Bienn. Symp. North. Wild Sheep
and Goat Counc. 9:110-115.

EVALUATION OF BIGHORN SHEEP IN THE TEN LAKES SCENIC AREA OF MONTANA

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Abstract: Demographic characteristics, distribution and movements of the Phillipps Creek herd of bighorn sheep (*Ovis canadensis canadensis*) in Montana were investigated during July through September 1991 and all of 1992. The most conservative population estimate for December 1992 was 82. Lamb:ewe ratio in June 1992 was 90:100 and declined to 47:100 by December. The herd spent the rut, winter, and spring periods (mid November through mid May) in British Columbia. The spring range was an enlarged winter range. Two lambing/nursery areas were located in Montana, 17 and 24 km southeast of the winter/spring range. Mixed groups (ewes, lambs, young rams) used areas north and south of the international border, from mid June through mid November. During this same period, ram groups were most often observed south of the border.

In 1977, the Montana Department of Fish, Wildlife and Parks (MDFWP) began documenting reports of bighorn sheep in the Ten Lakes Scenic Area (TLSA) of northwest Montana (MDFWP, unpubl. data). The Fortine Ranger District of the Kootenai National Forest also received reports of sheep in the area over many years and staff observed bighorn sheep during an aerial survey in 1989 (G. Heinz, Wildlife Biologist, U.S. For. Serv., pers. comm.). The existence of this bighorn sheep herd has been known for at least 40 years by the local residents in British Columbia (A. McDonald, Grasmere, B.C., pers. comm.).

The primary objective of our study was to conduct ground surveys during all seasons of the year to determine abundance, composition, and productivity of the bighorn sheep population that inhabits the TLSA in summer. We also describe the distribution and movements of the herd.

This project was designed initially as an observational field study. After the first field season, the cooperators decided that due to the limited access and rugged topography of the area data collection could be enhanced by putting radio-collars on some bighorns. However, because of a limited budget for flying, the basic study plan was not altered.

The study was funded cooperatively by the Ministry of Environment and the East Kootenay Wildlife Association in Canada; the USDA Forest Service: Kootenai National Forest and MDFWP in the United States; and the Foundation for North American Wild Sheep.

STUDY AREA

The study area (Fig. 1) includes a portion of the southwestern end of the Galton Range in British Columbia (B.C.) and the northwestern end of the Whitefish Range in Montana. The TLSA (2,603 ha) is within the Kootenai National Forest, immediately south of the international border. The western boundary of the study area is formed by the Rocky Mountain Trench.

METHODS

Bighorn sheep were captured with a drop-net at 2 different sites, in February and March 1992. Sites were baited daily with alfalfa hay and apple mash or whole apples. A mineral block and a pan of granular minerals, containing vitamin E-selenium, also were available at each site. Captured bighorns were hobbled and blindfolded. Sex, age, and any identifying marks were noted. All animals were marked with a numbered ear tag and a shot of vitamin E-selenium (1 cc adults, 0.5 cc lambs, I.M.) to guard against capture myopathy (Hebert and Cowan 1971, Dalton et al. 1978, Kock et al. 1987). Radio-collars were attached to 9 bighorns.

Bighorn sheep were located by hiking or driving to likely locations within the study area and looking for them with a 7x binocular or a 15-60x variable power telescope. Additionally, aerial survey flights in fixed or rotary wing aircraft were conducted approximately once per month to locate and

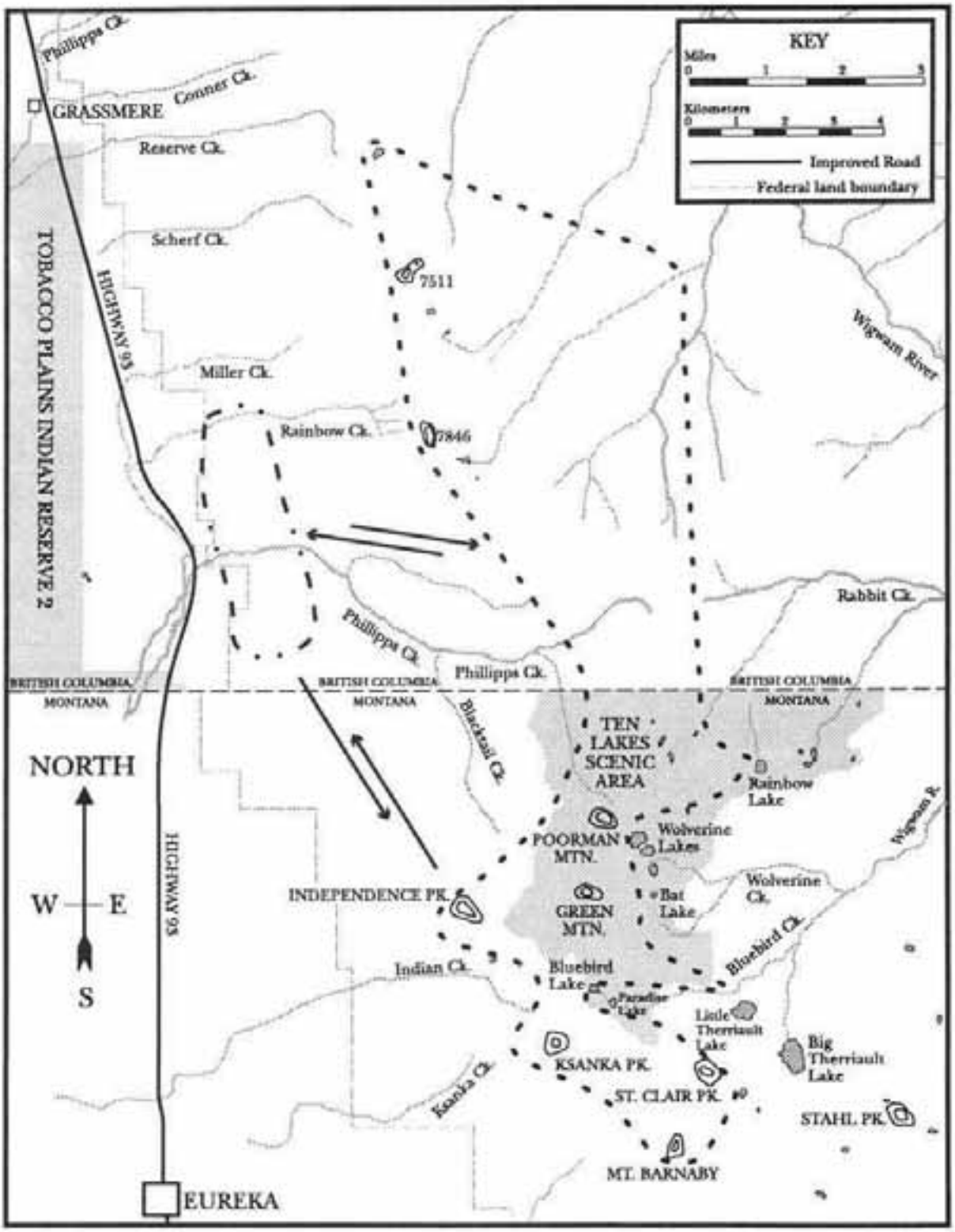

Figure 1. Seasonal ranges and travel corridors of the Phillips Creek bighorn sheep herd.

winter and spring range
summer and fall range
travel corridors

observe bighorns. Later, radio telemetry was used to locate bighorns during fixed wing aerial surveys and on the ground.

Once located, the number in the group and the age and sex class of each individual, according to their horn size and shape and body size (Geist 1971), was identified. The location of each observation was recorded on an aerial photograph or topographic map so the site could be visited later to determine habitat type and measure topographic characteristics. The timing of each season is based on the activities of the bighorn sheep herd.

Observations from 12 days during December 1992 were used to estimate the size of the bighorn population. Two population estimates were calculated: one using the Schumacher-Eschmeyer equation (Caughley 1977), one using a technique developed by Miller et al. (1987), in which the authors modified the standard capture-recapture technique so that the geographic closure requirement was not necessary. The maximum number of bighorn sheep observed in each age and sex class during the same period (December 1992) was used to estimate the size of the population and calculate the percentage of the population in each age and sex class. Lamb/ewe ratios were calculated according to Bowden et al. (1984).

A yearly home range of the herd was calculated using the harmonic mean method (Dixon and Chapman 1980). The accurate determination of a harmonic mean home range is dependent on 2 assumptions: locations are independent of each other and the probability of detecting an animal is proportional to the amount of time the animal spends in that area (Samuel et al. 1985). Further, the use of fewer than 50 locations to determine harmonic mean home range results in an enlarged home range (Jaremovic and Croft 1987). These requirements were addressed by using 84 observations and radio locations obtained during aerial surveys. The calculation of seasonal home ranges would have required the division of the 84 locations into at least 2 groups. Therefore, it was decided a yearly home range was the most accurate home range that could be determined.

RESULTS

Sixteen bighorn sheep were captured and marked in 2 trapping attempts. Radio-collars were put on 6 females and 3 males. Upon release, no bighorns showed any symptoms of capture myopathy, as described by Dalton et al. (1978). No animals were injured or killed during the trapping or handling procedure.

The Schumacher-Eschmeyer equation produced an estimate of 92 (0.95 CI = $70 \leq X \leq 132$) individuals during December, 1992. The technique developed by Miller et al. (1987) provided an average population estimate of 82 (0.95 CI $49 \leq X \leq 106$) during the same period (see Table 1 for data used to calculate estimates). Using the conservative estimate of 82, we estimate the population contained 34 females, 32 males and 16 lambs during December 1992.

The observed lamb/ewe ratio for February 1992, was 34:100 (0.95 CI, $19 \leq X \leq 49$) (Fig. 2). By April it had dropped to 10:100 (0.95 CI, $0 \leq X \leq 22$). Productivity during 1992 was high. The observed lamb/ewe ratio for June was 90:100 (0.95 CI, $70 \leq X \leq 100$). The lamb/ewe ratio declined throughout the summer and by December it was 47:100 (0.95 CI, $41 \leq X \leq 53$).

Mixed groups of ewes, rams, and lambs wintered on the hills and benches 3 km north of the international border (Fig. 1). Phillipps Creek bisects the winter range (Fig. 1). A portion of the area used by bighorn sheep south of the Creek is private land. Much of the forested private land has been logged and the remaining over story canopy cover is <10%.

Ram groups were seen regularly in the same area as mixed groups, during January. However, after 5 February, few mature rams were encountered. A group of rams was seen on 24 March, on the ridge north of Rainbow Creek. Subsequent visits revealed several rams using this area.

The spring range was an expanded winter range. In late April, radio-collared ewes began making movements east up the Phillipps Creek drainage and south along the west face of the mountains. However, they returned to the core winter range. On 14 May, they began moving to lambing/nursery areas and did not return. Only 1 ram group was observed during spring, on the ridge above Rainbow Creek.

Two lambing/nursery areas were identified south of the international border. Ewes with their lambs used the south face of Mt. Barnaby, 24 km southeast of the winter range. They also were found on the south face of "No Grizzly Ridge", 17 km southeast of the winter range and 1 km northwest of Little Therriault Lake.

During summer, most radio-collared ewes moved back and forth across the international border several times. They traveled throughout the TLSA and were observed 12 km north of the Border

Table 1. Data used to calculate population estimates for Phillipps Creek bighorn sheep herd, 1992.

M Number of marked animals in the area	m Number of recaptured animals in each sample	n Number of animals in each sample
7	7	53
6	4	46
6	3	25
7	4	58
7	1	20
6	4	54
7	2	15
5	0	33
6	3	44
7	2	35
6	1	27
6	3	36

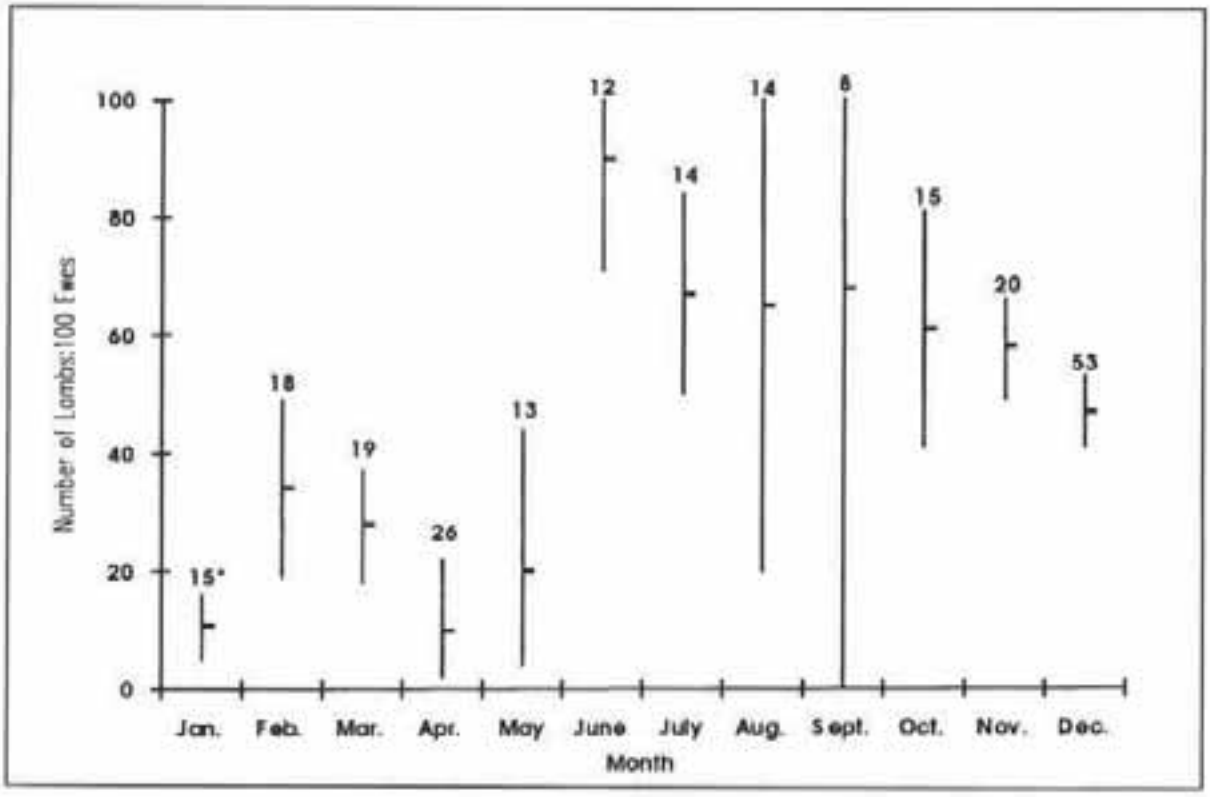

Figure 2. Number of lambs:100 ewes and 95% confidence intervals for the Phillipps Creek bighorn sheep herd, 1992 (* Number of observations).

in B.C. (Fig. 1).

Rams appeared to move less than mixed groups and spent most of the early and late summer in the Ksanka Peak area in the southern portion of the summer range. Poor Man Mountain and the Ten Lakes Basin, immediately to the east, were used during mid-summer. Small groups of rams were observed in other parts of the range throughout the summer. Some mixed groups moved north into B.C. and remained there during fall. Others remained in the TLSA until they moved onto the west face of the mountains. Ram groups were most often observed in the Ksanka Peak-Independence Peak area.

The herd returned to the winter range area and the rut started in mid-November (Fig. 1). Most of the mating activity occurred south of Phillipps Creek. After mid-December mixed groups began redistributing over the winter range.

Based on radio-locations, observations, and reports from hunters, 2 travel corridors were identified (Fig. 1). One route took the bighorns east-west along the ridge north of Phillipps Creek. On the other route, bighorns traveled north south along the west side of the mountains when moving between winter and summer ranges.

The area included in the yearly 0.95 harmonic mean home range was 207 km^2.

DISCUSSION

The Schumacher equation (Schumacher-Eschmeyer 1943) is one of a number of techniques based on the mark-recapture method. All such techniques include several assumptions that must be met to produce an accurate estimate. The assumptions are: geographic and demographic closure of the population, correct identification of marked animals, independent probability of capture, and no loss of marks (Caughley 1977, Neal et al. 1993). The method developed by Miller et al. (1987) is also based on mark-recapture techniques. However, it has been modified to correct for a lack of geographic closure. In this study, the 2 methods produced similar estimates of the size of the Phillipps Creek herd, resulting in increased confidence in the estimate.

In unhunted populations, bighorn rams may equal or outnumber ewes (Buechner 1960, Woodgerd 1964). A nearly equal male:female ratio (0.9:1) has been reported for a lightly hunted bighorn population (Cowan and Geist 1971). The Phillipps Creek herd has a sex ratio (0.94), similar to lightly hunted bighorn populations.

Caughley (1974) demonstrated that age ratios do not necessarily reflect changes in wildlife population trend. He showed that both increasing and decreasing populations could have similar age ratios. More specifically, Geist (1971), Festa-Bianchet (1992), and Jorgenson (1992) have discussed the difficulties of using age ratios to predict trends in bighorn sheep populations. The only reliable information that can be gathered from the high lamb:ewe ratio documented for this population during June 1992, is that most females in the population produced viable offspring. The declining ratio from June through December, demonstrates that summer-fall lamb loss may be fairly high.

LITERATURE CITED

Bowden, D. C., A. E. Anderson, and D. E. Medin. 1984. Sampling plans for mule deer sex and age ratios. J. Wildl. Manage. 48:500-509.

Buechner, H. K. 1960. The bighorn sheep in the United States; its past, present, and future. Wildl. Mono. 4. 174pp.

Caughley, G. 1974. Interpretation of age ratios. J. Wildl. Manage. 38: 557-562.

_____. 1977. Analysis of vertebrate populations. John Wiley & Sons, New York, N.Y. 234pp.

Cowan, I. Mct., and V. Geist. 1971. The North American wild sheep. Pages 58-83 in R. S. Waters (ed.). North American Big Game. The Boone and Crockett Club, Pittsburgh, PA.

Dalton, L. B., J. A. Roberson, and J. W. Bates. 1978. Capture myopathy in desert bighorns - literature review and treatment. Desert Bighorn Sheep Trans. 22:31-36.

Dixon, K. R., and J. A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology 61:1040-1044.

Festa-Bianchet, M. 1992. Use of age ratios to predict bighorn sheep population dynamics. Bienn. Symp. North. Wild Sheep and Goat Counc. 8:227-236.

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. Univ. Chicago Press, Chicago, IL. 383pp.

Hebert, D. M., and I. Mct. Cowan. 1971. White muscle disease in the mountain goat. J. Wildl. Manage. 35: 752-756.

Jaremovic, R. V., and D. B. Croft. 1987. Comparison of techniques to determine eastern grey kangaroo home range. J. Wildl.

Manage. 51: 921-930.

JORGENSON, J. T. 1992. Seasonal changes in lamb:ewe ratios. Bienn. Symp. North. Wild Sheep and Goat Counc. 8: 219-226.

KOCK, M. D., D. A. JESSUP, R. K. CLARK, AND C. E. FRANTI. 1987. Effects of capture on biological parameters in free-ranging bighorn sheep (*Ovis canadensis*): evaluation of drop-net, drive-net, chemical immobilization, and the net-gun. J. Wildl. Dis. 23: 641-651.

MILLER, S. D., E. F. BECKER, AND W. B. BALLARD. 1987. Black and brown bear density estimates using modified capture recapture techniques in Alaska. Int. Conf. Bear Res. and Manage. 7: 23-35.

NEAL, A. K., G. C. WHITE, R. B. GILL, D. F. REED, AND J. H. OLTERMAN. 1993. Evaluation of mark-resight model assumptions for estimating mountain sheep numbers. J. Wildl. Manage. 57: 436-450.

SAMUEL, M. D., D. J. PIERCE, E. O. GARTON, L. J. NELSON, AND K. R. DIXON. 1985. User's manual for program Home Range. For., Wildl. and Range Exp. Sta. Tech. Rep. 15, Univ. Idaho, Moscow. 70pp.

SCHUMACHER, F. X., AND R. W. ESCHMEYER. 1943. The estimate of fish population in lakes or ponds. J. Tenn. Acad. Sci. 18:228-249.

WOODGERD, W. 1964. Population dynamics of bighorn sheep on Wildhorse Island. J. Wildl. Manage. 28:381-391.