Population dynamics of bighorn sheep on the Beartooth Wildlife Area, Montana
by Terrence A Enk

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Fish and Wildlife Biology
Montana State University

Abstract:
The population dynamics of Rocky Mountain bighorn sheep (Ovis canadensis canadensis) inhabiting the Beartooth Wildlife Management Area in west-central Montana were investigated during 1995-1997. Research focused on quantifying and qualifying sheep reproduction and mortality with particular emphasis on determining the extent of mountain lion (Felis concolor) predation and on evaluating effectiveness of population augmentation.

A total of 39 sheep and 8 mountain lions were marked and monitored. Sheep were limited in distribution to small core use areas and utilized moderately steep slopes. Travel between core use areas necessitated crossing of riparian areas and forested patches which increased sheep vulnerability to predation.

Lamb production was highly correlated with June precipitation, and lamb survival was highly correlated with April/May cumulative precipitation and August maximum temperatures. The data suggest that reproduction was largely determined by forage quality as mediated by precipitation and temperature levels during the growing season. Fecal nitrogen analyses indicated sheep were at maintenance nutritional levels for at least 6 months and that constraints of late summer/fall forage quality limited ewe reproductive fitness. Lungworm levels (LPG) were low to moderate, and the presence of larvae in lamb pellet samples was suggestive of transplacental transmission.

Mountain lions had relatively small seasonal core use areas and overlapping individual home areas. Mountain lion movements mirrored seasonal ungulate migrations and mountain lions were seasonal occupants of bighorn range. Sheep predation was limited and opportunistic. Mountain lions utilized riparian areas, forested patches, and rocky reefs for travel and foraging which resulted in significant spatial overlap with sheep.

Augmentation did not result in bighorn sheep population growth, and population estimates indicated a decrease subsequent to augmentation. Transplants were lost through dispersal, predation, and disease. Reproduction by transplanted ewes was limited. Population models indicate a substantial difference between expected and observed results of augmentation. My results suggest that augmentation was ineffective for a population primarily regulated by density-independent factors, and that preaugmentation evaluation of local population dynamics would increase augmentation efficiency.

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APPROVAL

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Terrence A. Enk

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

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INTRODUCTION

The Rocky Mountain bighorn sheep (*Ovis candensis canadensis*) is a charismatic and highly valued game species indigenous to the northern Rocky Mountain region. Although once widely distributed and abundant, with an estimated 2,000,000 individuals at the beginning of the 19th century (Seton 1929), the species experienced marked reduction in distribution and abundance during the late 19th and early 20th century. The dramatic decline of the Rocky Mountain bighorn sheep has been well-documented and is attributed to a suite of factors associated with human settlement of western North America including overharvesting, introduction of diseases, loss of habitat, and competition with domestic livestock (Buechner 1960).

One significant result of the species' decline through disease and other factors has been the creation of small, isolated remnant populations. The viability of such populations is often tenuous as they are extremely vulnerable to extirpation through demographic and/or environmental stochastic processes and catastrophes (Gilpin and Soule 1986). In his review of desert bighorn populations, Berger (1990) found that larger populations (> 101 individuals) were likely to persist much longer than smaller populations, and all populations < 50 individuals were extirpated within 50 years.

Bighorn sheep are highly susceptible to bacterial pneumonia (Buechner 1960) and disease plays an integral role in sheep population dynamics. Bacterially-induced die-offs have been recorded among numerous North American bighorn sheep populations (Foreyt 1990). These disease-mediated, all-age die-off events influence populations through

immediate large-scale mortality (Semmens 1996) and long-term reduction of adult vigor, reproductive output, and lamb survival and recruitment (Ryder et al. 1994). The violent population fluctuations associated with die-offs have limited the ability to successfully manage the species utilizing conventional wildlife management strategies.

While the mechanisms and ultimate causes of die-offs are believed to be population-specific, there is general consensus that stress influences herd susceptibility to pneumonia by compromising the immune system of individual sheep (Onderka and Wishart 1984). Lungworm parasitism historically received considerable attention as an agent of stress (Marsh 1938, Buechner 1960, Forrester and Senger 1963, Geist 1971), but recent die-offs in herds with low rates of lungworm infection have caused investigators to evaluate other potential stressors including nutrition, climate, population density, and harassment (Onderka and Wishart 1984, Ryder et al. 1994).

Montana historically supported a relatively large number of bighorn sheep which were well distributed throughout the State (Couey 1950). Die-offs were documented in Montana bighorn sheep populations as early as the 1880's, and Couey (1950) noted that while larger bighorn sheep populations in Montana (i.e. Sun River) appeared to be regulated by periodic die-offs, they were less vulnerable to extirpation than smaller populations. In Montana, small bighorn sheep populations had disappeared from all the mountain ranges east of the Rocky Mountain cordillera by the late 1930's (Couey 1950). This included the population that historically inhabited the Gates of the Mountains area in the Big Belt Mountains, which was extirpated in the early 1930's as a result of overharvesting and disease (Hilger 1989).

A common management practice in many western States and Provinces has been to relocate bighorn sheep in an effort to re-establish sheep populations on historically occupied ranges and to augment existing, small sheep populations. The basic assumption of augmentation programs is that an infusion of transplants will improve herd reproductive output, thereby stimulating population growth and reducing the risk of local extirpation.

Montana initiated bighorn sheep restoration programs in 1941 and has conducted numerous reintroduction and augmentation programs over the past 55 years (Rognrud 1983). As of 1996, a total of 1,754 bighorn sheep had been relocated in Montana (McCarthy 1996). Augmentation has been implemented as a method of improving reproductive output and growth of small post-die-off populations throughout the western United States with limited success. Two factors inhibiting the potential for successful augmentation programs are a lack of knowledge regarding post-die-off population dynamics and inadequate monitoring of transplanted sheep to facilitate program evaluation (Wishart 1975).

The population dynamics of bighorn sheep are primarily determined by annual rates of reproduction and mortality (Geist 1971). Reproductive rates are directly related to the physiological status of the ewes within a population, which in turn is highly correlated with individual nutritional status and the presence of stressors such as parasites and disease. Mortality rates are associated with nutritional status, immunocompetence, predation, and annual harvests for most bighorn populations. Without adequate knowledge of the specific factors influencing the dynamics of small, post-die-off

populations, the potential for successful augmentation is limited and left largely to chance.

Predators have long fascinated the public and wildlife professionals alike, and the role of predation in prey population dynamics continues to be a topic of interest. The recent expansion of mountain lion (*Felis concolor*) populations and decline of mule deer (*Odocoileus hemionus*) and bighorn sheep populations in Montana and other western states has resulted in renewed interest in determining the influence of predators upon prey populations. Boutin (1992) identified 4 hypothetical predator-prey interactions based upon review of pertinent literature. These interactions include:

1) **Predator Regulation**- density-dependent; predation *regulates* prey density;
2) **Predator Limitation**--density-independent; predation *limits* prey density;
3) **Predator Pit**- predation limits prey density, but the prey population can exceed a "threshold" level and escape regulation; and
4) **Stable Limit Cycle**- prey populations are cyclic and cohorts born in poor years are more vulnerable to predation throughout their lives.

Rocky Mountain bighorn sheep have been subject to numerous studies on behavior (Geist 1971, Horejsi 1972), ecology (Todd 1972), distribution and seasonal range use (Erickson 1972, Hengel et al. 1992), disease (Forrester and Senger 1964, Jones and Worley 1994), mortality (Woodward et al. 1972, Hebert and Harrison 1988), nutrition (Hebert 1973), and interspecific relations (DeMarchi 1965). Few studies have investigated the population dynamics of small, post-die-off herds which are unable to recover to pre-dieoff densities after >10 years. Reduced adult vigor and low reproduction

rates are often assumed to limit such populations, but without herd-specific data neither the long-term population viability nor the potential for successful augmentation can be determined. Determining the role of predation in locations where bighorn sheep and potential predator distributions overlap is crucial to fully understanding the dynamics of such populations.

This study evaluates the population dynamics of the bighorn sheep herd which inhabits the Beartooth Wildlife Management Area (BWMA) and adjacent Gates of the Mountains Wilderness Area (GOMWA) in west-central Montana. This population experienced an die-off in 1984 and has remained well below pre-dieoff densities during the subsequent 12 years. In response, the Montana Department of Fish, Wildlife & Parks (MFWP) initiated an augmentation program in an effort to stimulate population growth. The BWMA population represented an opportunity 1) to investigate population dynamics in a small, post-die-off sheep herd and 2) to monitor and evaluate the effectiveness of herd augmentation. This research project was initiated simultaneously with the augmentation program and was designed to address the following objectives:

1) identify sheep distribution and habitat use;
2) quantify and qualify annual sheep reproduction, recruitment, and mortality;
3) determine the role of mountain lion predation in sheep population dynamics;
4) evaluate the effectiveness of augmentation; and
5) determine which predator-prey hypothesis (Boutin 1992), if any, applies to this herd.

STUDY AREA

Location

The BWMA is located at the northern end of the Big Belt Mountains in west-central Montana (46° 55′ N latitude, 111° 55′ W longitude) approximately 36 km north of Helena, Montana. The BWMA encompasses approximately 18,390 ha and is generally bounded by the Missouri River and Holter Lake (an impoundment on the Missouri River) to the west, the GOMWA to the south, and large private ranches to the north and east (Figure 1). The nature of these surrounding lands serve to buffer the BWMA from human influences.

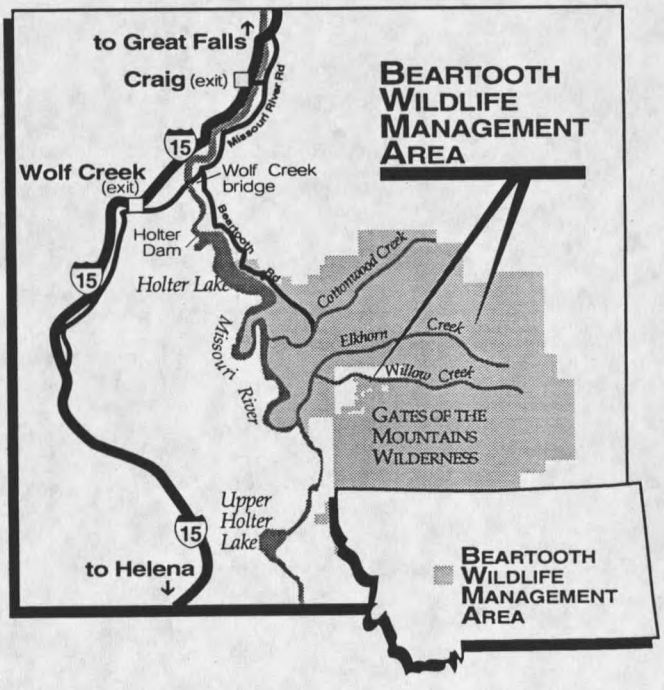

Figure 1. Study area location map.

The area represents excellent wildlife habitat, including critical elk (*Cervus elaphus*) winter range. The lands which currently comprise the BWMA were purchased by the State of Montana in 1970 from Mr. Pierce Milton, who had actively ranched the property for 13 years and who stipulated the property be preserved as wildlife habitat in perpetuity.

Upon its purchase, the area was immediately designated the Beartooth State Game Range (subsequently changed to Beartooth Wildlife Management Area). MFWP management objectives for the BWMA include preserving wildlife habitat and providing recreational opportunities (Auchly and Williams 1994). The area is closed annually from December 1 through May 15 to minimize disturbance of elk and other ungulates on winter range. During that portion of the year when public access is permitted, the BWMA receives substantial recreational use.

There have been 2 major wildfires in the area over the past 50 years. In 1949, a wildfire burned Mann Gulch (in the GOMWA) and the southern edge of what is now the BWMA. This fire was immortalized in Norman Maclean's book entitled Of Young Men and Fire. Despite nearly 50 years since this fire, the vegetation in Mann Gulch has yet to return to pre-fire conditions. While grass and shrub communities have recovered, Ponderosa pine (*Pinus ponderosa*) has not yet re-established in this area which is indicative of the relatively harsh, windy, xeric conditions in the study area. A wildfire in 1990 burned approximately 80% of the BWMA (Auchly and Williams 1994). This fire significantly altered the vegetative communities throughout the BWMA by eliminating forest cover and stimulating regeneration of grass and shrub communities that had been