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Title: HABITAT USE AND SPATIAL INTERACTIONS OF CATTLE, WILD HORSES, MULE DEER, AND CALIFORNIA BIGHORN SHEEP IN THE OWYHEE BREAKS OF SOUTHEAST OREGON

Abstract approved: Signature redacted for privacy.

Dr. Martin Vavra

The objectives of this study were to quantify and describe: (1) the major plant communities and their distribution, (2) the distribution and movement patterns of large herbivores relative to water, topography, and plant communities, (3) the daily activity patterns of each herbivore, and (4) the home range size of wild horse bands and studs on a 376 $km^2$ area in southeast Oregon.

Distribution of plant communities about the area was indicative of a history of overgrazing and fire. Communities in low ecologic condition were associated with relatively level terrain and basin areas.

Wild horses and bighorn sheep were year-around study area residents. Cattle occupancy was from April through October, and intensive deer use occurred from October through April. Deer movement to and from the area was correlated with, but probably not caused by cattle activities. Deer, however, preferred cheatgrass communities previously grazed by livestock.

Ellipse estimates of home ranges for bands and studs averaged 28.3 and 25.8 $km^2$, respectively. Polygon estimates for band and stud home ranges averaged 11.8 and 12.3 $km^2$, respectively. Home

ranges of bands and studs overlapped substantially, and no territorial behavior was observed. Home range size showed a significant, but weak, negative correlation with water hole density.

With the exception of bighorn sheep, habitat use by large herbivores was negatively correlated with increasing slope. Species order for progressively greater use of slopes was cattle, horses, deer, and bighorn sheep.

Of the 4 herbivores studied bighorn sheep were the most restricted in distribution. Progressive rankings of greater spatial distribution were: bighorn sheep, cattle, horses, and deer. Patterns of resource use by large herbivores did not always conform to mathmatical expectations.

# HABITAT USE AND SPATIAL INTERACTIONS OF CATTLE, WILD HORSES, MULE DEER, AND CALIFORNIA BIGHORN SHEEP IN THE OWYHEE BREAKS OF SOUTHEAST OREGON

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# HABITAT USE AND SPATIAL INTERACTIONS OF CATTLE, WILD HORSES, MULE DEER, AND CALIFORNIA BIGHORN SHEEP IN THE OWYHEE BREAKS OF SOUTHEAST OREGON

## INTRODUCTION

Historically management and development of much of our public rangeland has been single use oriented. Within approximately the last 20 years, however, public land management has shifted more toward optimum development of the land's many potentials. Management under this policy demands an intimate knowledge of an area's resources and an understanding of the requirements, utilization patterns, impacts, and interactions of the various users present on each piece of ground.

For much of our public rangelands little data exist which address the intricacies of resource partitioning by large herbivores. Past research on habitat use by large herbivores has generally focused on a single species. Although valuable information has been gained from these efforts, habitat diversity and potential interspecific interactions often prohibit application of compiled results and recommendations to other areas. The Bureau of Land Management's Vale District was faced with such a problem in southeast Oregon were cattle (*Bos* spp.), big game, and wild horses (*Equus caballus*) have access to common grazing lands.

This research was conducted on the Three Fingers Wild Horse Management Area and adjacent lands located on the east bank of the Owyhee Resevoir, and was an effort to describe the habitat and spatial interactions of wild horses, cattle, California bighorn sheep (*Ovis canadensis californiana*), and mule deer (*Odocoileus hemionus hemionus*).

The objectives of this study were to quantify and describe the:

1. Major plant communities and their distribution about the study area;
2. Distribution and movement patterns of herbivores in relation to water, topography, and plant communities;
3. Daily activity patterns of each herbivore;
4. Home ranges of wild horse bands and studs.

# LITERATURE REVIEW

## Animal Distribution and Habitat Use

Dispersal of herbivores about the landscape is influenced by several interacting environmental and animal factors. Ultimately animal distribution is a product of the patterns of food, shelter, and water found in a particular environment and an animal's capacity and willingness to tolerate environmental extremes and to utilize available resources. Optimum animal and habitat management thus requires an awareness of resource location as well as user requirements and use patterns

## Distribution of Cattle

Topography. In rugged terrain, slope gradient is a major determinant of livestock distribution with cattle favoring the relatively level ground associated with drainages, basins, and ridgetops (Glendening 1944, Phinney 1950, Stoddart 1960, Blood 1961, Demarchi 1965, Julander and Jeffery 1964, Mueggler 1965, Phillips 1965, Cook 1966, Mackie 1970, Patton 1971, Gillen 1982, Barrett, 1982). Slopes greater than 30% approach the maximum limits of cattle use (Patton 1971, Blood 1961, Gillen 1982), however, upslope presence of palatable forage (Gonzales 1964, Cook 1966, Bryant 1982), salt (Champline and Talbot 1926, Skovlin 1965), or water (Skovlin 1965) may encourage additional utilization of hillsides. Coefficients of determination relating distances cattle travel upslope to slope gradient range from 0.26 (Mueggler 1965) to 0.76 (Van Vuren 1980), however, Cook (1966) warned that various interacting factors specific to each site prevent universal application of prediction equations.

Plant Community and Vegetation Management. In the absence of overriding factors such as steep slopes or poor water availability, cattle prefer to graze areas supporting the greatest concentration of palatable species (Julander and Jeffery 1964, Patton 1971, Heady 1975, Miller and Krueger 1976, Gillen 1982). In sagebrush/grassland environments cattle typically prefer grasses (Sneva and Vavra 1979), however, their degree of selectivity is a function of forage availability. Seasonal changes in diets (Vavra and Sneva 1978) may result in shifts in cattle habitat selection (Skovlin 1961, Bryant 1982, Gillen 1982). Annual precipitation fluctuations may also influence animal dispersion. Gonzales (1964) and Mackie (1970) reported improved cattle dispersal during years of favorable precipitation when temporary water catchments were fully charged.

Management practices which enhance forage quantity, quality, or availability may attract cattle to areas prone to less use under normal circumstances. Seeding of palatable grasses may create preferred use areas for cattle (Cook et al. 1956, Miller and Krueger 1976). Fertilization has been shown to increase forage production (Cook 1965, Sneva and Rittenhouse 1976), enhance forage crude protein levels, and intensify cattle use of treated areas due to improved plant palatability (Cook 1965, Holt and Wilson 1961). Fertilization may also increase forage utilization on adjacent untreated areas (Smith and Lang 1958). Herbicide treatments also have the potential of attracting cattle to particular range locations. Cook and Jeffries (1963) reported a 74%

increase in cattle use following application of 2,4-D(2,4-dichlorophenoxyacteic acid). They stated, however, that while cattle did not actively seek out treated areas, they tended to remain on site for longer periods of time. Removal of rank, old growth material by burning or grazing will also attract cattle to treated areas (Willms et al. 1980). Duvall and Whitaker (1964) reported that rotation burning may be used to rotate cattle without the additional cost of fencing.

Water. Where water is plentiful and well dispersed on rangelands, it has little influence on cattle distribution (Julander and Jeffery 1964, Cook 1966). For much of our western range, however, stockwater is the center of grazing activity. Mature beef cattle use from 26 to 45 liters per day (Olsen and Fox 1972). Sneva et al. (1977) reported that watering cattle every other day, or requireing them to trail 1.6 to 3.2 km to water, reduced water intake by 25 to 35% without causing permanent weight reductions. Nursing calves, however, showed reduced performance.

Several researchers have reported linear or curvilinear decreases in cattle utilization with increasing distance from water (Glendening 1944, Phillips 1965, Mackie 1970, Miller and Krueger 1976, Hodder and Low 1978, Roath 1980, Van Vuren 1980). Some reports have also shown strong negative correlations between cattle use and vertical distance to water (Roath 1980, Van Vuren 1980). In the absence of other controlling factors, distance to water may ultimately limit vegetation utilization by cattle (Roath and Krueger 1982).

Barnes (1914) suggested cattle not be forced more than 3200 m from water on level tarrain or 1600 m in rough topography. The greatest distance cattle have reportedly traveled from water was 8000 m (Glendening 1944, Hodder and Low 1978). Forage availability may also influence livestock dispersal from water. Hodder and Low (1978) found cattle ranging 8000 m from water in poor forage years and only 4000 m from water in good forage years. Skovlin (1965) and Cook (1967) considered water development an excellent tool for improving cattle distribution. Bryant (1982), however, found upland water developments in rugged terrain ineffective in luring cattle away from well watered drainages.

Salt. Cattle may exist without ill effects for up to 1 year on salt free diets. However, they exhibit an abnormal appetite for salt after 2 to 3 weeks of abstinence (Babcock 1905). Salting has long been used as a means of enhancing cattle distribution (Champline and Talbot 1926), and several workers have reported decreases in forage utilization as distance from salt increases (Phillips 1965, Patton 1971, Roath 1980, Gillen 1982). Typically, salt should be placed away from areas where the attraction of water promotes excessive utilization (Skovlin 1965). When placed properly, salt has increased grazing capacity by 19% (Cook 1967).

Hedrick *et al*. (1968) found salting to be a supplemental rather than a primary determinant in livestock distribution. Bryant (1982) found salting ineffective in rough terrain, however, Skovlin (1965) reported that introducing cattle to new salt grounds may stimulate their use of the area.

Herding. On rugged rangelands untended cattle typically settle in one area and graze there indefinitely (Skovlin 1965).

Herding animals to unused range will decrease forage utilization on habitual concentration areas (Phillips 1965) and increase grazing capacity by harvesting forage from more remote areas of the range (Cook 1967). Once cattle have been imprinted to an area they may return on their own accord in subsequent years (Skovlin 1965). Riders or herders with intimate knowledge of range conditions and animal preferences and behavior patterns can contribute significantly toward the success of range management efforts (Skovlin 1957).

Animal Factors. Animal heritage may influence livestock distribution on rangelands. Although there are no supporting data, Hedrick *et al*. (1968) indicated it is desirable to graze livestock which used the same range earlier as replacement animals. Skovlin (1965) observed that cattle which were wintered or calved on range were more amendable to use of remote areas than were pastured animals.

Younger cattle are reported to make more even use of rugged terrain than older animals. The ranking from good to poor dispersal is: yearlings, young cows, older dry cows, and older cows with calves (Hedrick *et al*. 1968, Hickey and Garcia 1964, Skovlin 1965). Breed of animal may also influence distribution. Herbel *et al*. (1967) found Santa Gertudis cattle spent more time walking and grazed further from water than Herefords. They also reported, however, that Santa Gertudis cattle tended to segregate and move as a unit while Herefords were found in small scattered groups. Elliott (1976), Roath (1980), and Skovlin (1965) reported cattle formed family-type or social groups which functioned as a unit.

Each group used a fairly well defined home range, however, some area overlap and exchange of animals was detected (Elliott 1976, Roath 1980). Skovlin (1965) recommended a group be moved to new areas as a unit to discourage return of individuals to their former territories.

## Distribution of Deer

Topography. Only cursory statements relating slope gradient to deer occupancy were found in the literature. Mackie (1970) reported degree of slope did not pose a serious problem to deer in negotiating terrain. Barrett (1982) found deer showed little response to topographic variation in Sierra foothills, and Demarchi (1965) found no significant correlation between deer use and slope in British Columbia.

Dusek (1975) detected increased deer use of side hills during winter months in Montana. He believed this shift was a means of avoiding deep snow accumulations in drainages (Wilkins 1957, Loveless 1967, Dusek 1975, Gilbert et al. 1970). Snow depths exceeding 0.46 to 0.60 m were avoided by deer.

Several researchers report slope affects distribution indirectly through its impact on microclimate and vegetation (Julander 1966, Loveless 1967, Mackie 1970). With the onset of colder months deer shift from north to south and west aspects (Julander 1966, Loveless 1967, Mackie 1970) which have milder microclimates and less snow cover. During winter deer prefer sunny bed grounds and will often move to avoid shifting shadows (Dixon 1934, Hosley and Ziebarth 1935, Loveless 1967, Mackie 1970). Above $10^{\circ}C$ deer prefer shaded areas (Mackie 1970). In extreme cold or storm conditions deer will concentrate and move to areas supporting dense shrub or timber(Hammerstrom and Blake 1939, Lovaas 1958, Loveless 1967). In the absence of vegetative thermal cover, topographic features (rim rock, depressions, or boulders) may provide some shelter from the elements (Mackie 1970, Leckenby et al. 1982). Topography and distance may also serve as escape cover for mule deer if insufficient vegetation is available for concealment (Leckenby et al. 1982).

Plant Community and Vegetation Management. Mule and black-tailed deer (*Odocoileus hemionus columbianus*) are extremely adaptable. Of 60 vegetation types identified by Kuchler (1964) west of the 100th meridian in the United States, all but two or three are or once were occupied by one or both species (Wallmo 1981). Because they have such a wide ecological amplitude, vegetation structure is probably more important to deer than is specific composition (Leckenby et al. 1982).

Leckenby et al. (1982) listed five types of habitat and the percentages of each found on optimum mule deer range. These were: foraging areas, 55%; hiding cover, 20%; thermal cover, 10%; fawning habitat, 5%; and fawn rearing cover, 10%. They also suggested there be less emphasis on fawn related habitats and more emphasis placed on thermal cover on deer winter ranges. Idealy, deer favor areas supporting mosaics of these various habitats.

While deer will use grassland types to some degree, they tend to favor more productive sites with grasses, forbs, and shrubs interspersed with dense cover (Julander and Robinette 1950, Bissel et al. 1955, Sugden 1961, Julander 1966, Skovlin et al. 1968, Mackie 1970, Dusek 1975, Leckenby et al. 1982). Deer may be selective feeders, and if given a diversity of plants are better able to cope with the fluctuating forage quality found on rangelands (Smith 1950, 1959, Bissell et al. 1955, Plummer et al. 1968, Leckenby et al. 1982).

Shrubs are a particularly important component on mule deer winter ranges. On many areas browse species constitute the bulk of winter deer diets (Kufeld et al. 1973), and are often emphasized when planning big game range restoration projects (Plummer et al. 1968, Leckenby et al. 1982). Shrubs also provide escape and thermal cover for big game. Leckenby et al. (1982) felt the tall sagebrush shrub-steppe vegetation of Oregon generally provided both adequate thermal and escape cover. Short sagebrush sites, however, were rated poorly as deer habitat. They also estimated optimum thermal cover for deer to be 1.5 m tall with a 75% crown closure, and reported openings greater than five times the height of adjacent cover provided little thermal moderation.

Foraging habitat may or may not be synonymous with thermal or hiding cover. Leckenby et al. (1982) found deer reluctant to forage further than 125 m from cover. Mackie (1970) reported wintering deer faced with a choice of occupying either feeding or cover sites would select the feeding area. He frequently detected deer concentrated near food on exposed slopes, while nearby sites supporting adequate cover, but poor forage, went unused.

Deer cope with declining forage quality by selecting plants or plant parts that are phenologically younger (Leach 1956, Hungerford 1970, Willms and McLean 1978, Holl et al. 1979). With such a feeding strategy, deer should benefit from nearly any management practice which enhances either forage diversity or availability. Wallmo (1978) proposed three axioms for mule deer habitat management. These were:

1. Early stages of plant succession are more beneficial than climax vegetation;
2. A mixture of plant communities provides better habitat than any single community; and
3. More browse is preferable to less browse.

Livestock grazing may have both positive and negative impacts on mule deer. In localized instances severe overgrazing by livestock has been credited with retrogressive succession resulting in replacement of original vegetation by species more beneficial to deer. Subsequent deer eruptions, however, may result in further range degradation and ultimately in population crashes (Leopold 1933, Julander 1962, Longhurst et al. 1968, 1976).

Properly managed livestock may be used as a management tool. Cattle, being primarily grass consumers, may enhance forage quality and availability by removing cured top growth from grasses and by stimulating nutritional and palatable regrowth which may be left for wildlife (Anderson and Scherzinger 1975, Willms et al. 1980, Leckenby et al. 1982). Soil nutrients and moisture may also be reserved for browse production by focusing livestock grazing efforts on competing grasses and forbs (Smith 1949, Clawson and Lesperance 1973, Urness 1976,1982, Tueller and Tower 1979, Leckenby et al. 1982). Reiner and Urness (1982) significantly stimulated bitterbrush

(*Purshia tridentata*) twig production in Utah by pasturing horses on deer winter range. Best results were obtained with heavy horse grazing during the period of rapid bitterbrush twig elongation.

Prescribed fires may be used to enhance the appeal of herbaceous vegetation for deer by removing unpalatable barrier shrubs (Schallenberger 1965, Bailey 1970) and standing litter (Barker and Erickson 1974, Lauer and Peek 1976, Peek *et al.* 1979, Willms *et al.* 1980). In areas where shrubs form large impenetrable thickets, small prescribed fires enhance accessibility and increase herbaceous production (Biswell *et al.* 1952) and palatability (McCulloch 1969, Willms *et al.* 1980).

Herbicides are frequently employed on rangelands to reduce woody plant competition. Leckenby *et al.* (1982) suggested deer may benefit from sagebrush control where cover is excessive and green forage is in short supply. Bitterbrush, a desirable shrub often in association with sagebrush, can be spared from herbicidal effects by treating sagebrush during the earliest phase of its susceptable period (Hyder and Sneva 1962). The ecology of mountain-mahogany (*Cercocarpus ledifolius*), also a desirable shrub, is not well understood (Dealy 1975), and Leckenby *et al.* (1982) discourage attempts at herbicidal manipulation of this species where it exists in small stands.

*Water*. Mule deer distribution in the southwestern deserts is closely related to water (Julander 1966, Wallmo 1981). Hanson and McCulloch (1955) found deer home ranges in Arizona centered around permanent water if habitat was suitable in all directions. Rodgers *et al.* (1978), also in Arizona, found each home range to contain two or more permanent watering sites.

In more northern areas deer distribution is less dependent on free water (Julander 1966, Mackie 1970). During winter months deer may subsist on snow (McKean and Bartman 1971). Succulent forage may also serve as a source of water for deer (Verme and Ullrey 1972). Elder (1956) believed, however, that succulent forage only marginally met deer requirements, and Leckenby et al. (1982) stressed that free water should be within 600 m of fawn rearing habitat.

Bonn (1976) reported mule deer consumed approximately 3 liters per visit to big game guzzlers. Church (1971) reported water intake in deer was related to dry matter intake, and in a controlled environment Verme and Ullrey (1972) found deer consumed 2.9 liters of water per kilogram dry food eaten.

Salt. Deer use natural salt licks and mineral blocks supplied for domestic livestock (Short 1981), and they may drink brackish surface water when vegetation is low in sodium (Short et al. 1966). Despite their demonstrated fondness for salt no references regarding its use in deer management were found in the literature.

Animal Factors. Mule deer may occupy either permanent home ranges (Hanson and McCulloch 1955, Dasmann and Taber 1956, Swank 1958, Rodgers et al 1978) or migrate to and from seasonal ranges where they still inhabit well defined areas (Gruell and Papez 1963, Zalunardo 1965, Julander 1966, Leckenby et al. 1982). Leckenby et al. (1982) using data from several studies, reported an average home range of 260 ha for individual deer. Ranges varied in size from 50 to 1240 ha. Seasonal home ranges are smallest in spring and largest during the breeding season (Clark 1953, Rodgers _et al_. 1978). Bucks tend to range over larger areas than does (Dasmann and Taber 1956, Swank 1958, Robinette 1966, Rodgers _et al_. 1978).

Topography has some influence on size and shape of deer home ranges. On relatively rugged terrain home ranges are smaller (Severson and Carter 1978) and appear as corridors (Gilbert _et al_. 1970, Leckenby _et al_. 1982). On relatively level areas home ranges are more blocky or compact (Leckenby et al. 1982). Home range size may also be a function of the proximity of resources required by deer (Severson and Carter 1978).

Deer herds do not move to and from seasonal ranges as a unit. Migrations appear rather random with individual family groups dispersing to their selected areas and forming a different aggregation of animals (Gruell and Papez 1963). Fawns are imprinted to seasonal home ranges by following their mothers, and they subsequently return to the same areas as adults (Gruell and Papez 1963, Zalunardo 1965, Leckenby 1977, Leckenby _et al_. 1982). The home range instinct in mule deer is quite strong and they will occupy degraded ranges to the point of starvation rather than move to adjacent areas supporting more abundant resources (Cliff 1939, Julander 1966). Such extreme fidelity should be considered if large scale treatments are applied to deer habitat (Leckenby _et al_. 1982).

Deer are generally intolerant of the presence of large numbers of cattle. Rodgers _et al_. (1978) reported no displacement of deer by cattle when cattle stocking rates were set to obtain 40% use of perennial grasses in Arizona. Other references, however, report an avoidance of cattle by deer. Skovlin _et al_. (1968) found deer tended to use deferred-rotation pastures more than season-long ranges, and they made heavier use of those pastures grazed heavily by cattle early in the grazing season. Other research indicates that after cattle "turnout" deer either leave the area or become more active and use all parts of the range (Merrill et al. 1957, Knowles 1975, Dusek 1975, Komberec 1976). Where livestock grazing is heavy and forage is severely depleted, deer mortality rates, particularly in young animals, increase significantly (Robinette et al. 1952, Julander 1962, McMahan and Ramsey 1965, McKean and Bartman 1971), and birth rates decline (Julander et al. 1961, McMahan and Ramsey 1965). These effects are probably related to the lowered nutritional plane on poor condition range (Bryant et al 1981). At moderate stocking rates, however, McKean and Bartman (1971) believed cattle, sheep, and deer could be grazed singly or in combination without serious competition and accompanying range regression.

## Distribution of Wild Horses

Topography. Very little quantitative data relating wild horse use to topography were found in the literature. Hall (1972) believed topography did not limit utilization of the Pryor Mountain Wild Horse Range In Montana and Wyoming. Pellegrini (1971) indicated horses avoided steep hills if possible and traveled quickly over unavoidable rough terrain. Other references generally indicate horses have an affinity for knobs and ridges (Pellegrini 1971, Welsh 1975, Sneva and Vavra 1979, Miller 1980). Miller (1980) seldom found horses further than 1.6 km from ridges in Wyoming's Red Desert. He and Welsh (1975) speculated horses sought out ridge tops to gain exposure to cooling winds.

Pellegrini (1971) observed that home range boundaries generally coincided with major ridges in Nevada. He found bands of horses occupied the high ground, and lone studs were forced to inhabit narrow canyon bottoms. Because bands rank higher than studs in the dominance hierarchy, one may infer that ridges and ridgetops constitute preferred horse habitat.

Plant Community and Vegetation Management. No published accounts of wild horse research were found where occupancy of quantified plant communities were reported. Several researchers, however, have observed seasonal movements by wild horses which they attributed to plant phenology and forage availability (Green and Green 1977, Nelson 1978, Salter and Hudson 1979, Miller 1980).

Nelson (1978) found horses in New Mexico grazed on improved range which greened up earlier than surrounding vegetation.

This resulted in localized damage to vegetation from close cropping and trampling. Because horses can crop forage quite close they appear to continue using heavily grazed areas more often than cattle (Rittenhouse _et al_. 1982).

_Water_. Fonnesbeck (1968) found light weight horses (average weight 427 kg) at rest and on a roughage diet average 29.1 kg of water intake per day. He also observed water intake to be strongly correlated with dry matter intake and the proportion of cell wall constituents in the diet. Horses on grain supplements consumed less dry matter and water than animals on roughages. On roughage diets water consumption averaged 3.6 kg/kg of forage consumed. No estimates of water consumption rates for wild horses were found in the literature.

Water availability strongly influences wild horse distribution on rangelands. Seasonal trends are a concentration near water during warm, dry months and a dispersal with the onset of precipitation (Hall and Kirkpatrick 1975, Welsh 1975, Hansen 1976, Hansen _et al_. 1977, Storrar _et al_. 1977, Green and Green 1977, Miller 1980). Green and Green (1977) and Miller (1980) found maximum horse activity occurred within 4.8 km of water. If forage was scarce around water sources, horses would move out as far as 11.2 km before turning back to water (Pellegrini 1971, Green and Green 1977). Feist (1971) reported horses in the Pryor Mountains were usually within 6.4 to 8.0 km of water. Use of snow as a water source also enables greater dispersal of horses (Pellegrini 1971, Hall 1972, Salter and Hudson 1979).

Miller (1980) observed competition for water between feral horses, cattle, and pronghorn antelope (Antilocapra americana) in Wyoming. A single well, with a flow of 221 liters/hour, supported approximately 200 horses and an unreported number of livestock and game. During summer months horses were present continuously with some bands waiting as long as 5 hours to drink. Horses and cattle forced each other from water, but pronghorn would circle, wander off, and return later. On another Nevada site supporting six water sources no competition between horses and cattle was observed (Pellegrini 1971).

Pellegrini (1971) found horses watered every other day with the favored watering periods being dusk and dawn. Miller (1980) also found a favored dusk-dawn watering pattern. Feist (1971) and Blakeslee (1974) found no consistent watering schedules. Most accounts indicate horses typically require between 2 and 10 minutes to drink before leaving the area (Feist 1971, Miller 1980). Pellegrini (1971), however, observed horses occassionally remaining near water throughout the night. No accounts of horses fouling water were found in the literature. They will paw out springs (Feist 1971), however, which could be either beneficial by improving wildlife access to water or detrimental if water development structures were damaged.

Salt. Salter and Hudson (1979) observed wild horses using natural and artifical salt licks. While no references describe specific horse salt requirements, N.A.S.-N.R.C. (1978) recommendations suggest a 0.5 to 1.0% diet salt component will meet horse needs.

Animal Factors. The highly developed social organization of wild horses has been the focus of numerous reports (Pellegrini 1971, Feist 1971, Hall 1972, Green and Green 1977, Zarn *et al*. 1977, Berger 1977, Nelson 1978, Salter 1978, Miller 1980). These authors described harem groups, multiple male and female groups, and bachelor groups. Group size ranged from single bachelors to groups of 21 animals. Miller (1980) also defined a "herd" which consisted of groups having overlapping and similar movement patterns, intergroup recognition, and an intergroup dominance hierarchy.

Territorial behavior in wild horses has been documented only in the Wassuk Range of Nevada (Pellegrini 1971). Other researchers describe arrangements of overlapping home ranges (Feist 1971, Hall 1972, Welsh 1975, Green and Green 1977, Miller 1980) where the dominant males of harem or multiple male-female groups maintain a sphere of intolerance about their group (Hall 1972). Home range size estimates range from 0.9 $km^2$ in Nova Scotia to 303 $km^2$ in Wyoming's Red Desert (Feist 1971, Berger 1977, Miller 1980, Pellegrini 1971). Although no supporting data were presented, Hall (1972) and Miller (1980) indicated home range size may be related to forage and water availability.

Like seasonal water availability, topography also influences home range size and shape in some instances. Pellegrini (1971) found home range boundaries often overlooked deep canyons. He also detected an avoidance of large areas within home ranges that supported extremely rocky soils. Intergroup dominance may also influence size and shape of home range by crowding subordinate animals into interspaces if territorial behavior is exhibited (Pellegrini 1971).

In Alberta, Canada, Salter and Hudson (1979) found horses quite capable of coping with snow. When foraging, they pawed through snow up to 60 cm deep and often ingored adjacent bare areas. Horses can exist on low quality feed but experience weight loss on native range over winter (Dawson _et al_ 1945). When trapped by heavy snows, they will consume their own feces (Hall 1972). Deep snow and severe weather conditions, however, have caused large die-offs in Alberta and British Columbia (Salter and Hudson 1979).

Horses are generally tolerant of other species. Wishart (1958) found horses, deer, and bighorn sheep grazing in close association. Rittenhouse _et al_. (1982) found a high degree of spatial and temporal overlap in cattle and horses in research pastures in Colorado. Salter and Hudson (1979) found little spatial overlap between horses and cattle. They did not, however, indicate whether this was simply a difference in habitat selection or avoidance. Pellegrini (1971) believed introduction of cattle hastened but did not cause evacuation of areas by horses. Aggression by horses toward other species has not been documented. I received two reports (Allison and Tomblin personal communication) of horses repeatedly hazing or scattering cattle by running through concentrated groups of animals. These instances had more of an appearance of sport than aggression.

## Distribution of Bighorn Sheep

A 1978 maximum estimate placed 41500 bighorn sheep in North America (Wishart 1978). Of that number only 3450 were classified as as California bighorn with the remainder split between the Rocky Mountain bighorn (Ovis canadensis canadensis) and several subspecies of desert bighorn (Ovis canadensis nelsoni, mexicana, cremnobates, and weemsi). Because documentation for each subspecies exists in about the same proportion as population estimates, I have borrowed heavily from the desert and Rocky Mountain bighorn literature.

Topography. In 1928, Grinnell reported bighorn on the northwest plains as well as in mountainous terrain. He found the plains bighorn more approachable than mountain sheep and theorized that perhaps this was the cause of the rapid extinction of the plains animals. Today, however, bighorn habitat is synonymous with rugged cliffs and highly dissected terrain (McCann 1953, Harris 1956, Russo 1956, McCullough and Schneegas 1966, Todd 1972, Jones 1980), and with the exception of mountain goats (Oreamnos americanus) they may now be limited more by topographic requirements than any other species (Capp 1967).

Because few animals can match the bighorn's ability to navigate rough topography, bighorn use such areas for escape terrain (Wishart 1958, Welles and Welles 1961, Wilson 1968), shelter and thermal cover (McMichael 1964, Wilson et al. 1980), and bedding sites (Van Dyke 1978, Hansen 1982). Ewes also seek out the most rugged and inaccessable areas as lambing sites (Welles and Welles

1961, Blood 1963, Hansen 1982) where they remain until their young are 10 to 14 days old (Honess and Frost 1942). On some bighorn ranges a shortage of lambing grounds may be limiting population growth by exposing young in marginal lambing habitat to additional predation (Hansen 1982).

Even after lambs become relatively mobile, ewes tend to remain closer to escape terrain than rams (Hansen 1982). Maximum reported distances ewes travel from escape terrain range from 100 to 400 m (Van Dyke 1978, McCollough _et al_. 1980, Hansen 1982). Maximum reported distance for rams was 1.3 km (Leslie and Douglas 1979). This strict requirement for suitable escape terrain restricts the use of other habitats for forage or water. Thus bighorn populations may be limited by either escape terrain or suitable foraging habitat (Wishart 1958).

Although many observers have commented on the bighorn's affinity for mountainous terrain, little data on their use of various slope gradients were found. Demarchi (1965) found the frequency of bighorn sightings positively correlated with increasing slope. Cattle sightings were negatively correlated with increasing slope, and deer showed no significant correlation. Blood (1961) found cattle more evenly distributed over a 0 to 30% slope gradient than bighorn. Eighty one percent of his bighorn observations were on slopes ranging from 0 to 15%. Hansen (1982) found 50% of his ewe-lamb sightings on gradients between 0 and 25%. Rams, on another portion of his study area, used more rugged terrain.

_Plant Community and Vegetation Management_. Bighorn feed on a variety of forages and consume between 1.8 and 2.7 kg of dry matter daily (Palmer 1944, Wilson et al. 1980). Typically bighorn are associated with grassland communities in climax or high ecological condition (Blood 1963, Demarchi 1965, Wilson 1968, Wishart 1978, Wilson et al. 1980), and optimum ranges should support nearly equal amounts of palatable grasses, forbs, and shrubs (Hebert 1973, Wilson et al. 1980).

When forage is dry, bighorn graze areas supporting an abundance and diversity of vegetation (Van Dyke 1978, Hansen 1982). During spring green up, however, they concentrate where plants are in their earliest phenological or most succulent stage of growth (Russo 1956, Wishart 1958, Welles and Welles 1961, Deming 1964, Oldemeyer 1966, Wilson 1968, Woolf 1968, Cooperrider 1969, Morgan 1970, Dunaway 1972, Todd 1972, Hansen 1982).

Stelfox (1975) found bighorn consumed more browse and utilized grasses more intensely on poor condition than on better condition ranges. Bighorn declines are often associated with range deterioration (Buechner 1960, Morgan 1970), and adequate winter ranges are generally considered most critical to their survival (Honess and Frost 1942). Hebert (1973) believed adequate summer ranges were as important to bighorn survival as winter range conditions. He found that bighorn with access to high quality summer diets entered winter with better pelage and more fat than animals on poor quality feed. He also found the better conditioned animal required less digestible energy per day during winter (111.8 kcal/kg $BW^{0.75}$) than the poor conditioned bighorn (156.3 kcal/kg $BW^{0.75}$).

Unlike deer, bighorn avoid dense brush or timber, and they are hesitant to travel through vegetation taller than 76 cm (Devan

1958, Sugden 1961, Van Dyke 1978, Wilson *et al*. 1980, McCollough *et al*. 1980). They will use small stands of shrubs associated with cliffrock areas to escape summer heat and as lambing grounds (Van Dyke 1978, Wilson *et al*. 1980).

Occassional fires are beneficial to bighorn where woody vegetation tends to invade their habitat (Lauer and Peek 1976). Peek *et al*. (1979) also found fire enhanced bunchgrass habitat by removing standing litter and increasing availability of subsequent growth. Four years after a fall burn they found bighorn utilization still intense enough to prevent accumulation of dead material on the site.

Water. Monson (1968) reported on a herd of desert bighorn which existed for 6 months without drinking. While such endurance is possible, the consensus is healthy herds require free water and that water is indeed a limiting factor on many bighorn ranges (Jones *et al*. 1957, Welles and Welles 1961). Jones *et al*. (1957) and Koplin (1960) estimated bighorn consumed between 7.6 and 18.9 liters of water/day. Turner and Boyd (1970) estimated the bighorn's minimum daily water requirement at 4.0% of body weight. These same authors also observed sheep at water consuming the equivalent of 23% of their body weight in one session. When water is readily available, bighorn may water daily, however, Graves (1961) and Saint John (1965) found desert bighorn watered on 3 to 5 day schedules during dry weather.

When precipitation fills temporary catchments, bighorn disperse widely over their range (Jones *et al*. 1957, Denniston 1965, Turner and Boyd 1970, Leslie and Douglas 1979). During winter months they may subsist entirely on snow (Sugden 1961, Hansen 1982).

Warm dry weather, however, quickly concentrates bighorn in the vicinity of water (Jones *et al.* 1957, Irvine 1968, 1969b), with ewes, because of their lactation demands, remaining closer than rams (Leslie and Douglas 1979). Blong and Pollard (1968) found ewes and lambs within 1.2 km of water in July and August. Rams ranged out as far as 4.8 km and returned less often. Irvine (1969a) found 82% of observed bighorn within 1.6 km of water in Utah, and Leslie and Douglas (1979) reported 84% of their summer observations in Nevada within 3.2 km of water. On the Sheldon National Wildlife Refuge 90% of the bighorn sightings were within 1.0 km of water (Hansen 1982). One water hole per 10.4 to 13.0 $km^2$ is the suggested optimum density for bighorn water sources (Hansen 1966, Blong and Pollard 1968).

Bighorn usually water during daylight hours with early morning and late afternoon being the favored periods (Hansen 1964, Simmons 1964, Leslie and Douglas 1979, Browning and Monson 1980, Seegmiller and Ohmart 1981). They are quite willing to use developed water sources (Halloran and Deming 1958, Browning and Monson 1980), but will not venture far from escape terrain to drink from any source. McMichael (1964) observed bighorn traveling 2.4 km to an alternate source to avoid crossing an 0.8 km open flat to a nearby spring.

While there have been some concerns regarding aggressive interspecific competition for water between bighorn and burros (McKnight 1958, Sumner 1959), no accounts of aggressive behavior between sheep and cattle or horses were found. One instance of deer aggressively driving ewes and lambs from water was reported by Jones (1980). Rams, however, were not intimidated by deer and watered at will.

When water is indeed limited, interspecific competition is unavoidable. Intraspecific competition may also be quite severe, and dominant animals will force their way through subordinates to water. In these instances the hierarchy of access is rams, ewes, and lambs (Browning and Monson 1980).

Salt. Data on bighorn salt requirements are unknown. Bighorn seasonally use natural salt licks with maximum activity concentrated in the post lambing and spring green up periods (Carson 1941, Green 1949, Hansen 1982). Sugden (1961) and Van Dyke (1978) found no natural salt licks or use on livestock sources in their studies.

Couey et al. (1940) attempted to lure bighorn away from possible poaching by placing calcium phosphate salt in less accessible areas. Animal response, however, was not reported. Moser (1962) felt that if salt must be given bighorn, it should be used carefully to avoid animal concentrations, or the attraction of other herbivores to critical areas.

Animal Factors. Bighorn are social animals and generally move about in small groups. Average group sizes reported by Hansen (1982) were 9.2 for ewes and lambs and 5.6 for rams. When bighorn are not concentrated by water shortages or restricted habitat, some degree of spatial separation between mature rams and ewe-lamb groups is usually evident (Woolf et al. 1970, Van Dyke 1978, Leslie and Douglas 1979, Hansen 1982, Shank 1982). Rams are less dependent on water and escape terrain and are prone to wander more widely than ewe-lamb groups (Van Dyke 1978, Leslie and Douglas 1979, Hansen 1982, Shank 1982). Leslie and Douglas (1979) found ewe-lamb home ranges averaged 16.9 $km^2$ while ram home ranges averaged 24.7 $km^2$ and appeared to expand as rams aged. Seasonal bighorn movements include concentration of animals during the late summer and fall breeding season and some altitudinal shifts in response to winter snows (Honess and Frost 1942, Simmons 1961, Blood 1963, Van Dyke 1978). Bighorn are quite capable of tolerating winter conditions as they paw through snow to gain access to grasses (Mills 1937, Todd 1972) and will move to windswept ridges in extreme conditions (Wilson et al. 1980). They will also dig through soil or gravel in search of palatable roots and bulbs (Honess and Frost 1942, Spencer 1943, Todd 1972).

Bighorn herds, particularly the ewe-lamb component, appear quite hesitant to expand their ranges even when apparently adequate habitat is available (Van Dyke 1978, Ebert 1978, Wilson et al. 1980, Durbin 1980, Hansen 1982). Van Dyke (1978) theorized ewes had little inclination to wander because they are more at ease when completely familiar with their habitat.

Interspecific competition for limited water is often unavoidable in the arid west (Jones 1980). Competition for forage, because it is not a single point resource, is not so clearly demonstrated. Suspected competition between bighorn and deer, cattle or horses has been reported but not clearly proven in any instance (Cowan 1947, Halloran and Kennedy 1949, Woodgerd 1964, Wilson 1968, Morgan 1970, Sugden 1961, Thomas 1979). The inference has usually been that dietary overlap was synonymous with competition without any consideration for spatial overlap or resource availability. Bighorn are tolerant of other large herbivores. Several instances of deer and bighorn feeding, bedding, and traveling together are documented (Russo 1956, Wishart 1958, Simmons 1961, Schallenberger 1965, Jones 1980). Wishart (1958) observed bighorn and horses in close association, and Jones (1980) documented bighorn-cattle associations. While these observations illustrate the possibilities of competition, they are not indicative of habitual interspecific associations and habitat occupancy, and each report on competition should be evaluated objectively.

Bighorn tolerance of human disturbance is quite variable and reactions may range from indifferent to total range abandonment (DeForge 1972). Intrusions from expected directions may be met with only mild curiosity (Denniston 1965), while activity in an unusual locale may cause substantial shifts in range use (Hansen 1982). DeForge (1972) suggested critical range areas be closed to off road traffic, and Wilson _et al_. (1980) encouraged camping restrictions within 0.4 km of water sources.

# LOCATION AND DESCRIPTION OF STUDY AREA

## Location

The study area is situated approximately 64 km south of the town of Vale in southeast Oregon and borders the east bank of the Owyhee Reservoir (Figure 1). The area's northern boundary is approximately 4 km south of the Owyhee Dam and the southern boundary is on an east-west line roughly 6.5 km south of Leslie Gulch. Total area is approximately 375.6km$^2$.

## Physiography and Climate

Topography ranged from well-eroded, gently rolling hills to mountainous ridges, cliffrock, and canyons. Elevation ranged from 809 m, pool level of the Owyhee Reservoir, to 1687 m on Grassy Ridge in the southeast corner of the area. Thirty year average annual precipitation at the Owyhee Dam is 22.25 cm. Record high and low temperatures recorded at the dam are 44 and -30$^{\circ}$C, respectively.

## Vegetation

The area occurs within the shrub-steppe region as outlined by Franklin and Dyrness (1973) and supports shrub overstorys dominated by either Wyoming big sagebrush (*Artemisia tridentata* ssp. *Wyomingensis*) or low sagebrush (*Artemisia arbuscula*). The herbaceous layer may be dominated by bluebunch wheatgrass (*Agropyron spicatum*), Sandberg's bluegrass (*Poa sandbergii*), or cheatgrass (*Bromus tectorum*).

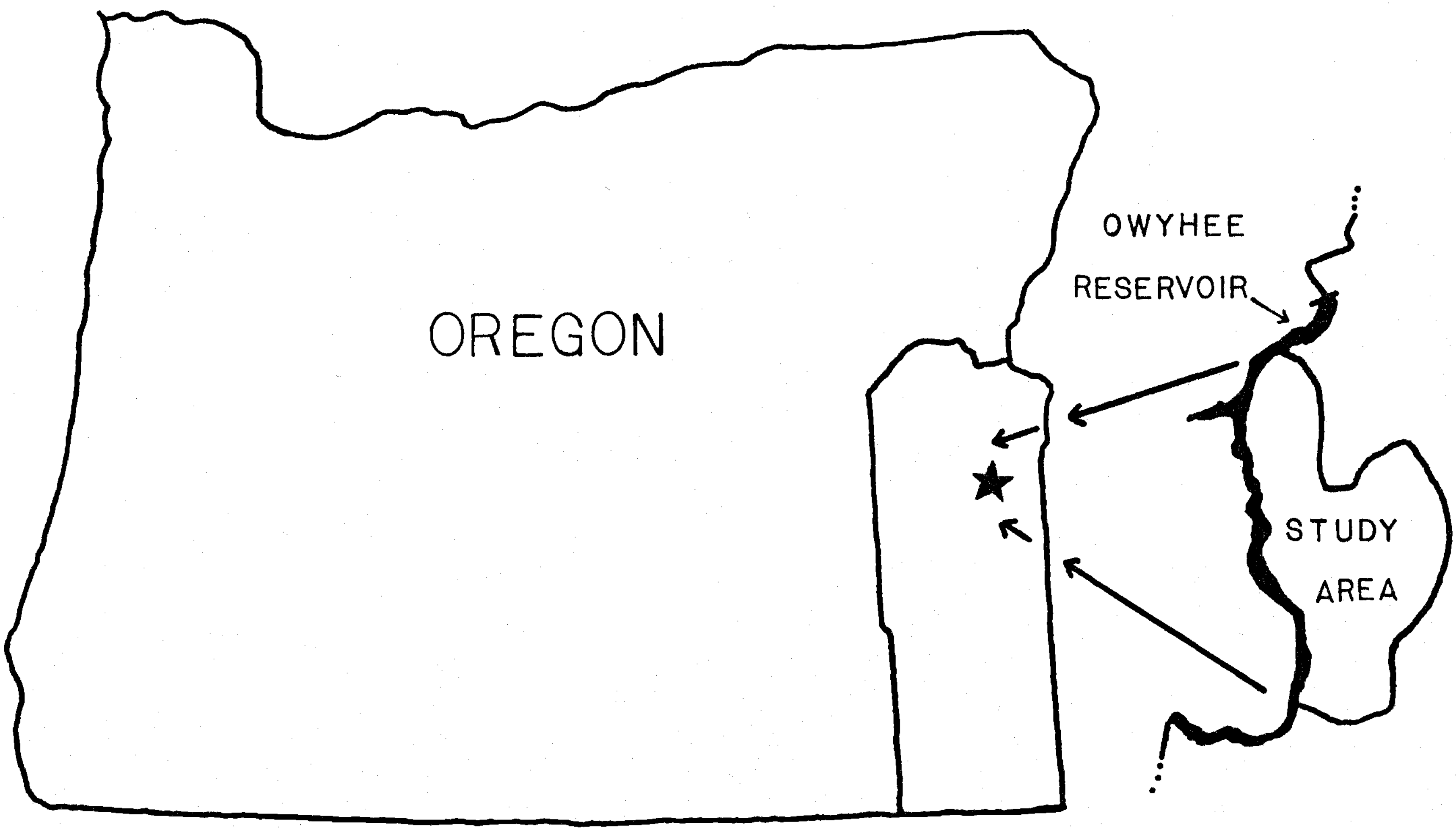



Figure 1. Geographic location of Three Fingers study area.

## History

Livestock and Horses. The first stockmen in the region were John Strode and Con Shea (1870's) who ran cattle in the vicinity of Mahogany Mountain just south of the study area. In 1881 Strode released 300 brood mares into the Owyhee Breaks, and the first sheep, owned by a Mr. Philpot, arrived (Younger 1957).

By the 1940's feral horses had become a serious problem in the area, and organized efforts were made to remove unlicensed animals from the range. A 1940 application for horse trap construction on the study area stated the well being of 5000 sheep, 1000 cattle, and 100 licensed horses would be affected by the wild horse roundup. In 1944 A.J. Seale, district grazier, estimated 2500 horses roamed the area east of the Owyhee Reservoir, and he organized a drive involving approximately 80 riders in an unsuccessful attempt to remove the animals (Seale 1944, Baltazor and Baltazor 1976).

Subsequent roundups involved professional mustangers or rancher coordinated roundups of much smaller scale. These efforts were more successful, but there are no records of number of animals removed. The difficulty of capturing horses in such rugged terrain led Baltazor and Baltazor (1976) to speculate wild horses would always exist in the area. Bureau of Land Management, Vale District, records indicate 895 horses were removed from the area between 1968 and 1978. Currently the Three Fingers Herd Management plan specifies horse numbers are to range between 90 and 180 animals.

Bighorn Sheep. In 1965 California bighorn sheep were reintroduced to the area through the cooperative efforts of the Bureau of Land Management and the Oregon Department of Fish and Wildlife. Six rams, eight ewes, and three lambs from Hart Mountain, Oregon were released at that time. The population has since grown to an estimated 100+ animals. Extremely rugged terrain, however, has prevented an accurate estimate of herd size.

## Pasture Arrangement and General Animal Use

The study area is divided into four areas by fences or geologic barriers (Figure 2). Wildhorse, McIntyre, and Riverside pastures were delineated by partial fencing and natural barriers. Pasture boundaries generally contained livestock, however determined animals could traverse the area at will.

Leslie Gulch was assumed to be the southern boundary of the Riverside pasture. The area south of Leslie Gulch was added to the study to include additional bighorn sheep range, and will be referred to as the Spring Creek area. Approximately 35 ha of irrigated alfalfa (<u>Medicago</u> <u>sativa</u>) is produced along Spring Creek proper.

The cattle grazing season for Wildhorse, McIntyre, and Riverside pastures is from April 1 to October 31. Livestock follow a deferred rotation grazing plan in conjunction with pastures to the east and south of the area. A portion of the Spring Creek area serves as a transition pasture between fall and winter ranges to the south.

Feral horses are year-around residents in the three pastures. Deer use is seasonal with the area serving primarily as winter

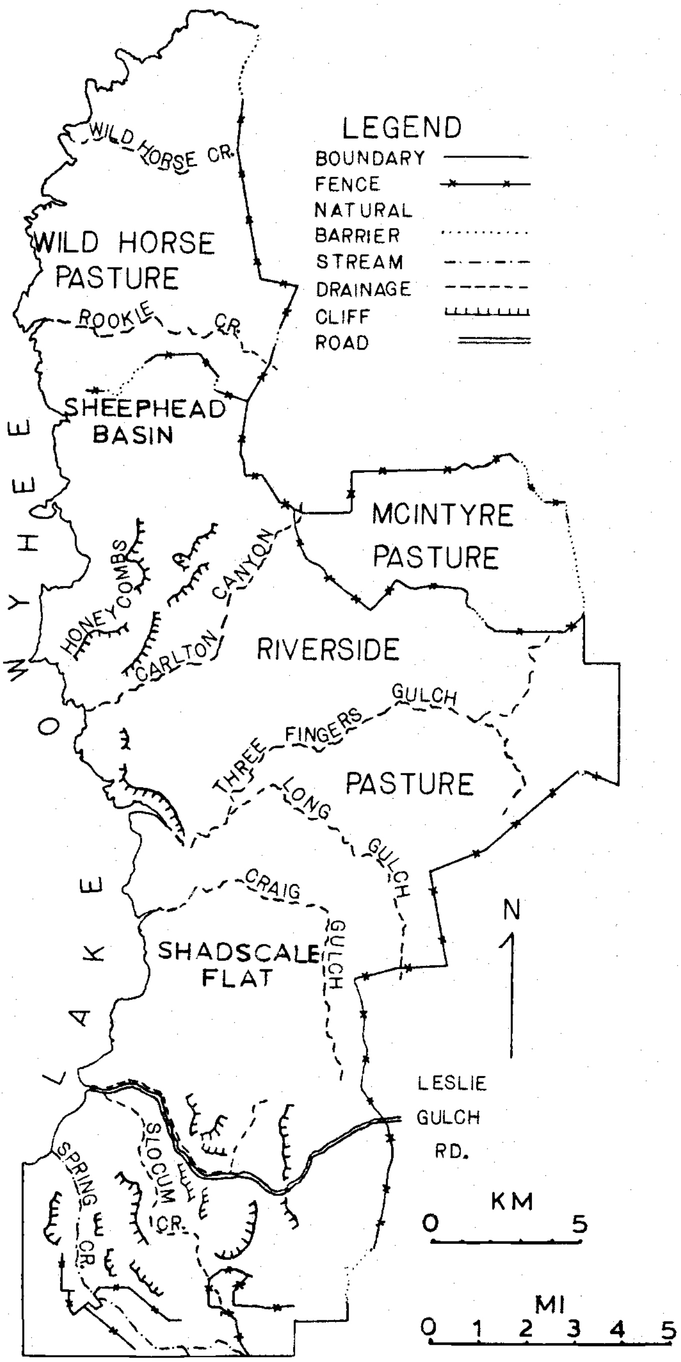



Figure 2. Pasture layout and reference points on study area.

range. Bighorn are year-around residents. Only a few head of pronghorn (*Antilocapra americana*) were observed on the area.

# METHODS

## Characteristics of the Study Area

### Mapping of Vegetation

Major plant communities and habitats were delineated on aerial photos having an approximate scale of 1 : 16710. Because some shrub and herbaceous types could not be distinguished on photos, reconnaissance of the area with photos in hand was used to delineate plant communities.

Pasture and plant community areas were estimated from U.S.G.S. maps. An electronic planimeter was used to estimate pasture areas. A random dot overlay and count of dots falling in each community were used to estimate the proportion of each community occurring in each pasture. A total of 8333 points was used to estimate community areas.

### Relationships of Slopes and Plant Communities

To examine relationships between plant communities and slope gradients, 1545 random points were sampled from the vegetation-U.S.G.S. topographic maps. Plant community and slope gradient were noted for each point. Data for the entire area and each plant community were tallied in 10% slope categories ranging from 0 to 80+%. A Chi square analysis of homogeneity (Steel and Torrie 1960) tested the null hypothesis ($H_o$) that plant communities were distributed randomly over the nine slope categories on the area. If $H_o$ was rejected, simultaneous confidence intervals for differences between proportions in each category were derived to determine which categories contained significantly ($P<.02$) more or less of the community than expected. The Bonferroni approach, as outlined by Marcum and Loftsgaarden (1980), was used to construct the 98% confidence intervals for each category. Plant community data were also pooled by habitat type (Daubenmire 1970) and the above analysis repeated.

## Description of Major Plant Communities

Plant communities were described during August 1980. Herbaceous constituents were sampled along three 50 m transects placed in an area thought to be representative of the community in question. A 0.2 $m^2$ rectangular frame placed at 5 m intervals yielded 30 plots per location. Data included rooted density for perennials and cover estimates for annuals and perennials. Also recorded were estimates of percent area occupied by mosses and lichens, litter, rock, and bare ground in each plot (Daubenmire 1959).

Shrub cover was estimated with twelve 25 m line intercept transects per location (Canfield 1941). Shrub density was estimated from twelve 25 X 1 m belt transects.

## Availability of Forage in Major Plant Communities

Herbage production was estimated for major plant communities using the double sampling, weight estimate method of Pechanec and Pickford (1937). Sampling periods were May, July, and October of 1979 and 1980. Communities and number of sites sampled for each were:

Wyoming big sagebrush
/bluebunch wheatgrass (Hironaka and Fosberg 1979) (Winward 1970) — 3 sites

Wyoming big sagebrush
/Sandberg's bluegrass (Hironaka and Fosberg 1979) — 3 sites

Wyoming big sagebrush
/Cheatgrass (Hironaka and Fosberg 1979) — 1 site

low sagebrush
/Sandberg's bluegrass (Hironaka and Fosberg 1979) — 1 site

cheatgrass (Daubenmire 1970) — 1 site

During initial sampling efforts (May 1979) two 25 m transects were placed at each site and data recorded from a 0.5 $m^2$ circular plot positioned at 1 m intervals. Weight estimates were recorded for each species occurring in the plot. Rare species were clipped and weighed whenever encountered. Herbage in every fifth plot was also clipped, weighed, oven dried, and reweighed to allow correction for estimator bias and green to dry weight conversion. Using the initial May 1979 data, sample numbers sufficient to estimate dominant species production within 10% of the mean with 90% confidence were calculated for each site and employed in subsequent sampling periods (Stein 1945).

October 1979 and 1980 estimates of current year leaf and twig production of Wyoming big sagebrush and low sagebrush were derived using weight to crown volume regression techniques described by Rittenhouse and Sneva (1977). September crown measurements and harvest of all leaves and current year twigs from 50 randomly selected shrubs of each species provided data for development of regression equations.

Crown dimensions of all shrubs occurring in twelve 25 X 1 m belt transects were recorded at each site sampled for herbaceous production. Data were then processed with the appropriate equation (Appendix 3) to estimate annual shrub production for each site.

Ecologic Condition of Plant Communities

Major plant communities on the study area were assigned to ecologic condition classes by following procedures presented by Dyksterhuis (1949). As proposed by Dyksterhuis (1949), classification of ecologic condition is related to the percent (relative cover) of climax vegetation supported by a given community. Climax vegetation, as defined by Daubenmire 1970), refers to natural vegetation that has not been modified by man or his endeavors. A community composed of 75 to 100% of climax vegetation is classified in excellent ecologic condition. Upper bounds of good, fair, and poor condition categories are 75, 50, and 25%, respectively (Dyksterhuis 1949). In this project plant communities were assigned either a high or low condition classification with the 50% value separating the 2 categories.

The greatest difficulty encountered in the classification process was determination of an area's climax vegetation or habitat type (Daubenmire 1970) designation after disturbance had severely altered the character or composition of the vegetation. In such instances one must rely on site specific evidence and a knowledge of vegetation response to various disturbances to ascertain the climax or potential vegetation for the area in question.

Site specific evidence included knowledge of the climate, soils, and history of an area as well as the location of relict areas or the detection of character or indicator species. In some cases evidence of the type of disturbance affecting the area was also discovered.

Vegetation response to disturbance or treatment was gathered from a variety of literature sources. Excellent beginning sources for Pacific northwest sagebrush-bunchgrass rangelands include Daubenmire (1970), Franklin and Dyrness (1973), Hironaka and Fosberg (1979), and Hironaka _et al_. (1983).

Several communities of minor importance or small size were detected on the area. Data were not gathered from these communities, and in some cases no precedents for ecologic comparison exist in the literature. With the exception of a stand of cultivated alfalfa, these communities were assumed to be in high ecologic condition.

## Characteristics of Habitat Use by Large Herbivores

### Estimating Home Range Size of Horses

Repeated relocation of radio-collared or easily identified horses and bands from April, 1979 through March, 1981 allowed estimation of home range sizes. A coordinate grid was superimposed on a 1: 63360 map of the area and appropriate X and Y values recorded when undisturbed horses were sighted. Resolution of the coordinate system placed sightings within 16 ha.

Home range for this project was defined as that area traversed by an individual or socially cohesive group in its normal activities of foraging, mating, and caring for young (Burt 1943). Two methods were used to derive indices of home range size. The first method involved construction of the smallest convex polygon enclosing all relocations (Southwood 1966). Area was calculated using the map-maker's formula (Jennrich and Turner 1969).

$$\text{Area} = \frac{1}{2} \Sigma (X_i Y_{i+1} - X_{i+1} Y_i)$$

Where $X_i$ and $Y_i$ were the coordinates of relocations constituting the corners of the polygon.

This method of home range estimation has historical prominance and graphical simplicity but contains serious negative bias with small sample sizes (Jennrich and Turner 1969, Schoener 1981). Jennrich and Turner (1969) found bias of the minimum convex polygon method for small sample sizes to be enormous when the true home range consisted of a bivariate-normal distribution truncated at the 90% contour ellipse. On the average only a little over 50%

of the home range area was circumscribed with 25 observations and a minimum convex polygon. When sample size was increased to 50, approximately 71% of the area was delineated with the minimum convex polygon (Schoener 1981).

Because the number of relocations per individual horse were few ($\bar{x}$ = 21.3 relocations) the ellipse procedures as described by Jennrich and Turner (1969) and modified by Koepple et al. (1975) were employed to derive a second estimate of home range size. This method involved construction of a 90% confidence ellipse about relocation points and enabled one to determine a probability of finding an individual or group in a given area (Harrison 1958). This method has gained recent acceptance (Hawes 1977, Randolph 1977, O'Farrell 1978, Zach and Falls 1978, Gavin 1979, Inglis et al. 1979, Waldschmidt 1979, Danner and Smith 1980, Wasserman 1980, Smith 1983) and may be the best procedure for estimating home range proposed to date (Schoener 1981).

Schoener (1981) outlined three disadvantages encountered with the ellipse method. These were (1) elimination of deviant points, (2) selection of a confidence level, and (3) meeting the assumption of a bivariate-normal distribution which is necessary for valid implementation of ellipse procedures.

Relocations were discarded in only one instance when a band of horses was observed well away from their normal activity area. While this decision was more or less arbitrary, the elimination of these points was more in the spirit of the original verbal definition of home range, in which only places customarily frequented are included (Burt 1943, Hayne 1949, Stickel 1954).

A 90% confidence level was selected for ellipse construction. Schoener (1981) illustrated that the ratios of minimum convex polygon estimates to confidence ellipse estimates most closely followed expected values from a bivariate-normal distribution when a 90% confidence value was employed.

Relocation data for each horse were tested for conformation to a bivariate-normal distribution using a procedure presented by Smith (1983). The null hypothesis was rejected at $P<.05$ level. As a minimum of ten data points are required for application of Smith's (1983) procedures, home ranges were estimated only for animals having 10 or more relocations.

Home range ellipses and polygons were drawn and placed on a map of the study area. If some portion of either outline extended into areas deemed inaccessable to horses (over cliffs, lake surfaces, or fences), that area was discounted from the home range size estimate. Density of permanent water sources in each polygon and ellipse was determined. Each polygon and ellipse was also superimposed on the plant community map and the area of each community occurring in its bounds estimated with the aid of a random dot overlay and count of dots falling in each community. Average maximum herbaceous production per hectare for each home range was estimated by:

Average forage production per hectare $= \Sigma(P_i K_i)$ where:

$P_i$ = proportion of home range occupied by community i

$K_i$ = average maximum herbaceous production (kg/ha) by community i.

Average forage production per hectare, water source density, and number of horses per band (independent variables) were regressed (Neter and Wasserman 1974) to home range area to examine relationships between home range size and resource availability. A t test (Snedecor and Cochran 1967) was used to examine differences in average home range size of studs and bands.

Daily Watering Patterns of Horses

Watering patterns of horses were monitored in July and August, 1979 with the aid of time lapse cameras. Cameras were placed over developed water sources in Wildhorse and McIntyre pastures. Exposure rates ranged from 30 to 90 seconds. Photocells actuated cameras from roughly 1/2 hour before sunrise to 1/2 hour after sunset.

Developed film was viewed on an 8 mm editor. Because time of day could not be accurately determined, the number of frames exposed each day were counted and the day divided into 12 periods. Data were then assigned to the appropriate period after the entire day had been tallied.

An "animal frame" was defined as an exposure containing one or more animals within approximately 15 m of water and was not weighted by the number of animals present. A watering "event" was the total number of continuous frames in which the watering area was occupied by one or more animals, multiplied by the exposure rate. The number of animals engaged in "drinking" (head down over water) and other activities were recorded for each animal frame. The maximum number of animals visible in a single frame of an event was assumed to be the group size involved in that event.

A Chi Square analysis of homogeneity (Steel and Torrie 1960) tested the null hypothesis ($H_o$) that animals watered randomly throughout the day. If $H_o$ was rejected, procedures outlined by Marcum and Loftsgaarden (1980) were used to determine the preferred and avoided watering periods.

## Documenting Distribution and Habitat Use

The following data were recorded when large herbivores were encountered on the area:

Species _____

Date ______ ______ ______

Time ______

Location coordinates X ____ Y ____

Percent slope ______

Group size ___ Males ___ Females ___ Young ___ Unclass. ___

Activity ____ Number ____ Plant community ____

Horse identification ____

Slope Use. Percent slope, or average percent slope if a group of animals was observed, was estimated for the site occupied. Occassional clinometer measurements were made as a training exercise. Observations were unweighted and data were pooled by species in 10% categories ranging from 0 to 80+%. Chi square analysis was used to test the null hypothesis ($H_o$) that each species used slope categories in proportion to their occurrence on the area. If $H_o$ was rejected the Marcum and Loftsgaarden (1980) procedures were used to determine the preferred and avoided habitat gradients. Because horses appeared to segregate into 6 distinctive herd areas, slope occupancy data were also pooled by herd. Herd areas were defined by a modified minimum convex polygon method. The modification involved sightings within 400 m of an impassable barrier (fence or cliff). In these cases the barrier was assumed to be the boundary of the herd area. Available slope data were generated from the 4 herd areas having the largest data base and the above analysis repeated. A similar analysis was performed with the cattle data in which pastures served as subdivisions.

Equations predicting the proportion of observations of large herbivores expected on sites with increasing slope were derived through regression analysis (Neter and Wasserman 1974). These were graphed to provide visual comparison of slope utilization patterns of the 4 species.

Plant Community Use. Unweighted observations were tallied by animal species, herd area, and plant community and subjected to Chi square analysis. The null hypothesis was that each animal species or herd occupied plant communities in proportion to their occurrence on the area or designated habitat. If $H_o$ was rejected, the Marcum and Loftsgaarden (1980) procedures were used to determine which plant communities were favored, received casual use, or were avoided.

<u>Similarity of Habitats and Habitat Utilization</u>. In evaluations of species interaction and habitat structure it is often useful to quantify overlap of resource utilization or similarity of habitat composition. Kulczynski's mathmatical expression (Oosting 1956) was used to express the similarity of habitat utilization by large herbivores (as related to slope and plant community) and to express the degree of structural (slope and plant community) similarity exhibited by compared habitats.

$$S = \frac{2(\Sigma M_{i(x,y)})}{A_{ix} + A_{iy}}$$

When comparing habitat utilization by herbivores, A refers to the quantity of resource i utilized by species x and y, and M refers to the lesser value of $A_{(x,y)}$ found in resource i.

When comparing the structural similarity of 2 defined habitats, A refers to the quantity of attribute i contained in habitats x and y, and M refers to the lesser value of $A_{(x,y)}$ of attribute i. When data are condensed to relative values (proportions or percentages) the similarity index reduces to (Renkonen 1938):

$$S = \Sigma M_{i(x,y)}$$

S ranges between 0 and 100 when data are expressed in percent. A value of 0 indicates no overlap or similarity in conditions, and a value of 100 indicates complete overlap or duplication of conditions.

Over the years the above relationships have been rediscovered in a variety of algebraic forms and employed by numerous plant and animal ecologists (Renkonen 1938, Motyka <u>et al</u>. 1950, Whittaker 1952, Oosting 1956, Bray and Curtis 1957, Schoener 1970, Goodall

1973, Pielou 1979, Abrams 1980). In the synthesis of vegetation data, plant ecologist have relied on Kulczynski's and various other indices of similarity to provide objective and repeatable procedures for defining the degree of similarity exhibited by samples of plant communities. Kulczynski's similarity index, however is most widely used for ordination purposes by plant ecologists (Mueller-Dombois and Ellenberg 1974). Types of data to which this procedure has been applied include: biomass, constancy, frequency, and density (Mueller-Dombois and Ellenberg 1974).

Kulczynski's index is used in a botanical sense in this project when applied to data (slope and plant community composit-ion) describing the compositions of designated habitats. As such, the index is intended to convey the degree to which compared habitats are alike in structural composition.

Animal ecologists employ similarity indices as measures of niche overlap. In these cases overlap is based on the degree of common use of some resource or resource state (Hurlbert 1978). Resources typically involved include space, food, water, or time. The resource state may refer to any of several classes or entities defined within the resource. These may be quadrats (Schoener 1970), plant species (Hansen and Reid 1975), or any attribute grouped on the basis of similarity in some respect (Hurlbert 1978).

There is little agreement among animal ecologists as to which of the many indices best describe niche overlap (Hurlbert 1982), Abrams 1980, 1982). Abrams (1980) suggested 4 criteria to be considered in selection of measures of overlap. These were:

(1) ease of calculation, (2) the formula should be free of

assumptions of competitive processes, (3) the overlap measure should facilitate inter-community comparisons, and (4) the measure should not change due to subdivision of resource states which are not distinguished by the competitors.

Based on these criteria Abrams (1980) recommended Schoener's (1970) equation, which is an algebraic equivalent of Kulczynski's formula, as the most acceptable index of niche overlap.

Consideration of the above criteria, coupled with the need for an index capable of describing both habitat and habitat use, led to selection of Kulczynski's index for this study. The derived values in this project are simply indices of habitat similarity or theoretical spatial overlap and should not be interpreted as indicators of interspecific competition.

Spearman's coefficient of rank correlation (Steel and Torrie 1960) was used to compare rankings of similarity indices. Intuitively one would expect patterns of herbivore use to be most similar when habitats show a high level of similarity. Degree of agreement among rankings was assumed significant at $P<.05$.

Activity. Activity codes included feeding, drinking, bedding, standing, ruminating, traveling, courtship, fighting, nursing, and playing. In summary, however, data were reduced to feeding, resting which included bedding and standing, and "other" which included the remaining activities but consisted mostly of traveling and drinking. These data were weighted by the number of animals involved in each activity and tallied by time period.

Distance to Water. Coordinates for each animal sighting were used to estimate distance to the nearest permanent water source. Data were pooled by species and season and analysis of variance used to detect significant difference between species across seasons and across species within seasons. If significance ($P<.05$) was detected, Least Significant Difference procedures (Steel and Torrie 1960) were employed as a mean separation test.

# RESULTS AND DISCUSSION

## Weather Patterns During the Study

Maximum and minimum temperatures recorded at the Owyhee Dam during the study were 41 and -21°C. The 1979 and 1980 crop year (Sneva and Hyder 1962) precipitation accumulations were 91 and 114% of the 30 year average (Figure 3). Employment of Sneva and Hyder's (1962) forage prediction equation estimated 1979 and 1980 crop year forage production levels at 90 and 115% of the long term average.

## Vegetation Mapping

Fifteen plant communities and 2 descriptive habitats were detected and mapped on the study area (Figure 4). The Wyoming big sagebrush/bluebunch wheatgrass community occupied 36% of the study area (Table 1). Major concentrations of this community were found in the Wildhorse pasture and the Honeycombs and Spring Creek areas.

Second in total area was the Wyoming big sagebrush/Sandberg's bluegrass community which occurred on 22% of the area. The east central portion of the study area supported the largest single block of this community with 66% of the McIntyre pasture being of this composition.

Approximately 17% of the area was occupied by the Wyoming big sagebrush/cheatgrass community. Major portions of this community were on the north central and central portions of the area and occupied many of the lakeside basins and larger drainages.

Fourth largest in area was the low sagebrush/Sandberg's

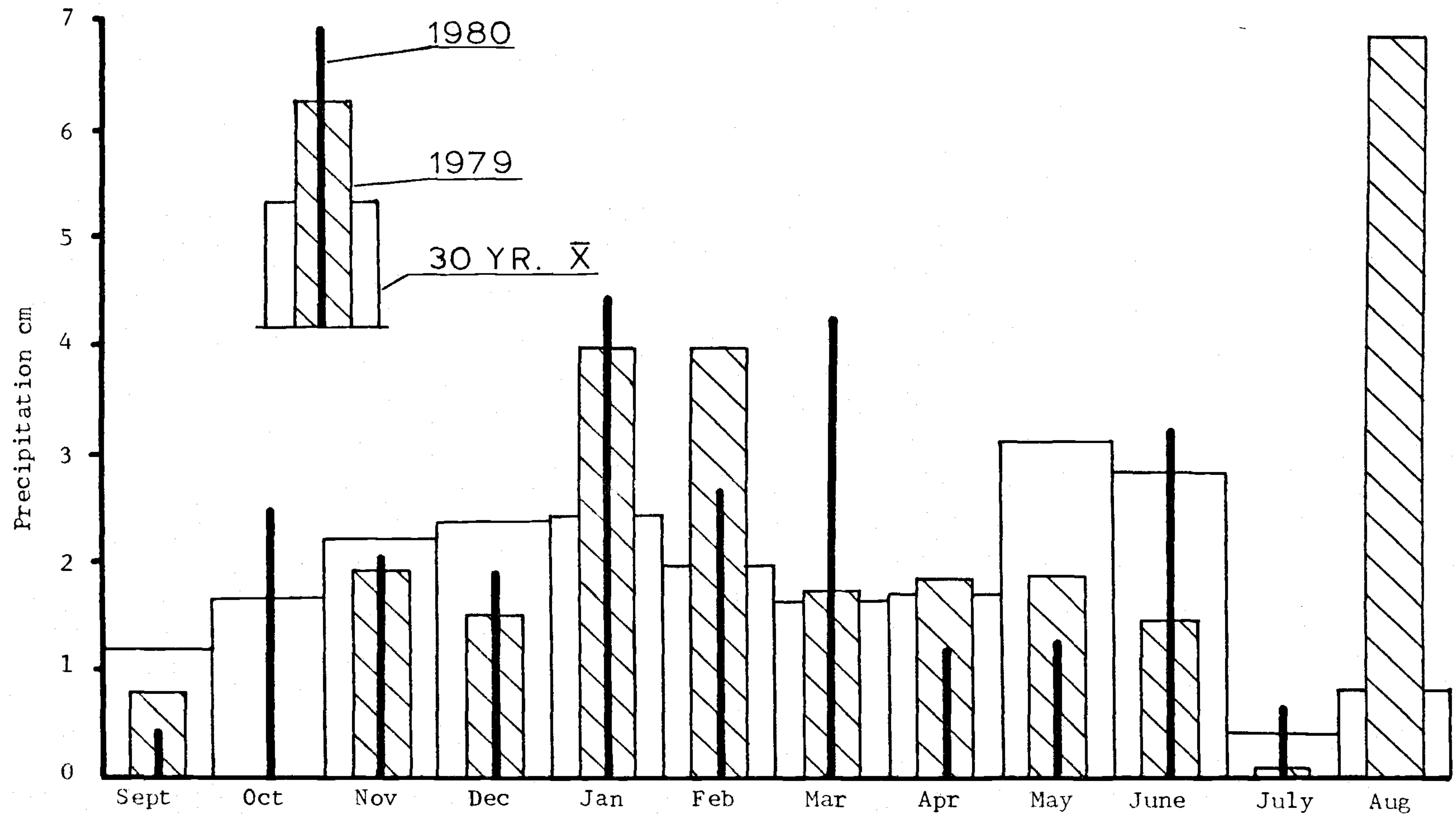



Figure 3. Thirty year average monthly and monthly precipitation for the 1979 and 1980 crop years (Sneva and Hyder 1962) at Owyhee Dam.

Table 1. Area (hectares) of plant communities or habitats found in each pasture of the study area.1/

| Plant community | Pasture and area | | | | |
|---|---|---|---|---|---|
| | Wildhorse | McIntyre | Riverside | Spring Creek | Study area |
| Wyoming big sagebrush/ bluebunch wheatgrass | 4193 | 31 | 5443 | 3862 | 13529 |
| Wyoming big sagebrush/cheatgrass | 762 | 69 | 5272 | 207 | 6310 |
| Wyoming big sagebrush/Sandberg's bluegrass | 589 | 2046 | 5173 | 364 | 8172 |
| Low sagebrush/bluebunch wheatgrass | - | - | 1029 | 683 | 1712 |
| Low sagebrush/Sandberg's bluegrass | - | 879 | 2288 | 17 | 3184 |
| Bluebunch wheatgrass | - | - | 120 | 196 | 316 |
| Cheatgrass | 347 | - | 401 | 84 | 832 |
| Alfalfa | - | - | - | 34 | 34 |
| Cliffrock | - | - | 192 | 28 | 220 |
| Gravel slopes | - | - | 51 | 84 | 135 |
| Low sagebrush/cheatgrass | - | - | 17 | - | 17 |
| Shrub scabland | 314 | 22 | 1882 | 129 | 2347 |
| Bitterbrush/grass | - | 12 | 55 | - | 67 |
| Stiff sagebrush/Sandberg's bluegrass | - | 32 | - | - | 32 |
| Mountain mahogany/grass | - | - | 26 | 509 | 535 |
| Silver sagebrush | 3 | - | - | - | 3 |
| Juniper scabland | - | - | - | 118 | 118 |
| Total | 6208 | 3091 | 21949 | 6315 | 37563 |

1/ Nomenclature follows Hitchcock and Cronquist (1973). A listing of plant species detected on the area is found in Appendix 1.

bluegrass communtiy. This community occurred on 8% of the area with the largest blocks found in the far eastern portions of the Riverside and McIntyre pastures.

The shrub scabland community (6% of study area) was not found in large continuous blocks, but consisted generally of small islands of shrubs on steep, south slopes and eroded outcroppings. Greatest concentrations of this community were in the west-central portion of the Riverside pasture. The community supported very little herbaceous growth but possessed a diversity of woody species. Commonly encountered species included: Wyoming big sagebrush, gray ball sage (Salvia dorrii), slenderbush buckwheat (Eriogonum microthecum), barestem buckwheat (Eriogonum nudum), bitterbrush, spiny hopsage (Atriplex spinosa), gray rabbit-brush (Chrysothamnus nauseosus), and sheepfat (Atriplex confertifolia).

Sixth in size was the low sagebrush/bluebunch wheatgrass community which comprised 4.5% of the study area. Largest blocks were in the southwest portions of the area on high ridges and areas surrounded by steep slopes.

Seventh in rank was the cheatgrass community occupying slightly more than 2% of the area. These areas were the result of past fires, were virtually shrub free, and with the exception of cliffrock areas, were lowest in species diversity. Subordinate species were Sandberg's bluegrass, Jim Hill mustard (Sisymbrium altissimum), and filaree (Erodium cicutarium).

Of the remaining categories, only the cliffrock and alfalfa areas will be mentioned. Approximately 34 ha of irrigated alfalfa were found along Spring Creek on the south west portion of the area.

This community was the focus of considerable bighorn grazing during dry summer months.

Cliffrock habitats were devoid of vegetation. Although quite prominent, the vertical nature of these landforms confounded mapping efforts and my estimate of their total area is probably negatively biased. Greatest expanses of cliffrock were in the Honeycombs, Leslie Gulch, and Spring Creek areas.

## Plant Community Descriptions

Descriptive data were gathered from 5 of the 17 plant communities on the area (Table 2 and Appendix 4). These five communities constituted 85% of the total study area, and supported most of the large herbivore use observed during the study.

Maximum herbaceous cover and minimal bare ground were found in the Wyoming big sagebrush/cheatgrass community. Maximum herbaceous production occurred in the cheatgrass community with the Wyoming big sagebrush/cheatgrass community ranking a close second. The Wyoming big sagebrush/bluebunch wheatgrass community ranked lowest in total herbaceous cover and highest in percent bare ground. Grass production was high (671.9 kg/ha) but about 150 kg/ha less than that attained by the cheatgrass dominated communities. Maximum shrub cover and production were found in the low sagebrush/ Sandberg's bluegrass community. This community also supported the most diverse and productive forb component and the lowest level of grass production of the communities sampled on the area.

Table 2. Characteristics and average of 1979 and 1980 maximum productivity for 5 major plant communities on the Three Fingers study area.

| Plant Community | Wyoming big sagebrush/ bluebunch wheatgrass | Wyoming big sagebrush/ Sandberg's bluegrass | Wyoming big sagebrush/ cheatgrass | Low sagebrush/ Sandberg's bluegrass | Cheatgrass |
|---|---|---|---|---|---|
| Percent cover | | | | | |
| shrub | 8 | 17 | 18 | 30 | - |
| grass | 19 | 24 | 63 | 17 | 44 |
| forb | 3 | 1 | 2 | 5 | 5 |
| total herbaceous | 21 | 26 | 65 | 22 | 49 |
| moss and lichens | 7 | 11 | - | 12 | - |
| litter | 6 | 12 | 11 | 15 | 11 |
| rock | 26 | 15 | 16 | 26 | 11 |
| bare ground | 41 | 37 | 8 | 26 | 30 |
| Density/$m^2$ | | | | | |
| dominant shrub | .3 | .6 | .7 | 4.5 | - |
| dominant grass | 5.0 | 45.7 | - | 47.3 | - |
| Average maximum production (kg/ha) | | | | | |
| grass | 672 | 119 | 817 | 80 | 821 |
| forb | 39 | 32 | 18 | 75 | 20 |
| shrub | 99 | 314 | 239 | 381 | - |

## Ecologic Condition of Plant Communities

The dominant and subordinate vegetation of the Wyoming big sagebrush/bluebunch wheatgrass community (Appendix 4) on the study area conformed quite closely with the description of climax vegetation of the Wyoming big sagebrush/bluebunch wheatgrass habitat type provided by Hironaka et al. (1983). Wyoming big sagebrush and bluebunch wheatgrass clearly shaped the character of this community. Because invader (cheatgrass) and increaser species (Sandberg's bluegrass and bottlebrush squirreltail (Sitanion hystrix)) were only minor components of the vegetation, this community was classified as a high ecologic condition example of the Wyoming big sagebrush/bluebunch wheatgrass habitat type.

The Wyoming big sagebrush/Sandberg's bluegrass community was classified as a low ecologic condition example of the Wyoming big sagebrush/bluebunch wheatgrass habitat type. Excessive grazing of this habitat type often increases the density of sagebrush and shifts dominance in the understory to Sandberg's bluegrass (Daubenmire 1970, Hironaka et al. 1983). Sagebrush cover and density in this community were twice that detected in the Wyoming big sagebrush/bluebunch wheatgrass community. Sandberg's bluegrass density and cover were nearly 3 times that in the Wyoming big sagebrush/ bluebunch wheatgrass community (Appendix 4).

Hironaka et al. (1983) recognize a Wyoming big sagebrush/ Sandberg's bluegrass habitat type. Evidence, however, indicated the Wyoming big sagebrush/Sandberg's bluegrass community on the area did not belong in this habitat type classification. Hironaka et al.

(1983) report the Wyoming big sagebrush/Sandberg's bluegrass habitat type is incapable of supporting deep-rooted, long-lived perennial grasses. Traces of bluebunch wheatgrass and relict areas dominated by bluebunch wheatgrass could be found within the Wyoming big sagebrush/Sandberg's bluegrass community suggesting the potential to support large perennial bunchgrasses was present. Additional evidence of the communitie's productive potential exists immediately north of McIntyre pasture where a highly productive crested wheatgrass (Agropyron desertorum) seeding is established. Islands of vegetation within the seeding support a Wyoming big sagebrush/ Sandberg's bluegrass community identical to that on the study area. Boundaries of these islands were defined by man (section lines, areas isolated by road cuts, and private ownership within public land) and do not appear to be separate ecologic entities by any other character. Annual production by crested wheatgrass was estimated at 800 kg/ha during the years field work was in progress. The success of this seeding, coupled with its high annual production, suggests the productive potential of the Wyoming big sagebrush/ Sandberg's bluegrass community far exceeds that of the Wyoming big sagebrush/Sandberg's bluegrass habitat type.

The Wyoming big sagebrush/cheatgrass community was also classified as a low condition component of the Wyoming big sagebrush/bluebunch wheatgrass habitat type. With the exception of sagebrush and small amounts of Sandberg's bluegrass, very little of the original perennial vegetation could be found in this community. Relict areas, associated surrounding vegetation, and the level of herbaceous production attained by this community were other clues used in assigning the habitat type designation.

The high level of herbaceous production (835 kg/ha attained primarily by cheatgrass) suggested the productive potential of this community was comparable to other sites in the Wyoming big sagebrush/bluebunch wheatgrass habitat type. Daubenmire (1970) found cheatgrass capable of invading nearly all of the steppe habitat types of Washington if the perennial herbaceous layer was altered by severe disturbance. Other workers (Hironaka et al.1983), however, believe the shrub overstory must be removed prior to establishment of a dense cover of cheatgrass. Sagebrush then reinvades the site. Evidence of past fires was detected in some stands of the Wyoming big sagebrush/cheatgrass community, however, this was not the case with all stands scattered over the area.

The cheatgrass community was also assigned to the Wyoming big sagebrush/bluebunch wheatgrass habitat type. This community was obviously in low ecologic condition as 85% of the herbaceous ground cover was cheatgrass, an introduced invader species. Fire was an obvious component in the history of this community. Ecotones were quite abrupt, and charred sagebrush stumps were detected in all examples of the cheatgrass community. The habitat type assignment was based on islands of relict vegetation within the community and on the composition of adjacent communities.

The bluebunch wheatgrass community was a high ecologic condition example of the Wyoming big sagebrush/bluebunch wheatgrass habitat type. No data were gathered from the bluebunch wheatgrass community. During reconnaissance, however, these sites were found to be a product of past fires. Charred stumps were easily located in most instances, and evidence of fire was clearly visible on the 1976 aerial photos of the area south of Leslie Gulch. The nearly complete elimination of sagebrush was the only long term effect of fire on these sites, as the herbaceous component of the vegetation appeared identical to that found in the Wyoming big sagebrush/bluebunch wheatgrass community.

Data were not gathered from the low sagebrush/bluebunch wheatgrass community. My examination of these areas found them to be quite similar to the low sagebrush/bluebunch wheatgrass habitat type described by Hironaka et al. (1983), and they were assigned a high ecologic condition classification. This community was restricted to the highest ridges and buttes where there has been little if any use by large herbivores.

The low sagebrush/Sandberg's bluegrass community was a low ecologic condition example of the low sagebrush/bluebunch wheatgrass habitat type. Although not detected when data were gathered for descriptive purposes (Appendix 4) both bluebunch wheatgrass and bottlebrush squirreltail were found in trace amounts when sampling this community for herbaceous production. Sandberg's bluegrass, however, clearly dominated the herbaceous layer in this community. The presence of relict species and the intergrading of this community with the low sagebrush/bluebunch wheatgrass community served as primary justification for the habitat type designation.

Hironaka et al. (1983) found the low sagebrush/bluebunch wheatgrass habitat type to be quite fragile and describe instances of poor drainage and trampling damage if animals graze when the soil is wet. Given the heavy surface runoff observed each spring in this community, and a long history of year-around use of the area by horses, it is no surprise that the community supports little of its original large stature, bunchgrass cover.

The low sagebrush/cheatgrass community was very limited in size (17 ha) and distribution on the area. Because the herbaceous layer was dominated by cheatgrass, it was assigned a low ecologic condition classification. Most likely the community is a result of localized fire. Culver (1964) documented the presence of cheatgrass in a low sagebrush/bluebunch wheatgrass association, however, no reports of cheatgrass dominating low sagebrush habitat types were detected in the literature. Because this community was adjacent to stands of low sagebrush/bluebunch wheatgrass, it was placed in the low sagebrush/bluebunch wheatgrass habitat type.

The alfalfa community was obviously the result of human effort and was placed in the low ecologic condition classification. Because all native vegetation had been removed from this site the placement of this community in the Wyoming big sagebrush/bluebunch wheatgrass habitat type was based solely on the composition of surrounding vegetation.

No attempts were made to quantify or investigate the ecologic status of the remaining communities on the area. With the occasional exception of cliffrock, gravel slope, and shrub scabland areas, these communities were simply assigned to an "other" category and all were assumed to be in high ecologic condition. Communities in this category included the: bitterbrush/grass, mountain mahogany (Cercocarpus ledifolius)/grass, stiff sagebrush (Artemisia rigida)/ Sandberg's bluegrass, silver sagebrush (Artemisia cana), and juniper scabland. In total these communities occupied only 9% of the study area, and with the exception of the cliffrock and gravel slope areas, supported no observed use by large herbivores.

Slope : Plant Community Relationships

Slope gradient ranged from level to vertical on the area and averaged 37% with a standard deviation of 32%. Median grade was 31%. Slope : plant community relationships were examined for 7 of the 17 plant communities noted on the area. These 7 communities (Table 3) occupied 90% of the study area. The remaining 10 communities were either limited in area or directly related to various landscape features and were excluded from this analysis.

Distribution over slope categories for 5 of the 7 communities was found to vary significantly (P<.01) from the slope distribution of the study area. In general low ecologic condition communities (Wyoming big sagebrush/Sandberg's bluegrass, Wyoming big sagebrush/cheatgrass, and low sagebrush/Sandberg's bluegrass) were detected in significantly greater proportions (P<.02) than expected on the lower slope gradients and significantly less than expected in the steep slope categories. The cheatgrass community was an exception as its dispersal over slopes did not vary significantly from a random distribution. Because the cheatgrass community is a product of past fires on the area, its random distribution indicated the fires were not influenced by degree of slope.

High ecologic condition communities (Wyoming big sagebrush/bluebunch wheatgrass and low sagebrush/bluebunch wheatgrass) were not randomly distributed relative to slopes. Both communities were significantly (P<.02) less prominent than expected on lesser slopes and more prevalent than expected on the steeper grades. All communities appeared to be distributed as expected on grades between

Table 3. Percent of study area and plant communities found in 10% slope categories. ** indicates plant community was not distributed as expected over all slope categories (P<.01). In categories a – indicates significantly less than expected, 0 indicates no significant difference, and a + indicates significantly greater than expected (P<.02).

| Community | Slope gradient (%) 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
|---|---|---|---|---|---|---|---|---|---|
| Study area | 14.7 | 17.7 | 14.1 | 13.5 | 10.9 | 9.5 | 9.3 | 3.3 | 7.0 |
| Wyoming big sagebrush/bluebunch wheatgrass ** | – 6.5 | – 10.6 | 0 11.7 | 0 13.0 | 0 13.0 | 0 12.6 | + 15.0 | 0 5.4 | + 12.2 |
| Bluebunch wheatgrass | 14.3 | 0.0 | 0.0 | 42.9 | 0.0 | 14.3 | 14.3 | 0.0 | 14.3 |
| Wyoming big sagebrush/Sandberg's bluegrass ** | + 24.7 | + 27.6 | 0 17.3 | 0 13.3 | 0 8.0 | – 3.7 | – 2.0 | – 1.4 | – 2.0 |
| Wyoming big sagebrush/ cheatgrass ** | + 22.5 | 0 20.6 | 0 15.0 | 0 13.1 | 0 10.9 | 0 6.4 | 0 7.9 | – 1.1 | – 2.5 |
| Cheatgrass | 25.0 | 27.7 | 16.7 | 13.9 | 8.3 | 0.0 | 5.6 | 2.8 | 0.0 |
| Low sagebrush/ bluebunch wheatgrass ** | – 4.8 | 0 11.3 | 0 11.3 | 0 14.5 | 0 12.9 | + 27.4 | 0 4.8 | 0 4.8 | 0 8.2 |
| Low sagebrush/Sandberg's bluegrass ** | 0 17.6 | + 31.1 | 0 20.2 | 0 10.9 | 0 5.9 | 0 5.9 | – 4.2 | – .8 | – 3.4 |

20 and 49%. When data of the 7 communities were pooled by habitat types (Wyoming big sagebrush/bluebunch wheatgrass and low sagebrush/bluebunch wheatgrass (Hironaka and Fosberg 1979, Hironaka *et al.* 1983)), the 2 habitat types were found to be randomly distributed relative to the slope composition of the area (Appendix 7).

In general these data indicate the deterioration of ecologic condition on the area has been significantly more pronounced on the lesser slopes than on the steep hillsides. The historic year-around use of the area by large numbers of horses and the pressures of seasonal livestock use during the same period were probably the major causes of range deterioration. Past wildfire influences on vegetation were evidenced in the cheatgrass, bluebunch wheatgrass, and portions of the Wyoming big sagebrush/cheatgrass communities where charred sagebrush stumps were found.

# Wild Horses

## Characteristics of the Population

When field work was initiated in April, 1979, ground census and identification data of horses indicated there were 133 animals on the area. Forty two horses were female, and 91 were male. Of the 91 males, 37 were associated with bands and 54 roamed in bachelor groups or as lone studs. All females were associated with bands. One male, approximately 6 years old, was found dead (the result of a fall in steep, rocky terrain) in May 1979. Seventeen foals (9 male and 8 female) were documented in 1979 during April through June, and all survived the year increasing the population to 149 animals. Twenty one bands were detected with band size ranging from 2 to 9 and averaging 4.6 animals.

Twenty two foals were born during spring 1980 increasing the population to 171 animals. One band dissolved and six new bands formed leaving 25 bands on the area. Band size averaged 4.5 and ranged between 2 and 10 animals during the second year. One hundred thirteen horses were associated with bands.

Detected mortality for 1980 was 3 animals. One foal was abandoned by its mother and subsequently disappeared. A second foal of the year was seen with a broken rear leg in December and also vanished. A 5 year old mare died during the winter of 1980 when its front foot became caught in a boulder pile. Estimated population at the close of the study (March 1981) was 168 animals. Annual rate of population increase averaged 13% during the study.

Band Stability

As a generalization, band compositions remained relatively stable over the 2 years of observation. Mature animals were especially loyal to their respective bands. The formations of new bands typically involved bachelor studs and their acquisitions of recently maturing, 2 year old females. Most band formations or inter band exchanges occurred during the breeding season (April - June).

Only one instance of a 4 member harem being temporarily seized by force was observed. The band moved from its habitual range due to our presence in the area and encountered a bachelor stud. After a brief dispute the bachelor drove the harem stallion away and assumed control of the group. Three days later, however, the band was again observed in its habitual range under the control of the original stallion.

During the breeding season established bands tended to cluster or gather together in what appeared to be a defensive tactic employed by dominant stallions to acquire assistance in the defense of their harems. Despite these associations, close or extended observation usually revealed that band continuity was maintained within the larger group. The only permanent breakup of a band resulted from an extended association of several bands during the breeding season. During this association harem members were gradually assimilated into 2 other bands, leaving the stallion as a bachelor when the group dispersed at the close of the breeding season.

Characteristics of Home Ranges

A total of 523 sightings of horses was documented on the area (Figure 5). Home range sizes were estimated for 14 bands and 10 studs (Table 4). Data for band B and stud number 12 differed significantly from the bivariate normal distribution ($P<.05$). For this reason ellipse estimates of home range size for these 2 animals should be accepted with some reservations. Figure 6 provides an example of the 2 home range estimate methods used. Average home range estimates for bands and studs with the polygon method were 11.8 and 12.3 $km^2$, respectively. With the ellipse method band and stud home ranges averaged 28.3 and 25.8 $km^2$. No significant differences between band and stud home range sizes were detected within either estimation method ($P>.05$). The ratio of minimum convex polygon estimates to 90% confidence ellipse estimates averaged 0.50 and ranged from 0.25 to 0.81 (Appendix 5). Because the number of relocations used to estimate home ranges was relatively small ($\bar{x}$ = 21.3), I believe the ellipse procedures provided the most accurate estimate of true home range size.

Horses did not appear to be confined by pasture boundaries, as no home range encompassed the entire area within a pasture. No instances of horses breaching or jumping fences were observed. With few exceptions both bands and studs showed remarkable fidelity to their home ranges. No seasonal shifts in use areas were detected. Only one animal, a stud, failed to settle in a defined area. Polygon and ellipse estimates (19 observations)

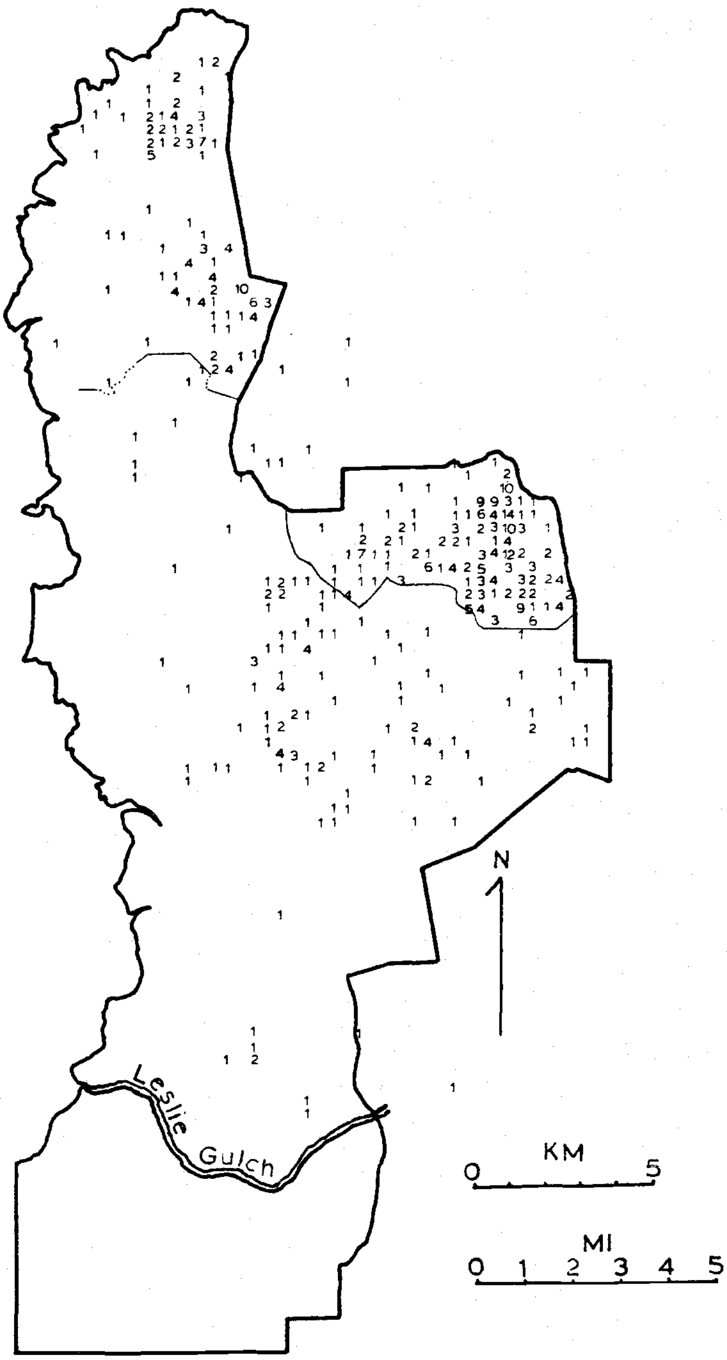



Figure 5. Distribution of horse sightings over the Three Fingers study area. Numerals indicate repeated relocations at that coordinate. N= 523.

Table 4. Number of relocations, span of months observed, minimum convex polygon, and 90% confidence ellipse estimates of home range size for 14 bands and 10 studs.

| Band | Number relocations | Number months observed | Area convex polygon km$^2$ | Area ellipse km$^2$ |
|---|---|---|---|---|
| A | 56 | 23 | 12.0 | 17.0 |
| B 1/ | 30 | 17 | 8.1 | 11.3 |
| C | 24 | 20 | 6.5 | 13.3 |
| D | 17 | 19 | 6.6 | 14.1 |
| E | 14 | 19 | 5.4 | 15.6 |
| F | 16 | 19 | 5.4 | 13.0 |
| G | 17 | 18 | 6.7 | 13.3 |
| H | 23 | 22 | 12.1 | 16.0 |
| K | 15 | 7 | 5.7 | 11.8 |
| K' | 10 | 15 | 18.5 | 72.8 |
| L | 23 | 23 | 24.8 | 54.1 |
| N | 15 | 15 | 25.2 | 60.7 |
| P | 10 | 17 | 11.6 | 45.8 |
| S | 14 | 14 | 16.4 | 37.0 |
| Mean | 20.4 | 17.7 | 11.8 | 28.3 |
| Standard dev. | | | 6.9 | 21.4 |
| Stud | | | | |
| 1 | 49 | 22 | 15.0 | 20.3 |
| 2 | 47 | 21 | 18.0 | 22.0 |
| 5 | 29 | 24 | 11.8 | 23.1 |
| 6 | 11 | 3 | 2.6 | 8.1 |
| 8 | 13 | 22 | 12.7 | 26.6 |
| 11 | 17 | 22 | 18.1 | 38.1 |
| 12 1/ | 16 | 22 | 23.6 | 33.2 |
| 26 | 14 | 20 | 6.4 | 15.0 |
| 28 | 10 | 17 | 12.1 | 45.7 |
| Mean | 22.9 | 19.2 | 12.3 | 25.8 |
| Standard dev. | | | 5.1 | 11.6 |
| Stud | | | | |
| 10 | 19 | 21 | 74.7 | 147.3 |

1/ Relocation data differs significantly from the bivariate normal distribution ($P<.05$).

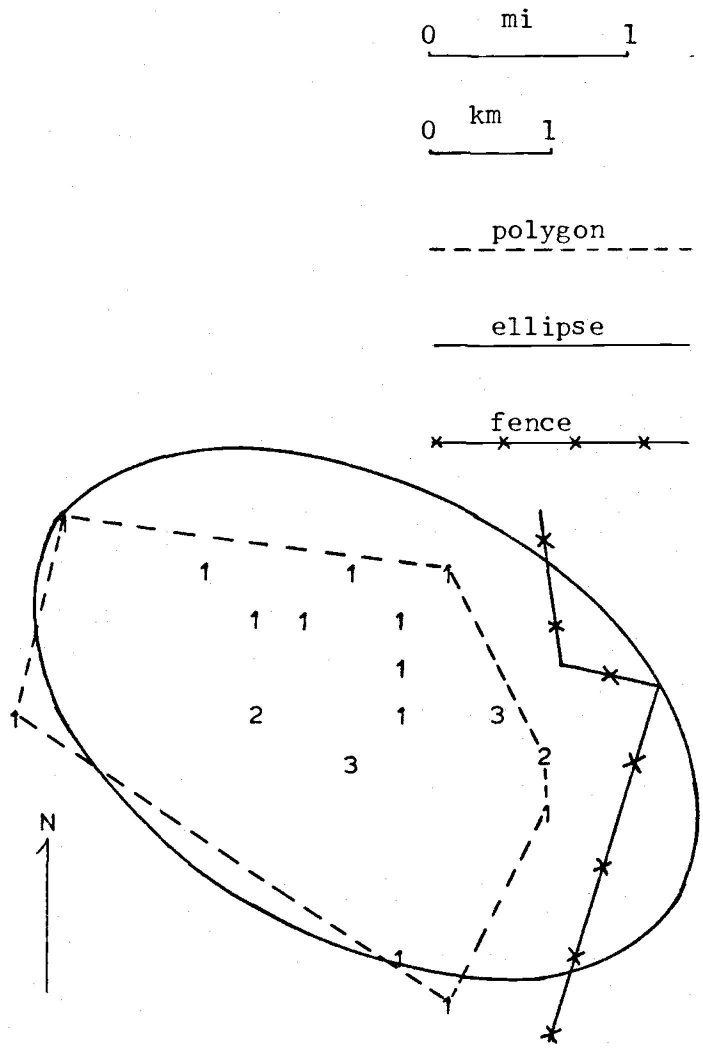



Figure 6. Home range determinations for band H using the minimum convex polygon and 90% confidence ellipse methods. Area to right of fence has been discounted from ellipse area.

for this horse were 74.7 and 147.3 $km^2$, respectively. As these values seemed atypical for the area, they were dropped from the data summary.

One band and two studs made permanent shifts to new home ranges. Band K moved from McIntyre into Riverside pasture (Band K' Table 4). Distance from the center of the first to the second home range was 8.5 km. Two studs (Figure 7), located southeast of McIntyre pasture, moved permanently into the east portion of McIntyre. Only 8 relocations were made of these animals in each pasture and their data were not included in Table 4.

Temporary but substantial shifts in use areas were made by one band and one stud. The stud, located initially in the southeast portion of Riverside, moved off the study area to the south and east in September 1980 and joined saddle stock from nearby ranches. In February, 1981 he was captured and transported approximately 16 km north into McIntyre pasture. When field work was completed in March, 1981, this animal was still in McIntyre. When I briefly returned to the area in June, 1981, he had returned approximately 14 km to the original sighting area in southeast Riverside.

Band E, located in north Wildhorse pasture, shifted approximately 4.3 km south of their habitual use area during May and June of 1980 (Figure 8). These animals then returned to their traditional range to the north. As the southernmost sightings did not fall within the area normally occupied by these animals during their habitual activities these points were rejected (Burt 1943), and the home range size was estimated with the reduced data base.

Band and stud home ranges overlapped substantially on the area and in many cases were nearly superimposed. Harem studs defended a small perimeter in the immediate vicinity of their bands, but no territorial behavior as described by Pellegrini (1971) was observed.

The horse "herd" concept as defined by Miller (1980) appeared quite applicable to the study area (Figure 7). Herds C and F were not well documented as each consisted of only five horses. The bands and studs making up each herd habitually remained within the outlined areas with very few permanent interherd exchanges or encounters occurring. While herds D and E overlapped slightly and had the greatest opportunity for animal exchange, only 1 instance, the shift of band K's home range from herd D to E, was noted. Although herd boundaries roughly paralleled fences and major drainages, no physical restraints continuously impeded horse movements. Gates were often left open, and natural boundaries were quite passable.

Movement between McIntyre and Riverside pastures (herd E) was through an open gate which allowed a single water source to service both pastures. No movement of horses was observed between Wildhorse and Riverside pastures.

Regression of home range size to average maximum herbaceous production/ha for each home range yielded no significant ($P > .05$) correlations with either home range estimation procedure. Herbaceous production for the 23 band and stud home ranges outlined with ellipse procedures ranged between 153 and 711 kg/ha. Average production was 389 kg/ha with a standard deviation of 215. The percent of each ellipse for which applicable forage

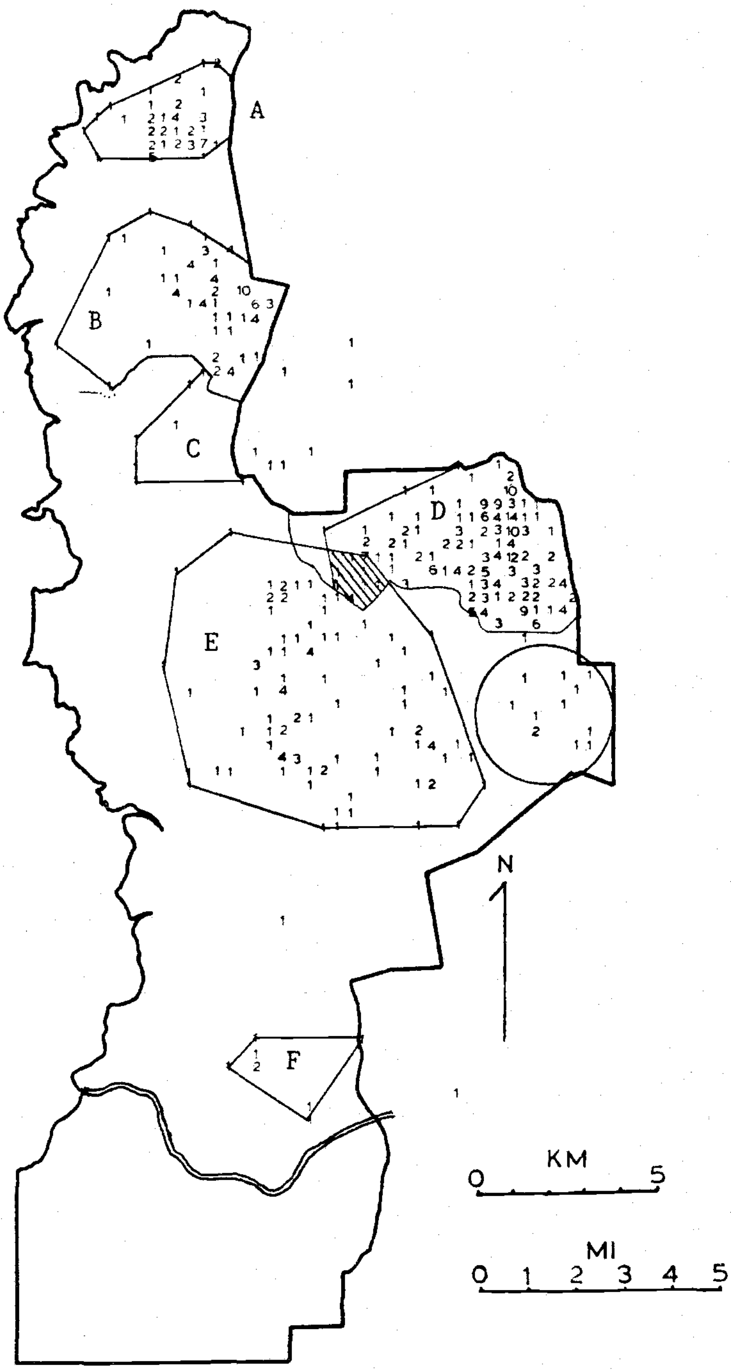



Figure 7. Distribution of six horse herds on the Three Fingers study area. The circled area designates relocations for two studs prior to a permanent move into McIntyre pasture during mid study.

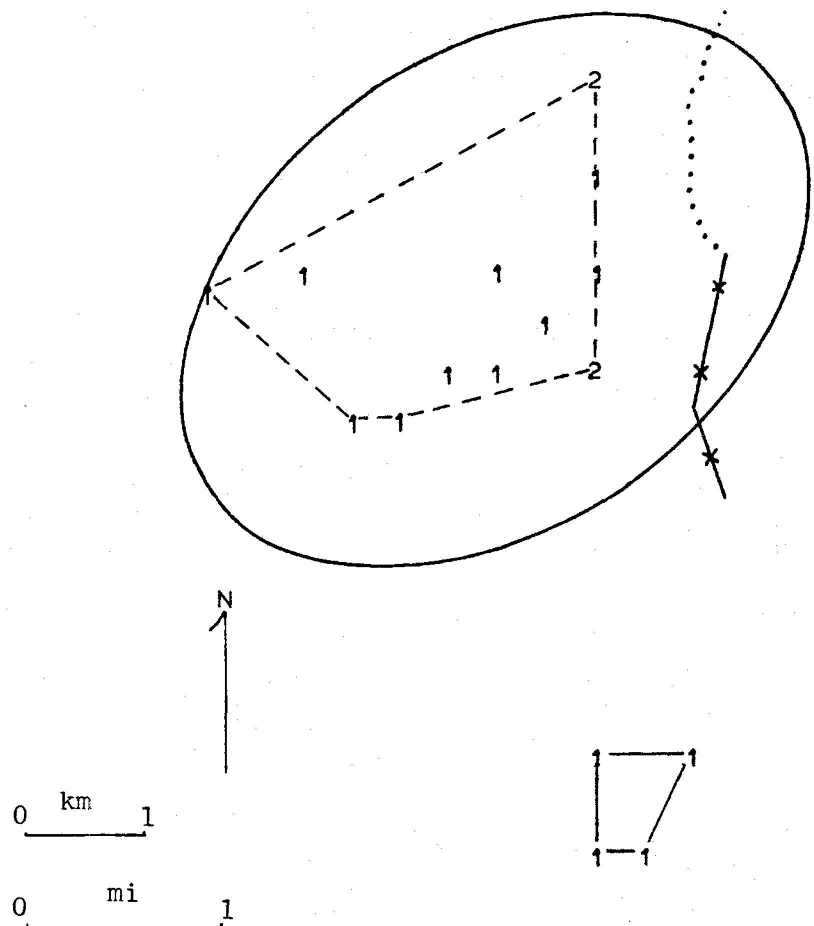



Figure 8. Band E home ranges and locations of 4 sightings within a two month period not included in home range estimation procedures.

production data were available averaged 95% with a standard deviation of 5.

For the home ranges outlined with convex polygons average herbaceous production was 355 kg/ha with a standard deviation of 207. Range in production was 150 to 733 kg/ha. The percent of each polygon for which applicable forage data were available averaged 96% with a standard deviation of 6.

Number of horses per band also failed to yield a significant correlation with home range size. Home range size, however, showed significant ($P<.01$) negative, but weak, correlations with water hole densities with both the polygon ($R^2= 0.52$) and ellipse ($R^2= 0.37$) procedures (Appendix 6). Water source density averaged 0.10 and 0.18 /$km^2$, respectively, for polygon and ellipse estimates of home range.

## Patterns of Water Utilization

Watering patterns of horses were documented during July and August 1979 with time lapse cameras in Wildhorse and McIntyre pastures (Table 5). Twelve thousand one hundred eight frames were processed with 339 frames being occupied by horses. Chi square analysis indicated horses did not water randomly throughout the day ($P<.01$). The first and last periods of the day were significantly favored with either no preference or significant avoidance exhibited for the midday periods ($P<.02$).

Duration of watering events ranged from 1 to 45 minutes. Groups of horses, however, typically moved rapidly to and from water. The 45 minute event involved at least 3 bands of horses watering in sequence. However, the inability to accurately determine when one band departed and another arrived prevented an accurate breakdown of those data. Average duration of a watering event was 16.1 minutes ($\pm$ 9.0, 95% CI). During the period horses occupied watering sites 39.3% ($\pm$ 12.9, 95% CI) were observed drinking while 60.7% ($\pm$ 12.9, 95% CI) were engaged in other activities. This indicated a horse required approximately 6.3 minutes of drinking time to quench its thirst. Groups never completely depleted a trough when drinking from developed water sources, so animals were not required to wait for water to accumulate before drinking.

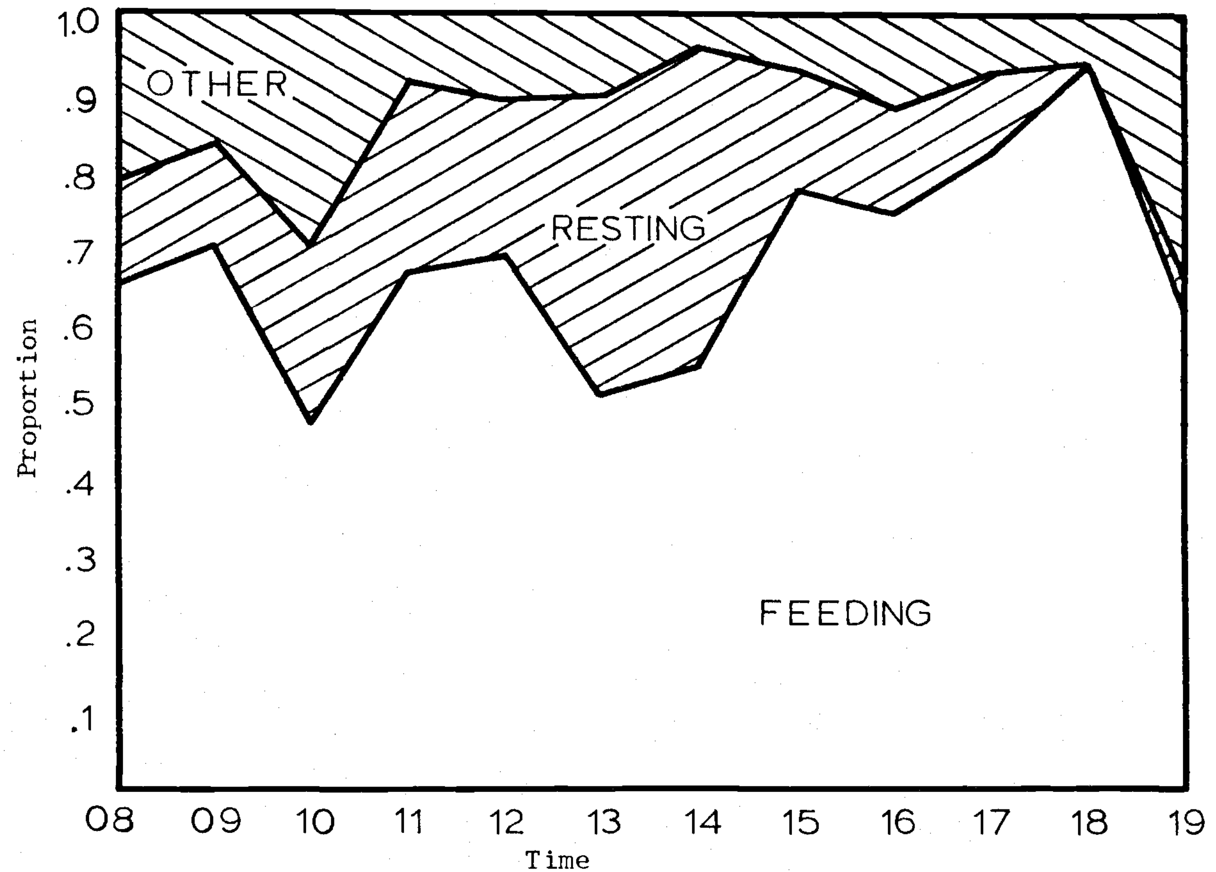
Table 5. Distribution of occupied frames during 12 dawn to dusk daylight periods. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided watering periods, respectively ($p<.02$). N=339.

| | Period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Percent of occupied frames | 46 | 13 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| Preference rating | + | 0 | – | – | 0 | – | – | – | – | – | – | + |

## Patterns of Daily Activity

Daily activity patterns of horses were derived from 1817 visual observations. Feeding efforts averaged 68% of the horses' daylight activities, with three peaks of feeding occurring: morning, midday, and evening (Figure 9). Feeding was most intense during the early evening period when 95% of the observations were involved in this activity. Resting averaged 18% of daylight activities. The greatest proportion of resting occurred in early afternoon, and very little occurred during the late afternoon feeding period. Other activities, primarily traveling and drinking, accounted for an average of 14% of the day. In support of the camera obtained watering data, "other" activities for the first and last one half hours of the day consisted solely of watering observations.

Rittenhouse et al. (1982) reported horses were active throughout the night. My observations support this as evening and subsequent morning relocations seldom placed animals in the same locale. My efforts at night observations were not successful.




N= 135 154 200 162 140 149 139 138 151 171 141 137

Figure 9. Daily horse activity patterns on the Three Finger study area. Total N= 1817.

Patterns of Slope Utilization

Horses on the area generally had an affinity for high benches and gently sloping ridgetops. Typically they would rapidly traverse rugged or steep topography to gain access to elevated but level terrain. Only 2 bands, the first in Sheephead basin and a second north of Wildhorse Creek, showed a reversal of this tendency and occupied basin areas. Ridges encircling both of these areas supported little level ground, and horses were probably forced to the basins to avoid use of steep slopes.

Because horses were not distributed over the entire study area (Figure 5), data were processed on both a population and herd basis. The population analysis assumed all habitat north of Leslie Gulch was available to horses, while the herd analysis assumed available habitat was restricted to the outlined areas for herds A, B, D, and E (Figure 7).

Chi square analysis of both population (Table 6) and herd data (Table 7) indicated horses did not occupy slope categories in the same proportions present on their respective areas ($P<.01$). Average grade for horse sightings on a population basis was 11.2%. Significantly favored slopes ($P<.02$) were those between 0 and 19% with 79% of all observations falling in those 2 categories. Horses were indifferent to the 20 to 29% category and avoided grades greater than 30%.

Herd analyses (Table 7) yielded results similar to those obtained with the population data. Some subtle differences appeared, however, in response to habitat variation. Herds A and

Table 6. Percent of study area north of Leslie Gulch and percent of horse observations occurring in progressive 10% slope categories. The +, 0, and − preference ratings indicate significantly favored, no preference, and avoided categories respectively ($P<.02$). N= 394.

| | Grade % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
| Study area % | 15 | 19 | 15 | 14 | 11 | 8 | 9 | 3 | 6 |
| Horse obs. % | 43 | 36 | 14 | 4 | 2 | 1 | 0 | 0 | 0 |
| Prefer. rating | + | + | 0 | - | - | - | - | - | - |

Table 7. Percent of herd area and percent of horse observations falling in progressive 10% slope categories. The +, o, and − preference ratings indicate significantly favored, no preference, and avoided categories respectively ($P<.02$). Respective N's for herds A,B,D, and E are 47,64,152, and 100.

| | | Grade % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Herd | | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
| A | Herd area % | 11 | 21 | 21 | 11 | 19 | 10 | 5 | 2 | 0 |
| | Horse obs. % | 47 | 36 | 11 | 2 | 4 | 0 | 0 | 0 | 0 |
| | Prefer. rating | + | 0 | 0 | 0 | - | - | 0 | 0 | |
| B | Herd area % | 13 | 31 | 29 | 14 | 3 | 3 | 4 | 1 | 2 |
| | Horse obs. % | 30 | 58 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Prefer. rating | + | + | - | - | - | - | - | 0 | 0 |
| D | Herd area % | 27 | 30 | 24 | 10 | 4 | 3 | 1 | 0 | 1 |
| | Horse obs. % | 43 | 41 | 11 | 4 | 1 | 0 | 0 | 0 | 0 |
| | Prefer. rating | + | 0 | - | - | 0 | - | 0 | | 0 |
| E | Herd area % | 13 | 16 | 20 | 20 | 12 | 7 | 5 | 3 | 5 |
| | Horse obs. % | 43 | 20 | 23 | 5 | 5 | 3 | 0 | 0 | 1 |
| | Prefer. rating | + | 0 | 0 | - | - | 0 | - | - | - |

E occupied more rugged habitat (respective average slope 30 and 34%) than did herds B and D (respective average slope 24 and 20%). Initial negative preference for slope with herds A and E was detected at 40 and 30%, respectively. Herds B and D initially demonstrated negative preference for the 20 to 29% category. Thus, it appears that horses having a greater proportion of gentle habitat available were less inclined to occupy steep slopes than those animals inhabiting more rugged habitats.

Spearman's coefficient of rank correlation ($r_s$) was used to compare rankings of Kulczynski's similarity indices derived from both the animal observations and available slope data for the 4 herds (Table 8). Intuitively one would expect patterns of herbivore utilization to be most similar where habitats demonstrate the greatest degree of similarity. No significant correlation was revealed, however, between the rankings of the 2 similarity indices ($P > .05$, $r_s = -0.47$).

Herds A and D showed the highest similarity in utilization of slopes (93%) but ranked only fifth (71%) out of the 6 possible comparisons in similarity of habitat. Herds B and D ranked highest in the similarity of habitats (85%) and shared the lowest rating of 62% similarity in utilization of slopes with the comparison of herds B and E.

These data demonstrate horses did not respond as expected relative to the similarities in habitat. Therefore, factors other than slope composition should be considered to thoroughly understand or predict patterns of slope use by horses. Other attributes of a site which may affect their use of slopes include:

Table 8. Similarities (%) of slope utilization and slope availability for 4 herds of horses and their habitat on the Three Fingers study area. Numerical pairs indicate percent similarity in animal utilization and percent similarity in defined habitat, respectively.

| Herd | B | D | E |
|---|---|---|---|
| A | 77 75 | 93 71 | 80 84 |
| E | 62 76 | 79 68 | |
| D | 62 85 | | |

spatial distribution of topographic features, proximity and distribution of forage and water, and presence or absence of natural or artificial barriers.

Patterns of Use on Plant Communities

Because horses were not distributed over the entire study area, data on use of plant communities were analyzed on both a population and a herd basis. Available habitat for population analysis included all the area and plant communities north of the Leslie Gulch road. Available habitat for the herd analysis included only those areas and plant communities contained by the defined boundaries of herds A, B, D, and E (Figure 7). Because the area defined for the entire population of horses was larger (312.5km$^2$) than that enclosed by the 4 herd boundaries (125.2 km$^2$), the population analysis contained greater diversity and different proportions of plant communities than the herd areas (Tables 9 and 10).

Horses did not utilize plant communities in a random fashion in the population or herd analyses ($P<.01$). As a population, horses demonstrated significant ($P<.02$) positive selection for 3 communities (Table 9). These were the bluebunch wheatgrass, Wyoming big sagebrush/Sandberg's bluegrass, and low sagebrush/ Sandberg's bluegrass communities.

The bluebunch wheatgrass community occupied less than 0.5% of the area and contained 2% of the observations of horses. As these numbers are rather small proportions of the whole, they are probably of little significance from a management standpoint.

The positive preference of the population for the Wyoming big sagebrush/ Sandberg's bluegrass and low sagebrush/Sandberg's bluegrass communities, while significant ($P<.02$), seems unusual for a herbivore requiring large amounts of forage. As herbaceous

Table 9. Percent of study area and percent of horse observations occurring in each plant community north of Leslie Gulch. The +, 0, and − preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively ($p<.02$). N= 430.

| | Community | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | High ecologic condition | | | | | | Low ecologic condition | | | | |
| | Wyoming big sagebrush/ bluebunch wheatgrass | Low sagebrush/blue- bunch wheatgrass | Bluebunch wheatgrass | Cliff rock | Gravel slopes | Other 2/ | Wyoming big sagebrush/ cheatgrass | Wyoming big sagebrush/ Sandberg's bluegrass | Low sagebrush/ Sandberg's bluegrass | Cheatgrass | Low sagebrush/ cheatgrass |
| Study area % | 30 | 4 | t | 1 | t 1/ | 8 | 20 | 25 | 10 | 2 | t |
| Horse observations % | 23 | t | 2 | 0 | 0 | 0 | 21 | 35 | 18 | t | 1 |
| Preference rating | − | − | + | − | − | − | 0 | + | + | − | 0 |

1/ t = less than 0.5%.

2/ Other = shrub scabland, bitterbrush/grass, stiff sagebrush/Sandberg's bluegrass, mountain mahogany/grass, and silver sagebrush.

production for these 2 communities was less than 160 kg/ha, the population appeared to favor the least productive, low ecologic condition communities on the area. The Wyoming big sagebrush/cheatgrass and Wyoming big sagebrush/bluebunch wheatgrass communities, with much greater herbaceous production (>700 kg/ha), received either no preference or negative preference ratings.

Because the densities of horses varied considerably over the area (Figure 5), and plant communities were not evenly distributed about the area (Figure 4), analysis and interpretation of the population data were greatly confounded. Data derived from the herds, however, presented more realistic and interpretable examples of habitat utilization and animal preferences.

Herd A (Figure 7 and Table 10) made greatest use (77%) of the Wyoming big sagebrush/bluebunch wheatgrass community. Eighty five percent of the range supported this community, however, and it received a no preference rating. This community and most of the observations of horses occurred on the upper elevations of the herd area. The Wyoming big sagebrush/cheatgrass community received a positive preference rating by herd A. More of this community was available than the data indicate. Numerous islands of Wyoming big sagebrush/cheatgrass, too small to be included on the vegetation map, were scattered within the Wyoming big sagebrush/bluebunch wheatgrass vegetation. These islands contained most of the observations of horses in the Wyoming big sagebrush/cheatgrass community. Their combined area, however, was not substantial enough to alter the results or interpretation of these data.

The Wyoming big sagebrush/Sandberg's bluegrass community

Table 10. Percent of herd area and percent of horse observations occurring in each plant community. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively (P<.02). Respective N's A,B,D,and E= 47, 64, 152, and 100.

| Herd | | Community: Artrwy/Agsp 1/ | Arri/Posa 2/ | cliff rock | shrub scab. | Putr/grass 3/ | Arar/Posa 4/ | Artrwy/Posa 5/ | Artrwy/Brte 6/ | Brte 7/ |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Herd area % | 85 | | | 1 | | | 14 | 1 | |
| | Horse obs. % | 77 | | | 0 | | | 4 | 19 | |
| | Prefer. rating | 0 | | | – | | | – | + | |
| B | Herd area % | 38 | | | 4 | | | 17 | 31 | 10 |
| | Horse obs. % | 64 | | | 0 | | | 23 | 9 | 3 |
| | Prefer. rating | + | | | – | | | 0 | – | – |
| D | Herd area % | 1 | 1 | | 1 | 1 | 29 | 65 | 2 | |
| | Horse obs. % | 1 | 0 | | 0 | 0 | 39 | 57 | 3 | |
| | Prefer. rating | 0 | – | | – | – | + | 0 | 0 | |
| E | Herd area % | 17 | | 2 | 11 | t | 4 | 32 | 32 | 3 |
| | Horse obs. % | 7 | | 0 | 0 | 0 | 2 | 32 | 53 | 6 |
| | Prefer. rating | – | | – | – | 0 | 0 | 0 | + | 0 |

1/ Wyoming big sagebrush/bluebunch wheatgrass
2/ stiff sagebrush/Sandberg's bluegrass
3/ bitterbrush/grass
4/ low sagebrush/Sandberg's bluegrass
5/ Wyoming big sagebrush/Sandberg's bluegrass
6/ Wyoming big sagebrush/cheatgrass
7/ cheatgrass

received a negative preference rating by herd A. In the area occupied by herd A this community was situated in a large, low basin, and was frequented primarily by horses on their way to water.

Horses in herd B made greatest use of, and showed a positive preference for, the Wyoming big sagebrush/bluebunch wheatgrass community. This community was situated on ridge tops and high basins in the eastern half of the herd area. The Wyoming big sagebrush/Sandberg's bluegrass community occurred on gentle slopes and foothills in the southeast corner of the herd area, and contained 2 of the 3 water sources utilized by these horses. Because it was utilized roughly in proportion to its availability, this community received a no preference rating.

The Wyoming big sagebrush/cheatgrass and cheatgrass communities received negative preference ratings by herd B. Both of these communities occupied large, low basins and were frequented more by cattle than by horses.

Herd D made greatest use of, but showed no preference for, the Wyoming big sagebrush/Sandberg's bluegrass community. The low sagebrush/Sandberg's bluegrass community, which occurred on 3 parallel ridges in the eastern one third of McIntyre pasture, was the only community receiving a positive preference rating by herd D. Because both communities supported forage of nearly equal quantity and composition (Table 2), the herd's preference for the low sagebrush/Sandberg's bluegrass community was probably correlated with its topographic position.

Herd E made greatest use of, and showed positive preference for, the Wyoming big sagebrush/cheatgrass community. This community covered 32% of the herd area and supported 53% of the observations of horses. The Wyoming big sagebrush/Sandberg's bluegrass community also occupied 32% of the herd area. It supported 32% of the observations of horses, and received a no preference rating. The largest blocks of this community were peripheral to the outlined herd area and occurred on foothill and basin topography. This, coupled with the greater herbaceous production of the Wyoming big sagebrush/cheatgrass community may explain why this herd did not favor the Wyoming big sagebrush/Sandberg's bluegrass community.

When examined on a herd basis, the horses were most frequently observed in the community making up the greatest proportion of their defined range. Three of the 4 herds (A, B, and E) made greatest use of, or favored, plant communities producing in excess of 700 kg/ha of forage annually. Ninety six percent of the range occupied by herd D was dominated by a Sandberg's bluegrass understory, so this herd had little opportunity to demonstrate a preference for a more productive community.

The shrub scabland community received a negative preference rating from each herd. Because average slope for this community was 45%, and herbaceous production was virtually non existent in the understory, horses had little inclination to occupy areas supporting this community.

No community received a positive preference rating from each of the herds. This, coupled with the fact that each herd made greatest use of the most prevalent community in its area indicated that horses were not selective for any specific community. Similarities of habitat use and habitat composition showed significant ($P < .01$, $r_s = 0.94$) agreement in ranking (Table 11). Average similarity of habitat composition ($\bar{x} = 44.7$), however, was greater than the average similarity of habitat utilization ($\bar{x} = 37.0$) demonstrated by the 6 herd combinations. Since habitats were more similar than utilization patterns, other factors must have influenced distribution of horses. Distribution patterns of communities, relationships of communities to topographic features, distribution of water sources, and the horses' character of occupying areas with a commanding view may all affect their selection of habitats.

Table 11. Similarity of plant community utilization and plant community availability for 4 herds of horses on the Three Fingers study area. Numerical pairs indicate percent similarity in animal utilization and percent similarity in defined habitat, respectively.

| Herd | B | D | E |
|---|---|---|---|
| A | 74 54 | 8 17 | 30 33 |
| E | 42 72 | 38 40 | |
| D | 27 52 | | |

## Availability of Water on the Study Area

Because the Riverside pasture provided the greatest opportunity for animals to disperse from water (Figure 10), only observations from that pasture and the Spring Creek area were summarized. Average distance between single point water sources in Riverside was 1.74 km. If the Owyhee Reservoir and Spring Creek were included, 64% of the Riverside-Spring Creek area was within 1600 m of permanent water. When compared to other western ranges, however, animals had little opportunity to exercise their full capacity to range away from water (Pellegrini 1971, Green and Green 1977).

## Seasonal Distances of Sightings From Water

Average minimum and maximum seasonal distances of sightings of horses from water were 1.53 and 2.12 km, respectively, for summer 1979 and winter 1980 (Table 12). No significant differences were detected between seasons ($P>.05$). A trend, however, showing movement away from permanent water as seasons progressed from summer through fall, winter, and spring was evident and corresponded with the filling and drying of small natural catchments about the area. Generally horses made very little use of the Owyhee Reservoir as a water source, however, horses north of Wildhorse Creek and those in Sheephead basin habitually watered from the lake. Steep slopes bordering much of the lake shore probably restricted their use of this source in the remaining areas.

In general horses ranged further from water than any other large herbivore on the area. I attribute this to their preference

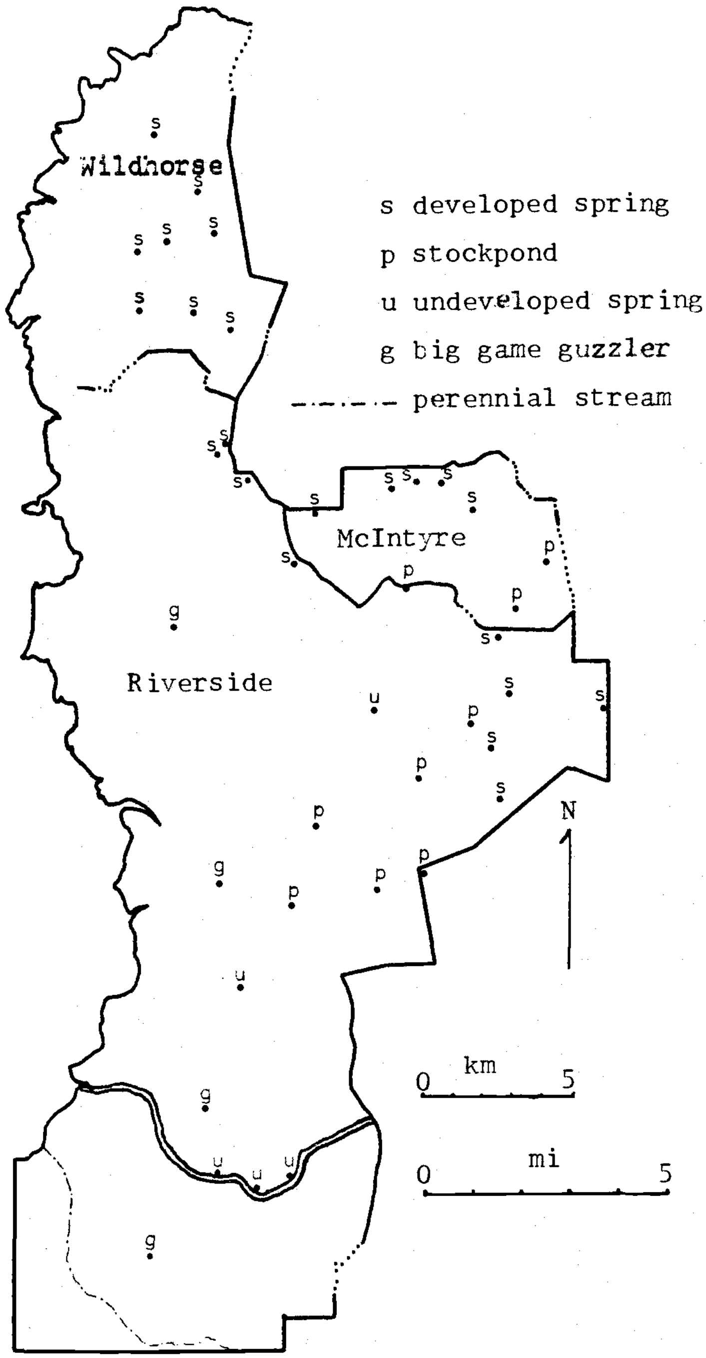



Figure 10. Distribution and type of permanent water sources on the study area.

Table 12. Average seasonal distance (km) from permanent water in the Riverside-Spring Creek areas for cattle, bighorn, deer, and horses. No significant differences were found between means in columns. Means in rows sharing a common underline are not significantly different (P>.05).

| Season and year | Cattle | Bighorn | Deer | Horse |
|---|---|---|---|---|
| Summer 1979 | | .94 | | 1.53 |
| Fall 1979 | 1.00 | .88 | 1.49 | 1.89 |
| Winter 1979 | | 1.09 | 1.32 | 1.91 |
| Spring 1980 | .92 | 1.10 | 1.46 | 1.99 |
| Summer 1980 | .98 | 1.24 | | 1.59 |
| Fall 1980 | | 1.09 | 1.10 | 1.92 |
| Winter 1980 | | .79 | 1.00 | 2.12 |

to occupy high ridges and plateaus, a habit which would naturally remove them from water in low lying areas.

Conclusions

When this study was initiated in April 1979, 133 horses were identified on the area with 32% of the initial population being females. The population reached a maximum of 171 during late spring of 1980, demonstrating an annual rate of increase of 13%. Theoretically at this rate 5.7 years are required for the population to double in size. Had the population supported an equitable sex ratio with an equivalent birth rate, the theoretical rate of increase would have been 21%. At this rate only 3.7 years are required for population doubling. Detected mortality for the 2 year field period was 4 animals. Two of these were adults, and 2 were young of the year.

Bands and studs on the area segregated into 6 distinct herds. Very few inter-herd encounters or inter-herd exchanges of animals occurred. Herd boundaries consisted of fences, natural barriers, or major drainages. As each of these boundaries were often passable, herds appeared to be the result of voluntary associations and loyality to an area.

The number of bands of horses ranged between 21 and 25 with mature animals showing a high level of fidelity to their bands. Most inter-band animal exchanges and band formations occurred during the spring breeding seasons and involved acquisitions or exchanges of recently maturing animals.

Both bands and studs remained within well-defined home ranges. Respective convex polygon estimates of home range size were 11.8 and 12.3 $km^2$. With 90% confidence ellipse procedures band and stud home ranges averaged 28.3 and 25.8 $km^2$, respectively. Due to small numbers of relocations, ellipse procedures probably provided the most accurate estimate of home range size. Horses showed no seasonal shifts of home ranges. One band and 2 studs made permanent shifts of their home ranges.

Band and stud home ranges overlapped substantially with no territorial behavior exhibited by horses. No significant ($P>.05$) correlations between home range size and number of horses per band or forage production were detected. Significant ($P<.05$), but weak, correlations between home range size and water source densities were obtained.

Average minimum and maximum seasonal distances of sightings of horses from water sources were 1.5 and 2.1 km, respectively. While no significant ($P>.05$) differences were detected between seasons, a trend showing movement of horses away from permanent water as seasons progressed from summer through fall, winter, and spring was evident and corresponded with the filling and drying of small natural catchments about the area. Horses watered most often during the first and last periods of the day. Elapsed time at watering sites averaged 16.1 minutes, with horses rapidly vacating the area after drinking.

Feeding efforts averaged 68% of the horses' daylight activities with morning, midday, and early evening being the 3 peak foraging periods. Resting averaged 18% of daylight activities. Other activities, primarily traveling and drinking, accounted for an average of 14% of the day.

Horses tended to occupy ridgetops and high basins but avoided steeper slopes. As a population horses favored slopes between 0 and 19%, were indifferent to slopes between 20 and 29%, and avoided slopes greater than 30%. Patterns of slope use by horses changed slightly with variation in habitat. A herd in less rugged terrain made less use of steeper topography than herds inhabiting more rugged habitats. Animals on smoother terrain showed a negative preference rating when slopes exceeded 20%. Animals occupying the most rugged area initially showed a negative preference rating when slopes exceeded 40%.

Horses in general made greatest use of the plant community occupying the largest proportion of their habitat. They did not show a universal preference for any single community, however, and thus were not selective for any particular community. Use of plant communities by horses appeared to be strongly influenced by the topographic features of the area in question. Typically they favored elevated, but level ground, providing a commanding view over the surrounding areas. Three of the 4 herds examined showed a positive preference for communities producing in excess of 700 kg/ha of herbaceous material annually. The fourth herd had little opportunity to occupy productive communities as 96% of their habitat produced less than 160 kg/ha annually. When similarities of habitat composition and habitat utilization were compared, habitats were more similar than the plant community utilization patterns of the horses. This suggested that factors other than plant community composition affect the distribution of horses over the landscape.

# Cattle

## Distribution on the Study Area

Because the bulk of cattle sightings were north of Leslie Gulch road (Figure 11), only data from that area were used to evaluate cattle habitat use. Data on use of slopes and use of plant communities by cattle were analyzed on both a population and a pasture basis.

The permitted cattle grazing season was April through October for both years of study. Dates of use and AUM's supported on a pasture basis are found in Appendix 2. Scheduled use for 1979 included 863 AUM's in Wildhorse pasture. Livestock movement into the pasture, however, was voluntary in nature as east boundary gates were opened but no cattle were driven into the area. Actual use was approximately 40 AUM's for 1979. In 1980 cattle were moved to the pasture, however, no animals were placed north of Wildhorse Creek where adequate forage and water were available. That area was used almost exclusively by horses and deer throughout the study.

## Patterns of Daily Activity

Activity patterns of cattle were derived from 3199 observations. Cattle feeding activities averaged 57% of daylight observations. Peak periods of feeding were early morning and late evening when 75 to 85% of the observations were so involved (Figure 12). Resting averaged 39% of daylight observations and was most extensive during late morning and afternoon periods.

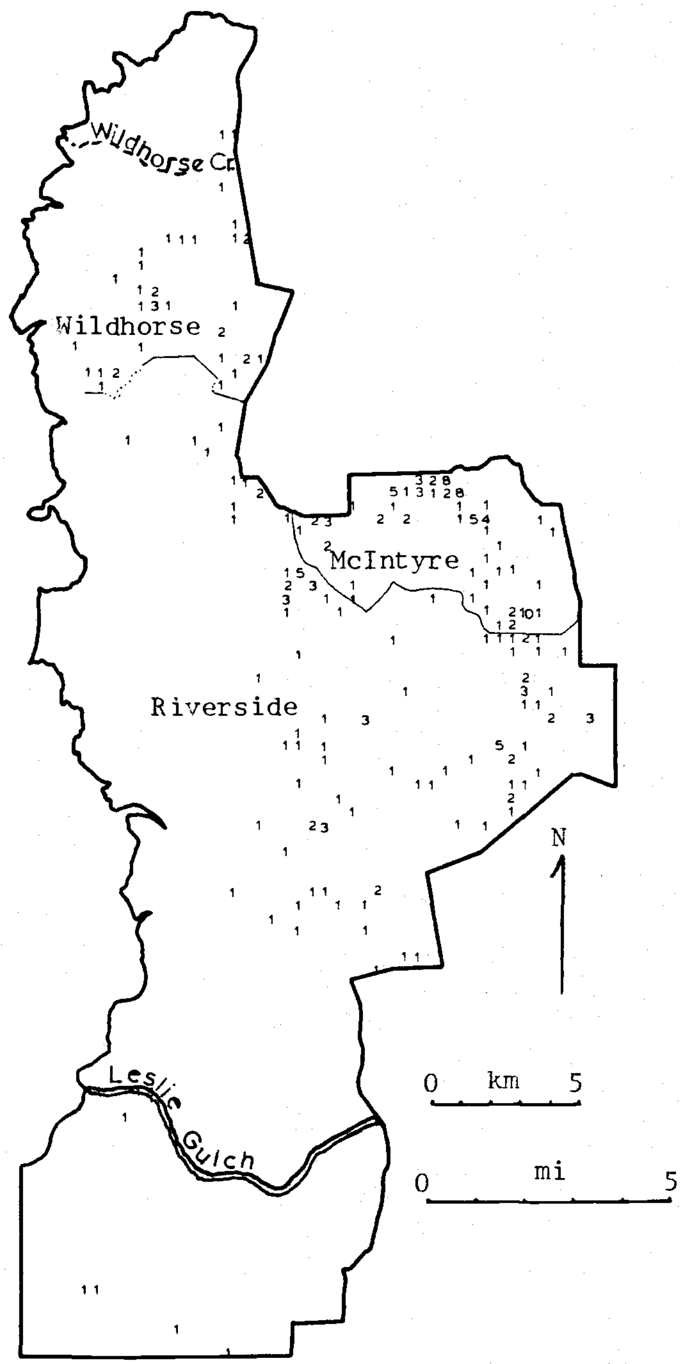



Figure 11. Distribution of cattle sightings over the Three Fingers study area. Numerals indicate number of relocations at that coordinate. N = 247.

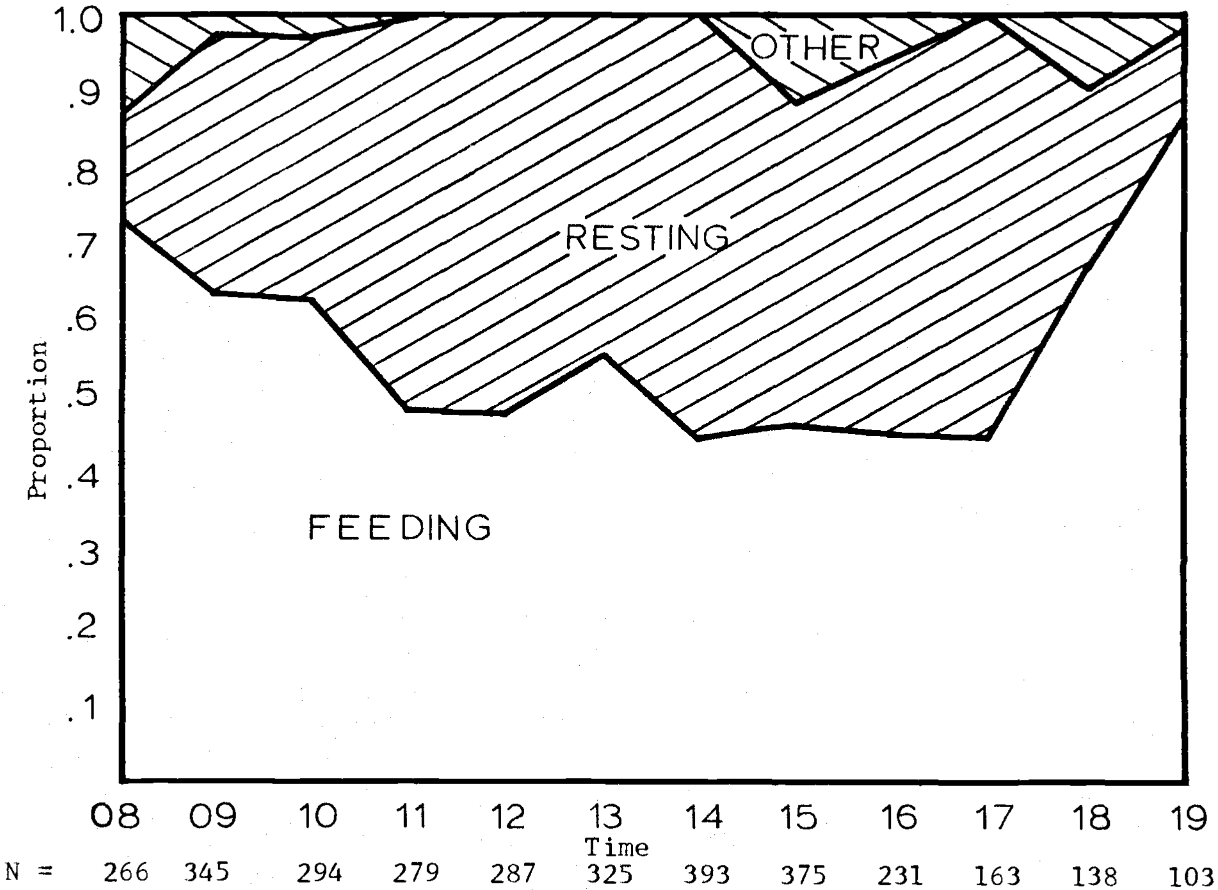



Figure 12. Daily cattle activity patterns on the Three Fingers study area.

Cattle tended to water during these same periods and often paused to rest in the vicinity of water holes.

Other activities, primarily traveling, averaged only 4% of the cow's day. Cattle are active at night (Rittenhouse *et al.* 1982), however, no night observations were attempted.

Patterns of Slope Utilization

The average slope of the areas occupied by cattle was 5.8%. The upper limit for a cattle sighting was 1 observation on a 70% grade. All other observations were on less than 40% slopes.

Chi square analysis indicated cattle did not occupy slopes in a random manner ($P<.01$). As a population cattle favored the 0-9% category, were indifferent to slopes between 10 and 19%, and showed a negative preference for grades above 20% (Table 13). If slope was considered the single determining factor governing cattle utilization, approximately 66% of the area north of Leslie Gulch would fall into significantly ($P<.02$) avoided categories.

Results were slightly different within pastures. Cattle still showed a positive preference for 0-9% slopes. In the more rugged pastures cattle were indifferent to 10-19% slopes. This occurred in Wildhorse and Riverside pastures where respective slope compositions averaged 35 and 37%. In the McIntyre pasture, however, where slopes averaged 19%, a negative preference rating surfaced for the 10-19% category. Slopes greater than 20% received negative preference ratings in all 3 pastures. The no preference ratings for the 40-49 and 50+% categories in McIntyre pasture result from an inability of the statistical procedures to detect differences between small proportions, and are not truly indicative of cattle preferences.

In general these data indicate cattle inhabiting rugged terrain will make slightly greater use of slopes than animals inhabit-

Table 13. Percent of study area, pasture, and observations of cattle occurring in progressive 10% slope categories. Study area data includes only the area north of Leslie Gulch. The +, 0, and − preference ratings indicate significantly favored, no preference, and avoided categories, respectively (P<.02). N= 222, 33, 79, and 110.

| | Grade % | | | | | |
|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50+ |
| Study area % | 15 | 19 | 15 | 14 | 11 | 26 |
| Cattle obs. % | 76 | 18 | 4 | 3 | 0 | 0 |
| Prefer. | + | 0 | − | − | − | − |
| Wildhorse pasture % | 11 | 20 | 19 | 13 | 10 | 27 |
| Cattle obs. % | 79 | 18 | 3 | 0 | 0 | 0 |
| Prefer. | + | 0 | − | − | − | − |
| McIntyre pasture % | 23 | 36 | 24 | 11 | 2 | 4 |
| Cattle obs. % | 82 | 15 | 3 | 0 | 0 | 0 |
| Prefer. | + | − | − | − | 0 | 0 |
| Riverside pasture % | 16 | 17 | 13 | 14 | 12 | 28 |
| Cattle obs. % | 70 | 20 | 5 | 5 | 0 | 0 |
| Prefer. | + | 0 | − | − | − | − |

ing less rugged topography. Pastures averaged a 74% similarity in slope composition while similarities of slope use by cattle averaged 92% (Table 14). This suggests that patterns of slope utilization are well ingrained in cattle and that patterns of slope use are subject to only slight alteration despite more substantial differences in habitat.

Table 14. Similarities of slope utilization by cattle and slope availability in 3 pastures on the Three Fingers study area. Numerical pairs are percent similarity in utilization by cattle and percent similarity in habitats, respectively.

| Pasture | McIntyre | Riverside |
|---|---|---|
| Wildhorse | 97 67 | 91 91 |
| Riverside | 88 63 | |

Patterns of Use on Plant Communities

Chi square analysis rejected the hypothesis that cattle used plant communities in proportion to their availability on the area ($P<.01$). Pooling and analysis of data obtained north of Leslie Gulch showed 4 of the 5 communities in low ecologic condition receiving positive preference ratings (Table 15). The fifth community, low sagebrush/cheatgrass, received no use by cattle. Its minute presence on the area, however, prevented statistical procedures from assigning it a negative preference rating.

Of the communities in high ecologic condition, only the Wyoming big sagebrush/bluebunch wheatgrass and the "others" category occupied enough area to be of management significance. Both received negative preference ratings. The Wyoming big sagebrush/bluebunch wheatgrass community, which occupied 30% of the area north of Leslie Gulch, contained only 5% of the sightings of cattle. The "others" category also received a negative preference rating. Seven eighths of the 8% in the "other" category consisted of shrub scabland vegetation.

Preferences were quite similar when data were presented on a pasture basis (Table 16). Cattle still showed a positive preference only for communities in low ecologic condition and a negative preference for high ecologic condition communities in all 3 pastures. The Wyoming big sagebrush/cheatgrass community received a positive preference rating in all 3 pastures. The cheatgrass and Wyoming big sagebrush/Sandberg's bluegrass communities received positive preference ratings in Wildhorse and Riverside

Table 15. Percent of study area and percent of cattle observations occurring in each plant community. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively ($P<.02$). N = 224.

| | Community | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | High ecologic condition | | | | | | Low ecologic condition | | | | |
| | Wyoming big sagebrush/ bluebunch wheatgrass | Low sagebrush/blue- bunch wheatgrass | Bluebunch wheatgrass | Cliff rock | Gravel slopes | Others[1] | Wyoming big sagebrush/ Sandberg's bluegrass | Wyoming big sagebrush/ cheatgrass | Low sagebrush/ Sandberg's bluegrass | Low sagebrush/ cheatgrass | Cheatgrass |
| Study area % | 30 | 4 | t[2] | 1 | t | 8 | 25 | 20 | 10 | t | 2 |
| Cattle observations % | 5 | 0 | 0 | 0 | 0 | 0 | 43 | 32 | 14 | 0 | 6 |
| Preference rating | – | – | – | – | – | – | + | + | + | 0 | + |

1/ includes shrub scabland, bitterbrush/grass, stiff sagebrush/Sandberg's bluegrass, mountain mahogany/grass, and silver sagebrush

2/ less than 0.5%

Table 16. Percent of pasture and percent of observations of cattle occurring in each plant community. The +, 0, and − preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively ($P < .02$). Respective N's for Wildhorse, McIntyre, and Riverside pastures = 33, 81, and 110.

| | Community | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | High ecol. cond. | | | | Low ecol. cond. | | | |
| Pasture | Artrwy/Agsp 1/ | Agsp 2/ | Arar/Agsp 3/ | Others 4/ | Artrwy/Posa 5/ | Arar/Posa 6/ | Artrwy/Brte 7/ | Brte 8/ |
| Wildhorse | | | | | | | | |
| Area % | 67 | | | 5 | 10 | | 12 | 6 |
| Cattle obser. % | 12 | | | 0 | 18 | | 37 | 33 |
| Prefer. rating | − | | | − | 0 | | + | + |
| McIntyre | | | | | | | | |
| Area % | 1 | | | 3 | 66 | 28 | 2 | |
| Cattle obser. % | 0 | | | 0 | 61 | 24 | 15 | |
| Prefer. rating | − | | | − | 0 | 0 | + | |
| Riverside | | | | | | | | |
| Area % | 25 | 1 | 5 | 11 | 23 | 10 | 24 | 1 |
| Cattle obser. % | 6 | 0 | 0 | 0 | 36 | 11 | 44 | 3 |
| Prefer. rating | − | − | − | − | + | 0 | + | 0 |

1/ Wyoming big sagebrush/bluebunch wheatgrass
2/ bluebunch wheatgrass
3/ low sagebrush/bluebunch wheatgrass
4/ includes cliffrock, gravel slopes, low sagebrush/cheatgrass, shrub scabland, bitterbrush/grass, stiff sagebrush/Sandberg's bluegrass, mountain mahogany/ grass, and silver sagebrush
5/ Wyoming big sagebrush/Sandberg's bluegrass
6/ low sagebrush/Sandberg's bluegrass
7/ Wyoming big sagebrush/cheatgrass
8/ cheatgrass

pastures, respectively. The low sagebrush/Sandberg's bluegrass community was used roughly in proportion to its availability in both the McIntyre and Riverside pastures and was assigned a no preference rating in both cases.

Cattle showed a greater preference for communities supporting cheatgrass understories than for communities with Sandberg's bluegrass understories. In 4 out of 5 instances the cheatgrass understory received positive preference ratings while 4 out of 5 occurrences of Sandberg's bluegrass received no preference ratings. This was most likely a response to the greater herbaceous production (>700 kg/ha) exhibited by the cheatgrass communities. Where Sandberg's bluegrass dominated the understory herbaceous production averaged less than 160 kg/ha.

The disparity between levels of cattle utilization on low and high ecologic condition communities was probably a result of the slope-plant community relationships of the area. Cattle avoided grades exceeding 20%, and nearly 80% of the study area occupied by high ecologic condition communities occurred on areas where slopes were greater than 20%. The low ecologic condition communities contained 95% of the observations of cattle on the area. Fifty one percent of the low ecologic condition communities occurred where slopes were less than 20%.

Similarities of the 3 pastures (based on the availability of plant communities) averaged 36%, while comparisons of the utilization patterns of cattle produced an average similarity of 53% (Table 17). This indicated that cattle responded less than

Table 17. Similarity of plant community utilization by cattle and plant community availability in 3 pastures on the Three Fingers study area. Numerical pairs indicate percent similarity in animal utilization and percent similarity in defined habitats, respectively.

| Pasture | McIntyre | Riverside |
|---|---|---|
| Wildhorse | 33 16 | 64 53 |
| Riverside | 62 39 | |

expected to substantial differences in the compositions of the 3 pastures. This observation is somewhat explained by the positive preference of cattle for gentle topography and the fact that relatively level ground was both limited in area and typically associated with plant communities in low ecologic condition.

Seasonal Distances of Sightings From Water

Distance from water for sightings of cattle averaged 0.97 km ($\pm$ 0.1, 95% CI) in the Riverside pasture. Data for cattle in the Riverside pasture were available for the fall of 1979 and spring and summer of 1980 (Table 12). During these periods sightings of cattle were significantly ($P<.05$) closer to water than the observations of horses. Distances for cattle, however, were generally less than, but not significantly ($P>.05$) different from, distances traveled by bighorn or deer.

## Conclusions

Cattle grazing was permitted on the area from April first through October during both years of study. The greatest proportion (57%) of their daylight activities involved foraging efforts. The 2 highest peaks in feeding occurred in early morning and late even- when 75 and 85% of the observations were so engaged. Resting averaged 39% of their daylight activities and was most concentrated around the late morning and afternoon periods. Other activities, primarily traveling, averaged only 4% of the cow's day.

Cattle did not use slopes at random on the area, but prefered relatively gentle topography. The average slope of the areas occupied by cattle was 5.8%. Where topography was rugged, cattle favored 0-9% slopes and were indifferent to slopes in the 10-19% category. In more gentle terrain cattle showed a negative preference rating for slopes greater than 10%. This suggested cattle inhabiting rugged terrain will make slightly greater use of steep slopes than cattle occupying less rugged topography. Substantial differences in the topographic compositions of pastures, however, resulted in only slight changes in the use of slopes by cattle.

Cattle on the area showed an avoidance for the plant communities in high ecologic condition and either no preference, or preference for communities in low ecologic condition. This was probably a result of the slope-plant community relationships of the area. Cattle made little use of grades exceeding 20%, and nearly 80% of the study area occupied by high ecologic condition communities occurred on areas where slopes were greater than 20%. Fifty one percent of the low ecologic condition communities occurred wher slopes were less than 20%.

Cattle showed a greater preference for communities supporting cheatgrass understories than for communities with Sandberg's bluegrass understories. Most likely this was a selection for the greater forage availability (>700 kg/ha) provided by the cheatgrass.

Average distance from water for sightings of cattle was 0.97 km in the Riverside pasture. In general, cattle remained closer to water than horses, deer, and bighorn sheep. Observations of cattle were significantly ($P<.05$) closer to water than were those of horses, but comparisons of cattle among deer and bighorn produced no significant ($P>.05$) differences. Throughout the study area cattle made greater use of areas close to water than the other large herbivores.

# Deer

## Distribution and Population Characteristics

During both years of study deer occupied the area primarily from late October through late April. Eighty nine percent of the sightings of deer occurred during those periods. Deer were more evenly distributed over the study area than any of the other large herbivores (Figure 13). Areas A, B, and C were winter range concentration areas. Groups of 25 - 50 animals were frequently sighted in areas B and C, while area A supported a smaller number of animals (15-25). Sightings of deer in McIntyre and Wildhorse pastures were generally of fewer animals (1-5). The entire study area was assumed available to deer for analyses of slope and plant community data.

Total number of deer sighted on the area was 1467. Average group size was 8.5 animals. A total of 1157 animals were classified to sex and age with yearling females being classified as mature animals. During the winter of 1979 (October - April) the fawn to doe ratio was 73.8 fawns/100 does. The ratio during the second winter of study was 68.9/100. Respective buck to doe ratios for the same periods were 14.1/100 and 12.9/100.

Remains from approximately 15 deer were found on the area each winter and were probably the result of coyote predation. Remains of one buck taken by poachers were found in Leslie Gulch in October of 1980.

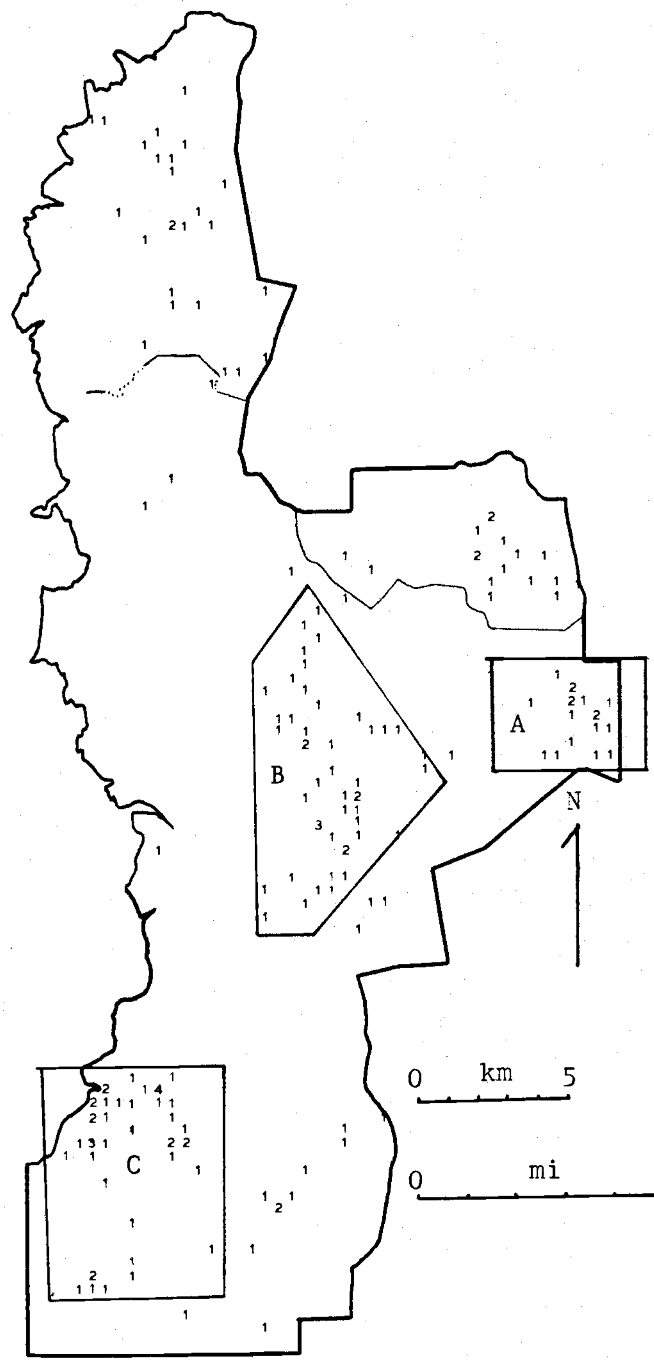



Figure 13. Distribution of deer sightings on the Three Fingers study area. Numerals designate number of sightings at each coordinate. Letter designated blocks indicate winter concentration areas. N= 177.

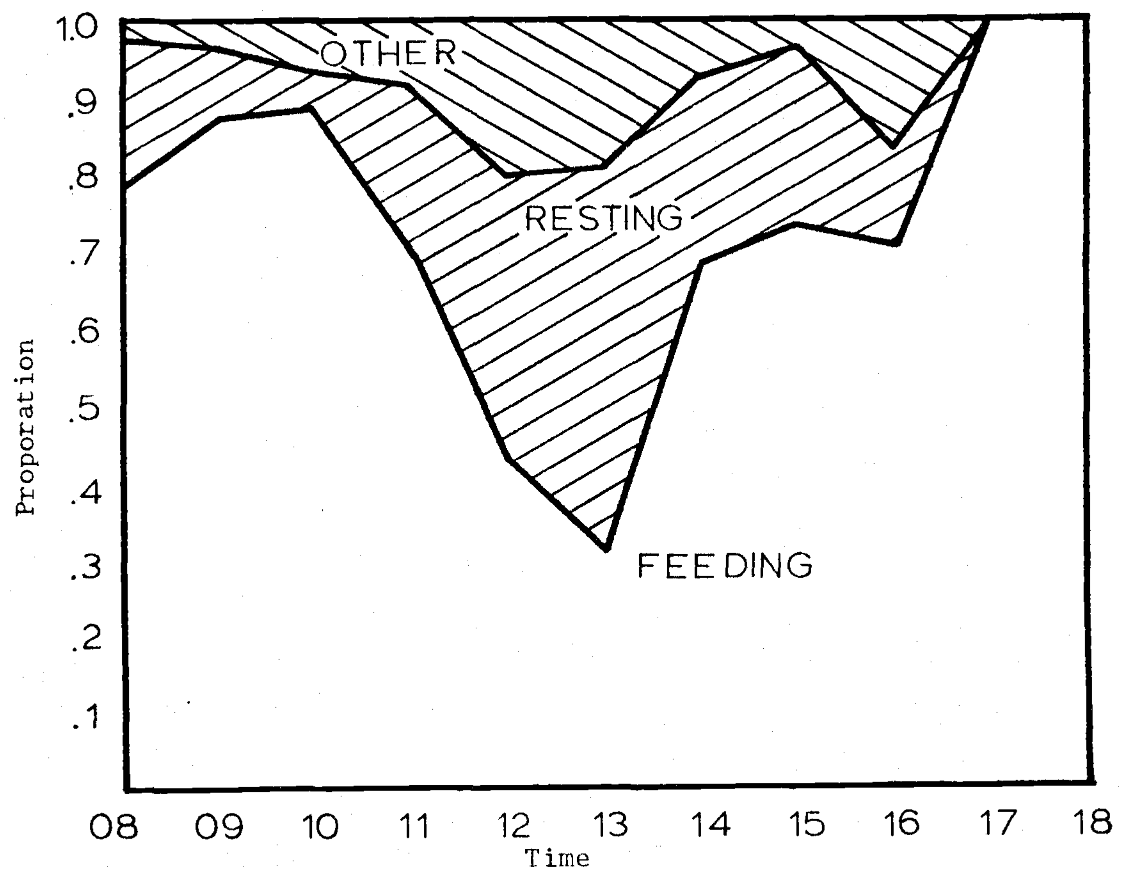
## Patterns of Daily Activity

Activity patterns of deer were derived from 1452 observations. Feeding activities averaged 74% across the day (Figure 14). Feeding intensity peaked in midmorning and early evening when 87 to 100% of the observed animals were eating. Resting peaked at midday when 50% of the animals were inactive. Resting decreased to zero during the last hour of the day when all animals were feeding. "Other" activities averaged 8% across the day, consisted primarily of traveling, and were most concentrated at midday and midafternoon. Deer are active at night, but my efforts at night observations were unsuccessful.

## Patterns of Slope Utilization

Deer generally showed an affinity for basins and their surrounding hillsides. Their observed upper limit of slope use was 2 observations on 75% grades. Average grade for occupied areas was 15.7%.

Chi square analysis indicated deer occupied slopes in proportions significantly ($P<.01$) different from those present on the study area (Table 18). Deer demonstrated a significant preference for 0-9% grades ($P<.02$) and used the 10-39% categories in roughly the same proportions present on the area. Grades steeper than 40% were significantly ($P<.02$) avoided except for the 70 to 79% category which received a no preference rating. This was probably a chance intersection of 2 nearly equal proportions and a negative preference rating could probably be safely assigned to that category.




N = 42 218 277 153 144 84 180 131 128 37 11

Figure 14. Daily deer activity patterns on the Three Fingers study area.

Table 18. Percent of study area and percent of deer observations falling in progressive 10% slope categories. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided categories, respectively ($P<.02$). N= 173.

| | Grade% | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
| Study area % | 15 | 18 | 14 | 14 | 11 | 9 | 9 | 3 | 7 |
| deer obs. % | 47 | 19 | 13 | 10 | 4 | 3 | 2 | 3 | 0 |
| Prefer. rating | + | 0 | 0 | 0 | – | – | – | 0 | – |

Patterns of Use on Plant Communities

Chi square analysis rejected the hypothesis ($P < .01$) that deer used plant communities in proportion to their availability on the area. Preference ratings (Table 19) indicated positive selection for cheatgrass and Wyoming big sagebrush/cheatgrass communities. These areas supported nearly 43% of the deer activities on the study area. Overall, communities in low ecologic condition accounted for 73% of the deer sightings, and none of the communities in this category received a negative preference rating.

Communities in high ecologic condition received either negative or no preference ratings with only 27% of the deer sightings occurring on these areas. The bulk of these observations (24%) were in the Wyoming big sagebrush/bluebunch wheatgrass community which was utilized significantly less ($P < .02$) than its availability would suggest.

Deer were probably drawn to cheatgrass areas by an abundance of succulent green feed throughout the winter. Cheatgrass is typically a winter annual. Seeds germinate with adequate fall moisture, and plants pass the winter in a vegetative state. Deer were also attracted to cheatgrass areas which had been heavily grazed by livestock the previous summer. Peak production for the cheatgrass community (area B Figure 14) used most frequently by deer was 942 kg/ha in May 1979. By October, however, only 86 kg/ha of standing forage remained. Similar cheatgrass areas in southern Wildhorse pasture received relatively little cattle use and subsequently relatively little deer use during the winters.

Table 19. Percent of study area and percent of deer observations occurring in each plant community. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively (P<.02). N= 189.

| | Community | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High ecologic condition | | | | | | Low ecologic condition | | | | | |
| | Wyoming big sagebrush/ bluebunch wheatgrass | Low sagebrush/blue- bunch wheatgrass | Bluebunch wheatgrass | Cliff rock | Gravel slopes | Other 1/ | Wyoming big sagebrush/ cheatgrass | Wyoming big sagebrush/ Sandberg's bluegrass | Low sagebrush/ Sandberg's bluegrass | Cheatgrass | Low sagebrush/ cheatgrass | Alfalfa |
| Study area % | 36 | 5 | 1 | 1 | t 2/ | 8 | 17 | 22 | 9 | 2 | t | t |
| Deer observa. % | 24 | 1 | 1 | 1 | 0 | 0 | 36 | 20 | 8 | 7 | 1 | 2 |
| Preference rating | – | – | 0 | 0 | – | – | + | 0 | 0 | + | 0 | 0 |

1/ Other = shrub scabland, bitterbrush/grass, stiff sagebrush/Sandberg's bluegrass, mountain mahogany/ grass, silver sagebrush, and juniper scabland.

2/ t= less than 0.5%

Bitterbrush is generally considered a desireable and palatable species, especially on deer winter ranges. Bitterbrush communities were of limited size and received relatively little deer use on the study area. Small areas dominated by this shrub occurred in area A (Figures 13 and 4), but even there received only light utilization. Successful bitterbrush reproduction was quite evident in all stands on the area. The green feed provided by cheatgrass may have reduced the attractiveness of these areas to deer. In more xeric climatic conditions, or deep snow cover, bitterbrush communities may receive more intense use.

## Seasonal Distances of Sightings From Water

Because deer were present during winter months and are capable of subsisting on snow, their demand for traditional water sources was probably at a minimum. Average distances from water for observations of deer ranged between 1.00 and 1.49 km (Table 12) and were typically intermediate in value when compared to bighorn and horses. No significant differences between seasonal averages of deer were detected ($P>.05$). The fact that observations were slightly closer to water in winter than in other seasons was probably a function of their seeking lower elevations providing an escape from winter snow and not a need for water.

## Conclusions

Deer utilized the study area as winter range with the greatest numbers of animals present from late October through late April. In general, they were more evenly distributed over the study area than any of the other large herbivores. Three areas were identified, however, where large numbers of deer occassionally concentrated. The average fawn to doe ratio for the 2 winter periods was 71.4 fawns/100 does. The average buck to doe ratio for the same periods was 13.5/100.

Deer spent the greatest proportion ($\bar{x}$ = 75%) of their time feeding. Midmorning and early evening were peak foraging periods. Resting peaked at midday when 50% of the deer were inactive.

Deer did not use slopes in a random manner. They showed a positive preference for relatively level topography and were indifferent to slopes between 10 and 39%. Slopes exceeding 40% received negative preference.

Plant communities were not used in a random fashion by the deer. Low ecologic condition communities received either positive or no preference ratings. The cheatgrass and Wyoming big sagebrush/cheatgrass communities received positive preference and together contained 43% of the observations of deer. Deer made greatest use of these communities where they had been previously grazed by livestock. They were probably drawn to these areas by an abundance of green cheatgrass seedlings and the absence of a standing layer of litter. Portions of these communities which were not grazed by cattle received relatively little use from deer in subsequent seasons.

Plant communities in high ecologic condition received either negative or no preference ratings. The Wyoming big sagebrush/ bluebunch wheatgrass community occupied 36% of the area and was assigned a no preference rating. It supported 24% of the observations of deer, however, and should not be dismissed as unimportant.

Bitterbrush, traditionally considered a palatable and desirable species on deer winter ranges, received relatively little use on the area. The green feed provided by cheatgrass may have reduced the attractiveness of these areas to deer. If cheatgrass fails to germinate or heavier snows occur, however, bitterbrush may be of greater importance.

Average distances from water for observations of deer ranged between 1.0 and 1.5 km, and were intermediate when compared to average distances for horses and bighorn sheep. Deer are capable of subsisting on snow, however, and their demands for traditional water sources were probably at a minimum during the winter period.

Bighorn Sheep

Distribution and Population Characteristics

Observations of bighorn were generally concentrated in the Spring Creek and Leslie Gulch areas (Figure 15). Rams were occasionally detected in the Three Fingers Gulch and Honeycombs regions. My returns per time invested were low in those vicinities, however, and use of those areas was not well documented.

Because observations of bighorn were quite concentrated, a 90% confidence ellipse was constructed around the sighting coordinates to define habitat boundaries. Area of the ellipse was 73.3 $km^2$ after discounting unavailable habitat, and available plant community and slope data were derived from the outlined area only.

A total of 811 observations of sheep was documented during the study. Group size ranged from 1 to 65 animals and averaged 6.7 animals per sighting. Throughout the study 691 bighorn were classified to age and sex with yearlings being classified as mature animals. Lambing season on the area spanned a period from mid-March through mid-May. During the first 11 months of study (April 1979 - February 1980) the lamb/ewe ratio was 55.1/100, and the ram/ewe ratio was 42.2/100. In the second year of field work, the lamb/ewe ratio was 53.2/100, and the ram/ewe ratio was 75.2/100. Ram/ewe ratios may be negatively biased as rams were more widely dispersed to the north of Leslie Gulch and may not have been adequately sampled.

Remains of 4 bighorn were found during the study. Bureau of Land Management personnel reported reported remains of a ewe and

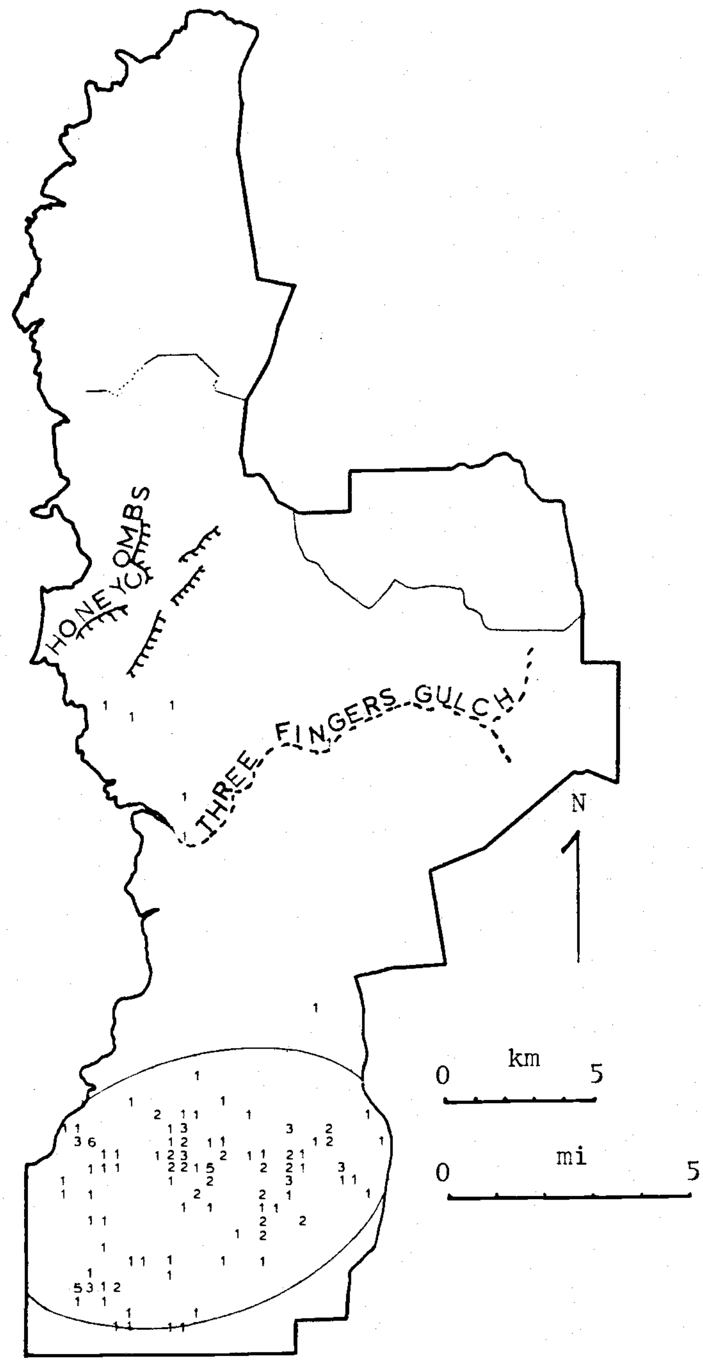



Figure 15. Distribution of bighorn sightings on the Three Fingers study area. Numerals designate number of sightings at each coordinate. N = 131.

lamb in the Spring Creek area. Death was believed to be the result of natural causes. Skeletal remains of a young ram were found approximately 200 m from the Leslie Gulch road during the spring of 1980. All bones were present and unbroken, but decomposition was too advanced to speculate on cause of death. A second ram was killed by poachers and left beside the Leslie Gulch road in Sept. 1980.

Three injured rams were observed on the area. During the 1979 bighorn breeding season one ram lost the entire sheath from one horn and a second ram was observed with a horn broken off nearly flush with the skull. Neither animal was seen again. The third injury detected was in August 1980 and involved a young ram with a broken shoulder.

No evidence of predation on bighorn was encountered during the study. Two instances of golden eagle (*Aquila chrysaetos*) harassment of bighorn were documented, however. In both instances eagles hovered over and made diving passes at ewe-lamb groups but made no physical contact with sheep. Bighorn reacted in both instances by retreating to the bottom of a rocky outcropping where they huddled until eagles left the area.

Patterns of Daily Activity

Activity patterns of bighorn were derived from 770 observations. Feeding dominated most of the day and averaged 68% over all periods. Two peaks of feeding efforts occurred (Figure 16). During early morning and late evening all observations were of feeding animals. Intense feeding also occurred in mid-afternoon when nearly 90% of the bighorn were so engaged.

Resting averaged 23% across the day and was most concentrated after the early morning feeding period when nearly 60% of observed bighorn were inactive. The increase in resting at the 1700 hour may be invalid as the number of observations was small for that period. Other activities consisted primarily of traveling and averaged 9% across the day. These activities peaked in midmorning when sheep were moving from feeding to resting areas and in late evening when they were seeking bed grounds. Bighorn are generally thought to be inactive at night (Van Dyke 1978). I tend to agree as bighorn were often found near their bed grounds on subsequent mornings.

Patterns of Slope Utilization

Chi square analysis rejected the hypothesis that bighorn used slopes in the same proportions available to them ($P<.01$). Null hypothesis rejection was marginal, however, as the tabular $X^2$ value was 20.1 ($P=.01$) and the calculated $X^2$ was 21.2. The preference ratings (Table 20) indicated only 1 category (70-79%) was responsible for the detected significant difference between

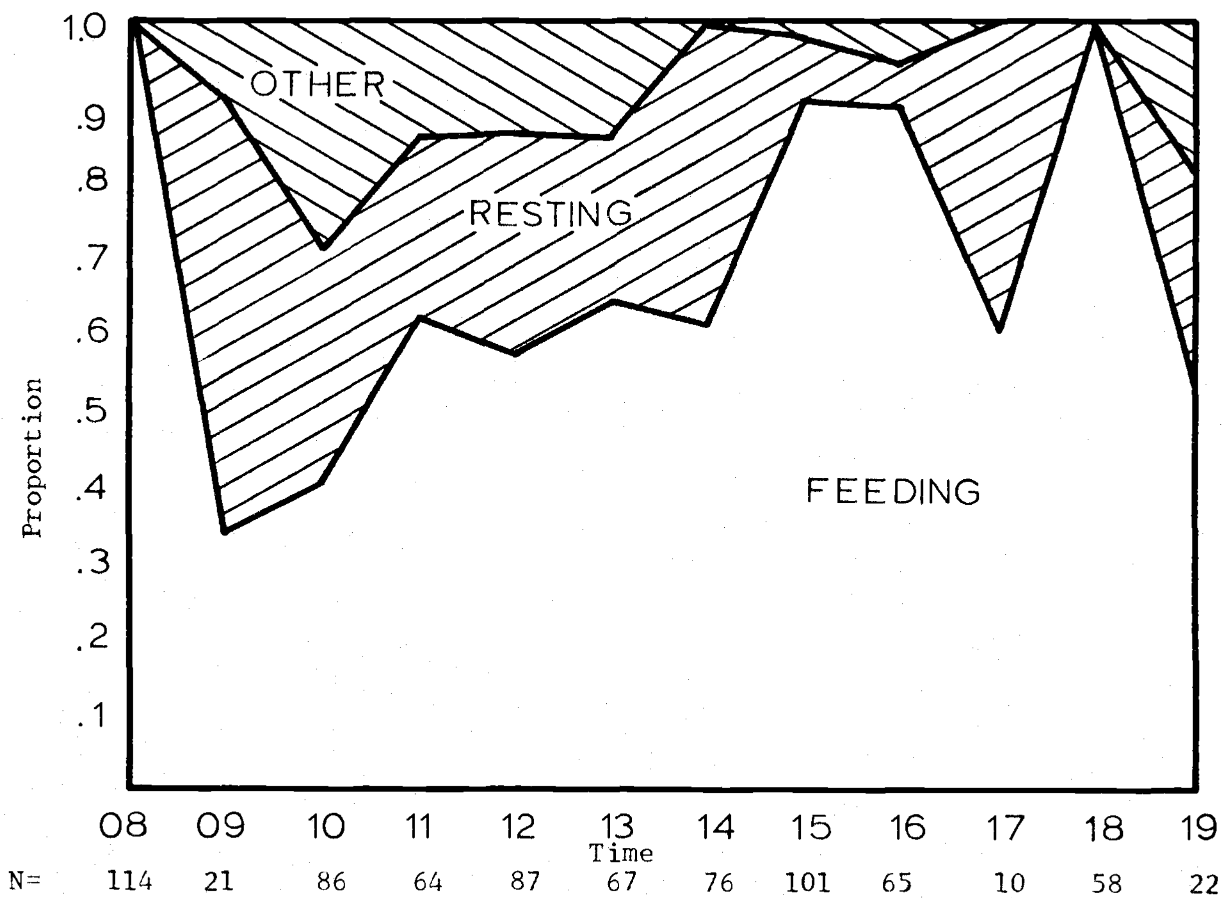



Figure 16. Daily bighorn avtivity patterns on the Three Fingers study area.

Table 20. Percent of range and percent of bighorn observations falling in progressive 10% slope categories. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided categories, respectively ($P<.02$). N = 121.

| | Grade % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
| Study area % | 12 | 10 | 8 | 13 | 12 | 16 | 14 | 5 | 11 |
| bighorn obs. % | 17 | 8 | 5 | 8 | 15 | 11 | 15 | 14 | 7 |
| Prefer. rating | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | 0 |

available and observed distributions. Because no preference ratings spanned the entire range of categories, I believe bighorn activities were not hindered by grades within the range sampled on the area.

Patterns of Use on Plant Communities

Bighorn did not use plant communities in the same proportions available ($P<.01$). Four communities were favored. These were: bluebunch wheatgrass, cliffrock, cheatgrass, and alfalfa (Table 21). Together these communities constituted only 3.9% of the outlined bighorn range and supported 31.5% of the observations of bighorn. Cliff rock areas were used primarily as bighorn resting habitat. Sixty nine percent of the observations in cliffrock were of resting bighorn and the remaining observations involved traveling animals. The bluebunch wheatgrass, cheatgrass, and alfalfa communities were utilized as feeding sites. The alfalfa in the Spring Creek area was used heavily by ewes and lambs during dry summer months. As many as 30 to 40 ewes and lambs could be seen there during morning and evening hours. Alfalfa use was less intense during the summer of 1980. Above average June and July precipitation maintained green growth on more traditional bighorn forages later into summer and probably lessened the attractiveness of irrigated alfalfa. Alfalfa use by bighorn has been tolerated by the landowner to date. If the population continues to increase, however, significant crop damage may occur, particularly in below average precipitation years.

Only the low sagebrush dominated communities and the "others" category were significantly ($P<.02$) avoided by bighorn. The low

Table 21. Percent of study area and percent of bighorn observations occurring in each plant community. The +, 0, and – preference ratings indicate significantly favored, no preference, and avoided plant communities, respectively (P<.02). N = 133.

| | Community | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High ecologic condition | | | | | | Low ecologic condition | | | | | |
| | Wyoming big sagebrush/ bluebunch wheatgrass | Low sagebrush/blue-bunch wheatgrass | Bluebunch wheatgrass | Cliff rock | Gravel slopes | Other 1/ | Wyoming big sagebrush/ cheatgrass | Wyoming big sagebrush/ Sandberg's bluegrass | Low sagebrush/ Sandberg's bluegrass | Cheatgrass | Low sagebrush/ cheatgrass | Alfalfa |
| Study area % | 56 | 12 | 2 | 1 | 1 | 6 | 6 | 5 | 9 | 1 | t 2/ | 1 |
| Bighorn observa. % | 53 | 2 | 8 | 7 | 5 | 0 | 5 | 2 | 2 | 9 | 0 | 8 |
| Preference rating | 0 | – | + | + | 0 | – | 0 | 0 | – | + | 0 | + |

1/ Other = shrub scabland, bitterbrush/grass, mountain mahogany/grass, juniper scabland
2/ t = less than 0.5%

sagebrush areas were peripherally located in the outlined bighorn range and consisted of generally wide expanses on relatively gentle grades with very little escape terrain nearby. "Other" communities included primarily the shrub scabland, mountain mahogany/grass, and juniper scabland. No observations of bighorn occurred in these areas.

The Wyoming big sagebrush/bluebunch wheatgrass community supported the largest percentage of bighorn observations and covered the largest area on the bighorn range. Cover of shrubs was slight in these areas (<1.0%), and when coupled with steep slopes the shrubs constituted little visual handicap for bighorn. A no preference rating, however, was assigned to this community.

Bighorn were the only large herbivore to make substantial use of gravel slope areas. From a distance these areas appeared devoid of vegetation. Close examination, however, revealed an abundance of Nuttal's sandwort (Arenaria nuttalli) which produced little top growth but supported an extended, succulent, carrotlike root. Bighorn would occassionally spend an entire day digging up and consuming both roots and herbage. Bighorn used these areas during all seasons.

As mentioned previously, bighorn are typically associated with plant communities in climax or high ecologic condition, and the inference is often made that such habitat is either required or selected by bighorn. In this study, communities in high ecologic condition occupied 78% of the outlined bighorn range and contained 74% of the observations of bighorn. Communities in low ecologic condition occupied 22% of the range and supported 26% of the bighorn sightings. Compilation and analysis of data within these 2 categories resulted in no preference ratings (P>.02) being assigned to both categories. With no clear selection for either condition class being demonstrated by bighorn, I speculate that much of their habitat use was dictated by the proximity of suitable escape cover and community structure rather than community composition.

The only structural feature avoided by bighorn appeared to be high densities of big sagebrush associated with degraded drainages and small basins. When forced to enter such areas bighorn would pause, examine the area carefully from a vantage point, and then traverse the area as rapidly as possible. Similarly, bighorn were never observed feeding in drainages dominated by big sagebrush. They utilized edges of such areas, but only those areas where visibility over encroaching shrubs was provided. Basins and drainages supporting little shrub overstory were used freely.

Seasonal Distances of Sightings From Water

Average seasonal distances of sightings of bighorn from water ranged from 0.79 to 1.24 km, and they were not significantly (P>.05) different from average distances for cattle and deer in seasons where comparisons were possible (Table 12). No significant differences (P>.05) between seasons and no clear seasonal trends in distances from water were detected.

When bighorn sheep data were pooled across all seasons, ram groups ranged significantly (P<.05) further from water than ewes and lambs. Distance from water for observations of rams averaged 1.3 km, while the average for observations of ewes and lambs was 1.0 km. This supports literature observations suggesting rams are slightly less reliant on free water than ewes and lambs (Leslie and Douglas 1979).

Bighorn were observed drinking from Spring Creek and from small, temporary, natural catchments in the Leslie Gulch area. Sheep were never observed at the 3 undeveloped water sources in Leslie Gulch (Figure 10). Possibly bighorn were hesitant to enter the tall sagebrush surrounding 2 of these sources. At the third source, a seep in the ditch beside the Leslie Bulch road, pawing or digging were required to create a water pocket in the sandy bottom. Human interference may also influence use of the Leslie Gulch sources as camps were frequently erected within a few meters of the 2 westernmost springs.

Rams were observed drinking from the Owyhee Reservoir near the Three Fingers Gulch and Honeycombs areas. Ewes and lambs, however were never encountered along the shoreline. An absence of suitable escape terrain along the lake probably prevented their use of that source.

Four big game guzzlers were constructed for bighorn during the second year of study (Figure 10). No use was observed, however, in the short time they were available.

Conclusions

Bighorn were more restricted spatially in their use of the study area than any of the other large herbivores common to the area. Their requirements for escape and resting habitat (cliff rock) within close proximity of foraging and watering areas caused bighorn to be concentrated in the Spring Creek and Leslie Gulch areas. Rams were somewhat less stringent in their habitat requirements and ranged further north than the ewe/lamb component of the population. Ewe/lamb ratios were 55.1/100 and 53.2/100, respectively, for the first and second years of study. Ram/ewe ratios for the same periods were 43.2 and 75.2/100. The disparity between ram/ewe ratios for the 2 years could not be explained.

No evidence of predation on bighorn was detected. Remains of 4 bighorn, 1 a victim of poaching, were found during the study. Three injured rams were also observed. Their eventual fates were undetermined, however.

Bighorn were most active during early morning and late evening, when nearly all animals were feeding. Intense feeding also occurred in mid-afternoom when nearly 90% of the bighorn were so engaged. Resting peaked after the morning feeding period when nearly 60% of observed bighorn were inactive.

Chi square analysis marginally rejected ($P<.01$) the hypothesis that bighorn used slopes in a random fashion. Preference ratings, however, indicated activities of bighorn were not hindered by slopes within the range (0-80+%) sampled on the area.

Bighorn did not use plant communities in the same proportions available on the area. Preferred communities were: bluebunch wheatgrass, cheatgrass, alfalfa, and cliff rock. Cliff rock areas were utilized as resting and escape habitat, and the other 3 communities were used primarily as feeding sites. Use of the alfalfa pastures was most intense during dry summer months and has been tolerated by the landowner to date. Should the bighorn population continue to increase, however, substantial crop damage may occur, particularly during below normal precipitation years.

The Wyoming big sagebrush/bluebunch wheatgrass was assigned a no preference rating. It contained 53% of the observations of bighorn, however, and should not be dismissed as unimportant. Shrub cover was minimal in this community and the communities receiving positive preference ratings ($\bar{x}$ 1.0%) and posed little if any hindrance to the vision of bighorn. Other areas and communities, however, supporting high densities of big sagebrush, were avoided by bighorn.

Bighorn were not clearly selective for plant communities in high or low ecologic condition. The stability and productivity of the perennial vegetation associated with high ecologic condition communities, however, makes them a desireable component of big game ranges.

Average seasonal distances of sightings of bighorn from water sources ranged between 0.77 and 1.24 km and were not significantly ($P>.05$) different from distances for cattle or deer. Rams occasionally watered from the Owyhee Reservoir. Ewes and lambs, however, were observed drinking only from Spring Creek and from small temporary catchments in the Leslie Gulch area. Tall shrubs and human interference around springs in Leslie Gulch may have reduced use of those sources by bighorn.

## Spatial and Temporal Overlap of Large Herbivores

Spatial overlap of large herbivores may be evaluated to some degree by examining the distribution patterns of each species (Figure 17). Wintering deer had the greatest spatial overlap with bighorn sheep in the southern portion of the study area. During spring and summer months, however, bighorn had nearly exclusive use of the Leslie Gulch and Spring Creek areas.

Cattle overlapped only slightly with bighorn. Cattle were present on some portion of the study area for approximately 7 months each year (April- October). A small number of cattle utilized the Leslie Gulch area in early spring. These animals, however, confined most of their activities to the bottoms of the canyons near the lake and showed little inclination to disperse into the surrounding hills. Cattle also used the Spring Creek area briefly in November as they were being moved to winter ranges south of the study area.

Horses also showed a slight spatial overlap with bighorn sheep. That which did occur involved only the bighorn rams and horses in the central portion of the study area. Only 1 simultaneous observation of horses and bighorn occurred in that area, and animals were separated by approximately 400 m at that time. Potential encounter between horses and ewes and lambs was restricted to the northern edge of the outlined bighorn range (Figure 17). Ewes and lambs were never detected in the open terrain north of the Leslie Gulch canyons, and rugged topography appeared to prevent southerly movement of horses into bighorn range.

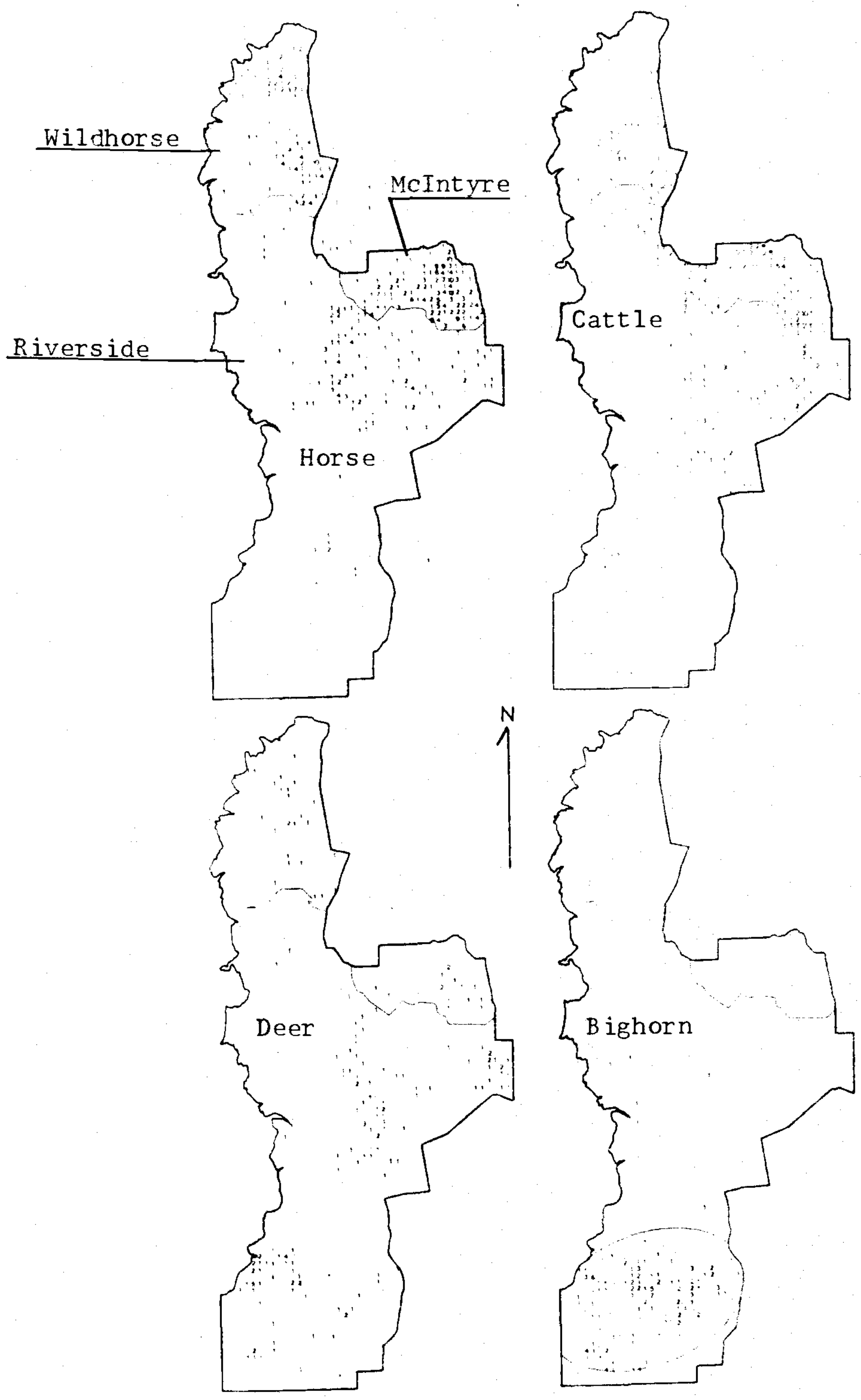



Figure 17. Distribution of horse, cattle, deer, and bighorn sightings on the Three Fingers study area.

Horses and wintering deer shared much of the same habitat on the northern three-quarters of the study area. Horses in the extreme eastern portion of the Riverside pasture moved to the north during mid-study, and deer were the sole users of that area during the second winter of field work.

Deer and cattle made little concurrent use of the area. They did graze many of the same locations, however, and the deer tended to concentrate and remain on cheatgrass dominated areas previously grazed by livestock. Removal of mature cheatgrass stems by cattle in summer and fall allowed deer to graze newly emerged cheatgrass seedlings without the inconvenience of sorting old and new growth materials. Fall moisture was sufficient for cheatgrass germination during both years of study, and patterns of utilization by deer and cattle were similar for both years.

Some degree of spatial separation between horses and cattle resulted from the horses' preference for ridgetops and benches and the cattle preference for basin areas. These preferences were best exemplified in Wildhorse pasture where horse and cattle locations show a high degree of separation. Cattle had nearly exclusive use of basin areas in north central McIntyre but overlapped considerably with horses in the eastern portion of that pasture. Cattle had nearly exclusive use of the eastern portion of the Riverside pasture after the horses moved from that area. Horses and cattle overlapped substantially in central Riverside, however, cattle tended to use basin areas in the south-central portion of the pasture more than horses.

Interspecific agressive behavior was not detected during any of the observations of encounters between the various species on the area. Bighorn, deer, and cattle were occasionally observed feeding, resting, or traveling together in the Spring Creek area. Cattle, horses, and deer were similarly observed on the northern portions of the area. Horses, deer, and bighorn sheep responded to indications of possible danger expressed by another species. Cattle, however, would vacate an area only after the actions of one of their own species signaled the presence of a possible threat.

## Theoretical Spatial Overlap of Large Herbivores

The observation data for each herbivore (slope and plant community) and Kulczynski's formula were used to estimate the percent of spatial overlap expected between horses, deer, cattle, and bighorn sheep. Managers seldom have, but frequently require such information when allocating resources for large herbivores. These indices are not meant to be indicative of actual spatial overlaps on the study area. They are simply expressions of the geometric similarity of relative frequency distributions and are representative of the levels of overlap to be expected if these species were to inhabit a common environment. Because these data were derived from different and artificially defined habitats, and because animal behavior would be expected to change if all species shared a common environment, these indices should be viewed as only the roughest approximations of reality.

### Interspecific Overlap Based on Slope Utilization

The highest similarity or overlap (81%) in utilization of slopes was obtained with the horse-deer comparison (Table 22). Second and third rankings were the deer-cattle and horse-cattle comparisons with respective overlap indices of 72 and 67%. Deer had the greatest overlap with bighorn sheep (50%), and the cattle-bighorn comparison ranked lowest of all with a value of 31%.

A similar interpretation of these data may be obtained by graphing regression equations expressing the relationships between

Table 22. Percent of interspecific overlap based on patterns of slope utilization by horses, deer, cattle, and bighorn sheep.

| | Horse | Deer | Bighorn |
|---|---|---|---|
| Cattle | 67 | 72 | 31 |
| Bighorn | 37 | 50 | |
| Deer | 81 | | |

slope and the percent of observations of large herbivores expected in the various categories (Figure 18). Best fit for cattle, horse, and deer data was obtained with quadratic functions, while a third order equation was required for a significant ($P<.05$) fit of bighorn data. The close proximity of the lines for deer and horses is indicative of the high level of similarity expressed by the 2 species. The disparity between the cattle and bighorn lines is indicative of the lowest degree of overlap.

Interspecific Overlap Based on Use of Plant Communities

Interspecific overlap, based on the utilization of plant communities by large herbivores, produced relative rankings almost identical to those obtained with the slope data. Deer-horse and deer-cattle comparisons produced the highest level of overlap with identical values of 74% (Table 23). Deer again produced the highest overlap with bighorn (45%), while the cattle bighorn comparison ranked lowest with a value of 20%.

The strong agreement in rankings between the slope and plant community indices can best be visualized by graphing the values in Tables 22 and 23 (Figure 19). Perfect agreement between the 2 indices would place all points on the $45^{\circ}$, dashed line. The strong correlation ($r = 0.98$) of the 2 indices is probably due to the slope-plant community relationships of the area and the fact that horses, cattle, and possible deer have heavily influenced the composition and distribution of the vegetation on the area.

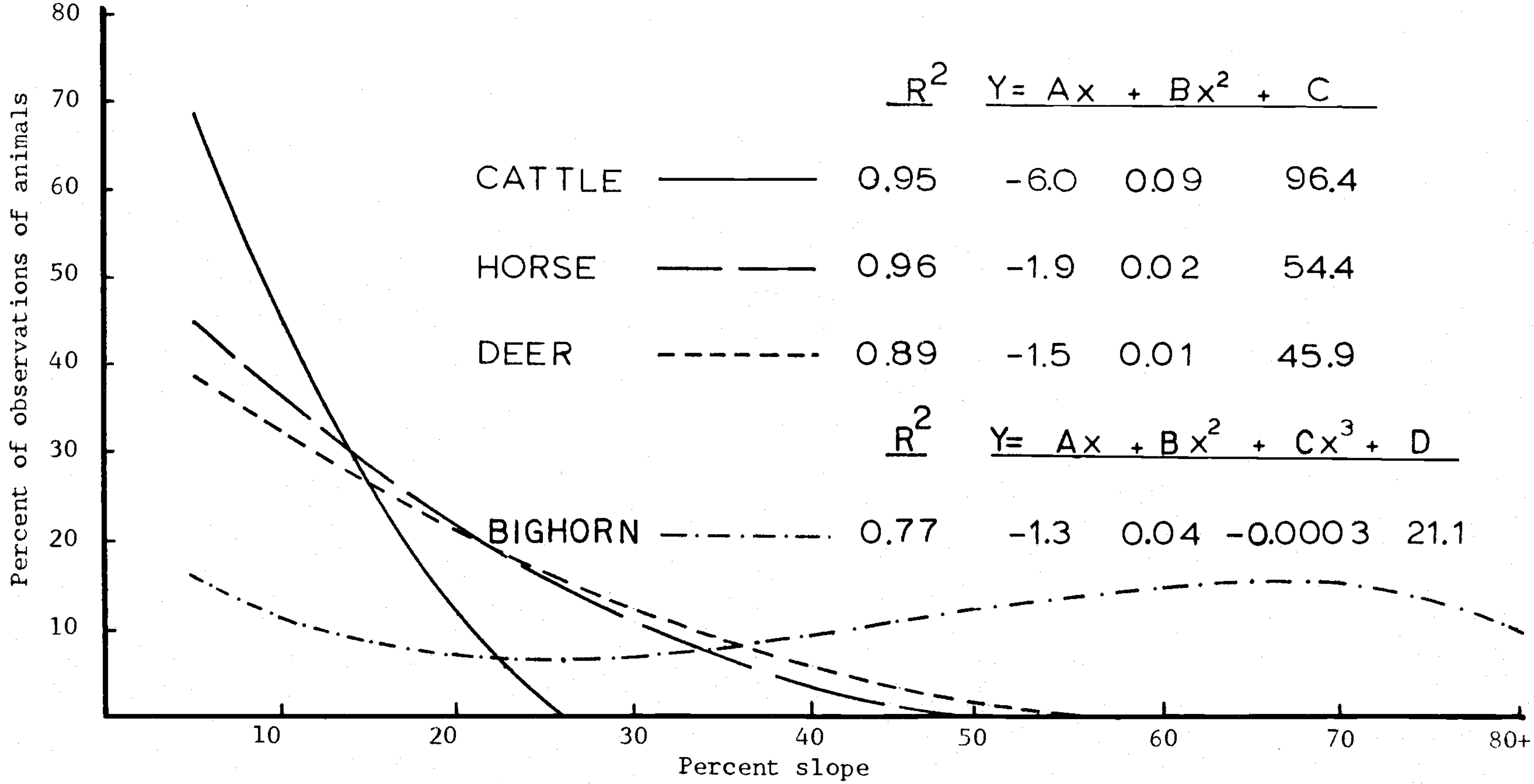



Figure 18. Relationships of slope gradient to cattle, horse, deer, and bighorn observations.

Table 23. Percent of interspecific overlap based on patterns of plant community utilization by horses, deer, cattle, and bighorn sheep.

| | Horse | Deer | Bighorn |
|---|---|---|---|
| Cattle | 73 | 74 | 20 |
| Bighorn | 35 | 45 | |
| Deer | 74 | | |

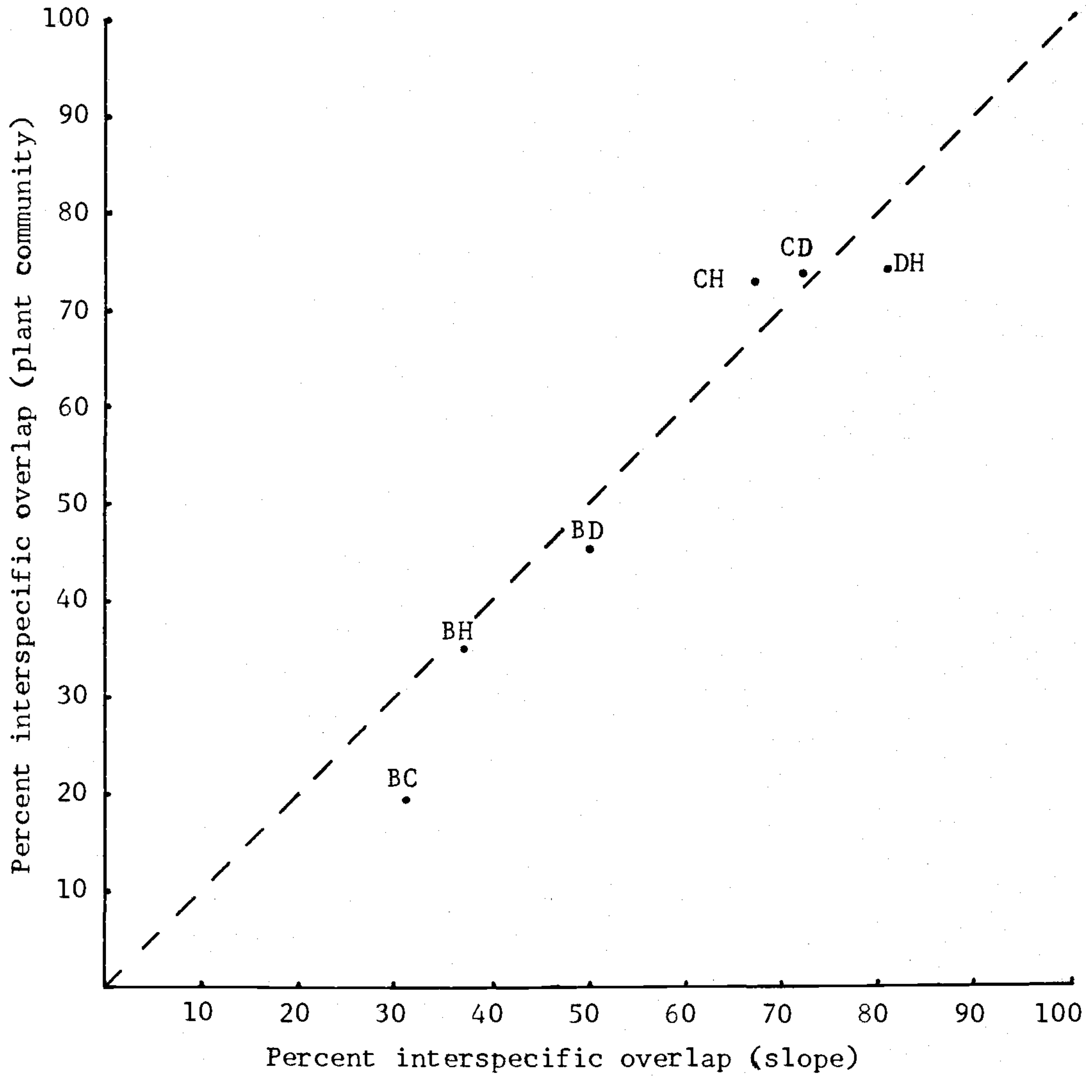



Figure 19. Percent of interspecific overlap based on patterns of use on slopes and plant communities by bighorn sheep (B), cattle (C), deer (D), and horses (H).

## Conclusions

The rugged topography and diversity of plant communities common to this study area combined to produce a wealth of unique and varied habitats. In theory each of the large herbivores had opportunity to utilize the entire study area. This was not the case, however, as each species was frequently observed in some areas and not detected in others. While many factors interact to influence the patterns of movement and selection of habitats by an animal, something of the animals' character may be learned by observing its use or non use of particular environments.

Of the 4 herbivores studied in this project the bighorn sheep were the most specific in their habitat requirements. This was evidenced by their concentration in the extreme southern portion of the study area. The habitat attribute which most restricted their distribution was a stringent requirement for cliff rock in close proximity to adequate food and water. Steep slopes were of little hindrance to bighorn, and the only attribute which limited their use of plant communities was high densities of tall shrubs. Their habitat was quickly defined, but predicting which portion of the area they would choose to ocupy was quite difficult.

Next to bighorn sheep, cattle ranked second in their restricted use of the area. Their patterns of use were quite predictable, because they made limited use of slopes and remained relatively close to water. For these reasons cattle made the greatest demands on the resources of basins and lowlands of the area. Their habitat selection was primarily a product of an aversion to steep topography and not a selection for specific plant communities.

Wild horses were slightly more dispersed than cattle. They were afforded more habitat than cattle because of their greater willingness to traverse steeper slopes, a characteristic which gave them access to elevated but relatively gentle topography.

Deer were the least limited and most general in their selection of habitats. This was evidenced by their wide dispersal over almost the entire study area. Because they were the most widely dispersed species on the area, each of the other herbivores overlapped more with deer than with any other species.

This project examined the influences of topography and the compositions of plant communities relative to the presence of large herbivores. More than likely these data were confounded, because the ecologic condition of most plant communities was strongly correlated with the degree of slope on which they occurred. Further problems were introduced by the fact that horses, cattle, and possibly deer have heavily influenced the composition and distributions of the vegetation on the area. For these reasons interpretation based on patterns of slope utilization are probably more applicable to other areas than interpretations related to the compositions of plant communities.

Some degree of replication was attained with comparisons of cattle in the 3 pastures and comparisons of the 4 herds of horses. These illustrated that patterns of resource use by large herbivores do not always conform to mathematical expectations. Also, these data were gathered in climatic conditions approaching the long term average for the area, and they may or may not be representative of range animal relations expressed during stress periods. Replication of this project during harsh winter and extreme drought conditions would possibly reveal interspecific interfacings and tolerances under limiting conditions. Information derived in such conditions would also assist in identifying key habitats for each herbivore and allow managers to focus their efforts on the maintenance or improvement of potentially limiting resources about the area.

For these reasons managers should be most prudent in applying these findings to other areas. These discussions, however, should stimulate consideration of some aspects often ignored in management and research endeavors.

# Management Implications and Suggestions

## Revegetation Efforts

Approximately 49% of the study area was classified in low ecologic condition. These areas supported understories dominated by either Sandberg's bluegrass or cheatgrass. Although forage production is high in cheatgrass dominated communities during average or better precipitation years, extreme year to year variation in production and poor curing qualities make this species less desirable than native or introduced perennial bunchgrasses. The forage quantity and quality of Sandberg's bluegrass are also poorer than that of the bluebunch wheatgrass it has replaced, and the productive potential of many of the sites it now occupies is not being realized.

Range deterioration is so severe on the low ecologic condition communities that complete grazing protection would do little to enhance range condition or forage availability. Forage production and quality potentials could best be realized by reestablishing perennial bunchgrass on depleted areas. The soils and gentle topography of major portions of McIntyre pasture and large areas in the extreme eastern portion of the Riverside pasture are adequate for revegetation. Rugged topography and possible wilderness classification prevent effective, large scale reclamation efforts in the western portion of the Riverside pasture.

Enhancing the Distribution of Large Herbivores

Due to the rugged topography of the area probably very little can be done to enhance voluntary dispersal of livestock. Salting practices could be improved substantially, but they would probably have only a marginal impact on patterns of utilization. Further subdivisions of the pastures with permanent fencing would certainly enhance the control of livestock and permit the harvest of previously unused forage. Fencing would be most efficient if basins and more rugged areas were separated. If not divided and isolated, however, cattle would drift to the lowlands and the existing situation would continue. Nearly all existing water sources have been developed on the area. Only the central and northern portions of the Riverside pasture were water deficient. Water could possibly be piped to these areas, but these regions would probably remain unused due to extremely rugged topography.

Horses on the area appeared to respect fences, and they could probably be controlled to some degree with standard stock fences if pastures were not too confining. The fact that bands and herds showed little inclination to wander could be utilized in treating localized range management problems. If a single herd is involved, removal of the offending animals would probably exempt the area from use by horses for several years. Horses could possibly be drawn to alternative ranges by limiting their access to water. Whether or not they would return to their habitual range when the source was reopened is subject to speculation. Salting practices would have little if any influence on horses.

With the exception of some seasonal overlap with deer, bighorn had nearly exclusive use of their range. More than adequate forage was available to support the population. The only potential management problem with the bighorn is their use of the irrigated alfalfa pastures in the Spring Creek area. One solution to this potential problem is the installation of a game proof fence. A second possible solution involves the alteration of the bighorns' feeding habits through the use of prescribed burning.

Bunchgrass stands in the Leslie Gulch-Spring Creek area contain large amounts of standing litter. Prescribed burns would remove much of this litter and perhaps enhance the appeal of some areas by removing sagebrush. Bighorn responses to small test burns or wildfires should be monitored before large scale treatments are considered, however.

The appeal of the Leslie Gulch area could also be enhanced by removing a large proportion of the tall sagebrush surrounding 2 of the 3 springs in that area. Both of the springs appeared to be dependable water sources and were within meters of suitable escape terrain. Camping activities in the vicinity of the springs should also be discouraged to allow bighorn free access to those sources.

The Honeycombs region to the north of Three Fingers Gulch has every appearance of excellent bighorn habitat. Its only shortcoming is an absence of water. Bighorn rams frequented the area and watered from the Owyhee Reservoir. A big-game guzzler was constructed in the Honeycombs during the second year of study but had not been discovered in the short time it was available. Ewes and lambs have not been sighted in the area and probably will not cross the open ground to access that area on their own accord. Ewes and lambs from an outside source could probably be successfully transplanted to the area. This would not be advisable, however, until additional water sources can be developed. It would not be safe for these animals to depend on a single point water source unless funds and personnel were available to insure its proper functioning.

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# APPENDICES

Appendix 1. Alpha code, scientific name, and common names of plant species found on the study area.

| Alpha code | Scientific name | Common name |
|---|---|---|
| **Grasses** | | |
| AGDE | *Agropyron desertorum* Fish. | standard crested wheatgrass |
| AGSM | *Agropyron smithii* Rydb. | bluestem wheatgrass |
| AGSP | *Agropyron spicatum* (Pursh) Scribn. & Smith | bluebunch wheatgrass |
| AGTR | *Agropyron triticeum* Gaertn. | |
| ARLO | *Aristida longiseta* Steud. | red threeawn |
| BRBR | *Bromus brizaeformis* Fisch. & Mey | rattle grass |
| BRJA | *Bromus japonicus* Thunb. | Japanese brome |
| BRTE | *Bromus tectorum* L. | cheatgrass |
| ELCA | *Elymus caput-medusae* L. | medusahead wildrye |
| ELCI | *Elymus cinereus* Scribn. & Merr. | giant wildrye |
| FEBR | *Festuca bromoides* L. | barren fescue |
| FEID | *Festuca idahoensis* Elmer | Idaho fescue |
| HOGE | *Hordeum geniculatum* All. | Mediterranean barley |
| HOJU | *Hordeum jubatum* L. | squirrel-tail |
| HOLE | *Hordeum leporinum* Link | charming barley |
| ORHY | *Oryzopsis hymenoides* (R. & S.) Ricker | indian ricegrass |
| POBU | *Poa bulbosa* L. | bulbous bluegrass |
| POPR | *Poa pratensis* L. | Kentucky bluegrass |
| POSA | *Poa sandbergii* Vasey | Sandberg's bluegrass |
| POMO | *Polypogon monspeliensis* (L.) Desf. | rabbitfoot polypogon |
| SIHY | *Sitanion hystrix* (Nutt.) Smith | bottlebrush squirreltail |
| SIJU | *Sitanion jubatum* Smith | big squirreltail |
| STCO | *Stipa comata* Trin. & Rupr. | needle-and-thread |
| STTH | *Stipa thurberiana* Piper | Thurber's needlegrass |
| **Grasslikes** | | |
| CAREX | *Carex* sp. L. | sedges |
| ELPA | *Eleocharis palustris* (L.) R. & S. | creeping spike-rush |
| JUBA | *Juncus balticus* Willd. | baltic rush |

Appendix 1. (continued)

| Alpha code | Scientific name | Common name |
|---|---|---|
| Forbs | | |
| ACMI | Achillea millefolium L. | yarrow |
| ALPA | Allium parvum Kell. | dwarf onion |
| AMRE | Amsinckia retrorsa Suksd. | rigid fiddleneck |
| ANLU | Antennaria luzuloides T. & G. | woodrush pussy-toes |
| ARHO | Arabis holboellii Hornem. | Holboell's rockcress |
| ARNU | Arenaria nuttalli Pax. | Nuttall's sandwort |
| ARLU | Artemisia ludoviciana Nutt | prairie sage |
| ASAT | Astragalus atratus Wats. | mourning milk-vetch |
| ASER | Astragalus eremiticus Sheld. | hermit milk-vetch |
| ASFI | Astragalus filipes Torr | threadstalk milk-vetch |
| ASLE | Astragalus lentiginosus Dougl. | freckled milk-vetch |
| ASPU | Astragalus purshii Dougl. | wooly-pod milk-vetch |
| BAHO | Balsamorhiza hookeri Nutt. | Hooker's balsamroot |
| BASA | Balsamorhiza sagittata (Pursh) Nutt. | arrowleaf balsamroot |
| BLSC | Blepharipappus scaber Hook | blepharipappus |
| CAMA | Calochortus macrocarpus Dougl. | sagebrush mariposa |
| CAMI | Camelina microcarpa Andrz. | littlepod falseflax |
| CABU | Capsella bursa-pastoris (L.) Medic. | shepherd's-purse |
| CACH | Cardaria chalapensis (L.) Hand | chalapa hoarycress |
| CACHR | Castilleja chromosa A. Nels. | desert paintbrush |
| CHDO | Chaenactis douglasii (Hook.) H. & A. | hoary chaenactis |
| CHTE | Chorispora tenella (Pall.) DC. | chorispora |
| CIUT | Cirsium utahense Petr. | Utah thistle |
| CLPU | Clarkia pulchella Pursh | pink fairies |
| CLLI | Clematus lingusticifolia Nutt. | western clematis |
| COPA | Collinsia parviflora Lindl. | small flowered blue-eyed Mary |
| COLI | Collomia lineraris Nutt. | narrow leaf collomia |
| COUM | Comandra umbellata (L.) Nutt. | bastard toad-flax |
| CRRO | Cryptantha rostellata Greene | beaked cryptantha |

Appendix 1. (continued)

| Alpha code | Scientific name | Common name |
|---|---|---|
| CRAC | Crepis acuminata Nutt. | long-leaved hawksbeard |
| CRAT | Crepis atrabarba Heller | hawksbeard |
| CRIN | Crepis intermedia Gray | gray hawksbeard |
| CRMO | Crepis modocensis Greene | low hawksbeard |
| DENU | Delphinium nutallianum Pritz. | larkspur |
| DESO | Descurainia sophia (L.) Webb | flixweed |
| DISY | Dipsacus sylvestris Huds. | gypsy's combs |
| DOCO | Dodecatheon conjugens Greene | slimpod shooting star |
| EPPA | Epilobium paniculatum Nutt. | annual willow-weed |
| ERBL | Erigeron bloomeri Gray | scabland fleabane |
| ERPU | Erigeron pumilus Nutt. | shaggy fleabane |
| ERMI | Eriogonum microthecum Hook. | slenderbush buckwheat |
| ERNU | Eriogonum nudum Dougl. | barestem buckwheat |
| EROV | Eriogonum ovalifolium Nutt. | oval-leaved eriogonum |
| ERSP | Eriogonum sphaerocephalum Dougl. | round-headed eriogonum |
| ERLA | Eriophyllum lanatum (Pursh) Forbes. | woolly sunflower |
| ERCI | Erodium cicutarium (L.) L'Her. | filaree |
| ERRE | Erysimus repandum L. | spreading wallflower |
| FRPU | Fritillaria pudica (Pursh) Spreng | yellow bell |
| GAAP | Galium aparine L. | goose-grass |
| GIAG | Gilia aggregata (Pursh) Spreng | scarlet gilia |
| GUSA | Gutierrizia sarothrae | broom snakeweed |
| HARE | Haplopappus resinosus (Nutt.) Gray | snarled goldenweed |
| HEAN | Helianthus annuus L. | common sunflower |
| HEUN | Helianthella uniflora (Nutt.) T. & G. | little-sunflower |
| HIAL | Hieracium albertinum Farr. | western hawkweed |
| HOUM | Holosteum umbellatum L. | jagged chickweed |
| LASE | Lactuca serriola L. | prickly lettuce |
| LARA | Lagophylla ramosissima Nutt. | slender hareleaf |
| LARE | Lappula redowski (Hornem.) Greene | western stickseed |
| LALA | Lathyrus lanszwertii Kell. | peavine |

Appendix 1. (continued)

| Alpha code | Scientific name | Common name |
|---|---|---|
| LEPE | Lepidium perfoliatum L. | clasping peppergrass |
| LEMO | Leucocrinum montanum Nutt. | sandlily |
| LERE | Lewisia rediviva Pursh | bitterroot |
| LIPE | Linum perenne var. lewisii (Pursh) Eat. & Wright | wild blueflax |
| LIBU | Lithophragma bulbifera Rydb. | bulbiferous fringecup |
| LODI | Lomatium dissectum (Coult. & Rose) Cronq. | fern leaved lomatium |
| LOSA | Lomatium salmoniflorum (Coult. & Rose) Math. & Const. | Salmon river lomatium |
| LOTR | Lomatium triternatum (Pursh) Coult. & Rose | nine-leaf lomatium |
| LUCA | Lupinus caudatus Kell | tailcup lupine |
| LULA | Lupinus laxiflorus Dougl. | lupine |
| LYAL | Lychnis alba Mill. | white campion |
| LYSP | Lygodesmia spinosa Nutt. | spiny skeletonweed |
| MAVU | Marrubium vulgare L. | horehound |
| MESA | Medicago sativa L. | alfalfa |
| MITR | Microseris troximoides Gray | false-agoseris |
| MIGR | Microsteris gracilis (Hook.) Greene | pink microsteris |
| MOOD | Monardella odoratissima Benth. | mountain monardella |
| MOPE | Montia perfoliata (Donn) Howell | miner's lettuce |
| OECA | Oenothera caespitosa Nutt. | rock-rose |
| OETA | Oenothera tanacetifolia T. & G. | tansy-leaf evening-primrose |
| ONAC | Onopordum acanthium L. | Scotch thistle |
| ORFA | Orobanche fasciculata Nutt. | clustered broomrape |
| PEDE | Penstemon deustus Dougl. | hot-rock penstemon |
| PESE | Penstemon seorsus (A. Nela.) Keck | short-lobed penstemon |
| PESP | Penstemon speciosus Dougl. | royal penstemon |
| PHHA | Phacelia hastata Dougl. | whiteleaf phacelia |
| PHLI | Phacelia linearis (Pursh) Holz. | threadleaf phacelia |
| PHHO | Phlox hoodii Rich. | Hood's phlox |
| PHLO | Phlox longifolia Nutt. | long-leafed phlox |

Appendix 1. (continued)

| Alpha code | Scientific name | Common name |
|---|---|---|
| PHCH | Phoenicaulis cheiranthoides Nutt. | daggerpod |
| POAV | Polygonum aviculare L. | doorweed |
| PORA | Polygonum ramosissimum Michx. | bushy knotweed |
| RAGL | Ranunculus glaberrimus Hook. | sagebrush buttercup |
| RATE | Ranunculus test culatus Crantz | hornseed buttercup |
| RONA | Rorippa nasturtium aquaticum (L.) Schinz & Thell. | watercress |
| RUCR | Rumex crispus L. | curly dock |
| SAKA | Salsola kali L. | Russian thistle |
| SCAN | Scutellaria antirrhinoides Benth | snapdragon skullcap |
| SEER | Senecio eremophilus Rich | dryland ragwort |
| SEIN | Senicio integerrimus (Nutt.) Cronq. | western groundsel |
| SIAL | Sisymbrium altissimum L. | Jim Hill mustard |
| SOMI | Solidago missouriensis Nutt. | goldenrod |
| SPMU | Sphaeralcea munroana (Dougl.) Spach. | Munro's globe-mallow |
| TAOF | Taraxacum officinale Weber | common dandelion |
| THLA | Thelypodium laciniatum (Hook. Endl. | thickleaved thelypody |
| TRDU | Tragopogon dubius Scop | yellow salsify |
| TRLA | Trifolium latifolium (Hook.) Greene | twinclover |
| TRMA | Trifolium macrocephalum (Pursh) Poiret | big-head clover |
| VETH | Verbascum thapsus L. | mullein |
| VEAN | Veronica snagallis-aquaticua L. | water speedwell |
| VICR | Vicia cracca L. | birdvetch |
| WYAM | Wyethia amplexicaulis Nutt. | northern mule's-ears |
| XAST | Xanthium strumarium L. | cocklebur |
| ZIPA | Zigadenus paniculatus (Nutt.) Wats. | panicled death-camas |
| Shrubs | | |
| AMAL | Amelanchier alnifolia Nutt. | western service berry |
| ARAR | Artemisia arbuscula Nutt. | low sagebrush |

Appendix 1. (continued)

| Alpha code | Scientific name | Common name |
|---|---|---|
| ARCA | *Artemisia cana* Pursh | silver sage |
| ARRI | *Artemisia rigida* (Nutt.) Gray | stiff sagebrush |
| ARTRTR | *Artenisia tridentata* ssp. *tridentata* Nutt. | basin big sagebrush |
| ARTRWY | *Artemisia tridentata* ssp. *wyomingensis* Beetle | Wyoming big sagebrush |
| ATCA | *Atriplex canescens* (Pursh) Nutt. | fourwing saltbush |
| ATCO | *Atriplex confertifolia* (Torr. & Frem) Wats. | sheepfat |
| ATSP | *Atriplex spinosa* (Hook.) Collotzi | spiny hopsage |
| CELE | *Cercocarpus ledifolius* Nutt. | curl-leaf mountain-mahogany |
| CHNA | *Chrysothamnus nauseosus* (Pall.) Britt. | gray rabbit-brush |
| CHVI | *Chrysothamnus vicidiflorus* (Hook.) Nutt. | green rabbit-brush |
| GLNE | *Glossopetalon nevadense* Gray. | spiny green-bush |
| HODU | *Holodiscus dumosus* (Hook.) Heller | gland oceanspray |
| PRVI | *Prunus virginiana* L. | common chokecherry |
| PUTR | *Purshia tridentata* (Pursh) DC. | bitterbrush |
| RIAU | *Ribes aureum* Pursh | golden currant |
| RICE | *Ribes cereum* Dougl. | squaw currant |
| ROWO | *Rosa woodsii* var. *ultramontana* (Wats.) Jeps. | pearhip rose |
| SALIX | *Salix* sp. | willow |
| SADO | *Salvia dorrii* (Kell.) Abrams | gray ball sage |
| SACE | *Sambucus cerulea* Raf. | blue elderberry |
| SAVE | *Sarcobatus vermiculatus* (Hook.) Torr. Black g. | greasewood |
| TECA | *Tetradymia canescens* DC. | gray horse-brush |
| TEGL | *Tetradymia glabrata* Gray | little leaf horse-brush |
| Trees | | |
| JUOC | *Juniperus occidentalis* Hook. | western juniper |

Appendix 2. AUM's of livestock use on the Three Fingers study area for the 1979 and 1980 grazing season.

| | 1979 | | 1980 | |
|---|---|---|---|---|
| Pasture | Period | AUM's | Period | AUM's |
| Riverside | 4- 1 to 6-15<br>8-16 to 11- 1 | 1340 | 4- 1 to 6-23 | 3547 |
| McIntyre | 6-15 to 10-28 | 268 | 6-15 to 6-23<br>8-28 to 10-23 | 84 |
| Wildhorse | 6-18 to 10-30 | 40 1/ | 9-16 to 10-31 | 299 |
| | Total | 1648 | | 3930 |

1/ Scheduled use was 863 AUM's, however, animals moved into pasture on a volunter basis only.

Appendix 3. Equations used to estimate shrub production for the 1979 and 1980 growing seasons. ** = Sig. P<.01

Wyoming big sagebrush

| | | |
|---|---|---|
| 1979 | $Y = 1.0919(WI) - 32.4320$ | $R^2 = .63^{**}$ |
| 1980 | $Y = 0.0087(Pi(\frac{WI}{2})^2) + 0.7857(WII) - 16.3328$ | $R^2 = .84^{**}$ |

low sagegrush

| | | |
|---|---|---|
| 1979 | $Y = 0.0188(Pi(\frac{WII}{2})^2) + 2.2669$ | $R^2 = .91^{**}$ |
| 1980 | $Y = 9.4734^{10-5}(Pi(\frac{WI + WII}{2})^2\ Ht) + 1.1071$ | $R^2 = .93^{**}$ |

Y= annual production leaves and twigs (grams dry weight)

WI= greatest diameter of crown viewed from above (cm)

WII= greatest diameter of crown viewed from above perpendicular to WI (cm)

Ht= height from ground to tallest growing point (cm)

Pi= 3.1416

Appendix 4. Descriptive data of 5 major plant communities sampled on the Three Fingers study area.

Plant community: Wyoming big sagebrush/Sandberg's bluegrass

| Species | Frequency | Density/$m^2$ | %Cover |
|---|---|---|---|
| Grasses | | | |
| Sandberg's bluegrass | 100 | 45.7 | 25 |
| cheatgrass | 25 | | 4 |
| bluebunch wheatgrass | t | t | t |
| Forbs | | | |
| sagebrush mariposa | 1 | t | t |
| annual willow-weed | 13 | 2.0 | 1 |
| low hawksbeard | 1 | t | t |
| threadstalk milkvetch | 1 | t | t |
| yellow salsify | 1 | t | t |
| Shrubs | | | |
| Wyoming big sagebrush | | .6 | 17 |
| low sagebrush | | t | 1 |
| Other | | | |
| moss | 86 | | 11 |
| litter | 87 | | 12 |
| rock | 81 | | 15 |
| bare ground | 90 | | 37 |

Appendix 4. (continued)

Plant community: Wyoming big sagebrush/bluebunch wheatgrass

| Species | Frequency | Density/$m^2$ | %Cover |
|---|---|---|---|
| Grasses | | | |
| bluebunch wheatgrass | 56 | 5.0 | 11 |
| Idaho fescue | 5 | .9 | 2 |
| Sandberg's bluegrass | 90 | 15.1 | 4 |
| cheatgrass | 33 | | 1 |
| bottlebrush squirreltail | 2 | .1 | t |
| Forbs | | | |
| annual willow-weed | 4 | .2 | t |
| broom snakeweed | 4 | .2 | t |
| clustered broomrape | 2 | .1 | t |
| filaree | 5 | .2 | t |
| hermit milk-vetch | 2 | .1 | t |
| Hooker's balsamroot | 5 | .5 | 1 |
| low hawksbeard | 10 | .6 | t |
| prickly lettuce | 2 | .1 | t |
| scabland fleabane | 7 | .3 | t |
| threadstalk milk-vetch | 1 | .1 | t |
| Shrubs | | | |
| Wyoming big sagebrush | | .3 | 8 |
| Other | | | |
| moss | 33 | | 6 |
| litter | 62 | | 6 |
| rock | 85 | | 26 |
| bare ground | 89 | | 41 |

Appendix 4. (continued)

Plant community: Wyoming big sagebrush/cheatgrass

| Species | Frequency | Density/$m^2$ | %Cover |
|---|---|---|---|
| Grasses | | | |
| cheatgrass | 100 | | 60 |
| Sandberg's bluegrass | 70 | 10.3 | 3 |
| Forbs | | | |
| Jim Hill mustard | 6 | .5 | 2 |
| Shrubs | | | |
| Wyoming big sagebrush | | .7 | 18 |
| Other | | | |
| moss | t | | t |
| litter | 86 | | 11 |
| rock | 93 | | 16 |
| bare ground | 50 | | 8 |

Appendix 4. (continued)

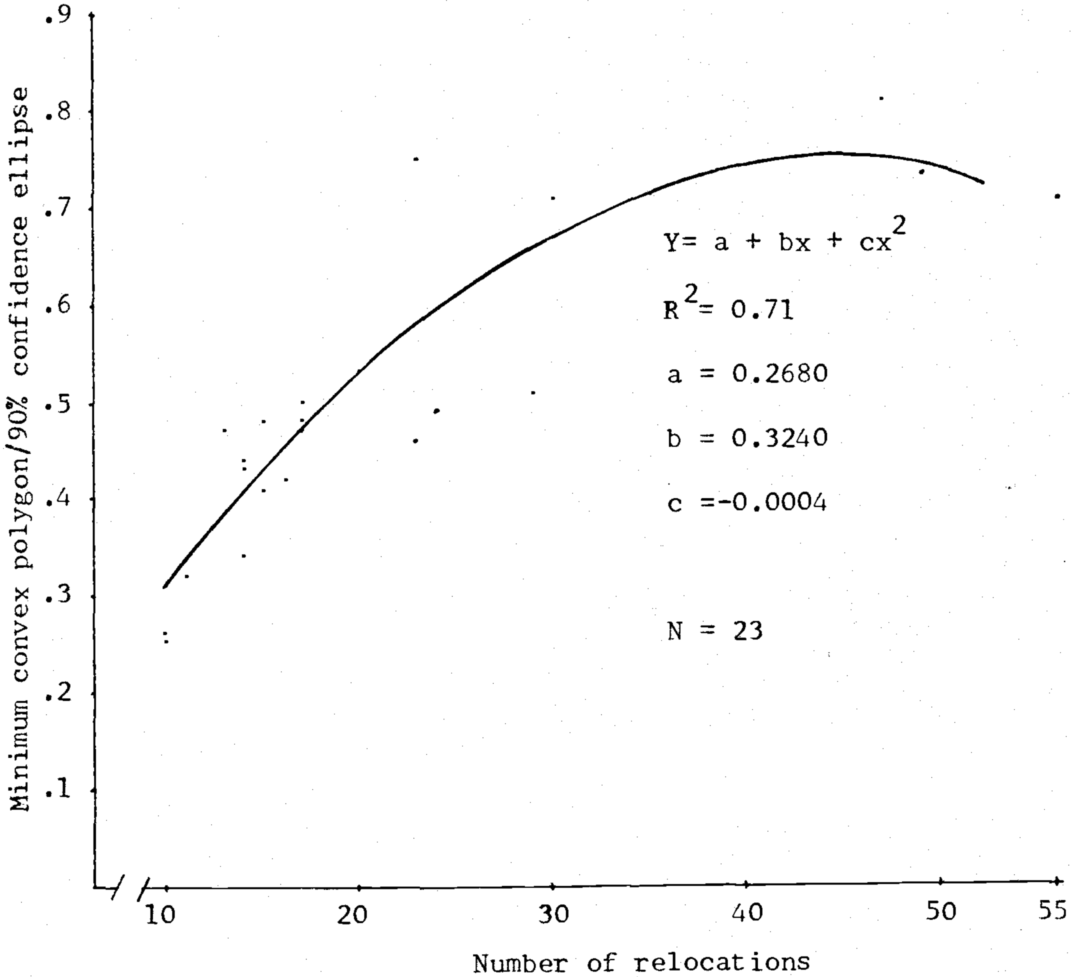
Plant community: low sagebrush/Sandberg's bluegrass

| Species | Frequency | Density/$m^2$ | %Cover |
|---|---|---|---|
| Grasses | | | |
| cheatgrass | 10 | | t |
| Sandberg's bluegrass | 100 | 47.3 | 17 |
| Forbs | | | |
| annual willow-weed | 7 | .5 | 1 |
| broom snakeweed | 23 | 1.5 | 2 |
| false agoseris | 3 | .3 | t |
| long-leafed phlox | 10 | 2.8 | 1 |
| low hawksbeard | 3 | .3 | t |
| mourning milk vetch | 7 | .5 | 1 |
| nine leafed lomatium | 20 | 1.0 | 1 |
| Shrubs | | | |
| low sagebrush | | 4.5 | 30 |
| Other | | | |
| moss | 83 | | 12 |
| litter | 77 | | 15 |
| rock | 100 | | 26 |
| bare ground | 97 | | 26 |

Appendix 4. (continued)

| Plant community: cheatgrass | | | |
|---|---|---|---|
| Species | Frequency | Density | %Cover |
| Grasses | | | |
| cheatgrass | 100 | | 41 |
| Sandberg's bluegrass | 63 | 9.8 | 3 |
| Forbs | | | |
| filaree | 70 | 9.8 | 4 |
| Jim Hill mustard | 10 | .5 | t |
| Other | | | |
| moss | 1 | | t |
| litter | 90 | | 11 |
| rock | 83 | | 11 |
| bare ground | 100 | | 30 |

Appendix 5. Regression of minimum convex polygon estimate of home range size/90% confidence ellipse estimate of home range size to number of relocations per animal.



Appendix 6. Results of regression of home range size (minimum convex polygons and 90% confidence ellipses) to water source densities. Model: Y= a+bx. ** indicates significant correlation (P<.01).

| Procedure | $R^2$ | a | b | F |
|---|---|---|---|---|
| Ellipse | 0.37 | 53.21 | -141.23 | 12.29** |
| Polygon | 0.52 | 47.75 | -208.00 | 21.15** |

Appendix 7. Percent of study area and 2 habitat types found in 10% slope categories.

| | Slope gradient (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ |
| Study area | 14.7 | 17.7 | 14.1 | 13.5 | 10.0 | 9.5 | 9.3 | 3.3 | 7.0 |
| Wyoming big sagebrush/ bluebunch wheatgrass ht. | 15.9 | 18.2 | 14.1 | 13.3 | 10.8 | 8.3 | 9.4 | 3.2 | 6.8 |
| Low sagebrush/blue bunch wheatgrass ht. | 13.3 | 24.3 | 17.1 | 12.2 | 8.3 | 13.3 | 4.4 | 2.2 | 4.9 |