EVALUATION OF AN AERIAL PHOTOCENSUS TECHNIQUE FOR CARIBOU BASED ON RADIO-TELEMETRY

by

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Abstract: We conducted 3 postcalving censuses of Alaskan caribou in a manner that allowed comparing results of a radio-search technique to the conventional visual-search technique. One rut-aggregation census was also done by radio-searching alone. During radio-searches, caribou associated with or within sight of radio-collared caribou were considered found. In the 3 postcalving censuses, 87, 89, and 90% of the caribou found by extensive visual searching would also have been located using the radio-search technique alone. We could not reject the hypotheses that (1) aggregation size and the proportion of radio-collared caribou in an aggregation are independent variables; and (2) distribution of radio collars among groups is random.

Résumé: Nous avons mené trois recensements du caribou de l'Alaska suivant la mise bas. Ces recensements ont été faits d'une façon permettant de comparer les résultats d'une technique de recherche d'émetteurs radio aux résultats obtenus par la méthode conventionnelle de recherche visuelle. Un inventaire de regroupements pendant le rut fut aussi réalisé, par recherche d'émetteurs seulement. Pendant les recherches d'émetteurs, les caribous associés ou à vue de ceux portant un collier émetteur furent considérés comme retrouvés. Au cours des trois recensements suivant la mise bas, 87%, 89% et 90% des caribous retrouvés par des recherches visuelles étendues auraient été aussi retrouvés en utilisant seulement la technique de recherche d'émetteurs. Nous ne pouvions pas rejeter les hypothèses voulant que (1) la grosseur des regroupements et la proportion de caribous porteurs de colliers émetteurs sont des variables indépendantes; et (2) la distribution des colliers émetteurs parmi les groupes est aléatoire.

INTRODUCTION

Accurate estimation of the size of caribou populations is critical to understanding their population dynamics and ecology. Major breakthroughs in improving the accuracy of caribou census techniques began in the late 1940's and 1950's with the increased use of aircraft (Watson and Scott 1956, Bergerud 1963, Siniff and Skoog 1964). Lent (1966) experimented with aerial photography and later Hemming and Glenn (1968) developed the aerial photo-direct count-extrapolation (APDCE) technique. Further refinements of this technique were reported by Davis et al. (1979).

In the late 1970's, radio-telemetry contributed significantly to the confidence and efficiency of caribou censuses; although in most cases, it has not led us to change the basic approach.

Most censuses of Alaskan caribou rely on aerial photography of postcalving or rutting aggregations. An important assumption in these censuses is that all major aggregations are found, and this requires thorough searching of large areas using many aircraft. Instead of relying on an expensive visual search to locate aggregations, we have considered using only a radio-search of instrumented caribou to lead us to aggregations. In a radio-search an observer would track in and locate all radio-collared caribou and then photograph or count all caribou associated with or within sight of the radio-collared individual or those encountered en route. The purpose of this paper is to evaluate the merits of this approach based on 4 censuses in which both visual and radio-search techniques were used.

For a radio-search census to be successful, 3 conditions must be met. The first is that radio-collared caribou must be randomly distributed throughout the population. If there is social bonding or a tendency for some radio-collared individuals to associate, some aggregations may contain many radios, while other aggregations of a similar size may contain few or no radios. Valkenburg et al. (1983) found no evidence of social bonding in Western Arctic caribou. Nonrandom distribution of radio-collared caribou can also result from age/sex segregation if radios are placed predominantly on members of one age or sex class. We addressed the question of uniform distribution of radio-collared individuals through contingency analysis (Tables 1-4) of the 4 data sets used in this paper.

A second condition is that the caribou must be grouped during censusing, and that the number of groups is not large compared with the number of radio-collared individuals. This condition can be verified by precensus reconnaissance. Clearly, if the radio-search census is done at a time when the number of aggregations is small and the mean aggregation size is large, the best results will be obtained.

The third condition is that all radio-collared caribou are heard and are precisely located. Skill and experience in radio-tracking is particularly important here. Missing radio collars, radio failures, or imprecise locations will reduce the accuracy of census results.

Battery failure and emigration are potential problems. Preselecting a subsample of radio collars known to be functioning within the herd's range and using only those radios during the census is a potential solution. Preselection must be made well before the census (e.g., in late winter for a census of postcalving aggregations). This would allow time for radio-collared caribou to uniformly mix within the herd. All radios within the preselected sample would have to be accounted for during the census.

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PROCEDURES

We documented the distribution of radio-collared individuals among postcalving aggregations during censuses of 3 caribou herds in interior and northern Alaska. We also searched the entire area in which aggregations were likely to be found and photographed or enumerated the caribou in all aggregations found within the area. During each census, we used several aircraft to search assigned areas simultaneously. Each aircraft was to cover its assigned area thoroughly enough that no groups of caribou were missed. The aircraft either flew closely spaced transects or blocks depending on terrain. All groups were photographed, or if small enough, they were counted. Photographed caribou were counted later. All caribou in aggregations containing at least 1 radio-collared individual were considered found by the radio-search as were aggregations located within sight of radio-collared caribou. In contrast, caribou that were not associated with radio-collared individuals were considered missed by the radio-search technique.

We also completed 1 census of rutting groups of Delta Herd caribou in October 1983 using the radio-search technique alone. Results of this census were compared to a conventional (Davis *et al*. 1979) census of the Delta/Yanert Herd in June 1984, with allowances for calf production in May 1984 and exclusion of Yanert caribou.

RESULTS AND DISCUSSION

In the 3 postcalving censuses, 87, 89, and 90% of the caribou found during the visual-search would have been found by the radio-search technique alone (Tables 1-5). The radio-search census of the Delta Herd conducted 4 October 1983 (Table 2) also yielded results roughly comparable to the visual-search census of the Delta/Yanert Herds in June 1984 (Table 4) if allowance is

Table 1. Distribution of 30 radio-collared caribou among postcalving aggregations of Western Arctic Herd caribou, 6 July 1982.

Group no.	Group size	Number of radio-collared caribou in group	Expected number of radio-collared caribou in group[a]
1	53,245	13	9.4
2	45,155	8	7.9
3	22,975	2	4.0
4	9,000[b]	0	1.6
5	8,788	3	1.6
6	8,000[b]	1	1.4
7[c]	7,530	0	1.3
8[c]	6,144	1	1.1
9[c]	4,000[b]	1	0.7
10[c]	3,667	1	0.7
11[c]	1,556	0	0.3
12[c]	479	0	0.1
Total	170,539	30	30.1

Number of caribou per radio collar = 5,685

Contingency table $X^2 = 5.81$, d.f. = 6, $0.3 < P < 0.5$

[a] Calculated by dividing group size by number of caribou per radio collar.

[b] These values are a combination of counts and estimates, and include several small groups.

[c] For contingency analysis, groups of less than 8,000 were lumped.

Table 2. Distribution of 39 radio-collared caribou among rutting groups of Delta Herd caribou, 4 October 1983.

Group no.	Group size	Number of radio-collared caribou in group	Expected number of radio-collared caribou in group[a]
1	1,296	6	10.0
2	1,072	7	8.3
3	970	7	7.5
4	336	3	2.6
5	212	2	1.6
6[a]	180	1	1.4
7	166	2	1.3
8	84	0	0.6
9	70	0	0.5
10	68	2	0.5
11	63	1	0.5
12	63	0	0.5
13	63	0	0.5
14	63	0	0.5
15	60	1	0.5
16	60	1	0.5
17	35	1	0.3
18	32	0	0.2
19	31	1	0.2
20	26	0	0.2
21	21	0	0.2
22	17	0	0.1
23	15	0	0.1
24	13	0	0.1
25	13	0	0.1
26	10	0	0.1
27	7	0	0.1
28	4	0	0.0
29	3	1	0.0
30	2	0	0.0
Total	5,055	39	39.0

Number of caribou per radio collar = 130

Contingency $X^2 = 0.9$, d.f. = 5, $0.95 < P < 0.98$

[a]For contingency analysis, groups of less than 200 were lumped.

Table 3. Distribution of 19 radio-collared female caribou among post-calving aggregations of the Fortymile Herd, 20 June 1984.

Group no.	Group size	Number of radio-collared caribou in group	Expected number of radio-collared caribou in group[a]
1	1,910	5	3.1
2	1,781	3	2.9
3	1,777	3	2.9
4	1,627	5	2.6
5	634	2	1.0
6	617	0	1.0
7[a]	494	1	0.8
8	466	0	0.7
9	311	0	0.5
10	290	0	0.5
11	244	0	0.4
12	192	0	0.3
13	167	0	0.3
14	155	0	0.3
15	138	0	0.2
16	128	0	0.2
17	91	0	0.1
18	58	0	0.1
19	39	0	0.1
20	18	0	0.0
21	424[b]	0	0.6
22	226[c]	0	0.4
Total	11,787	19	19.0

Number of caribou per radio collar = 620

Contingency table $X^2 = 9.01$, d.f. = 6, $0.1 < P < 0.2$

[a]For contingency analysis, groups of less than 600 were lumped.

[b]Includes all incidental animals counted outside aggregations during photography.

[c]Predominantly a male group.

Table 4. Distribution of 53 radio-collared caribou among postcalving aggregations of Delta and Yanert caribou, 22 June 1984.

Group no.	Group size	Number of radio-collared caribou in group	Expected number of radio-collared caribou in group
1	1,679	21	13.9
2	1,369	9	11.3
3	909	11	7.5
4	700[a]	1	7.5
5	455	4	3.8
6	359	3	3.0
7[b]	211	1	1.8
8[b]	156	1	1.3
9[b]	118	0	1.0
10[b]	108	0	0.9
11[b]	90	1	0.7
12[b]	252[c]	1	2.1
Total	6,406	53	53.0

Number of caribou per radio collar = 121

Contingency table $X^2 = 11.60$, d.f. = 6, $0.05 < P < 0.10$

[a] Predominantly male and includes estimates and counts of several groups

[b] For contingency analysis, these groups of less than 300 were lumped.

[c] Includes many small groups of 1-30 each.

Table 5. Comparison of radio-search and visual-search techniques during 3 censuses of Alaskan caribou herds.

Census	No. of caribou found by visual-search	No. of caribou found by radio-search	(% of visual search)	% of caribou in groups larger than 3x[a]
July 1982 Western Arctic	170,539	154,000	(90)[b]	71
June 1984 Fortymile	11,787	10,246	(87)	16
June 1984 Delta/Yanert	6,406	5,722	(89)	85

[a]x = the number of caribou/radio-collared caribou.

[b]Without radio collars, one group of 8,000 would not have been found in the visual search. If this is considered, the percentage would be higher.

Table 6. Sex and age composition of aggregations sampled during 4 censuses of Alaskan caribou herds.

Census	Composition					Sample size
	% cows	% bulls	% calves	Bulls/ 100 cows	Calves/ 100 cows	
July 1982 Western Arctic		not available				
October 1983 Delta	50	27	23	54	46	1,333
June 1984 Delta/Yanert	58	10	32	17	56	2,604
June 1984 Fortymile	53	23	24	42	45	3,940

made for calf production in 1984. If 50% of the Delta Herd were females older than calves in October 1983 and there were 50 calves per 100 cows during the June 1984 census, then 1,260 calves would have been added to the previous fall's Delta population assuming no overwinter mortality of adult females. We would therfore expect the Delta herd to number about 6,200 in late June 1984. The observed June 1984 population was about 6,400, but this value includes 700-900 Yanert caribou which were mixed with the Delta caribou during the June census. The fall 1983 radio-search census may in fact have yielded better results than the summer 1984 visual search census.

In all 4 data sets, contingency analysis failed to reject the null hypothesis that group size and the proportion of radios in a group are independent. In other words, the proportion of radio-collared caribou was as expected in a random assortment among groups, despite almost all radio collars being on females in all 3 herds. The data set with the highest Chi-square value was the summer 1984 Delta/Yanert census where bulls were largely segregated from cows (Table 6) and the largest aggregation contained almost twice the expected number of radio-collared individuals (Table 4). As we had anticipated, the data set with the lowest Chi-square value was the the October 1983 Delta census of relatively evenly mixed rutting groups.

The requirement that most caribou are in large aggregations at the time of the census was verified in censuses where visual- and radio-searches were completed simultaneously. The Delta/Yanert census of 1984 was followed by almost complete visual coverage of the herd's range, and very few additional caribou were located. Extensive searching of peripheral areas also accompanied the 1982 Western Arctic census, including transect sampling on the entire arctic coastal plain within the herd's range. It is possible, however, that some groups of males and nonaggregated caribou were missed in the Western Arctic and Fortymile Herd censuses, although composition counts of the Fortymile Herd indicated that most males were in the postcalving aggregations (Table 6). During the October 1983 Delta census, snow cover aided in locating caribou through tracking although no extensive visual search was conducted.

During visual searches, the location of the intensive search areas may have been influenced by the locations of radio-collared caribou during precensus reconnaissance, but the size of the intensive search area was determined mostly by the number of planes available for simultaneous searching. In this respect, visual- and radio-search techniques were not entirely independent.

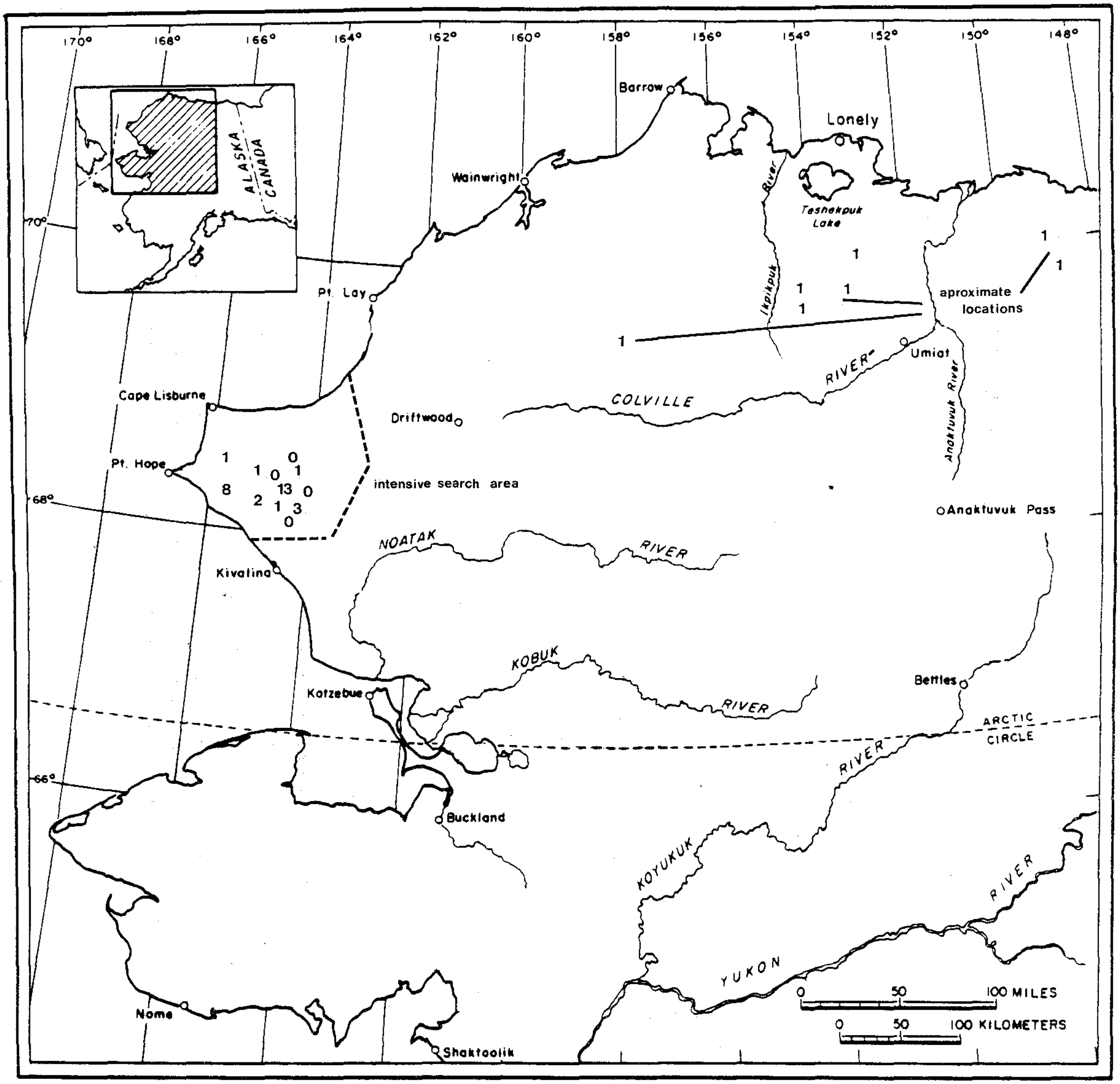
With the possible exception of the 1982 Western Arctic Herd census, missing radio-collared caribou were not a problem. All radio-collared caribou were found in aggregations during the Fortymile census. During the October 1983 Delta census, 3 of the radio-collared caribou were not heard, but their fate later became known. One radio-collared caribou was shot the day before the census, and 2 were found dead a month later; we expect all 3 died before the census. In the 1984 Delta/Yanert census one frequency was inadvertently deleted from the scanner/receiver during the census, and one active radio was not located. In fall 1981, 44 radio collars were known to be on caribou in northwestern Alaska (not necessarily Western Arctic Herd caribou). In July 1982, 30 of these were in the postcalving aggregations, 6 were on caribou that calved east of the traditional Utukok calving area and did not join aggregations, 2 had either dispersed to the Central Arctic Herd (or were Central Arctic caribou that were collared on the winter range when the 2 herds were mixed) (Fig. 1), 3 were not heard since fall 1981, and 3 were expected to be in postcalving aggregations but were not heard. Four of the 6 missing caribou were instrumented in 1979, and battery exhaustion could have been a factor. One complication with the Western Arctic Herd is that, within the range of the large migratory herd, small, usually sedentary groups of caribou occur, especially on the arctic coastal plain. For the most part, collars were put on in winter when these sedentary groups are inundated by Western Arctic caribou. Some of these individuals on occasion apparently abandon their sedentary way of life and use the calving grounds of the Western Arctic Herd and are also present in post-calving aggregations of Western Arctic caribou. As the Western Arctic Herd expands its range with increasing population size, the situation may become even more complicated.

The probability of finding a group of a given size by relying solely on a given number of radio collars is central to the theory upon which the radio-search technique is based. We addressed this problem by imagining a theoretical caribou population of 1,000 animals, 10 of which are radio-collared. Using standard 'ball and urn' sampling theory, we can calculate the probability that a randomly chosen group of 100, 200, 300 caribou, etc., will include at least 1 radio-collared animal. These probabilities are approximated by the function $f(n) = 1 - (1 - 1/x)^n$ (Mendenhall and Scheaffer 1973:72) where n = group size and x = the number of caribou per radio-collared caribou (Fig. 2). For large values of x, f(n) closely approximates the exact probability obtained by sampling without replacement.

We can also estimate the proportion of a herd that must be radio-collared to be, for example, 95% certain that a randomly chosen band of n (or more) caribou will contain at least 1 radio-collared animal. Setting $f(n) = 0.95$ results in $1/x = 1 - (0.05)^{1/n}$. For the theoretical population of 1,000 animals, n = 100 implies that $1/x = 0.03$ or that 30 animals must be radio-collared. More generally, 30 animals must be radio-collared to be 95% certain that a randomly chosen band composing 10% of the population will contain at least 1 radio. These theoretical observations may be of limited practical value, because the theoretical process of randomly selecting bands does not necessarily correspond with the actual formation of caribou aggregations as visual units.

CONCLUSIONS

We do not necessarily advocate use of the radio-search technique to replace visual searching; biologists are interested in getting the most accurate results possible, and in many



13 number of radio collars in the area
0 group with no radio collars

Fig. 1. Distribution of radio-collared caribou in northwestern Alaska during the 1982 Western Arctic Herd census.

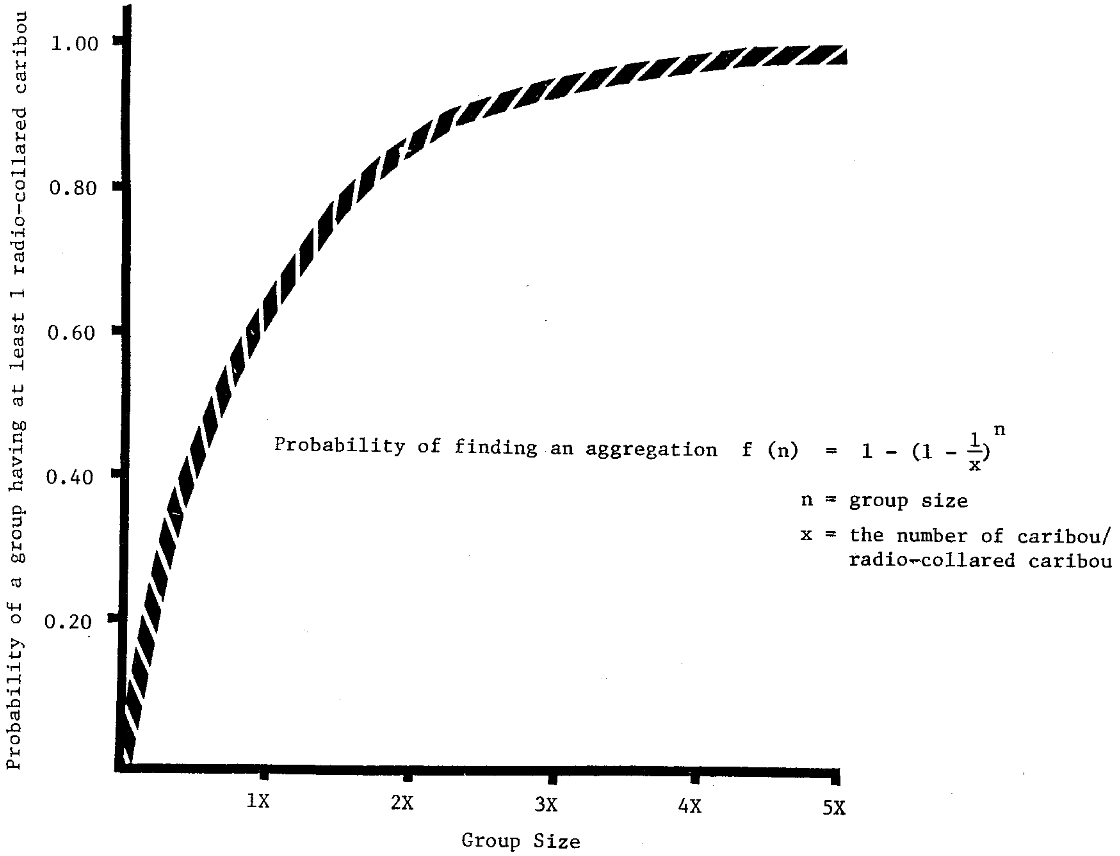


Fig. 2. Approximate probability of locating a group of caribou by radio-telemetry as a function of group size and the number of radio-collared caribou in the herd assuming random distribution.

situations the visual search is feasible and will find more caribou. However, in cases where relatively few widely scattered aggregations contain most of the caribou in the herd, the radio-search technique is very attractive and radio collars can be easily justified in aiding precensus reconnaissance for delineating herd distribution. Once in place, radio collars provide the option of a radio-search and of at least obtaining a minimum population estimate when conditions are not suitable or money is not available for extensive visual searching.

REFERENCES

Bergerud, A.T., 1963. Aerial winter census of caribou. J. Wildl. Manage. 27(3):438-449.

Davis, J.L., P. Valkenburg, and S.J. Harbo, 1979. Refinement of the aerial photo-direct count-extrapolation caribou census technique. Alaska Dep. Fish and Game, Fed. Aid Wildl. Rest., Final Rep. Proj. W-17-11. Juneau. 23 pp.

Hemming J.E., and L.P. Glenn, 1968. Caribou report. Alaska Dep. Fish and Game, Fed. Aid Wildl. Rest., Final Rep. Proj. W-15-2 and W-15-3. Juneau. 41 pp.

Lent, P.C., 1966. The caribou of northwestern Alaska. Pages 481-517 in N.J. Wilimovsky and J.N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. USAEC. Oak Ridge, Tenn. 1250 pp.

Mendenhall, W., and R.L. Scheaffer, 1973. Mathematical statistics with applications. Duxbury Press. North Scituate, Mass. 561 pp.

Siniff, D.B., and R.O. Skoog, 1964. Aerial censusing of caribou using stratified random sampling. J. Wildl. Manage. 28(2):391-401.

Valkenburg, P., J.L. Davis, and R.D. Boertje, 1983. Social organization and seasonal range fidelity of Alaska's Western Arctic caribou -- preliminary findings. Acta Zool. Fennica 176:125-126.

Watson, G.W., and R.F. Scott, 1956. Aerial censusing of the Nelchina Caribou Herd. Trans. N. Amer. Wildl. Conf. 21:499-510.

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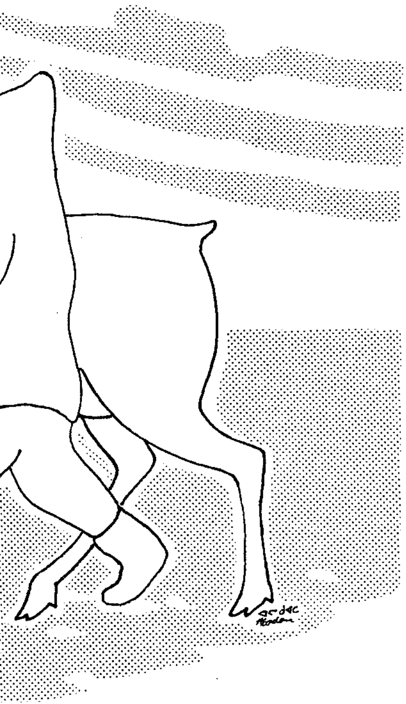

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