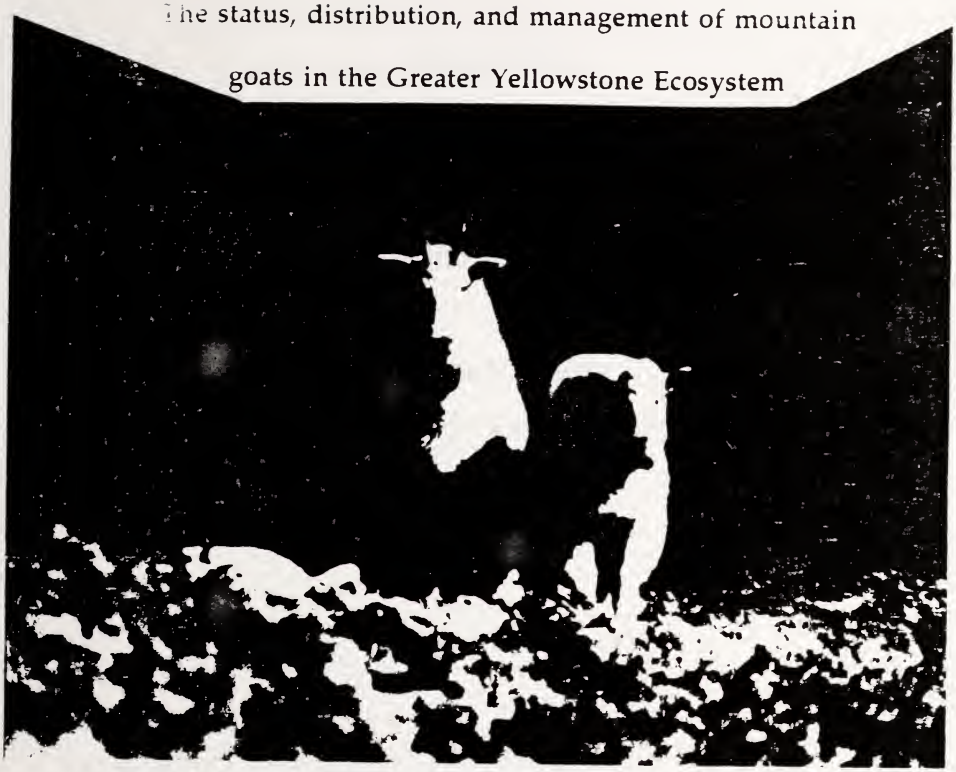
FINAL REPORT

The status, distribution, and management of mountain goats in the Greater Yellowstone Ecosystem



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NPS Order # PX 1200-8-0828

Submitted: 9/30/90

Covering the time: 5/88 - 8/90

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ABSTRACT

Mountain goats (*Oreamnos americanus*) are not thought to be historic natives to the Greater Yellowstone Ecosystem. They occurred in the area >10,000 B.P. but all evidence indicates they were extirpated from the area by the time Europeans arrived there. The Idaho Department of Fish and Game and the Montana Department of Fish, Wildlife, and Parks introduced goats into the area in the mid 1900's. Goats have expanded in numbers and range and are occasionally seen within Yellowstone and Grand Teton National Parks. Their presence in the Parks might negatively impact native plants and animals there. This study assessed the current distribution of mountain goats and their potential impact on fauna and flora of the Parks. The current distribution of mountain goats in the Greater Yellowstone Ecosystem was determined by consulting area resource managers, perusing sighting records, and conducting field surveys. The potential impact of goats on the fauna and flora of Yellowstone and Grand Teton Parks was assessed by compiling all available information on mountain goat behavior and ecology.

Mountain goat distribution within the Greater Yellowstone Ecosystem has not changed significantly from previously reported accounts. If goats do colonize either Park, low and high population levels of 95 and 500 for Yellowstone and 160 and 500 for Grand Teton Parks were estimated. Based on existing literature, little impact of goats on vegetation and the physical environment is anticipated in either Park. The main wildlife species that goats may impact would be bighorn sheep (*Ovis canadensis*). General food habits and habitat requirements of mountain goats and bighorn sheep overlap in a broad sense. However, in sympatry, investigators have found minimal overlap in specific foods used and habitat selected. At low population estimates of goats, no negative impact on sheep in Yellowstone is anticipated. In Grand Teton Park, even low numbers of goats may impact sheep because of constricted sheep winter range. Goats are expected to negatively impact sheep in both Parks at high density estimates. At this time, it is difficult to predict future population trends of goats and their total impact on the two Parks.

If the National Park Service classifies goats as exotic to the Greater Yellowstone Ecosystem, Park personnel will have to develop a management plan for them. Three management alternatives are presented: No action, limited control of mountain goats, and total elimination of goats within Park boundaries. Of the three alternatives, it was recommended no action be taken at this time. However, a multi-option plan should be formulated to respond to whatever changes in goat numbers and distribution occur in the future.

ACKNOWLEDGMENTS

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INTRODUCTION

Mountain goats (*Oreamnos americanus*) are indigenous to western North America but in the United States were historically limited to northern Idaho, northwestern Montana, and western Washington (Guenzel 1980). Since the 1920's state wildlife agencies in the northwestern U.S. have introduced goats into previously uninhabited regions. Consequently goats are now found in areas where they historically did not occur.

These range expansions have increased recreation opportunities for hunting and wildlife watching and have been popular with the American public. Ecologically, goats in these areas are exotic species. Exotic species usually have a negative impact on native fauna and flora in an ecosystem and either cause reductions in densities or extirpation of native populations.

Although there is some debate (Lyman 1988), it appears goats historically did not occur on the Olympic Peninsula of Washington. They were introduced between 1925-1929 (Houston et al. 1986). From the 11 or 12 animals introduced (Anonymous 1987a), the population has grown to over 1,000 animal (Houston et al. 1986) and has profoundly affected native fauna and flora of the Park. Native species of plants that evolved in the absence of mountain goats are now threatened from overgrazing (Pike 1981) and dust wallowing activity of goats (Anonymous 1987a). The impact of goats is compounded in Olympic Park because goats are protected from human hunting and therefore occur in higher densities than in exploited populations (Kuck 1977; Swenson 1985).

Mountain goats are also not thought to be historic natives in the Greater Yellowstone Ecosystem (Skinner 1926). Animals were released at several sites in National Forests surrounding Yellowstone National Park (YNP) and Grand Teton National Park (GTNP) in the 1950's and 60's. The introductions have been successful and goat populations are increasing. Goats are now reported in many mountain ranges surrounding the Parks and occasional sightings are reported within both Parks.

If mountain goats were not part of the original fauna of the Yellowstone Ecosystem, their introduction outside and possible movement inside Yellowstone and Grand Teton National Parks presents practical and philosophical problems. Based on experiences in Olympic National Park, the immigration introduction of goats into Yellowstone and Grand Teton Parks could threaten native alpine habitat and certain wildlife species such as bighorn sheep (*Ovis canadensis*). The presence of mountain goats in the Parks could also violate Park System mandates to preserve original faunal and floral communities.

Mountain goats could eventually colonize Yellowstone and Grand Teton National Parks. Their potential impacts on native fauna and flora need to be assessed and a management plan needs to be formulated to avoid crisis management after goats become established. Sufficient information on the ecology of goats is available to assess their potential impact on Park ecosystems. This assessment can be used to develop a management plan before colonization occurs. This planning would allow Park personnel sufficient time to consider all management options and implement the management strategy selected.

The general objective of this project was to conduct an impact assessment of mountain goats on the Yellowstone and Grand Teton National Park ecosystems and develop management alternatives for Park personnel.

There are three specific objectives for this study:

1) Determine current population status of mountain goats in the Greater Yellowstone Ecosystem.

2) Assess potential impacts of mountain goats on floral and faunal species of the Parks.

3) Based on findings of the first two steps, formulate different management scenarios and assess their feasibility and anticipated impacts.

METHODS

CURRENT STATUS OF MOUNTAIN GOATS

Data on the current distribution and status of mountain goats are necessary to determine likely colonization sites and probable timing of those colonizations. Park managers then can anticipate where and how soon management strategies will have to be implemented.

To assess the current status of mountain goats, I perused various sources of information. All of the mountain goat populations surrounding the Parks are from transplant efforts by state wildlife agencies from Idaho and Montana. These agencies maintain information on the status and distribution of the goats under their jurisdiction in the form of published manuscripts, internal reports, and personal knowledge. Wildlife biologists employed by the National Forests on which goats live also have data on goats. Park personnel maintain records of goat sightings in Yellowstone and Grand Teton National Parks. I contacted all these agencies and compiled any information they had.

In addition to compiling existing information on goat sightings, I conducted ground and air searches in areas where sightings were most prevalent in Yellowstone Park. I used all this information to update the current distribution map for goats (Anonymous 1987b).

IMPACT OF GOAT COLONIZATION

Impact of mountain goat colonization on Park habitat.

Mountain goats primarily graze on grass and forb species in alpine meadows (Saunders 1955; Hibbs 1967; Peck 1972; Johnson et al. 1978; Adams and Bailey 1983; Dailey et al. 1984). I assessed their impact on the alpine habitat in the Parks by:

1) Determining location and calculating size of habitat likely to be colonized by mountain goats.

2) Quantifying habitat composition of potential goat range and establishing permanent vegetation reference plots.

3) Reviewing current literature on mountain goat food preferences.

4) Determining effect of goat populations on alpine habitat in adjacent National Forests.

Location and size of impact areas:--From available habitat maps, the total amount of alpine/subalpine habitat in the Parks was estimated. These areas represent the maximum amount of habitat that might be colonized and affected by goats. Estimates of the number of goats likely to inhabit appropriate areas were based on population density estimates reported in the literature.

Habitat composition of impact areas:--Plant species lists of areas likely to be used by goats were compiled from existing literature. Thirty permanent vegetation reference plots in areas considered most likely to be colonized by goats were established. Plots were marked with 30 cm lengths of iron rod driven in the ground to a depth of approximately 20 cm. Brass tags imprinted with the area and plot numbers were affixed to the rods with stainless steel wire and rocks were piled around the exposed rod and tag. In the sparse, low vegetation of these areas, the rock piles are distinctive enough to facilitate future relocation of the plots. Photographic records (Houston 1982) were made of reference points and percent plant cover was estimated from the photographs.

Food preferences of goats:--Mountain goats are indigenous to many areas with faunal and floral compositions similar to the Greater Yellowstone Ecosystem. Various investigators have studied food preferences of mountain goats in many of these areas (Anderson 1940; Casebeer 1948; Brandborg 1955; Saunders 1955; Hibbs 1967; Peck 1972; Adams and Bailey 1983; Campbell and Johnson 1983). I used the data from these and other studies to compile a list of food preferences for mountain goats. I compared these food preferences with plant species lists for the Parks to predict the impact of goats on floral makeup of those areas.

Impact of goats on surrounding Forest Service Lands:--Goats currently live in alpine habitat adjacent to the Parks. Personnel from local state and federal agencies were consulted concerning the impact of goats on these areas. Additionally, selected areas were visited and qualitative and quantitative assessments of habitat composition of these areas were made. Quantitative measurements were made of percent cover of randomly selected photo points. The point frame method described by Floyd and Anderson (1982) was used for these measurements. Based on the information and data collected, changes in habitat in impact areas within the Parks were predicted for low and high goat densities.

Impact of mountain goats on bighorn sheep.

The most likely animal species to be affected by mountain goats is bighorn sheep (Adams et al. 1982b) because colonization by mountain goats will likely be within existing sheep range. I assessed anticipated impacts of goats on sheep by:

1) Calculating resource overlap of food and habitat preferences of goats and sheep.

2) Reviewing current literature on mountain goat and bighorn sheep interactions.

3) Analyzing population trends of goats and sheep in National Forests surrounding Yellowstone and Grand Teton National Parks.

Resource overlap:--Food and habitat preferences of sheep and goats were determined from the literature. Resource overlap indices (O) were calculated from these data with equation 1 (Lawlor 1980).

(1)

$$O_{ik} = \sum p_{ij}\, p_{kj} \,/\, [\sum(p_{ij})^2 \cdot \sum(p_{kj})^2]^{1/2}$$

Where: p_{ij} and p_{kj} are the proportions of resource type j used by species i and k.

Goat-sheep interactions:--Goats and sheep co-occur in a variety of areas in the northwest. Data exist on several aspects of their relationship (R.W. Thompson 1981; Adams et al. 1982b; Johnson 1983; Dailey et al. 1984). These studies were reviewed to assess impacts goats may have on sheep in the Parks.

Population trends in surrounding National Forests:--Sheep and goats presently co-occur in areas adjacent to the Parks. Records on the population status of bighorn sheep and goats are available from the literature and wildlife agencies. This information was examined for trends in sheep densities relative to introduction and establishment of goat populations.

MANAGEMENT OPTIONS AND FINAL RECOMMENDATIONS

After objectives 1 and 2 were completed, three management strategies were developed. They were: 1) no action, let goats become part of faunal component of the Parks, 2) control goats at certain densities within the Parks, and 3) removal of all goats that enter the Parks. The viability of each option was assessed based on:

1) Feasibility of implementation:	Cost and logistics in meeting management goals.
2) Implications to Park policy:	Compatibility of management plan with Park philosophy.
3) Public acceptance:	Anticipated reaction of public to management plan.
4) Environmental impacts:	Impact of management plan on mountain goats and native plants and animals in the Greater Yellowstone Ecosystem.

Information on these criteria were collected from existing literature and from consulting with Park personnel. The strategies were then prioritized and management recommendations made to Park Service personnel of both Parks.

RESULTS AND DISCUSSION

CURRENT DISTRIBUTION AND STATUS

Original transplants of mountain goats within the Greater Yellowstone Ecosystem were made in Idaho and Montana. Personnel of the Montana Department of Fish, Wildlife, and Parks introduced 55 goats into various ranges northwest of Yellowstone Park between 1947-59 and 72 goats into the Absaroka/Beartooth mountains between 1942 and 1958 (Unpublished data, Montana Department of Fish, Wildlife and Parks). Twelve goats were introduced by the Idaho Department of Fish and Game into the Palisades/Black Canyon area near Swan Valley, Idaho in 1969-71 (Hayden 1984).

Goats have increased in number from these initial transplants. The original 23 goats transplanted near Pine Creek in the Absaroka Mountains had increased to approximately 100 animals by 1983 (Swenson 1985). By 1983, the original population of 12 goats in the Palisades area had increased to approximately 150 animals (Hayden 1984). In the Absaroka population, the kid:100 adult goat ratio reached a high of 60 in 1966 (Swenson 1985). The Palisades

population had a similar ratio of 75 kids:100 adults in 1983. These kid:adult ratios indicate a rapidly increasing population and are considered high compared to native populations (Hayden 1984). Data from other transplanted populations indicate such rapid increases in numbers after a transplant are common (Guenzel 1980). The main effect of the increase in goat numbers has been expansions of ranges of the goats (Fig. 1) (Anonymous 1987b).

Figure 1. Current (1987) distribution of mountain goats in National Forests adjacent to Yellowstone National Park (Anonymous 1987b) and recent sightings of goats reported to various resource management agencies.

Yellowstone National Park

Four visits were made to Yellowstone National Park in 1988. On the first visit (15-16 June 1988), Park personnel were consulted and records were examined for information on mountain goats in and near Yellowstone Park. This information was used to identify areas where goats most likely occurred. During the second visit (19-21 June 1988), the Mt. Holmes and Wolverine Peak areas were searched for goats. No goats were sighted on Mt. Holmes but 8-10 goats, including 2 kids, were sighted on and near Wolverine Peak. On 12-14 July 1988 an aerial survey of the north half of the Park was made. All likely goat habitat in the northwest, northcentral and northeast sections of the Park was searched. Goats were again sighted in the Wolverine Peak area but not in other areas. Because of a recent reported goat sighting in the Hellroaring Mountain area, a ground search was conducted there; no goats

Table 1. List of mountain goat sightings reported for Yellowstone National Park and adjacent National Forests.

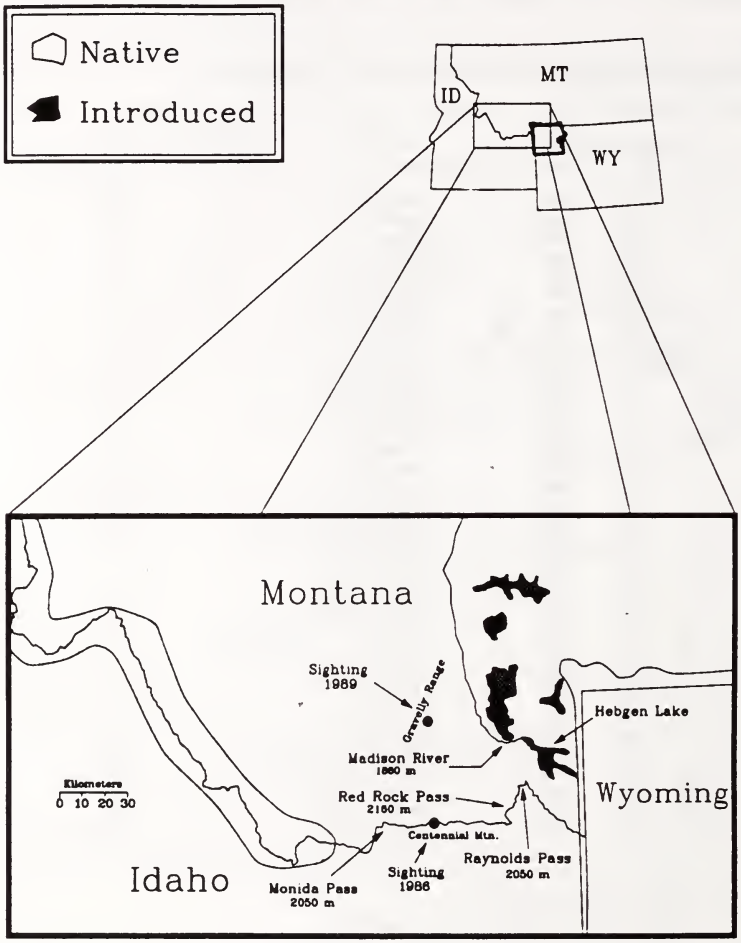
Date of Observation			Location	Number	Sex/age
20	Jul	1965	Bighorn Peak	2	?/Ad
29	Jun	1966	Meridian Peak	1	?/Ad
2	Jul	1969	Bighorn Peak	2	?/Ad
	Jul	1969	Sepulcher Mtn.[1]	13-15	?/?
	Sep	1972	Wolverine Peak	3	M/Ad
6	Sep	1978	Bliss Pass	1	?/Ad
9	Jul	1981	Gallatin River	1	?/Ad
5	Sep	1982	Wolverine Peak	1	?/Ad
10	Sep	1982	Sunset Peak	4	?/Ad
10	Sep	1982	Wolverine Peak	1	?/Ad
8	Sep	1983	Wolverine Peak	1,2	F/Ad-?/kid
16	Jul	1984	Barronette Peak	1	M/Ad
	Jun	1985	Specimen Cr.	5	?/Ad
20	Aug	1985	Hellroaring Cr.	1	?/Ad
	Aug	1985	Sunset Peak	1	?/Ad
19	Oct	1985	Wolverine Peak	1	?/Ad
1	Jan	1986	Bliss Pass	1,2	F/Ad-?/kids
12	Apr	1986	Ishawoon Hills[2]	1	M/Ad
17	Apr	1986	Ishawoon Hills[2]	1	M/Ad
18	Apr	1986	Beem Gulch[2]	1	?/?
22	Apr	1986	Ishawoon Hills[2]	1	?/?
17	May	1986	Ishawoon Hills[2]	1	M/Ad
24	May	1986	Ishawoon Hills[2]	1	M/Ad
31	Jul	1986	Bliss Pass	1	?/Ad
11	Aug	1986	Cutoff Mtn.	1	?/Ad
19	Aug	1986	Hardpan Creek[2]	1	?/?
11	Sep	1986	Irish Rock[2]	1	M/Ad
21	Aug	1987	Mtn. Everts	1	?/Ad
31	Aug	1987	Dome Mtn.	2	?/Ad
4	Sept	1987	Dome Mtn.	2	?/Ad
22	Oct	1987	Electric Peak	2	?/Ad
20	Jun	1988	Wolverine Peak	8,2	?/Ad-?/kids
30	Oct	1988	Abiathar Peak	1	?/Ad
27	Oct	1988	Wolverine Peak	4,2	2M&2F/Ad-?/kids

[1]Likely a band of bighorn sheep
[2]Outside established range on adjacent National Forests

were found. On 26-28 October 1988, Wolverine Peak was revisited in conjunction with collecting habitat data in the area. At that time, four adults (2 male and 2 female) and 2 kids were seen on the summit of Wolverine Peak. Sex determination of adult animals was based on criteria outlined by Smith (1988).

Table 1 and Figure 1 present the reported sightings of mountain goats for Yellowstone National Park and adjacent National Forests. Sightings in most areas are sporadic and the reliability of the sightings varies. All sightings were within current bighorn sheep range and inexperienced individuals can mistake bighorn ewes for mountain goats. Although sightings

Figure 2. Distribution of mountain goats near the extreme northwest corner of Yellowstone Park relative to native populations to the west. The two sightings indicated were in the Gravelly Mountain range north of Red Rock Lakes Wildlife Refuge and the Centennial Mountains south of the refuge.



in some areas are more consistent, there is no evidence goats have actually become established in most areas. Based on the aerial survey, the field surveys, and reports, goats are currently established only in the Wolverine Peak/Sunset Peak area in the northeast corner of the Park. Adult goats with young were consistently seen in this region throughout the summer and fall. In the other areas, animals seem to be transient. Whether goats will become established in other areas where they have been reported is unknown.

There is some uncertainty as to the origin of mountain goats sighted in the northwest corner of the Park (Fig. 1). It is assumed the goats being reported are emigrants from introduced core populations to the northwest. However, it is possible goats may be immigrating into the Park from existing native populations to the west along the Montana-Idaho border. These populations are found within 30 km west of Monida Pass (Fig. 2) but may be extending their range. There has been one confirmed sighting of a goat in the Gravelly Range north of the Red Rock Lakes Refuge and possible sightings in the Centennial mountains to the south (Fig. 2). These animals may have come from the western populations as there are no significant barriers to movement of goats to the east; the lowest pass is 1860 m (Fig. 2). It is generally thought that goats are relatively poor dispersers (Stevens 1983) and that it is unlikely that they would colonize areas to the east. However, the relatively rapid and widespread dispersal of introduced goats from all the release points north of Yellowstone Park, including into the Park, tends to refute this hypothesis. The close juxtaposition of native and introduced populations and the conflicting evidence of their dispersing ability puts the origin of any dispersers in doubt. It may become critical to determine if goats moving into the northwest corner of the Park are descendants of introduced stock to the north or are from native stock to the west. Animals moving into the Park from native populations, could represent a "natural" extension of their range; goats from introduced populations might be considered exotic. DNA fingerprinting would be necessary to determine origins of goats moving into the Park in the northwest corner. However, taking such action would depend on the historic/prehistoric status of mountain goats in the Yellowstone Ecosystem. This topic will be discussed later.

Grand Teton National Park

Two visits to Grand Teton National Park and vicinity were made during this study. The first visit (14 July 1988) was to consult with Park personnel and review reports of goat sightings. A summary of those sightings inside and near the Park are presented in Table 2 and Figure 3. As with Yellowstone Park, all sightings in Grand Teton Park were within or near existing bighorn sheep range (Fig. 3) and seem to be of transient individuals. When checking on sighting reports, Park personnel have not consistently relocated animals and there have been no sightings of young.

South of Grand Teton National Park, sightings have been more frequent and consistent (Table 2). Most of the sightings have been from the Taylor Mountain region. Hikers have reported seeing goats in the Taylor Mountain area yearly since 1981, including at least one sighting of a yearling. During this study, I sighted three adult goats on the southeast side of Taylor Mountain on 30 October 1988. Thus, there seems to be a small but persistent population of goats in this area. It is unknown why the population has not expanded

Figure 3. Current (1987) distribution of mountain goats in National Forests adjacent to Grand Teton National Park (Anonymous 1987b) and recent sightings of goats reported to various resource management agencies. The current distribution of bighorn sheep is also indicated.

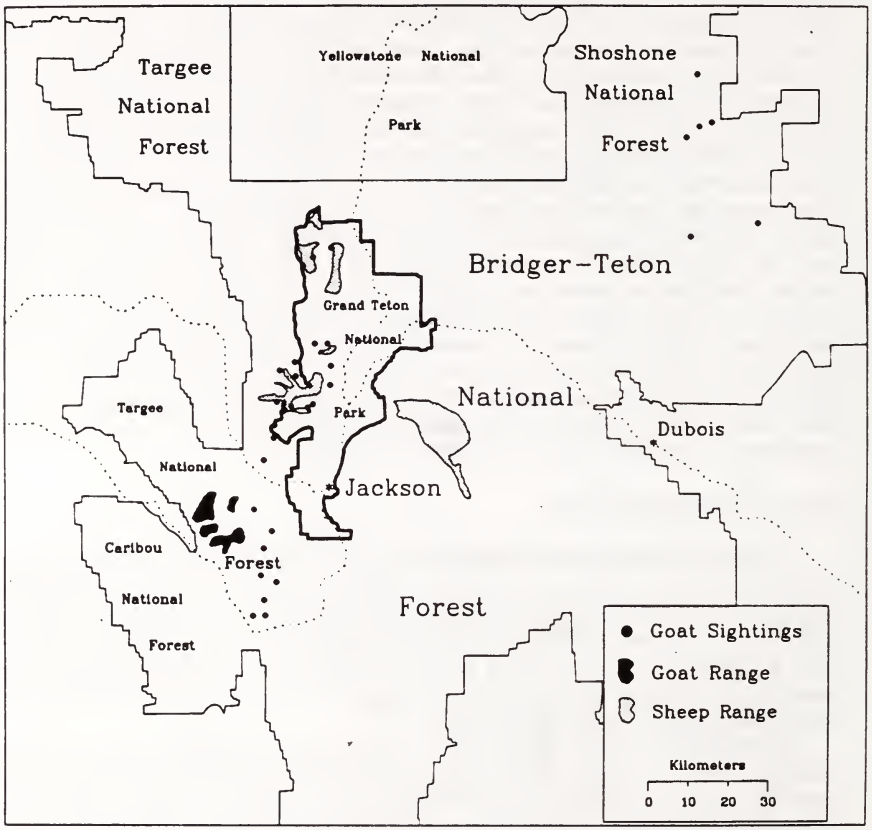


Table 2. Sightings of mountain goats in and adjacent to Grand Teton National Park.

Date			Location	Number	Age/Sex
	Aug	1977	Teton Pass	2	?/Ad-?/Juv
16	Jul	1979	Game Ck. Divide	1	M/Ad
25	Aug	1979	Paintbrush Canyon	1	M/Ad
28	Aug	1979	Holly Lake	1	?/Ad
29	Aug	1979	House Top Mtn.	1	?/Ad
1	Sep	1979	Amphitheater Lake	5	?/Ad
3	Sep	1979	Paintbrush Divide	2	?/Ad
23	May	1980	Death Canyon	1	?/Ad
	Jul	1980	Teewinot area	1	?/Ad
10	Aug	1980	Owl Peak	1	?/Ad
1	Sep	1980	Fox Cr. Pass	1	?/Ad
24	Sep	1980	Teton Canyon	1	M/Ad
25	Sep	1980	Forellen Peak	1	?/Ad
29	Sep	1980	Moose Basin Divide	1	?/Ad
24	Oct	1980	Treasure Mtn.	1	M/Ad
1	Nov	1980	Coal Ck.	1	M/Ad
12	Jul	1981	Teton Pass	3	?/Ad
	Aug	1981	Housetop Mtn.	2	?/Ad
1	Sep	1981	Taylor Mtn.	1	?/Ad
22	Jul	1982	Taylor Ck	2	F/Ad
20	Aug	1982	Fossil Mtn. Pass	1	?/Ad
18	Sep	1982	Taylor Mtn.	4/1	?/Ad-?/Juv.
26	Oct	1982	Taylor Mtn.	1	?/Ad
12	Jul	1983	Observation Peak	4	?/?
24	Sep	1983	Long Spring Canyon	3	?/Ad
1	Oct	1983	South Fork Ck	1	?/Ad
14	Oct	1983	Taylor Mtn.	1	?/Ad
16	Oct	1983	Taylor Mtn.	2	?/Ad
23	Sep	1983	Long Spring Canyon	3	?/Ad
14	Sep	1985	Ferry Peak	2	?/Ad
17	Sep	1985	Garden Canyon	4	?/Ad
20	Sep	1985	Burnt Timber Canyon	5	?/Ad
21	Jul	1986	Taylor Mtn.	1	?/Ad
24	Aug	1986	Burnt Timber Canyon	3	?/Ad
3	Sep	1986	North Fork Ck	1	?/Ad
14	Sep	1986	Ferry Peak	7	?/Ad
15	Oct	1986	North Fork Ck	1	F/Ad
16	Oct	1986	Taylor Mtn.	1	F/Ad
26	Jul	1987	Treasure Mtn.	2	?/Ad
7	Aug	1987	Death Canyon	2	?/Ad
15	Sep	1987	Taylor Mtn.	3	?/Ad
12	Oct	1987	Mud Peak	1	M/Ad
27	Jun	1988	Taylor Mtn.	2	?/Ad
30	Oct	1988	Taylor Mtn.	3	?/Ad

beyond the few animals that are periodically seen. There are ample mountain peaks that appear suitable for goats. Possibly the area lacks adequate winter habitat. This aspect will be addressed later.

Conclusions

Ranges of goat populations have not changed significantly from 1987 (Anonymous 1987b). The only place goats are firmly established within Park boundaries is the northeast corner of Yellowstone Park. These animals are extensions of a well established population in the Absaroka/Beartooth Mountains and move in and out of the Park on a daily basis. From these established population centers, goats are venturing into various interior areas in both Parks. Reports of these visits have increased in recent years but may be a result of increased use of back country areas by hikers rather than an increase in the number of goats visiting.

Field evidence indicates these vagrants are most likely billies (Stevens and Driver 1978; Adams et al. 1982a; Stevens 1983) and such sojourns are scouting trips by adult males for females or dispersal from home areas by young billies. Adult males looking for females move into an area and when no females found, move back out again. These "probe movements" (Stevens 1983) could explain the one or two ephemeral sightings of an animal in an area. Dispersing subadults might move into an area and remain a year or more and eventually leave the area or die. Such "wandering movements" (Stevens 1983) could account for the persistent sightings of one or two animals in an area. Based on sighting records, such trips have been occurring in both Parks for at least the last 10-15 years.

It is unclear why goat populations have yet to become established in the Parks. Perhaps goat population densities outside the Parks are not high enough to force sufficient numbers of animals to pioneer the new areas. The Absaroka population studied by Swenson (1985) reached a peak in the early 1970's, declined slightly by 1978 and then stabilized by 1983. Kid:adult ratios in the 1980's was approximately 20:100 compared to 60:100 during the expansion years. The population density of the Palisades population in 1986 had increased to 230 animals with approximately 46 kids. However, in 1988 the Idaho Fish and Game found a population of 214 with approximately 52 kids. Thus, between 1986 and 1988, the population stabilized with kid production lowering to 32 kids:100 adults compared to 75:100 for 1983 (Hayden 1984). The sigmoid growth and declining kid:adult ratios were found in other transplanted populations (Guenzel 1980; R.W. Thompson 1981) and may be typical of such populations (Caughley 1970). If populations at the initial release areas are stabilizing because of low kid production, there would be fewer numbers of animals that might emigrate to surrounding ranges.

There are several factors that may contribute to stabilization of goat numbers. All established populations of goats outside the Parks are currently hunted. Kuck (1977) and Houston and Stevens (1988) found goat populations were susceptible to overharvest. Swenson (1985) also found a negative correlation between population trends in the Absaroka goats and harvest rates. Reproduction rates can also be negatively correlated with snow depth (Bailey and Johnson 1977; R.W. Thompson 1981; Adams and Bailey 1982; Swenson 1985) and population density (Swenson 1985). These three factors, harvest, snow depth, and population density, operating in synchrony could stabilize a population and slow the rate of colonization of new areas of appropriate habitat. These factors would only slow, not eliminate, colonization. Goat populations still might eventually become established in the Parks in the future.

Another reason goats may not be established in the Parks is because of insufficient winter habitat. Winter conditions in many of the areas where goats have been sighted may

be too harsh for survival of pioneering individuals. Swenson (1985), Bailey and Johnson (1977), and Adams and Bailey (1982) found low kid:adult ratios when snow depth on 1 May exceeded 200 cm. Snowfall between 1700 and 2500 m in the northern range of Yellowstone averages 378 cm (Oldemeyer et al. 1971). In the northeast corner of Yellowstone and adjacent mountains, snow depth varies from 119 to 230 cm (Pallister 1974; Stewart 1975; Martin 1985; Swenson 1985). Snow pack in the Grand Teton area can be in excess of 240 cm (Whitfield 1983). These snow depths could affect kid and adult survival.

There are 200-300+ bighorn sheep in Yellowstone Park (M. Meagher, Personal Communication) and historically there were good populations in the Grand Teton area. Goats and sheep have extensive overlap in habitat requirements and an area that could support sheep should also support goats. Winter habitat requirements do differ somewhat between species. Bighorn sheep often migrate to lower elevations (Woolf et al. 1970; Keating et al. 1985; Martin 1985) while goats tend to winter in or near their high altitude summer range (Chadwick 1977; Rideout 1977). If the snow is too deep for goat survival in higher elevations, winter could limit goat distribution and numbers more than sheep. If winter conditions are the factors limiting expansion of goats into Yellowstone and Grand Teton National Parks, the ephemeral status of goats would not be expected to change.

Based on sight records, pioneering goats are using habitat currently occupied by sheep (Fig. 3). A third possible explanation for the lack of colonization of the Parks by goats is competitive exclusion by sheep. There is some ambiguity in the literature as to competitive interactions between sheep and goats. Goats and sheep co-occur over most of the range of mountain goats without obvious effects on either species. Observations range all possible outcomes from no interaction (Holroyd 1967) to seemingly aggressive behavior by sheep and goats (Reed 1986 & unpubl. data). Reed (1986) found over 50% of the interactions he recorded between sheep and goats to be neutral but 41% of the time, goats displaced sheep from a resource (feeding site, bed area, etc). Whitfield (1983) concluded sheep, at least in Grand Teton Park, would be the weaker competitors. It is unlikely the presence of sheep would prevent colonization of the Parks by goats. Goats and sheep rarely interact aggressively and when they do, goats are most often the aggressor.

Of the possible factors that may account for the limited presence of goats in the Parks, the most likely explanation for their current distribution is a lack of sufficient time and/or founding individuals to establish core populations.

IMPACT OF GOAT COLONIZATION

Impact on Park habitat

Location and size of impact areas:—If the current low occurrence of goats in both Parks is a result of competition with sheep or lack of sufficient habitat, then goat numbers in either Park would not increase much beyond current levels. However, if goat numbers are currently low because of insufficient time and/or numbers of pioneering animals, the number of goats within each Park would eventually increase.

If mountain goats will ultimately colonize interior areas of both Parks, it is necessary to try and predict the areas most likely to be colonized and the maximum number of goats that might occur. Reported densities of goats elsewhere vary considerably among studies (Hayden 1989). These variations can reflect true differences in population densities as well

as different modes of calculation. Population density can be based on the total area of a watershed or only on the area of observed use. Densities can also be calculated based on the size of summer or winter ranges. The calculations for this report are based on total available area of the summer watershed. This was done because of the uncertainty of exactly which areas goats would actually occupy in the Parks. To generate estimates of total population and population densities for Yellowstone Park, I used data from Swenson's (1985) study of goats in the Absaroka mountains. For Grand Teton Park, I used data from the Palisades population (Hayden 1984;1989).

From 1981 to 1983, Swenson (1985) found a population of 90-96 animals in the Absaroka area. His study area was approximately 275 km^2. If it is assumed 95 animals represents a stable population, the population density of his study area was 0.34 goats/km^2. No estimate of the amount of suitable goat habitat in Yellowstone Park exists. The topography of the mountain ranges is gradual enough that nearly all mountainous areas are usable by bighorn sheep in the summer. Summer habitat use by goats and sheep overlap extensively (Adams et al. 1982b). Assuming the 250 km^2 of sheep habitat in Yellowstone Park (Anonymous 1987b) would also be suitable for goats, the total number of goats the Park would support, at 0.34 goats/km^2, would be 95 animals.

The densities found in Swenson's study area compare to the lower density estimates from other studies (Hayden 1989). Densities of goats from other areas range from a high of 15.4/km^2 found in Glacier National Park (Singer and Doherty 1985) to a low of 0.2/km^2 in British Columbia (Herbert and Turnbull 1977). The summer range densities of various studies reported by Hayden (1989) were averaged and had a mean of 1.9 goats/km^2. Densities in northern Yellowstone are not likely to be higher than 1.9 goats/km^2. This density is five times higher than that reported by Swenson and should be sufficient to accommodate any eruptive growth (Caughley 1970) in this area, even in the absence of hunting. Consequently, this density was used to generate a high estimate of 522 goats for the Park.

Potential goat habitat in Yellowstone is dispersed among several fragmented mountain ranges. Some of these ranges, e.g., Mt. Washburn, may be too small to support as high a density of goats as larger ranges. The quality of goat habitat likely varies among the ranges, also affecting accuracy of the calculations. Consequently, the density of goats would vary considerably among the different ranges in the Park and the total number of goats that might inhabit the Park is difficult to predict. However, the high and low estimates should represent a realistic range of possible numbers.

Hayden (1989) found goat densities for summer range in the overall Palisades study area averaged 6.8 goats/km^2. There are 83 km^2 of existing sheep habitat in Grand Teton Park (Anonymous 1987b). If habitat within Grand Teton Park, could support this density, the number of goats possible in the Park would be 564. The density found by Hayden is considerably higher than most other areas and might represent a peak in an eruptive growth phase for that area. Because of the high densities found near GTNP, the low density estimate from the area north of Yellowstone Park may not be realistic for Grand Teton Park. To develop a range of possible numbers of goats, the average density of 1.9 goats/km^2 was used to calculate a low estimate of 158 goats.

In Grand Teton Park, it is difficult to determine how much potential habitat exists *a priori*, without extensive field analysis. Goats can use more rugged and steeper areas than sheep and could likely use more of the precipitous habitat in Grand Teton Park than sheep,

provided adequate food existed. Thus the estimates of potential goat numbers based only on current sheep habitat could be underestimated.

Suring et al. (1988) developed a habitat capability model for mountain goats in Alaska which is currently being verified by the authors. The main factors in the model are habitat type, aspect, and distance from escape terrain (Fox 1983). Goats in southeast Alaska use forested areas more than goats in Montana (Peck 1972; Fox and Smith 1988). However, modifications could be made to this model to correspond to conditions in the intermountain west. The model could then be used to assess the habitat suitability of potential range in the Parks and calculate more accurate population estimates. The model would require detailed field analysis of the potential habitat for each Park. Such detailed field work was not in the scope of this project. However, it is recommended that such an effort be undertaken once the model has been verified and modified appropriately.

Habitat composition of impact areas:--Alpine and subalpine communities in Yellowstone and Grand Teton Parks are characteristic of such communities in the intermountain west. Structurally, the communities consist mainly of low growing grasses, forbs, and shrubs. Subalpine communities will have varying percents of evergreen trees. Typical species found in alpine and subalpine communities in Yellowstone and Grand Teton Parks were listed in Martin (1985) and Whitfield (1983) respectively and are summarized in Table 3.

Whitfield (1983) measured percent cover for various vegetal components of summer range of bighorn sheep in Grand Teton Park. He found grasses and grasslike plants with 11% cover (Table 4), forbs had 28% cover, and shrubs and trees constituted 11% cover. Keating et al. (1985) estimated summertime percent cover for grasses, forbs and shrubs for the Mt. Everts and Cinnabar winter ranges in and near Yellowstone Park (Table 4). Grasses had 60% cover on Mt. Everts and 50% in the Cinnabar area. Forbs covered 18% of the ground on Mt. Everts and 13% in the Cinnabar winter range. Shrubs constituted 21% of the canopy on Mt. Everts and 37% in the Cinnabar area. Stewart (1975) assessed percent cover for grasses, forbs, and shrubs on the West Rosebud area in the Beartooth Mountains north of Yellowstone Park (Table 4). He found percent grass cover varied from 2% to 38% and forbs ranged from 4% to 82%.

The Wolverine Peak area has been identified as the initial colonization site of goats in Yellowstone Park. If goat numbers increase in this area, it is important to have baseline data on percent cover of alpine vegetation for future comparisons. In the summer and fall of 1988, permanent photoplots were established and photographed. Three general areas were selected for sampling. Area 1 is the south side slope of Wolverine Peak. Area 2 is the west side slope and Area 3 is a plateau area down slope from the west side location (Fig. 4). Selection of these areas was based on observations of mountain goat use. Ten photoplots per area were randomly selected. All sample points were on slopes without trees or shrubs. Approximate locations of the photoplots are shown in Figure 4.

Total percent cover in summer and fall was lowest in Area 1 and highest in Area 3 (Table 4). Goats have only recently invaded the area and are still in low numbers. The percent cover measurements taken in these three areas should provide baseline data for future comparisons when or if goat numbers increase.

Table 3. List of grass, forb, and woody species found in alpine and subalpine communities in Yellowstone and Grand Teton National Parks (Whitfield 1983; Martin 1985).

Species (Hitchcock & Cronquist 1973)	Common Name (Hitchcock & Cronquist 1973)	Status (Shaw 1976[a])
Grass and grasslike plants		
Agropyron caninum	Bearded wheatgrass	-[b]
Agropyron scibneri	Spreading wheatgrass	Frequent
Agropyron spicatum	Bluebunch wheatgrass	Frequent
Agrostis humilis	Alpine bentgrass	Infrequent
Agrostis scabra	rough hair-grass	Frequent
Agrostis thurberiana	Thurber bentgrass	Rare
Agrostis variabilis	Variant bentgrass	Rare
Alopecurus alpinus	Alpine foxtail	Rare
Bromus ciliatus	Columbia brome	-
Bromus inermis	Smooth brome	-
Calamagrostis canadensis	Bluejoint reedgrass	Frequent
Calamagrostis scopulorum	Cliff reedgrass	Rare
Carex albonigra	Black and white scaled sedge	-
Carex concinniodes	Northwest sedge	-
Carex elynoides	Kobresia-like sedge	Frequent
Carex geyeri	Elk sedge	Common
Carex paysonis	Payson sedge	Frequent
Danthonia californica	California oatgrass	Rare
Deschampsia atropurpurea	Mountain hairgrass	Frequent
Deschampsia cespitosa	Tufted hairgrass	Frequent
Deschampsia elongata	Slender hairgrass	Rare
Festuca idahoensis	Idaho fescue	Frequent
Festuca ovina	Sheep fescue	Frequent
Juncus drummondii	Drummond's rush	Frequent
Juncus parryi	Parry's rush	Frequent
Juncus tenuis	Slender rush	-
Koeleria cristata	Koeleria's junegrass	Frequent
Luzula parviflora	Small flower woodrush	Common
Luzula hitchcockii	Smooth woodrush	Common
Oryzopsis hymenoides	Indian ricegrass	Infrequent
Phleum alpinum	Alpine timothy	Frequent
Poa alpina	Alpine bluegrass	Infrequent
Poa grayana	Gray's bluegrass	Infrequent
Poa juncifolia	Alkali bluegrass	Frequent
Poa nevadensis	Nevada bluegrass	Rare
Poa rupicola	Timberline bluegrass	Rare
Sitanion hystrix	Bottlebrush squirreltail	Frequent
Stipa lettermanii	Letterman's needlegrass	Frequent
Stipa occidentalis	Western needlegrass	Rare
Trisetum spicatum	Downy oat-grass	Frequent
Forbes		
Achillea millefolium	Yarrow	Infrequent
Agoseris glauca	Pale agoseris	Frequent
Androsace septentrionalis	Northern rock jasmine	Infrequent
Anemone multifida	Pacific anemone	Infrequent
Antennaria alpina	Alpine pussy-toes	Frequent
Antennaria corymbosa	Flat topped pussy-toes	Common
Aquilegia flavescens	Yellow columbine	Infrequent
Arabis lyallii	Lyall's rockcress	Frequent
Arenaria congesta	Ballhead sandwort	Common
Arenaria nuttallii	Nuttall's sandwort	Rare
Arenaria obtusiloba	Arctic sandwort	Frequent
Arenaria rossii	Ross sandwort	-

Table 3. cont.

Species (Hitchcock & Cronquist 1973)	Common Name (Hitchcock & Cronquist 1973)	Status (Shaw 1976[a])
Arnica cordifolia	Heart-leaf arnica	Common
Arnica latifolia	Mountain arnica	Frequent
Arnica longifolia	Seep-spring arnica	-
Arnica parryi	Nodding arnica	Frequent
Arnica rydbergii	Rydberg's arnica	-
Artemisia frigida	Fringed sagebrush	Infrequent
Artemisia michauxiana	Michaux sagebrush	Rare
Artemisia scopulorum	Alpine sagebrush	Rare
Aster alpigenus	Alpine aster	Frequent
Astragalus alpinus	Alpine milkvetch	Common
Astragalus kentrophyta	Kentrophyta	Frequent
Astragalus vexilliflexus		
Balsamorhiza sagittata	Arrowleaf balsamroot	Abundant
Bupleurum americanum	American thorway	Frequent
Caltha leptosepala	Elkslip	Frequent
Campanula parryi	Parry's harebell	-
Castilleja cusickii	Hairy indian paintbrush	-
Castilleja pulchella	Showy indian paintbrush	Frequent
Cerastium berringianum	Alpine chickweed	Frequent
Chaenactis alpina	Alpine dusty maiden	Frequent
Cirsium scariosum	Elk thistle	Common
Claytonia lanceolata	Western springbeauty	Common
Claytonia megarhiza	Alpine springbeauty	Rare
Cymopterus hendersonii	Henderson's cymopterus	Frequent
Dodecatheon conjugens	Shooting star	Frequent
Draba crassifolia	Thickleaved draba	Infrequent
Draba densifolia	Nuttall's draba	-
Draba lonchocarpa	Lancefruit draba	Infrequent
Draba oligosperma	Few-seeded draba	Frequent
Epilobium angustifolium	Fireweed	Abundant
Epilobium glaberrimum	Smooth willow-weed	-
Erigeron compositus	Cutleaved daisy	Infrequent
Erigeron rydbergii	Rydberg's daisy	-
Erigeron simplex	Alpine daisy	-
Eriogonum ovalifolium	Oval-leaf eriogonum	Frequent
Eriogonum umbellatum	Sulfur buckwheat	Common
Eritrichium nanum	Pale alpine forget-me-not	Frequent
Erysimum asperum	Rough wallflower	Infrequent
Fragaria vesca	Woods strawberry	Frequent
Fragaria virginiana	Broadpetal strawberry	Frequent
Galium trifidum	Sweet scented bedstraw	Frequent
Gentiana algida	Whitish gentian	-
Geum rossii	Ross' avens	Frequent
Hedysarum sulphurescens	Yellow hedysarum	-
Lewisia pygmaea	Alpine lewisia	Frequent
Lloydia serotina	Alpine lily	Infrequent
Linnaea borealis	Twin flower	Frequent
Linum perenne	Blue Flax	Frequent
Lomatium cous	Cous biscuit-root	Frequent
Lupinus argenteus	Silvery lupine	Common
Lupinus sericeus	Silky lupine	Abundant
Mertensia alpina	Alpine bluebell	-
Mertensia ciliata	Broad-leaf bluebell	Frequent
Myosotis sylvatica	Alpine forget-me-not	Infrequent
Oenothera caespitosa	Tufted evening primrose	Infrequent
Oxyria digyna	Mountain sorrel	Frequent
Oxytropis sericea	Silky crazyweed	Frequent
Parnassia fimbriata	Fringed parnassia	Frequent
Pedicularis bracteosa	Bracted pedicularis	Frequent

Table 3. cont.

Species (Hitchcock & Cronquist 1973)	Common Name (Hitchcock & Cronquist 1973)	Status (Shaw 1976[a])
Pedicularis groenlandica	Elephantshead	Common
Penstemon fruticosus	Shrubby penstemon	-
Penstemon procerus	Small-flowered penstemon	Frequent
Phacelia hastata	Silverleaf phacelia	Frequent
Phacelia sericea	Silky phacelia	Frequent
Phlox pulvinata	Cushion phlox	Frequent
Polemonium viscosum	Sticky polemonium	Frequent
Polygonum bistortoides	Western bistort	Common
Polygonum viviparum	Alpine bistort	Infrequent
Potentilla diversifolia	Diverse-leaved cinquefoil	Common
Potentilla gracilis	Soft cinquefoil	Common
Potentilla quinquefolia	Five-leaved cinquefoil	-
Potentilla recta	Erect cinquefoil	-
Ranunculus eschscholtzii	Subalpine butterweed	Widespread
Saxifraga arguta	Brook saxifrage	-
Saxifraga bronchialis	Yellowdot saxifrage	Common
Saxifraga flagellaris	Stoloniferous saxifrage	Rare
Saxifraga oppositifolia	Purple saxifrage	Frequent
Saxifraga oregana	Bog saxifrage	-
Saxifraga rhomboidea	Diamond-leaf saxifrage	Frequent
Sedum lanceolatum	Lance-leaf stonecrop	Common
Sedum roseum	Roseroot	Frequent
Sedum stenopetalum	Wormleaf sedum	Infrequent
Senecio canus	Wooly groundsel	Infrequent
Senecio crassulus	Thick-leaved groundsel	Frequent
Senecio fremontii	Dwarf mountain butterweed	-
Senecio fuscatus	Twice hairy butterweed	-
Senecio serra	Tall butterweed	Frequent
Senecio triangularis	Arrow-leaf groundsel	Common
Senecio werneriaefolius	Rock butterweed	-
Sibbaldia procumbens	Creeping sibbaldia	Frequent
Silene acaulis	Moss champion	Frequent
Smelowskia calycina	Alpine smelowskia	Frequent
Solidago multiradiata	Northern goldenrod	Frequent
Stellaria americana	American starwort	-
Taraxacum lyratum	Alpine dandelion	-
Thalictrum occidentale	Western meadowrue	Frequent
Townsendia parryi	Parry townsendia	-
Trifolium dasyphyllum	Whiproot clover	Common
Trifolium haydenii	Hayden's clover	Common
Trifolium nanum	Dwarf clover	Common
Trifolium parryi	Parry's clover	-
Veronica wormskjoldii	American alpine speedwell	Frequent
Viola adunca	Early blue violet	Frequent
Zygadenus elegans	Alpine death camas	Infrequent
Shrubs/trees		
Abies lasiocarpa	Subalpine fir	Abundant
Alnus incana	Thinleaf alder	Frequent
Alnus sinuata	Sitka alder	-
Arctostaphylos uva-ursi	Kinnikinnick	Frequent
Artemisia arbuscula	Dwarf sage	Frequent
Artemisia tridentata	Big sage	Abundant
Berberis repens	Creeping Oregon grape	Frequent
Betula occidentalis	Water birch	Rare
Ceanothus velutinus	Snowbrush ceanothus	Frequent
Cornus stolonifera	Red dogwood	Frequent
Dryas octopetala	White dryas	Infrequent
Juniperus communis	Common juniper	Frequent

Table 3. cont.

Species (Hitchcock & Cronquist 1973)	Common Name (Hitchcock & Cronquist 1973)	Status (Shaw 1976[a])
Phyllodoce empetriformis	Pink mountain heath	Frequent
Phyllodoce glanduliflora	Yellow mountain heath	Infrequent
Physocarpus malvaceus	Ninebark	-
Picea engelmannii	Engelman's spruce	Common
Pinus albicaulis	Whitebark pine	Common
Pinus contorta	Lodgepole pine	Abundant
Populus tremuloides	Quaking aspen	Abundant
Potentilla fruticosa	Shrubby cinquefoil	Common
Pseudotsuga menziesii	Douglas fir	Common
Ribes spp.	Gooseberry	Frequent
Rosa acicularis	Prickly rose	Frequent
Salix spp.	Willow	Common
Symphoricarpos spp.	Snowberry	Frequent
Vaccinium globulare	Blue huckleberry	Frequent
Vaccinium scoparium	Grouse whortleberry	Abundant
Vaccinium spp.	Blueberry	Frequent

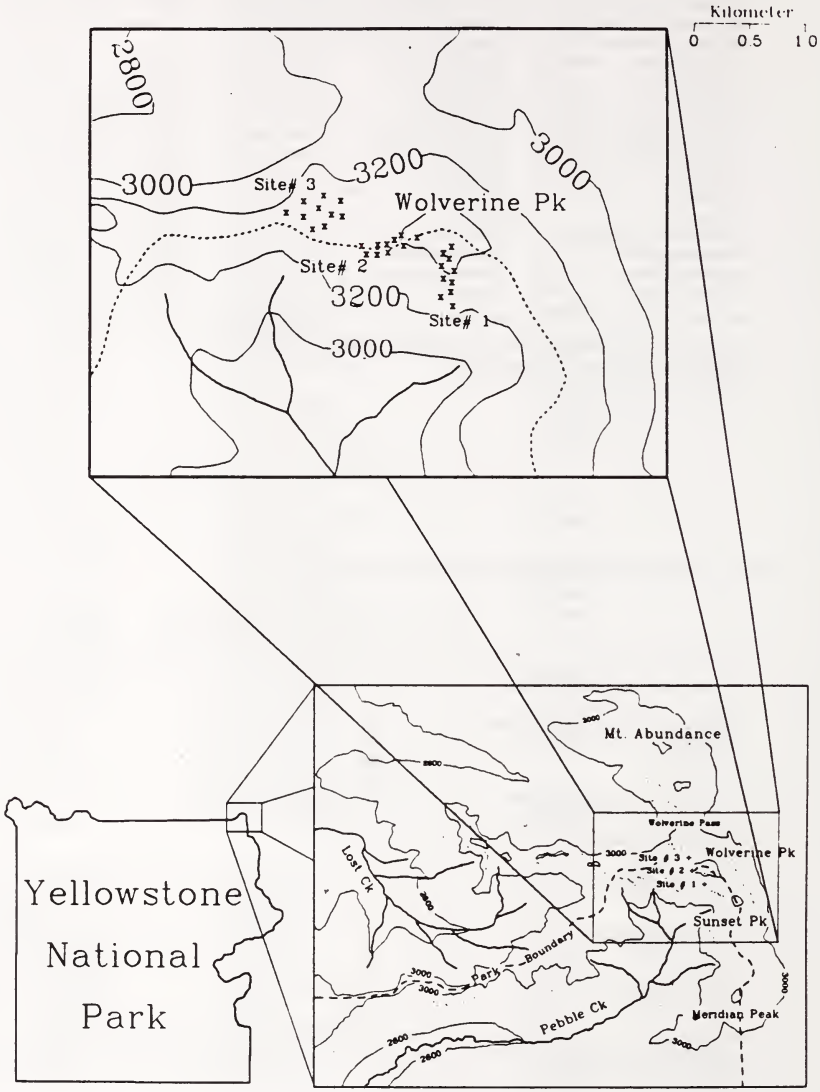
[a]Status relative to Teton County, Wyoming (Grand Teton Park) and may be different for Park County (Yellowstone Park).
[b]Not listed in Shaw (1976).

Table 4. Percent cover of various areas in Yellowstone and Grand Teton Parks.

		Mosses	Grasses	Forbs	Shrubs/Trees	Total[a]
Grand Teton Park (Whitfield 1983)		1.4%	11%	28%	11%	
Yellowstone Park (Keating et al. 1985)						
Mt. Everts			60%	18%	21%	
Cinnabar area			50%	13%	37%	
West Rosebud Area (Stewart 1975)			19%	35%	12%	
Wolverine Peak (This study)						
Area 1	Summer					39.2±14.4
	Fall					23.3±17.3
Area 2	Summer					71.1±17.3
	Fall					50.3±27.2
Area 3	Summer					74.3±23.6
	Fall					75.5±25.4

[a]Grass and forb species only.

Figure 4. Approximate location of the three sites on Wolverine mountain where permanent photo-points were established. Each photo-point is marked with a steel rod and a landmark of rocks.



Food preferences of mountain goats:–Researchers have studied food habits of mountain goats in different areas of their geographic range. In one of the earlier studies, Casebeer (1948) found goats in western Montana relying primarily on grouse whortleberry (*Vaccinium scoparium*) and the sedge *Carex geyeri* in the summer. During the winter, goats primarily ate junegrass (*Koeleria cristata*), wheatgrass (*Agropyron spicatum*), and willows (*Salix* sp.). Hjeljord (1973) reported summer food of goats in Alaska consisted of various forbs, depending on the habitat type they used. In winter, goats primarily fed on rough fescue grass (*Festuca* sp.) and coiled sedge (*Carex* sp.). Fox and Smith (1988), however, found Alaskan goats they studied relying more on mountain hemlock (*Tsuga mertensiana*), mosses (*Hylocomium* sp.), and lichen (*Lobaria* sp.) in the winter.

Table 5. Summary of general food habits of goats from various studies. Estimates are expressed as percent of total use and are based on either fecal or rumen analyses.

	Summer			Winter		
Grasses	76%	Montana	(Saunders 1955)	59%	Montana	(Saunders 1955)
	97%	Colorado	(Hibbs 1967)	88%	Colorado	(Hibbs 1967)
	22%	Montana	(Peck 1972)	90%	Montana	(Peck 1972)
	40%	Montana	(Pallister 1974)	45%	Colorado	(Adams and Bailey 1983)
	60%	Colorado	(Johnson et al. 1978)	47%	Montana	(Thompson 1981)
	84%	Colorado	(Thompson 1981)	31%	Washington	(Johnson 1983)
	11%	Montana	(Thompson 1981)			
	47%	Montana	(Stewart 1975)			
	44%	Washington	(Johnson 1983)			
Mean	53%			60%		
Forbes	14%	Montana	(Saunders 1955)	10%	Montana	(Saunders 1955)
	3%	Colorado	(Hibbs 1967)	0%	Colorado	(Hibbs 1967)
	78%	Montana	(Peck 1972)	6%	Montana	(Peck 1972)
	60%	Montana	(Pallister 1974)	2%	Montana	(Thompson 1981)
	29%	Colorado	(Johnson et al. 1978)	24%	Colorado	(Adams and Bailey 1983)
	15%	Colorado	(Thompson 1981)	3%	Washington	(Johnson 1983)
	9%	Montana	(Thompson 1981)			
	53%	Montana	(Stewart 1975)			
	20%	Washington	(Johnson 1983)			
Mean	31%			8%		
Browse	2%	Montana	(Saunders 1955)	30%	Montana	(Saunders 1955)
	0%	Colorado	(Hibbs 1967)	12%	Colorado	(Hibbs 1967)
	0%	Montana	(Peck 1972)	1%	Montana	(Peck 1972)
	0%	Montana	(Pallister 1974)	51%	Montana	(Thompson 1981)
	7%	Colorado	(Johnson et al. 1978)	30%	Colorado	(Adams and Bailey 1983)
	1%	Colorado	(Thompson 1981)	65%	Washington	(Johnson 1983)
	79%	Montana	(Thompson 1981)			
	0%	Montana	(Stewart 1975)			
	35%	Washington	(Johnson 1983)			
Mean	14%			32%		

Several researchers quantified goat diets for summer and winter. Their data are based on percent use or occurrence in stomach or scats and are not adjusted for forage availability (Rominger and Bailey 1982) relative to percent use. Table 5 summarizes their data. The data concur with general findings of a heavy reliance on grasses (53%) and forbs (31%) in the summer and a shift primarily to grasses (60%) in the winter.

Some researchers presented detailed analyses of food habits of goats relative to forage species used (Table 6). Based on the results of these studies, the main summer diet of mountain goats consists of sedges (*Carex* sp.), wheatgrass (*Agropyron* sp.), kobresia (*Kobresia* sp.), bluegrass (*Poa* sp.), fescue (*Festuca* sp.), sandwort (*Arenaria* sp.), bluebells (*Mertensia* sp.), Jacob's ladder (*Polemonium* sp.), groundsel (*Senecio* sp.), and clover (*Trifolium* sp.). Winter diets consists mainly of sedges (*Carex* sp.), wheatgrass, fescue, bluegrass, muhly (*Muhlenbergia* sp.), hairgrass (*Deschampsia* sp.), and spruce (*Picea* sp.). The data in Table 6 include results of work in Colorado and Washington. Food habits of animals reflect preferences and availability (Rominger and Bailey 1982). The availability of food species in Colorado and Washington can differ from that found in Yellowstone and Grand Teton Parks and may not be an accurate estimate of food habits of goats in these areas. Alpine and subalpine communities in Montana should more closely parallel conditions in the Parks and provide more realistic estimate of food preferences of goats in the Parks. If the data from the Montana studies are considered separately, the main foods in summer diets of mountain goats are: sedges, bluegrass, sandwort, bluebells, Jacob's ladder, and clover. Winter diets consists of sedges and unidentified grasses.

Mountain goats can possibly affect vegetation in the Parks through direct consumption and/or destruction by wallowing (Pfitsch 1981; Pike 1981). Based on the data in Table 6, goats would rely primarily on three grass-grasslike genera (*Agropyron, Carex, Poa,* and 7 genera of forbs (*Arenaria, Arnica, Erigeron, Mertensia, Polemonium, Polygonum,* and *Trifolium*. Most of the alpine species in these genera are frequent to common in their occurrence in Yellowstone and Grand Teton Parks (Table 3). Unless goat densities attain the high estimates projected, no adverse affect from grazing by goats on these genera of plants is expected.

In Olympic Park, goats were found to affect rare and/or endemic species even at low levels of grazing pressure (Pike 1981). There are no known endemic alpine plant species nor species listed as endangered or threatened in Yellowstone Park. There is one species, Shultz's milkvetch (*Astragalus shultziorum*) in Grand Teton Park listed as a Category 2 candidate for Federal listing (R.P. Wood, Personal Communication, GTNP). However, little is known of its distribution and its taxonomic status is in debate. There are also 13 species listed in Table 3 classified as rare. Little is also known of the distribution of most of these species. Until more is learned of the distribution of these species relative to potential goat colonization sites, it is not possible to assess the impact goats might have on them. If these species occur in areas of goat colonization and goats become numerous or selectively feed on them, goats could negatively impact these species.

Impact of goats on surrounding National Forests:--Goats in Olympic Park had a major impact on the physical and floral environment through their extensive wallowing (dust bathing) behavior (Hutchins and Stevens 1981; Pike 1981, Pfitsch 1981; Reid 1983). Goats significantly reduced percent plant cover and created wallows which eroded extensively. On 10 September 1988, a survey was made of goat range on Mt. Baldy in the Swan Valley area of Idaho. Goat densities are considered extremely high (10.8/km^2) (Hayden 1989) on Mt.

Table 6. Summary of specific plants used by goats

Species	Peck 1972 Summer	Peck 1972 Winter	Hibbs 1967 Summer	Hibbs 1967 Winter	Adams & Bailey 1983 Winter	Pallister 1974 Summer	Johnson et al. 1978 Summer	Thompson 1981 Summer	Thompson 1981 Winter	Stewart 1975 Summer	Johnson 1983 Summer	Johnson 1983 Winter
Grasses												
Unidentified	2%	82%	-	-	-	-	-	-	-	-	7%	1%
Agropyron sp.	-	<1%	29%	4%	2%	-	6%	-	-	8%	18%	13%
Agrostis scabra	-	-	-	-	-	-	-	1%	-	-	-	-
Avena sp.	-	-	-	-	-	-	<1%	-	-	-	-	-
Bromus sp.	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis sp.	-	-	-	-	<1%	-	-	-	-	-	4%	2%
Carex sp.	19%	7%	8%	11%	29%	4%	33%	-	3%	-	6%	1%
Deschampsia sp.	-	-	1%	-	<1%	-	3%	<1%	1%	-	-	-
Festuca sp.	-	-	3%	26%	12%	<1%	18%	7%	43%	-	4%	7%
Helictotrichon sp.	-	-	2%	-	-	-	-	-	-	-	-	-
Juncus tenuis	-	-	-	-	-	-	-	-	-	-	-	-
Kobresia sp.	-	-	36%	6%	-	-	-	-	-	-	-	-
Koeleria cristata	-	-	<1%	-	-	-	1%	-	-	-	-	-
Luzula sp.	-	<1%	1%	-	-	-	<1%	-	-	-	-	-
Muhlenbergia montana	-	-	-	27%	-	-	1%	-	-	-	-	-
Poa sp.	-	-	16%	12%	1%	36%	4%	2%	-	39%	5%	7%
Sitanion sp.	-	-	-	-	<1%	-	-	-	-	-	-	-
Stipa robusta	-	-	-	2%	-	-	2%	-	-	-	-	-
Trisetum spicatum	-	-	2%	-	-	-	<1%	-	-	-	-	-
Forbs												
Unidentified	-	-	-	-	8%	-	-	-	-	2%	10%	1%
Achillea millefolium	-	<1%	-	-	-	-	-	-	-	-	3%	-
Agoseris sp.	<1%	-	-	-	-	-	-	-	-	-	-	-
Antennaria alpina	-	<1%	-	-	-	-	-	-	<1%	-	-	-
Aquilegia flavescens	-	<1%	-	-	-	-	-	-	-	-	-	-
Arenaria sp.	-	<1%	<1%	-	-	-	-	-	-	-	4%	-
Arnica sp.	22%	<1%	-	-	-	-	-	-	-	19%	-	-
Artemisia sp.	-	-	-	-	10%	1%	-	-	-	-	-	-
Aster sp.	-	-	-	-	<1%	-	-	-	-	-	-	-
Astragalus sp.	-	-	-	-	<1%	-	-	2%	<1%	-	-	-
Caltha leptosepala	-	-	-	-	-	3%	-	-	-	-	-	-
Castilleja pulchella	<1%	-	-	-	-	-	-	-	-	-	-	-
Cerastium sp.	<1%	<1%	-	-	-	2%	2%	-	-	-	-	-
Descurainia sp.	-	-	-	-	2%	-	-	3%	-	-	-	-
Erigeron sp.	1%	-	-	-	-	-	<1%	-	-	31%	-	-
Eriognum sp.	-	<1%	<1%	-	<1%	-	1%	-	-	-	-	-
Gentiana sp.	-	-	-	-	-	-	<1%	-	-	-	-	-
Geum roseii	-	-	-	-	-	-	4%	-	-	-	-	-
Haplopappus macronema	-	-	<1%	-	-	-	-	-	-	-	-	-
Heracleum sp.	-	<1%	<1%	-	-	-	-	-	-	-	-	-
Heuchera sp.	-	<1%	<1%	-	-	-	-	-	-	-	-	-
Lesquerella sp.	-	-	-	-	<1%	-	-	2%	-	-	-	-
Lupinus sericeus	-	<1%	-	-	-	-	-	-	-	-	-	-
Mertensia sp.	24%	<1%	<1%	-	-	20%	9%	-	-	-	-	-
Penstemon sp.	-	-	-	-	-	-	-	-	-	-	2%	-
Polemonium viscosum	-	<1%	-	-	-	14%	1%	-	-	-	-	-
Polygonum bistortoides	<1%	<1%	-	-	-	6%	-	-	-	-	-	-
Potentilla sp.	2%	<1%	1%	-	1%	3%	3%	1%	-	-	-	-
Ranunculus sp.	-	-	-	-	-	1%	<1%	-	-	-	-	-
Saxifraga bronchialis	-	<1%	-	-	-	-	-	-	-	-	-	-
Sedum stenopetalum	-	<1%	-	-	-	-	-	-	-	-	-	-
Senecio sp.	29%	3%	<1%	-	-	<1%	-	-	-	-	-	-
Silene sp.	-	-	-	-	-	-	-	-	-	-	-	1%
Trifolium sp.	1%	<1%	1%	-	<1%	10%	1%	<1%	-	-	-	-
Verbascum sp.	-	-	-	-	-	-	-	-	-	-	1%	-

Table 6. cont.

Species	Peck 1972 Summer	Peck 1972 Winter	Hibbs 1967 Summer	Hibbs 1967 Winter	Adams & Bailey 1983 Winter	Pallister 1974 Summer	Johnson et al. 1978 Summer	Thompson 1981 Summer	Thompson 1981 Winter	Stewart 1975 Summer	Johnson 1983 Summer	Johnson 1983 Winter
Woody species												
Unidentified	-	-	-	-	-	-	-	-	-	-	11%	12%
Abies sp.	-	2%	-	-	-	-	-	-	-	-	-	-
Acer glabrum	-	-	-	1%	-	-	-	-	-	-	-	-
Alnus sp.	-	<1%	-	-	-	-	-	-	-	-	-	-
Amelanchier sp.	-	-	-	-	<1%	-	-	-	-	-	-	4%
Artemisia sp.	-	-	-	-	-	-	-	-	-	-	7%	3%
Berberis sp.	-	-	-	-	-	-	-	-	8%	-	-	2%
Ceanothus sp.	-	-	-	-	-	-	-	-	-	-	1%	6%
Cercocarpus montanus	-	-	-	1%	-	-	3%	-	-	-	-	-
Unidentified conifers	-	-	-	-	-	-	-	-	-	-	6%	28%
Dryas octopetala	-	-	-	-	-	-	<1%	-	-	-	-	-
Haplopappus sp.	-	-	-	-	<1%	-	-	-	-	-	-	-
Juniperus sp.	-	<1%	-	-	-	-	-	-	-	-	-	-
Phyllodoce glanduliflora	-	<1%	-	-	-	-	-	-	-	-	-	-
Picea sp.	-	-	-	-	28%	-	-	-	-	-	-	-
Pinus sp.	-	<1%	-	-	<1%	-	-	<1%	<1%	-	-	-
Pseudotsuga sp.	-	-	-	-	<1%	-	-	-	13%	-	-	-
Ribes sp.	-	-	-	2%	<1%	-	2%	-	-	-	1%	5%
Rosa sp	-	-	-	-	-	-	-	5%	-	-	-	-
Rubus sp.	-	-	-	-	-	-	-	1%	<1%	-	-	-
Salix sp.	0	<1%	-	4%	-	-	1%	30%	2%	-	-	-
Sambucus sp.	-	-	-	4%	-	-	1%	-	-	-	-	-
Shepherdia sp	-	-	-	-	-	-	-	42%	28%	-	9%	5%
Symphoricarpos sp.	-	-	-	-	<1%	-	-	-	-	-	-	-
Vaccinium sp.	0	<1%	-	-	-	-	-	-	-	-	-	-

Baldly but only limited damage from wallowing by goats was found. A few small wallow depressions were found along ridge edges. No major erosion from these depressions was seen. Five randomly chosen photoplots were sampled on a slope considered characteristic of goat use in that area. Combined percent cover of grasses and forbs averaged 28.7$\pm$11.7 % for these plots and was comparable to similar habitat in Yellowstone Park (Table 4).

On 25-26 July 1988, I visited Glacier National Park, another area characterized by high goat densities (2.8 goats/km^2; Chadwick 1974). Near Logan Pass, an area of high goat concentrations, no evidence of extensive habitat destruction by goats was found. These findings are in contrast to Olympic National Park (14 goats/km^2; Stevens 1983) where extensive wallowing by goats has had a major impact on the physical and floral environment. It is unclear why goats should have an increased impact in Olympic Park but not other areas. Goats wallow to cool off and/or protect themselves from insect pests (Hutchins and Stevens 1981; Chadwick 1983). The summer climate in Olympic Park is milder than interior areas and could account for the increased wallowing by goats. Olympic Park also receives substantially more rainfall than Swan Valley and Glacier Park and could exacerbate the effect of wallowing.

Based on the observations made in Glacier National Park and the Swan Valley area, environmental modification by wallowing goats in Yellowstone and Grand Teton Parks is predicted to be minimal at low density estimates. At high goat densities some damage may occur locally if goats concentrate their activity in selected areas. This damage, however, is not expected to be as severe as experienced in Olympic National Park.

Impact of mountain goats on bighorn sheep

Goat-sheep interactions:--Of all the faunal species in the Parks, increasing mountain goat populations would most likely affect bighorn sheep. Goats and sheep have similar niches along several resource axes (Adams et al. 1982b) and co-occur over much of their respective ranges. Mountain goats and bighorn sheep could compete for these resources through either interference or resource competition.

With regards to interference competition, few qualified recorded instances of goats and sheep interaction were found in the literature. Holroyd (1967) observed sheep and goats together but never saw any "intolerance" between the species. Stewart (1975) reported seeing sheep and goats in close proximity on six occasions. Five of the times, sheep and goats fed within 300 m of each other with no apparent concern. The sixth instance involved a pregnant ewe, believed to be looking for a lambing site, moving away from the area when a goat approached. During this study, I saw goats and sheep in the Wolverine Peak area feeding within 100 m of each other without apparent concern. In Glacier National Park, I also viewed a band of approximately 25 goats feeding within 200 m of a band of 15 sheep, again without apparent concern from either. Reed (1986 & unpubl. data) studied interactions between sheep and goats in Colorado. Out of 69 instances of direct interactions, 54% were neutral. Goats prevented sheep from using a particular resource (bedding site, feeding area, etc) 41% of the times but did not cause the sheep to leave the area. Sheep caused movement of goats only 5% of the instances. The fewest interactions were in the winter and all of them were neutral.

Based on the limited data available, goats seem to be mildly agonistic toward sheep. Individual goats will displace individual sheep from particular resources but will rarely displace or chase them from the immediate area. Such agonistic interactions are minimal during the winter months when they might have the greatest affect on survival of individuals.

To assess resource competition, between mountain goats and bighorn sheep, it is necessary to identify the resources goats and sheep would most likely compete for. For goats and sheep the two most critical resources would be food and habitat. Thus food and habitat requirements of sheep were determined and compared to the requirements of goats.

Food habits of Bighorn Sheep:--Studies on food habits of sheep, including sheep in both Yellowstone and Grand Teton Parks, indicate bighorn sheep generally rely on a variety of grass and forbs (Davis 1938; Honess and Frost 1942; Spencer 1943; Couey 1950; Smith 1954; McCann 1956; Berwick 1968; Cooperrider 1969). There have been several studies quantifying food habits of bighorn sheep. Table 7 summarizes the results of these studies relative to grasses, forbs, and browse. Based on these studies, diets of sheep and goats are quite similar

Table 7. Summary of general food habits of bighorn sheep from various studies. Figures are expressed as percent of total use and are based on either fecal or rumen analyses.

	Summer			Winter		
Grasses	60%	Yellowstone	(Mills 1937)	98%	Yellowstone	(Mills 1937)
	75%	Colorado	(Moser 1962)	61%	Yellowstone	(Oldemeyer et al. 1971)
	12%	Montana	(Pallister 1974)	98%	Montana	(Pallister 1974)
	95%	Montana	(Frisina 1974)	92%	Montana	(Frisina 1974)
	44%	Montana	(Stewart 1975)	40%	Montana	(Stewart 1975)
	65%	Colorado	(Todd 1975)	23%	Colorado	(Todd 1975)
	46%	New Mexico	(Johnson & Smith 1980)	83%	New Mexico	(Johnson & Smith 1980)
	25%	Grand Teton	(Whitfield 1983)	30%	Grand Teton	(Whitfield 1983)
	74%	Montana	(Martin 1985)	39%	Montana	(Martin 1985)
	30%	Washington	(Estes 1979)	56%	Yellowstone	(Keating et al. 1985)
	51%	Wyoming	(Honess & Frost 1942)	87%	Montana	(Schallenberger 1966)
	88%	Colorado	(Harrington 1978)	62%	Washington	(Estes 1979)
				65%	Montana	(Kasworm et al. 1984)
				54%	British Columbia	(Blood 1967)
				72%	Montana	(Constan 1972)
Mean	56%			64%		
Forbs	35%	Yellowstone	(Mills 1937)	0%	Yellowstone	(Mills 1937)
	6%	Colorado	(Moser 1962)	17%	Yellowstone	(Oldemeyer et al. 1971)
	55%	Montana	(Pallister 1974)	2%	Montana	(Pallister 1974)
	4%	Montana	(Frisina 1974)	6%	Montana	(Frisina 1974)
	6%	Colorado	(Todd 1975)	11%	Colorado	(Todd 1975)
	47%	Montana	(Stewart 1975)	40%	Montana	(Stewart 1975)
	50%	New Mexico	(Johnson & Smith 1980)	10%	New Mexico	(Johnson & Smith 1980)
	12%	Grand Teton	(Whitfield 1983)	32%	Grand Teton	(Whitfield 1983)
	16%	Montana	(Martin 1985)	50%	Montana	(Martin 1985)
	8%	Washington	(Estes 1979)	7%	Yellowstone	(Keating et al. 1985)
	30%	Wyoming	(Honess & Frost 1942)	9%	Montana	(Schallenberger 1966)
	12%	Colorado	(Harrington 1978)	3%	Washington	(Estes 1979)
				12%	Montana	(Kasworm et al. 1984)
				5%	British Columbia	(Blood 1967)
				17%	Montana	(Constan 1972)
Mean	23%			15%		
Browse	5%	Yellowstone	(Mills 1937)	0%	Yellowstone	(Mills 1937)
	19%	Colorado	(Moser 1962)	22%	Yellowstone	(Oldemeyer et al. 1971)
	32%	Montana	(Pallister 1962)	0%	Montana	(Pallister 1962)
	1%	Montana	(Frisina 1974)	1%	Montana	(Frisina 1974)
	29%	Colorado	(Todd 1975)	67%	Colorado	(Todd 1975)
	8%	Montana	(Stewart 1975)	20%	Montana	(Stewart 1975)
	4%	New Mexico	(Johnson & Smith 1980)	7%	New Mexico	(Johnson & Smith 1980)
	63%	Grand Teton	(Whitfield 1983)	39%	Grand Teton	(Whitfield 1983)
	10%	Montana	(Martin 1985)	10%	Montana	(Martin 1985)
	62%	Washington	(Estes 1979)	38%	Yellowstone	(Keating et al. 1985)
	19%	Wyoming	(Honess & Frost 1942)	2%	Montana	(Schallenberger 1966)
	0%	Colorado	(Harrington 1978)	35%	Washington	(Estes 1979)
				23%	Montana	(Kasworm et al. 1984)
				40%	British Columbia	(Blood 1967)
				8%	Montana	(Constan 1972)
Mean	21%			21%		

Table 8. Summary of specific food habits of bighorn sheep.

	Whitfield		Frisina		Pallister		Stewart		Mills	Martin		Johnson & Smith		Keating et al.	Oldemeyer et al.	Constan	Kasworm et al.
	1983		1974		1974		1975		1937	1985		1980		1985	1971	1972	1984
	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Sum	Win	Sum	Win	Win	Win	Win	Win
Grass and grass-like species																	
Unidentified	-	-	1%	1%	-	19%	-	-	-	-	-	-	-	-	-	-	11%
Agropyron	<1%	<1%	39%	37%	-	-	5%	2%	-	-	<1%	-	-	22%	25%	40%	21%
Agrostis	<1%	-	-	-	-	-	<1%	-	-	-	<1%	-	-	-	-	-	-
Alopecurus	-	-	-	-	1%	-	-	-	-	-	-	-	-	-	-	-	-
Bromus	5%	5%	3%	1%	-	-	-	-	-	<1%	-	-	-	5%	-	1%	3%
Calamagrostis	-	-	-	-	-	-	-	-	-	-	<1%	-	-	-	-	1%	-
Carex	5%	17%	<1%	-	4%	22%	13%	20%	-	52%	15%	27%	63%	3%	3%	1%	4%
Danthonia	-	-	-	-	-	-	-	-	-	-	-	3%	6%	-	-	-	-
Deschampsia	1%	<1%	-	-	<1%	-	3%	-	-	6%	4%	4%	5%	-	-	-	-
Equisetum	-	-	-	-	-	-	-	-	-	-	<1%	-	-	-	-	-	-
Festuca	4%	3%	35%	26%	-	-	1%	11%	-	11%	18%	7%	10%	5%	9%	23%	18%
Hesperochloa	-	-	-	-	-	-	-	7%	-	-	-	-	-	-	-	-	-
Juncus	<1%	-	-	-	<1%	-	-	-	-	2%	-	-	-	-	-	-	-
Koeleria	1%	1%	4%	6%	-	-	1%	-	-	-	-	-	-	9%	7%	-	7%
Luzula	-	-	-	-	-	-	<1%	-	-	<1%	<1%	-	-	-	-	-	-
Oryzopis	<1%	-	-	6%	-	-	-	-	-	1%	1%	-	-	<1%	-	-	-
Phleum	-	-	<1%	-	<1%	57%	-	-	-	-	<1%	-	-	-	-	-	-
Poa	7%	2%	12%	-	7%	-	18%	-	60%	2%	1%	-	-	<1%	5%	4%	<1%
Sitanion	-	-	-	14%	-	-	-	-	-	-	<1%	-	-	-	-	-	-
Stipa	-	-	<1%	-	-	-	-	-	-	-	<1%	-	-	6%	10%	1%	3%
Forbs																	
Unidentified	2%	3%	-	<1%	-	-	-	-	-	-	-	-	-	-	-	<1%	5%
Achillea	-	<1%	-	<1%	-	-	-	-	-	-	-	-	-	-	-	<1%	-
Agoseris	-	-	-	-	-	-	6%	-	-	-	-	-	-	-	-	-	-
Antennaria	-	-	1%	-	-	-	-	-	-	-	-	-	-	-	<1%	-	-
Apocynum	-	-	-	-	3%	-	<1%	-	-	-	-	-	-	-	-	-	-
Aquilegia	-	-	-	-	5%	-	<1%	-	-	-	-	-	-	-	-	-	-
Aplopappus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1%	-	-
Arnica	-	-	-	-	6%	-	3%	-	-	-	-	-	-	-	-	-	-
Artemisia	-	-	<1%	<1%	2%	-	-	2%	-	1%	25%	-	-	-	-	10%	-
Astragalus	2%	4%	<1%	4%	-	-	3%	-	-	2%	3%	-	-	<1%	2%	-	<1%
Balsamorhiza	-	-	-	-	-	-	-	3%	-	-	-	-	-	-	-	<1%	2%
Caltha	-	-	-	-	<1%	-	-	-	-	-	-	-	-	-	-	-	-
Castilleja	-	-	-	-	-	-	2%	-	-	-	-	-	-	-	-	-	-
Cirsium	-	-	<1%	1%	-	1%	-	-	-	-	-	-	-	<1%	-	-	-
Compositae	<1%	-	-	-	<1%	-	-	-	-	<1%	1%	-	-	-	-	-	<1%
Cruciferae	-	-	-	-	-	-	-	-	-	-	-	-	-	<1%	-	-	<1%
Delphinium	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Descurainia	<1%	-	-	-	-	-	-	-	-	2%	<1%	-	-	-	-	-	-
Draba	<1%	6%	-	-	-	-	-	-	-	-	<1%	-	-	-	-	-	-
Epilobium	-	-	-	-	4%	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron	-	-	-	-	-	-	<1%	-	5%	-	-	-	-	-	<1%	1%	-
Erigonum	<1%	<1%	-	-	-	-	-	-	<1%	-	-	-	-	-	-	-	<1%
Eurotia	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae	-	-	-	-	-	-	<1%	<1%	-	-	-	-	-	-	-	-	-
Fern	1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Geum	-	-	-	-	-	-	-	31%	-	-	-	-	-	-	-	-	-
Lesquerella	2%	2%	-	-	-	-	-	-	-	-	1%	-	-	-	-	-	-
Lichen	-	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 8. cont.

	Whitfield		Frisina		Pallister		Stewart		Mills	Martin		Johnson & Smith		Keating et al.	Oldemeyer et al.	Constan	Kasworm et al.
	1983		1974		1974		1975		1937	1985		1980		1985	1971	1972	1984
	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Sum	Win	Sum	Win	Win	Win	Win	Win
Lloydia	-	-	-	-		<1%	-	6%	-	-	-	-	-	-	-	-	-
Lupinus	1%	2%	-	<1%	-	-	-	-	-	5%	16%	-	-	-	3%	4%	-
Mertensia	-	-	-	-	14%	-	<1%	-	-	-	-	-	-	-	-	-	-
Oxytropis	-	-	-	-	-	-	<1%	-	-	-	-	-	-	-	<1%	-	-
Pedicularis	-	-	-	-	-	-	-	-	25%	-	-	-	-	-	-	-	-
Phacelia	-	-	-	-	-	-	-	-	-	-	<1%	-	-	-	-	-	-
Phlox	<1%	8%	-	-	-	-	-	1%	-	-	1%	-	-	2%	6%	1%	<1%
Plantago	-	-	-	-	-	-	-	-	-	<1%	-	-	-	-	-	-	-
Polemonium	-	-	-	-	<1%	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum	-	-	-	-	1%	-	<1%	-	5%	-	-	-	-	-	-	-	-
Potentilla	2%	1%	1%	2%	2%	1%	<1%	-	-	<1%	<1%	23%	1%	-	-	-	-
Saxifraga	<1%	3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Senecio	-	-	-	-	-	-	2%	-	-	-	-	-	-	-	-	-	-
Sibbaldia	<1%	-	-	-	-	-	-	-	-	4%	<1%	-	-	-	-	-	-
Silene	-	-	-	-	-	-	4%	2%	-	-	-	-	-	-	-	-	-
Solidago	1%	<1%	-	-	-	-	<1%	-	-	-	-	-	-	-	-	1%	-
Sphaeralcea	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stellaria	<1%	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifolium	-	-	<1%	-	17%	-	8%	-	-	-	-	12%	1%	-	-	-	-
Zygadenus	-	-	2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shrubs																	
Abies	-	2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus	-	-	-	-	1%	-	-	-	-	-	-	-	-	-	-	-	-
Amelanchier	<1%	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artemisia	<1%	<1%	-	-	<1%	-	-	20%	-	-	-	-	-	16%	3%	4%	15%
Berberis	1%	<1%	<1%	<1%	-	-	-	-	-	-	4%	-	-	-	-	-	-
Ceanothus	-	-	-	-	4%	-	-	-	-	-	-	-	-	-	-	-	-
Chrysothamnus	-	-	-	-	-	-	-	-	-	-	-	-	-	4%	8%	2%	-
Eurotia	-	-	-	-	-	-	-	-	-	-	-	-	-	14%	10%	-	-
Juniperus	<1%	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2%
Physocarpus	-	-	-	-	2%	-	-	-	-	-	-	-	-	-	-	-	-
Picea	<1%	3%	-	-	-	-	-	-	<1%	-	-	-	-	-	-	-	-
Pinus	<1%	7%	<1%	<1%	-	-	-	-	-	1%	2%	-	-	-	-	-	<1%
Populus	-	<1%	<1%	-	-	-	-	-	-	-	-	-	-	-	-	-	<1%
Prunus	-	-	-	-	2%	-	<1%	<1%	-	-	-	-	-	-	-	-	<1%
Pseudotsuga	7%	13%	-	-	-	-	-	-	-	-	1%	-	-	-	-	-	1%
Ribes	-	-	-	-	19%	-	-	-	-	-	-	-	-	-	-	-	-
Rosa	<1%	-	-	<1%	-	-	1%	-	-	1%	2%	-	-	-	-	1%	-
Rubus	-	-	-	-	-	-	-	-	-	<1%	3%	-	-	-	-	-	-
Salix	28%	12%	-	-	<1%	-	1%	-	-	5%	1%	-	-	-	-	-	-
Shepherdia	-	-	-	-	-	-	1%	-	-	2%	-	-	-	-	-	-	-
Symphoricarpos	14%	3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium	12%	<1%	-	-	<1%	-	4%	-	-	-	-	-	-	-	-	-	-

throughout the year. As with goats, several of the researchers presented a breakdown of the specific plants used by bighorns. The summary of specific plant genera used by sheep is in Table 8.

Of the plant species in Tables 6 & 8, only a few were used by goats and/or sheep >1%. These preferred genera, and estimates of their use by goats and sheep are presented in Table 9. Data in Table 9 were used to calculate indices of resource overlap (Lawlor 1970) (Fig. 5). The indices indicate overlap in food habits of goats and sheep but, based on Tables 6 and 8, they both have diets that vary spatially and temporally. The variability in diets is mainly attributable to both species selecting foods based on differing availability among areas. To best determine overlap in diets, it is necessary to compare food preferences of sympatric populations. Data from several such studies are available. Dailey et al. (1984) conducted parallel feeding trials on goats and sheep in Colorado (Table 10). These data were also used to calculate indices of resource overlap (Fig. 5). Diets of sheep and goats overlapped substantially in the summer (O = 0.97) but dropped to 0.64 in the winter. This decrease in overlap in the winter resulted from goats eating more forbs and sheep consuming more grasses.

Pallister (1974) and Stewart (1975), working with sheep in the Beartooth mountains north of Yellowstone Park, also recorded food habits of mountain goats observed in their study area. Pallister (1974) found summer diets of mountain goats consisted of 40% grasses and 60% forbs. During the same time, sheep consumed 12% grass, 55% forbs, and 32% shrubs. Although both species relied on forbs to a similar level, comparisons of specific forb species eaten (Table 11) indicate little overlap except for clover (*Trifolium parryi*). Stewart (1975) found a similar reliance on grasses by sheep (44%) and goats (47%) but goats relied most on *Poa* sp. while sheep were more evenly divided among three species (Table 11).

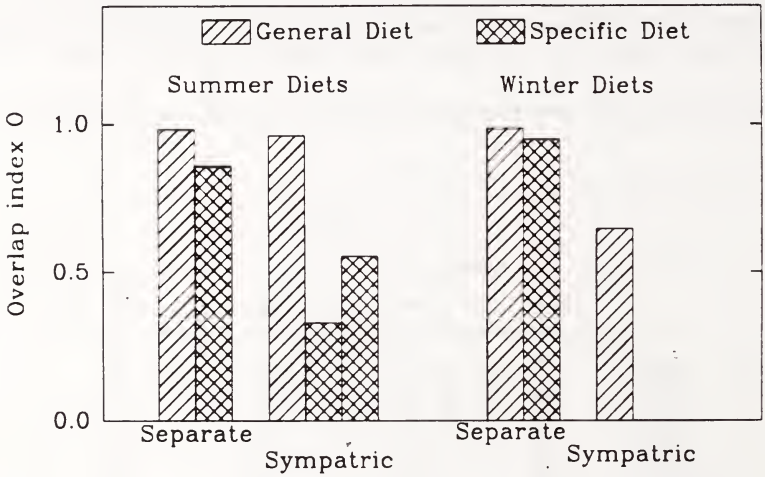
Table 9. Comparison of specific preferred plant genera for goats and sheep. The percents are averages of the values reported in Tables 6 and 8.

	Percent use			
Species	Summer		Winter	
	Sheep	Goats	Sheep	Goats
Agropyron sp.	6%	9%	15%	4%
Artemisia sp.	<1%	1%	10%	3%
Carex sp.	15%	10%	15%	8%
Deschampsia sp.	2%	<1%	<1%	<1%
Festuca sp.	8%	5%	12%	18%
Koeleria sp.	<1%	5%	3%	1%
Mertensia sp	2%	6%	0%	<1%
Poa sp.	15%	14%	1%	4%
Potentilla sp.	4%	1%	<1%	<1%
Salix sp.	5%	4%	1%	1%
Stipa sp.	<1%	<1%	2%	<1%
Trifolium sp.	5%	2%	0%	<1%

Table 10. Summary of the findings of Dailey et al. (1984) on feeding trials for bighorn sheep and mountain goats in Colorado.

	Grass	Forbs	Browse
Summer			
Goats	11%	88%	0%
Sheep	30%	70%	0%
Winter			
Goats	27%	59%	14%
Sheep	75%	22%	3%

Figure 5. Resource overlap indices (O) (Lawlor 1970) for food habits of goats and sheep. Overlap indices are for pooled data from separate studies (Table 9) and data from comparative studies of Dailey et al (1984) (Table 10) and Pallister (1974) and Stewart (1975) (Table 11).



Overall forb use by sheep and goats were also similar, 47% for sheep, 53% for goats but specific use of forbs differed; most of diet of goats consisting of two species (Table 11). When the data in Table 11 were used to calculate indices of overlap (Fig. 5), these indices averaged 0.44.

Pallister and Stewart had data on food habits of sheep during winter (Table 11) but did not collect data on goat diets during that time. Thus, no comparison of winter food habits between sheep and goats was possible.

If food use is averaged over several areas or only broad categories, food habits of sheep and goats overlap extensively and competition for food seems likely. However, when in sympatry, calculated amounts of overlap between summer diets of goats and sheep were

Table 11. Summary of findings of Pallister (1974) and Stewart (1975) on summer sheep and goat food habits. Only the major food items used are listed.

	Pallister		Stewart	
	Bighorn Sheep	Mountain Goats	Bighorn Sheep	Mountain Goats
Grasses				
Agropyron sp.	-	-	5%	8%
Carex albonigra	4%	2%	-	-
Carex sp.	<1%	2%	13%	-
Deschampsia sp.	-	-	2%	-
Koeleria caespitosa	-	-	2%	-
Poa sp.	7%	36%	18%	39%
Forbs				
Agoseris glauca	-	-	6%	-
Aquilegia flavescens	5%	-	-	-
Apocynum androsaemifolium	-	-	2%	-
Arnica latifolia	5%	-	3%	19%
Astragalus vexilliflexus	-	-	3%	-
Caltha leptosepala	-	3%	-	-
Castilleja cusickii	-	-	2%	-
Epilobium angustifolium	4%	-	-	-
Erigeron sp.	-	-	7%	31%
Fabaceae				
Lloydia serotina	-	-	6%	-
Mertensia alpina	-	20%	-	-
Mertensia ciliata	14%	-	-	-
Polemonium viscosum	-	14%	-	-
Polygonum bistortoides	-	6%	-	-
Potentilla ovina	1%	2%	-	-
Silene acaulis	-	-	4%	-
Trifolium parryi	17%	10%	8%	-
Shrubs				
Ceanothus velutinus	4%	-	-	-
Prunus virginiana	2%	-	-	-
Ribes aureum	4%	-	-	-
Ribes montigenum	15%	-	-	-
Rubus idaeus	2%	-	-	-
Salix arctica	4%	-	-	-
Vaccinium sp.	-	-	4%	-

reduced when specific forage species were identified. Overlap was also low during the winter for general food categories, a time when competition could be most intense. Some of the differences in food habits stem from different habitats selected. Differences in habitat selection between sheep and goats found by Pallister (1974) and Stewart (1975) are addressed in the next section.

General habitat preferences of sheep and goats:--The second general resource for which sheep and goats could compete is habitat. Sheep and goats are both adapted to subalpine and alpine communities. However, they are considered to have some unique requirements (Adams et al. 1982b). Predator evasion is thought to dominate habitat selection by sheep (Shannon et al. 1975; Adams et al. 1982b). Thus sheep prefer to forage in large groups on abundant, open, continuous areas of forage near steep, rugged "escape" terrain. Goats primarily live in escape terrain (Adams et al. 1982b) and predator evasion is less important. Food resources are usually dispersed in such terrain and goats are normally found in smaller groups than sheep. Based on this assessment, Adams et al. (1982b) concluded there was little overlap in a variety of vegetal and structural habitat characteristics of sheep and goats. Sheep were more adapted to using a wider range of habitat types. Goats are more limited to tracts of rugged terrain. There is, however, some overlap in their habitat selection and under conditions that limit selection by sheep [land development, livestock, etc. (Adams et al. 1982b)], these areas of overlap could result in direct competition between the two species.

Several investigators have studied the details of habitat selection of sheep and goats. Results of these studies should provide insight into the amount of overlap that may exist between the species.

Habitat use by sheep:--Oldemeyer et al. (1971) divided the habitat in Yellowstone National Park into three general vegetation types: forest, grass and shrub. In the winter, they found sheep used the forest type 13%, the grass type 78%, and the shrub type 9%. When they divided the area based on terrain, they found sheep used "steep" areas 39%, rocky outcrops 14%, ridgetops 36%, hilly areas 8%, and level areas 4% of the time. Of the numerous structural/vegetational formations defined by Martin (1985) in Montana, sheep spent most of their summer time in the "alpine turf" formation (approximately 50%) and the "sparsely vegetated dirt scree" formation (approximately 28%). In the spring, Frisina (1974) found sheep 36% of the time in the "rocky reef" and 59% of the time in the "bunchgrass" types he defined. In the fall, sheep use of the rocky reef type increased to 64% and decreased to 34% in the bunchgrass type. Tilton and Willard (1982) divided their study area in Montana into rockland, shrub/grass, open forest, and closed forest habitat types. They found sheep spending 14% of their time in the rockland type, 46% in the shrub/grass, 40% in the open forest, and 1% in the closed forest types.

Habitat use by goats:--Peck (1972) divided goat habitat into 4 types: timber, sliderock, ledge, and ridge. In summer, he found goats spending 4% of their time in timber, 36% in sliderock, 54% in ledge, and 6% in ridge areas. In winter, goats were seen 16% of the time in timber, 70% in ledge areas, and 14% of the time on ridges. M.J. Thompson (1981) found goats in Montana spending 90% of their time in the summer and 68% of their time in early winter on glacial cirques. In the winter in the Bitterroot Mountains, Smith (1976) found goats 62% of the time in the "bunchgrass" association he defined. Goats in Colorado spent 85% of

their time in the substrate type described as "intermittent boulder" by R.W. Thompson (1981). Adams and Bailey (1980) classified the habitat into alpine and subalpine areas. Within the alpine community, they identified tundra and rock subcomponents. During winter, goats spent 58% of their time in the tundra and 42% of the time in rock areas. The subalpine community was subdivided into rock, shrubs, and trees. Goats were seen 35% of the time in rock areas, 10% in shrub, and 55% in tree areas. Von Elsner-Schack (1986) studied goats in Alberta and divided the study area into rock, gravel, and grass substrate types. In spring-summer, goats used the rock substrate 24%, the gravel substrate 27%, and the grass areas 50% of the time.

Table 12. Summary of habitat use of sympatric sheep and goats in the Absaroka Mountains of Montana. The habitat classifications were derived by the authors and detailed descriptions of each can be found in the original literature.

	Pallister (1974)									
	Streambank hardwood	Spruce/fir	Rock outcrop	Streambank forb	Alpine tundra	Rock/snow	Bunchgrass forb	Fir/shrub	Meadow	Rock/forest
Summer										
Goats	-	3%	-	-	94%	3%	-	-	-	-
Sheep	13%	-	13%	13%	14%	2%	10%	35%	-	-
Winter										
Goats	-	18%	-	-	82%	-	-	-	-	-
Sheep	-	-	-	-	34%	-	58%	-	5%	4%

	Stewart (1975)						
	Carex/Podi	*Carex/Podi* Rock	*Abla/Vasc*	*Abla/Vasc* Rock	*Abla/Vagl* Rock	*Pial/Acmi*	*Pipo/Feid Artr*
Summer							
Goats	81%	12%	-	-	6%	-	-
Sheep	14%	14%	5%	4%	58%	3%	-
Winter							
Goats	52%	48%	-	-	-	-	-
Sheep	55%	7%	-	-	-	-	37%

Carex/Podi: *Carex* sp. and *Potentilla diversifolia*
Alba/Vasc: *Abies lasiocarpa* and *Vaccinium scoparium*
Alba/Vagl: *Abies lasiocarpa* and *Vaccinium globulare*
Pial/Acmi: *Pinus albicaulis* and *Achillea millefolium*
Pipo/Feid/Artr: *Pinus ponderosa*, *Festuca idahoensis* and *Artemisia tridentata*

Comparison of habitat use by sheep and goats:--In reviewing the literature on habitat use by sheep and goats, it was difficult to make comparisons between the two species because habitat types identified by the authors were not standardized. In general, data from the various separate studies of habitat use indicate extensive resource overlap for goats and sheep. In the general category of "grass", goat use averaged 56% for two studies (Smith 1976; von Elsner-Schack 1986) and sheep averaged 54% use for three studies (Oldemeyer et al. 1971; Frisina 1974; Tilton and Willard 1982). The use of "tree" type habitat was also similar: 36% for goats (Peck 1972; Adams and Bailey 1980) and 27% for sheep ((Oldemeyer et al. 1971; Tilton and Willard 1982). Use of "rock" habitat did differ with goats spending an average, based on four studies, of 47% of their time (Peck 1972; R.W. Thompson 1981; Adams and Bailey 1980; von Elsner-Schack 1986) while sheep only averaged 21% (Oldemeyer et al. 1971; Frisina 1974; Tilton and Willard 1982). It must be stressed these averages and any conclusions drawn from them, are tenuously based on general habitat classifications that were assumed, but not known, to be similar among these studies.

Few studies were found where habitat use by sheep and goats was studied simultaneously. Chadwick (1974) found some habitat segregation but did not quantify the differences. Geist (1971) found goats in the winter preferred cliff areas more than sheep; goats spent approximately 52% of their time in sheer cliff areas while sheep only spent 28% of their time in these areas. In two studies of bighorn sheep, Stewart (1975) and Pallister (1974) also recorded habitat use by non-native goats on their study areas. Stewart divided the study area into a series of habitat/topographic subtypes. His findings of sheep and goat use of these subtypes are in Table 12. Pallister also divided his study area into habitat subtypes but used different classifications (Table 12). Overlap indices derived from Stewart's and Pallister's data (Fig. 6) indicate a high amount of habitat segregation.

Figure 6. Niche overlap indices for habitat selection by sheep and goats. The indices are based on data from Table 12 for the comparative studies by Pallister (1974) and Stewart (1975).

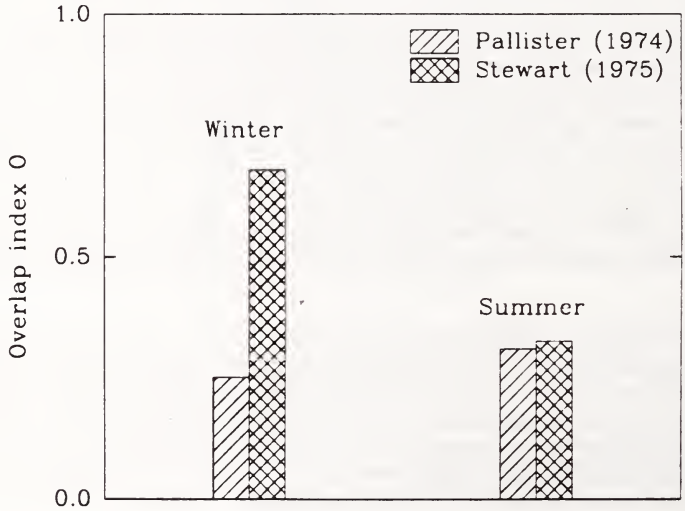


Table 13. Selection of physical habitat characteristics by sheep and goats. Distance to escape habitat values are the maximum distances in which at least 80% of the animals were found. Values for slope and elevation are the means of data reported in the literature.

	Sheep			Goats	
	Summer	Winter		Summer	Winter
Distance to escape habitat:					
Frisina (1974)	140 m	140 m	Fox (1983)	300 m	-
Pallister(1974)	140 m	550 m	McFetridge (1977)	300 m	-
Oldemeyer et al. (1971)	-	100 m	Hjeljord (1971)	275 m	-
Whitfield (1983)	100 m	-	Smith (1986)	400 m	-
Martin (1985)	100 m	-	Thompson, R.W.(1981)	250 m	-
Tilton & Willard (1982)	-	320 m			
Mean	120 m	278 m	Mean	305 m	
Slope (degrees):					
Frisina (1974)	23°	31°	Kuck (1970)	-	60°
Pallister (1974)	19°	18°	Chadwick (1977)	40°	-
Whitfield (1983)	17°	-	Smith (1976)	48°	49°
Martin (1985)	29°	24°	Thompson, R.W. (1981)	50°	-
			Hayden (1989)	27°	31°
Mean	22°	24°	Mean	41°	47°
Elevation:					
Frisina (1974)	1687 m	1690 m	Adams & Bailey (1980)	-	3050 m
Pallister (1974)	2867 m	2180 m	Thompson, M.J. (1981)	2256 m	2256 m
Whitfield (1983)	3034 m	3033 m	Smith (1976)	2441 m	1756 m
Martin (1985)	3035 m	2822 m	Thompson, R.W. (1981)	3700 m	-
			Hayden (1989)	2800 m	-
Mean	2655 m	2431 m	Mean	2799 m	2354 m

Reed (Colorado Division of Wildlife, Ft. Collins, CO; unpubl. data) specifically tested habitat use by sympatric native sheep and introduced goats in Colorado. He identified 25 alpine habitats and recorded frequency and intensity of use. His data were not available for calculation of an overlap index. However, in general, he found goats were more selective in habitat use than sheep and the two species rarely selected the same habitat types simultaneously.

Based on the findings of Pallister (1974), Stewart (1975) and Reed (unpubl. data), there was significant separation in habitat use between sympatric sheep and goats. This separation in habitat use is likely a major factor in the coexistence of sympatric native goat and sheep populations. The occurrence of habitat separation in these three studies indicates goats and sheep will also likely coexist when goats are exotic introductions, unless sufficient habitat restriction for sheep has occurred (Adams et al. 1982b).

Another area of potential competition between goats and sheep is for the physical environment. Several investigators have quantified habitat use by goats and sheep relative to elevation, slope, and distance from escape terrain. Table 13 summarizes the findings of these studies. There was no difference in mean elevation used by goat and sheep. However, the average degree slope used by goats was significantly steeper ($F = 15.19$, $P < 0.01$) than

for sheep. Distance to escape terrain was significantly less for sheep than goats (t = 6.04, P < 0.01). Thus goats preferred steeper slopes but explored further from escape terrain than sheep.

A major factor in different habitat use by sheep and goats, primarily in the winter, is the greater tendency of sheep to migrate longer distances to winter range than goats (Rideout 1977; Martin and Stewart 1980). This tendency is most evident in Yellowstone Park where sheep have distinctive traditional wintering areas (e.g. Mt. Everts). When spatial separation exists during winter, e.g. YNP, the effect of goats on sheep would be less than when such separation may not occur, e.g. GTNP.

Population trends in sheep:—In assessing possible effects of goats on sheep in the future, it is of value to summarize past and current estimates of sheep populations in the potentially affected areas. In Yellowstone Park, sheep on the north range would be the first to be impacted by goats. Numbers of bighorn sheep in the northern section of Yellowstone Park have been estimated since 1903. Buechner (1960) summarized population estimates from 1903 to 1955 and Woolf (1968) added estimates to 1966. Oldemeyer et al. (1971) censused sheep in 1965-68. Houston (1982) presented population figures up to 1978. The methods used to estimate numbers have changed through the years and the accuracy of the methods likely varies. Table 14 summarizes population estimates for the north range from 1903 to 1981. In 1981 there was a outbreak of pinkeye (*Chlamydia* sp.) in the sheep on the Mt. Everts winter range in Yellowstone Park. Approximately 300 of the 550-600 animals on the north range were exposed and mortality was estimated to be approximately 50 animals (Meagher, unpubl. Park Service data). The effect of the outbreak seems to have been localized and short term.

Table 14. Summary of winter population estimates of bighorn sheep on the north range of Yellowstone Park.

Year	Number	Year	Number	Year	Number	Year	Number	Year	Number
1903	100	1926	217	1936	118	1949	144	1970	384
1905	100	1927	346	1937	175	1955	192	1971	227
1907	200	1928	170	1938	181	1956	121	1972	373
1911	250	1929	77	1939	219	1961	118	1973	332
1912	210	1930	125	1940	272	1962	148	1974	446
1916	200	1931	101	1941	200	1965	222	1975	404
1922	233	1932	86	1943	138	1966	229	1976	426
1923	200	1933	82	1945	203	1967	231	1977	430
1924	217	1934	125	1946	176	1968	257	1978	471
1925	195	1935	126	1948	176	1969	295	1981	550[a]

[a]M. Meagher (Personal Communication)

Buechner (1960), Oldemeyer et al. (1971), Keating (1982), and Martin (1985) present data on specific herds and/or bands of sheep within the northern range. Additionally, Mills (1937) presented winter estimates for various locations in the Park. Several of these divisions represent sheep numbers in the northeast corner of the Park where goats presently occur. If sheep numbers are affected by future increases in goats, these sheep bands would be the first to exhibit population changes. The data of Mills (1937), Buechner (1960), Oldemeyer et

al. (1971), and Martin (1985) are summarized in Table 15 for use in future comparisons. Martin (1985) also estimated summer populations in 1978-79 of approximately 75 sheep in the Wolverine/Cutoff Peaks area and 40 sheep in the Amphitheater Peak region.

Table 15. Summary of winter population estimates for specific herds or bands of sheep in the north range of Yellowstone Park

Herd	1935	1955	1965	1966	1967	1968	1970	1972	1974	1976	1977	1978	1979	1981	1982
Mt. Everts	106	36	48	50	44	76	95	132	190	202	190	220	220	190	
Yellowstone River															
Reese Creek		7	6	5	2	7									
Deckard Flats		67	42	44	43	40									
Specimen Ridge	28	27	34	48	47	56									109[a]
Soda Butte Creek															
Druid Peak		28	36	30	60	43									
Mt. Norris		9	20	24	15	19									
Barronette Peak		2	11	12	9	1									
Abiathar Peak		16	25	16	11	15									
Wolverine Peak												36	41	32	
Soda Butte	30														
Cottonwood	7														
Oxbow Crags	5														
Turkey Pen	15														
Daly Creek	35														

[a]M. Meagher (Personal Communication)

There are no long term surveys of sheep populations in Grand Teton National Park. The general consensus is sheep population in Grand Teton has continually declined since settlement of the adjacent valleys (Whitfield 1983). Buechner (1960) reported a population of 21 animals in 1954 for the "Teton wilderness". Whitfield (1983) reported minimum population estimates of 70 in 1969, 71 in 1976 and 62 in 1979. Whitfield(1983) speculated the actual population in 1981 was approximately 125 sheep. The main factor limiting sheep numbers in Grand Teton is the loss of low elevation wintering areas (Whitfield 1983).

HISTORICAL AND PREHISTORICAL OCCURRENCE OF MOUNTAIN GOATS

Critical to the discussion of mountain goats is their historical status in the Yellowstone Ecosystem. If goats occurred in the Yellowstone area in the historical past (250-0 years B.P.), then they would not be considered exotic and the movement of goats into Yellowstone and

Grand Teton Parks, regardless of their origins, could be considered an establishment of an extirpated native species.

On a historical scale, the presence of goats in the Greater Yellowstone Ecosystem cannot be confirmed. The earliest whites to travel into the Greater Yellowstone Ecosystem were Spanish explorers in the mid 1700's (Nasatir 1952). However, these earlier explorers recorded little concerning wildlife species seen. The earliest explorers of the region who kept detailed accounts were Lewis and Clark in 1804 to 1806 (DeVoto 1953). Their course skirted north of Yellowstone Park but their journals were reviewed for possible references to the Yellowstone area. Burroughs (1961) summarized all the references to wildlife Lewis and Clark made during their journey. The first time mountain goats were mentioned was when Clark sighted one as the expedition crossed the continental divide near Lemhi Pass, 190 km west of Yellowstone Park. This area is recognized historic goat range (Hall 1981). Goats were not mentioned again until Lewis and Clark reached the east side of the Cascades. When the expedition reached the west coast, they were brought skins of goats and Lewis mentioned one of soldiers commented on seeing similar animals when they were near the "black hills where the little Missouri passes them...". It is assumed this is in reference to the Black Hills of South Dakota. However, there is less evidence goats historically occurred in that range and this reference likely represents a misidentification. Throughout Lewis' and Clark's journals, references are made to "goats" but it is widely accepted these remarks refer to pronghorn antelope (*Antilocapra americana*) (Burroughs 1961).

After the expedition of Lewis and Clark, others ventured near and into the Yellowstone area. The main white visitors to the area up to the mid 1800's were hunters and trappers. However, few reported on what wildlife they saw or caught. One of the few men to spend an extended period of time (1834 to 1843) in the Yellowstone area and write about it was Osborne Russell (Haines 1969). During his extensive travels in the area in connection with the fur trade, Russell recorded seeing a variety of wildlife but never mentions seeing mountain goats. After Russell's accounts and to the late 1800's several private and government sponsored expeditions were made (Raynolds 1868; Doane 1871; Jones 1875; Ludlow 1876; Roosevelt 1893; Chittenden 1895) to the Yellowstone area but again, none mention seeing mountain goats. In the early 1900's, Skinner (1926) reviewed the literature and talked to various hunters, rangers, and guides who were familiar with the area at that time. He concluded mountain goats were not historically in Wyoming, including the Yellowstone area. Thus, in the recent history of the Yellowstone Ecosystem, evidence of goats being part of the faunal complex is lacking.

There are also no records of prehistorical (< 12,000 years B.P., approximate time of human occupation of North America (Martin 1967)) occurrence of mountain goats in the Ecosystem. Excavations of Mummy Cave (9,000 years B.P.) (McCracken et al. 1978), 19 km east of Yellowstone Park and of Lamar Cave (1,700 years B.P.) (Hadly 1990), in northern Yellowstone, notably lack goat remains.

It can be argued the lack of historical and prehistorical evidence is not conclusive proof goats were not present in the Ecosystem during those times (Lyman 1988). Most early explorers of the Yellowstone area traveled in the valleys, rarely scaling the high peaks where goats would have lived. Likewise, the few archeological/paleontological excavations of recent sites (< 10,000 years B.P.) (McCracken et al 1978; Hadly 1990) were in valleys. However, unless conclusive evidence is found, it seems likely mountain goats were not

present in the Yellowstone area at the time of arrival of Europeans and possibly not present for several thousand years prior to that time.

In contrast to historical and prehistorical data, there is ample published evidence mountain goats ranged well south and east of the Yellowstone area during the late Pleistocene (15,000 - 10,000 years B.P.) and before (Sinclair 1905; Stock 1918 & 1936; Wilson 1942; Guilday et al. 1967; Anderson 1968; Mead 1981; Logan 1981; Walker 1982). Additionally, several fossil mountain goat specimens were collected in the Greater Yellowstone Ecosystem from the Palisades reservoir area in Idaho from 70,000+ years B.P. deposits (S. Miller, Idaho Museum of Natural History, personal communication). Figure 7 summarizes the known Pleistocene sites of *Oreamnos* sp. records.

Figure 7. Locations of known paleontological sites where mountain goat (*O. americanus* or *harringtoni*) remains were found (Harris 1985).

With the advance of the Cordilleran ice sheet (Waitt and Thorson 1983), goats were forced to southern refugia (Harington 1971). During that time, fossil evidence indicates *O. americanus* extending as far east as southeastern Wyoming (Fig. 7) and a smaller species *O. harringtoni* extending into east-central Mexico (Fig. 7). The dispersal route of goats to the east, in advance of the ice sheet, is hypothesized as being through the Greater Yellowstone Ecosystem (Mead 1983). During the same time, extensive mountain glaciation existed south of the Cordilleran sheet terminus (Porter et al. 1983) and covered much of the Greater Yellowstone Ecosystem. The presence of fossil goat remains in the Palisades, Idaho area supports Mead's (1983) hypothesized migration route through the Yellowstone area. These specimens represent habitation of the area well before the last advancing mountain glaciers but goats had to have either inhabited the Yellowstone area, or move through it, prior to the last advance of the Cordilleran ice sheet (20,000-18,000 years B.P.). It is unknown if goats recolonized the area after recession of the glaciers. Regardless, there is irrefutable evidence mountain goats were Pleistocene inhabitants of the Yellowstone area.

A factor germane to determining the exotic or native status of present day goats to the Ecosystem is their taxonomic relationship to the prehistoric and Pleistocene mountain goats. If modern goats are significantly different from their ancestors, then considering them native to the Ecosystem is as incongruous as concluding modern camels and horses are native to an area because of the Pleistocene occurrence of ancestral forms. Based on taxonomic analyses, investigators identify all the fossils found in Wyoming as *O. americanus*. Thus, modern forms of mountain goats are not exotic to the Yellowstone area on a late Pleistocene basis. Additionally, based on discussions presented relative to recognized native floral and faunal components of the Yellowstone Ecosystem, goats could also not be considered ecological exotic. Goats co-occur in other climatologically and physiognomically similar areas with most, if not all, the recognized native faunal and floral species of the Yellowstone area. Thus, given the Pleistocene occurrence of goats, native plants and animals of the Yellowstone area have had an evolutionary past that might included mountain goats.

What is unknown is how long ago goats were extirpated from the Yellowstone area and what caused their extinction. If goats were indeed not present historically (250-0 years B.P.), at what time between their Pleistocene occurrence and 250 years B.P. did they become extinct? Did goats fail to colonize the Yellowstone area after the glacial ice receded? This seems unlikely as they would have had to move back through the area to repopulate more northern areas. If colonization occurred, was extinction a random event (Newmark 1987) or result from overharvest by aboriginal people (Martin 1967)? Palynological records from the Yellowstone area (summarized in Hadly 1990) indicated a warming trend between 9,000 and 5,000 years B.P. Possibly this postglacial warm period caused a recession of goat ranges northward of the Yellowstone area. If mountain goats have slow dispersal rates (Stevens 1983), the current historical range may represent a re-advance southward with the return of a cooler climate; an advance possibly interrupted by the arrival of Europeans. Given time, goats might have eventually moved back into the Yellowstone Ecosystem, as they may presently be doing from historic range into the Centennial Mountains. Currently, all this is speculation and the rapid expansion of goat range in the mountains north of Yellowstone Park would tend to contradict this hypothesis. Perhaps discovery and excavation of other paleontological/archeological sites within the Yellowstone area will answer many of these questions.

Park Service personnel must decide if sufficient time has elapsed since extirpation to classify goats entering the Park as exotic. If the Park Service classifies goats as native to the Yellowstone Ecosystem, no action would be required and goats would be allowed to become established in both Parks. If goats are classified as exotic, Park personnel will need to develop a management plan relative to their eventual establishment in the Parks. The following section is provided as a guide to the development of such a plan.

MANAGEMENT ALTERNATIVES

Based on what has been presented, there are three possible scenarios for goat populations in Yellowstone and Grand Teton National Parks. In the first, the status of goat populations in the Parks would remain approximately the same. The populations would primarily consist of transitory or ephemeral individuals with some animals persisting in limited areas along the border of Yellowstone Park. In the second scenario, goats would become established in the interior of both Parks but be at relatively low population densities. Under this scenario, an approximate population of 100 animals would inhabit Yellowstone Park and approximately 160 animals would be in Grand Teton Park. The third scenario predicts higher numbers of goats for both Parks. Approximately 500-550 goats would be in Yellowstone and Grand Teton Parks. At this time, it is difficult to predict which of the three scenarios is most likely to occur. If the first scenario proves accurate, there would be no need for Park personnel to develop a management strategy. Thus, in assessing management alternatives, only the low and high population scenarios will be addressed.

Goats are currently not significantly impacting the fauna and flora of either National Park. However, under the low population scenario for Grand Teton Park and the high population scenario for both Parks, some negative impacts could be realized. Three alternatives exist for managing mountain goats in the Parks: No action, selective control of goats at a predetermined population level, and total elimination of goats within Park boundaries. These alternatives will be assessed relative to impacts on Park ecosystems, Park visitors, and the National Park Service. Additionally, estimated costs of each action will be analyzed. These categories parallel those used by personnel of Olympic National Park (1987a).

No Action

Impacts on the ecosystem:–Surveys of goat range in Glacier National Park, Montana and Mt. Baldy, Idaho with high densities of goats indicate little physical damage and percent cover of grass and forbs comparable to similar habitat in Yellowstone Park. Based on these surveys, goat densities in both Parks, even at high population estimates, would likely not be high enough to significantly impact the physical or floral components of the Parks.

If numbers of goats in Yellowstone Park increase, the area to be initially impacted would be Wolverine Peak. Monitoring of the photo points established in that area would help assess any impact goats might have on the floral component of the Park.

Establishment of goats in both Parks would be within existing bighorn sheep range. At both the low and high population estimates, some impact of goats on sheep would be expected. The extent of the impact would depend on the degree of overlap in food and habitat use by sheep and goats. Data indicate food habits of sympatric sheep and goats

diverge, especially in winter. Habitat use by both species also overlap but again, in sympatry, some separation seems evident. The differences in winter food and habitat use goats and sheep results mainly from differing wintering patterns. Sheep will often travel to traditional winter ranges well apart from summer ranges; goats more often concentrate their winter movements within or near their summer range. Indications are such movements are typical for sheep in Yellowstone Park. The result is a reduction in completion during the most critical time of the year. In the mountains north of Yellowstone, there is no evidence sheep populations have decreased as a result of increasing numbers of goats (Frisina 1974; Stewart 1975). Consequently, under the low population scenario, it is predicted goats will have little to no impact on sheep in Yellowstone Park.

Under the high population scenario, an estimated 500-550 goats would inhabit Yellowstone Park, likely in much of the existing sheep range. This number of goats is higher than current levels of bighorn sheep and such an increase in goats would likely be at the expense of sheep numbers. At this time, it is difficult to estimate the proportions of goats and sheep that might occur at an equilibrium. Goats and sheep co-exist at relatively high numbers elsewhere in the West. However, carrying capacities for both species likely differ between these areas and Yellowstone Park. Some ecological separation of the two species, especially in the winter, would be expected. If mountain goats exclude sheep primarily from summer range, their impact would be less than if they established themselves in major sheep winter ranges such as Mt. Everts. Because of these uncertainties, it is difficult to predict the exact impact goats would have on sheep.

In Grand Teton Park, the sheep population is considered extremely low compared to historic estimates and is viewed as a remanent population (Whitfield 1983). Sheep in the Park use combined winter and summer ranges (Anonymous 1987b) because traditional winter range was lost to human development (Whitfield 1983). Assuming that establishment of and increases in goats would occur on the present combined range of sheep, some negative impacts could be expected even at the low population estimate. These negative impacts would be exacerbated at higher goat numbers. Competition for food and habitat in the summer may not prove critical. However, areas where sheep winter in the Park would likely also be attractive to goats. Based on the literature, (Pallister 1974; Stewart 1975; Dailey et al 1984; Reed 1986) minimal overlap of resource use and agonistic interactions in such a situation would be predicted. However, because of the compressed winter range of sheep, competition for food and shelter could be more intense than what is indicated by the literature (Adams et al. 1982b). If this management option is chosen, intensive monitoring of goat-sheep interactions should be carried out.

Impact on human use:--With the current status and distribution of goats, most visitors to Yellowstone and Grand Teton Parks are unaware of the goats in the Parks. Under both the low and high population estimates, goats would invade interior parts of the Parks and become more readily visible. Sightings by hikers, campers, and day visitors would increase. These sightings would likely be viewed favorably by most people. Goats are considered by many as charismatic megafauna, characteristic of wild areas. Sighting of goats is considered an enhancement to the outdoor experience. Mountain goats in Glacier National Park are considered the main species to view while visiting the Park and souvenir stores stock a wide variety of goat paraphernalia. It is likely that goats in Yellowstone and Grand Teton would initially receive similar favorable public support, regardless of population levels.

In Olympic National Park, goats habituated to humans and developed a "fondness" for salty foods and human sweat (Anonymous 1987a). The goats often became nuisances and at times aggressive in their pursuit of these items, detracting from the outdoor experience. Other Parks, in particular Glacier Park, do not have similar problems and none are anticipated in Yellowstone or Grand Teton Parks unless goats become established in high human use areas, e.g. Mt. Washburn.

Impact on Park Service:--The Park Service has the charge "to perpetuate the native animal life..." of National Parks and not allow exotic species "to displace native species if this displacement can be prevented by management" (Anonymous 1988). If mountain goats are considered "exotic" because they historically did not inhabit the Greater Yellowstone Ecosystem, the Park Service would have to develop a management plan, including possible eradication, depending on whether goats "... threaten Park resources...". At the low population estimate for goats in Yellowstone, minimal impact on plants and animals is expected. Thus, the presence of goats would not violate any management mandates and action by the Park Service would not be necessary. The Park Service would receive favorable comments from visitors who sighted goats. These favorable responses could enhance the Park Service's public image.

At the high population estimate, goats would become a prevalent component of Yellowstone's wildlife. Assuming no negative interactions between goats and humans, public support would remain favorable. However, with the higher densities of goats, there may be negative effects on the bighorn sheep populations. The Park Service would then have to decide if the impact is sufficient to warrant initiation of control measures.

In Grand Teton National Park, the Park Service would receive the same favorable response from the public as in Yellowstone. However, even at the low estimate of goat numbers, negative impacts on sheep are possible. Depending on the severity of the impacts, the Park Service may have to develop a management plan for goats.

Cost:--With this alternative, there would be no cost in managing goat numbers. The only cost incurred would be for research and monitoring of goats. Research projects could include: 1) a study of goat and sheep interactions in the Wolverine Peak area of Yellowstone Park and 2) a detailed comparative study in northern Yellowstone of vegetation in areas with and without goats.

Monitoring activities should include: 1) periodic sampling of permanent photo points on Wolverine Peak (YNP), 2) aerial surveys for goats in likely habitat areas to determine population trends, and 3) annual census of bighorn sheep, especially in Grand Teton Park, to monitor potential effects of goats on sheep.

Selective Control of Goats

Impacts on the ecosystem:--Under this management option, some predetermined population level and/or distribution pattern of goats would be selected. The population level chosen should be below the level at which negative effects on faunal or floral components of the Park become apparent. This would seem like *a postori* planning but if the low population

scenario proposed proves to be accurate and no negative impacts on native fauna and flora are realized, little or no control of goats would be needed.

Management of the specific distribution of goats in Yellowstone Park would have to be on a range by range basis. Control in certain areas may be warranted regardless of the overall population level in the Park. As previously mentioned, some locations in Yellowstone Park might support higher numbers of goats than others and produce negative impacts. Control would be needed to maintain acceptable numbers in these areas. Additionally, if goats should invade major wintering areas of sheep, for example, Mt. Everts, they may adversely affect sheep survival, even at low numbers. In such cases, minimal numbers or total removal from those areas would be warranted.

In Grand Teton Park, the number of goats projected by the low population scenario could negatively impact sheep because of their compressed winter range. However, because of the monetary and social implications of any control measure, a conservative approach is still advised. Under this management option, it would not warrant the expenditure of time and resources to control goat numbers until or unless they reach a level where they begin to negatively affect the sheep population or the habitat.

Impact on human use:--The potential impact of control measures on human use of the Parks will depend on the population level of goats selected. If the level is at or near the predicted low population scenario and that scenario proves accurate, the impact would be as outlined under the no action management plan. Maintenance of population levels between the low and high population scenarios would have intermediate impacts. The extent of the impacts would be a deciding factor in establishing a particular population level for a specific location. For example, an equal density of goats on Mt. Washburn, an area of high human use, might have different impacts on Park visitors than an area of light use such as Mt. Holmes. Goats might become more habituated to humans on Mt. Washburn and become a nuisance. In this situation, a lower density of goats on Mt. Washburn might be appropriate.

Control of goats below a natural equilibrium will require removal of excess individuals. Impact of removal on human use of the Parks will depend on the removal methods used. Removal methods and their impacts will be discussed in detail later.

Impact on Park Service:--Maintenance of any level of goats in the Parks would impact Park Service policy regarding exotic species. As per the policy (Anonymous 1988), the target density of goats selected by Park personnel would be sufficiently low to prevent negative impacts on native species. Maintenance of low to moderate levels of goats within Park boundaries would likely not negatively impact the public's perception of the Park Service. Selection of this management option would require the Park Service to initiate several long term monitoring programs. Annual surveys would be needed to determine goat numbers and distributions. Such surveys would also be needed to monitor the population status of bighorn sheep. Vegetation sample plots such as those established during this study would have to be set up in other areas of the Parks where goats might become established.

If goats reach a level at which control is needed, the Park Service would have to initiate a removal program. The specifics of such a program will be discussed later. Removal of goats, depending on the method, may create a negative public image of the Park Service.

Costs:--The selection of this management option would require annual funding of the monitoring programs established. Existing Park personnel could conduct these programs but this would divert time and effort from current functions. Alternately, specialized personnel on loan from regional state or federal resource agencies could conduct these programs.

If goats reach the preselected population level, Park personnel would have to remove excess goats by capturing and relocating or shooting individuals. The cost of removal is dependent on the type of capture technique used. Personnel at Olympic National Park developed a simplified comparison of various control techniques (Anonymous 1987a) (Table 16). The various techniques listed are applicable to Yellowstone and Grand Teton Parks and costs per method are realistic. Initiation of a control program would require long term commitment of funds for annual or periodic removal operations.

Table 16. Comparison of capture and control techniques for goats (From Anonymous (1987a)).

Technique	Precapture Requirements	Sensitivity	Multiple Capture	Safety Personnel	Safety Goats	Relative Efficiency[1]	Cost per Animal[2]
Foot Snare	Minimal	Good	No	Good	Good	Poor	$ 50-100
Drop Net	Extensive	Good	Yes	Good	Good	Fair	$300-500
Aerial Net Gun	Minimal	Excellent	No	Fair	Poor	Good	$800-1000
Ground Darting	Minimal	Excellent	No	Fair	Fair	Poor	$200-400
Aerial Darting	Minimal	Excellent	No	Good	Fair	Good	$600-800
Drive Net	Extensive	Poor	Yes	Fair	Poor	Poor	$900-1000
Aerial Shooting	Minimal	Excellent	N/A	Good	N/A	Good	$ 30-50

[1]Number of captures per unit effort.
[2]Excludes transportation costs.

Elimination of Goats Within Park Boundaries

Impacts on the ecosystem:--Except for the few animals on the northeast boundary of Yellowstone Park, there are currently no established populations of goats in either Park. Thus, maintaining goat-free Parks would require removal of all goats as they enter the Parks. Removal of goats as they enter the Parks would require capture operations when and where goats become established. Depending on the removal method used and the location of the operation, some negative impacts could result. Methods requiring intensive manpower or ground equipment would increase human impact on an area. Locations currently readily accessible to humans would not experience as much of an impact as would more remote wilderness areas.

Impact on human use:--Currently, sightings of goats by visitors to both Parks are sporadic. Most Park visitors do not know goats are present or periodically enter the Parks. Thus,

removal of existing goats and future immigrants will not be noticed by Park visitors. Depending on the removal method chosen, most visitors would also not be aware of removal activity. High profile removal methods would likely arouse the curiosity of Park visitors. However, visitor awareness would be minimal because most sightings and consequently removal operations are in more remote locations in the Parks.

Impact on the Park Service:--Selection of this option would require periodic surveillance of likely locations of goat colonizations. It would also require checking every reported goat sighting and removal action if the sightings were verified. Because of current distributions of mountain goat populations in the Greater Yellowstone Ecosystem, the selection of this management option will require a long term commitment of resources and personnel to removal activity by the Parks.

At Yellowstone Park, there are major concentrations of goats juxtaposed to Park boundaries. These populations are under the jurisdiction of the Montana Department of Fish, Wildlife and Parks and the Wyoming Department of Game and Fish. Introductions of goats into these areas were intentional and main management efforts are to maintain or increase goat numbers. Total long term elimination of goats from Yellowstone Park is not likely because of consistent re-invasion of the Park by dispersing individuals from these reservoir populations.

At Grand Teton Park, the major concentration of mountain goats is approximately 40 km south of Park boundaries near Swan Valley, Idaho. This population of goats is under the jurisdiction of the Idaho Department of Fish and Game. To date, these goats have not extended their range significantly from the original transplant areas. There have been sightings of goats in the areas between current goat range and Park boundaries. These sightings are sporadic except for consistent reports of a few goats just south of the Park on Taylor Mountain. Because of the distance between the reservoir population and Grand Teton Park, keeping the Park goat free will not be as difficult or time consuming as in Yellowstone. If there are any goats currently within Park boundaries, re-invasion by new individuals after their removal would not likely reoccur very rapidly. However, if goat populations eventually become well established near the Park boundaries, persistent re-invasion of Grand Teton Park would necessitate constant surveillance and removal operations.

Cost:--This management option would commit the Park Service to long term control of a large ungulate species. Both Parks would have to make a long term commitment of funds and personnel for periodic surveillance of likely colonization sites and checks of reported goat sightings. The Parks would also have to maintain sufficient funds and resources for removal of any goats found within Park boundaries. Amounts and consistency of funding would depend on the rate of re-invasion. Presently, costs of this option would be greatest for Yellowstone Park. However, if goat populations become established just outside of Grand Teton Park, costs to Grand Teton could be higher because the more rugged terrain would make removal more difficult than in Yellowstone Park.

Other Alternatives

Besides the three management options considered, there are several other alternatives that exist. Control or removal of goats from the Parks could be accomplished by opening the

Parks to public hunting. Grand Teton Park currently has a controlled hunt on elk (*Cervus elaphus*). However, this hunt is presently under review because National Parks are not normally open to public hunting. Thus, this option is not deemed feasible.

The potential of re-introducing wolves into the Greater Yellowstone Ecosystem is being investigated (Anonymous 1987c). If re-introduction occurs and wolves become well established in Yellowstone and Grand Teton Parks, some loss of mountain goats to wolf predation is likely to occur. However, given the high densities of other ungulates in the Parks, it is unlikely predation levels on goats would be sufficient to control their numbers.

REMOVAL METHODS

The 2nd and 3rd management options require removal of goats from the Parks. There are several removal methods available and their feasibility for use in a National Park setting has been addressed by personnel in Olympic National Park (Anonymous 1987a). The methods include sterilization, live capture and shooting. Sterilization was considered to be the least feasible of the three methods because of its difficulty in administration and duration of effect (Anonymous 1987a) and will not be discussed further.

Live capture of animals can be accomplished by several methods ranging from foot snaring to drive nets. Personnel from Olympic Park (Anonymous 1987a) assessed the advantages and disadvantages of the various live capture techniques. Their assessment is reproduced in Table 16 (Pg 45). Each technique has advantages and disadvantages depending on the terrain, the number of animals needed to capture, and cost. Some techniques are better adapted to capture of one or two animals while others are more efficient for capturing large numbers. Some techniques will only work in specific terrains. Capture of goats in the Parks would involve differing numbers of goats and be in a variety of terrains. Because of the differing circumstances that might arise, no one method of live capture is being recommended at this time. All the methods are presented as a guide to technique selection if the decision to remove animals is made.

Regardless of the removal method, the Park Service would have to dispose of the animals captured. Currently, state resource personnel in various western states have active programs for re-introducing mountain goats into historic ranges. The Park Service would have to make arrangements with these agencies on the transport of captured goats to designated sites. As control of goats would be an ongoing operation, it is uncertain how long state agencies would accept goats before their re-introduction plans are complete. If state agencies would no longer need excess goats, the Park Service might have problems disposing of the animals they capture.

The logistics of live capturing animals would also vary considerably. All the techniques would require either capture or removal of animals from the mountains with helicopters. Park personnel would have to establish staging areas for helicopters to land and trucks to load captured animals. Some environmental damage would be expected in such areas. The amounts of helicopter noise and truck traffic would vary with the intensity of the operation. Moderate to intensive operations might negatively impact human use of the Park, especially in back country areas. The impact could be reduced by timing the operations in early spring or late fall when visitor use of the Parks is lower.

The third removal technique is shooting of mountain goats. Park employees or federal animal control agents would be responsible for shooting animals. Dead animals could be left

where shot, buried, or removed. If Park personnel remove the carcasses, they would have to dispose of them in line with Park Service policy.

The impact on the environment of shooting goats should normally be minimal. If Park personnel use helicopters, they can operate from airports in nearby towns. Leaving the carcasses to decompose would not differ much from natural mortality, if only a few animals are involved. Shooting large numbers of animals would necessitate removal or burial of the carcasses. Removing the carcasses could be accomplished with horses or by helicopter with a minimal impact on vegetation.

Shooting of goats could have an extensive negative impact on the Park Service. As previously mentioned, mountain goats are viewed favorably by the general public. The public's reaction to killing of goats within Park boundaries could be extremely vocal and negative. The media would likely not portray the Park Service in a very positive light.

Actual shooting operations should not impact human use of the affected areas. In the more remote areas of the Parks, few people would be aware of the operations. Closing of back country areas to hikers when operations are to be conducted and/or conducting operations in early spring or late fall would further reduce the impact on human use. In areas more frequently used by visitors, shooting of goats would have to be done in late fall, winter, or early spring and all animals killed would have to be removed.

In summary, the various impacts of the three management alternatives considered are summarized in Table 17. The "no action" management option is the least expensive; selective control and elimination of goats will require long term commitment of personnel and funds for removal of excess goats from the Parks. If populations of goats in either Park only increase to the low population estimates, the no action management option also has the least negative impact on human use of the Parks and the Park Service. Initiation of control measures, either non-lethal or lethal, will likely result in some negative impacts on human use and the Park Service image. No negative impact on Park vegetation is anticipated under the "no action" option even at the high population estimate. Some localized impact is expected under both "selective control" and "elimination" plans. If estimates of future population levels of goats are in error, however, the no action option could have the greatest negative impact on bighorn sheep in both Parks.

RECOMMENDATIONS

The first decision Park Service personnel must make concerns the status of goats in the Greater Yellowstone Ecosystem. No evidence was found that goats were part of the historic fauna but, data indicate goats were at least late Pleistocene transients through the area. Consequently, regardless of timing and causes of extirpation, goats are not prehistoric exotic of the Greater Yellowstone Ecosystem. Park personnel must decide if sufficient time has elapsed since extirpation to classify goats as historical exotic. This presents a complex issue and would likely require a review of the concept of what constitutes an exotic species. Because of the complexity of the issues involved, no formal recommendation is made at this time. Needless to say, the decision made will greatly impact the Park Service's response to the presence of mountain goats in both Parks. If goats are classified as native to the area, then no further action is recommended; goats would be allowed to establish themselves as part of the faunal complex of the Parks. If the decision is to consider goats exotic to the Ecosystem, the following recommendations concerning management alternative are made.

Table 17. Summary of impacts of the three management plans presented relative to the two Parks.

Management Alternatives	Ecosystem impacts	Visitor Impacts	National Park Service Impacts	Costs
YELLOWSTONE NATIONAL PARK				
No Action				
Low Scenario:	Minimal impact on vegetation or sheep. species.	Favorable impact Highly desirable policy.	Minimal conflict with Park Service studies and surveys.	Least expensive. Cost only for selective
High Scenario:	Minimal impact on vegetation. Possible impact on sheep.	Favorable impact unless goats become nuisances.	Possible conflict with Park Service policy.	Same as for low population scenario.
Selective control	Minimal impact on sheep. Some impact on vegetation in staging areas.	Possible noise and visual intrusion. Negative impact on finding killed goats.	Attain Park Service policy. Negative public opinion from noise/dead animals.	$50-$1100/animal plus transportation. Cost for periodic census of the population.
Elimination of Goats	Same as for selective control.	Same as for selective control.	Same as for selective control.	$50-$1100/animal plus transportation. Costs for checking goat sightings.
GRAND TETON NATIONAL PARK				
No Action				
Low scenario:	Minimal impact on vegetation. Possible impact on sheep.	Favorable impact. Highly desirable species.	Minimal conflict with Park Service policy.	Least expensive. Cost only for selective studies and surveys.
High scenario:	Minimal impact on vegetation. Likely negative impact on bighorn sheep.	Favorable impact unless goats become nuisances.	Likely conflict with Park Service policy.	Same as for low population scenario.
Selective control	Minimal impact on bighorn sheep. Some impact on vegetation of staging areas.	Same as for Yellowstone Park.	Same as for Yellowstone Park.	$50-$1100/animal plus transportation. Cost will likely be higher than for Yellowstone because of the more rugged terrain. Cost for periodic census of the population.
Elimination of goats	Same as for selective control.	Same as for selective control.	Same as for selective control.	Same as for Yellowstone Park except cost of capture likely higher because of the terrain.

Because of the uncertainty of eventual goat numbers, it is recommended Park Service personnel develop a multi-level decision oriented management plan to respond to future trends in goat populations. Considering the current number and distribution of goats relative to the Parks, it is premature to initiate any control measures at this time. Thus the "no action" management option is recommended as the initial stage (Fig. 8). Essential to the implementation of such a plan is a long term commitment to monitoring goat and sheep populations. Selection of appropriate management pathways would be keyed to future trends in goat populations. If goats numbers continue to remain low, the "no action" policy would stay in effect. If goat numbers reach a level where negative impacts are observed, then an appropriate alternate control plan would be activated.

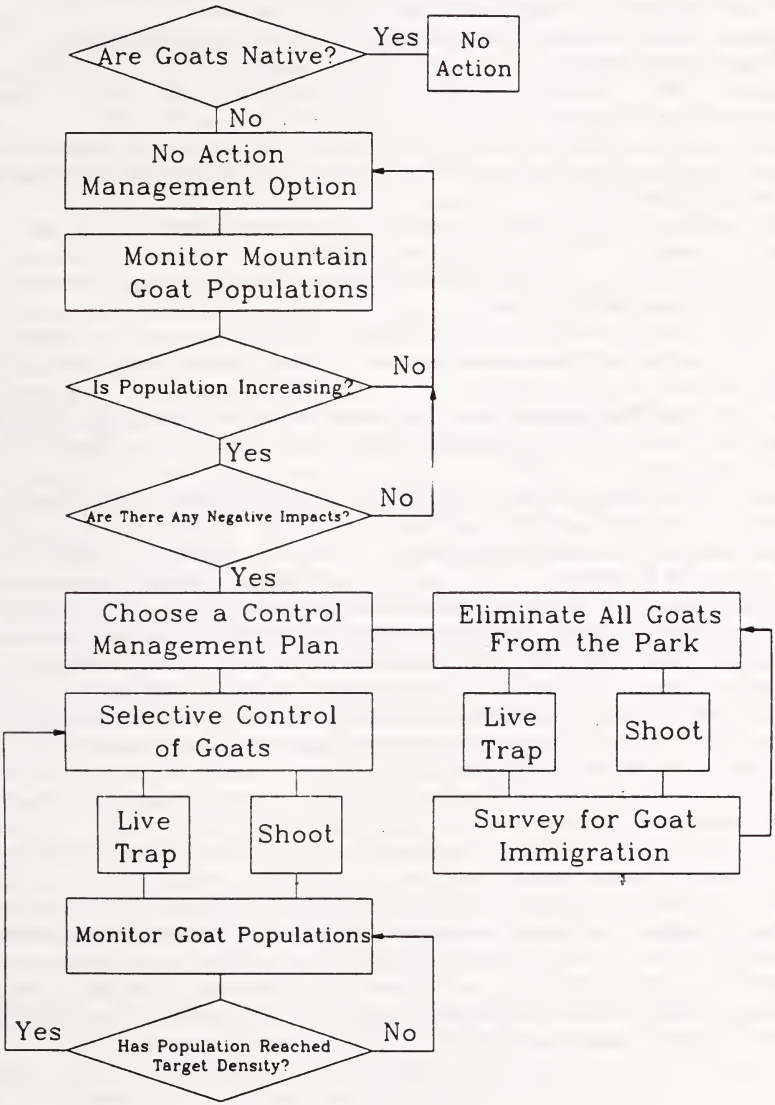
If removal of goats is required at some future date, the contingency plan recommended is selective control of goats at an acceptable level. Elimination of goats from Yellowstone and Grand Teton Parks is considered the least viable option. Large reservoir populations of goats are currently near Yellowstone and would exist near Grand Teton Park if goat numbers in that Park were high enough to cause problems. Because goats in these populations will readily move in and out of Park boundaries, removal of all goats on the periphery of the Parks would be impossible. Maintaining a goat-free Park interior would create an ecological vacuum that would attract goats from outside of the Parks and necessitate constant surveillance and removal activities.

Selective control of goats would involve removal of animals once a target density was reached. If sufficient numbers of goats are removed, control operations would only be conducted periodically. The presence of a resident number of goats in the Parks might also reduce the immigration of animals from outside populations.

Regardless of the control option selected, it is recommended that such an option not be initiated unless absolutely necessary. Both removal oriented management options would result in severe negative public response and commit the Park Service to long-term cyclic endeavors (Fig. 8). The no action option would require a long term commitment to monitoring goat and sheep populations but such monitoring would still be less expensive than control activities. This more conservative approach initially would give the Park Service time to adopt a long term management plan such as the one suggested and, as importantly, build public support, through education, for whatever plan is decided on.

In summary, if goats are classified as native to the Greater Yellowstone Ecosystem, no further action would be necessary. If goats are classified as exotic, the recommendations of this report are: 1) no action at this time, 2) monitor goat and sheep populations, 3) develop alternate courses of action to respond to the different possibilities in future goat numbers, and 4) develop a plan to build public support, and possibly input, for the course of action to be taken.

Figure 8. Flow diagram for selecting management options relative to mountain goats in Yellowstone and Grand Teton Parks.



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