Seasonal locations of bighorn sheep, mountain goats, and elk on the Haystack Domestic Sheep Allotment, Montana
by Boyd Raldon Byelich

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
In response to allegations that a bighorn population along the upper Boulder River was declining in numbers due to the presence of domestic sheep each summer on the Haystack Grazing Allotment, the objective of this thesis was to describe the seasonal and spatial locations of bighorn sheep and domestic sheep, as well as elk and mountain goats, between November of 1987 and September of 1989. Ungulate locations were identified using aerial surveys between September and May followed by ground observations from June through August. Compilation of this data indicated that interactions might occur between elk and domestic sheep during July and August, between bighorns and mountain goats from September through May, and among bighorns throughout the year. Evidence of domestic sheep use on observed bighorn sheep range was also observed on two occasions. Chi-square analyses revealed that bighorns did not use the Monument and Baboon mountain complexes in proportion to suitable habitat availability during the summer ($P < .05$) and that Monument might be used significantly more during the winter ($P < .05$). People do use the area between Monument and Baboon for recreational activities throughout the year. Paired t-tests indicated that bighorn sheep locations were not dependent on domestic sheep locations ($P > .50$). In conclusion, domestic sheep are only one of many factors along the upper Boulder that might affect bighorn sheep numbers. A more detailed study would be needed to determine the relative importance of these observations.

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Boyd Raldon Byelich

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.

10 Jan 1994
Date

Chairperson, Graduate Committee

Approved for the Major Department

1/10/94
Date

Head, Major Department

Approved for the College of Graduate Studies

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Signature Boyd Colton Byelich

Date January 10, 1994

To my parents, George and Louella, who taught me to respect all living things.

VITA

Boyd Raldon Byelich was born in 1963 in Freemont, Michigan. He was raised on a beef farm near Harrisville, Michigan and graduated from Lincoln-Alcona High School in 1982. He graduated from Lake Superior State University in Sault Ste. Marie, Michigan with a bachelor of science degree in fisheries and wildlife management in 1987. His graduate career at Montana State University also began in 1987.

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ABSTRACT

In response to allegations that a bighorn population along the upper Boulder River was declining in numbers due to the presence of domestic sheep each summer on the Haystack Grazing Allotment, the objective of this thesis was to describe the seasonal and spatial locations of bighorn sheep and domestic sheep, as well as elk and mountain goats, between November of 1987 and September of 1989. Ungulate locations were identified using aerial surveys between September and May followed by ground observations from June through August. Compilation of this data indicated that interactions might occur between elk and domestic sheep during July and August, between bighorns and mountain goats from September through May, and among bighorns throughout the year. Evidence of domestic sheep use on observed bighorn sheep range was also observed on two occasions. Chi-square analyses revealed that bighorns did not use the Monument and Baboon mountain complexes in proportion to suitable habitat availability during the summer ($P < .05$) and that Monument might be used significantly more during the winter ($P < .05$). People do use the area between Monument and Baboon for recreational activities throughout the year. Paired t-tests indicated that bighorn sheep locations were not dependent on domestic sheep locations ($P > .50$). In conclusion, domestic sheep are only one of many factors along the upper Boulder that might affect bighorn sheep numbers. A more detailed study would be needed to determine the relative importance of these observations.

INTRODUCTION

The headwaters of the Boulder River, a tributary of Montana's Yellowstone River, are historic Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) range. In spite of gold mining activity around the turn of the century, this area has remained virtually undeveloped. Approximately half of the watershed lies within the Absaroka - Beartooth Wilderness while the remaining portions are other national forest lands administered by the Big Timber District of the Gallatin National Forest. Remoteness and immediate proximity to Yellowstone National Park mean that the upper Boulder has the potential for being very important wildlife habitat. Wildlife diversity, the opportunity for primitive recreation, and rugged mountain scenery combine to make this area attractive for backpacking, horseback camping trips, hunting, fishing, and snowmobile excursions.

In addition to recreational use, Baboon Mountain, the Independence - Monument Peak complex, and adjacent areas along the upper forks of the Boulder River are used for summer range by domestic sheep (Ovis aries) as part of the Haystack domestic sheep Allotment. Although Forest Service records indicate that as many as 2000 sheep may have grazed these portions of the upper Boulder earlier this century, the permitted numbers have been reduced over the years. Following

non-use in the late 1970's, the allowable number of domestic sheep was set and has been maintained at 640 ewe/lamb pairs. In the early 1980's, following the reinstatement of permitted domestic sheep use, there were reports of fewer bighorns in the area. This alleged decline concerned local camping and hunting outfitters, wildlife enthusiasts, and the Forest Service. Bighorn numbers from aerial winter range surveys conducted by Montana Department of Fish, Wildlife, and Parks personnel also suggested that the resident bighorn population might be declining (Figure 1).

Some interested parties contended that the recorded high bighorn populations came during a brief period when there was no grazing by domestic sheep. However, this relationship could not be justified by the existing data base because the records on bighorn population levels and distributions within the upper Boulder were scanty and were developed from sightings by sheepherders and hunters or sporadic flights. The situation is complicated further by the lack of information on bighorn population levels during the years when domestic sheep numbers exceeded 1000. In effect, the information base on the surviving bighorns was insufficient to determine much about the effect of domestic sheep on the resident bighorn population.

In 1987, representatives of the Montana Woolgrowers Association approached the Animal and Range Sciences Department of Montana State University about the possibility

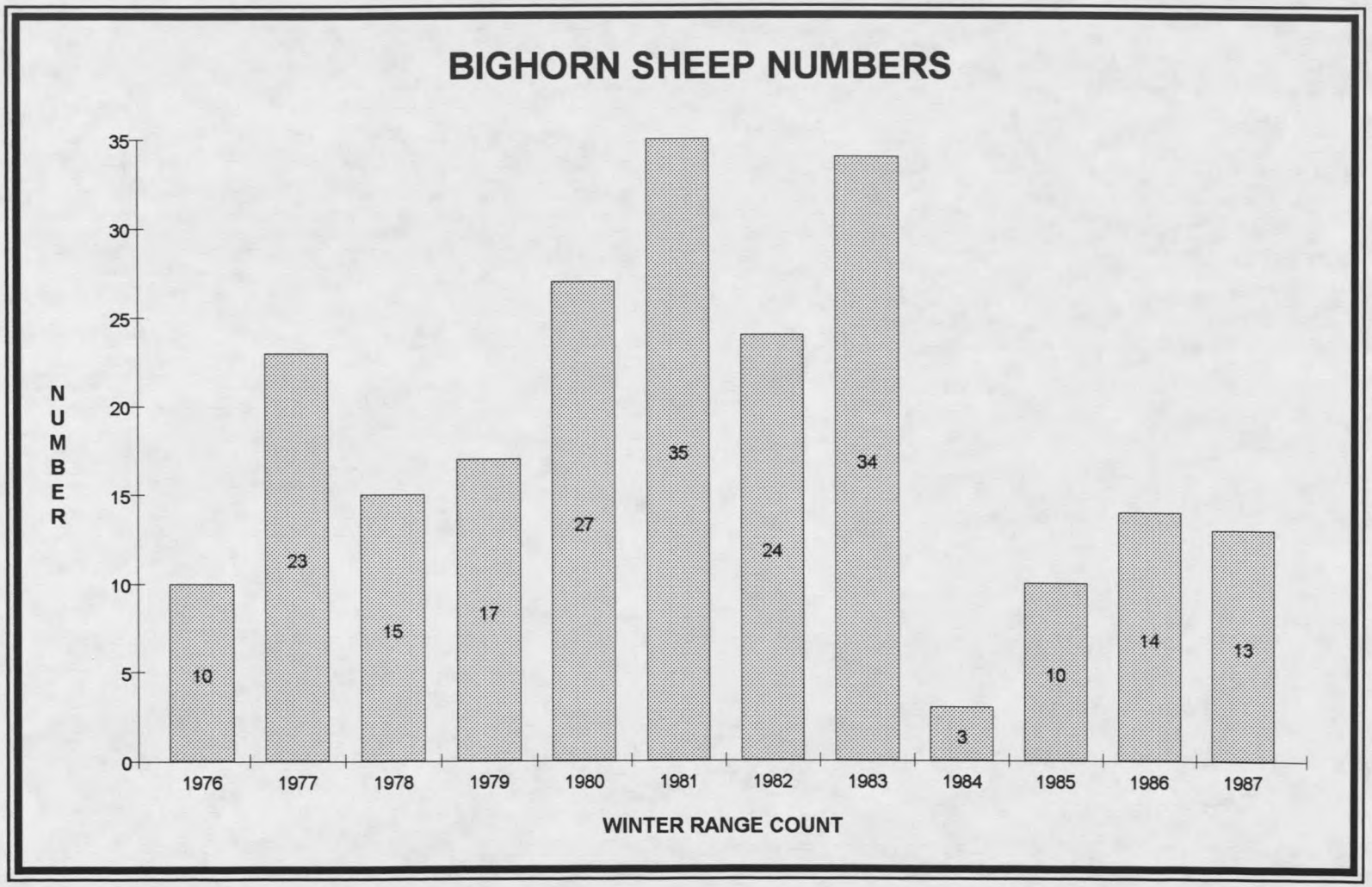

Figure 1. Annual Monument Peak bighorn sheep winter range aerial census, Montana Department of Fish, Wildlife, and Parks, 1976-1987.

of a cooperative research effort into the reported bighorn - domestic sheep conflict on the Haystack Grazing Allotment. This prompted an initial site visit in early August (1987) by Dr. Clayton B. Marlow, along with the permittee and representatives from the Big Timber Ranger District, Montana Woolgrowers Association, Montana Department of Fish, Wildlife, and Parks, and Montana Farmer-Stockman. Their subsequent observations and discussions revealed the possibility of at least two other factors that might be affecting bighorns: displacement attributed to snowmobile recreation and competition with Rocky Mountain goats (Oreamnos americanus americanus Blainville). Following this site visit, a cooperative research agreement was developed between the Montana Woolgrowers, the Montana Agricultural Experiment Station, and the Big Timber Ranger District. The intent of this partnership was to stage a thorough, unbiased investigation into the possible relationship between the domestic sheep grazing under a Forest Service permit and the observed variation in bighorn numbers.

Although the fluctuation in bighorn numbers may have been due to disease, Montana Fish, Wildlife, and Parks biologists recommended that the issue of competition be addressed first. They reasoned that if the occurrence and extent of competition could be verified, then trauma induced mortality resulting from the need to capture the surviving bighorns to obtain blood and nasal discharge samples might be avoided.

In addition, seasonal forage availability may be critical to bighorn survival because of reports that the upper Boulder population uses some of the same areas year long. The possibility of predation by coyotes (Canus latrans latrans Say) was also mentioned.

Since there was little information on movement patterns and preferred habitats for this bighorn population, the first objective in testing the potential for competition was to identify seasonal habitat use patterns of bighorns, mountain goats, and domestic sheep. Habitat features and forage availability levels within possible seasonal ranges were to be recorded. This data would then be transferred to a common base map to determine potential overlapping use patterns by the various wild and domestic grazers.

With the Storm Creek and Hellroaring fires raging out of control nearby, a portion of the forest that included the study area was closed to the public in mid-August of 1988. This complicated the study as we were not permitted to return until the fires were extinguished, which was early October of 1988. No funds were available for a 1989 summer field season.

The objective for this thesis is to use the 1987, 1988, and 1989 aerial surveys and 1988 ground observations to describe the seasonal and spatial locations of bighorn sheep, elk (Cervus elaphus nelsoni Bailey), Rocky Mountain goats, and domestic sheep along the upper forks of the Boulder River. Attention was directed towards areas of adjacent or

overlapping use, particularly on suitable bighorn sheep habitat, to evaluate the potential for forage competition among the various large herbivores. The accumulation of bighorn sheep locations was compared with suitable habitat availability to determine if bighorns might be selecting or avoiding portions of the study area. Bighorn and domestic sheep distributions were also compared to determine if domestic sheep distribution could have influenced bighorn spatial use. Evidence of other potentially limiting factors, such as predation and human disturbance, was recorded.

LITERATURE REVIEW

Bighorn sheep were numerous and widely distributed across western North America until the late 1800's (Geist 1971). Since that time, many researchers contend that there has been a general decline in wild sheep populations (Marsh 1938, Buechner 1960, Stelfox 1971, Goodson 1982). Competition with livestock for forage on seasonal ranges, disease transmission from domestic sheep, and indiscriminate hunting have been implicated as the principle causes of these declines (Cowan 1940, Buechner 1960, Foreyt and Jessup 1982). Disease relationships and hunter induced mortality were not addressed in this study. However, other extrinsic factors which might contribute to fluctuations in bighorn populations were considered. Competition for available forage among bighorns (Wishart 1978) and with other populations of wild grazing ungulates, particularly mountain goats (Dailey et. al. 1984) and elk (Constan 1972), can limit the carrying capacity of bighorn occupied ranges. Spatial distribution may be influenced by the presence of domestic sheep (Thilenius 1975), mountain goats (Reed 1986), or elk (Goodson 1978). While human disturbance (Hicks and Elder 1979) and predation (Post 1971) can certainly effect the stability of bighorn populations, the various forms of competition may have the greatest long term impact.

Competition occurs when different organisms seek a common, limited resource. Interspecific competition occurs among two or more species and intraspecific among two or more individuals of the same species (Smith 1980). Either form of competition can be further described as exploitative or interference (Miller 1967). Exploitative competition refers to the effectiveness of competitors to utilize a common resource. Interference competition occurs when one competitor either directly or indirectly denies or limits another competitor access to a resource. Selection of identical forages by two different ungulates is an example of exploitative competition. The presence or activity of one species or individual that results in the displacement of another from suitable habitat that would otherwise be occupied is a form of interference.

The occurrence and degree of forage competition can be ascertained by examining the following components: (1) overlaps in distribution, (2) sympatric habitat use, (3) similarities in food habits, and (4) extent to which mutually-used forages limit the productivity of at least one species (McCollough et. al. 1980). Assessing interference would involve a comparison of observed differences in distribution or habitat use which could be attributed to the presence or activities of potential competitors (Miller 1967). Either form of competition could impact bighorn sheep habitat selection and distribution patterns.

Bighorn sheep seasonal distribution patterns are dominated by a predator-evasion strategy made apparent by their tendency to select high visibility habitats with forage in close proximity to escape cover (Geist 1971, Shannon et. al. 1975, Risenhoover and Bailey 1980, Fairbanks et. al. 1987). While both rams and ewes may exhibit strong fidelity to several seasonal home ranges (Geist 1971, Becker et. al. 1978), precipitous, rocky terrain is probably the predominant habitat feature selected by mountain sheep in all seasons (Tilton and Willard 1982, Risenhoover and Bailey 1985, Cooperrider et. al. 1986, Wakelyn 1987). The onset of winter causes migration to either lower elevation ranges or to portions of their summer habitats where favorable aspect and wind can minimize snow accumulation (Geist 1971, Berger 1979).

Bighorn populations inhabiting interior mountain ranges often do not have the option of migrating to lower elevation winter ranges that satisfy their habitat requirements. Instead, they implement behavioral adaptations to avoid deep or crusting snow (Stelfox 1975). When snow depth or hardness impairs foraging on open, grass covered slopes, they move up to windswept ridges (Shannon et. al. 1975, Schuerholz 1984) and prefer southerly exposures (Hudson et. al. 1976, Tilton and Willard 1982). Cliffs may be used in late winter (Geist 1971) when the effects of wind and sun enhance forage availability. Consequently, competition may be for landscape features as well as foraging opportunities.

While the selectivity of bighorns indicates that plant phenology is important in determining habitat use patterns (Hobbs et. al. 1983, Schuerholz 1984, Goodson and Stevens 1988), the influence of the bighorn predator-evasion strategy dictates that dietary intake may be predicated by forage availability rather than quality (Cooperrider et. al. 1980, Adams et. al. 1982, Festa-Bianchet 1988). Like other grazing ungulates, bighorns will select actively growing plants and plant-parts in early stages of phenological development (Johnson and Smith 1980, Cooperrider and Hansen 1982, Cooperrider et. al. 1986), which correlates to the most palatable, nutritious forage available. Consequently, forbs generally make their greatest contribution to bighorn diets during spring and summer (Andryk and Irby 1986, Brown and Yde 1988) and may be preferred (Pitt and Wikeem 1978, Cooperrider et. al. 1980, Johnson and Smith 1980).

Many researchers concur that graminoids dominate the diets of the northern races of bighorns in all seasons due to their greater year-round availability on alpine and subalpine rangelands (Capp 1967, Todd 1972, Stelfox 1975, Wishart 1978, Schuerholz 1984, Andryk and Irby 1986, Brown and Yde 1988). Browse is generally recognized as an important winter range forage (Shallenberger 1966, Stelfox 1975, Keating et. al. 1985). However, there are inconsistencies in the literature. Hobbs et. al. (1983) reported that forbs were the major component of bighorn winter diets. Shrubs have been

identified as important summer forage (Rominger et. al. 1988), and not necessarily in proportion to availability (Cooperrider and Hansen 1982). Summarizing the available literature leads one to conclude that bighorn food habits vary from season to season, year to year, and site to site. It appears that they are selective grazers as long as preferred forages are snow-free and abundant proximal to escape cover. They become opportunistic under heavy snow conditions and when forage close to escape terrain is less than optimal.

Domestic sheep exhibit food habits similar to those of bighorn sheep and are capable of exploiting steep, high elevation rangelands (Bowns 1971, Goodson 1982). Like their wild cousins, domestics are selective (Weir and Torell 1959) yet opportunistic (Cook et. al. 1965). Much evidence exists supporting domestic sheep preferences for grasses, sedges, and forbs on higher elevation spring and summer ranges (Stevens 1966, MacCracken and Hansen 1981, Thilenius and Brown 1987). The relative amounts of graminoids and forbs in their diet varies with location, with the tendency being to consume more forbs subject to availability (Pickford and Reid 1943, Schwartz and Nagy 1976). Some studies have demonstrated the importance of shrubs as summer forage for domestic sheep (Smith and Julander 1953, Jensen et. al. 1972).

The distribution of domestic sheep on public summer range depends to a great extent on the experience and willingness of the herder to follow the recommended grazing schedule imposed

by the corresponding administrative agency (Thilenius and Brown 1987). The similarities in diet suggest that any lapse from the predetermined grazing plan could perpetuate interspecific competition for available forages between domestic and wild sheep.

While individual bighorns (almost exclusively males) have been observed to associate with domestic sheep, social avoidance is the rule (Thilenius 1975, Goodson 1982). This could lead to the displacement of bighorns from any one of their home ranges or discourage them from occupying suitable habitats. Stevens (1982) reported that historic bighorn ranges were not recolonized following the removal of domestics, even after forage was available. Skiba and Schmidt (1982) hypothesized that dispersal patterns are genetically controlled. They contended that competition with livestock limited bighorn movements at a critical stage of range establishment and facilitated inbreeding. After the livestock were removed, bighorns did not disperse into the vacated suitable habitat. However, others have reported that bighorns will expand their range into areas previously used by domestic sheep (Bear and Jones 1973, Thilenius 1975).

While mountain goats prefer habitats resembling those considered ideal by bighorns, they tend to make greater use of cliff topography (Rideout 1978, Smith and Raedeke 1982). Since high visibility is not a requirement (Adams et. al. 1982), some mountain goat populations inhabit heavily forested

habitats (Smith 1982). Desirable habitat is generally a function of forage availability, escape terrain, and thermoregulatory opportunities within the landscape during summer (Michalovic 1984) and winter (Fox 1983). Summer movement patterns correspond to melting snow and green-up of vegetation (Adams et. al. 1982). Ranges are constricted in the winter and increasing snow depth may cause movement to either lower or higher elevations (Lentfer 1955, Adams and Bailey 1980, Fox et. al. 1989). South-facing aspects (Brandborg 1955) and windswept ridges (Hjeljord 1973, Cooperrider et. al. 1986) are preferred at the higher elevations. Female and nursery groups tend to be oriented towards the more optimal habitats while males and male groups occupy the more marginal range (Michalovic 1984).

Mountain goats have general food habits, apparently due to their relatively narrow habitat preferences (Geist 1971). Graminoids (Hibbs 1966, Johnson et. al. 1978), forbs (Hjeljord 1973), and shrubs (Casebeer 1948) have all been reported as primary summer forages. The winter diet appears even more variable. Dailey et. al. (1984) found that goats ate more shrubs and forbs than grass throughout winter. Saunders (1955) and Hibbs (1967) reported graminoids as important winter forage. Peck (1972) indicated that shrubs were the major component of winter diets. Fox and Smith (1988) stated that when preferred forage is limited due to heavy snow, goats rely on the most abundant plants available, including

conifers, ferns, lichens, and mosses. One might speculate that their plastic food habits and demonstrated ability to forage successfully in deeper snow (Adams 1981) could potentially transcend any competitive advantage sympatrically occurring bighorns may have over mountain goats. Interspecific social contacts may complicate this level of competition. Reed (1986) observed that nearly half (41%) of all direct interactions between bighorns and goats resulted in the displacement of the bighorns.

Interference or exploitative competition could also occur if elk are present on bighorn ranges. Elk tend to migrate to higher elevation grasslands in the spring and early summer in search of lush, green forage (Murie 1951). Seclusion is important, made evident by their selection of summer range away from human activity (Grover and Thompson 1986). They prefer smaller openings (Lyon and Jensen 1980), especially in late summer due to the decreased palatability of forage in larger, open areas (Edge et. al. 1988). Like many northern bighorn populations, elk prefer graminoids and forbs throughout spring and summer (Pickford and Reid 1943, Morris and Schwartz 1957, Stevens 1966, Constan 1972, Edge et. al. 1988), and into autumn (Kufeld 1973). Elk have also been observed to displace bighorns from summer ranges above tree line (Goodson 1978).

Investigations into intraspecific competition among bighorn sheep appear quite limited. Constan (1972) and

Wishart (1978) imply that intraspecific competition can be a concern when bighorns occupy only a small portion of their available habitat. Bighorn lambs learn traditional migration routes from older ewes and rams so the loss of mature, experienced individuals could alter traditional movement patterns and perpetuate intraspecific competition among bighorns. Low status individuals and juveniles may be forced onto poor quality ranges as well (Van Horne 1983).

Bighorn sheep have been known to habituate to human activity (Geist 1971, Stelfox 1975) and may tolerate controlled human visitation (Hicks and Elder 1979). However, there are recorded incidents of passive human disturbance affecting bighorns. Several researchers have observed bighorns altering behavior patterns in the presence of humans. Packard (1946) noted that bighorns vacated suitable habitat because they were annoyed by camera enthusiasts. Horejsi (1976) and Stevens (1982) reported that parts of traditional ranges were abandoned when human recreation interrupted bighorn activity and distribution patterns. Leslie and Douglas (1980) believe disturbances near critical resources, such as watering sites, may amplify behavioral response patterns. Distance from human disturbance (Etchberger et. al. 1989), herd size (Hicks and Elder 1979), and elevational position of approaching humans (MacArthur et. al. 1982) are also important in determining the reactions of bighorns to the presence of people. However, the threat of predation probably

alters bighorn sheep behavior patterns to a greater extent, as evidenced by their apparent evolutionary predator-evasion strategy relating to habitat selection (Adams et. al. 1982).

Coyotes are one of many predators with the ability to pursue and capture bighorn sheep (Post 1971), and are among the most opportunistic predators (Toweill and Anthony 1988). They may consume carrion (Grater 1943) or change their diet as different prey species become more vulnerable (Gese et. al. 1988), making adult ungulates more susceptible when snow is deep. However, indirect effects can be just as significant as an actual incidence of predation. Foraging behavior may be influenced when the threat of predation prevents bighorns from grazing the choicest ranges (Festa-Bianchet 1988). Bighorn ewes in groups of ten or less appear to exhibit a decreased foraging efficiency because they spend more time alert for predators and less time foraging than bighorns in larger groups (Risenhoover and Bailey 1985). Smaller nursery bands tend to select more precipitous escape cover and do not range as far from escape terrain (Gionfriddo and Krausman 1986), which means forage selection would be limited to available instead of preferred plants. The presence of canids has also been associated with increased heart rates, indicating a higher level of stress (MacArthur et. al. 1982).

Habitat loss may be the most serious threat to bighorn sheep (Wakelyn 1987) because survival is uncertain without spatial and habitat resources (Wilcox and Murphy 1985). While

loss of habitat resulting from agricultural, industrial, and recreational development has been well documented (Buechner 1960, Bear and Jones 1973, Campbell and Remington 1981), recent work indicates that the encroachment of tall, dense shrubland and forest can result in the fragmentation and reduction of high-visibility habitats used by bighorn sheep in some areas (Wakelyn 1987).

STUDY AREA

General Description

The study area is located approximately 80 km (50 mi) south of Big Timber, Montana, and 19 km (12 mi) north of the Montana - Wyoming state boundary (Figure 2), near the head of the Boulder River. The entire 6634 ha (16392 ac) study area can be found on the 1987 edition of the USGS Haystack Peak quadrangle 7.5-minute series topographical map.

Physiographically, the study area can be subdivided into three distinct mountain complexes. The Baboon Mountain complex (Figure 3) marks the northern limit of the study area and is near the confluence of the East Fork and Main Boulder Rivers. Lying to the south, respectively, are the Monument and Sheepherder Peak complexes (Figure 4). Independence and Haystack Peaks are included in the Monument Peak complex. Baboon and Monument form the divide separating the East Fork and Main Boulder rivers while the north facing cirque basins of Sheepherder serve as the rivers' headwaters.

The topography of the area is diverse, ranging from gently sloped, meandering stream bottoms to high plateaus. Near-vertical cliffs and steep talus slides characterize the northern and western faces of each complex. Convex and concave shaped grassy slopes adjacent to rock outcrops typify the southern and eastern aspects. Elevations increase from 2280m (7478 ft) along the lower East Fork of the Boulder to

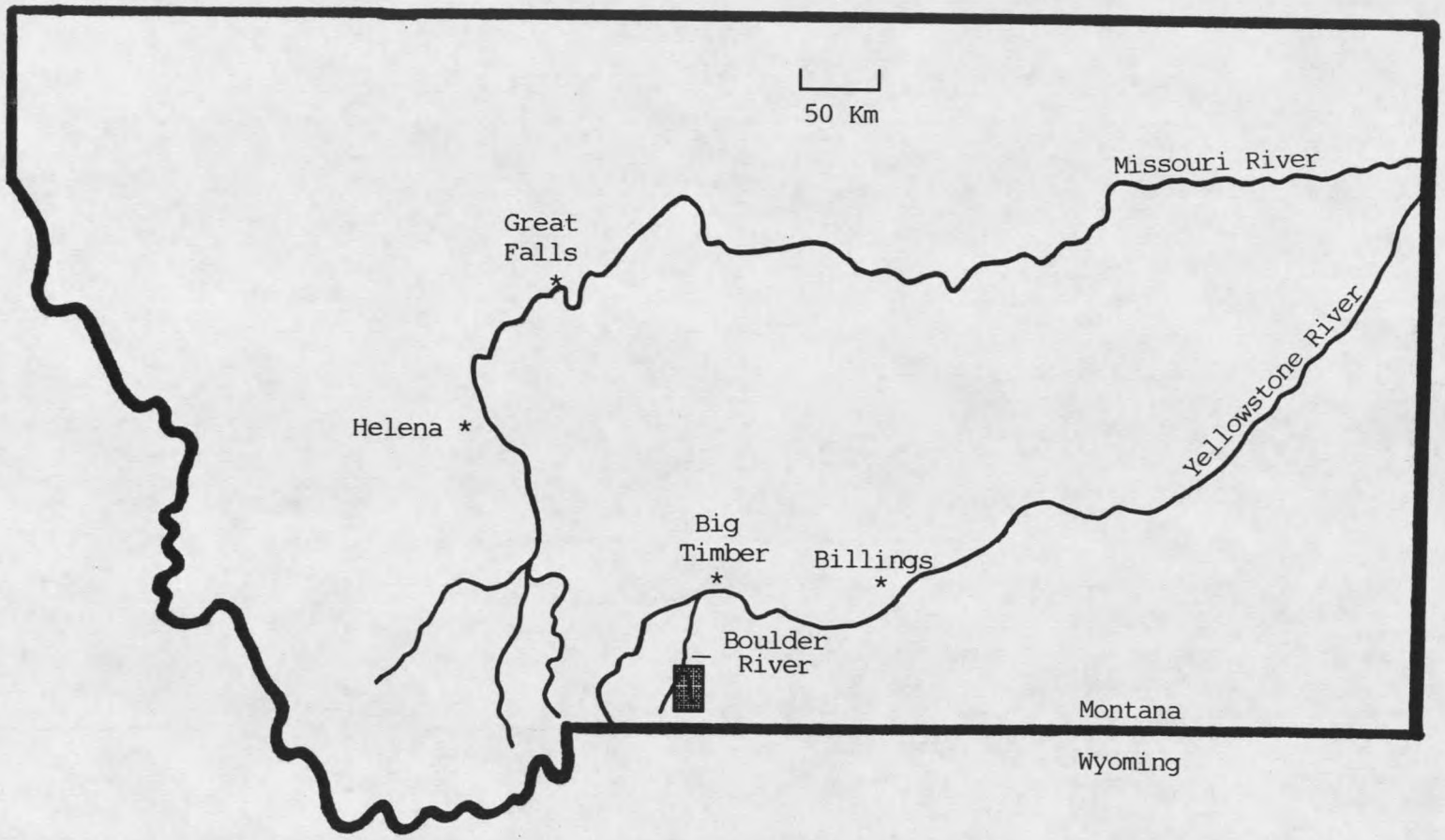

Figure 2. Location of the study area relative to the state of Montana.

Figure 3. Baboon Mountain, 1987 photo.

Figure 4. Haystack and Monument Peaks (foreground), Sheepherder Complex (background), 1988.

3351m (10995 ft) at the summit of Monument Peak.

Parent material formation along the upper Boulder has been influenced by volcanic and glacial events following earlier Precambrian crystalline and Cambrian sedimentary rock formation. Erosion has stripped much of the early strata, except for granitic outcrops and cliffs composed of interlaid bands of limestone, shale, and sandstone. Surficial deposits are primarily glacial in the river bottoms and colluvial along the lower slopes and cirque basins (1976 High Absaroka Sheep Range Environmental Analysis). The known soil families are a combination of Dystric Cryochrepts and Argic Cryoboralfs on the ridgetops, Cryoborolls and Cryoboralfs in the glacial cirque basins, and Typic Cryochrepts and Mollic Cryoboralfs on the glacial moraines (USDA, unpubl. soil survey, Gallatin Forest area). Most of these soils are immature.

Annual precipitation averages 107cm (42 in), of which 70 percent is snow. According to the Monument Peak snow monitoring station, permanent snow cover usually extends from early October through late June, with maximum accumulation in March. While there is an annual average of 103 snow-free days, snow banks may remain along north facing talus slopes throughout the year.

The overstory vegetation on the steeper, upper slopes generally consists of stunted Engelmann's spruce (Picea engelmannii (Parry) Engelm.) and subalpine fir (Abies lasiocarpa (Hook) Nutt.). Whitebark pine (Pinus albicaulis

Engelm.) and Rocky Mountain Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) are found at slightly lower elevations. Understory vegetation common to ridgetops and grassy slopes above treeline includes alpine bluegrass (Poa alpina L.), spike trisetum (Trisetum spicatum L.(Richt.)), sandwort (Arenaria spp.), pussytoes (Antennaria spp.), bistort (Polygonum spp.), phlox (Phlox spp.), and assorted lichens and mosses. The meadows lying along the forested slopes below treeline are primarily composed of Kentucky bluegrass (Poa pratensis L.) and Columbia needlegrass (Stipa columbiana (Macoun.)) communities. Sedges (Carex spp.), tufted hairgrass (Deschampsia caespitosa L. (Beauv.)), and willows (Salix spp.) are most apparent throughout the riparian habitats.

The diversity of wildlife along the upper Boulder is comparable to that of the vegetation. Native bighorn sheep have been reported to occupy all three mountain complexes, with ram sightings more common on Baboon while nursery bands are more likely to congregate on Monument and Sheepherder (pers. comm. Simmons). Introduced Rocky Mountain goats from the Mill Creek divide, located approximately 13 km (8 mi) west of the study area, apparently began colonizing the upper Boulder in the early 1970's and appear to be continually increasing in number (pers. comm. Lemke). Sightings of mountain goats are sporadic on Baboon but occur regularly on Independence and Sheepherder. Rocky Mountain elk are present seasonally, migrating to higher elevation summer ranges from

the lower reaches of the Boulder and Slough Creek drainages (pers. comm. Simmons). Indications are that current population levels might be higher than at any other time this century, tripling in the last fifteen years. Shira's moose (Alces alces shirasi Nelson) were observed occasionally in association with dense willow thickets along the East Fork of the Boulder. Rocky Mountain mule deer (Odocoileus hemionus hemionus Rafinesque) are reported to inhabit certain mid-elevation openings (pers. comm. Atcheson) but were not observed.

Yellow-bellied marmots (Marmota flaviventris nosophora A. H. Howell) and pikas (Ochotona princeps ventorum A. H. Howell) frequent the upper elevation rock terrain. Coyotes are common throughout the area at all elevations. Black bears (Ursus americanus americanus Pallus) periodically traverse the stream corridors. The majority of the study area is also part of a grizzly bear (U. arctos horribilis Ord) recovery unit. Their presence is generally limited to late August through early September, when an occasional bear will wander into the upper East Fork from Slough Creek. An unconfirmed sighting of a wolverine (Gulo luscus luscus L.) during the 1988 field season exemplifies the wildlife diversity of the upper Boulder.

Historically, gold mining activity occurred from the 1890's into the 1930's at the Yeager Mine, located midway between Baboon and Independence Peaks at the head of Basin (Electronic) Creek. Remnants of the mining machinery and

associated structures are still present. In addition, 107 ha (264 ac) of private mining claims currently surround the abandoned mining operation.

The fire history of the study area is vague. According to USFS records, significant fire activity occurred in the early part of this century (circa. 1910) but the only other known fires in the vicinity were the Storm Creek and Hellroaring blazes in 1988.

A variety of recreationists visit the study area each year. Access is gained by four-wheel drive vehicle or on foot, horseback, or mountain bike. Hikers frequent the Independence and Monument Peak complex during the summer, often climbing to the summit. Pack-trip outfitters use the trail along the East Fork of the Boulder and cross over the divide into the Slough Creek drainage. Blue Lake and both forks of the river are fished with some regularity. While guided hunts for prized bighorn sheep rams were discontinued after the 1990 season with the closure of Hunting District 500, elk and deer hunters still frequent the area each autumn.

Haystack Domestic Sheep Allotment

In addition to recreational use, portions of the study area are grazed seasonally by domestic sheep. The boundaries of this 6524 ha (16121 ac) allotment are similar to those defining the limits of the study area. Both include all of

the Baboon and Monument complexes and the northern aspect of the Sheepherder complex. One camp unit of the allotment, the Columbine Plateau (east of Monument Peak across the E. Fork of the Boulder) was excluded from the study area because of few reports of bighorn sheep. Conversely, the southern exposure of Sheepherder is only included in the study area.

The U.S. Forest Service has been administering these lands since 1906. However, the Haystack Allotment was not officially designated until 1939 (pers. comm. Orr). The first permittee was P.A. Bruffey (Martin, unpubl. USFS files, Big Timber Ranger District). With the death of Mr. Bruffey in 1944, the public range permit was granted to Teddy Thompson. His current band of 640 Rambouillet-Targhee sheep using the allotment reflects the latest in a series of reductions of permitted sheep numbers (Table 1) and includes an additional 40 ewe/lamb pairs allowed due to the lease of the private mining lands.

Table 1. Grazing season and domestic sheep numbers history.

YEAR	GRAZING SEASON[1]	SHEEP NUMBERS[2]
1925-1938[3]	July 1 - Sept. 15	1500
1939-1943	July 1 - Sept. 15	1200
1944-1972	July 1 - Sept. 15	1000
1973,1974	July 8 - Sept. 2	800
1975,1976	non-use	
1977	July 8 - Sept. 2	600 + 40
1978-1980	non-use	
1981-1989	July 8 - Sept. 12	600 + 40

[1] Approximate season lengths.
[2] Sheep numbers are in ewe/lamb pairs.
[3] Only partial records are available prior to 1939.

Source: Haystack Allotment files, Gallatin National Forest.

These reductions correspond with changes in the acreage considered suitable for domestic sheep (Jensen, unpubl. USFS files, Big Timber Ranger District) and have an ecological basis (McCulloch, unpubl. USFS files, Big Timber Ranger District). McCulloch attributed the decline of permitted sheep numbers to fire-induced plant succession. He hypothesized that forage production increased in response to fire, creating a greater grazing capacity for domestic sheep and big game. However, as the burned areas reverted to forest, forage production decreased. This, combined with resource damage from overstocking during years of high forage production, reduced the carrying capacity for domestic sheep.

According to Jensen (1975), 2675 ha (6610 ac) were considered suitable in 1940. Subsequent acreage reductions were attributed to changing soil conditions, steepness of slope, increased downfall in timbered stands once considered suitable, and inadequate forage production. From 1982 through 1984, Forest Service personnel reevaluated the suitability of the allotment for domestic sheep. Criteria included forage composition and production, accessibility, and distance from water. They concluded that 730 ha (1806 ac) were suitable for domestic sheep grazing. This acreage reduction included the ridges between Sheepherder and Independence Peaks that had been closed to domestic sheep in 1977 (Figure 5) because they had been identified as key bighorn sheep winter range during the 1976 High Absaroka Sheep Range Environmental Analysis.

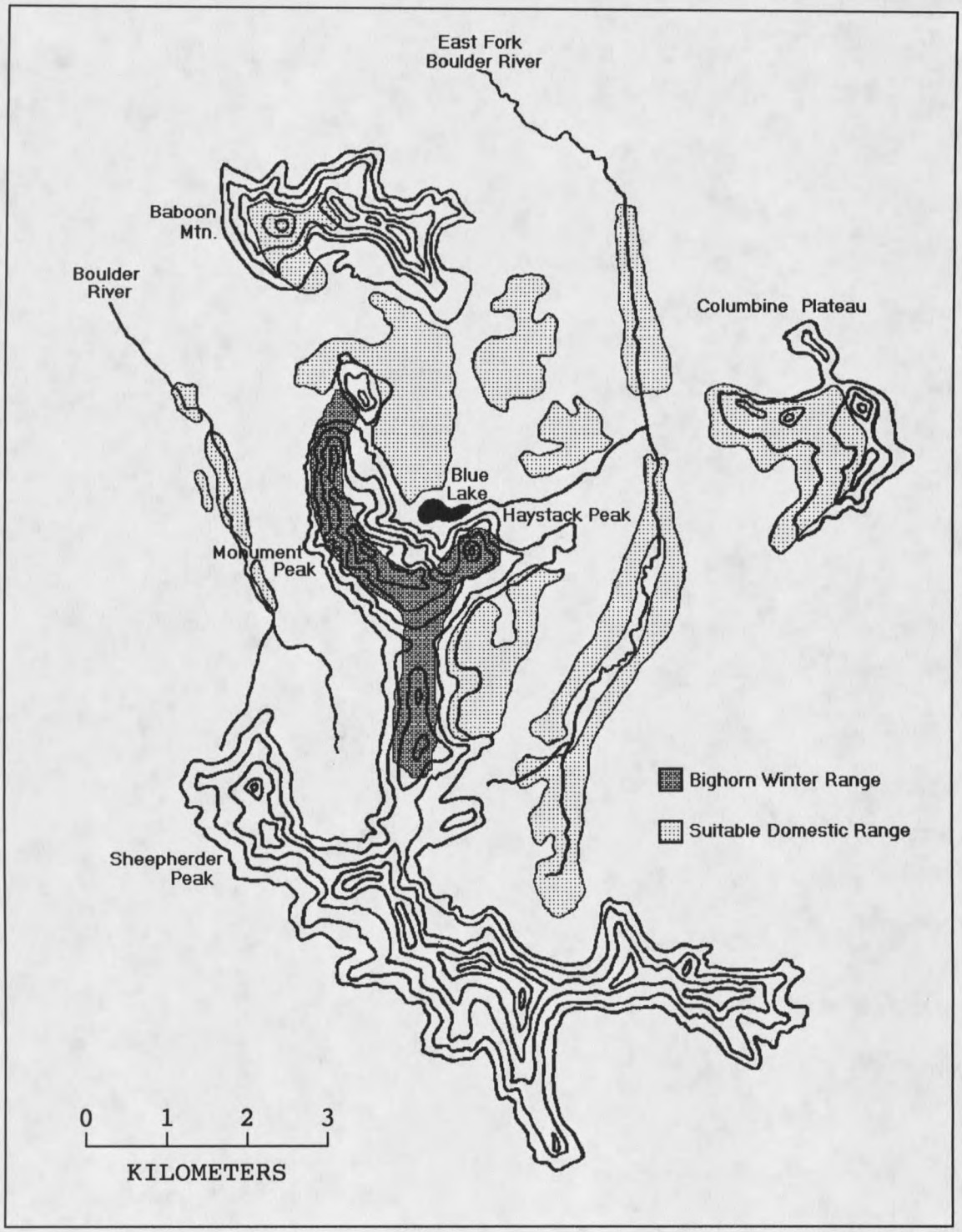

Figure 5. Suitable domestic sheep range versus critical bighorn winter range, Haystack Allotment files, Gallatin National Forest, 1984.

The grazing management scheme has also evolved. While specifics on grazing patterns prior to 1970 are not well documented, allotment files indicate that grazing has progressed though a series of camp units since the early 1930's (Table 2). The topographically separated camp unit boundaries (Figure 6) have remained constant since at least 1965 and include the addition of the Columbine Plateau to the allotment in the late 1970's (Cifala, unpubl. USFS files, Big Timber Ranger District). Forest Service records suggest that the nine camp units were used in the same clockwise progression until 1973 when a simple, deferred rotational grazing system was initiated. Entry routes between the Main Boulder and the East Fork were alternated annually. A modification in 1977 added five rotation options to facilitate better forage management and provide more weather-induced flexibility. The struggle to follow this system resulted in an additional refinement being instituted in the 1984 Haystack Allotment Grazing Management Plan.

Table 2. Camp unit numerical designations and common names.

CAMP UNIT NUMBER	COMMON NAME
1	Lower East Fork
2	Columbine Plateau
3	Willow Bottom
4	Upper East Fork
5	The Hole
6	Lake City
7	Yeager Mine
8	Baboon
9	Main Boulder

Source: Haystack Grazing Allotment files, Big Timber Ranger District, Gallatin National Forest.

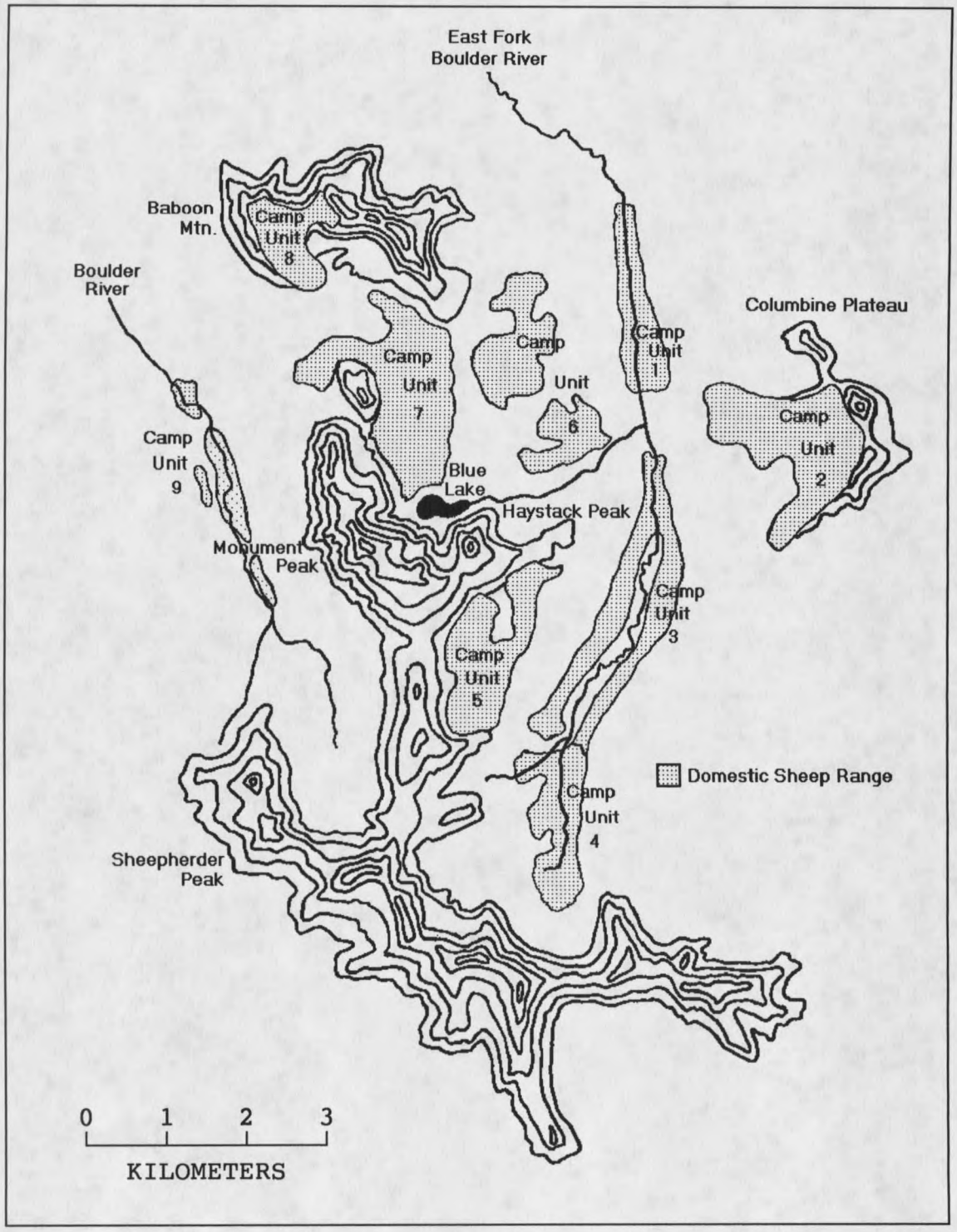

Figure 6. Camp units of the Haystack Grazing Allotment, Gallatin National Forest, 1984.

The current system includes three different rotations through the nine camp units. Selection of a particular rotation depends on the Independence Snow Course water content on the first of May. Snow Course water content serves as an indicator of range readiness (pers. comm. Orr). The amount and distribution of snowpack, plant phenological development, and soil stability (dryness) also influence range readiness and serve to support annual deviations in the scheduled rotations (pers. comm. Orr).

METHODS

Seasonal ungulate locations were determined through a combination of systematic aerial and ground observations. Aerial surveys were originally planned for at least once every other month from September through May of 1987-1988 and 1988-1989. However, actual flight scheduling was dependent on weather conditions, pilot obligations to other projects, and other researcher responsibilities, meaning that some flights occurred in consecutive months while others were separated by several months. A Supercub fixed-wing aircraft was selected because of the prohibitive cost of renting a helicopter. The Supercub does feature relatively slow airspeed and high maneuverability (pers. comm. Stradley) and tends to elicit fewer animal displacement responses (pers. comm. Simmons), making it useful for wildlife surveys in mountainous terrain.

All flights had the researcher and a pilot as observers. Each mountain complex was circumnavigated at least twice during a typical census. Flight patterns simulated those used by Montana Department of Fish, Wildlife, and Parks biologists for annual winter surveys of the study area (pers. comm. Simmons). The Baboon Mountain complex was circled first, followed by Monument and Sheepherder, respectively. Rocky terrain, grassy knolls, and windswept ridges associated with each complex above the tree line were examined.

Spotting individual animals from the aircraft depended on season, the targeted species, and the experience of the observers. Animal movement was essential for locating bighorn sheep during snow-free conditions. The white pelage of mountain goats was more conspicuous. During periods of snow-cover, successful observation of bighorns also relied on animal movement. An alternative method was to follow tracks until an animal was spotted. Strong winds were common so it was assumed that blowing snow would obliterate all tracks daily (pers. comm. Stradley). Hence, any visible tracks were considered "fresh". Goats were located by searching for their shadows or dull, yellow winter coats. Confirmation of an ungulate sighting prompted additional passes in the event conspecifics might be nearby. When it became apparent that animals were either seeking refuge in terrain that obstructed view from the aircraft or that the observers were unable to discern any additional ungulates, observations were concluded for the day.

Systematic seven to ten-day ground observation periods were scheduled for late June through mid-September to coincide with the presence of domestic sheep on the allotment. The strategy of each field survey period was subjectively oriented towards locating the maximum number of ungulates for each hour of observation per mountain complex. Therefore, initial amounts of time allocated each mountain complex were based on preliminary conversations with Forest Service and Montana

Department of Fish, Wildlife, and Parks personnel that indicated bighorns used Monument and Sheepherder to a greater extent than Baboon. Two researchers hiked from one vantage point to another throughout the study area during each survey period, allocating more time to Monument and Sheepherder as the summer progressed. Daily observations extended from dawn to dusk unless the researchers were travelling to another vantage point or weather conditions interfered with observations. A vantage point was any accessible location offering unobstructed visibility of upper elevation slopes and rocky terrain above tree line. Vantage points potentially occupied by bighorns were avoided or approached with caution to minimize displacement. Observations were made with a 15 to 60x60mm zoom spotting scope and 7x35mm binoculars.

Ungulate locations obtained from aerial and ground surveys were recorded on a U.S. Geological Survey 7.5-minute topographical map and later transcribed onto a computer generated figure. Socially aggregated ungulates were considered as a single location. Total man-hours of observation were tallied daily. One man-hour was equal to one person searching for herbivores for one hour. Species, number, activity (foraging, fleeing, travelling, or resting), age-class (immature or adult), and sex (when identifiable) were also recorded. Actual ungulate observations continued until terminated by the animals, the researchers, darkness, or inclement weather.

Suitable bighorn sheep habitat on each mountain complex was delineated on a 1:24000 orthophoto and measured with a digital planimeter. Suitability criteria were determined using the most consistent corroborating evidence reported in the literature suggesting that any open habitats within 250m (820 ft) of rocky escape cover are generally suitable for bighorn sheep (Wakelyn 1984, Cooperrider et. al. 1986). Talus slopes associated with tall, dense conifer stands or prolonged snowpack were excluded whereas talus slopes adjacent to open grasslands offering unrestricted visibility were included. Open conifer stands at lower elevations within 250m of escape cover were also included because a local biologist and a guide who had hunted the study area since 1972 indicated the resident bighorn population did not hesitate to use these fringe habitats (pers. comm. Simmons and Atcheson).

Lauer and Peek (1976) reported observed overlaps in range use and diets, along with the availability of preferred forages, as important criteria in any study of forage competition among large herbivores. McCollough et. al. (1980) further expounded the methodologies of investigations into forage competition by arguing that, in addition to the criteria selected by Lauer and Peek (1976), it is also necessary to determine the extent to which mutually-used forages limit the productivity of at least one species. Since data on forage availability and ungulate food habits along the upper Boulder were not collected in this study, actual

instances and subsequent degrees of forage competition could not be determined. Instead, some of the criteria common to the investigations by Peek and Lauer (1976) and McCollough et. al. (1980) were used to assess the potential for forage competition along the upper Boulder. These included overlaps in ungulate distribution, habitat use, and food habits. This was accomplished by comparing the accumulation of observed ungulate seasonal spatial locations and their respective diet preferences as reported in the literature. Early field work in 1988 indicated that, in addition to the presence of mountain goats and domestic sheep, elk were using the area for calving and summer grazing. Therefore, the potential for interspecific forage competition was assessed between bighorns and elk, mountain goats, and domestic sheep as was the potential for intraspecific forage competition among bighorns. Areas of potential conflict for available forage were identified to assist future research efforts into ungulate distributions and forage competition along the upper Boulder.

To determine whether or not bighorns along the upper Boulder were selecting or avoiding particular areas of the Haystack Allotment, it was hypothesized that the resident bighorn population utilizes each mountain complex in proportion to suitable habitat availability. Aerial survey data were analyzed separately from ground locations obtained during the 1988 field season. The assumptions for the flight data were: a) flight time over each mountain complex was

proportional to suitable habitat availability; b) individual bighorns had an equal chance of being observed on any complex during any flight; and c) all bighorns observed were counted only once per flight. The observed occurrence of bighorn sheep numbers on each mountain complex was compared with the expected occurrence relative to suitable habitat availability using a Chi-square test (Neu et. al. 1974). Significance was tested at the 95% confidence interval using a Bonferoni z-statistic.

A Chi-square test was also used to test the null hypothesis that observed summer use of each mountain complex by bighorns based on ground observations was proportional to suitable habitat availability. However, the data set was confounded by unequal hours of observation relative to the percentage of suitable habitat within each mountain complex. A weighted factor was obtained by multiplying the proportion of suitable habitat in each complex with the proportion of observation time respective to that complex. This value was subsequently used to calculate the expected number of bighorn groups per complex. The assumptions for this analysis were: a) no groups observed on a given day were counted more than once; b) each group of bighorns was equally observable, regardless of location; and c) all group observations were independent.

To determine if there might be a spatial relationship between observed bighorn sheep and domestic sheep, it was

hypothesized that the average distance between individual bighorn locations and the center of the camp unit currently being grazed by domestic sheep was not different than the average distance between domestic sheep and some random point within the study area or allotment boundaries. A paired - sample t test (Zar 1974) at the 95% confidence level was used to test the null hypothesis that the average distances were not different.

References to forage demand assumed ungulate forage intake approximates two percent of body weight per day for maintenance requirements (Moen 1973). Average body weights used were obtained from Murie (1951) for elk, Blood et. al. (1970) for bighorn sheep, Rideout and Hoffman (1975) for mountain goats, and Wuethrich and Schwab (1980) for Rambouillet - Targhee domestic sheep.

RESULTS

Six aerial surveys were conducted between November of 1987 and September of 1989. All flights had the same researcher and one of two different pilots. Each pilot had over 30 years of aerial wildlife survey experience while the researcher was a novice.

Numbers of bighorn sheep observed ranged from 13 in May of 1988 to three on two different occasions (Table 3). While nine mountain goats were located on September 4, 1989, the average was 2.3 per flight. Average group size was larger for bighorns than goats (3.6 to 2.0 individuals per group). Seven out of nine observed groups of bighorns fled into rocky terrain or onto timbered slopes (Appendix A). The aircraft did not elicit any detectable responses from mountain goats other than a casual glance (Appendix B). Nearly all observed bighorns and mountain goats were associated with the Monument and Sheepherder complexes (Figure 7). Closer examination of these distributions indicates at least two areas of sympatric habitat use: on the southern exposure of Monument and on the long ridge running south from Sheepherder. Although social interaction was not witnessed on this study area, bighorns and mountain goats were observed grazing together on a windswept ridge of another interior mountain range several kilometers west of this study area.

Table 3. Numbers of bighorn sheep and mountain goats observed on each mountain complex during aerial surveys, 1987 - 1989.

Flight Date	Baboon		Monument		Sheepherder	
	BH*	MG**	BH	MG	BH	MG
11/10/87		1	3		1	
2/25/88					4	1
5/11/88			8		5	3
2/08/89			5		4	
3/21/89	1		2			
9/04/89				4	3	5
Totals	1	1	18	4	17	9

*BH = bighorn sheep.
**MG = mountain goat.

Four field trips averaging eight days each were completed between June and August of 1988 by a team of two researchers with periodic assistance from the project advisor. The first trip began approximately two weeks before the planned arrival of domestic sheep and coincided with sufficient snowmelt to allow unrestricted access throughout the study area. A fifth trip was limited to three days because forestlands adjacent to the Storm Creek and Hellroaring fires, including the study area, were closed to the public on August 21. The base camp, located near Blue Lake, was removed three days later when permission was granted for that specific purpose. However, a spike camp located near the head of the East Fork was not retrieved until early October.

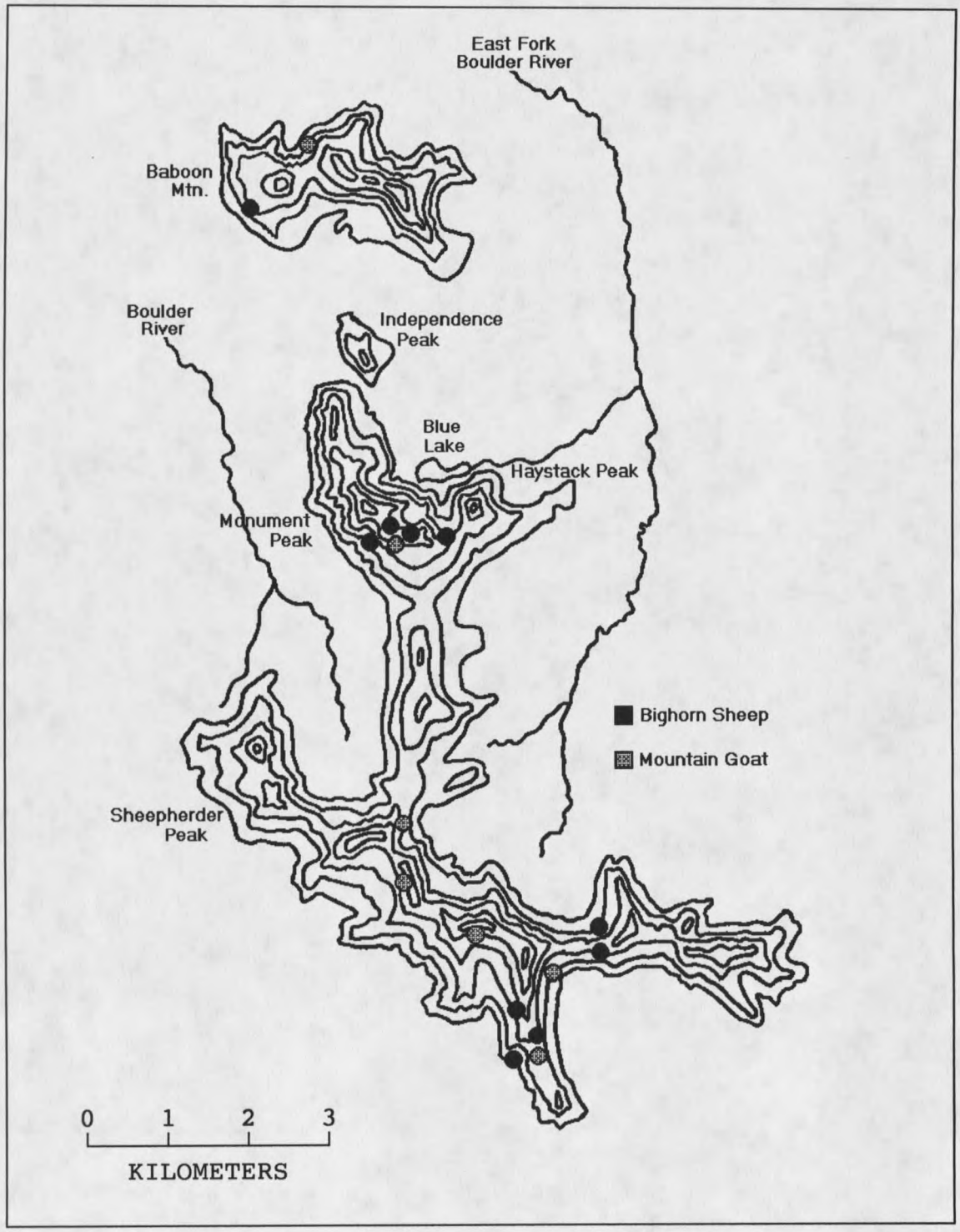

Figure 7. Locations of individual and grouped bighorn sheep and mountain goats observed during aerial surveys between November 1987 and September 1989.

Observation time during the summer varied according to the position of each mountain complex within the study area. The Baboon and Sheepherder complexes, lying respectively to the extreme north and south, were observed less frequently than the centrally located Monument complex (Table 4).

Table 4. Field trip dates and man-hours of observation for each mountain complex, 1988.

Field Survey Dates	Man-Hours of Observation			
	Baboon	Monument	Sheepherder	Totals
6/24 - 7/1	16	70	49	135
7/7 - 7/15	52	48.5	25.5	126
7/21 - 7/27	8	32	47	87
8/4 - 8/12	12	25.5	51.5	89
8/19 - 8/21	7.5	12.5	5	25
8/24	2	2		4
totals	97.5	190.5	178	466

The 466 hours of summer observation identified a total of 20 bighorn sheep and mountain goat locations among the three mountain complexes (Table 5). Activity for both species appeared to be centered around the Sheepherder complex (Figure 7), which ultimately meant less time was spent observing Baboon as the summer progressed. One mountain goat location was recorded on Baboon and two on Monument, but no bighorns were observed on either complex between June and August of 1988.

Identification of individual bighorns was uncertain but at least seven ewes and four lambs apparently inhabited the Sheepherder complex from June through August (Appendix C). No rams were observed. Mountain goats, observed as frequently as bighorns, were less numerous. Three individuals were the maximum located at any one time (Appendix D). Goats were either classified as adults or kids.

Table 5. Bighorn sheep and mountain goat locations for each mountain complex, June - August 1988.

Field Survey Dates	Baboon		Monument		Sheepherder	
	BH*	MG**	BH	MG	BH	MG
6/24 - 7/1					4	2
7/7 - 7/15		1		2	1	1
7/21 - 7/27					3	2
8/4 - 8/12					2	2
8/19 - 8/21						
8/24						
Totals:		1		2	10	7

*BH = bighorn sheep.
**MG = mountain goat.

Sympatric habitat use was not witnessed during the summer field season. Mountain goats primarily occupied the near-vertical cliff regions but occasionally ventured along adjacent grassy slopes. Bighorn sheep observations characteristically included intermittent foraging bouts and lounging periods on range spatially separate from that used by

mountain goats but always near rocky escape cover. However, mountain goats were sighted on some upper elevation grassy slopes and windswept ridges (Figure 8) used by bighorns in the winter (Figure 7). Bighorns easily negotiated rugged terrain while travelling between feeding sites or when disturbed. They did not habituate to human activity during the summer of 1988. Mountain goats, on the other hand, appeared indifferent to the presence of the researchers.

Elk were the most frequently observed ungulates during the summer (Appendix E). Elk tended to forage in the mesic meadows utilized by domestic sheep (Figure 8) but not concurrently. In fact, elk apparently moved to other grazing areas a day or two prior to the arrival of the domestics. An incidence of elk movement across one of the upper elevation slopes of Sheepherder used by bighorns was documented.

Domestic sheep use approximated the planned schedule (Appendix F). Herder controlled grazing generally occurred on the lower elevation meadows associated with the East Fork and Main Boulder Rivers as well as some higher plateaus adjacent to small lakes or pockets of melted snow (Figure 8). However, evidence of domestics on the upper slopes at the head of the East Fork on August 10 and on the southeast slope of Monument August 20 suggests they strayed across permitted boundaries on at least two occasions. There were no domestic sheep sightings on Baboon because it was the rested camp unit during 1988.

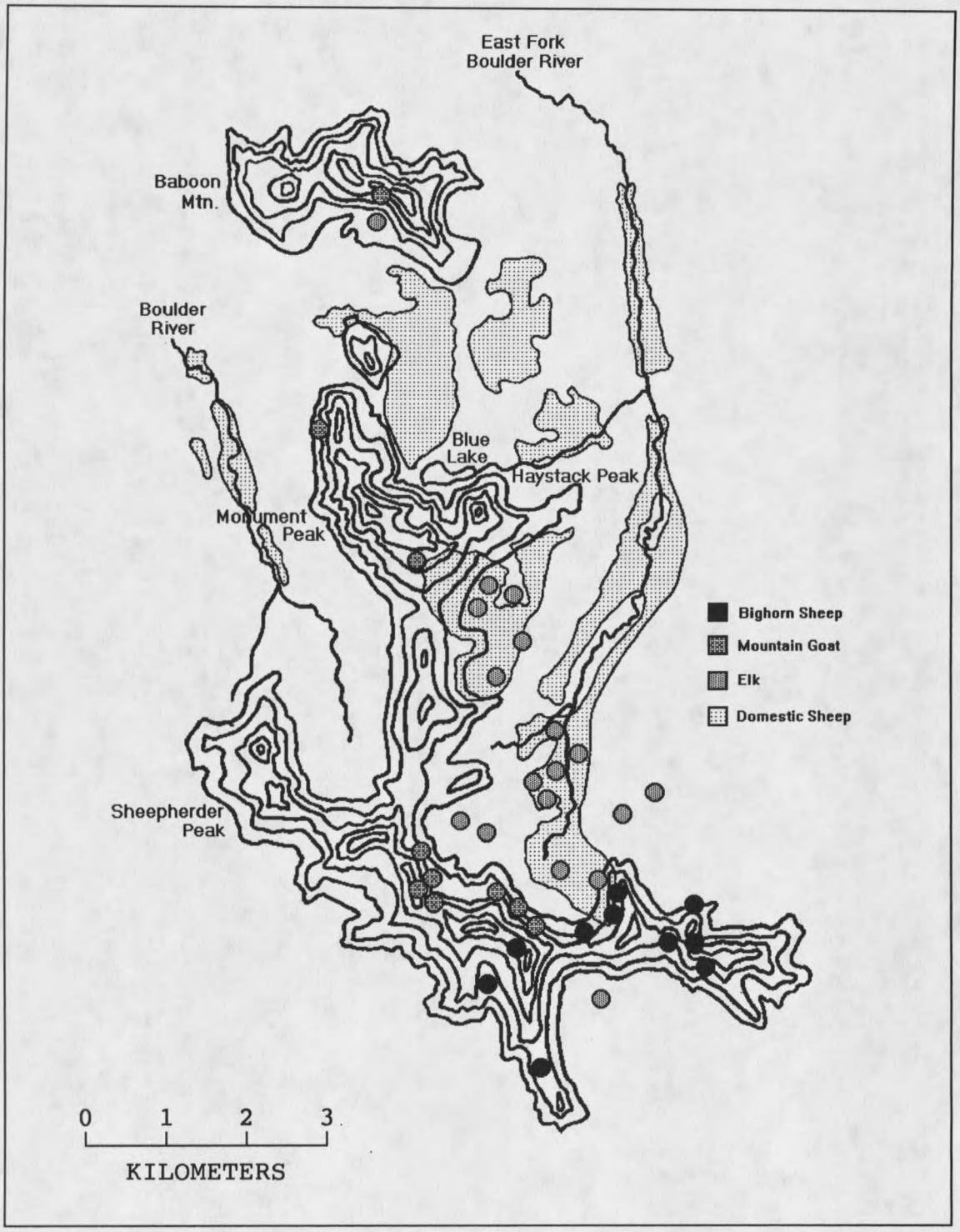

Figure 8. Locations of individual and grouped bighorn sheep, mountain goats, elk, and domestic sheep observed from June through August 1988.

The accumulation of bighorn observations suggests intraspecific use by bighorns of certain windswept ridges of Sheepherder year-round (Figure 9). All recorded locations were within the 1135 ha (2805 ac) of defined suitable habitat. More than half, 590 ha (1458 ac), were associated with Sheepherder while Monument, 308 ha (761 ac) and Baboon, 193 ha (477 ac) contained lesser amounts. The habitat on the flat ridge between Monument and Sheepherder was excluded from statistical analysis. Seasonal differences in suitable habitat availability could not be determined so the amount of suitable habitat remained constant for aerial and ground survey data analysis.

While analyzing gregarious animals by groups is recommended (Thomas and Taylor 1990), the objective of this study was to identify the numbers of individual bighorns inhabiting each mountain complex with respect to defined suitable habitat availability. Preliminary examination indicated that statistical analysis using groups of bighorns could skew desired interpretations of the data set. If group size on the Baboon and Sheepherder complexes averaged ten and one individuals, respectively, comparison by group would have underestimated bighorn use of suitable habitat on Baboon and overestimated use on Sheepherder. To remove this sampling bias, the data were transformed to total numbers of bighorns observed on each mountain complex during each aerial survey. Goodness-of-fit comparisons (Table 6) of this data showed that

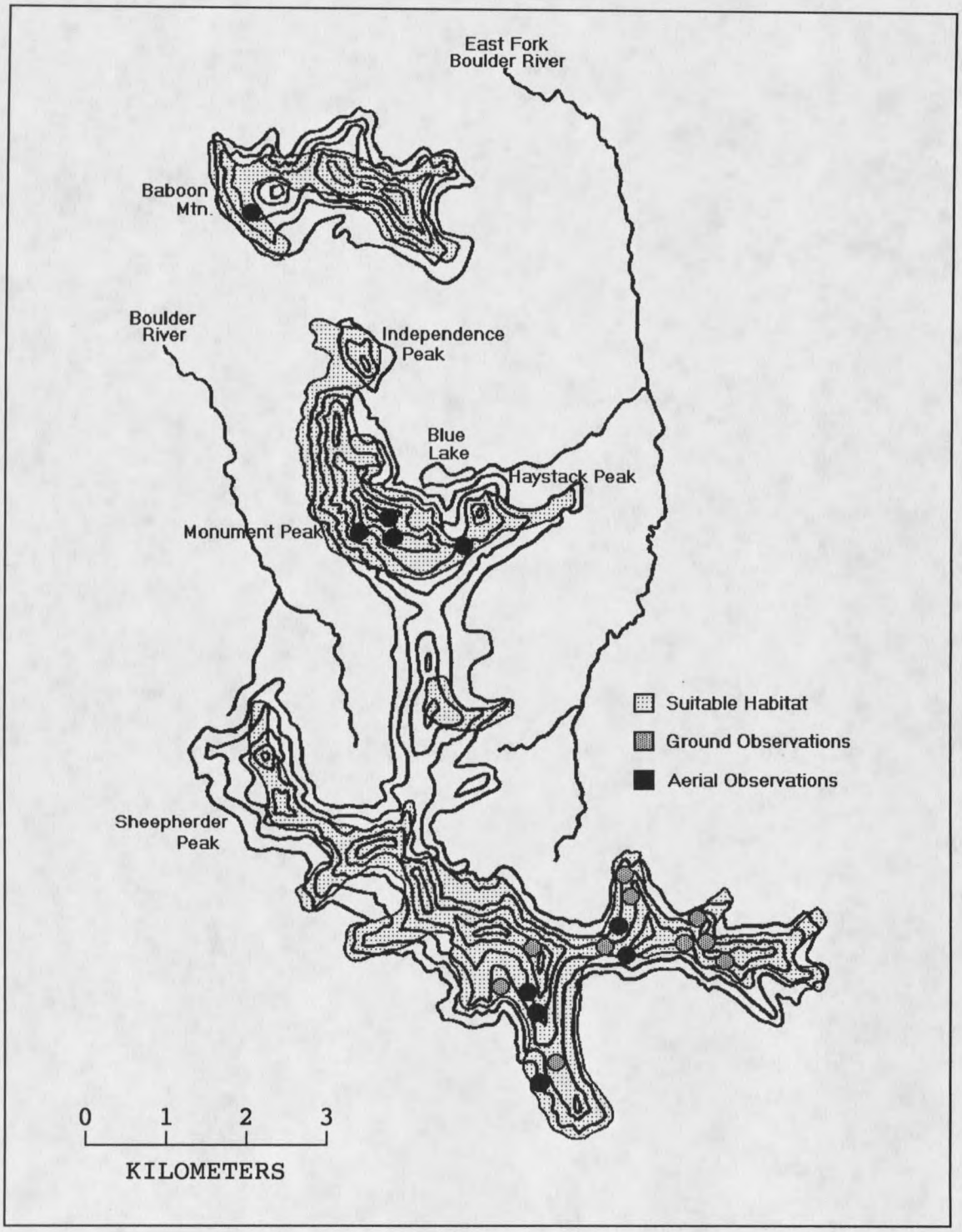

Figure 9. Suitable bighorn sheep habitat and all observed bighorn sheep locations, Nov. 1987 - Sept. 1989.

the expected number of bighorn observations on each mountain complex differed significantly from the proportional occurrence of suitable habitat (Chi - square calculated = 10.78; tabular value = 5.99, P <.05), so the null hypothesis was rejected.

Table 6. Occurrence of bighorn sheep relative to suitable habitat availability, September-May, 1987-1989.

Mountain Complex	Prop. Suitable Habitat	Observed Bighorns	Expected Bighorns	Prop. of Obs.	Confidence Interval 95%
Baboon	.176	1	6.34	.028	-.295<B<.351
Monument	.283	18	10.18	.50	.269<M<.731
Sheepherder	.541	17	19.48	.472	.235<S<.709
totals	1.0	36	36.00	1.0	

Total groups or individuals could have been compared for the field survey data collected during the summer of 1988 because the lack of bighorn sightings on Baboon and Monument eliminated the concern that analysis by groups might skew interpretations. In fact, analysis by group should generate more conservative results than comparison by total individuals. The subsequent Goodness-of-fit comparison of the ground survey data (Table 7) indicated a significant difference between the observed and expected numbers of bighorn groups on each mountain complex, relative to the proportion of available suitable habitat (calculated Chi-square = 7.72; tabular value = 5.99, P <.05), so the null

hypothesis was rejected. The "habitat/time" factors were used to correct for the unequal amounts of observation time relative to suitable habitat on each mountain complex.

Table 7. Occurrence of bighorn sheep relative to suitable habitat availability, June-August, 1988.

Mountain Complex	Prop. Suitable Habitat	Prop. Observ. Time	Prop. Hab./Time Factor	Observed Bighorn Groups	Expected Bighorn Groups
Baboon	.176	.209	.103	0	1.03
Monument	.283	.409	.322	0	3.22
Sheepherder	.541	.382	.575	10	5.75
totals	1.0	1.0	1.0	10	10.00

Geographical comparison with the seasonal locations of other ungulates indicated that, while all goat observations were within suitable bighorn habitat, only one elk location was identified on suitable bighorn range (Figure 10). Permitted domestic sheep range overlapped suitable bighorn habitat in some areas (Figure 11), particularly on the Baboon complex. Furthermore, summer field observations in 1988 documented evidence of domestic range use overlapping suitable bighorn habitat on two occasions (Figure 12).

Six different bighorn sheep locations were recorded during the permitted summer grazing period for domestic sheep (July 6 through Sept. 3). The paired t test comparison of the distances separating these bighorns and domestic sheep with the distances between the domestic sheep and random points

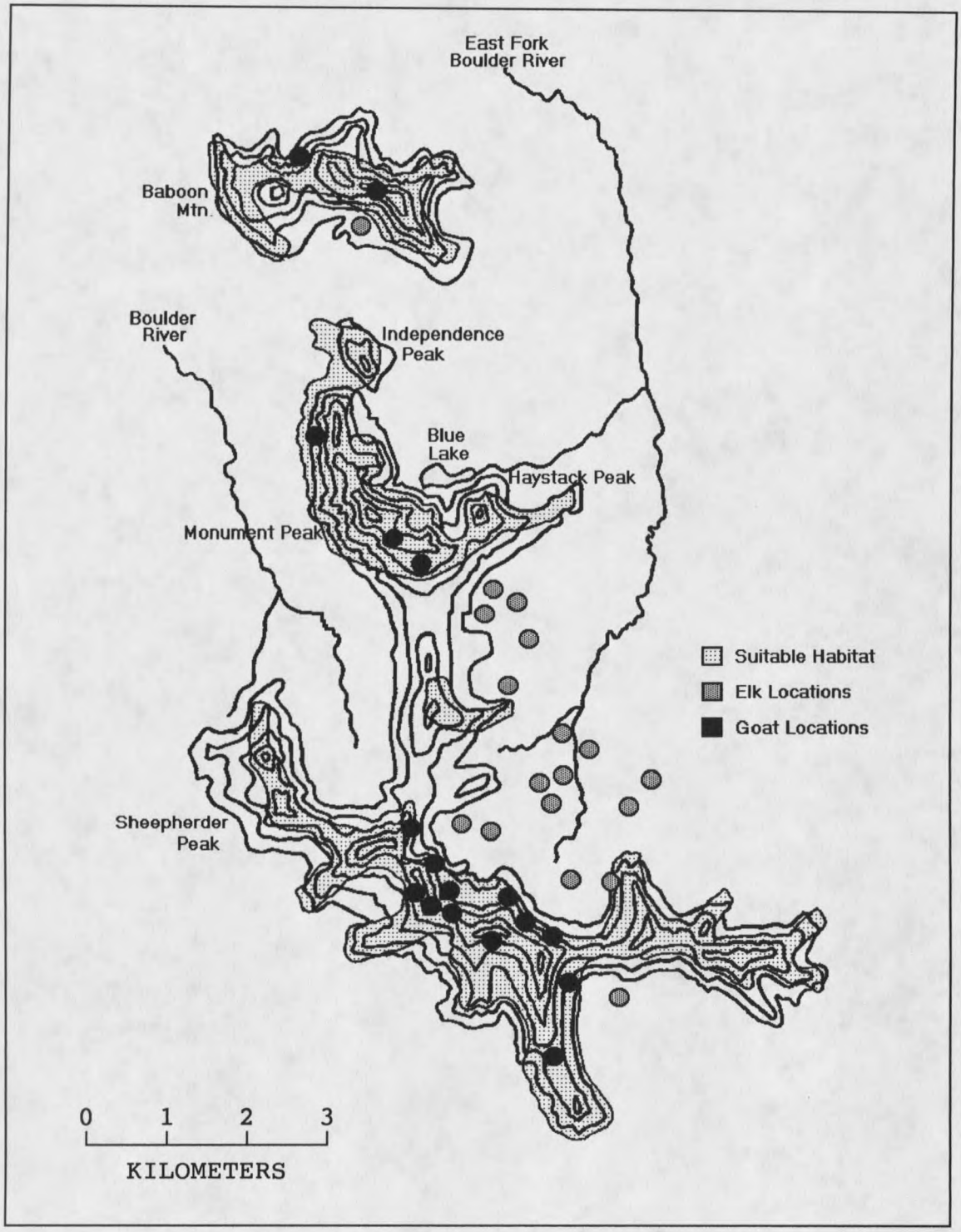

Figure 10. Suitable bighorn sheep habitat and all observed mountain goat and elk locations, November 1987 - September 1989.

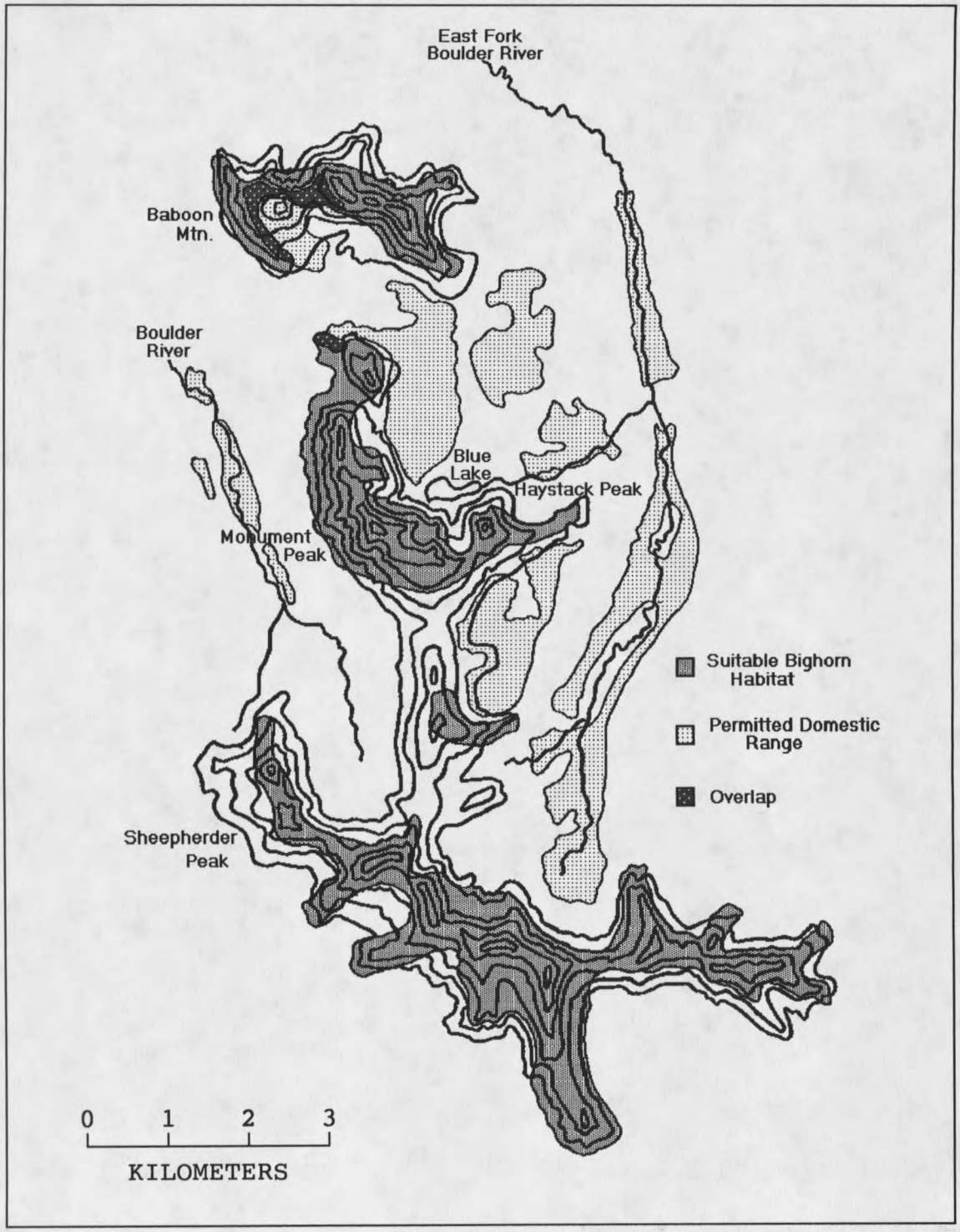

Figure 11. Suitable bighorn sheep habitat and permitted domestic sheep range.

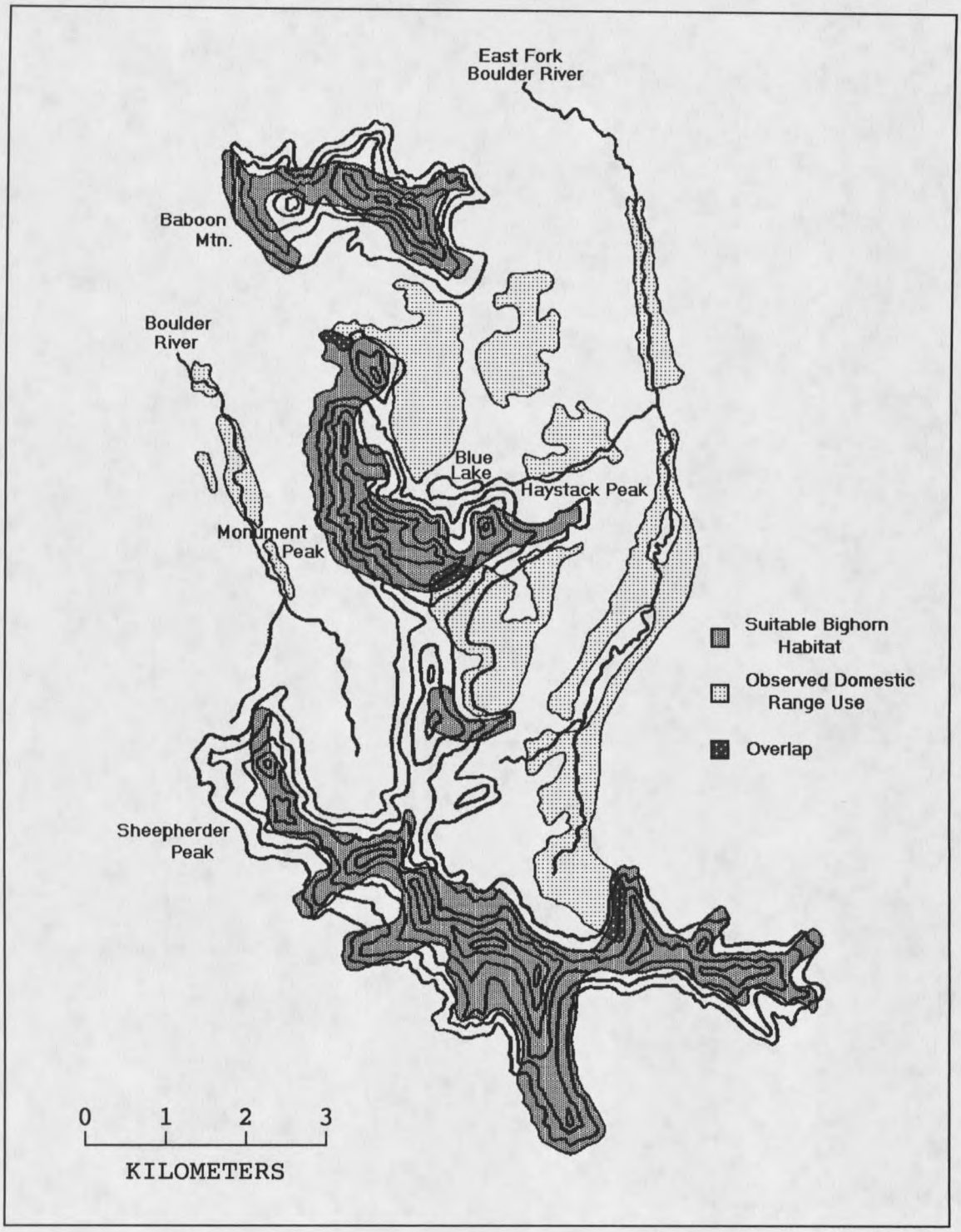

Figure 12. Suitable bighorn sheep habitat and observed domestic sheep range use during 1988.

(Table 8) did not indicate a significant difference (calculated t = .235; tabular t = 2.571, P >.50) so the null hypothesis was not rejected, implying that there was no difference in distance from bighorns to domestic sheep and random points to domestic sheep.

Table 8. Distances separating bighorns from domestic sheep and domestic sheep from randomly located points, 1988.

Bighorn Location	Domestic Location	Bighorn to Domestics	Random Point to Domestics
B10	Camp unit 9	6.23km	.64km
B11	Camp unit 3	3.63km	4.69km
B12	Camp unit 3	3.82km	4.22km
B13	Camp unit 3	3.53km	4.51km
B14	Camp unit 4	2.98km	2.84km
B15	Camp unit 4	2.19km	1.94km

Recreational use of the study area by humans occurs throughout the year (Appendix G). During an aerial survey on February 8, 1989, snowmobile tracks were observed on the plateau between the Baboon and Monument Peak complexes. Conversations with local officials indicated that snowmobile enthusiasts frequent the area during winter and sometimes ignore wilderness boundaries, as evidenced by reports of snowmobile tracks at the head of the East Fork of the Boulder River (pers. comm. Simmons). During the summer, hikers, cyclists, and motorists were regularly observed in the

vicinity of the old Yeager Mine and Blue Lake. Conversations with some hikers revealed that they had climbed or planned to climb to the summit of Monument Peak. Summer pack outfitters were also observed using the riparian meadows along the East Fork before crossing into the Slough Creek drainage. Several outfitters guide hunts along the forks of the Boulder in the fall but were not observed during this study.

Distance relationships between bighorns and areas of human activity were not compared because only one bighorn location was recorded on the same day as observed human activity (June 27). Incidentally, this was also the only occasion coyotes were observed in the study area, although they were heard on numerous occasions. The two coyotes were chasing two bighorn ewes (Appendix C: location B5).

DISCUSSION

Direct Observations

Aerial and ground observations indicated spatial segregation of mountain goats and bighorns during snow-free seasons (Figure 8). Mountain goats appeared to favor cliff habitats but occasionally foraged along adjacent grassy slopes whereas bighorns apparently preferred grassy slopes near rocky terrain that sometimes included cliffs. The observed similarities in summer habitat-type use by bighorns and mountain goats but differences in spatial distribution may indicate geographical partitioning, described by Adams et. al. (1982) as occurring when sufficient preferred niche habitats are available, or it might imply that traditional range use patterns of both species (Brandborg 1955, Geist 1971) may be precluding sympatric habitat use. Mountain goats appeared less confined to preferred habitats than bighorns. They continued foraging away from cliff terrain despite our presence. When our movements were perceived by bighorns, they promptly fled into rocky escape cover. Social relationships between bighorns and mountain goats could not be determined.

Restrictions on habitat use imposed by snow in winter probably produced the greatest opportunity for direct and indirect interspecific competition. Mountain goats were observed on the same windswept ridge of Sheepherder used by bighorns in all seasons. The ability of mountain goats to

successfully forage under deeper snow cover (Adams 1981) combined with their opportunistic food habits (Peck 1972, Dailey et. al. 1984) may give them an advantage over bighorns in procuring available winter forage. The issue was further complicated by the observed use of forage on Monument Peak by goats during the summer. This could have removed a portion of the forage base from identified bighorn winter range. Removal of forage from bighorn winter range by mountain goats in late summer or early fall might be especially critical if use occurs near the end of the growing season or after dormancy. Competition, if it exists, could intensify if the expansion of the local goat population continues (pers. comm. Lemke).

The evidence of domestic sheep exceeding permitted grazing boundaries on two occasions suggests that interspecific competition with bighorns is a potential concern. The incident in early August at the head of the East Fork of the Boulder occurred near the summit of the Sheepherder ridgeline on a steep, grassy, northwest-facing slope used by bighorns in late June and early July. While this incident occurred after observed bighorn use, the impact to the bighorns may not have been realized until the following winter when bighorn ewes and lambs were again observed on this same slope. Snow usually covers portions of the upper slopes of the Boulder drainages by mid-September so vegetation grazed in early August may not have sufficient time to regrow before dormancy occurs.

The second incident occurred in mid-August along the southeast aspect of Monument Peak. While bighorn use was not documented on this complex in the summer, repeated bighorn observations during aerial surveys (Figure 7) suggest it is important winter range. This inference is supported by the 1976 High Absaroka Sheep Study which indicated much of the Monument Peak complex is critical bighorn sheep winter range (Figure 5). Although the exact number of domestic sheep that escaped onto these areas is unknown, relatively few consuming two percent of their body weight daily, approximately 1.5 kg (3.4 lbs) of forage, might have a significant impact on a limited winter forage resource.

If the degree of competition depends on site-specific food and social habits of sympatrically distributed ungulates (Geist 1978), then perhaps domestics could have a greater impact on the bighorn forage base along the upper Boulder than in other areas. Stewart (1975) reported that Poa spp. and Carex spp. are important to both domestics and bighorns along the upper Boulder. This suggests domestics might limit bighorn productivity to a greater extent than observed in other areas if allowed to exceed permitted grazing boundaries and subsequently graze suitable (and/or occupied) bighorn range.

Social interactions between bighorns and domestic sheep were not observed. A comparison of the distances between bighorn locations and domestic sheep with the distances

between domestic sheep and randomly located points (Table 8) indicated that the average distances were not different. The apparent non-use of the Monument complex by bighorns during the summer can be no more attributed to the proximity of domestic sheep than to human activity or the fact that this area may not be traditional bighorn summer range (Geist 1971). Speculation as to whether or not bighorns would occupy this mountain during the summer if domestics were absent cannot be made with confidence because bighorns do not always exploit suitable habitat after the removal of domestic sheep (Thilenius 1975, Stevens 1982).

While elk food habits and distribution on alpine and subalpine rangelands during the summer can be similar to those exhibited by bighorns (Murie 1951, Green and Bear 1990), on only one occasion were elk observed on the higher elevation grassy slopes apparently preferred by bighorns in this study area. All other elk observations were associated with riparian meadows and grassy plateaus surrounded by forest. While these documented locations may alleviate the initial suspicion of elk as significant competitors with bighorns, the rapidly expanding local elk population (pers. comm. Simmons) warrants future monitoring. Increased exploitation of higher elevation grassy ranges may be anticipated if increasing population density forces elk onto other ranges (Van Horne 1983), especially since our observations and those of others (Rouse 1957, Stevens 1966) seemed to indicate a tendency for

elk to avoid domestic sheep. The most important forage resources for bighorn sheep may be associated with the Sheepherder complex. Repeated observations of ewes and lambs in all seasons confirms that bighorns occupied at least the eastern half of the Sheepherder complex throughout the study period (Figure 9). While conspecific relations among bighorns were not determined, the carrying capacity of bighorn range can be reduced as a result of competition for food among bighorns (Wishart 1978). Bighorn sheep might be creating a significant impact on their own winter forage base by summering on the same ridges of Sheepherder that they use in the winter. Removal of forage needed during winter may be enough added stress in an already harsh environment to affect the maintenance or expansion of the local bighorn population. Individual fitness may suffer, especially in late winter.

The local relationship between bighorns and coyotes is not well understood. The domestic sheep permittee believes coyotes must bear some of the responsibility for the reports of fewer bighorns in this study area (pers. comm. Thompson). Although conclusive evidence on the importance of predation on bighorns by coyotes was not obtained in this study, a juvenile bighorn was reportedly forced into deep snow near Independence Peak and killed by coyotes in 1987 (pers. comm. Simmons). In addition, two coyotes were observed pursuing two bighorn ewes along the rim of the Sheepherder complex during the 1988 summer field season. These observations indicate coyotes have

the ability to harass bighorns in all seasons and are not restricted by high elevations or rough terrain. In fact, bighorns may be at a greater disadvantage in winter because increased snow depth allows coyotes to prey more efficiently on larger ungulates (Gese et. al. 1988). Artificial control of a coyote population may be effective for increasing lamb survival and subsequent recruitment rates (Hebert and Harrison 1988) or may not cause noticeable changes (Honess and Frost 1942).

Bighorn sheep are reported to habituate readily to man if not hunted (Geist 1971). However, bighorn rams were hunted along the upper Boulder until 1990. The impact of guided elk and deer hunts that still occur each year on the potential habituation of upper Boulder bighorns to humans is not known. Areas with higher observed levels of other human activity had consistently fewer bighorn observations. In fact, the lone bighorn location recorded north of the Monument Peak complex consisted of a ram on the west rim of Baboon in late March. Recreationists explored the old Yeager Mine and fished Blue Lake periodically throughout the summer of 1988 (Appendix G). These activities could conceivably have interfered with any seasonal migration that might have occurred between Monument and Baboon. If regular human activity has occurred since the onset of mining operations in the early 1900's, migrational traditions may have been abandoned and not passed to successive generations.

Hikers regularly climbed to the summit of Monument Peak during the summer of 1988. This type of activity could be particularly disturbing to bighorns because human approach or appearance from a higher elevational position is likely to elicit an alarm response (Hicks and Elder 1979). Snowmobilers frequent the Baboon Peak, Yeager Mine, and Blue Lake vicinity in winter, which may be discouraging bighorns from using windswept habitats north of Monument Peak. Combined with the regular presence of hikers on Monument Peak during the summer, bighorns could be forced to use Sheepherder throughout the year.

Suitable Bighorn Sheep Habitat

All bighorns were observed within delineated suitable habitat limits (Figure 9), suggesting criteria proposed by Wakelyn (1984) and Cooperrider et. al. (1986) for establishing bighorn use areas were reliable for the upper Boulder. Similar critical distances have been reported by others. Andryk and Irby (1986) noted that 93 percent of all observations were within 230m (755 ft) of escape cover while McCollough et. al. (1980) recorded 90 percent of their observations within 240m (787 ft) of rocky terrain. Escape cover has been identified as the most consistent feature of mountain sheep habitat (Tilton and Willard 1982, Risenhoover and Bailey 1985), yet is apparently the most poorly defined. Biologists generally concur that escape cover is a subjective

description that commonly includes such language as "rugged terrain" or "precipitous rocks" (Cooperrider et. al. 1986). Only one known source (McCollough et. al. 1980) described escape cover in terms of measurable parameters: rocky terrain at least 8m (26 ft) in height and 220m (722 ft) in length. Suitable habitat delineation on the upper Boulder could not be further refined due to limited field time.

Bighorn sheep were not distributed proportionately to suitable habitat availability from September through May, 1987-1989. Furthermore, the data suggest Monument may have been utilized significantly more than expected during those time periods. It was not possible to determine what caused bighorns to be distributed disproportionately across the study area because of the limited study period. Harassment from humans can deny food and water to bighorns on potential range (Wishart 1978) but could not be substantiated in this study although the potential for harassment exists due to the activity of snowmobilers between Baboon Mountain and Blue Lake in the winter. Varying degrees of competition for forage among bighorns or between bighorns and mountain goats along the windswept ridges of Sheepherder might also be forcing some bighorns to winter on Monument Peak. Perhaps a greater portion of the bighorns inhabiting the study area learned to use Monument Peak for winter range and have maintained this seasonal range fidelity.

Observed bighorn groups were also not distributed proportionately to defined suitable habitat across all mountain complexes during the summer of 1988. The data suggest bighorns might have been selectively using the Sheepherder complex and either avoiding, or simply not using, the Monument and Baboon complexes. The inferred levels of selection and avoidance for Sheepherder and Monument, respectively, could have been even more significant than the data suggest. In regards to observation time, Monument was oversampled and Sheepherder undersampled relative to the mapped quantities of suitable habitat. The presence of domestics every other summer on Baboon combined with increased human activity around the Baboon and Monument complexes could have altered the traditional summer range use patterns of the resident bighorns.

The suitable bighorn habitat identified on the ridge between Monument and Sheepherder was excluded from analysis because its position midway between the two complexes prevented it from being included with either one. Its small size would have resulted in less than one expected bighorn observation during ground surveys and between one and two observations for all combined aerial surveys had it been compared with the other complexes. Furthermore, it may be the least attractive suitable bighorn habitat in the study area. The open, grassy area adjacent to escape cover is nearly flat and does not offer the visual perspective that the steeper

mountain complexes do. However, bighorns may use it as a seasonal migration corridor between the Monument and Sheepherder complexes.

Superimposing mountain goat, elk, and domestic sheep locations onto suitable bighorn habitat identifies other areas of potential concern and might help explain some of the variability associated with the bighorn habitat use versus availability observations. All mountain goat locations fell within the confines of defined suitable bighorn habitat but no interspecific interactions were observed. Although observed elk use overlapped suitable bighorn range on only one occasion, elk population expansion could easily lead to increased range overlap. Permitted and observed domestic sheep use indicated areas of overlap with suitable bighorn habitat. A small area on the west aspect of Independence and much of the defined suitable habitat on the western half of Baboon are currently within the permissible boundaries of domestic sheep use (Figure 11). Although no direct interactions between bighorns and other ungulates were observed in this study, these common use areas would be appropriate possibilities for observation of interactions in future studies.

SUMMARY AND CONCLUSIONS

The compilation of observation data indicates considerable overlap in habitat use by elk and domestic sheep, bighorns and mountain goats, and bighorns and bighorns. Although competition could occur, spatial overlap does not guarantee competition if none of the mutually used resources are limiting to sympatric species. Observed ungulate locations within defined suitable bighorn habitat indicate other areas of potential concern.

Although personnel familiar with the area suggested bighorns used the western and northern portions of Baboon Mountain, our observations placed all bighorn use on or within the Monument and Sheepherder complexes south of Blue Lake. If bighorns used suitable habitat in proportion to availability, all other conditions being equal, more observations would have been expected on the Baboon complex throughout the year and on the Monument complex during the summer. The permitted presence of domestics at least every other year coupled with regular snowmobile recreation north of Blue Lake may be precluding bighorn use of Baboon throughout the year. Baboon has the smallest quantity and may have the poorest quality of suitable habitat. Much of the available foraging area is relatively level and bighorns are known to prefer steeper slopes. Baboon is more spatially isolated relative to the

other complexes. The lower, timbered slopes on the south aspect and along the Electronic Creek drainage means bighorns would have to traverse less secure habitats to exploit Baboon than to travel between Monument and Sheepherder. Any one or combination of these factors may make Baboon the least "attractive" of the three complexes from the bighorns' perspective.

The most extensive use of Monument Peak by bighorns was during the winter. This may have been partially due to hikers regularly climbing to the summit during the summer, precluding bighorn grazing. Bighorns did appear less tolerant of our presence than were mountain goats. While an interaction between coyotes and bighorns was witnessed on Sheepherder, it did not prevent bighorns from concentrating activitities on that complex throughout the year.

There were only two small, localized areas where domestic sheep exceeded permitted range boundaries and grazed adjacent to or in habitats used by bighorns. While this is not sufficient evidence to substantiate forage competition, it certainly indicates the potential and suggests the Forest Service must work more closely with the herder and permittee to establish grazing boundaries which facilitate reasonable control of domestic sheep use.

This investigation indicates that the upper Boulder bighorn population is one component of a complicated relationship involving other ungulates, predation, and human

activity. While these observations provide insight on some factors which could potentially have negative repercussions on the resident bighorns, the level of mountain goat use and the number of visitor days within habitats frequented by bighorns appear to be as significant as the presence of domestic sheep in the area. A more detailed study would be necessary to determine the relative importance of these factors and should include collection of forage composition data, forage production data, and large herbivore diet preferences along the upper Boulder. These observed ungulate locations and areas of use as they relate to suitable bighorn habitat will assist the U.S. Forest Service and Montana Department of Fish, Wildlife, and Parks in developing future research and management objectives.

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APPENDICES

Appendix A

Bighorn Sheep Aerial Observations

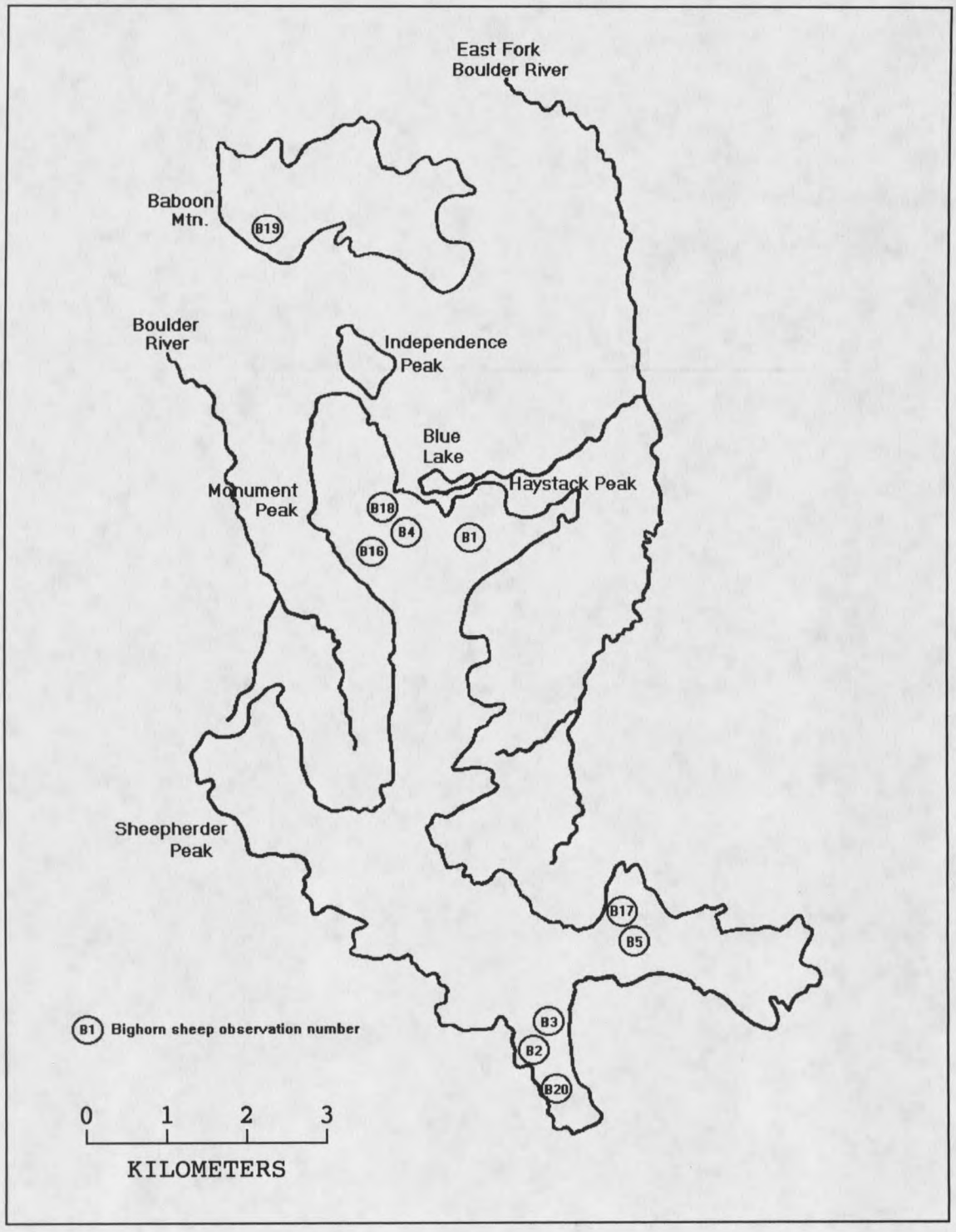

Figure 13. Locations of bighorn sheep from aerial surveys, November 1987 - September 1989 (Table 9).

Table 9. Aerial bighorn sheep data.

Location	Date	Number/Sex Age-class*	Activities
B1	11/10/87	3 adult rams	running along ridgeline
B2	11/10/87	1 adult ewe	running downslope from ridgetop
B3	2/25/88	2 adult rams 2 adult ewes	ran from windswept ridgetop into timber
B4	5/11/88	1 adult ram 7 adult ewes	milling around on windswept ridgetop
B5	5/11/88	5 adult ewes	running across rocky slope
B16	2/8/89	5 adult ewes	running through rocky terrain
B17	2/8/89	2 adult ewes 2 lambs	running across windswept slope
B18	3/21/89	2 adult ewes	running across ridge
B19	3/21/89	1 adult ram	standing on edge of cliff
B20	9/4/89	3 adult ewes	running from ridgetop into timber

* all individuals of similar size were considered adults but some might have been juveniles.

Appendix B

Mountain Goat Aerial Observations

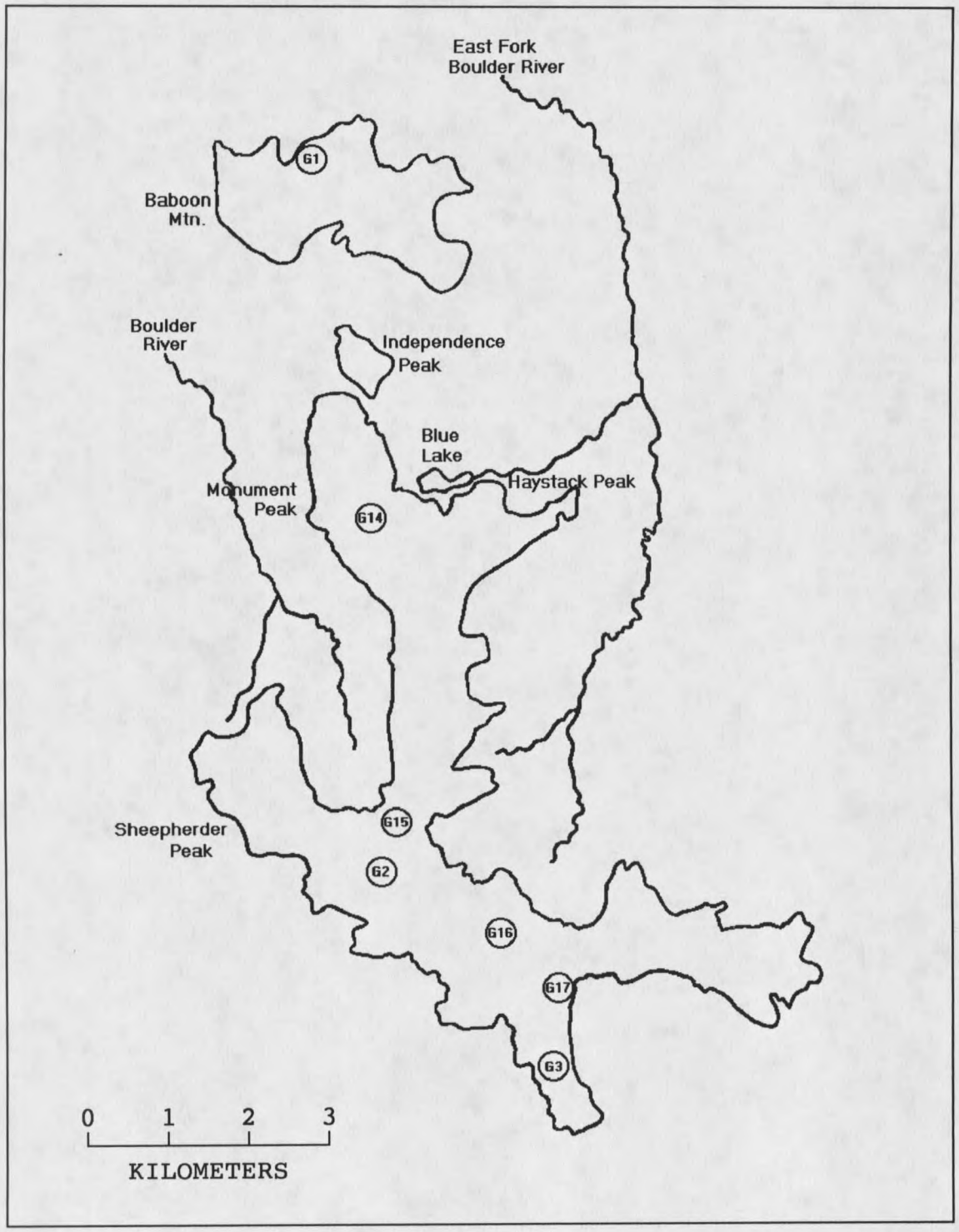

Figure 14. Locations of mountain goats from aerial surveys, November 1987 - September 1989 (Table 10).

Table 10. Aerial mountain goat data.

Location	Date	Number/Sex* Age-class	Activities
G1	11/10/87	1 adult	standing on cliff
G2	2/25/88	1 adult	standing on ridgeline
G3	5/11/88	3 adults	moving along ridgeline
G14	9/4/89	2 adults 2 kids	grazing along steep upper slope
G15	9/4/89	1 adult	moving across grassy slope
G16	9/4/89	3 adults	grazing on grassy plateau
G17	9/4/89	1 adult	standing on steep grassy slope

* unable to differentiate sex of adults unless accompanied by kids, in which case they were assumed to be female.

Appendix C

Bighorn Sheep Field Observations

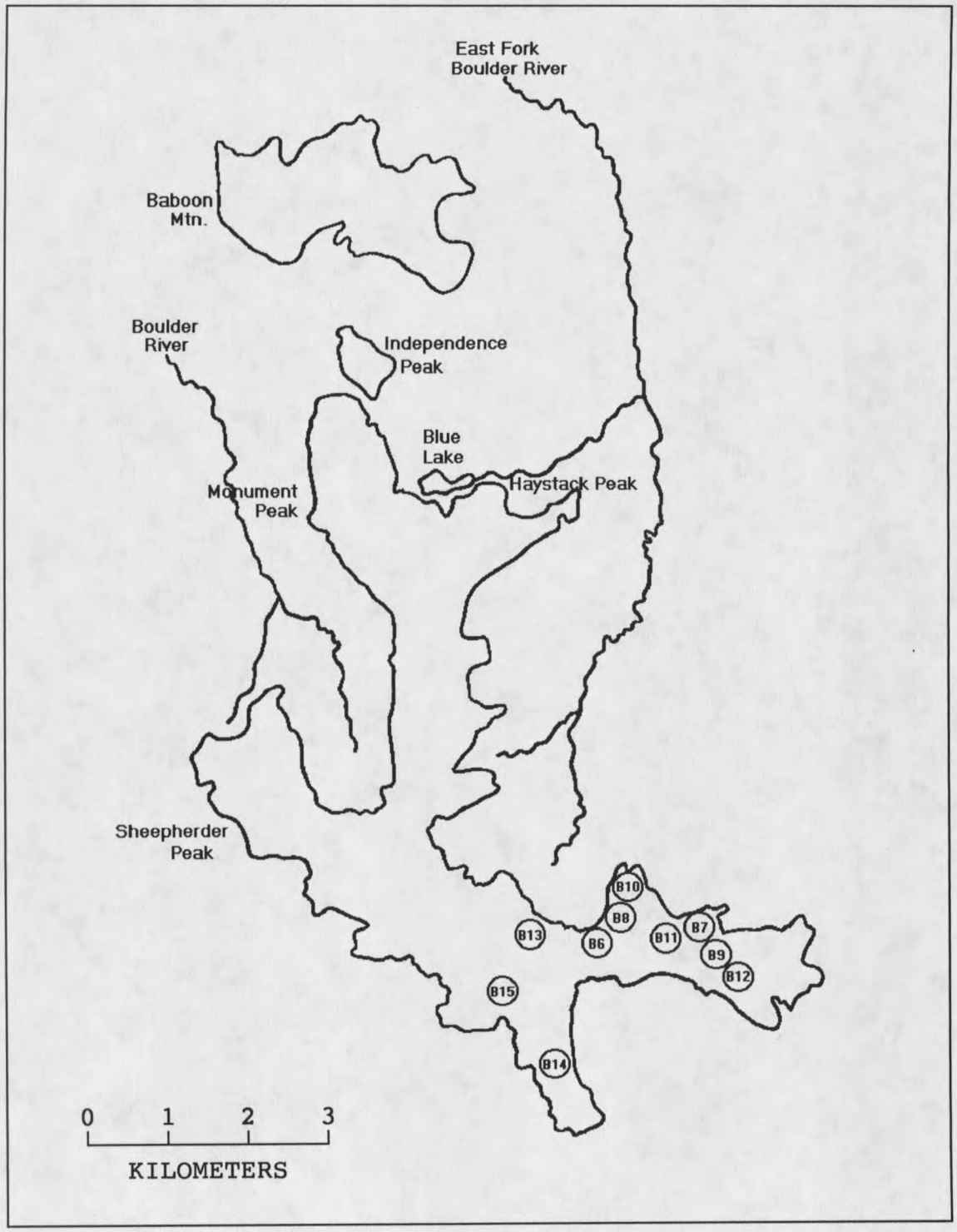

Figure 15. Locations of bighorn sheep from field surveys, June - August 1988 (Table 11).

Table 11. 1988 bighorn sheep data from field observations.

Location	Date	Number/Sex Age-class*	Activities
B6	6/27/88	2 adult ewes	being chased across slope by two coyotes
B7	6/28/88	7 adult ewes 4 lambs	foraging along cliffs
B8	6/30/88	3 adult ewes 1 lamb	foraging along steep grassy slope
B9	6/30/88	4 adult ewes 3 lambs	foraging along cliffs/ steep grassy slope
B10	7/9/88	3 adult ewes	foraging along steep grassy slope
B11	7/23/88	5 adult ewes 2 lambs	foraging along ridge
B12	7/24/88	3 adult ewes	foraging along grassy slope
B13	7/24/88	2 adult ewes 1 lamb	standing on ridgeline
B14	8/7/88	8 adult ewes 4 lambs	foraging/lounging on grassy ridgetop
B15	8/8/88	8 adult ewes 4 lambs	foraging in grassy hanging valley

* all individuals of similar size were considered adults but some might have been juveniles.

Appendix D

Mountain Goat Field Observations

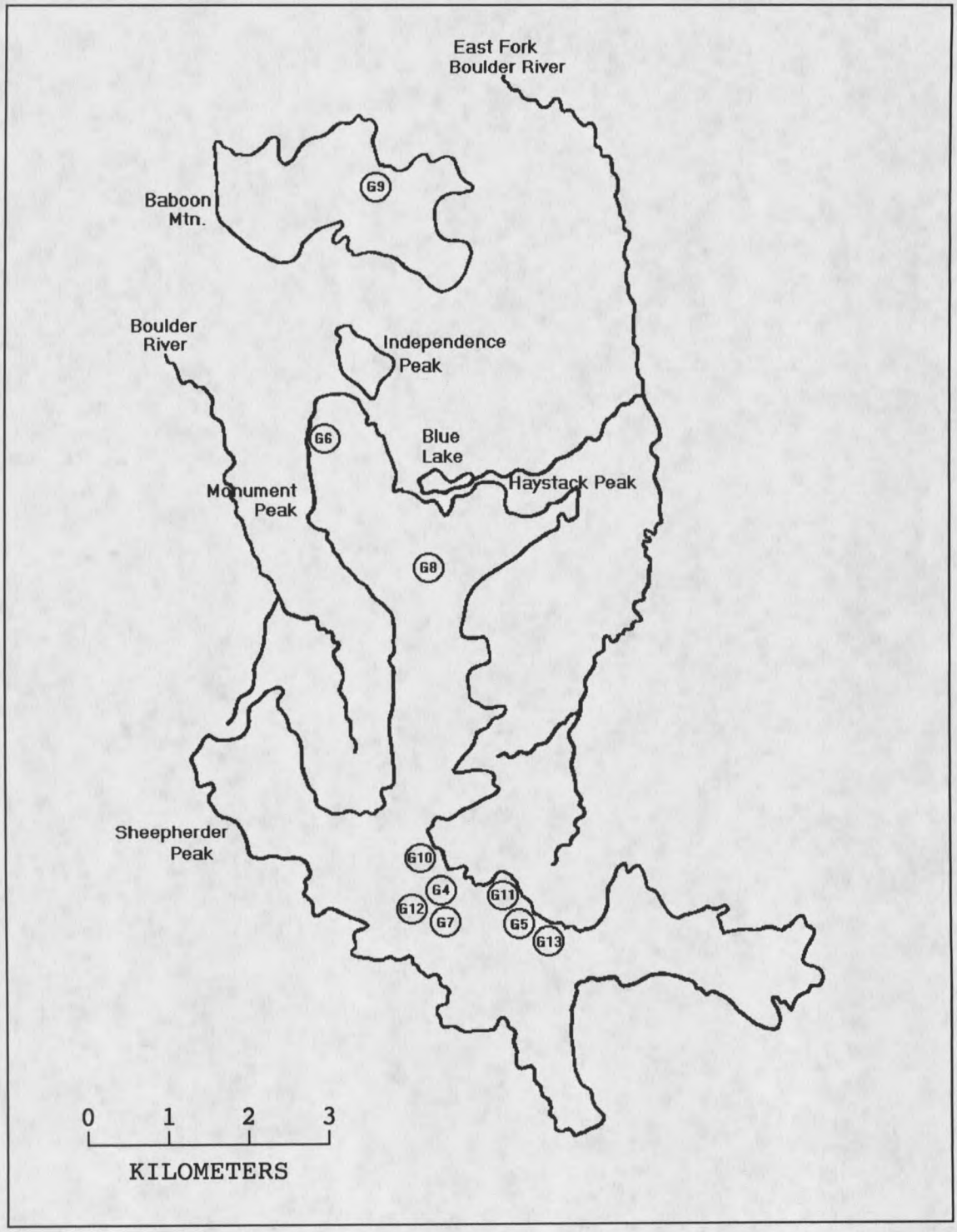

Figure 16. Locations of mountain goats from field surveys, June - August 1988 (Table 12).

Table 12. 1988 mountain goat data from field observations.

Location	Date	Number/Sex* Age-class	Activities
G4	6/27/88	2 adults	foraging on steep slope
G5	6/30/88	2 adults	foraging in cliffs
G6	7/9/88	1 adult	lying on a cliffledge
G7	7/13/88	3 adults	foraging on steep slope
G8	7/13/88	1 adult	moving across grassy slope
G9	7/14/88	1 adult	standing on ridgeline
G10	7/22/88	2 adults	foraging on steep slope
G11	7/24/88	2 adults	foraging/lounging all day
G12	8/8/88	2 adults	foraging on steep slope
G13	8/10/88	2 adults	moving along cliff

* unable to differentiate sex of adults unless accompanied by kids, in which case they were assumed to be female.

Appendix E

Elk Field Observations

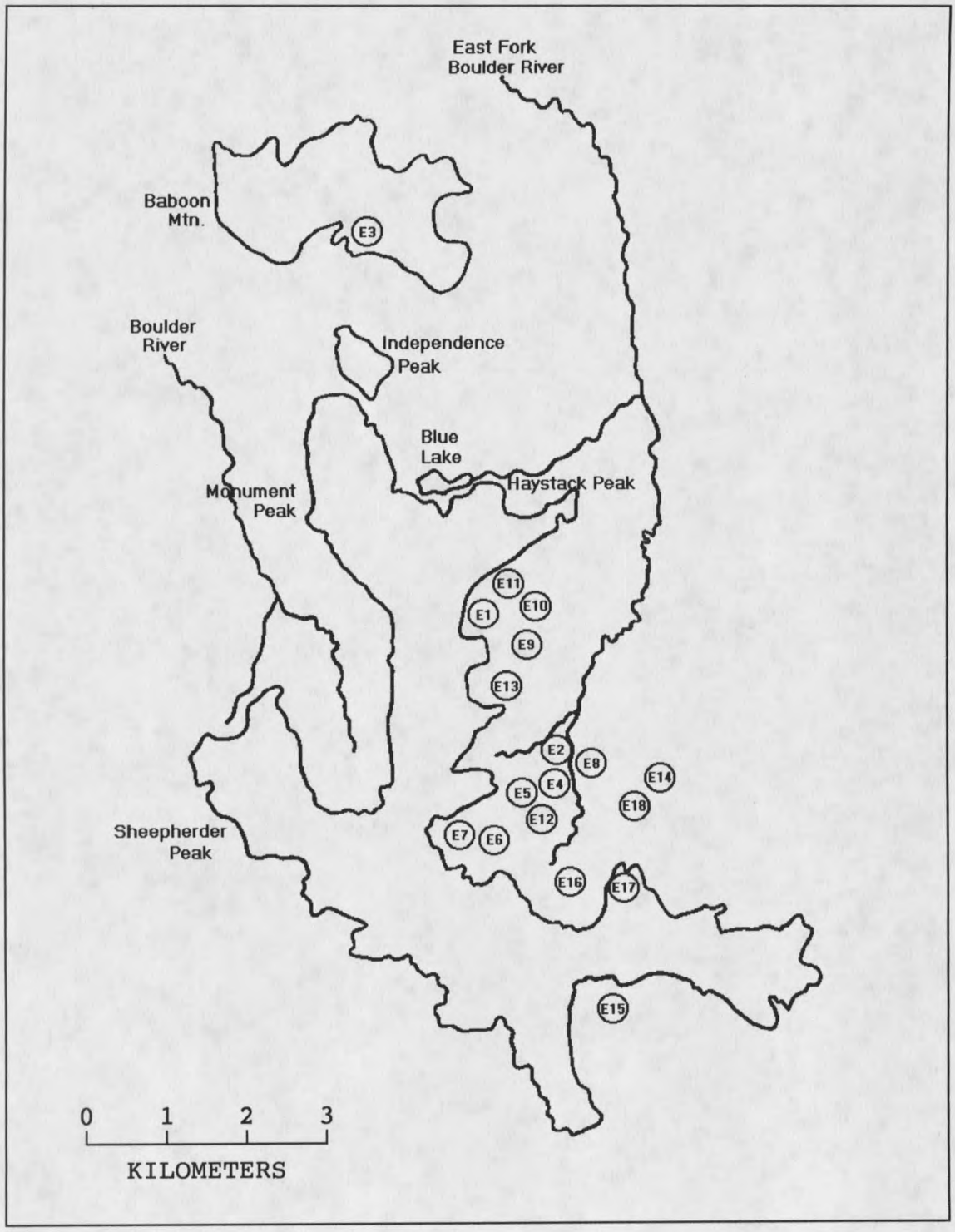

Figure 17. Locations of elk from field surveys, June - August 1988 (Table 13).

Table 13. 1988 elk data from field observations.

Location	Date	Number/Sex Age-class	Activities
E1	6/24/88	1 bull 4 cows 1 calf	foraging in meadow
E2	6/24/88	7 cows 1 calf	foraging in meadow
E3	6/25/88	2 cows	foraging on plateau
E4	6/27/88	12 cows 3 calves	foraging in meadow
E5	6/28/88	10 cows	foraging in meadow
E6	6/29/88	2 cows	foraging in meadow
E7	6/29/88	4 cows	foraging in meadow
E8	6/30/88	2 cows 1 calf	foraging in meadow
E9	6/30/88	1 cow 3 calves	lounging in timber
E10	6/30/88	1 cow 2 yearlings	lounging in timber
E11	6/30/88	1 bull	running across meadow
E12	7/10/88	14 cows	foraging in meadow
E13	7/13/88	5 cows 1 calf	foraging in meadow
E14	7/23/88	2 cows 1 calf	foraging in meadow
E15	7/24/88	2 bulls 15 cows	foraging/lounging on slopes at treeline
E16	7/24/88	2 bulls	foraging in meadow
E17	7/25/88	4 cows 2 calves	foraging in meadow
E18	7/26/88	2 cows	foraging in meadow

Appendix F

Domestic Sheep Grazing Schedule

Table 14. Scheduled and actual dates of use by domestic sheep during the summer of 1988.

Camp Unit	Scheduled Dates	Actual Dates
Main Boulder (CU9)	7/7 - 7/11	7/8 - 7/11
Lower E. Fork (CU1)	7/11 - 7/15	7/17 - 7/20
Columbine (CU2)	7/15 - 7/20	7/12 - 7/16
Willow Bottom (CU3)	7/20 - 7/28	7/21 - 7/29
Upper E. Fork (CU4)	7/29 - 8/8	7/30 - 8/8
The Hole (CU5)	8/8 - 8/14	8/9 - 8/14
Lake City (CU6)	8/14 - 8/22	8/15 - 8/22
Yeager Mine (CU7)	8/22 - 9/1	8/23 - 8/26
Baboon (CU8)	Rested	

Appendix G

Human Activities

Table 15. Observed human activity between November 1987 and September 1989.

Date	Number	Activity
6/25/88	5 cyclists	visited Yeager Mine and Blue Lake area
6/27/88	1 truck	picnic at Blue Lake
7/8/88	1 truck	fishing in Blue Lake
7/11/88	3 backpackers	camping near Independence
	1 cyclist	visited Yeager Mine and Blue Lake area
7/15/88	7 hikers	camping after climbing to the top of Monument Peak
	3 trucks	picnicing and fishing at Blue Lake
	4 horsemen	riding from Box Canyon to Slough Creek
7/26/88	7 horsemen	camping at Willow Bottoms and fishing the E. Fork of the Boulder
	8 hikers	camping near Yeager Mine and plan to climb Monument Peak
8/9/88	9 hikers	camping near Independence after climbing to the top of Monument Peak
2/8/89		snowmobile tracks between Baboon and Blue Lake