SUMMER DISTRIBUTION AND ABUNDANCE OF MOUNTAIN GOATS IN MT. RAINIER NATIONAL PARK, WASHINGTON

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ABSTRACT

During the summer of 1983, a study to determine the summer distribution and abundance of mountain goats in Mt. Rainier National Park, Washington, was undertaken. This was the first comprehensive attempt at quantifying goat numbers and locations parkwide. A systematic methodology was formulated which could be used by the park in future years to monitor population trends, and which would make subsequent data comparable to the present study.

Field methods used to gather data included three fixed-wing aerial surveys and nine systematic ground surveys, by all or some of the same four project participants. Support material was provided from random sightings reported on goat observation cards by backcountry rangers, and from historical data obtained from the park archives.

Since no animals were marked or collared during the study, it was necessary to obtain the best reliable data by minimizing counting error and duplicate sightings. Subpopulation units of mountain goats were determined by delineating and mapping areas of distribution and use obtained from the aerial and ground surveys, and comparing various characteristics of each unit to known information on goats reported in the literature, in relation to their environment and to each other. Based on the analysis, there were six subpopulation units of mountain goats in Mt. Rainier, National Park during the summer months, occupying about 314 square kilometers from roughly 1280 meters to 2280 meters in elevation. Each unit was inclusive of one or more nursery groups which appears to occupy central, apparently optimal home range, and was assumed to have limited association with similar groups in other units; associated male bands occupied what was assumed to be peripheral habitat in the unit, and may have had some limited contact with other units through wandering and dispersal.

The estimated population of mountain goats in the park was 374 to 500 individuals. An air to ground survey accuracy ratio of 69 percent to 92 percent was formulated from the ground and aerial surveys, and applied to the maximum aerial count in each subpopulation unit to obtain the indexed population range. Since it was assumed only a limited amount of intermingling occurred between units, duplication was equally assumed to have occurred only to a minimum extent.

Parkview mountain goat densities were 1.8 to 2.4 goats per square kilometer. Kid to older goat ratios ranged from 16:100 to 20:100.

No conclusive statements were made concerning population condition and trend. One year's worth of data that relies on unmarked animals is not sufficient evidence to substantiate conclusions regarding herd status,

fitness, or productivity. Data from other published studies were presented for illustrative purposes only, and may not be comparable to results in Mt. Rainier until further investigations refine more precisely the environmental and physiological parameters operating to influence populations within the park.

The study will continue during the summer of 1984 to obtain a second year's worth of data. In addition, fecal pellet analysis, including tests for parasites, nitrogen, and DAPA, are planned for the different subpopulation units. Coupled with abundance and density determinations, the investigations may provide additional, although generalized, insight into the relative quality of goat condition in the park, and will assist the National Park Service to priorize and determine the need for further research.

INTRODUCTION

Prior to the present study, there were limited attempts to quantify mountain goat (Oreamnos americanus) numbers and locations in Mt. Rainier National Park, Washington. Most of the early information about the native populations consisted of generalized statements, based on informal and periodic field sightings by park rangers on patrol. Other information on spring and fall migrations, winter range areas, rutting areas, kidding areas, winter survival rates and herd health and productivity was extremely limited, if not non-existent.

In 1964 and 1965, Johnson conducted what was then the most complete reconnaissance of mountain goats in Mt. Rainer National Park. He selected two areas for concentrated observations: one area in the eastern half of the park and one in the western half. Methods and procedures for censusing these two areas were of sufficient detail for repeatability, however, no quantitative method to systematically determine if observed goats were part of larger groups was established. For example, if one were to go into one of these areas today and not see any goats, it may not mean that the population has declined. It may just be that the animals were occupying a different part of their range. Johnson noted that "whole herds have disappeared from some areas under study and have remained absent for months at a time". This illustrated the disadvantages of censusing one particular location, rather than attempting to establish the geographical extent of an entire assemblage of goats.

There has been no one systematic methodology formulated for censusing mountain goat populations that is applicable to all circumstances. When studying goat populations, investigators frequently employ the use of radio collars, ear tags, or some form of marking. This is especially useful in monitoring movement, home range, or dispersal, with the assurance that one is tracking the same individuals over extended periods of time. Marking animals can also be used in a mark recapture program to obtain population estimates by finding a ratio of marked to unmarked goats during surveys, and applying various mathematical models for calculation.

Other researchers forego the use of collars or ear tags in surveying populations. Surveys which do not involve the use of marked animals are spoken of in vague generalities in the literature, and techniques employed are

not definite. Any attempt to duplicate these surveys or to try and retrieve a systematic methodology for use as a guide elsewhere would be a hard task.

McCrory and Blood (1977) conducted mountain goat surveys in Yoho National Park in Canada. They said their field methods made use of systematic surveys with care being taken not to allow overlap of counts. In 1961, the Washington State Department of Game conducted a statewide mountain goat survey primarily making use of ground counts. Johnson (1983) speaks of observers hiking through goat habitat, making counts, and estimating population numbers. Wright (1977) in his reconnaissance surveys into the Mt. Baler-Snoqualmie National Forest in Washington stated he made three to six backpack trips into summer goat range.

The objectives of the present study were to obtain previously non-existent baseline data on mountain goat distribution and abundance within the park by establishing systematic and repeatable methodology that could be employed by minimally trained park personnel. In this way, future population trends could be periodically monitored.

The use of radio collars or marked animals were not employed during the present study. Primary reasons centered around a lack of lead time for proper planning, lack of available funding, and lack of personnel that could devote substantial amounts of time to the project to justify the purchase and use of equipment.

National Park Service resource managers rarely have the luxury of implementing a pure research proposal when there are no apparent resource problems. Investigations which do get extensive funding are usually justified upon the extent to which results can directly aid management in decision making, or in helping to solve a crisis situation. However, a catch 22 exists in that we frequently cannot detect subtle deteriorations in the resource without first having the baseline data and continual monitoring, but we cannot have the data collection and monitoring until the crisis arises. I felt that what was most important, was to obtain as much reliable information as possible to expand the park's knowledge of its mountain goat population, given the constraints of time, funding, personnel, and lack of equipment.

Recognizing the limitations of a census without marked animals, I attempted to design a systematic methodology that would produce minimal duplication of counts. While not producing data that could be statistically tested to prove or disprove assumptions, it gives the park preliminary information upon which further investigations can be built and justified. All assumptions and limitations were clearly stated; if and when more detailed future research takes place, results can be further refined.

I wish to extend my deepest appreciation and respect to Bob Dunnagan, Assistant Superintendent of Natural Resource Planning at Mt. Rainier, who gave me the support, encouragement, and freedom to pursue the accomplishments of this and other studies. Cathy and Bill Franks and Tom Carrells spent immeasurable amounts of time in the office, in the field and in the air preparing for and carrying out the study. Their devotion, insight, and encouragement provided the impetus for much of the work accomplished. The

rangers and staff of Mt. Rainier, whose enthusiasm for resource management was made obvious during the summer, provided invaluable support material by dutifully and consistently filling out goat observation cards. I want to thank the numerous friends and associates who took the time to review my work and provide guidance and constructive criticism in refinement of my analysis, particularly Dale Reed, Torey Stevens, Murray Johnson, Ray Scharpf, Dick Taber, and Ed Schreiner. And finally, thanks to Bill Briggle, who brought me to Mt. Rainier in the first place.

THE STUDY AREA

Mt. Rainer National Park is located in south-central Washington on the western slopes of the Cascade Range. The park itself occupies roughly 98,600 hectares. Elevation ranges from 4,367 meters at the top of Mt. Rainer to a low of 488 meters in the Ohanapecosh Valley. The mountain supports approximately 48 active glaciers covering an area of about 9,800 hectares. The general topography could be described as extremely rugged with precipitous peaks and ridges centrally radiating from the mountain, dropping away to deep, U-shaped, and heavily forested valleys (Bradley 1982).

Annual precipitation is exceptionally heavy, ranging from 1.5 meters at the lowest elevation to over 2.5 meters at higher elevations. Approximately 90 percent of the total precipitation falls between November and April. At the higher elevations in the park, most of the winter precipitation accumulates as snow. The snowpack commonly reaches depths in excess of seven meters (Bradley 1982).

Air temperatures average -1 to -4°C in January. Summers are comparatively cool, with July averages of 10 to 15°C (Bradley 1982). The indicated low and high temperatures were from weather stations at 837 meters elevations and 1682 meters elevation, respectively.

Large expanses of subalpine and alpine meadows surround the mountain. The area comprises physiographic habitat requirements of mountain goats described by Chadwick (1977, 1983), Kuck (1977), Smith (1977), Bailey and Johnson (1977) and others, including steep cliffs, open meadows, permanent snowfields and ridgetops. The subalpine and alpine areas give way to permanent ice and snow at its upper reaches, and to dense old-growth coniferous forests at the lower elevations.

The subalpine meadow zone, including open subalpine woods, occurs from approximately 1,520 and 2,130 meters elevation, and comprises roughly 10,000 hectares. Vegetation in this zone has been extensively described by Henderson (1974). She identified 5 distinct vegetative types: heath-shrub, lush herbaceous, wet sedge, low herbaceous, and dry grass. Conspicuous shrubs within this zone include Phyllodoce empetriformis,Cassiope mertensiana, Vaccinium deliciosum, and Phlox diffusa. Common herbaceous plants are Valeriana sitchensis, Lupinus latifolius, Veratrum viride, Polygonum bistortoides,Aster ledophyllus,A. alpigenus,Ligusticum grayi,Castilleja parviflora,Anemoneoccidentalis, Potentilla flabellifolia, Arnica latifolia, and Antennaria lanata.The most common grass is Festuca viridula, and the most

common sedges are Carex spectabilis and C. nigricans (Bradley 1982). Tsuga mertensiana is interspersed with meadow vegetation in parkland areas.

Alpine flora grows from approximately 2,130 to 3,350 meters elevation and comprises an area roughly 6,200 hectares. Edwards (1980) described 2 main alpine community types on Mt. Rainier: heather meadows and fellfields. Of 117 species found in this zone, only 26 grow above 2,440 meters; 29 species are on the Washington state rare and endangered plant list. Many endemics may be locally abundant, but found nowhere else on earth. Subalpine species may also grow in the alpine. Species with the widest distribution around the mountain within the alpine include Draba aureola, Polemonium elegans, Tauchia stricklandii, Juniperus communis, Smelowskia ovalis, Saxifraga tolemeii, Phyllodoce glanduliflora, Carex phaeocephala, Spraguea umbellata, Lupinus lepidus, Phlox diffusa, Penstemon davidsonii, and Aster alpigenus.

From June through September 1983, approximately 6,224 visitors camped in subalpine meadow area of the park. About 4,317 additional mountain climbers, during the same period, camped in the alpine areas and higher.

METHODS

COLLECTION OF DATA

Historical Data

The park files, records, and archives contained much historical information on mountain goats which was retrieved and complied for limited use in the present study. The information was not used in determing present numbers and distribution, but only as corroborating evidence to support or reject assumptions. Historical park data was acquired from three primary sources:

1) Park wildlife observations cards documented goat sightings by park personnel and visitors from 1905 to the present. The cards are used to register all animal sightings as a part of the park's natural history records.

2) A search was made of the park archives to retrieve all historical information on mountain goat populations. Wildlife census reports (1926 - 1951), annual wildlife reports (1926 - 1976), annual superintendent's reports (1904 to 1966) showed population estimates that were based upon informal and insufficient field censusing procedures, and must not be regarded as dependable data (John Ritter, Superintendent, Mt. Rainier National Park 1966). During the war years, no information on wildlife was included in any reports.

3) From 1972 to the present, park personnel made summer aerial flights to census elk populations. Goat numbers and locations were recorded, along with other wildlife observations.

Aerial Surveys

Three aerial surveys were conducted to assess goat numbers and locations parkwide: two in mid-June and one in mid-September, 1983. Each flight had 4 observers, including the pilot. Scheduling was on a standby basis. Flights were made when the weather was clear, when the pilot had no other obligations, and when observers were not in the field or had no additional park responsibilities. Time allocated for each trip, based on available funding, was three hours. Census techniques were systematic, not random. All counts covering potential goat habitat consisted of systematically circumnavigating Mt. Rainier by flying up one side and down the other side of ridges which centrally radiate from the mountain. The elevation range covered was about 1,370 meters to 3,100 meters. Side trips to independent mountain ranges included the Tatoosh Range, Mt. Wow, Shriner Peak, and the Mother Mountains. Surveys here followed treeline at aproximately 1,676 meters elevation. Due to the limited flying time, the Crystal Mountains along the eastern boundary of the park were not surveyed.

During each flight, goat numbers and locations were recorded on a portable hand-held cassette player. No attempt was made to classify sex or age from the air. Following each flight, the information was transcribed to a U.S. Geological Survey 15 minute topographic map of Mt. Rainier.

Systematic Ground Surveys

Nine ground surveys were made into Mt. Rainier's backcountry by all or some of the same four observers, from June through August, 1983. Trip locations were based on areas of known goat habitation taken from Murray (1964 and 1965), from previous park wildlife observation cards, and from goat sightings retrieved from past elk census flights. Other factors influencing location selection were accessibility, ease of cross country travel, visibility in terms of amount of land area not obscured by trees or topographic features, and time availability of observers based on other park responsibilities.

Observations were made with a 20x and 48x power spotting scope, a 9x35 binoculars, 7 to 12x35 power binoculars, and 7x26 power binoculars. Because mountain goats are only sightly sexually dimorphic, classification is difficult at best, even to the trained observer, therefore animals were classified as either kids or older goats. Yearlings were only classified sporadically and therefore were not included in any data analysis. Nursery groups were distinguished from male bands based on the presence of kids, and certain behavioral and morphological characteristics of group members, including urination posture, stage of molt, and group size and composition. Horns were usually not used to differentiate between the sexes because the subtle differences were not always discernible at great distances. Identification was based on Nichols' (1980) summary of useful criteria for distinguishing age and sex of mountain goats during the summer.

No animals were marked or collared during the study. This had the potential to increase counting error due to movement within and between areas, causing duplicate sightings. In an effort to obtain the best reliable data within the constraints of limited time and funding, the following strategy was

employed for ground counts. During any one particular trip, the observers would individually, or in pairs, spread themselves over considerable distance throughout the area being surveyed, while keeping in radio communication. The number of goats that could positively be ascertained to have been in an area during the observation time, without duplication, was recorded and mapped in the field on U.S. Geological Survey 7-1/2 minute topographic maps. This information was transferred to 15 minute topographic maps upon return from each trip. Observation times were centered around periods of maximum synchronous goat activity (Peck and Freeman 1972, Rideout 1975, Fox 1977, Smith 1974, Chadwick 1973). This primarily occurred during early morning and late evening hours, but it was not uncommon for observers to actively search out goats all day long.

Random Sightings

Random goat sightings were made and reported from April through September in 1983 by park staff, primarily backcountry personnel. Goat observation forms, used by Nichols (1980) were duplicated and made available to park employees at seven ranger stations throughout the park. A summary of characteristics used to distinguish sex and age classes of goats was also furnished. During seasonal employee orientation, I spent a short period of time explaining identification techniques and the use of the goat observation form. Random sightings were also reported on the park's wildlife observation cards by employees and visitors. Forms and cards were returned to me. The sightings were plotted on a 15 minute topographic map of the park.

ANALYSIS OF DATA

Distribution

Analysis of data included the synthesis and interpretation of information obtained from the field work during the summer of 1983. Distribution of goats was established by compiling aerial, ground survey, and random sightings onto a composite map of Mt. Rainier, and by noting the date, time and method of each sighting on the map. Subpopulation units in Mt. Rainier were determined by delineating areas of concentration and comparing certain characteristics of each unit to known behavioral tendencies of mountain goats in relation to their environment. Parameters taken into account included size of home range of other goat populations reported in the literature; strong home range affinities of goats, especially females and nursery groups; higher tendency of males to disperse, wander, and occupy peripheral habitat between subpopulations; seasonality; elevation; topographic features potentially limiting movement (Stevens 1983, Johnson 1983, Kuck 1977, Rideout 1974 and 1977, Smith and Raedeke 1982, Risenhoover and Bailey 1982, Adams, Masteller, and Bailey 1982), and my personal knowledge and judgment of certain potential habitat areas. The subpopulation units in Mt. Rainier were defined as assemblages of goats which may include one or more nursery groups that appeared to occupy central, aparently optimal home range, and was assumed to have limited association with similar groups in other units; associated male bands occupied what was assumed to be peripheral habitat in the unit, and may have had some limited contact with other units through wandering and dispersal. The size of

each subpopulation unit was determined by planimetric estimation on a U.S. Geological Survey 15 minute map of Mt. Ranier National Park.

Abundance

Once the subpopulation units were defined, abundance was calculated and indexed. Air to ground survey accuracy ratios were established using data obtained from the aerial and ground surveys in Mt. Rainier during 1983.

Abundance in each of the subpopulation units in Mt. Rainier was calculated by an indexed population estimate:

1) The maximum ground survey count in three subpopulation units was obtained. (Data was used from only the three units where systematic ground surveys were done.)

2) The maximum aerial survey count in the 3 units was compared to the ground count to obtain an air/ground survey accuracy ratio.

3) An accuracy range was produced from the lowest and highest air/ground ratios to be applied to all the subpopulation units.

4) The maximum aerial flight count for each of the subpopulation units was then indexed using both the low and high air/ground ratio, producing a population range for each unit.

5) The overall population of the park was then a composite of all the subpopulation units, plus male groups not associated with any unit, or in transit (Stevens 1983).

Since it was assumed only a limited amount of intermingling occurred between subpopulation units, duplication was equally assumed to have occurred only to a minimum extent. However, because air and ground surveys did not occur simultaneously over a particular unit and animals were not marked, confidence limits in the expressed population range estimate were probably large.

Density Determination

Densities were determined for each subpopulation unit using the estimated population ranges and the planimetric computation for the area occupied by each unit. To calculate true density, however, one needs the actual area of suitable habitat occupied by goats, which can only be calculated using marked animals.

Kid:Older Goat Ratio Determination

Kid:older goat ratios were determined from observations during ground surveys by project observers, and were expressed at kids/100 older goats (yearlings and older), as did Kuck in his study of the impact of hunting on Idaho's Pahsimeroi goat herd (1977), Smith and Raedeke in Alaska (1982), and McCrory and Blood in British Columbia (1977). Data was also taken from other researcher's findings which reported population structure as kids:100 females,

yearlings:100 females, and males:100 females, and recalculated to represent kids:100 older goats, making it relatively comparable to the present study.

RESULTS AND DISCUSSION

Aerial Surveys

Three flights were conducted during the summer. The first two flights had the same four observers including the pilot; the last flight had two different observers participating. The pilot had previous experience flying Mt. Rainier on elk surveys during the 1982 field season. Results of each flight are summarized in Table 1.

Table 1. 1983 aerial surveys.

Date:	7/18/83	7/21/83	9/12/83
Plane	Cessna Turbo 182	Cessna Turbo 182	Cessna 182
Direction around mountain:	Counterclockwise	Clockwise	Counterclock-wise
Temperature (°F):	Low 60's	Low 60's	Low 70's
Cloud Cover:	40%	0%	0%
Turbulence:	None	None	None
Number of Goats observed:	301	277	204

A detailed account of the specific locations of goat sightings during each flight is available from Mt. Rainier National Park.

Many factors influenced the scheduling of aerial flights, however, the overriding control was always the weather. Rain, fog, or low clouds frequently cancelled previously arranged trips. At other times when weather was clear, high winds (greater than 30 to 35 mph) at upper elevations discouraged the type of small aircraft use necessary for routinely surveying the mountainside. An additional limitation to scheduling was other obligations and commitments of the participants, including the pilot. Attempts were made to fly the survey when there was a high cloud cover, minimal turbulence aloft, and in the early morning hours following sunrise, or early evening hours before dusk.

Aerial census techniques were systematic, not random. Caughley (1976) stated that estimation of numbers is most precise when sampling is random, however, in so doing problems are encountered which may often result in a loss of accuracy overwhelming the gain derived from immaculate survey design. Although systematic sampling is less theoretically sound, Caughley noted three major problem areas that do not hamper systematic sampling:

1) Random location of sampling units places a strain on the navigator, especially in mountainous terrain. Unit boundaries are difficult to determine and many mistakes can be made.

2) Planes are noisy, causing animals to move, and if sampling units are contiguous with one another, a double counting of animals may result.

3) Random location results in the lowest coverage of sampled area per hour of flying.

Ballard (1977) and Nichols (1980) have indicated that variability in counts was most closely associated to observability. Nichols found that more goats could be counted in high overcast conditions, with calm air, in early to mid summer. Hall (1977) also stressed the importance of having at least a 20 percent cloud cover, which would cause a soft, even light without glare. Conversely, sunny days produced a strong light contrast between sunny and shaded slopes which was difficult for the eyes to adjust to, produced a strong glare from snowfields, and may find goats less active (Fox 1977). Early morning and early evening hours were probably the best time to census populations, because goats would likely be feeding and hence more observable (Chadwick 1973, Peck 1972, Nichols 1980).

None of three aerial flights were conducted under completely ideal conditions, however, the first flight approximated the parameters outlined above most closely, due to the presence of clouds, late time of day, cool temperatures and season; this flight yielded the highest count of goats. The results are probably still low, due to the relative inexperience of two of the participants in aerial censusing.

The second flight, conducted in the early morning, yielded a similar, but slightly lower count. Even though temperatures were relatively cool and the observers were becoming more proficient, there were no clouds, and glare increasingly became a problem.

The third flight in September produced the lowest count, probably due to a combination of factors. Temperatures were high, cloud cover was absent, and there was much glare on the landscape. It is quite possible goats were seeking relief from the sun in concealed or timbered areas; few were seen on snowfields at the highest elevations. In addition, most of the snow had melted in alpine and subalpine meadows, revealing numerous rocks, which resembled dusty or dirt smeared goats. Hebert and Langin (1982) found aerial surveys in September unsuccessful in locating significant numbers of goats in coastal British Columbia. They indicated goats may be in the timber at this time. Nichols (1980) also found that from the end of July to the first

snowfall, many goats may not be visible during the main part of the day because they are seeking relief from the heat.

Another consideration in the low goat count in September may have been that two observers had been replaced with novice participants. Systematic transects using the same observers in British Columbia produced more accurate estimates (Hebert and Langin 1982). Houston (1982) implied a positive aspect of aerial flights included consistency of observers and pilots used. If it is an observer's first flight in a small plane over remote and awe inspiring wilderness, it is my opinion that the potential is there for the attention to drift from surveying for goats, to looking at the scenery.

The use of a non-turbo Cessna plane on the last flight probably had no effect on the number of goats seen. The difference between a turbo and non-turbo is that the engine performance of a turbo at high altitude is more efficient, not necessarily affecting maneuverability or air speed (personal communication, Renton Aviation, Renton, Washington).

All goats were probably not seen from aerial surveys. Caughley (1976) related a story of when he checked the accuracy of an aerial survey by sitting behind the regular observer and looking out the same side of the plane. The differences in observation were marked. He noted that every time survey accuracy had been tested, animals had been missed. The inexperience of the observers in aerial censusing, plus diverse terrain characteristics associated with mountain goats in Mt. Rainier probably emphasized this during 1983 aerial flights.

Other factors contributed to the knowledge and assumption that goats were missed during aerial surveys. Since billies were found in small groups during the summer in terrain that was more rugged, and in range that was peripheral to or separate from females, they were less likely to be observed, and therefore were probably under represented (Bailey and Johnson 1977, Risenhoover and Bailey 1982, Adams, Masteller and Bailey 1982).

There were instances when it was verified that the observers overlooked goat groups during aerial flights. However to be consistent with methodology, only the maximum number of goats seen by project observers was included in the population estimate.

In keeping with the methodology, some individuals could not be counted even though they were known to inhabit certain areas. For example, even though it was known that 5 individuals frequented the Stevens Peak area of the Tatoosh, as reported by U.S. Forest Service personnel, only the observation of one individual during an aerial survey was counted.

Finally, due to a lack of available flying time, the Crystal Mountains and the Chinook Pass area were not surveyed by air, nor were any ground trips made there. Since goats have been reported in this area, these groups, primarily males, were not represented.

Ground Surveys

Nine field trips were made into Mt. Rainier's backcountry to ground

survey for mountain goats by all or a combination of the same four observers for use in establishing air to ground survey acccuracy ratios. Results of each trip are summarized in Table 2.

Houston (1982), when discussing elk ground surveys, said that if observers were not in close contact, counting errors could result from animals moving within and between counting units. This was minimized during the present study with the use of radios by observers to keep in contact and verify synchronous sightings, by additional evidence from goat observation cards, and by meticulous and careful data analysis.

Wadkins (1962) in a Washington State Department of Game Job Progress Report estimated 50 percent of the population could be observed from ground surveys. Recent Department of Game studies to determine survey accuracy were undertaken using a capture/recapture program in Olympic National Forest in western Washington, and on Mt. Chopaka and Nason Ridge in eastern Washington. The intent was to intensively study areas to develop information that could be applied elsewhere. Results corroborate Wadkin's estimate.

Ground survey accuracy in Olympic National Park was calculated with marked goats over a six year period by using a ratio of number of goats seen during a census, to the estimated total. June through September ground survey accuracies from 1976 to 1981 averaged 68 percent (personal communication, Victoria Stevens, January 1984). The ground counts in Mt. Rainier were not adjusted to reflect ground survey accuracy prior to establishing an air to ground accuracy ratio. This information could not be obtained from my field work done in this study. I also felt it was not appropriate to interpolate from Olympic National Park data, even though terrain, vegetative cover and macroclimatic weather patterns associated with goat habitat were similar to Mt. Rainier. The goats in Olympic are in different stages of habitat colonization and dispersal, which may affect sightings.

In some instances, discrepancies arose as to whether sightings being made by the different groups of project observers were of the same or different groups of goats. To resolve questions such as this, it sometimes proved fruitful to go through the 1983 goat and wildlife observation cards for data to help substantiate a decision. In instances when collaborative evidence was not available, the decision was always to go with the conservative estimate to minimize duplication.

Detailed trip reports were prepared by participants and copies are available from Mt. Rainier National Park. The reports included information on weather, trail conditions, additional wildlife observations, and incident reports of movement, grouping, and behavior of goat populations being observed. In an effort to maximize repeatability of ground counts for future studies, vantage points used during each field trip, along with the locations of goat sightings were also included.

Random Sightings

From April until November, there were 95 goat observation cards and 56 wildlife observation cards with goat sightings made by park personnel and

Table 2. 1983 montain goat ground surveys.

Trip Location	Dates	Group of Observers	Observers Per Group	Maximum # of nonkids seen at one time	Maximum # of kids seen at one time	Total
Emerald Ridge	6/28-29	1	3	10	4	14
Shriner Peak	7/8-10	1	2	2	0	2
Windy Gap	7/12-14	1	3	6	0	6
N. Puyallup Glacier	7/16-17	1	2	21	5	26
Crescent Lake/ Mineral Mountain	7/22-25	2	2	51	9	62
Colonades	7/29-31	1	2	33	8	41
Spray Park	8/3-4	1	2	8	0	8
Cowlitz Chimneys/ Cowlitz Park/ Cowlitz Rocks	8/11-16	2	2		33/184*	223
Owyhigh Lakes	8/25-28	1	1	13	3	16

* A total of 33 kids out of 184 goats were observed at one time in the Cowlitz Chimneys, Cowlitz Park and Cowlitz Rocks area. The total number of goats in the next column (223) includes an additional 39 observed on Goat Island Mountain at the same time, however, distance was too great to distinguish kids at that location.

from occasional park visitors. The goat and wildlife observation forms provided supportive material. Due to the haphazard nature of the sightings, differing experience levels of observers, and inconsistent and non-systematic survey techniques, they were used only to collaborate conclusions drawn from the aerial and systematic ground surveys.

SUMMER DISTRIBUTION

Determining subpopulation units in Mt. Rainier assumed that the animals do not wander indeterminately around the mountain, without any sense of social structure limitations and resource utilization strategy, and that there were pliant limits to where they would go and to what they would do. Subpopulation units needed to be outlined in order to minimize the potential for duplicate counts during population estimation.

There were six subpopulation units of mountain goats in Mt. Rainier during the summer months, which were termed the West, Northwest, Northeast, East, South, and Mt. Wow (refer to Figure 1). They were inclusive of one or more nursery groups with females, kids and subadults, and male bands which had an association within the designated range. Movements between subpopulations were negligible for the purposes of the study, exclusive of wandering males. It was recognized that the units were not independent, isolated entities, but that migration, wandering and dispersal occurred. A boundary line is an abstraction, constantly expanding and contracting as goats respond to different physiological and environmental stimuli. The boundaries reflected and included those areas where the majority of goats were most likely to be associated with, given the parameters addressed in the following discussion. In addition to the six subpopulations, three independent male groups, which were either associated with populations outside the park, or in transit between subpopulation units within the park were noted and addressed. These were the Tatoosh, Shriner Peak, and Mother Mountain groups. A general discussion of the variables used in determining subpopulation units follows.

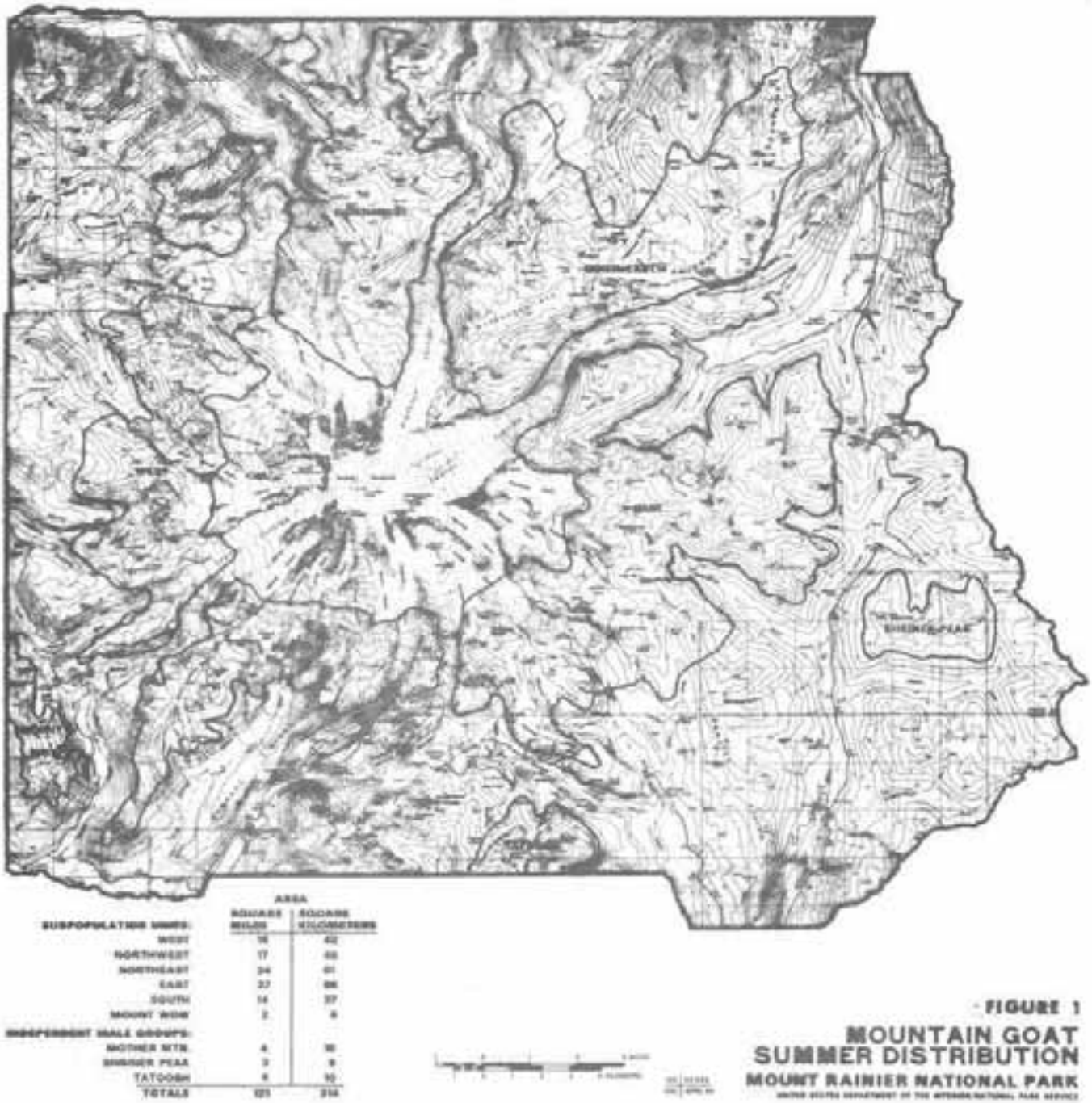
Goat locations were mapped from 1983 aerial surveys, systematic ground surveys, and random sightings, and preliminary boundaries around areas of habitual concentration, delineating the flexible limits of each subpopulation unit, were drawn. It soon became apparent that females and nursery groups were consistently oriented towards what appeared to be central, more desirable habitat in terms of apparent forage quality and quantity, escape terrain, and thermoregulatory features of the landscape, as others have described in the literature. Males and male groups occupied what appeared as peripheral, more marginal range. This type of grouping or configuration is documented extensively in the literature. Geist (1971) and Chadwick (1973) noted that females and subadults occupied optimum habitat within available range, assuring the resource base was available to the productive segment of the population, while males were found in more marginal range in rugged, higher elevation areas, specially in the summer. Risenhoover and Bailey (1982) also found that male groups were in more rugged terrain in the summer, peripheral to female groups, and may even be in forested areas.

In addition, many investigators have discussed in length the fidelity of goats, particularly females and nursery groups to home range, and the higher

Figure 1

MOUNTAIN GOAT SUMMER DISTRIBUTION

Mount Rainier National Park: Subpopulation Units, Independent Male Groups.



SUBPOPULATION UNITS:	AREA SQUARE MILES	AREA SQUARE KILOMETERS
WEST	16	42
NORTHWEST	17	44
NORTHEAST	24	61
EAST	37	96
SOUTH	14	37
MOUNT WOW	2	4
INDEPENDENT MALE GROUPS:		
MOTHER MTN.	4	10
SARVER PEAK	3	8
TATOOSH	4	10
TOTALS	121	314

FIGURE 1

MOUNTAIN GOAT SUMMER DISTRIBUTION

MOUNT RAINIER NATIONAL PARK

tendency of males to wander between areas. Stevens (1983), Kuck (1977), Rideout (1974, 1977), and Chadwick (1977) have reported that females had a strong fidelity for home range, and that summer range use from year to year was relatively constant. Chadwick goes further to say that consistent use of the same locations enforces knowledge of key feeding areas, protected bedding sites, escape terrain, and efficient daily travel routes, which may confer important survival advantages, primarily to females, since they are more likely to inherit the range.

I assumed therefore, that extensive movement of nursery groups between subpopulation units, at the expense of the aforementioned advantages to remaining traditional in range use, and therefore associations with other units, would be uncommon. I also recognized, as did Chadwick, that there could be extensive movement within subpopulation units.

By the time billies are about two to three years of age, they are becoming increasingly solitary, or associated with exclusively male groups. Because of this tendency, I assumed males were more likely to be represented on the periphery of a subpopulation unit. Chadwick (1977) found adult males solitary 50 percent of the time, and two year olds 36 percent of the time. Dane (1977) reported that adult males are only infrequently a part of the main female/subadult/kid herd. This separation was emphasized during the summer months (Johnson 1983), as I also found. Several reasons have been put forth to justify this behavior. Competition would be minimized and the potential for injury to kids from billies reduced (Risenhoover and Bailey 1982). Chadwick (1971) postulated that unsatisfactory social interactions and stress generated by conflicting sexual and agnostic drives caused adult males to move independent of female groups, and that there was greater social stability of male groups when not in association with female groups.

Once males leave, they may range widely and travel long distances between herds, Chadwick (1977), Dane (1977), Adams, Masteller and Bailey (1982), Rideout (1977), Smith and Raedeke (1982), and Stevens (1983), all refer to the tendency of males to move between areas, even outside of the rut. Dispersal may be an avoidance to inbreeding or a response to some limited resource base, as Stevens suggested, or to lessen social conflict as Chadwick emphasized. This further justified the initial perimeters of each subpopulation unit, which showed males on the edges where they could disperse freely, and which were apparent marginal areas in terms of optimum habitat requirements. This seemed to make the subpopulation unit boundaries a more accurate representation of potential range based on the known goat behavioral characteristics reported in the literature.

In addition to home range characteristics of female and male groups, elevation was used to further refine the limits of each subpopulation unit. Throughout its present range in North America, mountain goats occupy different elevations in the summer, due to latitudinal variations in vegetation structure and the location of the treeline (Johnson 1983). Treeline in Mt. Rainier ranges from 1,620 meters in the west and south parts of the park to 1,240 meters in the east (Henderson 1974).

Out of the 148 wildlife and goat observation forms dated from April until November, 95 had elevation reported on them. The range of goat sightings was

from 1,280 meters to 2,290 meters. Ninety one percent of the reports were between 1,650 meters to 2,160 meters. The most commonly reported elevation (19 percent) was 1,830 meters.

During the nine field trips made by project observers, all goat sightings and wanderings recorded were between 1,490 meters and 2,290 meters, occurring from the end of June to the end of August. The most common elevation was 1,950 meters.

All aerial survey sightings were also within the elevation range of 1,280 meters to 2,290 meters with one exception. Two adults, included in the southern peripheral edge of the northwest subpopulation unit, were observed at 2,530 meters on Curtis Ridge.

The elevation range of 1,280 meters to 2,290 meters was used as a guide in refining unit boundaries because it was inclusive of the ground, aerial and random sightings; it was not, however, used as an absolute. The author's personal knowledge of certain areas precluded their incorporation into subpopulation unit boundaries, because of dense forest without outcroppings, close proximity of visitor use or roaded areas, or areas with no past sightings even though they may have been within the appropriate elevational limits.

In general, boundary estimates using elevation were oriented towards the conservative side so as not to overrepresent marginal or peripheral habitat on the edges of the subpopulation units. Otherwise densities, when determined, would be grossly underrated, since goats, especially nursery groups, may use range intensively, not extensively, and the smaller male bands are the ones more typically found on the far reaching edges (Chadwick 1977).

Topographic features, to a lesser extent, were also used to ascertain subpopulation units. Stevens (1983) noted that topography was a limiting factor in home range. For example, while glacier travel is certainly not uncommon for mountain goats, if major glacial systems appeared to fall out at the margin of a subpopulation unit, and only males were observed in the vicinity, I assumed that major movements of nursery groups did not typically occur across these areas. In addition, even though goats have been known to swim across rivers, it has not been frequently documented in the literature, and therefore under the same conditions described for glaciers, major river systems were used to delineate boundaries where appropriate.

Each subpopulation unit had instances where the variables discussed could not resolve whether to separate or combine two units. On these occasions, I relied on personal knowledge and judgment, along with collaborating evidence from park records and historical files to justify decisions.

After examining the variables and refining the extent of each subpopulation unit's limits, area was calculated. Mt. Rainier National Park has approximately 314 square kilometers or about 31,300 hectares of potential goat habitat. This included central, optimum range occupied by females and nursery groups, and peripheral areas occupied by male bands. Vertical relief was not accounted for. A complete and thorough discussion illustrating specific rationale used in delineating each of the subpopulation units, giving

detailed boundary justification using the variables previously discussed, is available from Mt. Rainier National Park.

Table 3 summarizes particular aspects of each subpopulation unit's range and size. Henderson (1974) and Edwards (1980) respectively studied the vegetation in the subalpine and alpine areas in the park. Combined, the area supporting subalpine and alpine vegetation was 12,350 hectares. This is usually the type of habitat most typically associated with mountain goats. Clearly, the present study showed an estimate of potential goat habitat considerably higher, indicating that the animals used more of the landscape than just subalpine and alpine meadows, and may rely on glaciers, rocky areas and timber for ecological and physiological requirements.

Table 3. Size of mountain goat subpopulation units and independent male group range in Mt. Rainier National Park.*

Subpopulation unit or male group	Maximum linear distance of range (kilometers)	Area (sq. kilometers)	Area (hectares)
West	12.0	42	4,170
Northwest	12.0	45	4,490
Northeast	12.7	61	6,130
East	12.4	95	9,480
South	13.3	37	3,700
Mt. Wow	6.4	6	630
Shriner Peak	not applicable	10	1,130
Tatoosh	not applicable	8	810
Mother Mtn.	not applicable	10	950
	TOTAL	314	31,290

* Independent male group range is presented in order to calculate total area of summer distribution.

Different investigators have reported varying results when determining magnitude of home range. Johnson (1983) generalized that mountain goat summer range in Washington state averaged 11.4 to 15.4 square kilometers. However, the estimates for Washington were for the most part, determined from harvested and managed populations in areas that did not have the expanse of available and protected habitat found in Mt. Rainier National Park, and therefore may not be comparable. Goats on Klahhane Ridge in Olympic National Park had a summer range of 13 square kilometers, and at Royal Basin and Lake Constance in the same area the range was 16 square kilometers (Stevens 1983).

Rideout in Montana (1974, 1977) found mountain goat summer range varied with age and sex. Yearlings commonly averaged 41.2 square kilometers. The yearlings' maximum summer range coincided with most of the approximations for Mt. Rainier's subpopulation units (Table 3), which reflected all individual movements and were therefore also a maximum. This large range of yearlings is common in other ungulates as well, and Rideout stated it may be due to the

animal's sudden subordinate role when its nanny gives birth, and its rejection and subsequent forced movement from one female kid group to another. Relative to each other, the subpopulation unit characteristics within the park appeared fairly constant, with the exception of Mt. Wow. Mt. Wow appeared to have characteristics consistent with Steven's account of summer range in the Olympic Mountains, Johnson's statewide average, and Rideout's estimate for adult males and females in the Sapphire Mountains of Montana.

Some researchers have reported home range as the greatest linear distance between two observations of known individuals. Adams, Masteller and Bailey (1982) reported the average on Sheep Mountain and Gladstone Ridge in the Sawatch Range of Colorado was 6.4 kilometers, while the maximum was 15.9 kilometers. In the Bunker Creek drainage in Montana, Chadwick estimated 11.2 kilometers was the maximum length of summer range use. The maximum figures coincided well with the estimates for Mt. Rainier, which were also assumed as maximum distances. Mt. Wow again best corresponded to average findings (Adams, Masteller and Bailey 1982).

Mt. Wow may typically represent the habitat that is available to many other goat populations, in terms of its isolation from other expanses of habitat, small size, adjacent clearcutting in the national forest, and exposure to hunting pressures because of this proximity. As stated before, the habitat along the slopes of Mt. Rainier may be atypical because of the wide reaches of protected alpine and subalpine terrain.

It may not be appropriate to compare figures from one geographical area, and from one study to another. The subpopulation units in Mt. Rainier contained one to several nursery groups that may have periodically associated, disbanded, and reformed with one another. They also contained the individual male bands located throughout the area. The subpopulation unit estimates in Mt. Rainier therefore took into account all female range and all associated male peripheral wandering areas. They may appear high when compared to other studies, which may have just included the home range of one particular herd within a larger population, roughly corresponding to a nursery group within a subpopulation unit in Mt. Rainier. Also, results from other studies were from collared or marked animals, indicating more precise data.

In addition, different aspects of a population affect its behavior and movement. The Olympic mountain goats are recently introduced and are, generally speaking, in a state of dispersal and colonization, where Mt. Rainier's goats are native, and presumably have established traditional range. Density, competition, and availability of limiting resources also affected dispersal of goats and subsequent range size in Olympic (Stevens 1983). Since the status of these parameters has not been scientifically and quantitatively established for goats in Mt. Rainier, it is inappropriate to compare results with other populations where health, vigor, and population dynamics have been verified.

Abundance

The estimated population range of mountain goats in Mt. Rainier National Park was 374 to 500 individuals. This estimate was based on clear systematic

methodology making it possible to repeat in the future and thus detect trends in population size.

Table 4 illustrates the computation used in indexing the systematic ground surveys. Three subpopulation units, west, northwest, and east, had sufficient systematic ground survey time to establish a reliable count. The ground counts were then used to establish an air/ground survey accuracy range for use in population estimation. A resultant accuracy range of 69% to 92% was applied to the maximum aerial count in each subpopulation, as shown in Table 5. Many factors influenced survey accuracy, including but not limited to weather, topography, snow cover, vegetative cover, season, type of aircraft, and experience and consistency of observers. Estimates are probably low due to goats missed during ground and aerial surveys.

In 1894, John Muir "reckoned" there were over 200 goats on the slopes of Mt. Rainier (Johnson 1964). This largely reflected the manner in which goat numbers were recorded in the park over the years; the most striking feature of population estimates in historical and recent park files and archives is that they were always in neat, rounded figures, periodically shown to increase and decrease linearly. Most of the early information on goats consisted of generalized statements about population increases during the period which predator control philosophy was popular. Narrative descriptions were vague and qualitative. Estimates were usually dependent upon the interest and subjective interpretation of one or two rangers, whose prime duty was to patrol, not census mountain goats. Reports were laced with statements such as "past studies and present sightings were used as a guide;" and "no formal census was made." It cannot be ascertained how counts were performed, how numbers were estimated, how the goats were distributed parkwide, and if the numbers were truly accurate representations. The data cannot be taken as absolute, and can only be used as a reference to make generalized assumptions, not definite conclusions.

Partial data is presented for the reader's information to illustrate relative numbers and trends:

Year	Estimate
1926	250
1930	250-275
1935	310-400
1940	400-500
1945	350-400
1950	300
1965	350
1970	350
1975	400

Murray Johnson (1964) estimated the numbers of animals at 339-385. While based on actual counts, the figures did not account for all areas, and did not account for duplicate counts on wandering animals. Numbers were based on sightings at single locations in time. The potential errors of not accounting for total subpopulation structure, dynamics and movement are described elsewhere. Since methodologies were different, sources of data acquisition

Table 4. Determination of air/ground survey accuracy ratios for use in estimating population range.

Subpopulation unit or independent male group	Systematic ground survey results (G)*	Maximum aerial count (A)	Computation of air/ground survey accuracy ratio (A/G=X/100)	Air/ground survey accuracy ratio
West	41	31	31/41 = X/100	76%
Northwest	62	57	57/62 = X/100	92%
Northeast	No systematic ground survey done			
East	223	153	153/223 = X/100	69%
South	No systematic ground survey done			
Mt. Wow	No systematic ground survey done			
Tatoosh	No systematic ground survey done			
Mother Mtns.	No systematic ground survey done			
Shriner Peak	2	0	0/2 = X/100	0%**

*Maximum number of goats seen in an area during observation time without duplication.

**This percent is not used in the range of aerial survey accuracy when determining population estimates. Only one flight was made over this area.

Table 5. Determination of estimated mountain goat population using an aerial survey accuracy range of 69% to 92%.

Subpopulation Unit of independent male group	Maximum aerial count (A)	Calculation of low estimate (L) A/L = 92/100	Calculation of high estimate (H) A/H = 69/100	Estimated population range (L to H)
West	31	31/L = 92/100	31/H = 69/100	34-45
Northwest	57	57/L = 92/100	57/H = 69/100	62-83
Northeast	41	41/L = 92/100	41/H = 69/100	45-59
East	153	153/L = 92/100	153/H = 69/100	166-222
South	28	28/L = 92/100	28/H = 69/100	30-41
Mt. Wow	29	29/L = 92/100	28/H = 69/100	32-42
Tatoosh	1	1/L = 92/100	1/H = 69/100	1-2
Mother Mountains	4	4/L = 92/100	4/H = 69/100	4-6
Shriner Peak	0	0/L = 92/100	0/H = 69/100	0
			Total	374-500

different, and number of observers actively involved over the entire park different, it cannot be finally concluded that the population in Mt. Rainier has increased from 339 to 385 individuals in 1964, to a range of 374 to 500 individuals in 1983.

In general, it appears as if the mountain goat population within the park may be stable, or has slightly increased since the early part of the century. Most mountain goats are sensitive to disturbances, such as close proximity of roads and road building activities, increased access to habitat, loss of habitat, logging, mining, and visitor use. While populations in portions of the Olympic and Rocky Mountains can be approached to within a few feet at mineral licks, goats within Mt. Rainier exhibited a high intolerance of human interactions (generally less than several hundred yards). Wright (1977) studied the low productivity of the Barometer Mountain goat herd in the Mt. Baker-Snoqualmie National Forest in Washington. He observed the correlation of logging operations with the sudden movement of goats out of the area. Chadwick (1973) suggested goats abandoned areas where road building and logging operations occurred in the Swan Ranger of Montana. Wildlife biologists in Alberta, Canada partially attributed the mountain goat decline there to improved access into goat habitat provided by logging industries (Chadwick, 1973).

As is apparent to anyone who has visited Mt. Rainier, logging has occurred in some areas to within six inches of the park boundary; the park has been likened to an ecological island. Manipulation of habitat in the Gifford-Pinchot and Mt. Baker-Snoqualmie National Forests may have forced goat populations from adjacent Forest Service land, to immigrate into the protected and relatively undisturbed environment of Mt. Rainier. It is not known whether any subpopulations or groups of goats in the park are experiencing pressures of crowding, competition, and stress. This could only be determined from intensive, long term studies of population dynamics and population health and vigor, and forage quality and quantity.

However, the goats in Mt. Rainier may just be exhibiting a natural population increase due to long range climatic trends, decrease in predators or decrease in competition. The relatively high numbers may also just represent the results of the first comprehensive count.

DENSITIES

Mountain goat densities were calculated using the estimated population range. The densities for the individual subpopulation units are in Table 6. They ranged from 1.8 to 2.4 goats per square kilometer parkwide. The estimates did not include the three independent male groups, for it was not determined if they permanently used the range or were in transit between subpopulation units.

Since it has been theorized that goats use range intensively, not extensively (Chadwick 1977), the densities may be oriented towards the low end of the scale. This is especially true since subpopulation units included all the peripheral males wandering where female groups were rarely seen to venture during the summer months, if at all. To determine the actual home range size

of the involved nursery groups, and to calculate a representation of actual density, use of telemetry or marked animals must be employed, along with extended and continuous observations.

Table 6. Mountain goat density

	Goats/kilometer^2
West	.8 - 1.1
Northwest	1.4 - 1.8
Northeast	.7 - 1.0
East	1.8 - 2.3
South	.8 - 1.1
Mt. Wow	5.3 - 7.0
Parkwide Average	1.8 - 2.4

The same reasons that the author put forth for the difficulty of comparing home range size between Mt. Rainier and studies in other geographical areas are applicable here. Since the parameters of population health, vigor and fecundity have not been established for any of Mt. Rainier's goats, densities cannot be construed as being "high" or "low". Further investigations are required to determine if densities can be correlated with resource availability, competition, and individual and population health.

Selected results from other studies, presented in goats per kilometer squared on summer/fall range are presented only for illustrative purposes in Table 7.

Table 7. Comparison of mountain goat densities on summer/fall range; results of selected studies.

Area	Goats/kilometer^2	Source
Olympic Mountains, Washington		Stevens 1983
Klahhane Ridge	14.0	
Royal Basin	2.0	
Constance	4.0	
Mt. Anderson	1.7	
Baileys	3.2	
Glacier Meadows	0.06	
Yoho National Park, B.C.	1.5	McCrory & Blood 1977
Sapphire Mountains, Montana	0.6 - 1.1	Rideout 1977
Black Hills, South Dakota	1.5 - 4.6	Richardson 1971
Kodiak Island, Alaska	7.7	Hjeljord 1973
Kenai Peninsula, Alaska	2.6	Hjeljord 1973
Swan Mountains, Montana	1.2	Chadwick 1973
Glacier National Park	1.2	Chadwick 1973
Mt. Baker-Snoqualmie National Forest, Washington	0.6	Wright 1977

The Klahhane Ridge density of 14 goats per square kilometer is the highest known density in North America. Stevens (1983) extensively examined and compared characteristics of this subpopulation to others within the Olympic National Park. She consistently found that in this high density population there was slower growth and maturation, lower reproductive rates, lower nutritional levels as shown by nitrogen and hematocrit, declining average horn growth rates, and higher dispersal rates. A study such as this in Mt. Rainier, which would compare different groups between subpopulation units, would indicate the relative status of herd fitness. With a potential of increasing threats to the national park from external sources, the condition of internal resources, including goat populations, needs to be established and periodically monitored prior to any degradation.

Kid Ratios

Kid ratios were determined exclusively from systematic ground surveys and are expressed as kids per 100 older animals. Sufficient information was gathered to determine ratios from three subpopulation units as expressed in Table 8. Ratios ranged from 16 kids per 100 older goats in the Northwest unit to 20 kids in the West unit.

Table 8. Kid ratios in Mt. Rainier National Park, 1983.

Subpopulation Unit	Kids/100 older goats	Month
West	20	July
Northwest	15	July
East	18	August

Productivity is not an absolute indicator of population health and vigor although it has been used as a comparative index in a number of studies. The method of productivity in this study (kids:100 older goats) was the best that could be done under the circumstances although it was recognized that it was not the most refined indicator. However, it can be replicated in the future by minimally trained field assistants.

Johnson (1983), in his report on the mountain goats of Washington, presented the productivity of various populations around the state as kids per 100 adult females. The author recalculated his data to express population structure as kids per 100 older goats, for comparability with Mt. Rainier (Table 9). In studies undertaken in Washington state in 1939 and 1940, and again from 1976 through 1981, kid ratios ranged from 25 to 58 kids per 100 older goats.

At first glance, it appears as if kid ratios in Mt. Rainier may be substantially lower than other areas of Washington. However, this cannot be conclusively stated. A single year's worth of data does not show trends in the overall productivity of the population. Stevens (1983) found highly variable reproductive rates from year to year in Olympic National Park, corresponding to weather patterns, which in turn affected forage quality and availability.

She found a positive correlation of reproductive rates with the total winter precipitation (November to March) 1.5 years before birth; and a similarly high correlation between reproductive rates and April snow depths 13 months before birth. The model she presented assumed ovulation rates in the fall were dependent on the amount of nutrients stored by adult females during the previous summer, which would be dependent upon ther winter precipitation, affecting quality and/or availability of forage.

Table 9. Population structure of mountain goats in Washington (taken and recalculated from Johnson 1983).

Area	Period	Kids/100 Older Goats
Pasaytan Wilderness	1939-1940 S,F,W*	39
Chopaka Mountain	1939-1940 S,F,W	35
Mt. Chopaka	1977-1980 Sp	27
Lake Chelan	1939-1940 S,F,W	30
Olympic National Park	1976 F	58
Barometer Mtn./Mt. Baker	1976 S,F,W	25
Nason Ridge	1978-1981 Sp	33
Olympic National Forest	1979-1980 Sp	33

* Sp = spring; S = summer; F = fall; W = winter.

In April of 1982, precipitation reported at Paradise Ranger Station in Mt. Rainier was 28.5 centimeters; the previous 30 year average was 19.3 centimeters. The increased precipitation and resultant snowfall conceivably could have affected forage availability at higher elevations into the summer, thereby affecting the nutrients stored by the adult females pre-ovulation, and ultimately manifesting as low kid ratios during 1983. However, there was not sufficient data to perform statistically valid correlation analysis on reproduction in Mt. Rainier, and what influenced it.

Another variable influencing kid ratios is the time of year when counts are made. Late spring/early summer counts, when kids are first born, reflect higher numbers than late summer or fall. Surveys in Mt. Rainier to determine kid ratios were done from July through mid-August, which allowed time for neonate mortality to take its toll on the young. This is typically attributed to climbing accidents and rockfalls, and to a lesser extent, predation (Chadwick 1973).

A third factor in kid production involves the nature of the population. Tabor and Stevens (1980) found colonizing populations, such as the introduced

herds on the Olympic Peninsula, had higher reproduction than interior Washington populations. According to this postulation, ecological carrying capacity in Mt. Rainier may be realized, thus influencing forage availability and reproductive success.

Disturbance and adjacent land use may also reflect low kid ratios. This has been demonstrated in native, non-expanding populations. Chadwick (1973) associated initial logging activities and related hunting and poaching pressure, with low ratios in five areas in Montana; these ranged from 8 to 22 kids per 100 older goats (recalculated by the author from data expressed as kids per 100 adult females). It is not known what effects, if any, logging, road building, increased access, hunting, and poaching peripheral to Mt. Rainier are having on internal mountain goat populations.

Finally, as Johnson (1983) stated, "... annual kid production can only be assessed accurately if the proportion of young to breeding age females can be determined." This can prove to be a formidable and error laden task; one which was not undertaken in the scope of this project.

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