SAMPLING ERRORS ASSOCIATED WITH AERIAL TRANSECT SURVEYS OF CARIBOU

by

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Abstract: Five low-level caribou surveys were conducted by helicopter within a 1550-km² area of the Arctic Coastal Plain of Alaska on 11-14 June 1980-84. Caribou were counted using 12 contiguous north-south strip transects, each 3.2 km wide and extending 41 km inland; numbers of adults and calves seen within each strip were recorded, essentially providing direct total counts. Total numbers were also estimated by extrapolating from the results obtained with various combinations of systematic transect coverage equivalent to 50%, 33%, 25%, and 17% of the study area. Mean (± SD) differences between the extrapolated results and the direct total counts for the 5-year study period were 12% (8%), 17% (11%), 33% (30%), and 27% (24%); those for calf percentage were 3% (3%), 8% (6%), 11% (12%), and 10% (9%). Cumulatively, two-thirds or more of the possible transect combinations at and above 33% coverage yielded estimates of total caribou and calf percentage that were within 20% and 10% respectively, of the observed value, whereas half or less of the combinations at 25% and 17% provided estimates within these limits.

Résumé: Cinq inventaires de caribous ont été effectués à basse altitude, par hélicoptère, sur une superficie de 1550 km² de la plaine côtière arctique de l'Alaska , du 11 au 14 juin 1980-1984. Les caribous furent comptés le long de 12 transects contigus, orientés nord-sud; chacun de ces transects en bandes mesurait 3.2 km en largeur et s'étendait sur 41 km à l'intérieur des terres. Les nombres d'adultes et de veaux observés à l'intérieur de chaque bande ont été notés, fournissant essentiellement des comptes directs totaux. Des nombres totaux ont aussi été estimés par extrapolation des résultats obtenus avec diverses combinaisons systématiques de transects, dont la couverture équivalait à 50%, 33%, 25% et 17% de l'aire d'étude. Les différences moyennes (± écart type) entre les résultats par extrapolation et les comptes directs totaux, pour une période d'étude de 5 ans, étaient 12% (8%), 17% (11%), 33% (30%) et 27%

(24%); pour les pourcentages de veaux, ces différences étaient de 3% (3%), 8% (6%), 11% (12%) et 10% (9%). Cumulativement, au moins deux tiers des combinaisons possibles de transects qui ont une couverture de 33% ou plus ont produit des estimés du total de caribou et du pourcentage de veaux qui étaient respectivement à 20% et 10% des valeurs actuelles, tandis que la moitié ou moins des combinaisons à 25% et 17% ont fourni des estimés à l'intérieur de ces limites.

Key Words:

barren-ground caribou, aerial survey, sampling errors, transects, Alaska.

INTRODUCTION

Systematic transect surveys are commonly used for estimating the size and/or composition of North American caribou herds (Watson and Scott 1956, Bergerud 1963, Tener 1963, Thomas 1969, Parker 1972, Miller et al. 1977, Calef and Heard 1980, Carruthers and Jakimchuk 1983, Jakimchuk and Carruthers 1983). Evenly spaced parallel transects are flown over a predetermined area at a constant altitude, and caribou within a specified strip width are counted and classified. The area may be stratified on the basis of caribou density, in which case total numbers are estimated as the sum of the extrapolated totals for each stratum, and overall sex/age composition is calculted by weighting the observed values for each stratum in proportion to the size of the sample. Where stratifying is difficult or inappropriate, estimates generated by line-transect data assume that caribou are sampled in proportion to their occurrence.

Potential errors resulting from inability to accurately observe, classify, and record all caribou present on transects will not be considered here. Rather, this paper examines the more fundamental supposition that the level of coverage selected is sufficient to provide reasonably accurate data on population characteristics. Unfortunately, opportunities to determine actual errors incurred at different sampling intensities are rare, as concurrent total counts are seldom made. In this paper, we evaluate the extent of those errors, and hence the validity of the inherent assumptions, by comparing the projected results at 4 levels of partial coverage with total counts in a specific study area.

METHODS

A 1550-km² portion of the central Arctic Coastal Plain, approximately 35 km west of Prudhoe Bay, was surveyed intensively between 11 and 14 June each year from 1980 to 1984. Caribou were counted within 12 contiguous north-south transect strips, each 3.2 km (2 mi) wide and extending 41 km inland from the coast of the Beaufort Sea (Fig. 1). Survey conditions varied greatly from

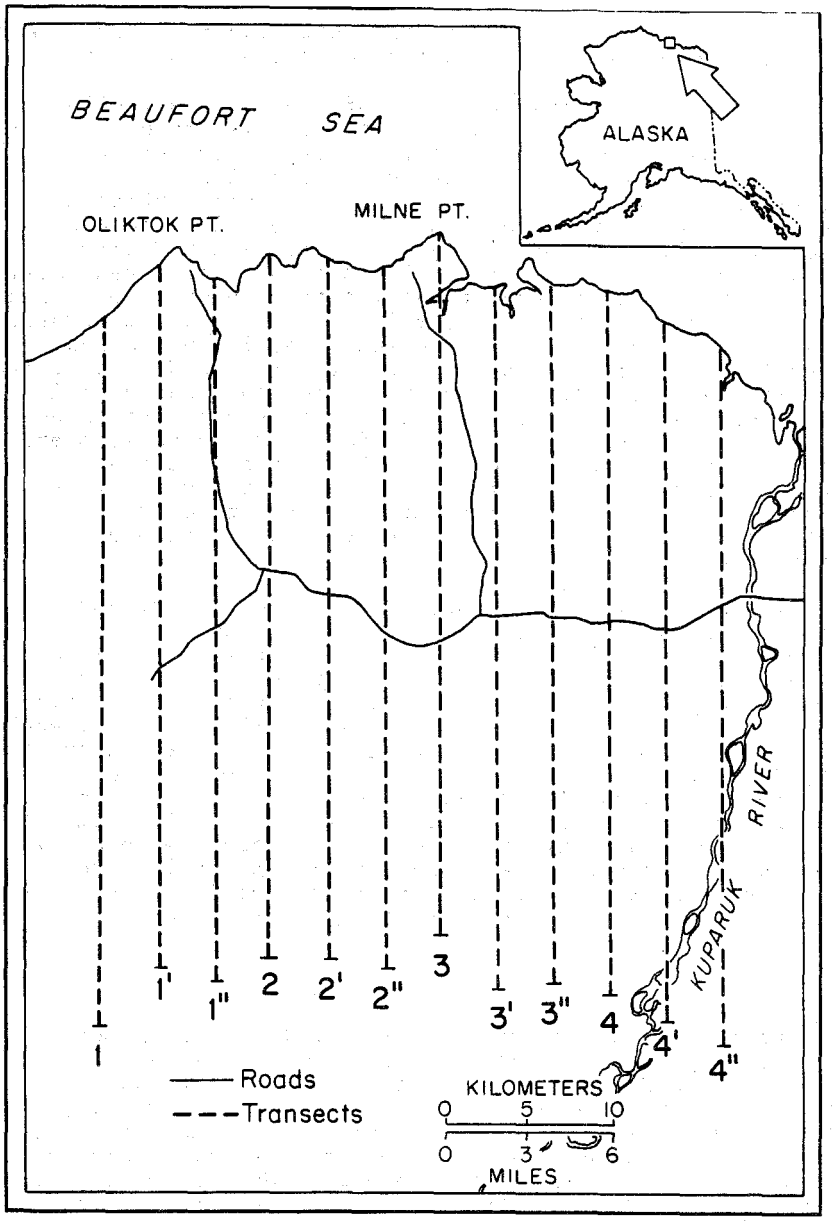

Fig. 1. Center lines of transects surveyed by helicopter, 11-14 June 1980-84.

year to year, but within any one year, snow cover, weather, and sightability were essentially uniform over the study area.

All surveys were flown by Bell 206-B helicopter; USGS 1:63,360 topographic maps were used for position reference. The pilot and 3 observers (1 front-seat, 2 rear-seat) searched each strip thoroughly. We used the transect centerlines for orientation, but in practice usually flew zig-zag patterns between transect strip boundaries. We varied altitude and airspeed to maximize sightability, and often scanned with binoculars in attempting to find all caribou in the transects. We made a low pass or hovered briefly near each group of caribou to positively count and classify all animals. Each observation was assigned a number which was marked directly on the map. Numerous lakes, rivers, roads, and construction pads facilitated course plotting and mapping. On rare occasions when ground reference was uncertain, we climbed to altitude to determine our exact position. Caribou did not run far from the helicopter, and movement between transects was minimal. Occasionally while flying one transect, we diverted to isolated areas (i.e., by lakes or streams) of adjacent transects and mapped groups there. For data analysis, however, groups were always included in their proper transect.

It was assumed that each survey resulted in 100% coverage of the study area, with data recorded for 12 transect strips. Simulated results at lower levels of coverage were obtained by combining observations from alternate transects, every 3rd transect, every 4th transect, and every 6th transect; designated 50, 33, 25, and 17% coverage, respectively (Fig. 2). For each of the 15 simulated partial surveys within a year (i.e., 2 at 50%, 3 at 33%, 4 at 25%, and 6 at 17%), the total number of caribou within the study area was estimated by multiplying by the appropriate conversion factor (i.e., 2 for 50%, 3 for 33%, etc.). Calf percentage was computed directly from each sample and was assumed to be representative of caribou in the entire area. Errors were expressed as percentage deviations from the corresponding values obtained through complete coverage.

RESULTS AND DISCUSSION

In many ways, our survey technique differed from most transect surveys in which constant altitude, airspeed, and direction are maintained. Our transect strip width was also much wider, 0.5-1.0 km being more common. Our goal was to map, as accurately as possible, the distribution of caribou within the study area. We make no claim that we observed every caribou, and it is possible that some caribou were recorded more than once. Our technique was designed to minimize such errors, but an objective discussion of how well this was accomplished is beyond the scope of this paper. For purposes of further discussion, we assume that all caribou on each transect were observed.

Total numbers of caribou observed within the study area ranged from 499 in 1980 to 2,601 in 1984 (Table 1). Calf percentage varied between 30.1 in 1980 to 46.8 in 1981. Variation in total numbers was in part due to annual snowmelt

Table 1. Numbers of caribou (numbers of calves) observed on each of 12 aerial survey transects, Central Arctic Coastal Plain, June 1980-84.

	Year				
Transect	1980	1981	1982	1983	1984
1	70(24)	25(13)	74(24)	130(39)	165(61)
1'	18(6)	119(49)	67(25)	45(10)	66(15)
1"	48(11)	63(30)	110(39)	13(0)	92(32)
2	27(5)	74(36)	141(44)	37(6)	68(15)
2'	38(13)	273(131)	134(52)	408(184)	422(172)
2"	69(16)	274(131)	111(43)	209(88)	239(102)
3	66(16)	166(80)	63(17)	48(8)	92(8)
3'	74(27)	115(53)	55(14)	248(97)	208(71)
3"	41(13)	129(60)	127(52)	262(116)	842(400)
4	26(9)	18(9)	53(15)	258(119)	324(138)
4'	16(8)	14(3)	61(25)	78(28)	30(6)
4"	6(2)	5(2)	30(4)	31(5)	53(15)
Total	499(150)	1275(597)	1026(354)	1767(700)	2601(1035)

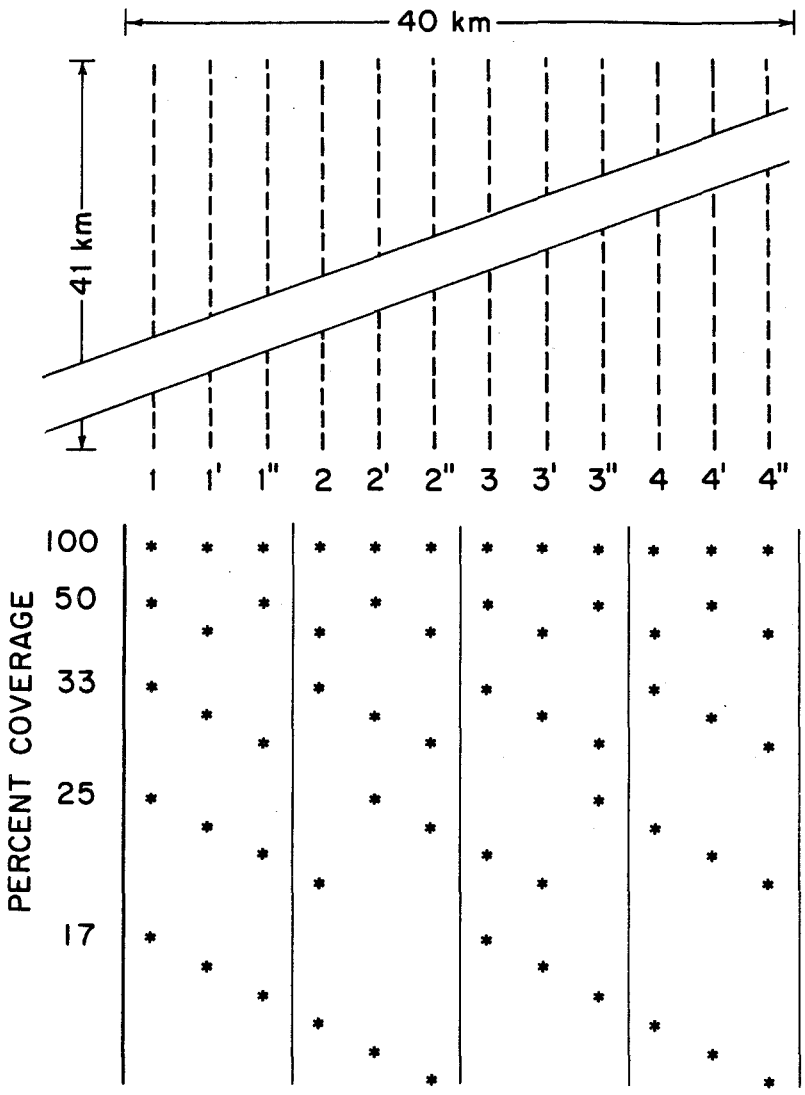

Fig. 2. Schematic representation of transect combinations used to achieve different levels of coverage within the study area (see Fig. 1).

conditions (drier conditions correlated with more caribou), and calf percentage was highly dependent on the number of yearlings accompanying cows to the calving grounds (Whitten and Cameron 1985). Generally increasing numbers also resulted from a population increase rate of about 13 % per year during the study period (Whitten and Cameron 1983; unpublished).

Five-year mean (± SD) errors associated with estimating total numbers of caribou from partial coverage indicate a generally decreasing trend with increasing survey intensity (Fig. 3a). Most striking, however, is that the maximum errors incurred at 17 and 25% coverage were substantially higher than those at 33 and 50% coverage (115 and 120% vs. 41 and 26%, respectively). The pattern of error for estimating calf percentage was similar but somewhat less variable, and maximum errors were all <50% (Fig. 3b). Overall, these data suggest that in order to minimize the possibility of errors exceeding 20%, total population estimates should be based on approximately 50% coverage, whereas for estimates of calf percentage it appears that 33% coverage would suffice.

Another approach is to calculate the proportion of possible sample estimates within each coverage level that are associated with errors within specified limits. For total caribou numbers, less than one-half of all possible estimates were in error by <10%. Approximately half of the estimates at 17 and 25% coverage, and two-thirds or more of those at 33 and 50% coverage, were within 20% of the actual value (Fig. 4a). The corresponding estimates of calf percentage were somewhat more accurate. All samples at 50% coverage, and the majority of those at lower levels of coverage yielded estimates with less than a 20% error. However, little more than half of the estimates at 17, 25, and 33% were in error by <10% (Fig. 4b).

Assuming that the 5 years' data from these surveys are reasonably representative of population variability, the data in Fig. 4 can be used to generate probability statements. For example, given survey coverage of 33%, there is a one-third probability that errors will exceed 20% for total numbers and 10% for calf percentage.

These error predictions can be useful elsewhere if one can be reasonably assured that caribou distribution falls within a similar range of density and variability. In this study, coefficients of variation for total numbers of caribou and percentage calves ranged from 43 to 106% and from 6 to 26%, respectively. Unfortunately, extensive coverage would be necessary to accurately quantify the characteristics of a particular study population on-site, effectively defeating the purpose. An alternative approach might be modest presurveillance of an area of interest to obtain a subjective indication of whether or not the population qualifies.

The area surveyed in this study is but a small portion of the calving grounds of the Central Arctic Herd (Whitten and Cameron 1985). Had we undertaken an area-wide census, the present study area might well have been considered a single, high density stratum, since caribou in the immediate surrounding areas

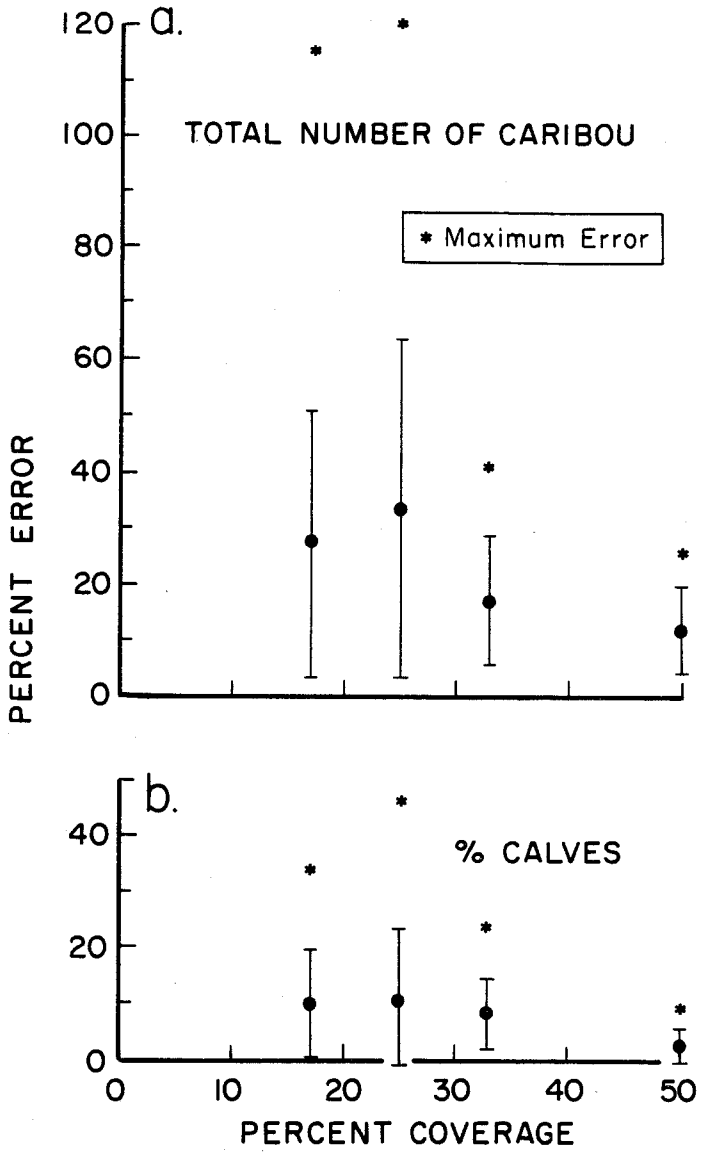

Fig. 3. Mean (±SD) and maximum errors for estimating (a) total numbers of caribou and (b) percentage calves at 4 levels of coverage, 11-14 June 1980-84.

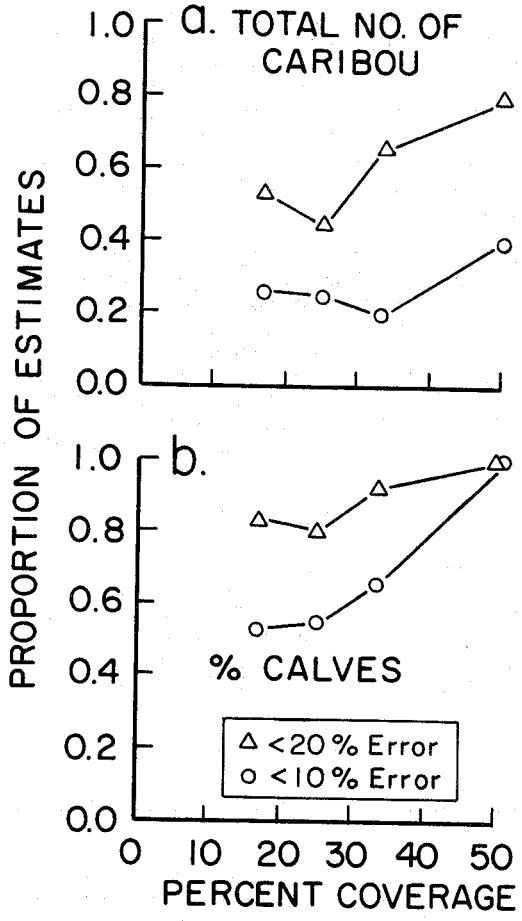

Fig. 4. Proportion of cumulative estimates, 1980-84, of (a) total caribou numbers and (b) percentage calves within 10% and 20% error.

typically occur at much lower densities during the first half of June. The point is that even when caribou distribution is relatively uniform, it appears that coverage of at least one-third is required to minimize the chances of serious error.

Bergerud (1963) suggested that at least one-third coverage would be necessary to assure accuracy within 10% for estimating caribou numbers where density exceeds 2.3 caribou/km² (6 caribou/mi²). Caribou density in the present study was considerably lower (0.3-1.6 caribou/km²), which some workers have suggested correlates with a more random distribution (Thomas 1969). Yet our analysis indicates that distribution was not random and at least 50% coverage would have been necessary to achieve accuracy within 10%; even then, the chances of error >10% were considerable (Figs. 3a, 4a).

We realize that time constraints, financial limitations, and logistics problems often preclude the high levels of coverage that are apparently necessary to obtain reasonably accurate population counts. For similar reasons, corrections for sightability are often ignored or inadequately addressed. It should be recognized, however, that even when numbers of caribou on transects are counted exactly, estimates based on less than one-third area coverage, and particularly those based on <10% coverage, may be little more than quantitative wild guesses.

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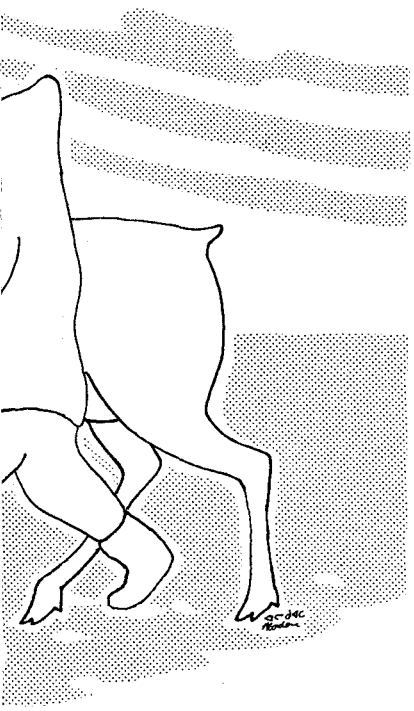

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