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Roosevelt Elk Density in Old-Growth Forests of Olympic National Park

Abstract

We explored the feasibility of censusing Roosevelt elk from a helicopter in the dense old-growth forests of Olympic National Park, WA. Mean observed densities ranged from 8.0-11.6 elk/km², with coefficients of variation averaging 19.9 percent. A provisional sightability factor of 74 percent suggested that actual mean densities ranged from 10.8-16.0 elk/km². We conclude that estimates of elk density probably could be refined, but not without a cost and level of disturbance in the park that seem unwarranted at present. The effort required to conduct the 18 counts made during 1985-86 was substantial. For almost every successful count an unsuccessful attempt was made. These included aborting five flights when counting conditions turned sour. Actual counting time for the successful flights was 15.7 and 16.2 hours in 1985 and 1986, respectively. Additional flight time for traveling to and from the census zones, refueling, and aborted attempts added 12.2 and 10.8 hours for the respective years.

Introduction

The Roosevelt elk (*Cervus elaphus roosevelti*) of Olympic National Park represent the last large populations of this subspecies that are relatively undisturbed in their natural habitat. Recent studies have added considerably to knowledge of elk-habitat relationships, social organization, and nutrition (Jenkins and Starkey 1982, 1984; Leslie *et al.* 1984). Techniques have not been developed to determine densities and population trends, primarily because elk occupy dense, old-growth coniferous forests. Moreover, there seemed to be no pressing need to do so; studies indicated that populations occurred at ecological carrying capacity with stable elk-vegetation relationships (C. Newman pers. comm.; Jenkins 1979, 1981; Leslie *et al.* 1984).

This laissez-faire management changed dramatically in 1984. A preliminary legal opinion (Weinberg 1984) indicated that Indian tribes retained hunting privileges within Olympic National Park stemming from the Treaty of Olympia, signed in 1856. Park managers directed that studies be undertaken to develop techniques to measure elk densities since the possibility now arose that these populations would be harvested.

Little empirical information has been published on either the density of Roosevelt elk or techniques suitable to measure density. Reported densities often are educated guesses or are calculated from estimates of herd composition and harvest for exploited populations (R. D. Taber pers. comm.). The usual indices of relative abundance appear to be of limited practical value in the Olympics: e.g., pellet group surveys present formidable sampling problems because the pellets decompose so rapidly (Fairbanks 1978).

The Olympic elk were known to undergo a major shift in habitat use with spring growth of herbaceous vegetation (Jenkins and Starkey 1982)—this apparently occurring just before leafout and subsequent canopy closure of deciduous trees. We took advantage of these earlier findings to explore the seemingly remote feasibility of aerial census. Preliminary helicopter counts conducted in 1984 suggested that substantial numbers of elk could indeed be observed during this brief, 2-3 week, period (Houston, unpublished). We report here the results from aerial census of Roosevelt elk carried out between 1984 and 1986. The primary objectives were: (1) to evaluate the precision (stability) of the index counts, and (2) to calibrate the counts to improve accuracy by using observations of radio-collared elk (Floyd *et al.* 1979, Samuel 1984).

Study Area and Methods

The census zones established on the Hoh, South Fork (SF) Hoh, and Queets River drainages covered the valley floors, and were bounded laterally by the steep valley walls (Figure 1). Two small census units established in 1984 (Areas "A") for preliminary surveys were expanded as shown. The U-shaped valleys are 1-3 km wide, and contain at least four river terraces of successively greater age (Fonda 1974, McKee *et al.* 1982, Tabor and Cady 1978). Elevations range

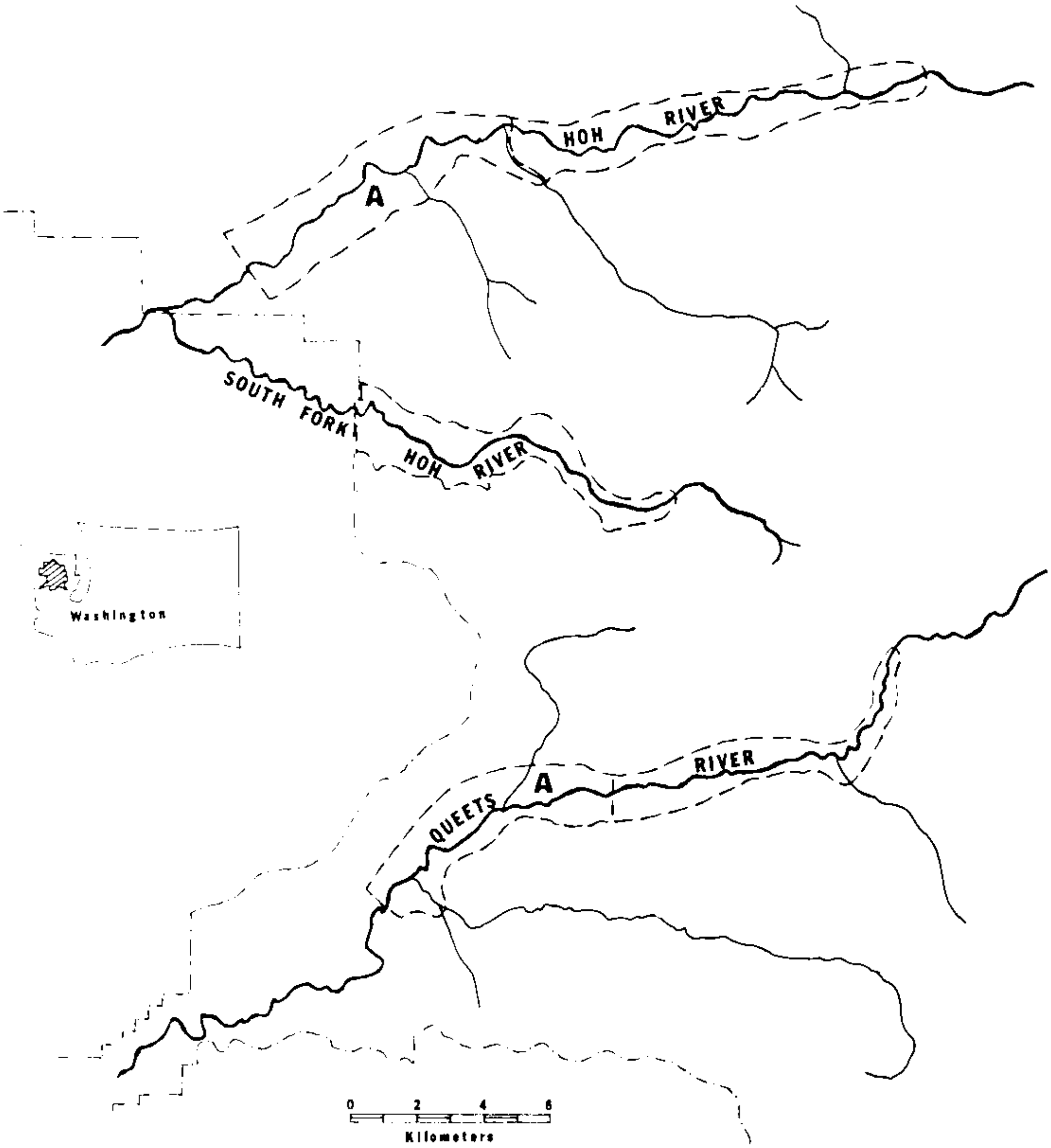

Figure 1. Elk census zones, Olympic National Park, 1985 and 1986. Areas "A" on mainstem Hoh and Queets Rivers were also censused during 1984. Queets Unit A = 11.0 km²; Total 19.4 km². Hoh Unit A = 11.5 km²; Total 23.4 km². S.F. Hoh = 11.1 km².

from 135 to 335 m. Precipitation ranges from 300 to 460 cm, with about 75 percent falling (mostly as rain) from November-April.

Forests of the census zones have been described as a sere from pioneer red alder (*Alnus rubra*) on active floodplains, through black cottonwood (*Populus trichocarpa*)-Sitka spruce (*Picea sitchensis*) on the younger terraces, to stands of western hemlock (*Tsuga heterophylla*) and Sitka spruce on older terraces. Groves of big leaf maple (*Acer macrophyllum*) occur throughout on shallow rocky soils. The coniferous forests are characterized by massive trees up to 90 m tall at densities of about 60-270 trees/ha (Fonda 1974, McKee *et al.* 1982).

The distribution and composition of the herbaceous understory vegetation within the forest communities on the census zones are particularly relevant to elk diets and sightability. Grasses and forbs dominate the herb layer on floodplains and the first river terraces. Grasses are largely absent from the older terraces; mosses and ferns predominate (Fonda 1974, McKee *et al.* 1982). The combined biomass of grasses and forbs is much greater in stands of deciduous trees and in forest clearings than in the mature conifer forest on the older terraces (Leslie 1983:77).

Forests of the adjacent valley walls are similar to those of the montane zone. Stands are dominated by massive red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), silver fir (*Abies amabilis*), and western hemlock. Densities are greater than on the valley bottom census zones, ranging from 400-600 trees/ha. The herb layer is sparse (Fonda and Bliss 1969, Fonda 1974). Wall forests are layered and canopy cover is virtually complete. Consequently, the forest floor was essentially invisible during helicopter census, and the walls were excluded from the census zones.

Elk show two different life history patterns in the census zones: (1) year-round residence, and (2) seasonal migrations to high elevation summer ranges (Schwartz and Mitchell 1945, C. Newman, personal comm., Jenkins 1979, Jenkins and Starkey 1982, Houston, Moorhead and Olson unpubl.). Resident cow-calf groups on the Hoh show high group constancy and have home ranges averaging about 11 km². Elk use shifts primarily to the valley floor during March. Red alder and cottonwood-spruce forests receive peak use in late winter as greenup begins, and grasses and forbs become increasingly important in elk diets (Jenkins and Starkey 1982, 1984, Leslie *et al.* 1984). This documented shift in elk distribution to more open forest types on the valley floor is crucial to the census.

Observations suggest that resident and migratory elk showed similar patterns of habitat use during the census periods. High elevation areas were still snow-covered and unavailable to migrants. Also, a radio-collared female elk, known to migrate to summer ranges, was always present during the counts.

Preliminary counts in 1984 suggested that the censuses should be conducted early in the morning, on overcast days, and with search intensities of at least 4 min/km² (Houston, unpublished). Census design consisted of repetitive surveys of the zones at treetop level ($\sim$100 m) using a Hughes 500D helicopter. A pilot, a navigator-observer, and two observers made up the census team. The search pattern consisted of slow (25-30 knot) zigzag coverage across the axis of the river. Conditions recorded during each flight included: cloudcover, snowcover, temperature, windspeed, extent of greenup of the herb layer, and phenology of hardwoods. The location of each elk group was plotted on 1:62,500 scale maps and, for 1985 and 1986, on 1:12,000 aerial photos.

Elk were immobilized with capture darts containing either M_{99} or carfentanil (Hebert *et al.* 1982, Meuleman *et al.* 1984) and fitted with radio collars (Telonics Model 5 or 6B). The census was conducted with the telemetry scanner-receiver (Telonics Model TR2-TS1) turned off. When a collared elk was observed, the receiver was turned on for a few seconds to identify the animal and then switched off. The remaining, unobserved, collared elk were located by telemetry after the census.

The observability of radio-collared elk was used to develop correction factors to improve census accuracy, following Floyd *et al.* (1979) and Samuel (1984). A sightability factor developed for elk *groups* on the Queets census area was applied to all zones. Corrected elk densities were calculated by estimating the number of groups actually present and then multiplying these values by the mean group size observed in each zone.

Results and Discussion

Counts were variable, but numbers did not differ significantly (Wilcoxon Two Sample tests $P > 0.10$) between 1985 and 1986 for any zone (Table 1). The 1984 counts were obtained under conditions generally comparable to 1985 and 1986, but counting time was less than in later years (4.48 ± 0.50 vs. 5.99 ± 0.62 min/km²) and there were minor differences in the lateral boundaries of Units A. Although the 1984 counts also do not differ from more recent counts, the 1985-86 counts represent our best efforts as the census team gained experience. Coefficients of variation (CV) averaged 19.9 percent over the three zones during 1985-86. Precision of the counts on the larger zones of the Hoh and Queets was greater (CV's $\sim$15%) than on smaller units ($\sim$30-33% for SF Hoh and Units "A"). Improved precision on the larger units may have resulted from including the entire valley bottom home ranges of more elk. Several times

TABLE 1. Elk counted on the Hoh and Queets Rivers, 1984-1986.

Area	Date		Elk Numbers Unit A	Elk Numbers Total	Elk/km² Unit A	Elk/km² Total
Queets	1984					
		3/13	83		7.6	
		3/19	189		17.2	
		3/27	122		11.1	
		$\bar{x} \pm$ SE[1]	131.3 ± 30.95		12.0 ± 2.80	
	1985					
		3/20	95	261	8.6	13.5
		3/29	58	163	5.3	8.4
		4/13	170	250	15.5	12.9
		$\bar{x} \pm$ SE	107.6 ± 32.95	224.6 ± 31.00	9.8 ± 3.00	11.6 ± 1.61
	1986					
		3/22	128	262	11.6	13.5
		3/29	121	215	11.0	11.1
		4/3	104	224	9.5	11.5
		$\bar{x} \pm$ SE	117.6 ± 7.13	233.6 ± 14.40	10.7 ± 0.62	12.0 ± 0.74
	Overall	$\bar{x} \pm$ SE	118.8 ± 13.64	229.2 ± 15.42	10.8 ± 1.24	11.8 ± 0.80
		CV[2]	33.4	15.6		
Hoh	1984					
		3/13	121		10.5	
		3/19	103		9.0	
		3/27	121		10.5	
		$\bar{x} \pm$ SE	115.0 ± 6.00		10.0 ± 0.50	
	1985					
		3/19	103	174	9.0	7.4
		3/25	49	144	4.3	6.2[3]
		4/4	55	186	4.8	8.0
		$\bar{x} \pm$ SE	69.0 ± 17.08	168.0 ± 12.49	6.0 ± 1.49	7.2 ± 0.53
	1986					
		3/17	85	211	7.4	9.0
		3/25	60	222	5.2	9.5
		4/2	62	185	5.4	7.9
		$\bar{x} \pm$ SE	69.0 ± 8.02	206.0 ± 10.97	6.0 ± 0.70	8.8 ± 0.47
	Overall	$\bar{x} \pm$ SE	84.3 ± 9.56	187.0 ± 11.29	7.3 ± 0.83	8.0 ± 0.48
		CV	33.0	14.0		
SF Hoh	1985					
		3/21		90		8.1[3]
		4/1		123		11.1
		4/12		130		11.7
		$\bar{x} \pm$ SE		114.3 ± 12.33		10.3 ± 1.11
	1986					
		3/20		104		9.4
		3/23		45		4.1
		3/31		87		7.8
		$\bar{x} \pm$ SE	78.6 ± 17.53	7.1 ± 1.57		
	Overall	$\bar{x} \pm$ SE		96.5 ± 17.64		8.7 ± 1.12
		CV		30.1		

1. Mean ± standard error.
2. Coefficient of variation as %, corrected for sample size (Sokal and Rohlf 1981:59). CV for elk/km² similar to those for elk numbers.
3. 3-20 cm new snow on Hoh prior to count; 3-5 cm on SF Hoh.

during 1984 (and SF Hoh in 1986) one or more groups of elk were observed alternately inside and then just outside established census units, indicating that boundaries bisected home ranges.

Two low counts on the SF and mainstem Hoh occurred immediately after snowstorms (Table 1), suggesting that elk moved off the zones. This was also indicated by the locations of elk that were observed; many occurred at the bases of valley walls. Elk are known to leave floodplains and move onto valley walls during winter snows (Jenkins and Starkey 1984). We could find no environmental explanation for several other low counts, so including the snowfall counts in calculations made little difference to precision.

Mean observed elk densities ranged from 8.0-11.6/km^2 for 1985-86 and were highest (Wilcoxon Two sample, $P<.05$) on the Queets. Maximum observed densities ranged from 9.5-13.5/km^2. Mean observed group size ranged from 11.6-13.3 elk and did not differ among years or areas (Table 2). Mean group size was smaller than the spring mean of 27 reported earlier from the Hoh (Jenkins and Starkey 1982) because our sample included small groups of bull elk in addition to the cow-calf groups.

TABLE 2. Observed elk group size, 1984-86.

		Group Size	
Area	Years	N	$\bar{X} \pm$ Std Dev (Range)
Queets	1984-86	133	13.3 ± 11.9 (1-61)
Hoh	1984-86	123	11.9 ± 10.0 (1-43)
S.F. Hoh	1985-86	50	11.6 ± 14 (1-46)

A provisional sightability factor of 74 percent was derived from 19 encounters with groups containing radio-collared elk (14 groups observed, 5 missed). [High mortality damaged efforts to determine sightability. Seven elk fitted with transmitters in the Queets census zone in 1985 had been reduced to two by the middle of the 1986 census period, mainly by cougar (*Felis concolor*) predation.] The provisional adjustment returned actual mean densities of about 16.0, 10.8 and 11.7 elk/km^2 on the Queets, Hoh and SF Hoh, respectively. We recognize that group size influences elk sightability (Samuel 1984), but size did not differ between sighted ($\bar{X} = 23.7 \pm 10.79$ elk) and unsighted groups (13.6 ± 14.17, $P>.05$, Wilcoxon Two sample) for these few observations.

The precision of the index counts encountered during the elk census (CV's 15-33%) is apparently in the range expected for many wild populations (Le Resche and Rausch 1974, Eberhardt 1978, Beasom 1979, Beasom *et al.* 1986, Harris 1986), particularly under difficult survey conditions. Approximate 95 percent confidence limits (Sokal and Rohlf 1981:148) for the mean counts of 1985-86 were 229 ± 40, 187 ± 29 and 96 ± 45 elk for the Queets, Hoh, and SF Hoh, respectively. These limits may give a preliminary indication of the amount of change necessary to detect real population trends.

Interpretation of the counts requires caution because the entire home ranges of the elk could not be included in the zones. Even though elk use was concentrated on the valley floors, part of the variation among counts surely resulted from elk moving to the valley walls where they could not be observed. However, earlier studies of habitat use and diet, plus 45 March-April radio locations of 10 collared elk during the present study (including 5 elk downstream from the zone) suggest that a very high proportion of the combined resident and seasonally migratory populations occupy the valley floor during the census period. Circumstances of the census did not permit complete sex and age composition tallies, but adult males appeared to be well represented in the counts.

Despite the recognized limitations of the counts, the observed elk densities are instructive, and apparently represent the only empirical data on Roosevelt elk densities. These estimates begin to provide a quantitative perspective for Raedeke and Taber's (1982) speculation that high Roosevelt elk densities occurred historically along floodplains.

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