because larger males appear to have higher rates of capture myopathy after handling (C. Wilson, pers. comm., H. Schwantje, pers. comm.). Capture and handling protocol was approved by H. Schwantje, Wildlife Veterinarian, BC Environment, Victoria (pers. comm.), and was conducted under BC Environment permit CB09-51173. All procedures meet Canadian Council on Animal Care Standards.

The GPS collars (model G2110B, Advanced Telemetry Systems [ATS], Isanta, Minnesota, USA) weigh approximately 450–500 g, and are equipped with a 12-channel Trimble GPS board (Fig. 2). Fluorescent orange tape was affixed to the webbing to enhance sightability in the field. Collars were set to a 10-hour fix rate (2.4 locations/day) to allow >2 years of monitoring (2 full winters), and to allow complete sampling of the 24-hour period (by shifting fix attempt timing each day). The collars were equipped with motion-sensitive mortality sensors. Each collar was also equipped with a VHF transmitter. To extend battery life, the VHF signal was programmed to come on only during daylight hours (8:00 to 17:00 hr MST) for 5–6 days each month. The collars were programmed to obtain a fix with 120-second maximum on time with no retry on failed attempts. The collars store data in nonvolatile memory, including horizontal position in the WGS84 datum, altitude, date, time, satellite data, fix mode [2- or 3-dimensional (2D or 3D)], dilution of precision (DOP), the time required to obtain a fix, ambient temperature, and tilt switch movements. An 810-day period was set for timed collar drop-off. If the batteries run low prior to the scheduled release date, the GPS function will stop and the collars will produce a 40 beats per minute

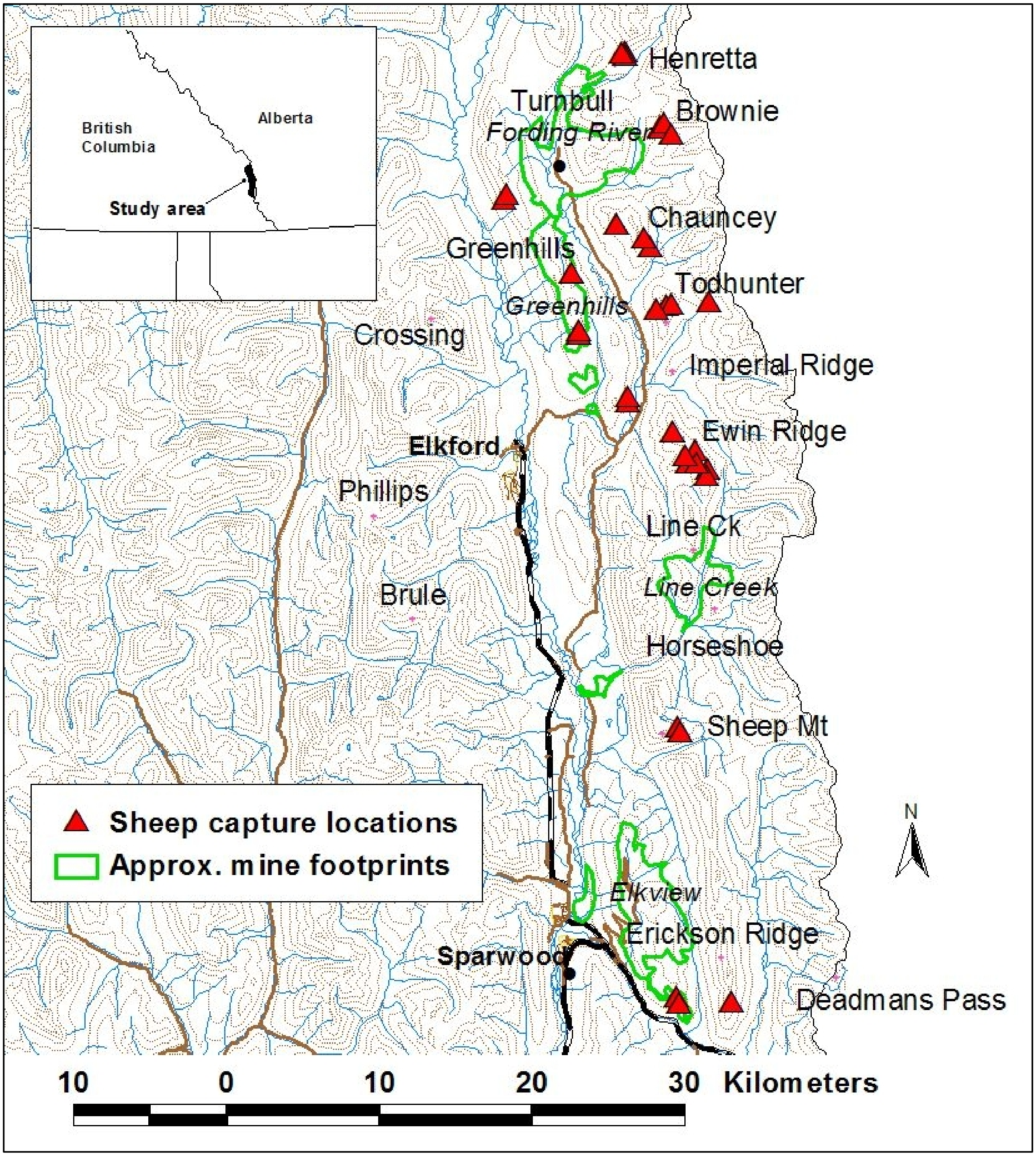

Figure 1. Location of bighorn sheep collars deployed in late February 2009, Elk Valley.

signal for 50 days, after which time the collar would release. The collars would then produce a VHF signal (120 beats per minute) for a minimum of 30 days, allowing ample time for retrieval. GPS locations are retained on board the collar even if low battery power is reached.

GPS collars retrieved from mortality sites will be redeployed by ground darting bighorn sheep. Personnel experienced in ground free-range darting and chemical immobilization will conduct this work. BC Environment veterinarian (H. Schwantje pers. comm) has recommended the drug combination Telazol/detomidine with atipamezole as the antagonist. Capturing and chemically immobilizing ewes should be avoided from April – July as stress and drugs can affect health of lambs.

Bighorn Sheep Monitoring

Collared sheep will be located monthly using a Piper Super Cub to monitor collars, identify mortalities and document broad movements. This monitoring schedule will not enable rapid detection of dead sheep and hence identify sources of mortality, but represents a compromise between maximizing collar battery life, saving money on aerial flights, and keeping in touch with the GPS collars to address mortalities and collar malfunctions. Because of the reduced need for aerial relocation flights, GPS collars are ideally suited to studies on ungulates that are sensitive to aircraft disturbance (Penner 1988, Côté 1996).

Sheep locations are recorded using a hand held GPS. The general habitat type of the location and the presence of accompanying sheep are also recorded. All collared sheep mortalities will be visited. The site will be described and GPS collar retrieved. We will attempt to determine the cause of mortality but as most site investigations will occur weeks after the date of mortality, cause of death may not be apparent.

Collar Retrieval

The collars will be released from the animals during May 2011, retrieved, and the GPS data will be downloaded to a computer Excel file (as a *.csv file).

Data Analysis

We will examine sheep habitat selection using multivariate logistic regression and RSFs, using both design II and design III studies (Manly et al. 2002). Seasons will be identified that reflect distinct periods of habitat use and spatial distribution. Specific dates of elevation and habitat shift may vary among years and animals, and using a specific date to stratify data into seasons may fail to clearly define seasonal habitat selection strategies (Apps et al. 2001). Therefore, we will stratify data according to seasonal elevation and habitat shifts made by each individual.

GPS location data will be screened by visual inspection, and likely inaccurate locations will be removed (based on dilution of precision (DOP)>10; D'Eon and Delparte 2005). The average accuracy of non-differentially corrected GPS locations is roughly 5–30 m (50% and 95% of locations, respectively; D'Eon et al. 2002), likely in the range of accuracy of the habitat data that will be used. Animal movements and home range will be determined using the Animal Movement extension (Hooge and Eichenlaub 1997) and the Home Range extension (Rodgers and Carr 1998) for ArcView (Environmental Systems Research Institute, Redlands California, U.S.A.). If the ATS collars are used, we will likely not need to correct for possible habitat-induced GPS bias (Hebblewhite et al. 2007).

We will obtain digital 1:20,000 scale topographic (Terrain Resource Information Mapping) and Forest Cover (B.C. Ministry of Forests, Forest Inventory Program) files of the study areas to obtain variables of relevance to sheep (elevation, slope, stand age, etc.). Use of Predictive Ecosystem Mapping (PEM), Terrestrial Ecosystem Mapping (TEM), and Vegetation Resource Inventory (VRI) mapping will be explored. Terrestrial Ecosystem Mapping is incomplete for the Elk Valley (P. Holmes, BC Environment, pers. comm. March 12, 2008). VRI mapping replaces Forest Cover maps but may not be available for the Elk Valley. Measures of solar radiation and terrain ruggedness have been developed for the East Kootenay (K. Poole, unpublished data).

The GPS collars will identify a number of seasonally important habitats within the study area, including lambing areas, mineral licks, and rutting areas. GPS collars on mountain goats in the East Kootenay enabled us to locate a number of new mineral licks frequented by goats (Poole and Bachmann 2007). It may be difficult to determine lambing sites from GPS collar data depending upon the pattern of movement and localization of ewes at lambing. Broad lambing areas can more easily be determined.

Snow survey (depth) and snow pillow data (snow water equivalent) will be obtained from government web sites (http://www.env.gov.bc.ca/rfc/river_forecast/spdcolumbia.html). Snow water equivalent is significantly related to snow depth ($r^2 = 0.82$; DelGiudice et al. 2001).

Sightability Estimate

Approximately 40 GPS collared sheep will be available to provide opportunities to test animal sightability during actual survey conditions, especially because both sexes will be collared. A sightability of 80-85% has been assumed during recent valley-wide surveys carried out by BC Environment (I. Teske, pers. comm.), but this value has never been tested. Our focus here is to quantify sheep sightability to provide some indication of the correction factor needed to provide more reliable population estimates.

A sightability survey is scheduled for February 2010 and 2011 using a Bell 206B helicopter. During the survey all high-elevation grasslands and known wintering areas for sheep will be surveyed, and observed sheep will be counted and classified. Sheep locations will be recorded by GPS. The collars on sheep should be visible as they are bright orange and sightings of collared animals can be recorded during the survey. To verify the location of all collared sheep during the survey, a fixed-wing telemetry flight will occur as the survey progresses (following behind the survey helicopter but out of contact with sightings).

Habitat Condition Assessments

In May of 2009, 62 vegetation production cages were deployed across the 7 winter range areas and ungulate faecal pellet sampling transects were established at each of these locations. From each of the transect sites 24 pellet samples were collected. A representative number of samples from each range unit will be analyzed while additional samples will be maintained for future use.

RESULTS

Bighorn Sheep Capture and Collaring

Collars were initiated on 25 February 2009, thus the projected time-release date is 16 May 2011. We captured and fitted GPS collars on 39 bighorn sheep (20 rams and 19 ewes) during 26–28 February 2009 (Fig. 1). The sample size for captures represents approximately 10% of the study area sheep population. Although there appeared to be some sexual segregation among winter ranges, we deployed the collars as planned among ranges. Most ranges received 4 collars (Sheep Mountain, Todhunter, Chauncey, Brownie, Henretta), Elkview/Erickson Ridge received 3 collars, and Ewin Ridge (8 collars) and Greenhills (6 collars) received greater emphasis because of greater numbers of sheep (both ranges) and likelihood of future development into sheep range (Greenhills). Six sheep were captured on mine-altered habitat: 2 in the Elkview, and 4 at Greenhills. Average age of collared ewes was 4.9 years (± 0.26 SE; range 3–6 years), and of collared rams was 2.7 years (± 0.21 SE; range 1–5 years). The ewe ages are likely an underestimate because annuli were less distinct in older animals; most (84%) were estimated to be 4 years or older. Eighty percent of rams were 2 or 3 years of age. Samples and measurements were obtained from most sheep. All sheep appeared to be healthy. Contagious ecthyma was not observed.

One ewe collar was not deployed because the release mechanism was inadvertently triggered during handling. This collar is repaired, and will be deployed from the ground in early fall 2009 along with other collars retrieved from mortality sites.

Bighorn Sheep Monitoring

Collared sheep are monitored monthly using a Piper Super Cub. As of July 2, 5 sheep have been located with their collars on mortality mode, signalling that the collars had remained stationary for at least 8 hours. Of these 5 mortalities, all but one were rams. Causes of mortality are: 1 avalanche (ewe), 1 drowning, 1 possible road kill and 2 unknown as site investigations have not yet occurred. Age class of the 4 rams that died were 2 CL1, 1 CL2 and 1 CL 3. The ewe that died in the avalanche was likely capture related as mortality occurred less than 6 hours after release. The ram that drowned may also be capture related as he died 47 hours after capture. All of the remaining collars are functioning normally, with 89% of these collars signalling that the previous GPS location attempt had been successful.

Movements of sheep were fairly restrictive until mid May where movements of some sheep (ewes and rams) increased. During the mid May telemetry, more than half the ewes (61%) were observed to be using mine disturbed habitats likely to lamb. Six of these ewes (33%) moved from native habitats to mine disturbed habitats (Fig 2). Locations selected were either reclaimed with vegetation or without vegetation with rugged terrain features. One ewe (10F) moved from Sheep Mt (April 16) to Greenhills mine site (May 21) a straight-line distance of 20 km. Two ewes were observed with lambs on May 21, 2009 telemetry flight. Until the end of May, movements of some rams remained localized. Only one ram (29M) moved 17km from winter ranges on Ewin Ridge to spring range on Greenhills mine site.

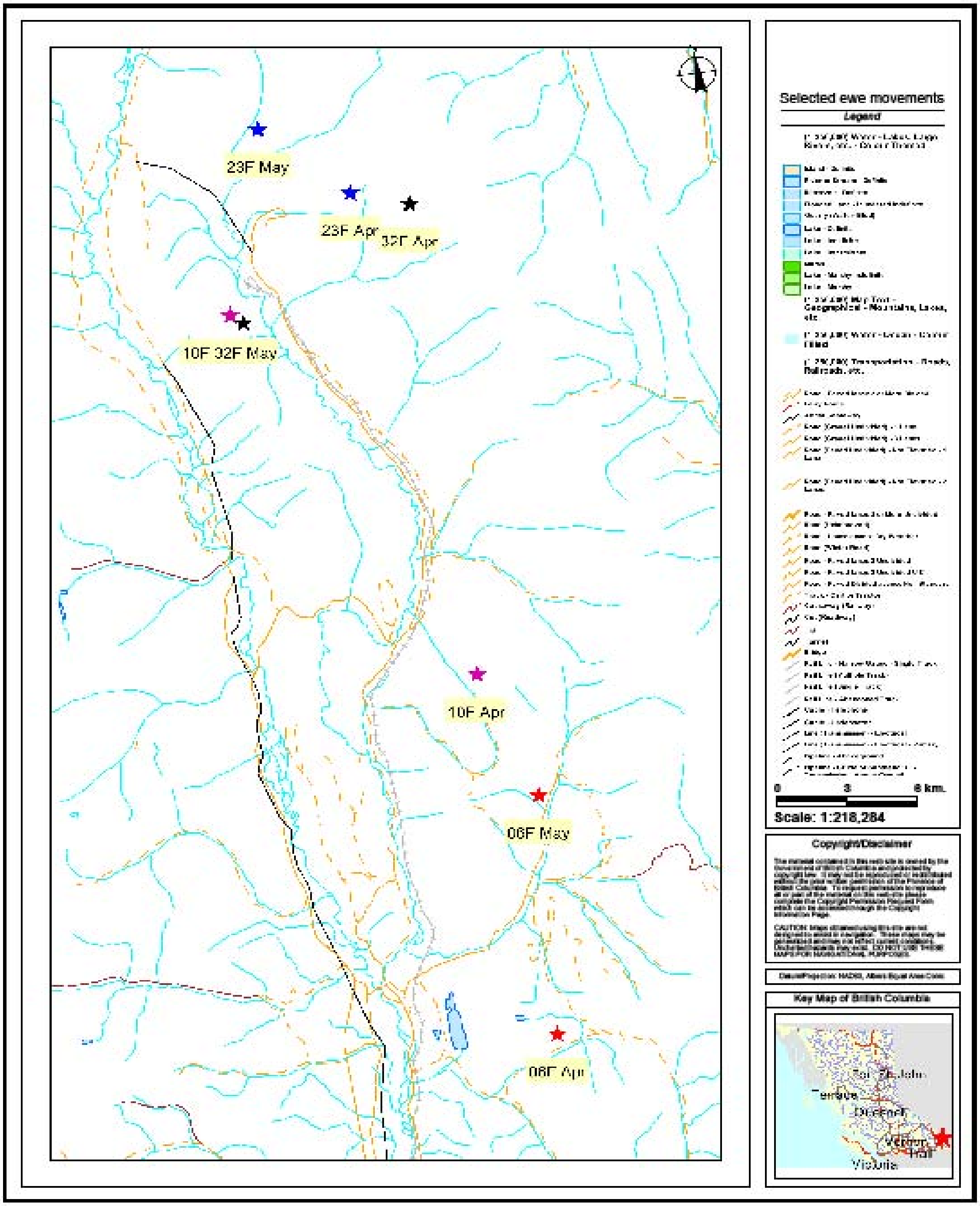

Figure 2: Movements of selected ewes from winter ranges (April 16) to spring ranges (May 21); all ewes in figure moved from undisturbed habitats to mine disturbed rugged habitats.

DISCUSSION

Despite unseasonably low snow levels for much of the winter, 3 days of snow and colder temperatures immediately prior to fieldwork resulted in excellent conditions for capture. Recent tracks were highly visible in most areas, animal visibility was good, and the limited cloud cover during captures provided minimal disruption. We successfully deployed all but 1 of the 40 GPS collars, distributing them in a near ideal pattern among winter ranges. Given current estimates of the number of sheep within the study area, about 10% of the population was collared.

The GPS collars fit well on the sheep. The collar fit on the ewes was very good. The ram collars were slightly large for the young animals targeted during capture, but the collars were placed on tight enough such that movement will be minimal, yet allowing for neck growth in these rapidly developing males. In some cases the GPS antenna did not end up at the top of the collar, but this should have minimal impact on fix acquisition success. Sizing of the ram collars was larger than expected because we targeted younger animals than I had originally anticipated.

The ewe mortality which occurred less than 6 hours after capture likely resulted due to capture. The ewe was captured on a ridgeline. After release and likely due to stress and fear, the ewe chose to travel mid slope instead of the ridgeline. We believe it was that choice that resulted in this ewe dying in an avalanche. The ram drowned in a pond less than 2 days after capture and travelled approximately 5 km after release; we are unsure if capture myopathy and/or exhaustion and hypothermia were the cause of death. The pond was more than 1 meter deep.

Activities proposed during 2009–10 include conducting telemetry flights every 1–2 months to monitor collar function and sheep movements and mortality, investigating mortalities and picking up collars, and re-deploying collars (in June and September 2009). Collars from any mortalities can be re-deployed once the data have been down-loaded. The collared animals will be used to test sheep sightability during an inventory scheduled for February 2010.

Habitat assessment and pellet composition data was not yet available at the time of preparation of this paper. In 2009, the planned work includes transect sampling (vegetation analysis and production clipping) as well faecal pellet collection. The vegetation work is planned to occur in July and September while pellet sampling is planned to occur in December 2009 and February and April 2010.

ACKNOWLEDGEMENTS

Teck Coal provided almost all of the funding for the first year of this study, including writing study design, purchasing 35 collars, covering capture, helicopter, contract biologist costs, funding the initial telemetry flight and habitat condition assessments. The Wild Sheep Society purchased 5 GPS collars. Habitat Conservation Trust Foundation has provided funding for study design, contract biologist, aerial monitoring, and some helicopter costs during the 2nd year. Many thanks to all funding agencies. BC Environment and Teck Coal have provided valuable in-kind staff support. We thank the EVBSC for their enthusiasm and support of the project. C. Wilson and M. Leuenberger, Bighorn Helicopters, expertly captured the sheep under challenging conditions, and G. Goodison, Bighorn Helicopters, provided skilled support piloting. H. Schwantje (BC Environment), T. Barr (Tobacco Plains Band), D. Charest (Greenhills Operations), G. Sword (Fording River Operations), and S. Medcalf (Sparwood Rod and Gun Club) handled sheep. Volker Scherm, Bearair, is providing experienced telemetry monitoring services. In addition, we thank A. Chirico for mapping, C. Nelson for preparing sampling kits and, H. Schwanjte for her expert veterinarian skills.

LITERATURE CITED

Adams, I., R. Rosentreter, and I. Teske. 2001. Elk Valley bighorn sheep cooperative plan. Submitted to the Elk Valley Bighorn Sheep Committee.

Barrett, M.W., J.W. Nolan, and L.D. Roy. 1982. Evaluation of a hand-held net gun to capture large mammals. Wildlife Society Bulletin 10:108–114.

DelGiudice, G.D., R.A. Moen, F.J. Singer, and M.R. Riggs. 2001. Winter nutritional restrictions and simulated body condition of Yellowstone elk and bison before and after the fires of 1988. Wildlife Monographs 147:1–60.

Demarchi, D.A. 1968. An ecological study of Rocky Mountain bighorn sheep winter ranges in the East Kootenay Region of British Columbia. Progress Report. Fish and Wildlife Branch, Victoria, BC. 51pp.

Poole, K. and B. McCallum. 2008. Bighorn sheep in the Elk Valley: evaluation of population dynamics, habitat Use and seasonal movements in relation to current and future mining projects. Review, study design, and detailed work plan. Prepared by Aurora Wildlife Research and Bighorn Wildlife Technologies, Nelson and Hinton. 37 pp.

Schuerholz, G. 1984. Annual ecological cycles of Rocky Mountain bighorn sheep populations with high elevation winter ranges in the East Kootenays. Proceedings of the 4th Biennial Symposium, Northern Wild Sheep and Goat Council 4:192–210.

Smyth, G. 2008. Teck Coal bighorn sheep Habitat study proposal. Prepared by Matrix Solutions, Calgary, AB. 22 pp