

MOUNTAIN GOAT CENSUS IN THE OLYMPIC MOUNTAIN RANGE, JULY 1994

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Report to the Superintendent Olympic National Park

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Abstract

We conducted a helicopter census of introduced mountain goats (*Oreamnos americanus*) in the Olympic Mountains during July 1994. The population on the 50,063 hectare census zone was estimated with a stratified random block design at 288 ± 32 (SE) goats. Confidence limits are ± 63 goats, thus with 95% certainty the true value of the population estimate lies between 225-351 goats. The 1994 estimate did not differ significantly from the 1990 census. Record high temperatures may have influenced goat observability.

Introduction

Mountain goats were introduced to the Olympic Mountains during the 1920's (Houston et al. 1994). An initial helicopter census conducted in July 1983 returned an estimate of 1175 ± 171 (SE) goats. A second census in July 1990, conducted following the extensive National Park Service management program to remove goats, produced an estimate of 389 ± 106 goats. Here we report results from the third extensive census, conducted during July 1994.

Study Area and Methods

The rationale for the helicopter census design has been described in detail (Houston et al. 1986, 1991). Briefly, the census zone included all of the 50,063 ha of land free of glacial ice above 1520 m (5000 feet) in the Olympic Mountains. A block count sampling method was used and four census strata were recognized:

(1) Known or suspected high density areas: Olympus, Chimney-Crystal, Carrie, Flapjack-Hopper, Washington, Buckhorn, Constance (Figure 1). 8700 ha total area. Aerial total counts were attempted on each of these units.

(2) Known or suspected medium density areas. 9246 ha. These were divided into 17 blocks of about 500 ha each. Twelve blocks (70.5%) were chosen randomly and censused.

(3) Known or suspected low density areas. 30,120 ha. These were divided into 61 blocks of about 500 ha each. Fifteen blocks (24.5%) were chosen randomly and censused.

(4) Klahhane Ridge. 1997 ha. An aerial total count was

conducted because of the long history of aerial censuses and population dynamics data available for this subpopulation (Small portions of this long-established unit extend below 1520 m elevation).

The population estimate for strata 2 and 3 was calculated with Jolly's (1969) method for unequal-sized sample units as described by Norton-Griffiths (1976:72). The counts for strata 1 and 4 were added, without variances, to the estimates for strata 2 and 3, a move analogous to "stratifying out large herds" (Norton-Griffiths 1978:84).

The same block boundaries used in the 1983 and 1990 census were used in 1994. Individual blocks were sometimes reassigned to low, medium or high density strata. Based on results from the 1990 census, we increased both the size and number of total count units suspected of supporting high densities of goats (locations also changed for two units). This restratification was an attempt to improve census precision by reducing the large standard errors of the estimates, which were 15% in 1983 and 27% in 1990.

Aerial census is known generally to underestimate the actual numbers of animals present. We used the 66% sightability adjustment (Houston et al. 1991) to produce a more accurate estimate (i.e., nearer the true total) for the 1994 count. Accordingly, the number of goats observed in each census unit was multiplied by 1.52 (the reciprocal of 0.66).

Results and Discussion

The census was conducted in six early morning flights between 19-25 July. Total census time (including travel among counting blocks and trips to the Hurricane Ridge refueling station) was 19.6 hours, comparable to the earlier counts. Detailed results by counting block are provided in the accompanying flight report.

A total of 153 goats (121 adults, 32 kids) was counted in the four strata (Table 1, Figure 1). The estimated goat population for strata 2-3 ($\hat{Y}_{2-3}$) was calculated as:

Stratum	$\hat{Y}_h$	$\text{Var}(\hat{Y}_h)$
2 (low density)	48.8	744.5
3 (medium density)	<u>61.6</u>	<u>274.9</u>
Total	110.4	1019.4

The standard error ($\hat{Y}_{2-3}$) is $\sqrt{\text{Var}(\hat{Y}_{2-3})}$ or 32 goats. When the 176.3 goats in the high density units and the 1.5 from Klahhane Ridge are added, $\hat{Y}_{1-4}$ totals $288 \pm 32(\text{SE})$ goats for the population in the census zone during July 1994. Approximate 95%

confidence limits are ± 63 goats ($1.96 \times \text{SE}$). Thus, with 95% certainty the true value of the population estimate in the census zone lies between 225-351 goats. We were successful in reducing the standard error by increasing the area and number of total count units; these units accounted for about 76% of the total number of goats counted.

Table 1. Area sampled and mountain goats counted in the 1994 census.

Stratum	Area (ha)	No. Blocks	Area Sampled	Blocks Counted	Goat Numbers ¹
1	8,700	---	8,700	---	116 (176.3)
2	9,246	17	6,393	12	28 (42.6)
3	30,120	61	7,472	15	8 (12.2)
4	1,997	---	1,997	---	1 (1.5)

1. (Numbers observed $\times 1.52$).

The 1994 estimate does not differ significantly from the 1990 estimate of 389 ± 106 goats (t test $\alpha_{0.05(2)}$, $t_{\text{calculated}} = 0.91$; Norton-Griffiths 1978:80, Gasaway et al. 1986:62) and we conclude that goat numbers did not change during the four years. Marked differences were recorded, however, in some units compared to 1990 (Figure 1). The Olympus count was much higher (41 in 1994 versus 8 in 1990), due in part to enlarging the total count unit. The Buckhorn-Warrior Peak-Mount Constance count was much lower (1 in 1994 versus 35 in 1990).

Caution must be used in interpreting the overall results of the census and the changes recorded within units because the 1994 count was conducted during a period that included record high temperatures for the Puget Sound region. Maximum outside air temperatures recorded from the aircraft during the census were significantly higher in 1994 compared to 1990 (Mann-Whitney test, $P < 0.05$). Goats are known to be sensitive to high ambient temperatures and may seek relief in forests (Stevens 1979). Forest habitat occurs mostly below the 1520 m lower boundary of the census zone. Several days prior to the count we received credible reports of 10 goats in the Buckhorn Unit, 6-8 goats at Lake Constance, and 9 on Klahhane Ridge. During the census we tallied 0, 1, and 1 goat in these respective areas. Differences may have reflected the effects of high temperatures on goat distribution.

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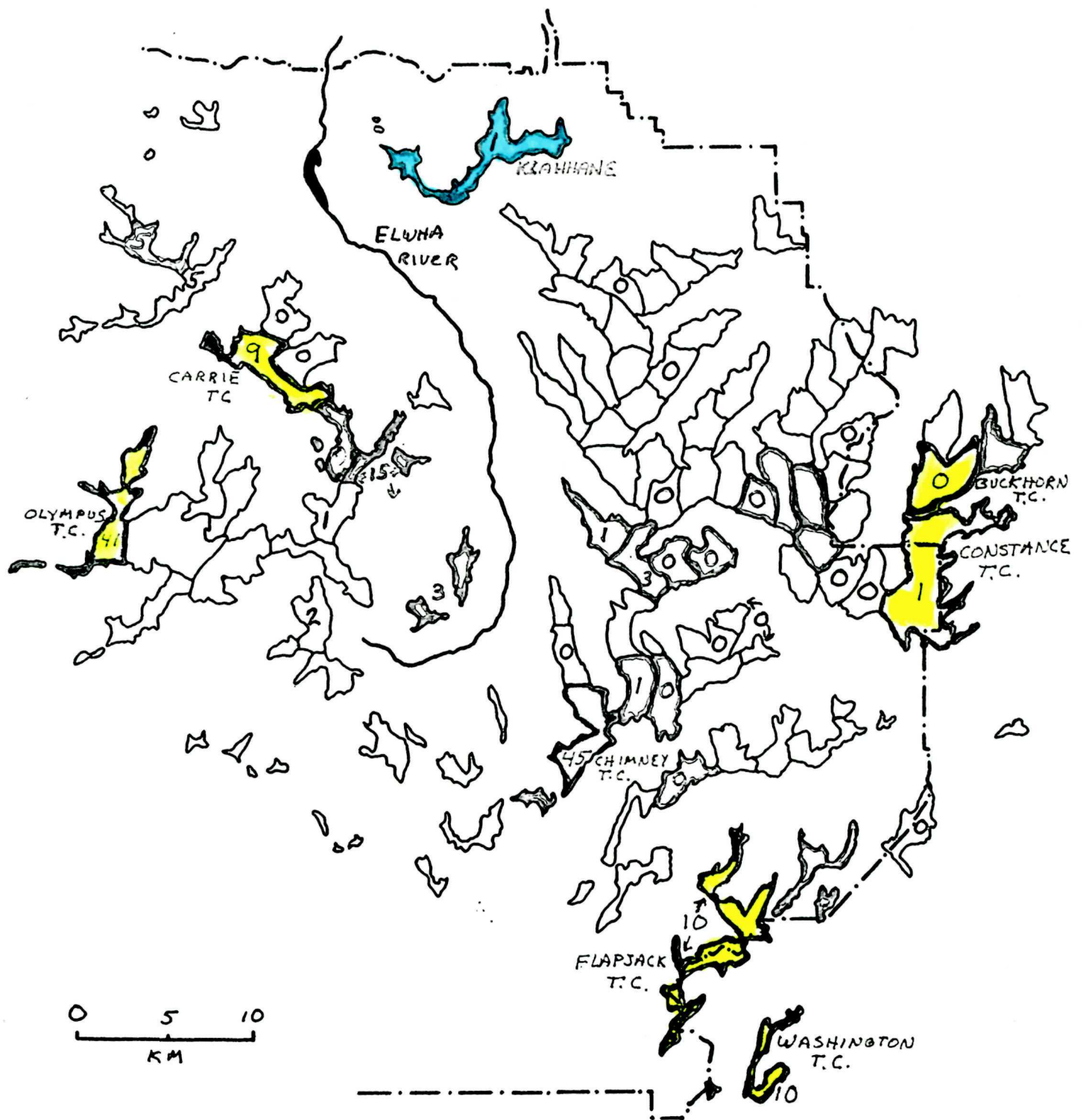


Figure 1. Number of mountain goats observed per census unit, Olympic Mountains, July 19-25, 1994. Total count (T.C.; red), Klahhane (blue), medium density (green) and low density (black) areas are indicated. Extensive areas of glacial ice are not shown. Heavy dashed line represents boundary between Olympic National Park and Olympic National Forest.

MOUNTAIN GOAT CENSUS -- FLIGHT REPORT

Olympic National Park and adjacent
areas of Olympic National Forest

July 19-25, 1994

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Richard W. Olson
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This report presents results from a stratified random-block census of mountain goats conducted during July 1994. Survey techniques were similar to those used during the 1983 and 1990 censuses (Houston et al. 1991 Northwest Science 65:212-216). The census zone included the 50,063 hectares of land, free of glacial ice, that occurs above 1520 m (5000 feet) in the Olympic Mountains. Four census strata were recognized:

(1) Known or suspected high density areas: Olympus, Chimney-Crystal, Carrie, Flapjack-Hopper, Washington, Buckhorn, Constance (Fig. 1). 8700 ha total area. Aerial total counts were attempted in each of these units.

(2) Known or suspected medium density areas: 9246 ha. These were divided into 17 blocks of about 500 ha each. Twelve blocks (70.5%) were chosen randomly and censused.

(3) Known or suspected low density goat areas. 30,120 ha. These were divided into 61 blocks of about 500 ha each. Fifteen blocks (24.5%) were chosen randomly and censused.

(4) Klahhane Ridge. 1997 ha. An aerial total count was conducted over the entire unit because of the long history of aerial censuses and other information on this subpopulation.

Essentially the same block boundaries used in the 1983 and 1990 censuses were used in 1994. However, individual blocks were sometimes "regrouped" into low, medium, and high density strata. Based on the 1990 census results, the areas and numbers of total count blocks were increased relative to earlier censuses (locations also changed for two units) in an effort to reduce the standard error of the estimated number of goats. Fog precluded a complete census of the Klahhane unit, small areas around Unicorn Peak and the road tunnels could not be surveyed.

Pilot, Aircraft, and Observers: J. Schuler, Eagle Air

Helicopters, Hughes 500D; R. Olson navigator/observer, R. Hoffman, D. Houston, B. Moorhead, observers. C. Hoffman served as alternate observer for 1 day.

Times, General Areas Censused, and Observing Conditions:

19 July	Mount Olympus and the Bailey Range. Clear, calm. Temperatures 15-17 C.
20 July	Mt. Washington, Elinor, Brothers. Clear, ~5 MPH E. wind. Temperatures 18-21 C.
21 July	Chimney Peak, Anderson, La Crosse. Clear, calm. Temperatures 16-20 C.
22 July	Buckhorn, Constance. Clear, calm. Temperatures 16-21 C.
23 July	Dana-Wilder, Claywood. Clear, calm. Temperatures 19-21 C.
25 July	Klahhane, Appleton. Mostly clear above 1520 m, but dense fog below that elevation obscured portions of the Klahhane census block. Temperatures 13 C throughout.

Note: Counts occurred during a period of record high temperatures in the Puget Sound Region. High temperatures are known to affect goat distribution.

Total counting time was 14.7 hours. Total census time (counting time plus travel between counting units and to and from the refueling base at Hurricane Ridge) was 19.6 hours. An additional 6.7 hours was expended on ferry time and other activities (a flight cancelled on 18 July due to poor weather, obtaining video of goats on the census blocks, search for an elk group, etc.).

Goat Numbers and Distribution: A total of 153 goats (32 kids, 121 "adults") was counted (Table 1, Fig. 1). These included 116 goats counted on the high density blocks, 28 on medium density blocks, 8 on low density blocks, and 1 on Klahhane. Overall, 73 groups were observed with a mean size of 2.05 ± 1.78 goats (range 1-9). The ratio of kids/adult was 0.26 overall. Goat counts will be expanded into a population estimate in a separate report.

Note: Several days prior to the census we received credible reports of 10 goats (including kids) in the Buckhorn Unit, 6-8 goats at Lake Constance, and 9 on Klahhane Ridge (including 3 kids). During the census we tallied 0, 1, and 1 goat in these respective areas. Differences may reflect the effects of warm temperatures on goat sightability during the census.

Other ungulates: 72 deer and 251 elk were counted in the census blocks (Table 2). A search of meadows in the upper Cameron Creek drainage on 23 July failed to locate the elk groups that usually occupy the area.

Carnivores: 34 black bears, 2 golden eagles, and one unidentified eagle were tallied during the count (Table 2). Twenty-nine bears occurred as single individuals; only 2 females with cubs-of-the-year were observed, one with a single cub and the other with twins.

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Table 1. Distribution of mountain goats by counting unit,
19-25 July, 1994.

Counting Unit	Adults*	Young	Total
<i>(1) High Density-Total Count</i>			
Olympus	35	6	41
Chimney-Crystal	35	10	45
Mt. Carrie	7	2	9
Flapjack-Hopper	8	2	10
Washington	7	3	10
Buckhorn	0	0	0
Constance	1	0	1
<i>(2) Medium Density-Sample blocks</i>			
01 Appleton	4	1	5
02 Mt. Ferry	0	0	0
03 Scott-Luden	10	5	15
04 Dana-Wilder	3	0	3
05 West Peak	1	0	1
06 Mt. Anderson	0	0	0
07 La Crosse	0	0	0
09 Wellesley	0	0	0
10 Thous. Acre Meadow	0	0	0
11 Mt. Fromme	2	1	3
12 Claywood	1	0	1
13 Graywolf	0	0	0
<i>(3) Low Density-Sample blocks</i>			
02 High Divide	3	2	5
03 Fitzhenry	0	0	0
04 Long Creek	0	0	0
06 Bear Pass	1	0	1
11 Mt. Queets	2	0	2
17 Mt. Norton	0	0	0
23 Brothers	0	0	0
26 Diamond Mtn.	0	0	0
27 Hatana Falls	0	0	0
29 Sunnybrook	0	0	0
30 Home Lake	0	0	0
31 Royal Cr.	0	0	0
42 Mt. Cameron	0	0	0
47 Moose Lake	0	0	0
55 Elk Mountain	0	0	0
<i>(4) Klahhane Ridge</i>			
Klahhane	1	0	1

* Considered here to be all animals older than kids.

Table 2. Elk, deer and carnivores counted, 19-25 July, 1994.

<u>Counting Unit</u>	<u>Elk</u>	<u>Deer</u>	<u>Bears</u>	<u>Other</u>
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(1) High Density-Total Count

Olympus	76	26	6	1 g. eagle
Chimney-Crystal	21	3	4	
Mt. Carrie	16	2	1	1 eagle
Flapjack-Hopper	21	0	0	
Washington	0	0	0	
Buckhorn	0	0	3	
Constance	0	2	0	

(2) Medium Density-Sample blocks

01 Appleton	6	0	1	
02 Mt. Ferry	0	0	1	
03 Scott-Luden	40	0	0	
04 Dana-Wilder	31	0	2	
05 West Peak	0	2	3	
06 Mt. Anderson	0	0	0	
07 La Crosse	0	0	0	
09 Wellesley	0	0	0	
10 Thous. Acre Meadow	0	1	2	
11 Mt. Fromme	0	0	3	1 g. eagle
12 Claywood	1	0	2	
13 Graywolf	0	1	0	

(3) Low Density-Sample blocks

02 High Divide	35	8	3
03 Fitzhenry	0	0	0
04 Long Creek	0	1	0
06 Bear Pass	0	0	0
11 Mt. Queets	0	0	0
17 Mt. Norton	4	0	0
23 Brothers	0	0	0
26 Diamond Mtn.	0	0	0
27 Hatana Falls	0	0	0
29 Sunnybrook	0	0	0
30 Home Lake	0	0	0
31 Royal Cr.	0	0	0
42 Mt. Cameron	0	2	1
47 Moose Lake	0	0	0
55 Elk Mountain	0	0	0

(4) Klahhane Ridge

Klahhane	0	24	2
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