Effects of Kensington Mine Development on Black Bears and Mountain Goats.

# Wildlife Baseline Studies and Monitoring Plan 1994 Progress Report

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Douglas, Alaska
December 1994

**Preface**

Proposals have been put forth to reopen the Kensington Venture (K-V) mine. This mine is situated in an area which supports populations of several economically and aesthetically important vertebrate species including mountain goats (*Oreamnos americanus*) and black bears (*Ursus americanus*). Proposals for the mine include water diversions of several creeks, damming of Sherman Creek in order to construct a 225 acre tailings disposal impoundment, and development of extensive above-ground support facilities such as an employee camp, roads, several heliports, marine terminal, fuel storage (aviation fuel, diesel fuel, and liquified petroleum gas) and power generating stations. This development would introduce heavy metals and other pollutants into the environment, alter or eliminate wildlife habitat and increase the overall human presence, amount of noise, and vehicular traffic in the area.

There is unavoidable mobilization of heavy metals from most ore extraction processes, including silver, cadmium, copper, lead, zinc, selenium, and mercury. These metals do cause biological effects when present in sufficient concentrations or form. Mercury, for example, is an important toxic heavy metal that is neurotoxic to all organisms, persistent in the environment, and bioaccumulative (Peterle 1991). Despite this, the levels of heavy metals in the area have not been determined, nor have the levels tolerable to most species of wildlife present in the area been determined.

The proposed tailings disposal impoundment and mine facilities sites will eliminate a portion of the total available habitat to K-V wildlife. Since black bears have been shown to avoid areas of intense human activity (Manville 1983), construction activities and increased human presence and noise associated with the mine and its development would likely decrease bear use of habitat above the Sherman Creek impoundment area and the mining compound. Wildlife currently utilizing or residing within the Sherman Creek impoundment site or other areas that will be developed would be displaced. Mortality induced by instraspecific competition for limited resources as these animals are forced to develop new territories is possible.

Mountain goat numbers are currently stable in the Kensington Venture area. Since mountain goats have been shown to be adversely affected by resource development such as logging, mining, road construction, and vehicle traffic (Brandborg 1955; Chadwick 1973; Rideout 1974; Singer 1975; Van Tighen and Holroyd 1983) considerable concern exists regarding potential impacts the development and operation of the mine may have on goats within the area. Additional studies indicate that mountain goats do not habituate to human activity and that disturbance factors appear to be additive (Foster and Rahs 1983). Joslin (1986) found that while goats did not abandon home ranges entirely, they did redistribute themselves in response to seismic energy exploration activities and helicopter use. However, Joslin (1986) also reported the findings of other investigators who did note abandonment of an area in response to blasting.

Since the mine exploration, development and operation procedures require extensive use of helicopters and explosives, some effect upon goats in the area is inevitable. Joslin (1986) correlated declines in female adults and kids to peaks in seismic exploration. Since the ability to reproduce successfully is perhaps the most important aspect of a populations ability to sustain itself, it follows that potential impacts of the Kensington Venture exploration and operation upon goat rearing habitat must be determined.

Although the hunting and trapping potential of K-V site has not been reached as access is difficult, requiring a boat, helicopter, or plane, the area is utilized by big game hunters. Since 1992 a total of

7 black bears, 5.5% of total black bear take in Game Management Unit (GMU) 1C, have been taken in the K-V area. Two goats have been taken in 12 hunts within the K-V area since 1990. As access to the area improves and/or the population base in the Juneau and surrounding area increases, the relative importance of the area to sportsmen and wildlife viewers will expand. Thus, the K-V site may be seen as both an important source of game meat and revenue, especially with regard to the future.

The importance of goats and other wildlife to the non-hunting public is evident. Goat viewing opportunities are promoted at both the Misty Fjords and Glacier Bay National Monuments (Fox et al. 1989). A goat re-introduction effort of Mt. Juneau was financially supported by funds raised by Juneau residents interested in hastening the recovery of area goat populations and increasing the opportunity of viewing wild goats. Moreover, Sheep Creek Valley near Juneau was recently closed to trapping in order to enhance wildlife viewing opportunities. Whereas the K-V site affords less readily available viewing opportunity, the potential opportunities it offers are equally important.

Displaced bears may also seek alternative sources of food present in the mining compound, creating nuisance problems. Juneau residents and animal rights activists from outside the state have expressed displeasure with the killings of "garbage-bears". In Juneau, cooperative education and enforcement programs financed by the State and City and Borough of Juneau has helped to decrease bear losses in recent years. Since displaced bears may enter the mining complex in search of food, and brown bears (Ursus arctos) are present in the area, potential conflicts between bears and humans exists. Implementation of a program similar to Juneau's or Greens Creek Mine (when it was active) is likely to be necessary at the K-V site. Thus, study of the area and the populations of animals within the area is required.

## Introduction

Commercial development of any site utilized by wildlife implies that an alteration of habitat will also occur. Similarly, an increase in human traffic or use of an area implies that the habits of wildlife present in the area must also change. Whereas a change in the use, or habitat, of an area does not necessarily translate to a decrease in the health of the wildlife populations present, the extent of any development projects potential effect on wildlife must be identified if one goal of the project is wildlife conservation.

Recognizing this Kensington Venture, and the Alaska Dept. of Fish and Game initiated studies in late 1990 to determine potential impacts to terrestrial wildlife from mineral development at the Kensington mine site near Juneau, Alaska. This study site is centered in the Berner's River Valley.

Study objectives included: 1) the acquisition of baseline data regarding the habitat use of, and movement patterns of, black bears (*Ursus americanus*) and mountain goats (*Oreamnos americanus*) which use the Kensington site; 2) the amount of heavy metals in the habitat to which the animals are exposed to and routinely ingest; 3) the presence of micropathogens in bear and goat populations; 4) the overall health of bear and goat populations. This report covers the third and fourth year of work, and includes preliminary analyses of data which have been obtained to date. Further analyses, including those of habitat type, slope, and aspect, will be reported later. These analyses must await the generation of such data by the USFS.

## Methods

Black bear and mountain goat were captured in areas adjacent to current or proposed mine development at the Kensington mine site. All goats were captured and marked using standard helicopter immobilization procedures (Spraker et al. 1981; Ballard et al. 1982; Reynolds and Hechtel 1985; Miller et al. 1987). Bears were captured using ground snares and barrel traps.

All bears were immobilized with with Telazol (tiletamine hydrochloride and zolazepam; Zoletil 100, Wildlife Laboratories, Fort Collins, Colorado) administered at a dosage of with 5.5 mg/kg of body weight either by dart projectiles fired from a Cap-Chur gun (Palmer Chemical Equipment Co., Douglasville Georgia) or jab stick. Ophthalmic ointment (Schein Pharmaceutical Inc.) was applied to the eyes of captured bears to prevent them from drying out during immobilization. Goats were immobilized with Wildnil (carfentanil citrate, Wildlife Pharmaceuticals Inc., Fort Collins, CO) and aroused with the antagonist Naltrexonil (naltrexone hydrochloride, Wildlife Pharmaceuticals inc., Fort Collins, CO). Wounds associated with capture and tagging were treated with Panalog (Solvay Animal Health Inc.), a topical antibiotic. Captured animals were treated with injectable (Penicillin G Benzathine and Penicillin G Procaine; GC Hanford Manufacturing Co.) when deemed necessary to reduce the risk of infection associated with capture and handling.

After capture and immobilization, demographic information on the animal (age, sex, weight) was gathered and the animal was collared, tagged, and (in the case of bears) tattooed to enable later relocation and identification. Captured bears and goats were fitted with Model 600 and 500 (Telonics, Mesa, Arizona) collars containing radio transmitters. Collars fitted to bears were modified with expandable tubing which allowed for seasonal weight and growth fluctuation. All animals were tagged in each ear with colored ear tags (Duflex or Roto; Nasco Farm and Ranch, Modesto, CA). The position of the Duflex tag indicated sex, with males receiving one in the right ear. Small Roto tags were attached to the ear opposite the one with the large Duflex tags.

To establish baseline information regarding the presence of heavy metals and microbial pathogens at the Kensington study site, hair and blood samples were obtained from all captured bears. Blood samples were obtained from all captured goats. Liver and kidney samples were also obtained from 10 marten (*Martes americana*) from Northeast Chichagof Island for comparison. Lesion samples from goats were analyzed with Electro-Microscopy for the presence of the viral disease Contagious Ecthyma (CE).

Telemetry flights were conducted when weather permitted (usually twice monthly) using fixed-wing PA-18 Super Cub and Helio Courier aircraft. Data collected included the location and elevation of radio-collared animals. Estimated locations of animals were plotted in flight on photocopies of 1:63 000 scale topographic maps of the study area. Latitude and longitude coordinates were obtained using the BASIC program DIGILABL (Venable et al. 1992) and a CalComp model 23360 digitizer (CalComp 320 Bellevue, Washington). These locations were converted to Universal Transverse Mercator (UTM) coordinates with the BASIC program LLTOUTM (Delong 1992).

Habitat data for relocation coordinates was generated using Arc View/Info Version 2.0 (Environmental Systems Research Institute, Include, Redlands, CA) running on a Data General MV20 operated by the USFS. Relocation sites were entered into the Arc View/Info program and judged to be correct when their position matched the original position as determined by proximity to topographical contours and stream channels. These relocation points were compared to USFS georeference survey positions and information regarding aspect, cover type, elevation, forest productivity, forest type, non-forest conditions, slope, plant associations (primary, secondary and tertiary), timber size class, and timber volume class was obtained.

Arcinfo was also used to obtain aspect, cover type, forest productivity, forest type, non-forest conditions, slope, plant associations (primary, secondary and tertiary), timber size class, and timber volume class data for *bear* and *goat* areas within the Kensington site. These areas were defined by a box drawn just outside of most bear and goat relocation sites (see Appendix I). Three relocation sites of Bear 113 (those nearest to Berners and Lace Rivers) and goat 120b (those farthest removed from Pt. Sherman) respectively were considered outliers and not included.

The computer program Ranges IV (Kenward 1990) was used to estimate mononuclear convex polygon home ranges for all bears and goats with at least 10 relocations. Home range sizes were generated for 90%, 95%, and all the relocations for each animal. Harmonic mean distances were used to exclude locations not included in 90 and 95% home range estimates. Diagrams of home ranges of animals are presented in Appendix I. The statistical package SPSS (Ver. 4, SPSS Inc., Chicago, Illinois) was used to examine relationships between and among sex, season, elevation, weight and age for each species of animal.

Specifically, SPSS was used to perform Chi-Square tests ($\chi^2$), and the non-paramentric Mann-Whitney (MW) and Kruskal-Wallis (KW) tests. Chi-Square tests of independence (single tests and crosstables) were used to address all questions of distributional independence. Mann-Whitney and Kruskal-Wallis tests were used to test whether the mean elevation was different among habitat and animal categories. Mann-Whitney tests were used when two categories were being compared whereas Kruskal-Wallis tests were used when more than one category was present.

To conduct tests among seasons, locations by months were partitioned into seasons for both bears and goats. When possible, seasons consisted of winter (November through March), spring (April through May), summer (June through August) and fall (September through October). However, it was necessary to reduce the year to three seasons consisting of winter (October through March), spring (April through May) and summer (June through September) for goats and some additional tests, particularly crosstables involving habitat characteristics.

To conduct tests among weights and ages, bears and goats were placed into weight and age categories. Bears and goats were placed into one of three weight categories consisting of low to 50 kg, 50 to 80 kg, and over 80 kg and low to 100 kg, 100 to 130 kg, and over 130 kg respectively. Bears and goats were divided into four age categories (ages 1 to 3, 3 to 6, 6 to 9, and over 9 yrs.). These age classes were designed so that few animals 'aged out' of the age class they were in at capture. However, since some animals did 'age out' of their original age class, two separate sets of age tests were conducted. Age at capture was used in the first analysis with the assumption that an animal did not change its behavior over the course of its study life. In the second analysis, 1.0 years was added to the age of each individual animal, resulting in an increase of original age class at capture of several animals. This effectively placed animals in the age categories they occupied for the majority of the study.

All statistical tests involving elevation and sex, elevation and ages, and elevation and seasons performed on our relocation data set was also performed on the ArcInfo relocation data set. To further analyze the ArcInfo data set, the independence of relocation distribution to given habitat types (non-forested and forested), slope and aspect was examined. Additionally, relationships between elevation and slope, habitat condition (forested and non-forested habitats), and aspect were examined to ensure objectivity regarding habitat conditions present. Finally, the distribution of habitat (cover type, non-forest conditions, size class, volume class, aspect, and slope) conditions and plant associations as represented by relocation sites were compared to those of *bear* or *goat area* habitats to determine if bears and goats are selecting for or against any one particular habitat condition or plant association. Although glacial habitat is not a plant association, it was categorized as a plant association in the georeference data and was therefore included in our Chi-Square tests of plant association distributions.

**Results**

At the time of this report, a total of 16 bears and 12 goats have been captured and radio-collared. Three new bears were captured and radio-collared in 1994. Three bears and one goat have died as a result of natural or human related causes so far. Additionally, the status of one goat (number 125) is unknown, due to what is believed is a collar malfunction. Thus, 13 bears and 10 goats remain relocatable at this time. This is well above the targeted number of 6 bears and 8 goats.

*Heavy Metals*

Veterinary toxicology analysis of the average content of selected metals in liver, kidney, hair, serum-EDTA, and blood samples appears to vary widely among tissues, animal species, and individuals (Tables 1, 2 and 3). For example, cadmium levels in the hairs of individual Kensington study bears ranged from below the detectable limit (0.03 µg/g) to 2.00 µg/g. Cadmium levels in Chichigof Island marten livers

(0.09 μg/g) and kidneys (0.45 μg/g) were significantly different (MW test, 2-tailed $P=0.0056$).

**Table 1.** Veterinary toxicology analysis of heavy metal content in the livers and kidneys of Chichigof Island martens. Means are given for both livers and kidneys. EDL is the estimated detection limit. BDL indicates that the metal was below detection limit, whereas '---' indicates that the test was not performed.

| Element<br>Units<br>EDL | Tissue | Mo<br>µg/g<br>0.07 | Zn<br>µg/g<br>0.06 | Cd<br>µg/g<br>0.03 | Pb<br>µg/g<br>0.27 | Mn<br>µg/g<br>0.02 | Fe<br>µg/g<br>0.03 | Cu<br>µg/g<br>0.01 | Hg<br>µg/kg<br>0.99 | Se<br>µg/g<br>0.002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Animal | | | | | | | | | | |
| Chi. I. Marten 493 | Liver | BDL | 30.00 | 0.07 | BDL | 4.00 | 320.00 | 4.00 | 110.00 | 0.87 |
| | Kidney | BDL | 32.00 | 0.33 | BDL | 2.60 | 210.00 | 3.90 | 260.00 | --- |
| Chi. I. Marten 500 | Liver | BDL | 41.00 | 0.09 | BDL | 2.40 | 280.00 | 3.60 | 410.00 | 0.60 |
| | Kidney | BDL | 52.00 | 0.60 | BDL | 0.89 | 180.00 | 2.50 | 660.00 | --- |
| Chi. I. Marten 501 | Liver | 0.08 | 61.00 | 0.13 | BDL | 12.00 | 320.00 | 7.30 | 730.00 | 0.98 |
| | Kidney | BDL | 49.00 | 0.47 | BDL | 1.70 | 200.00 | 5.20 | 1400.00 | --- |
| Chi. I. Marten 502 | Liver | BDL | 35.00 | 0.04 | 0.44 | 1.60 | 350.00 | 3.10 | 420.00 | 0.61 |
| | Kidney | BDL | 41.00 | 0.22 | 0.32 | 1.30 | 360.00 | 4.90 | 1300.00 | --- |
| Chi. I. Marten 503 | Liver | BDL | 47.00 | 0.08 | BDL | 4.80 | 370.00 | 6.40 | 640.00 | 0.80 |
| | Kidney | BDL | 47.00 | 0.32 | BDL | 1.10 | 200.00 | 3.00 | 1500.00 | --- |
| Chi. I. Marten 504 | Liver | 0.44 | 79.00 | 0.06 | BDL | 7.80 | 93.00 | 9.10 | 1400.00 | 0.98 |
| | Kidney | 0.14 | 42.00 | 0.19 | BDL | 1.10 | 74.00 | 3.80 | 1500.00 | --- |
| Chi. I. Marten 507 | Liver | BDL | 36.00 | 0.24 | BDL | 5.20 | 340.00 | 5.60 | 140.00 | 0.57 |
| | Kidney | BDL | 54.00 | 1.40 | BDL | 1.40 | 230.00 | 3.80 | 380.00 | --- |
| Chi. I. Marten 509 | Liver | 0.39 | 62.00 | 0.11 | BDL | 5.50 | 220.00 | 5.30 | 510.00 | 0.71 |
| | Kidney | BDL | 57.00 | 0.47 | BDL | 1.90 | 300.00 | 4.50 | 930.00 | --- |
| Chi. I. Marten 511 | Liver | BDL | 69.00 | 0.05 | 0.32 | 3.50 | 250.00 | 2.60 | 280.00 | 0.54 |
| | Kidney | 0.08 | 51.00 | 0.18 | BDL | 1.20 | 140.00 | 3.70 | 600.00 | --- |
| Chi. I. Marten 512 | Liver | 0.32 | 53.00 | 0.05 | 1.10 | 3.20 | 110.00 | 5.40 | 270.00 | 0.64 |
| | Kidney | 0.08 | 36.00 | 0.35 | 2.30 | 1.00 | 110.00 | 4.40 | 600.00 | --- |
| Liver Mean | | 0.31 | 51.30 | 0.09 | 0.62 | 5.00 | 265.30 | 5.24 | 491.00 | 0.73 |
| Kidney Mean | | 0.10 | 46.10 | 0.45 | 1.31 | 1.42 | 200.40 | 3.97 | 913.00 | --- |
| Marten Mean | | 0.22 | 48.70 | 0.27 | 0.90 | 3.21 | 232.85 | 4.61 | 702.00 | 0.73 |

**Table 2.** Veterinary toxicology analysis of heavy metal content in the hair of individual Kensington study bears. The mean level of each heavy metal is also given. EDL is the estimated detection limit. BDL indicates that the metal was below detection limit, whereas QNS indicates at insufficient sample was present to conduct the test.

| Element | | Mo | Zn | Cd | Pb | Mn | Fe | Cu | Hg | Se | Al | Cr | Ni | Co | Va |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units | | µg/g | µg/g | µg/g | µg/g | µg/g | µg/g | µg/g | µg/kg | µg/g | µg/g | µg/g | µg/g | µg/g | µg/g |
| EDL | Tissue | 0.07 | 0.06 | 0.03 | 0.27 | 0.02 | 0.03 | 0.01 | 0.99 | 0.002 | 0.50 | 0.33 | 0.15 | 0.22 | 0.07 |
| K Bear 101a | Hair | BDL | 1600.00 | 1.10 | 1.50 | 45.00 | 2700.00 | 31.00 | 240.00 | 0.270 | 980.00 | BDL | 2.10 | 1.20 | 7.20 |
| K Bear 101b | Hair | 0.76 | 160.0 | 2.00 | 5.10 | 28.00 | 130.00 | 9.90 | 150.00 | 0.510 | 100.00 | BDL | 0.52 | BDL | 1.80 |
| K Bear 102 | Hair | 1.10 | 190.0 | 0.75 | 3.30 | 7.80 | 140.0 | 9.50 | 350.00 | 0.460 | 78.00 | BDL | 0.37 | BDL | 1.50 |
| K Bear 113 | Hair | 6.10 | 3700.00 | 0.46 | 4.40 | 110.00 | 3500.00 | 18.00 | 150.00 | 0.002 | 760.00 | BDL | 1.70 | 18.00 | 5.40 |
| K Bear 1114 | Hair | 0.84 | 150.00 | BDL | BDL | 3.60 | 51.00 | 9.60 | QNS | QNS | 36.00 | BDL | BDL | BDL | 1.60 |
| K Bear 115 | Hair | BDL | 150.00 | BDL | 1.10 | 29.0 | 56.00 | 8.30 | 870.00 | 0.490 | 32.00 | BDL | BDL | BDL | 1.60 |
| K Bear 116 | Hair | BDL | 1700.00 | 0.66 | BDL | 75.00 | 650.00 | 10.00 | 210.00 | 0.110 | 190.00 | BDL | 9.30 | 0.39 | 2.30 |
| K Bear 117 | Hair | BDL | 270.00 | BDL | BDL | 110.00 | 100.00 | 8.80 | QNS | QNS | 55.00 | BDL | 0.43 | BDL | 1.70 |
| K Bear 118 | Hair | BDL | 460.00 | 0.19 | 2.30 | 15.00 | 360.00 | 8.60 | QNS | QNS | 170.00 | BDL | BDL | BDL | 2.20 |
| K Bear 119 | Hair | BDL | 1800.00 | 1.10 | 2.80 | 69.00 | 1500.00 | 12.00 | 240.00 | 0.230 | 790.00 | BDL | 1.30 | 0.96 | 4.50 |
| K Bear 139 | Hair | 0.94 | 1600.00 | 0.41 | 6.40 | 50.00 | 2200.00 | 15.00 | 160.00 | 0.190 | 960.00 | BDL | 3.70 | 1.50 | 5.70 |
| K Mean | Hair | 1.90 | 1070.91 | 0.83 | 3.36 | 49.31 | 1035.18 | 12.79 | 296.25 | 0.282 | 377.36 | BDL | 2.43 | 4.41 | 3.23 |

**Table 3.** Veterinary toxicology analysis of heavy metal content in bear blood serum and blood. Serum-EDTA is serum in which EDTA, an enzyme inhibitor and blood decoagulant, was added. Means are given for both Serum-EDTA and blood samples. EDL is the estimated detection limit. BDL indicates that the metal was below detection limit, whereas the presence of '---' indicates the test was not performed.

| Element<br>Units<br>EDL | Tissue | Zn<br>µg/g<br>0.06 | P<br>µg/g<br>3.44 | Fe<br>µg/g<br>0.03 | Mg<br>µg/g<br>0.06 | Cu<br>µg/g<br>0.01 | Ca<br>µg/g<br>0.17 | Se<br>µg/g<br>0.002 | Pb<br>µg/g<br>0.27 | Hg<br>µg/kg<br>0.99 | Cd<br>µg/g<br>0.03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K Bear 112 | Blood | | | | | | | | 0.02 | 33.00 | BDL |
| K Bear 113 | Blood | | | | | | | | 0.03 | 32.00 | BDL |
| K Bear 118 | Blood | | | | | | | | 0.01 | 32.00 | BDL |
| K Mean | Blood | | | | | | | | 0.02 | 32.33 | BDL |
| K Bear 101b | Serum-EDTA | 3.40 | 91.00 | 5.10 | 25.00 | 0.24 | 69.00 | 0.15 | | | |
| K Bear 114 | Serum-EDTA | 2.10 | 54.00 | 2.40 | 19.00 | 0.42 | 59.00 | 0.13 | | | |
| K Bear 115 | Serum-EDTA | 3.80 | 51.00 | 1.40 | 18.00 | 0.46 | 73.00 | 0.11 | | | |
| K Bear 116 | Serum-EDTA | 3.20 | 79.00 | 1.60 | 19.00 | 0.15 | 85.00 | 0.09 | | | |
| K Bear 117 | Serum-EDTA | 2.80 | 82.00 | 1.60 | 20.00 | 0.19 | 84.00 | 0.06 | | | |
| K Bear 118 | Serum-EDTA | 6.40 | 67.00 | 4.70 | 23.00 | 0.17 | 67.00 | 0.15 | | | |
| K Bear 119 | Serum-EDTA | 4.30 | 100.00 | 5.90 | 19.00 | 0.24 | 74.00 | 0.09 | | | |
| K Mean | Serum-EDTA | 3.71 | 74.86 | 3.24 | 20.43 | 0.27 | 73.00 | 0.11 | | | |

*Home Ranges*

A total of 9 bears (Table 4) and 11 goats (Table 5) from the Kensington site were analyzed for home range sizes. When all locations are considered, the home range size averaged 6502.22 ha (ranging from 591.78 to 28,624.74 ha) for bears and 6181.74 ha (ranging from 1396.03 to 23022.97 ha) for goats. As expected, 90 and 95% home ranges were smaller. This was especially true for those individuals with fewer locations.

**Table 4**. Number of locations, home range size, and demographic information for individual bears at the Kensington study site. Calculated means and standard deviations (SD) include only those animals for which home ranges were calculated, and are given for males, females and all animals respectively. The presence of '---' indicates that home ranges were not calculated due to insufficient relocation information.

| Animal ID | Capture Date | Num. of Relocations | 100% Home Range (ha) | 95% Home Range (Ha) | 90% Home Range (Ha) | [1]Age (yr.) | [2]Weight (kg) | Status |
|---|---|---|---|---|---|---|---|---|
| Males | | | | | | | | |
| K 102 | 09-30-90 | 11 | 9108.17 | 6713.30 | 6713.30 | 4.8 | 102.27 | Mort. |
| K 111 | 06-20-92 | 1 | --- | --- | --- | 1.0 | 13.64 | Active |
| K 113 | 06-14-92 | 17 | 28624.74 | 19714.40 | 9555.60 | *6.5 | 84.09 | Active |
| K 139 | 09-19-91 | | | | | 1.0 | 35.23 | |
| | 11-19-92 | 10 | 4482.80 | 4482.80 | 545.50 | | *75.00 | Active |
| K Male Mean | | 12.67 | 14071.90 | 10303.50 | 5604.80 | 4.10 | 80.49 | |
| SD | | | 12813.56 | 8226.03 | 4606.20 | 2.81 | 23.78 | |
| Females | | | | | | | | |
| K 101a | 09-30-90 | 3 | --- | --- | --- | *10.0 | 72.73 | Mort. |
| K 101b | 08-08-91 | 7 | --- | --- | --- | *10.0 | *109.09 | Mort. |
| K 105 | 07-12-94 | 2 | --- | --- | --- | 7.0 | 38.64 | Active |
| K 109 | 07-17-94 | 1 | --- | --- | --- | 6.0 | 40.91 | Active |
| K 116/ | 08-15-91 | | | | | *1.5 | 40.91 | |
| 112/ | 06-16-92 | | | | | | 29.54 | |
| 110 | 07-07-94 | 24 | 2335.71 | 2154.80 | 1817.40 | | 56.82 | Active |
| K 114 | 09-24-91 | 21 | 591.78 | 531.00 | 466.70 | 8.0 | 90.91 | Active |
| K 115 | 08-14-91 | 19 | 3834.52 | 3166.80 | 2701.20 | 3.0 | 86.36 | Active |
| K 117 | 08-11-91 | 22 | 4800.74 | 4417.00 | 2588.10 | *3.0 | 50.0 | Active |
| K 118 | 08-10-91 | 23 | 3051.42 | 2988.70 | 2604.80 | *11.0 | 75.0 | Active |
| K 119 | 08-10-91 | 23 | 1690.08 | 1588.20 | 1436.80 | *6.0 | 56.82 | Active |
| K Female Mean | | 22 | 2717.38 | 2474.42 | 1935.83 | 5.42 | 66.92 | |
| SD | | | 1511.24 | 1355.13 | 880.93 | 3.61 | 20.04 | |
| K Overall Mean | | 18.88 | 6502.22 | 5084.11 | 3158.82 | 4.97 | 71.44 | |
| SD | | | 8643.24 | 5778.26 | 3025.66 | 3.25 | 20.94 | |

[1] All ages are estimates except those superscripted with an * which are based on tooth analyses.

[2] All weights are estimates except those superscripted with an *.

**Table 5**. Number of locations, home range size, and demographic information for individual goats at the Kensington study site. Calculated means and standard deviations (SD) include only those animals for which home ranges were calculated, and are given for males, females and all animals respectively. The presence of '---' indicates that home ranges were not calculated due to insufficient relocation information.

| Animal ID | Capture Date | Num. of Relocations | 100% Home range (ha) | 95% Home Range (ha) | 90% Home Range (ha) | Age (yr.) | [3]Weight (kg) | Status |
|---|---|---|---|---|---|---|---|---|
| Males | | | | | | | | |
| K 120a | 10-04-90 | 30 | 3352.37 | 3313.80 | 3224.3 | 6.5 | 90.91 | Mort. |
| K 120b | 08-08-91 | 26 | 23022.97 | 21556.50 | 18485.20 | 1.5 | 79.55 | Active |
| K 121 | 10-04-90 | 34 | 21126.17 | 3547.50 | 3204.20 | 5.5 | 90.91 | Active |
| K 122a | 10-04-90 | 34 | 3792.04 | 3274.40 | 3093.60 | 1.5 | 45.45 | Active |
| K 125 | 07-24-92 | 4 | --- | --- | --- | 4.0 | 136.36 | [4]Unknown |
| K 127 | 07-24-92 | 18 | 2168.93 | 1890.50 | 1539.00 | 3.0 | 113.64 | Active |
| K 128 | 09-04-92 | 16 | 2317.34 | 1859.30 | 938.60 | 6.5 | 147.73 | Active |
| K 129 | 09-04-92 | 17 | 1525.40 | 1196.90 | 1193.30 | 2.5 | 113.64 | Active |
| K Male Mean | | 25 | 8186.46 | 5234.13 | 4525.46 | 3.86 | 97.40 | |
| SD | | | 9532.96 | 7253.29 | 6235.00 | 2.25 | 32.05 | |
| Females | | | | | | | | |
| K 122b | 08-08-91 | 27 | 3520.23 | 3376.80 | 2522.70 | 8.5 | 104.55 | Active |
| K 123 | 10-04-90 | 33 | 2443.16 | 1509.10 | 1316.80 | 6.5 | No Est. | Active |
| K 124 | 10-25-90 | 33 | 3334.54 | 2020.70 | 1625.50 | 3.5 | No Est. | Active |
| K 126 | 07-24-92 | 16 | 1396.03 | 801.80 | 570.40 | 3.0 | 97.73 | Active |
| K Female Mean | | 27.25 | 2673.49 | 1927.10 | 1508.85 | 5.38 | 101.14 | |
| SD | | | 972.78 | 1088.03 | 808.10 | 2.59 | 4.82 | |
| K Overall Mean | | 25.81 | 6181.74 | 4031.57 | 3428.51 | 4.41 | 98.23 | |
| SD | | | 7908.65 | 5891.10 | 5083.05 | 2.38 | 27.86 | |

Significant differences in home range sizes were shown among male and female Kensington bears, but not among weight or age classes of bears (Table 6). When all or 95% of the relocations were considered, home range sizes of males were significantly larger than female home range sizes. However, this relationship did not hold for home ranges based on 90% of the relocations. Male bears were not significantly heavier than female bears (MW test, 2-tailed P=0.5461) and no significant relationships were shown between weight and home range size (Table 6). Kruskal-Wallis tests of home ranges among age classes were not significant for males, females, or both sexes combined (Table 6). These relationships remained when 1.0 years was added to all individual bear ages.

[3] All weights, except for goats 166 and 160, are estimated.
[4] Radio collar malfunction between 11-15-92 and 1-13-93.

Kensington goat home range sizes (Table 5) did not show any significant relationships between weight and sex, home range size and sex, and home range size and age classes (Table 6). Goat home range sizes (Table 5) ranged from 1396.03 to 23022.97 ha when all locations were included, and from 570.40 to 18485.20 ha when 90% of the locations were included. Relationships among home range sizes and age classes remained insignificant when 1.0 years was added to all individual goat ages. All calculated inclusive home ranges for bears and goats are presented in Appendix I.

**Table 6.** Mann-Whitney (MW) and Kruskal-Wallis (KW) tests of home range sizes between males and females, and among age and weight classes. Values listed under home range sizes are 2-tailed P values for MW and $\chi^2$ significance values for KW. Ages$^+$ denote tests which involved the addition of 1.0 to individual animal ages.

| Group Tested (Test used) | Number of Samples | Inclusive Home Range | 95% Home Range | 90% Home Range |
|---|---|---|---|---|
| Kensington Bears | | | | |
| Sex (MW) | 9 | 0.0389 | 0.0201 | 0.3017 |
| Ages (KW) | 9 | 0.9828 | 0.9828 | 0.9536 |
| Ages$^+$ | | 0.6345 | 0.7424 | 0.4773 |
| Ages-Males (KW | 3 | 0.3679 | 0.3679 | 0.3679 |
| Ages$^+$ | | 0.3679 | 0.3679 | 0.3679 |
| Ages-Females (KW) | 6 | 0.2998 | 0.2998 | 0.2998 |
| Ages$^+$ | | 0.1940 | 0.1940 | 0.2322 |
| Weight (KW) | 9 | 0.4938 | 0.2314 | 0.3329 |
| Weight-Males (KW) | 3 | 0.2207 | 0.2207 | 0.2207 |
| Weight-Females (KW) | 6 | 0.6514 | 0.6514 | 1.0000 |
| Kensington Goats | | | | |
| Sex (MW) | 11 | 0.4497 | 0.3447 | 0.2568 |
| Ages (MW) | 11 | 0.4281 | 0.4281 | 0.6371 |
| Ages$^+$ | | 0.8625 | 0.7694 | 0.9798 |
| Ages-Males (KW) | 7 | 0.6011 | 0.6011 | 0.8515 |
| Ages$^+$ | | 0.0898 | 0.7237 | 1.0000 |
| Ages-Females (KW) | 4 | 0.4386 | 0.4386 | 0.4386 |
| Ages$^+$ | | 0.3916 | 0.3916 | 0.3916 |
| Weight (KW) | 9 | 0.4697 | 0.5662 | 0.2780 |
| Weight-Males (KW) | 7 | 0.0898 | 0.1054 | 0.0898 |
| Weight-Females (KW) | 2 | 0.3173 | 0.3173 | 0.3173 |

Significant differences in elevation were shown among male and female bears at the Kensington site. The overall elevation at which bears were observed (Table 7) was significantly different between males and females (MW test, 2-tailed P=0.0242). Male bears were observed at notably lower and higher elevations during the spring and summer respectively (Table 7).

Significant differences in elevational use were also shown among age classes of bears (KW test, $\chi^2$=22.93, significance=0.0000). Additionally, elevational use by different age classes of male and female bears were significantly different (KW test $\chi^2$=7.69, significance=0.0213; KW test $\chi^2$=27.42, significance=0.0000). Younger bears were present at lower elevations during all seasons except winter (Table 7). Whereas seasonal elevational use when all or only female bears were included was not significantly different (KW test, $\chi^2$=1.41, significance=0.7021; KW test, $\chi^2$=3.40, significance=0.3340 respectively) it was when only males were considered (KW test, $\chi^2$=10.12, significance=0.0184).

Significant differences in seasonal elevational use (Table 8) by goats were shown at the Kensington site (Table 9). This relationship was true for male (KW test, $\chi^2$=65.08, significance=0.0000) and female (KW test, $\chi^2$=39.30, significance=0.0000) goats as well as for all (see table 9) goats. Seasonal elevational use was not significantly different among age classes when all (KW test, $\chi^2$=0.9511, significance=0.6216), only male (KW test, $\chi^2$=0.9277, significance=0.6289) or only female goats (KW test, $\chi^2$=0.1103, significance=0.7398) were considered. Elevational use was significantly different between males and females (MW test, 2-tailed P=0.0030), with male goats being present at higher elevations during all seasons except spring (Table 8).

**Table 7**. Mean (and standard deviation) elevation in meters by season for all, male, and female Kensington study bears by season. Numbers below the Mean and SD indicate the number of relocations.

| Group | All Seasons | Winter (Nov. to March) | Spring (April to May) | Summer (June to Aug.) | Fall (Sept. to Oct.) |
|---|---|---|---|---|---|
| All Bears | 363.61 (189.44)<br>184 | 384.63 (147.40)<br>42 | 342.46 (184.43)<br>35 | 365.84 (207.47)<br>85 | 348.44 (202.91)<br>22 |
| Male Bears | 425.31 (183.90)<br>39 | 429.98 (141.73)<br>7 | 264.80 (163.52)<br>8 | 487.68 (181.27)<br>20 | 342.90 (199.68)<br>4 |
| Female Bears | 345.23 (188.38)<br>145 | 375.56 (148.81)<br>35 | 365.48 (186.75)<br>27 | 328.36 (201.68)<br>65 | 349.67 (209.32)<br>18 |
| Bears by age classes | | | | | |
| Age <= 3 | | 313.27 (83.47)<br>18 | 250.83 (122.76)<br>12 | 295.33 (190.08)<br>37 | 260.77 (125.08)<br>9 |
| Ages 3 to 6 | | 476.80 (134.22)<br>7 | 300.23 (203.98)<br>10 | 394.72 (241.79)<br>15 | 355.60 (381.10)<br>3 |
| Ages over 9 | | 422.24 (174.82)<br>17 | 459.54 (154.15)<br>13 | 431.80 (190.11)<br>33 | 425.20 (188.77)<br>10 |

**Table 8**. Mean (and standard deviation) elevation in meters by season for all, male, and female Kensington study goats by season. Numbers below the Mean and SD indicate the number of relocations.

| Group | All Seasons | Winter (Oct. to March) | Spring (April to May) | Summer (June to Sept.) |
|---|---|---|---|---|
| All Goats | 714.28 (338.59)<br>284 | 498.70 (245.94)<br>106 | 606.83 (323.81)<br>44 | 920.09 (280.64)<br>134 |
| Male Goats | 763.19 (333.94)<br>175 | 564.51 (234.51)<br>64 | 583.22 (309.80)<br>26 | 967.83 (280.57)<br>85 |
| Female Goats | 635.75 (332.63)<br>109 | 398.42 (230.94)<br>42 | 640.27 (349.27)<br>18 | 837.51 (263.51)<br>49 |

**Table 9**. Crosstable of seasons by elevation for Kensington goats. Values under seasons are count (relocations) and column percents respectively.

| Elevation (meters) | Winter (Oct. to March) | Spring (April to May) | Summer (June to Sept.) | Row Total |
|---|---|---|---|---|
| 0-365.76 | 38 | 13 | 8 | 59 |
| | 35.8 | 29.5 | 6.0 | 20.8 |
| 365.76-548.64 | 27 | 8 | 8 | 43 |
| | 25.5 | 18.2 | 6.0 | 15.1 |
| 548.64-701.04 | 17 | 7 | 10 | 34 |
| | 16.0 | 15.9 | 7.5 | 12.0 |
| 701.04-822.96 | 16 | 7 | 20 | 43 |
| | 15.1 | 15.9 | 14.9 | 15.1 |
| 822.96-1005.84 | 5 | 3 | 30 | 38 |
| | 4.7 | 6.8 | 22.4 | 13.4 |
| Over 1005.84 | 3 | 6 | 58 | 67 |
| | 2.8 | 13.6 | 43.3 | 23.6 |
| Column | 106 | 44 | 134 | 284 |
| Total | 37.3 | 15.5 | 47.2 | 100.0 |
| Chi-Square | 105.60 | Significance | 0.00000 | |

*Habitat of Kensington Bear and Goat Areas*

The habitat of both the *bear* and *goat areas* are diverse, with uneven distributions of various cover types, slope, and plant associations. Aspect of georeference sites is reletively evenly distributed among the four direction, however, most slopes are of less than 76% (Table 10). The most common slope in both areas is from 36 to 76%. A substantial portion of both the *bear* and *goat areas* is non-forested, with ice/snow fields and rocks being the most common non-forest condition (Table 10). Forested habitat in the *bear area* is primarily hemlock or of low density, whereas the forests of the *goat area* more diverse (Table 10). Forests of the *bear* and *goat areas* are generally sparse (53.65 and 55.41% respectively), containing from 0 to 8MBF (53.82 and 57.31% respectively). Old growth forests of from 8 to 20MBF typify most of the remaining forest.

The number of plant associations and the frequencies with which they occurred did differ between *bear* and *goat areas*, but the most common associations in both areas were identical (Table 11). Alpine lichen-rock outcrops and scrub-scrub riparian were the most frequent primary plant associations. Alpine meadows and hemlock-blueberry-devil's club (TSHE/VAsp-OPHO HP) were the most frequent secondary plant associations while hemlock-blueberry-devil's club (MP) was the most common tertiary plant association.

Elevation is not independent of slope or cover type for goat and bear relocation sites (Table 12). Relocation aspect is independent of elevation when goat relocations in all or non-forested cover types are considered but not when only forested cover is considered (Table 12). For bears, aspect is dependent upon elevation when all or forested cover is considered. Slope is significantly related to elevation for both species, regardless of the cover type (Table 12). Relocation site cover types are significantly related to elevation for all instances of both species except non-forested relocations of bears (Table 12). Non-forested conditions of goat sites are at higher elevations as compared to forested conditions.

*Bear-Habitat Relationships*

Bears were relocated in a variety of forested and non-forested habitats, with roughly one-half of all relocations appearing in each division. Whereas the relocation sites of bears appear to be dependent on the cover type (forest or non-forest; Table 12), the distribution of cover type at the relocation sites was not significantly different from the distribution of cover types present in the *bear area* (Table 10). Non-forested conditions bears were relocated in included slide zone, alpine, brush, and rocks (Table 10). Bears were relocated the most often within slide zones (Table 10). Despite their prevalence in the *bear area*, bears were never relocated on snow or ice fields. Forested habitats bears were relocated in included hemlock-spruce, hemlock, high elevation, low density, and muskeg forests (Table 10). Relocations of bears in these forests was not independent of the volume class, size class, or forest type. Bears were relocated the most often in hemlock-spruce forests (Table 10). Forests bears were relocated in were usually sparse, containing from 0 to 8MBF, with old growth forests accounting for nearly all remaining forested relocations.

Bear relocation sites, while not independent of slope and aspect (Table 12), were not significantly different from the *bear area* habitat (Table 10). Bears were relocated most often in habitats facing from 136 to 225 degrees and on slopes of from 36 to 76% (Table 10). Season was not significantly related to the slope at relocation (Table 12).

The frequency with which bears were observed in various plant associations is not significantly different than the frequencies of these plant associations which makeup the *bear area* (Table 11). Bears were relocated most frequently in primary associations of scrub-scrub riparian, secondary associations of TSHE/VAsp-OPHO (HP), and tertiary associations of TSHE/VAsp-OPHO (MP). The use of alternate plant associations was not significantly different among seasons for primary associations[5] ($\chi^2$=3.8390, significance=0.6991) and for secondary associations[6] ($\chi^2$=5.3238, significance=0.7225). There were not enough relocations regarding tertiary associations for meainingful analysis.

*Goat-Habitat Relationships*

Goats were also relocated in a variety of forested and non-forested habitats. While these relocations were seemingly independent of cover type (forest or non-forest; Table 12), the distribution of cover types was not significantly different from the distribution of cover types

[5] Primary plant associations were regrouped into four categories including alpine, scrub-scrub riparian, emergent sphagnum and TSHE/VAsp/LYAM, and all other plant associations.

[6] Secondary plant associations were regrouped into five categories including alpine, TSHE/VAsp-OPHO (HP), TSHE/VAsp-OPHO (MP), those including LYAM, and other forest types including VAsp.

present in the *goat area*. Goats were relocated the most frequently in non-forested habitats including slide zones, brush, rocks, snow/ice fields, and near fresh water (Table 10). Of the non-forested habitats, goats were relocated the most often in rocks (Table 10). Forested habitats in which goats were relocated included hemlock-spruce, spruce, high elevation, slide zone, low density, and rocky forests (Table 10), and of these goats were relocated the most often in sparse low volume forests, particularly slide zone forests (Table 10).

Although goat relocation distributions among the slope and aspect categories do not appear to be random (Table 12), they are not significantly different from the distribution of slope and aspect categories of the *goat area* (Table 10). Goats were relocated most often in habitats facing from 226 to 315 degrees and on slopes of greater than 76% (Table 10). Goat relocations among seasons were independent of aspect (Table 12). Slope at relocation was not independent of season however, with goats being relocated on steeper slopes (greater than 76%) more frequently during the summer and on slopes from 36 to 76% more frequently during the winter. Although few relocations (15) of goats were made on slopes less than 36%, the goats appear to be using this slope more frequently during the spring.

Goats were relocated primarily in scrub-scrub riparian and alpine plant associations. Although the frequency with which goats were relocated among the primary associations (including snow and ice fields) appears to differ from the general makeup of the goat area habitat, these differences are not significant (Table 11). Goats were relocated the most frequently in primary associations of scrub-scrub riparian and alpine-lichen/rocks, secondary associations of TSHE/VAsp-OPHO (HP) and alpine meadows, and tertiary associations of TSHE/VAsp-OPHO (MP).

The use of alternate plant associations was significantly different among seasons for primary associations[7] ($\chi^2$=63.1687, significance=0.0000) and for secondary associations[8] ($\chi^2$=60.7152, significance=0.0000). Higher elevation alpine associations were used more frequently in the summer, whereas lower elevation shrub and forest habitats were used more frequently in the winter. There were not enough relocations regarding tertiary associations for meainingful analysis.

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[7] Primary plant associations were regrouped into three categories including alpine, scrub-scrub riparian, and all other plant associations. This test should be regarded as tentative since an excessive number (25%) of expected frequencies were less than 5.

[8] Secondary plant associations were regroups into four categories including alpine, TSHE/VAsp-OPHO, mixed conifer-blueberry, and TSME/VAsp/VEVI.

**Table 10.** Percentages of the time in which bears and goats were relocated in specific habitat divisions and categories, and the percentage of the habitat which falls into these habitat divisions and categories as represented by all GIS georeference sites within areas defined by the total home ranges of bears and goats. The number of relocations and georeference sites for each division are also given. Categories are distinct for each division and are as follows: General cover type 1=hemlock-spruce, 2=hemlock, 3=cottonwood, 4=spruce, 5=non-forest, 6=high elevation forest, 7=slide zone forest, 8=low density forest, 9=muskeg forest, 10=rocky forest; Non-forest conditions 1=slide zone, 2=alpine, 3=brush, 4=rocks, 5=alders, 6=ice/snow, 7=near water; Size class 3=young saw, 4=old growth, 5=sparse forest; Volume class 3=0 to 8MBF, 4=8 to 20MBF, 5=20 to 30MBF; Aspect 1=46 to 135, 2=136 to 225, 3=226 to 315, 4=316 to 45, 5=flat; Slope 1=less than 36%, 2=36 to 76%, 3=76 to 121%, 4=greater than 121%. Chi-Square statisitics (value and significance) for each distribution are also given for each habitat division.

| **Category** | **General Cover Type** | | **Non-Forested Conditions** | | **Size Class** | | **Volume Class** | | **Aspect** | | **Slope** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Bears** | | | | | | | | | | | |
| Number of Obs. | 166 | 1280 | 37 | 637 | 129 | 643 | 129 | 641 | 166 | 1275 | 166 | 1280 |
| 1 | 16.87 | 5.86 | 75.68 | 13.34 | | | | | 15.66 | 27.69 | 47.59 | 35.39 |
| 2 | 19.28 | 17.03 | 27.00 | 2.51 | 0.00 | 0.31 | | | 15.06 | 18.98 | 38.55 | 46.64 |
| 3 | 0.00 | 0.31 | 2.70 | 3.92 | 6.98 | 3.11 | 49.61 | 53.82 | 53.61 | 37.10 | 13.86 | 16.56 |
| 4 | 0.00 | 0.08 | 18.92 | 37.99 | 43.41 | 42.92 | 43.41 | 36.82 | 15.66 | 16.24 | 0.00 | 1.41 |
| 5 | 22.29 | 49.77 | 0.00 | 0.00 | 49.61 | 53.65 | 6.98 | 8.74 | | | | |
| 6 | 9.04 | 2.50 | 0.00 | 41.29 | | | 0.00 | 0.62 | | | | |
| 7 | 4.82 | 4.38 | 0.00 | 0.94 | | | | | | | | |
| 8 | 20.48 | 14.92 | 0.00 | 0.00 | | | | | | | | |
| 9 | 7.23 | 4.92 | | | | | | | | | | |
| 10 | 0.00 | 0.00 | | | | | | | | | | |
| Chi-Square | 0.5682 | | 3.4336 | | 0.0543 | | 0.0249 | | 0.1385 | | 0.0746 | |
| Significance | 0.9998 | | 0.6335 | | 0.9967 | | 0.9990 | | 0.9977 | | 0.9947 | |
| | **Goats** | | | | | | | | | | | |
| Number of Obs. | 281 | 1470 | 166 | 936 | 115 | 527 | 115 | 527 | 281 | 1446 | 281 | 1470 |
| 1 | 8.90 | 8.16 | 21.0 | 12.50 | | | | | 6.00 | 32.92 | 10.70 | 24.08 |
| 2 | 3.90 | 6.53 | 0.00 | 1.07 | 1.70 | 1.90 | | | 39.90 | 16.25 | 32.70 | 52.04 |
| 3 | 0.00 | 1.22 | 5.40 | 6.30 | 0.90 | 4.36 | 70.40 | 57.31 | 49.10 | 31.81 | 50.50 | 21.09 |
| 4 | 0.00 | 0.07 | 70.10 | 41.24 | 28.40 | 38.33 | 24.30 | 35.86 | 5.00 | 19.02 | 6.00 | 2.79 |
| 5 | 5.91 | 64.15 | 0.00 | 0.00 | 69.00 | 55.41 | 5.20 | 6.83 | 0.00 | 0.39 | | |
| 6 | 0.40 | 2.11 | 3.00 | 37.82 | | | | | | | | |
| 7 | 22.80 | 8.16 | 0.60 | 1.07 | | | | | | | | |
| 8 | 4.60 | 7.76 | | | | | | | | | | |
| 9 | 0.00 | 1.29 | | | | | | | | | | |
| 10 | 0.40 | 0.54 | | | | | | | | | | |
| Chi-Square | 0.3304 | | 0.5934 | | 0.0869 | | 0.0709 | | 0.7598 | | 0.5955 | |
| Significance | 1.0000 | | 0.9965 | | 1.0000 | | 0.9652 | | 0.8591 | | 0.8975 | |

**Table 11.** Percentage of the time bears and goats were relocated in specific plant/habitat associations, and the percentage of the bear and goat areas characterized by this plant association. Primary associations include glacial habitat, however, secondary and tertiary associations do not. Associations are or the first two letters of the scientific names (sp indicates the presence of multiple species) of the plants comprising them are given. Separate columns are given for bears, goats, and the habitat within bear and goat areas respectively. The number of bear or goat relocations and the total number of georeference sites for which association data was available is given. Additionally, the Chi-Square statistic and significance regarding distributional comparisons are also provided.

| **Category** | **Primary Association** | | **Secondary Association** | | **Tertiary Association** | | **Primary Association** | | **Secondary Association** | | **Tertiary Association** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Bears** | **Area** | **Bears** | **Area** | **Bears** | **Area** | **Goats** | **Area** | **Goats** | **Area** | **Goats** | **Area** |
| | **166** | **1274** | **166** | **1081** | **119** | **521** | **280** | **1435** | **280** | **1204** | **142** | **590** |
| Glacial | 0.00 | 15.23 | ----- | ----- | ----- | ----- | 0.00 | 17.10 | ----- | ----- | ----- | ----- |
| Alpine-Lichen/Rock | 0.60 | 19.07 | 7.23 | 16.56 | 0.00 | 0.00 | 35.00 | 27.70 | 1.79 | 11.54 | 0.00 | 0.00 |
| Alpine Meadow | 7.23 | 14.05 | 4.22 | 28.03 | 0.00 | 0.00 | 1.79 | 9.70 | 35.00 | 33.89 | 0.00 | 0.00 |
| Scrub-Scrub Riparian | 39.18 | 16.41 | 0.00 | 0.00 | 0.00 | 0.00 | 43.57 | 21.50 | 0.00 | 0.00 | 0.00 | 2.37 |
| TSHE/VAsp-OPHO (HP) | 3.61 | 2.12 | 31.93 | 16.56 | 15.13 | 8.25 | 0.00 | 1.20 | 43.21 | 20.27 | 1.41 | 2.20 |
| TSHE/VAsp-OPHO (MP) | 0.00 | 0.00 | 15.06 | 9.99 | 44.54 | 33.78 | 0.00 | 0.00 | 2.14 | 5.40 | 85.21 | 41.36 |
| TSME/VAsp | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| TSHE-CHNO/VAsp | 0.00 | 0.00 | 6.63 | 6.94 | 0.00 | 0.96 | 0.00 | 0.00 | 4.64 | 10.88 | 0.00 | 0.85 |
| Mixed Conifer/VAsp | 0.00 | 0.39 | 5.42 | 3.70 | 10.92 | 20.92 | 0.00 | 0.30 | 0.71 | 3.65 | 9.86 | 25.93 |
| Mixed Conifer/VAsp/FACR | 5.42 | 3.14 | 0.60 | 1.30 | 10.08 | 10.94 | 0.71 | 3.30 | 0.00 | 1.16 | 0.00 | 1.36 |
| TSME/VAsp/VEVI | 0.00 | 0.00 | 1.20 | 2.13 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 3.82 | 0.00 | 0.00 |
| TSME/VAsp-CAME | 0.00 | 4.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mixed Conifer/VAsp/LYAM | 3.61 | 0.00 | 7.23 | 5.27 | 4.20 | 6.14 | 0.00 | 0.00 | 0.00 | 0.66 | 0.00 | 9.15 |
| TSHE/VAsp | 21.08 | 15.07 | 10.84 | 3.98 | 0.00 | 1.15 | 16.43 | 15.20 | 0.71 | 1.08 | 0.70 | 4.41 |
| TSHE/VAsp-LYAM | 0.00 | 0.00 | 5.42 | 1.11 | 10.08 | 10.94 | 0.00 | 0.00 | 0.00 | 0.75 | 2.82 | 3.22 |
| Emergent Sphagnum Muskeg | 7.83 | 5.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20 | 0.00 | 0.33 | 0.00 | 0.00 |
| PISI/VAsp-OPHO/CIAL | 0.60 | 0.86 | 0.00 | 0.09 | 0.00 | 0.00 | 1.79 | 0.80 | 0.00 | 0.33 | 0.00 | 0.00 |
| PISI/VAsp | 0.00 | 0.00 | 0.60 | 1.02 | 0.00 | 0.00 | 0.00 | 0.00 | 1.79 | 0.91 | 0.00 | 0.00 |
| PISI/OPHO | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 |
| PISI/ALsp | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 |
| TSHE/VAsp/LYAM | 10.84 | 3.61 | 3.61 | 2.50 | 0.00 | 0.00 | 0.71 | 0.90 | 0.00 | 1.41 | 0.00 | 0.00 |
| Emergent Short Sedge-Muskeg | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.16 | 0.00 | 0.00 |
| PISI | 0.00 | 0.00 | 0.00 | 0.65 | 5.04 | 5.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.88 |
| Emergent Tall Sedge-Muskeg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.66 | 0.00 | 0.00 |
| Emergent Mixed Forb/Grass | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 1.34 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 5.42 |
| Subtidal/Emergent Estuary | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.17 |
| Chi-Square | 0.8982 | | 0.8061 | | 0.2375 | | 0.5531 | | 0.6168 | | 0.8280 | |
| Significance | 1.0000 | | 1.0000 | | 1.0000 | | 1.0000 | | 1.0000 | | 1.0000 | |

**Table 12.** Statistical test results of elevation and Kensington bear (columns 1, 3, and 5) and goat (columns 2, 4, and 6) habitat characteristics. Tabled entries include the $\chi^2$ value (top values) and the level of significance (bottom value). Unless footnoted, habitats are the same as described in Table 10. INS and N/A indicate tests which could not be performed due to insufficient relocations or were not applicable respectively. Seasons consisted of winter (October through March), spring (April through May), and summer (June through September).

| **Characteristics Tested** | **All Habitats (170 and 281 Relocations)** | | **Non-Forested (37 and 166 Relocations)** | | **Forested (133 and 115 Relocations)** | |
|---|---|---|---|---|---|---|
| | **Kruskal-Wallis Tests** | | | | | |
| Elevation by NF conditions | N/A | N/A | 4.3833<br>0.2229 | 77.8080<br>0.0000 | N/A | N/A |
| Elevation by Slope | 47.5189<br>0.0000 | 24.3247<br>0.0000 | 6.6131<br>0.0366 | 15.8631<br>0.0004 | 30.4582<br>0.0000 | 6.7278<br>0.0346 |
| Elevation by Aspect | 24.9731<br>0.0000 | 1.8477<br>0.6046 | 4.6620<br>0.1983 | 2.6187<br>0.4542 | 15.2656<br>0.0016 | 16.2946<br>0.0010 |
| Elevation by Volume Class | N/A | N/A | N/A | N/A | 5.0911<br>0.0784 | 17.1486<br>0.0002 |
| Elevation by Cover Type | 76.9422<br>0.0000 | 95.5806<br>0.0000 | N/A | N/A | 42.3994<br>0.0000 | 25.0262<br>0.0001 |
| | **Chi-square Tests[9]** | | | | | |
| | **Overall** | | **Male** | | **Female** | |
| Cover Type[10,11] Selection | 16.212<br>0.006 | 194.117<br>0.000 | 24.842<br>0.000 | 129.628<br>0.000 | 19.455<br>0.002 | 65.422<br>0.000 |
| Non-Forest[12] Selection | 53.270<br>0.000 | 195.928<br>0.000 | -INS- | 144.714<br>0.000 | 45.200<br>0.000 | 57.885<br>0.000 |
| Forest[3] Selection | 13.880<br>0.008 | 36.852<br>0.000 | -INS- | 27.029<br>0.000 | 18.893<br>0.001 | 11.021<br>0.004 |
| Cover Type[3] by Seasons | 10.275<br>0.417 | 40.83785<br>0.00000 | -INS- | -INS- | -INS- | -INS- |
| Non-Forest[4] by Seasons | -INS- | 33.96930<br>0.00000 | -INS- | -INS- | -INS- | 26.97725<br>0.00000 |
| Slope by Seasons | 1.762<br>0.779 | 13.125<br>0.011 | -INS- | 15.160<br>0.004 | 3.868<br>0.424 | 10.430<br>0.034 |
| Aspect by Seasons | 7.290<br>0.295 | 5.829<br>0.443 | -INS- | -INS- | -INS- | -INS- |
| Slope Selection | 31.071<br>0.000 | 88.875<br>0.000 | 7.000<br>0.030 | 71.384<br>0.000 | 24.682<br>0.000 | 21.486<br>0.000 |
| Aspect Selection | 80.024<br>0.000 | 175.555<br>0.000 | 6.421<br>0.093 | 67.844<br>0.000 | 106.788<br>0.000 | 67.844<br>0.000 |

[9] Null hypothesis for the tests are that all cover types, non-forested habitats, slopes, and aspects are used equally.

[10] Goat cover type categories consisted of non-forest, conifer forest, low density, and scrub forests (high elevation, slide zone and rocky forests).

[11] Cover types of bears reduced by pooling slide zone and high elevation forests.

[12] The non-forest condition *near fresh water* was excluded from the tests.

## Discussion

### *Disease and Heavy Metal Assays*

Whereas the establishment of baseline disease levels in bear and goat populations in the Kensington site is necessary for a total understanding of the overall vitality of these populations and any potential impacts of mine development upon them, it is not clear whether this is being achieved by current sampling methods. The presence of Contagious Ecthyma has been confirmed among goats in the Kensington study site in previous years. However, the extent to which it is currently present, or the degree to which it affects the vitality of the goat population in the area is not known. Relatively few goats at the Kensington site have been sampled for the presence of the disease or antibodies against it, and many samples which were taken were lost as a result of transportation difficulties. A nine year old nanny which was heavily affected in 1990 appears to be exhibiting normal behavior at this time. Moreover, other goats which were thought to have been exposed to the disease appear to be faring similarly.

It is also important to note that prompt and complete necropsy of study goats which have died has been impossible. Deceased goats have invariably been fed upon by scavengers by the time inspection was possible, effectively masking the original cause of death and eliminating valuable information prior to examination. These animals may have died as a result of predation, old age, treacherous conditions, secondary complications associated with disease or harassment, or some combination thereof. Given the low frequency of relocation flights and the expense and difficulty in reaching deceased goats, it is unlikely that this study will be able to distinguish among these factors in the future.

Serological examination of bears showed no evidence of the microbial pathogen Trichina in 1993. However, since bears were not sacrificed, no cross testing using tissue and standard United States Department of Agriculture (USDA) methodology is possible. Thus, all results should be regarded as tentative. Whereas hunter-killed animals represented an opportunity for such analyses, they were not sampled.

Veterinary toxicology studies of heavy metal contents in marten and bear have been completed but interpretation of the results is impossible at this time. Many factors determine the tolerance of animals to various levels of heavy metals and it is not clear what levels are normal for the animals examined at the Kensington site, or for animals on Chichigof Island.

Additionally, assays of metal content may not be comparable between the Chichigof Island martens and the Kensington study bears. Samples from marten were obtained from livers and kidneys, whereas blood, hair and blood serum samples were obtained from bears. The absence of hair and blood samples from marten eliminates the possibility for direct comparison between marten and bears. Additionally, even if such samples were taken, it is probable that the diets, habits, and physiology of the two species are sufficiently dissimilar so as to alter the exposure to and subsequent incorporation of heavy metals in their various tissues.

Sampling strategy for heavy metals at the Kensington site needs to be re-examined, and additional samples need to be taken, in order for the current metal assay results to be meaningful. Since the Kensington site was formerly an active mining site, it is possible that levels of heavy metals in the area have already been altered from their natural state. Thus, comparisons to animals from locations which have never been developed may not be valid.

At the very least, future sampling should include identical tissues in all sampled animals, and include a stratification by habitat. Heavy metals are generally bio-accumulative, but levels of accumulated metals are not necessarily the same for all tissues as shown in this study by statistically significant differences in cadmium levels between martens. In order to document rising levels of heavy metals, animals need to be sampled yearly. Thus, while the results of the analyses may potentially be useful, an increased level of sampling over area and time is necessary before any valid conclusions can be drawn. Such a level of sampling has not been attainable under current budgetary and time constraints.

*Relocations*

Most relocations of bears and goats were based only on radio-receiver information. Best estimates of radio locations were placed on the data maps in flight. Radio location error may have been compounded by: 1) pilot skill and observer experience; 2) a deviation from map scale induced by the photocopy machine; 3) confusion of location due to an inability to identify landmarks near the location site; and 4) incorrect placement of the digitizing device. Although a quantification of these errors is desirable since they undoubtedly biased the results, it is not possible.

*Bears*

Home ranges of male and female bears in this study are similar to those reported in Washington (Poelker and Hartwell 1973), but smaller than those of other investigated areas (Amstrup and Beecham 1976; Modafferi 1978 and 1981; Schwartz and Franzmann 1981; Miller and McAllister 1982). Poelker and Hartwell (1973) estimated Washington black bear home ranges at between 5 and 52 $km^2$ for males, and between

2.4 and 4 $km^2$ for females. This is quite similar to our estimates of mean inclusive home ranges for male (14.07 $km^2$) and female (2.717 $km^2$) bears at the Kensington site. Moreover, home range estimates based on 90 and 95% of the relocations area also comparable to the estimates of Poelker and Hartwell (1973). Thus, the habitats of western Washington seem to be comparable to the Kensington site.

In contrast, home range estimates for male and female bears in this study are much smaller than those in Idaho (Amstrup and Beecham 1976; 112 $km^2$ and 34 $km^2$ respectively) or three regions within Alaska including Prince William Sound (Modaffari 1978 and 1981: 70-100 $km^2$, 10-30 $km^2$ respectively), the Upper Susitna (Miller and McAllister 1982; 234 $km^2$ and 200 $km^2$ respectively), and the Kenai Peninsula (Schwartz and Franzmann 1981; 98 $km^2$ and 16.8 $km^2$ respectively). This suggests that the Kensington site is a richer environment for bears than any of these other Alaskan sites and is capable of supporting a greater number of bears per unit area.

Of the sites, Idaho and the Upper Susitna are the least similar to the Kensington site. The Kensington site is a very diverse coastal rainforest, including steeply rising slopes from sea-level to alpine, timber, and an extensive low lying drainage system. The Kensington *bear area* with its many habitat conditions and plant associations offers a diverse array of food types to bears. The fact that bears are utilizing the various plant associations in proportion to their occurance indicates that this is an important feature of the area. In contrast, both the Idaho and Upper Susitna sites are drier inland environments, neither exhibiting such a dramatically diverse habitat.

Alternatively, the lower home range sizes of the Kensington study site may: 1) be a result of less interspecific competition with brown bears (*Ursus arctos*); 2) be indicative of too few relocation sites or study animals; 3) have resulted from excessive error in identifying the true locations of radio-located animals; 4) be reflective of the differences between the habitats at each of the study sites; or 5) be related to the proximity of the study area to humans. Brown bears are known to occasionally kill black bears and they consume many of the same foods and are present in greater numbers at the Upper Susitna and Kenai study sites than at the Kensington site. The greater density of brown bears at the Upper Susitna and Kenai study sites may have altered the availability of suitable black bear food. However, since brown bears are found at the Kensington site, it is more likely that most of the differences among the study sites is related to the differences in habitat. The degree to which each of these factors is influencing the home range size of black bears at the Kensington site is not known.

It should also be noted that human waste products are potentially available at the Kensington site, and were utilized problematically by bears 114 and 139. Bear 139 was eventually relocated as a result, however, all relocation points included in the home range estimation for this bear are subsequent to this move.

This study is in agreement with previous studies which have shown that male bears range over a greater area than female bears (Modaffari 1981). This is due in large part to the fact that male bears can, and often do, impregnate more than one female bear (Modaffari 1981). Thus, it is genetically advantageous for a male bear to maintain a large home range which overlaps multiple female home ranges. In contrast, the home range size for female bears is determined only by the habitat's ability to provide shelter and sustenance for the female and any offspring (Amstrup and Beecham 1976).

Male bears were seen to range over a significantly greater area than female bears (Table 4), in this study, except when 90% home range estimates were considered. It is probable that too few relocations were considered for 90% home ranges to have any significance. Additionally, although results of inclusive home ranges were significant, too few bears were examined for the results to viewed as anything more than preliminary. The combination of too few relocations and study animals reduces the power of the statistical tests used and allows possible outliers (such as bear 114) to unduly influence the results. The large differences between inclusive, 95% and 90% estimates of home range sizes coupled with the large standard deviations associated with the mean home range sizes of both sexes would seem to confirm this contention.

Differences in bear elevational use were shown between males and females, as well as among age classes of Kensington bears. Male bears were observed over a greater range of elevations than were females. Since male bear home ranges were significantly larger than female home ranges this difference is expected. Although younger bears seem to remain at lower elevations, caution must be used before this conclusion is adopted. Many of the mean elevational heights by season used for analysis are based on few locations. Moreover, this relationship is not true for winter (see Table 7).

*Goats*

Goat home range sizes were not significantly different between males and females. This is not consistent with Nichols' (1985) observation that males exhibited greater movement patterns than females. Nichols' contends that this reflects the fact that males are capable of breeding with more than one female. Whereas mean inclusive home ranges for male goats at the Kensington site was greater than for female goats, individual variation was extreme (see Table 5). This variation in male home range size was not significantly related to weight or age, suggesting that either too few male goats were studied, or too few relocations were obtained. It is probable that the results reflect some combination of these problems. Regardless, the limited nature of the data precludes any significant contradiction to Nichols' work.

Although the home ranges reported for goats do indicate the presence and use of habitat important to goats, it is likely that the home range sizes are underestimates of the true area occupied by individual goats for two reasons. First, the software used in determining the coordinates of goat relocation's did not provide for the three-dimensional nature of goat habitat. For this reason, Nichols (1985) declined to estimate home range sizes for goats. However, since the three-dimensional features of the habitat are necessarily contained within the planar nature of the terrain, we chose to report home range sizes. Assuming that the three-dimensional aspects are distributed uniformly throughout the study area, then the error may be assumed to be equal for each individual. Second, the large differences between inclusive, 90%, and 95% home range sizes indicate that insufficient relocations have been done for many of the animals. As previously discussed, standard deviations of male mean goat home ranges are much greater than for female mean home ranges, implying that this is especially true for male goats.

Our data clearly show a seasonality of habitat use by goats and is consistent with the results of Nichols (1985) and Shoen (1979). In general, goats seem to utilize higher elevational habitat in the summer and lower elevational habitat in the winter and spring. Presumably this is a result of decreased food availability at the higher elevations due to increased snow depth at higher elevations (Shoen 1979; Smith 1986; Fox et al. 1989) during the winter.

Our results agree with Fox et al. (1989) who found that the use of forested areas during the winter by goats is more prevalent in Southeast Alaska than in any other region. A total of 115 (40.92% of all relocations) relocations were made in forested areas, with most of these relocations having been made in the winter. Since the goats migrate to this area every year, despite an increased vulnerability to predators, the habitat must be vital for their survival.

Female goats in this study were seen to be present at significantly lower elevations for all seasons except spring. This may be indicative of possible biases introduced when animals were captured. Alternatively, it may be a result of increased nutritional requirements associated with gestation or female rearing patterns. Male goats seldom participate in the rearing of young kids. Additionally, male goats tend to be more solitary than females, which are often found in large groups comprised of other females and young animals. Since young animals are not as capable of moving or foraging in deep snow, females as a whole may be selecting lower elevations more suitable for young animals.

Estimation of goat populational densities is hampered by rugged terrain and large area in which they may be found and goat populations are currently estimated by multiplying the number of goats observed during reconnaissance flights by two. This method is routinely used to generate ballpark measures of goat density which, although useful for general management purposes, are rarely accurate or repeatable. Using this method, approximately 120 goats are estimated to be within the Kensington study area. However, this estimate of goat density should be regarded with caution since the method by which it was obtained is clearly dependent upon a host of uncontrollable factors including weather, visibility, season, and individual observer experience and bias. No more reliable method of censusing goat populations is currently available.

Identification and classification of winter goat range habitat may have potential as an alternative method of goat population censusing. Several investigators (Fox et al. 1982; Smith 1986; Fox et al. 1989) have found Winter goat habitat has been found to be predictable and include the use of lower elevations with predominant forages consisting of conifers, lichens, mosses, and some shrubs. The predictability of goat habitat is enhanced by their predator avoidance strategy, which requires a similar habitat structure regardles of season (Schoen 1979; Smith 1986; Fox et al 1989). The fact that Kensington goats are descending into forested habitat during the winter implies that the development of models relating browse availability to goat density may be possible.

*Summary and Conclusions*

Goals towards determining baselines regarding diseases and heavy metals are not being met. It is the recommendation of this report that the portion of this study regarding heavy metals be either wholly revised and begun anew, or disregarded in the future. It is likely that little information will be gained without such a revision. To assess the presence of disease, an increased number of individuals from each of the bear and goat populations must be examined. Moreover, these examinations must be done on a more timely basis. Since it is unlikely that this is achievable under current project time and budgetary restrictions, it is doubtful that the goals regarding this aspect of the study are attainable.

Bears may be seen to occupy smaller home ranges at the Kensington site than at any many other sites examined thus far. Additionally, bears seem to utilize all elevations regardless of the season. Given that the habitat appears to be very suitable for bears, and that bears are equally dependent upon all elevations, any alteration of the vegetation or accessibility to alternate elevations would seem to be detrimental. However, a greater number of bears needs to be sampled before any substantial conclusions can be drawn.

It has been demonstrated that while goats may possibly be limited by available winter forage and habitat, it is the vertical habitat-*cliffs* which affords them reproductive success, defense against predators, and is the most important feature of the habitat in which they occupy. This would seem to be confirmed by extensive goat use of ridges directly adjacent to the proposed mine development site and differential use of habitats as described by elevation and slope. However, we do not define what a *cliff* is. Thus, this report does not address a significant aspect of goat habitat makeup directly.

A better description of utilized habitats, including *cliffs*, and a more accurate estimate of goat population size is necessary before this project will be able to accurately predict any impacts on goats by the Kensington mine proposal. Future work on this project must include an attempt to define and identify *cliff* habitat in the Kensington *goat area*, as well as determine the number of goats using all habitats within the *goat area*, including *cliff* habitat. Our habitat data, while providing a useful description of the area, is indirect and should not be interpreted as determinant. For the data to be more accurate, a system by which habitat data is recorded at the time of relocation is needed.

This project was originally designed to collect observational data on bear and goat movements before and after the mine development. This is a methodology which is likely to identify development impacts on individual animals' habits and movements, however, it is not conducive to estimating the density of bears or goats within the study site because of home range overlap (see Appendix I). If the intention is to monitor developmental impacts on the bear and goat populations in their entirety, then an additional sampling procedure aimed at accurately determining population levels is necessary.

While an estimate of goat density has been obtained via reconnaissance flights and is presented in this document for goats in the Kensington area, the accuracy of this estimate is unknown. It is possible that a more accurate estimation of goat density may be obtained by: 1) examining the radio-telemetry data and results of Fox et al. (1982) to predict winter ranges; 2) monitoring the length of time goats frequent these areas through radio-telemetry; and 3) conducting field studies of goat pellet groups within this area. If forage availability information is also gathered in areas before winter ensues, this method would also allow the development of a goat population model for the area. Arial reconnaissance of bears for purposes of estimating populational density is an impossible proposition and the alternative methods proposed above for goats are equally impractical or undeveloped for bears. Thus, the only way to obtain an estimate for bears is to increase the sample size of radiocollared bears in a small area. This allows an estimation of range overlap, and hence, an estimate of total bear density to be made. However, since the above methodologies would undoubtedly require large amounts of time and involve considerable expense, implementation may not be possible at this time.

Deriving inferences regarding the population from observations of individuals requires that sufficient number of individuals be sampled to represent the populations as a whole. Whether this has been achieved in this study is not clear at this point. An insufficient number of relocations has been obtained for individual animals to allow individual comparison of habitat or plant association utilization. Moreover, while sufficient relocations have been made to allow the calculation of preliminary home ranges for all but one of the goats and two-thirds of the bears, there are insufficient numbers of animals among different age classes (goats and bears) or between sexes (bears) to make any meaningful statistical comparisons. Finally, while the study began in

1990, not all of the study bears have been followed for three years, a time period viewed as the minimum required for bear home range estimation (Modafferi 1978).

Future efforts should: 1) strive to increase the number of study animals; 2) include the continued tracking of currently collared animals; 3) incorporate a system whereby habitats could be recorded at the time of relocation; and 4) integrate relocation analyses procedures so that points only need to be entered once. Significant relationships reported here, while valid, are only tentative due to the limited nature of the data attained. With a larger sample size, relationships among groups of animals would likely become more lucid. Regardless, monitoring of the animals must be continued through mine development and during post-development if the original objectives of this project are to be met.

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# APPENDIX I

## Home Range Maps for animals

Contents