

## Mountain Goat Management on the Kenai Peninsula, Alaska: a New Direction

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**Abstract:** Management of mountain goats (*Oreamnos americanus*) on the Kenai Peninsula has varied over the last 4 decades. A sanguine description of a past harvest-tracking strategy was described by Del Frate and Spraker (1994). Despite the stated goal of their management protocol to allow for gradual increases in population size, the current Kenai population of roughly 3,000 goats declined 30-50% from 1992 to 2006. The goat range on the peninsula is divided into 31 areas that are managed as discrete populations and vary greatly in goat densities, habitat type, hunter accessibility, and allocation of hunting permits. We review 4 decades of survey and harvest information, discuss some of the consequences of past management protocols, and describe a conservative strategy that has been recently employed to reduce the potential for overharvest yet still provide sustainable hunting opportunities. Specifically, our new protocols use explicit criteria to determine the number of hunting permits to issue each year in each area by considering past harvest rates, the sex and age structure of the harvest, population size and trends, the age of the survey data, access, ecotype, winter severity, and other factors. We also discuss a new approach for reducing the harvest of female goats.

**Key Words:** Alaska, Kenai Peninsula, harvest rate, mountain goat, *Oreamnos americanus*.

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Mountain goats (*Oreamnos americanus*) are the most understudied ungulate in North America. Past mismanagement of some goat populations stemmed from incorrect assumptions made about their population dynamics, which led to excessive harvests. Specifically, excessive harvests occurred because native goat populations lacked compensatory reproduction in response to harvests, survival was influenced by highly variable density independent events, population growth rates were lower than other North American ungulates requiring lower sustainable harvest rates, and populations were often not managed at the subpopulation

level, which led to local extirpations (Kuck 1977, Herbert 1978, Bailey 1986, Kuck 1986, Glasgow et al. 2003). During the past decade, several studies have contributed greatly to our understanding of the ecology and conservation of mountain goats (Côté and Festa-Bianchet 2001a, 2001b; Festa-Bianchet et al. 2003; Festa-Bianchet and Côté 2008). Management protocols need to be reviewed periodically to incorporate new insights gained from field studies (Bailey 1982), especially considering the low growth rate of mountain goat populations.

The low growth rate in native populations of mountain goats (Festa-Bianchet et al. 1994, Côté and Festa-

Bianchet 2001*b*, Côté et al. 2001) is more comparable to that of brown bears than other northern ungulates such as caribou or moose. For example, although there is regional variation, primiparity for native goat populations averaged 4.6 years (Côté and Festa-Bianchet 2001*b*) compared to 4-5 years in brown bears (Schwartz et al. 2003), 3.0 years in caribou (Adams and Dale 1998), and 2-3 years in moose (Boertje et al. 2007). The  $\leq 2\%$  sustainable harvest rate calculated for native mountain goats on Caw Ridge, Alberta, (Gonzalez Voyer et al. 2003, Hamel et al. 2006) is far lower than the 5.5-5.7% sustainable harvest rate for brown bears (Miller 1990, Van Daele 2007), and the 7-8% harvest rate for some moose populations (Boertje et al. 2007). The lifetime reproductive success of females is variable but studies on native populations showed a mean of 5.7 kids produced with 3.6 kids surviving to age 1 (Festa-Bianchet and Côté 2008:132). Contrary to density dependent responses found in some cervids (McCullough 1979, Sand et al. 1996, Boertje et al. 2007), there is little if any evidence of compensatory reproduction in native goat populations; mortality is primarily influenced by density independent factors (Smith 1988, Festa-Bianchet et al. 2003), and hunting mortality is considered additive (Kuck 1977, Bailey 1986). A slow growth rate coupled with additive hunting mortality creates challenges for sustainable management of mountain goats, especially native populations.

While introduced goat populations can grow and expand quickly and are often able to sustain relatively high harvest rates (Swenson 1985, Houston and Stevens 1988), native populations are sensitive to harvest (Côté et al. 2001, Gonzalez Voyer et al. 2003, Hamel et al. 2006). Indeed, native goat populations are the only ungulate in North America in the past 50 years to be extirpated from large areas due to excessive

hunting (Smith and Nichols 1984, Glasgow et al. 2003). Aside from the intensively studied goat population on Caw Ridge, Alberta (Festa-Bianchet and Côté 2008), empirical support for most harvest strategies for mountain goats is weak (Bailey 1986). Annual differences in survival rates and reproductive success can be significant both across and within goat populations (Côté and Festa-Bianchet 2001*a*), so management actions need to be herd specific and based on many years of supporting data (Bailey 1986). Unfortunately, management of mountain goats across much of their range in Alaska is often compromised by a lack of information on herd specific dynamics and insufficient funding for adequate monitoring and research.

Past management protocols on the Kenai Peninsula may have negatively affected goat populations. The peninsula-wide population has declined 30-50% since the early 1990s. Our first objective was to review the past management protocols for goats on the Kenai Peninsula (Del Frate and Spraker 1994) by evaluating 4 decades of management actions that may have contributed to population trends. Secondly, we discuss new management protocols based on recently published studies on goat population dynamics and life history characteristics that will update our management strategy to help curtail the current population decline.

### Study Area

The Kenai Peninsula (24,000 km<sup>2</sup>), which lies between Prince William Sound and Cook Inlet, is in south-central Alaska (Fig. 1) and has over 12,000 km<sup>2</sup> of mountainous goat habitat. Over 90% of the habitat used by goats is within protected lands of the Kenai Fjords National Park (2400 km<sup>2</sup>), Chugach National Forest (5000 km<sup>2</sup>), Kachemak Bay State Park (1600 km<sup>2</sup>), and the eastern portion of the Kenai

National Wildlife Refuge (2100 km<sup>2</sup>). Apart from the introduced population on Kodiak Island, the Kenai Peninsula is the western most extent of the range of mountain goats. Goat habitat on the Kenai was described in Hjeljord (1973). The Kenai Mountains range in elevation from 1,300 m to 2,000 m. Alpine tundra (Viereck and Little 1972) covers most higher elevations but there is variation between coastal and inland areas. On the inland portion of the Kenai Mountains, goats are sympatric with approximately 1,000 Dall sheep (*Ovis dalli*). Both species have been present on the Kenai for centuries; native people hunted them long before Alaska was first settled by Russians in the late 1700s (Sherwood 1974) and large numbers were documented during early explorations of the area over a century ago (Bennett 1918). The total population size on the Kenai is currently about 3000 goats assuming our counts miss 20-40% of the goats present (Nichols 1980). For the purpose of controlling and distributing hunting effort, the Kenai Mountains were divided into 31 units, 25 of which currently have some level of goat hunting (Fig. 1). Although not completely panmictic, we know there is some level of movement of goats across these borders (Nichols 1985). Densities vary greatly; some units have over 300 goats, others fewer than 30.

## Methods

*Aerial Surveys.*— Population counts were conducted annually from 1968-2007 using aerial fixed-winged techniques (Nichols 1980). Goats were classified as kids or older goats (yearlings and adults). Not all animals were observed and counted during aerial surveys, so this sightability bias underestimated goat numbers. Due to the inability to estimate goats not seen during flights, our survey techniques produced minimum counts and not

population estimates. Although fine-scale and short-term trends cannot be detected from these types of surveys (Bailey 1986, Harris 1986), they are adequate for detecting broad trends in goat populations (Gonzalez Voyer et al. 2001). We assumed that our survey counts represented the individual goat populations. Goat surveys were conducted on only 20-40% of the Kenai Peninsula each year due to budgetary constraints. Surveys are not conducted in Kenai Fjords National Park (Fig. 1), where hunting has not been allowed since 1980.

*Harvest Data.*— Kenai specific data on hunter harvest has been collected since the early 1970s. The types of goat hunts have ranged from open hunts with no permit required, to hunts managed with drawing or registration permits. Drawing permits were limited in number, specific to a particular area (Fig. 1), and were issued on a lottery basis where hunters paid for the chance to win a permit. Registration hunts were typically unlimited, specific to a particular area (Fig. 1), and easily obtained at no cost. Registration permits allowed for in season management of harvest and hunter effort and could close early if harvest quotas were reached. In most years since 1976, successful hunters have been required to bring in the horns for sex determination, aging, and measurements (McDonough et al. 2006).

## Results

*Pre-1960s.*— Fewer than 100 goats were reported taken statewide each year during much of the 1920s and 1930s (Klein 1953). Although native peoples hunted goats for hundreds of years (Sherwood 1974) and it is likely that early settlers and miners on the Kenai Peninsula hunted goats as well, Kenai specific harvest statistics before 1972 are unknown. Aerial counts were conducted in some areas in the 1950s

(Klein 1953) but comprehensive surveys across the peninsula did not start until 1968. The bag limit for hunting in the 1920s was 3 goats per year and was reduced to 2 goats per year from the 1930s through the 1960s. The seasons were typically August through December, no permit was required, and no restrictions on hunter distribution were in place. Unrestricted hunting caused the extirpation of some small populations that were likely unable to support even limited hunting pressure (Klein 1953).

*1960s-1970s.*— The yearly bag limit was reduced to 1 goat starting in 1971. The season extended from August through December until the late 1970s. The first effort to collect harvest data came in 1969 from volunteer questionnaires; however, the response was very low. Reporting hunt success became a requirement in 1972. Response in the first several years of required reporting was low, so the actual harvest in these early years was higher than reported (Fig. 2).

No permit was required to hunt Kenai goats before 1976; any licensed hunter could hunt in nearly any location. From 1976-1979, all hunters were required to obtain a registration permit, which allowed managers to assess hunting effort. However, there were no limits to the number of registration permits issued, and few restrictions were in place to control the distribution of hunters. During this period when many local goat populations were declining, managers learned that the hunting effort was very high; records are incomplete but in at least one year, over 1000 registration permits were issued for a population that numbered less than 2000 goats.

Certainly, winter severity, predation, and other limiting factors may have contributed to the population decline during this period. However, our retrospective analysis focuses on harvest rate because it is

a factor managers can control and one that appears to have played a role in the population decline. When hunting pressure was first quantified in the early 1970s, the yearly harvest rates were well over 10%, occasionally reaching 15-40% in some areas. No native goat population has been found to sustain yearly harvest rates over 10% (Côté et al. 2001). The 25% population decline shown between 1968 and 1978 (Fig. 2) was likely the end of a long decline caused, at least in part, by years if not decades of overharvest. For example, unrestricted hunting in the early 1960s effectively extirpated the goat population on Cecil Rhode Mountain, an easily accessible area south of Cooper Landing. A reintroduction effort in 1983 was required to reestablish the population (Smith and Nichols 1984). Also, the highest nanny harvests recorded to date on the peninsula occurred from 1972-1975 (66-102 females taken each year).

*1980s-early 1990s.*— The population decline from 1968-1978 and the high hunting pressure documented during the registration hunts from 1976-1979 influenced managers to start a limited entry system in 1980. Also at this time, 31 discrete hunt units were established. A permit holder could only hunt in one of these predetermined units. This spread the hunting pressure across the landscape and decreased the chance of localized overharvest. The boundaries of the hunt areas established in 1980 are essentially the same ones currently used (Fig. 1). In the first 2 years of this limited entry system, only 185 drawing permits for the entire Kenai Peninsula were issued each year resulting in reduced yearly harvests (Fig. 2). This was a dramatic decrease in the allowable hunting pressure from the previous several years. The number of permits issued increased as goat populations rebounded.

The season for the drawing hunts varied in the 1980s but was typically August 10<sup>th</sup> through September or October. In 1982, late-season registration hunts were established. The registration season occurred after the drawing season, typically in October through November. Registration permits were issued in units ostensibly where the harvest during the drawing season was low and there was additional hunting opportunity available. Starting in 1989, in order to provide some protection to reproductive females, it became illegal to take a female accompanied by a kid.

We do not know exactly all the factors that may have influenced the population increase from 1980 to the early 1990s (Fig. 2). However, it is likely that the large increase in population size during this period resulted from the substantial reduction in the additive harvest mortality and by a density dependent response after unrestricted hunting reduced populations to low levels during the 1970s (Fig. 2). Although there has been little support for density dependent response to harvest in native populations (Smith 1988, Festa-Bianchet et al. 2003), there must be some density dependence at some point in growing populations (Hamel et al. 2006).

*Early 1990s-2006.*— When goat numbers were at their peak in the early 1990s, DelFrate and Spraker (1994) presented their paper at the Northern Wild Sheep and Goat Council symposium addressing the success of their management protocols. Steady declines throughout the 1990s were thought to be due to high winter mortality, a decline in habitat quality, poor recruitment, or competition with Dall sheep (Del Frate 1996, 1998, 2000, 2002). According to trend counts from aerial surveys, the goat population across the Kenai Peninsula declined >30% from the early 1990s to 2006 (Fig. 2). When using an index of the number of goats counted per

hour, which corrects to some degree for variable survey effort, the decline during this period was 50%. There was also a significant long-term decline in kid to older-goat ratios (Fig. 3;  $\beta = -0.29$ , 95% CI: -0.19 to -0.39). Although there may have been landscape level changes influencing this decline, we cannot rule out that an overharvest of reproductive females contributed to the decline in the ratio of kids to older-goats and the overall population decline.

The drawing season from the early 1990s to 2000 was August 10-September 30 with a registration season from October 15-November 30. From 2001 to the present, the drawing season has been August 10-October 15 and the registration season has been the month of November. The number of drawing permits issued ranged between 350 and 450 permits per year and peaked in 1997. The number of registration permits issued exceeded the number of drawing permits issued in the early 1990s but have been greatly reduced in the past 5 years. In 2006, we initiated changes to the protocols of the harvest tracking strategy outlined in Del Frate and Spraker (1994).

## Discussion

Management of mountain goats on the Kenai Peninsula has varied during the last 4 decades. Past harvest strategies may have played a role in influencing the large fluctuations in goat numbers. We outline new criteria used to manage goat hunting on the Kenai Peninsula in order to stem the current decline in goat numbers. The total number of goats counted in each unit during aerial surveys multiplied by the maximum allowable harvest rate gives a maximum allowable harvest, or quota. In order to keep the hunting mortality at or below the quota, we created specific criteria that provide guidance to managers for determining how

many permits to issue for drawing and registration hunts (Figs. 4 and 5) along with a more conservative maximum allowable harvest rate. Factors that influence management decisions are discussed below.

*Harvest rate.*— Mountain goats have been established on the Kenai for centuries (Sherwood 1974) and, therefore, must be managed as a native population. Native populations of mountain goats are more sensitive to harvest than introduced populations (Festa-Bianchet and Côté 2008). Introduced populations of goats can sustain much higher harvest rates than native populations, especially during the initial increase phase when high food availability results in high fecundity and low natural mortality (Swenson 1985, Houston and Stevens 1988, Côté et al. 2001). While variable across areas and time since the introduction, introduced populations may sustain 7-16% harvest rates (Adams and Bailey 1982, Swenson 1985, Van Daele 2006; but see Côté et al. 2001) whereas small native populations may only sustain a harvest rate of  $\leq$  2% if the harvest targets males only (Gonzalez Voyer et al. 2003, Hamel et al. 2006). In native populations in Idaho and British Columbia, recruitment and productivity declined as harvest rates increased (Kuck 1977, Herbert 1978). Due to the difficult nature of goat hunting and the isolation of many units, the overall yearly harvest rate on the Kenai Peninsula has been under 5% for about a decade, but this is not the proper scale to measure harvest pressure. Each hunt unit (i.e., population) needs to be assessed individually. During the population decline of the 1990s (Figs. 2 and 3), the objective maximum harvest rate for mountain goats on the Kenai Peninsula was maintained at 7% (DelFrate and Spraker 1994; Del Frate 1996, 1998, 2000) and the actual harvest rate in some areas frequently exceeded 7%.

Currently, we determine the maximum allowable harvest rate for each individual hunt area (Fig. 1) each year based on 4-5% of the number of goats counted in each area during aerial surveys. A 4% maximum harvest rate is used for interior populations which are smaller and more vulnerable to density independent events (Hamel et al. 2006), whereas a 5% rate is used for the coastal zones where population sizes are typically greater (>100 goats), and weather and habitat conditions more favorable than inland areas (see *Coastal vs. inland populations* section below). A maximum harvest rate of 4-5% of the goats seen during a survey, (or 2-4% of the actual population size), is a conservative adjustment from the previous allowable harvest levels (Del Frate and Spraker 1994) and, coupled with the other criteria outlined below, should help keep hunting mortality within sustainable limits.

*Age structure and female component of the harvest.*— Sustainable harvest rates for small native populations are greatly influenced by the sex and age structure of the harvest (Gonzalez Voyer et al. 2003, Hamel et al. 2006). Specifically, the harvest of 1-2% of female goats of reproductive age (4-9 years old) can negatively impact small populations (Hamel et al. 2006). In order to give females added weight when assessing maximum harvest rates, a harvested female counts as two goat ‘units.’ For example, an area with 100 goats and an acceptable harvest rate of 4%, a maximum harvest level would be 4 males or 2 females. Kenai managers have used this system for over a decade. Despite this system, the yearly harvest rate of females often exceeded 3-4% in a hunt area. The establishment of a female quota for each population has been implemented in Alberta where exceeding the female quota one year may result in the complete closure of the area to all goat hunting the following year (Glasgow et al.

2003). New management protocols will access the sex and age structure of the harvest within each hunt area and may adopt similar measures if additional protections are needed.

*Population size and trends.*—The status of a population and what level of harvest can be allowed will be assessed by looking at historical survey trends within each hunt unit (Fig. 1). Populations that show a significant downward trend in goat numbers over the past 3 survey cycles (8-10 years) will have the maximum harvest rate reduced to 3% and a reduction in permits issued, or a closure of all hunting (Fig. 4). Because registration hunts are now managed more conservatively (see *Registration permits* section below), no registration permits will be issued in areas with declining populations (Fig. 5). In other words, management restrictions will not wait until a population is reduced to low levels before restrictions or closures are established. A population that is declining will be managed more conservatively than one that is stable or increasing.

*Small populations.*— In the 1990s, when limited entry was well established, hunts were often held in areas even when the goat population size was very low. Permits were issued in areas that had <20 goats, and many hunts took place in populations <50 goats (Del Frate and Spraker 1994). Small goat populations of <50 animals have a high probability of decline or extirpation even in the absence of harvest, and likely could not sustain a harvest greater than 1% of goats 2 years and older (Hamel et al. 2006). New management protocols will not issue any drawing permits in areas with <50 goats (Fig. 4) and no registration hunts will occur in areas with <100 goats (Fig. 5; see *Registration permits* section below).

*Consecutive years of overharvest.*— Throughout the period of population decline starting in the 1990s, if the harvest in a

particular area exceeded the maximum harvest one year, harvest opportunities were often not restricted in subsequent years. This allowed for consecutive years of overharvest within the same population. New management protocols will restrict hunting opportunities if harvest limits were exceeded in the previous year, and additional restrictions if exceeded in consecutive years (Figs. 4 and 5).

*Age of the survey data.*— Management decisions are often made using aerial survey data that are several years old. A limited budget for goat management allows for only a portion of the range to be surveyed each year. High mortality and low recruitment due to severe winter conditions can reduce a population size in a local area so decisions on harvest levels need to be reduced when relying on survey data that is not current. Furthermore, the level of movement into and out of these units (Fig. 1) is unknown but does occur (Nichols 1985). Survey data that is >2 years old may not represent the current population. New management protocols will restrict hunting opportunities if the survey data is >2 years old especially when severe winters are believed to have occurred since the time of the last survey (Figs. 4 and 5).

*Access variation and success rates.*— The accessibility of goat habitat and success rates are quite variable on the Kenai Peninsula. Typically half of the permit holders hunt. Of those that hunt, success rates vary from 10-100% depending on access and other factors. Some areas are along highways that allow convenient access points or have trails that allow relatively quick access to alpine habitat. Other areas are very isolated and accessible only by airplane, boat, or very long hikes without trails. Although variable from year to year due to hunter diligence, weather, and other factors, the ease of access will greatly influence potential hunting success. New

management protocols will use the degree of accessibility to determine the number of permits to issue for both drawing and registration hunts (Figs. 5 and 6).

*Coastal vs. inland populations.*— There are major differences in the goat habitat of coastal versus inland areas (Herbert and Turnbull 1977). Goat populations that inhabit these diverse habitats have major differences in sensitivity to harvest (Hjelford 1973) and should not be managed with a homogeneous protocol. Goat population declines on the Kenai since the early 1990s have been much sharper for inland populations (48%) versus coastal areas (21%). New management protocols discussed above have a lower maximum harvest rate for inland populations and added restrictions for small or declining populations. Highly productive coastal populations may be able to sustain higher densities and harvest than inland populations but are still be vulnerable to severe winters (Smith 1984).

*Winter severity.*— Mortality rates for mountain goats are influenced by density independent events, such as severe winters (Fox 1983, Smith 1984, Smith 1988); the variability in winter conditions should be considered in management decisions. The impacts of severe winters may vary substantially depending on the population's age structure (Coulson et al. 2000). Models of survival rates in Alaska were greatly improved when an index of winter severity was incorporated into the analysis (White et al. 2008). In other words, the degree of snow deposition can help managers categorize a severe winter that could impact goat survival. Although measures of icing events, which can reduce the availability of forage, are not available, historic and current databases of winter snow depths from locations in Alaska, and specifically throughout the Kenai Mountains, are maintained by the Natural Resource

Conservation Service ([www.ambcs.org](http://www.ambcs.org)). We constructed a winter severity index by averaging the snow deposition levels at several locations in the Kenai Mountain during late winter. New management protocols will use this index to restrict hunting if recent winter conditions may have compromised goat survival.

*Registration permits.*— Registration hunts are managed conservatively because they are held after the drawing season in units that may have often already had some level of harvest; therefore, the remaining harvestable quota is often small. Also, the late season registration hunts tend to have a higher proportion of females taken than during the earlier drawing season. This may be due to early snowfall pushing nanny groups to lower elevations during the November registration season making them more available to hunters, as well as inclement November weather influencing hunters to take the first animal they see.

In season management for a limited harvest is difficult unless limits are imposed on the number of permits issued. Registration permits have recently been valid for only 7 days after the date of issuance but there were still problems with hunt management. On the Kenai, the number of registration permits issued typically was unlimited and the hunt only closed by emergency order when the maximum harvest quota was met. Closures by emergency order typically took a day or more to enact and the closure declaration did not get to permit holders that were in the field or in route to the hunting grounds. Also, there is a requirement to report the success of a hunt within 5 days of a kill. The inherent lag-time associated with a 5-day reporting period and the potential of having many hunters in the field after an emergency closure was enacted, increased the chance for overharvest, especially when available harvest quotas were low. There



were many examples of registration hunts where the maximum allowable harvest was 2 goats and over 100 permits were issued. New management protocols set clear criteria to be met before an area will open for a registration hunt, and, if met, the number of permits will be limited (Fig. 5).

*Reducing female harvest.*— Along with giving a harvested female added weight when calculating harvest quotas and the possibility of initiating a female quota outlined above, actually reducing the female portion of the harvest is a more proactive goal. Even a harvest of 1-2% of reproductive aged females in a population can have negative impacts (Hamel et al. 2006). Mountain goats are the only ungulate in Alaska to have no gender specific restrictions to harvests. Educational efforts to show hunters how to distinguish the gender of a goat and elucidation on why harvest efforts should focus on males have been available to Kenai goat hunters for decades. These efforts have resulted in no detectable decrease in the female proportion of the harvest for nearly 3 decades; the yearly female proportion of the harvest has ranged between 20-48% since 1980, averaging 34%.

We have a proposal that, along with continued and amplified educational efforts, might decrease the female harvest. Unlike many other states or provinces, goat hunting on the Kenai Peninsula is not a once in a lifetime opportunity. Over 97% of the hunters each year are Alaskan residents. Many Alaskan residents apply every year to win a drawing permit; the odds of winning depend on the area, the number of available permits, and the number of applicants but ranges between 2-25%. Furthermore, many hunters acquire a late-season registration permit in successive years. In other words, there typically is an opportunity for an individual to hunt mountain goats every year. Our proposal would encourage

hunters to be more selective. Taking a female would remain legal, but the hunter would not be eligible to hunt mountain goats on the Kenai for 3-5 years. The hunter who took a female goat on the Kenai could hunt all other species and still hunt mountain goats outside of the Kenai Peninsula. We believe that this stipulation may cajole hunters to truly make an effort to educate themselves on how to distinguish the sexes and target only males. Hunters would be engaged in the sound management of their goat populations. If successful, reducing the female proportion of the harvest would increase hunting opportunities and could also promote population growth (Hamel et al. 2006).

*Problems with timely decisions.*— There are other time-related issues that present challenges to goat management on the Kenai Peninsula. Decisions for how many drawing permits to issue must be made in the fall for hunts that will occur the following year. Therefore, a severe winter could cause unusually high mortality after decisions of drawing permit allocations have already been made. This is yet another reason for conservative permit allocations. However, restrictions to registration hunts can be imposed in-season if the previous winter conditions call for conservative management.

A lack of timely hunt reporting also poses a management challenge. Specifically, decisions for late-season registration hunts (November 1-30) are made based on the success of the earlier drawing season (August 10 – October 15). However, many hunters fail to report their drawing hunts according to the required time limits; 10 days after a successful hunt or, if unsuccessful, by October 25. Typically, decisions for what areas to open for a registration hunt are made with only 60% of the reports submitted from the drawing hunts. A lack of timely reporting

demonstrates additional need for conservative management of registration hunts.

*Other factors.*— There are many other factors that may influence goat populations on the Kenai Peninsula besides hunting. There has been growth in commercial heliski operations in large portions of the Kenai Mountains. These commercial operations are governed by the U.S. Forest Service on land within the Chugach National Forest. Many recommendations to mitigate impacts of helicopters on goats were presented to the U.S. Forest Service by local wildlife managers. Concerns outlined were in response to known disturbance of goats by helicopters (Côté 1996, but see Goldstein et al. 2005) and recommendations were taken directly from those provided by the Northern Wild Sheep and Goat Council ([www.nwsgc.org/StatementMountainGoats.pdf](http://www.nwsgc.org/StatementMountainGoats.pdf)). Many of these recommendations aimed to reduce or limit negative impacts of heliski operations on wintering goat populations that were provided by local wildlife managers were rejected by the U.S. Forest Service and not incorporated into the permit conditions for heliskiing. It is unknown what level of impact heliski activities may be having on goat populations but the affects are not likely benign.

The Kenai Peninsula has shown significant effects of climate change through increasing elevation of treeline, wetland drying, and glacier retreat (Klein et al. 2005, VanLooy et al. 2006, Dial et al. 2007). Climate change may impact mountain ungulates by decreasing the time of forage availability (Pettorelli et al. 2007) and increasing the prevalence of disease (Jenkins et al. 2006, Mainguy et al. 2007). Despite the array of diseases endemic to some goat populations (Toweill et al. 2004), there has not been much disease monitoring on the Kenai Peninsula. We do not know how all

the impacts of climate change might influence goat populations. However, an adaptive management plan, continued long-term monitoring, and future research must consider these potential landscape level changes.

In summary, the management issues outlined in this paper and the new protocols for issuing hunting permits (Figs. 4 and 5) will provide general guidelines to wildlife managers. There are often interactions among factors and unknown factors that make goat management challenging. If an area has multiple concerns, such as a high female harvest and a declining population, additional measures to monitor populations and restrict harvests will be taken. All the management issues outlined above will be assessed in each area (Fig. 1) individually, and management actions will be area specific.

### **Management Implications**

The population dynamics and limiting factors for mountain goats varies across their broad range. Therefore, goat management must be herd specific (Gonzalez Voyer et al. 2003). The Kenai Peninsula certainly has unique characteristics that elicit conservative management protocols, most notably, the significant decline in goat numbers in the last 15 years. In response to this decline, the management protocols have changed to ensure hunting opportunities are sustainable. Managers need to respond to both long-term and short-term management issues (Smith 1984). Specifically, along with responding to long-term declines, managers need to close or limit hunting following years when an excessive number of females are harvested (Côté and Festa-Bianchet 2003). In this respect, hunters can help goat management and increase hunting opportunities by targeting males only. The management protocols outlined in this paper

will be reviewed incrementally to assess success and allow for adaptive management changes based on the response of the goat populations. The management of Kenai goats could improve with increased budgets to survey populations more frequently and to conduct research to determine Kenai specific vital rates and limiting factors.

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Figure 1. Kenai Peninsula in south-central, Alaska, USA, showing 31 individual management units. Kenai Fjords National Park, where no hunting is allowed is hatched.

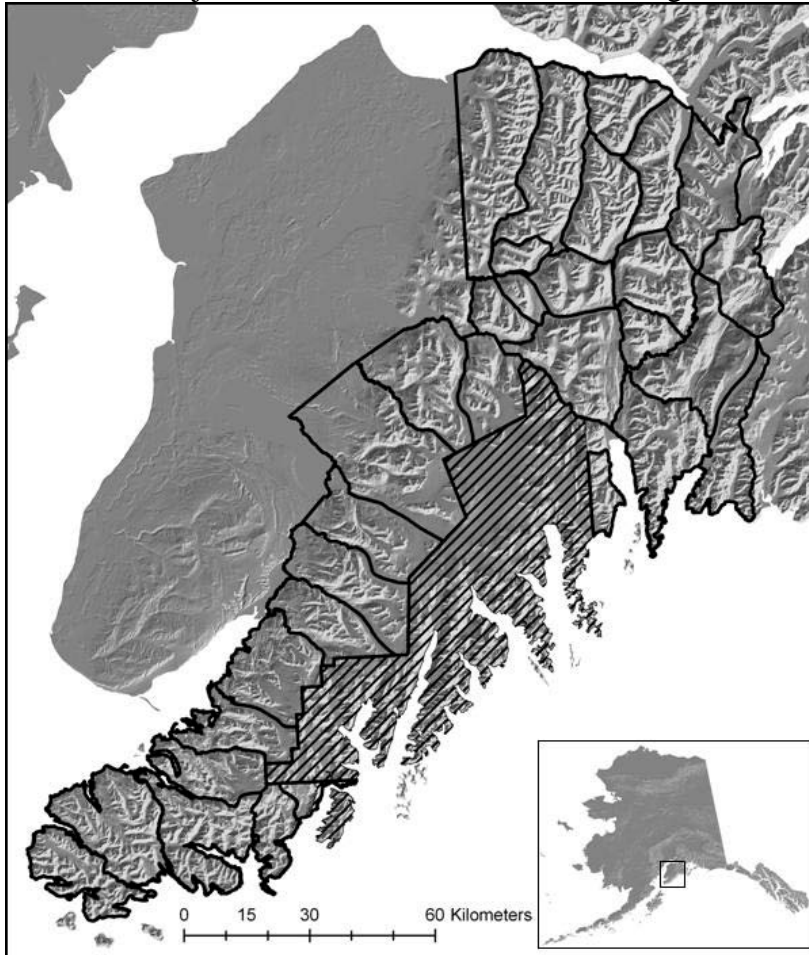


Figure 2. Mountain goat survey and harvest data from the Kenai Peninsula, Alaska, USA, 1968-2007. The yearly total of goats counted combines the most recent counts in 31 areas. Harvests occurred under varying management schemes.

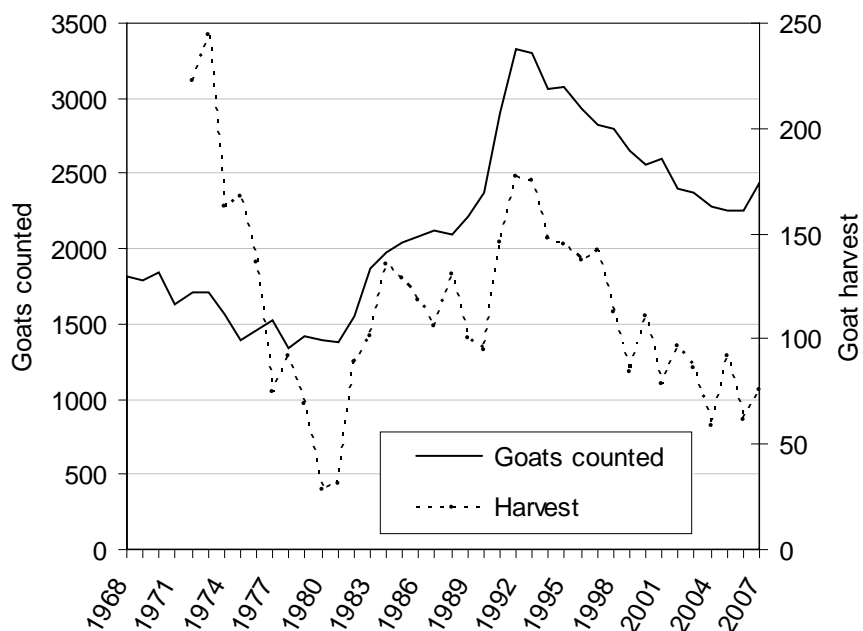


Figure 3. Regression of survey data showing decline in the ratio of kids: older-goats from the Kenai Peninsula, Alaska, USA, 1968-2007. Survey data is from 15 individual core areas. Surveys were conducted in each area once every 3-4 years.

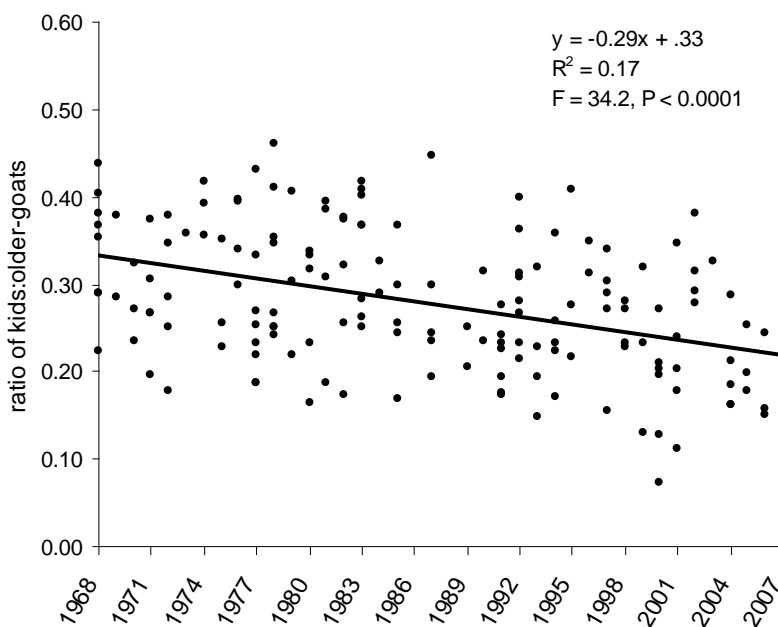




Figure 4. Flow chart for providing general guidelines for determining the number of drawing permits to issue for individual mountain goat hunts on the Kenai Peninsula, Alaska, USA. (Typically, less than half of the permit holders hunt).

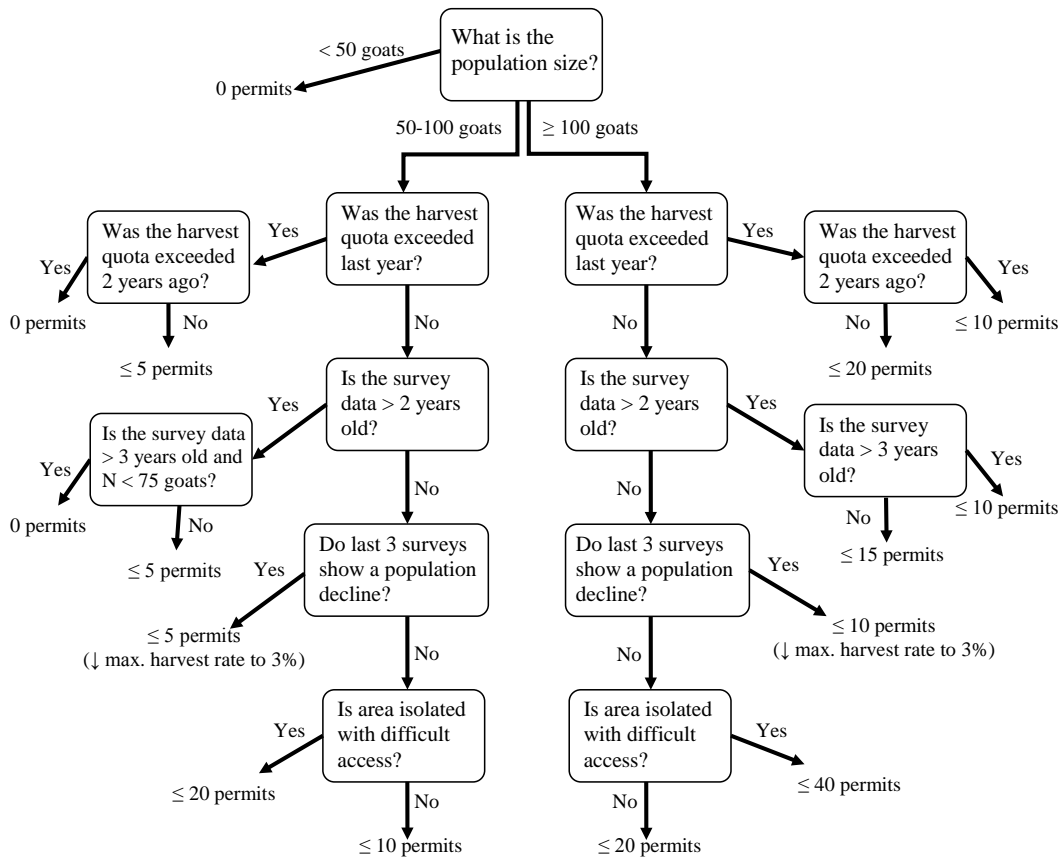


Figure 5. Flow chart of criteria that must be met for an area to open for a late-season registration hunt for mountain goats on the Kenai Peninsula, Alaska, USA. The survey count multiplied by a 4-5% harvest rate provides the harvest quota. A harvested male counts as one goat unit, a female is 2 units.

