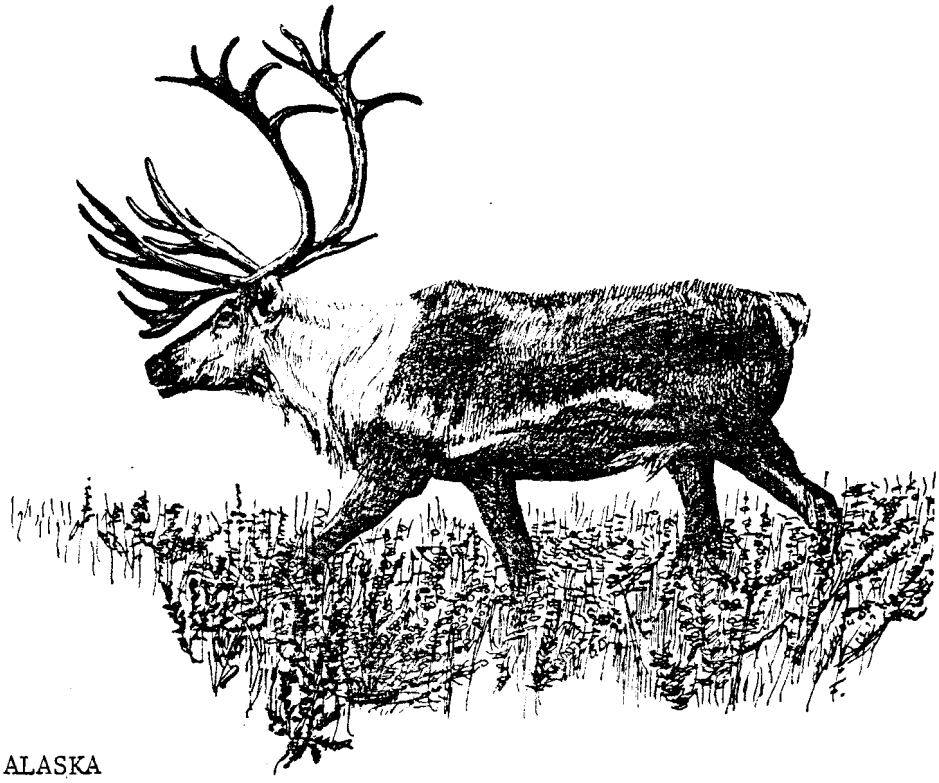
file

ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

PORCUPINE CARIBOU HERD STUDIES

By Robert E. LeResche



STATE OF ALASKA
Jay S. Hammond, Governor

DIVISION OF GAME
Frank Jones, Director
Donald McKnight, Research Chief

DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner

Final Report
Federal Aid in Wildlife Restoration
Project W-17-5, Jobs 3.10R, 3.11R and 3.12R

(Printed June, 1975)

FINAL REPORT (RESEARCH)

State: Alaska

Cooperators: Robert E. LeResche and Spencer Linderman

Project No: W-17-5 Project Title: Big Game Investigations

Job Nos:	Job Titles:
3.10R	Size, Composition and Productivity of the Porcupine Caribou Herd
3.11R	Movements and Distribution of the Porcupine Caribou Herd
3.12R	Characteristics of Habitat Used by the Porcupine Caribou Herd

Period Covered: October 1, 1972 - June 30, 1973

SUMMARY

In 1972 the Alaska Department of Fish and Game conducted intensive studies of the Porcupine caribou herd. Four major construction projects had been proposed within the current range of this herd and it was essential to gather baseline data on this herd so the influence of these developments may be assessed in the future.

Minimum herd size was determined to be approximately 100,000 animals in October 1972 using the "aerial photo-direct count-extrapolation technique. Previous estimates of herd size and techniques utilized to obtain them and the current estimate are discussed. Initial calf production in 1972 was a minimum of 55 calves:100 cows and classifications obtained in October suggested a calf:cow ratio of 30:100. These production estimates indicate that the Porcupine Herd was moderately productive and that in 1972 this herd's numbers were stable or increasing slightly. Sex composition data (28% of the herd consisted of adult bulls) and harvest estimates indicated that the Porcupine Herd had been little affected by hunting.

Herd movements during the study period indicate: 1) considerable calving occurs in Canada, 2) this herd and the Arctic Herd overlap ranges on winter range and spring migration routes, 3) significant numbers of Porcupine caribou sometimes winter in Alaska and 4) winter distribution of a large part of the Porcupine Herd near the Yukon River creates a very real potential for interchange between this herd and the Fortymile Herd.

Major caribou trail systems in the range of the Porcupine Herd were mapped and evaluated and the application of this technique for designing man-made structures which will accomodate caribou movement is discussed.

Vegetational characteristics of this herd's calving grounds and summer range are discussed.

CONTENTS

BACKGROUND

The Porcupine (Eastern Arctic) Herd is currently Alaska's second largest subpopulation of barren-ground caribou (*Rangifer tarandus granti*). Most animals in this herd are international travelers: occupying areas in Alaska in spring and summer but only occasionally in winter. A few Porcupine Herd caribou probably remain in the state throughout the year. The herd remains an important subsistence resource for residents of small bush communities in Alaska and Canada and sport hunters are just beginning to kill a number of animals from the Porcupine subpopulation annually. The herd has great potential value to nonappropriative users, for its huge post-calving concentrations on the Arctic coastal plain and spectacular massed crossings of the Porcupine River occur within reach of the general public. Few tourists have observed these spectacles to date, however.

Information concerning caribou associated with the present range of the Porcupine Herd dates from early explorations of the Arctic coast (Franklin 1826, Dease and Simpson 1838, Simpson 1843, Isbister 1845, Russell 1898, Pike 1892), when caribou were reported by whalers between Demarcation Bay and the Mackenzie River delta. Interesting reports indicated caribou were common year-round at Herschel Island, and that these animals intermixed with caribou east of the Mackenzie (Russell 1898). Nineteenth century reports from winter ranges (Funston 1896, Russell 1898) indicated distribution similar to today's, with semiannual crossings at the lower Porcupine River and some animals wintering near Arctic Village.

From 1900 until about 1940, the herd apparently increased in numbers and expanded wintering areas westward into the central Brooks Range (Skoog 1968, Hemming 1971). Murie (1935) indicated caribou were common in the Koyukuk-Chandalar area from 1917 through 1930. He mentioned that a harvest occurred at Fort Yukon in 1925 -- for the first time in a hundred years. Porsild (1945) described a huge southward migration ("millions") along the eastern Richardson Mountains at about the same time (1927); and, in the 1930's fall harvest increased steadily at Fort Yukon. Hemming (1971) cited a resident of Anaktuvuk Pass, in the central

Brooks Range, as saying caribou migrating through the Pass turned eastward (i.e. to the calving grounds of the Porcupine Herd) from about 1900-1920. Animals using the Pass since then have headed predominately westward, toward the Arctic Herd's calving grounds. Skoog (1968) suggested that the herd was actually two herds during this period: a northeast group and a Central Brooks Range group. No good estimate of the total number reached exists. In any event, a "drastic" (Skoog 1968) decline in numbers occurred following a population peak in the mid-1940's. Skoog (1968) attributed this decline to emigration to the Arctic Herd and/or across the Mackenzie into the Northwest Territories.

In 1953 Scott (1953) was the first to consider animals wintering from the Chandalar River to the Richardson Mountains as one herd. Since that time the Porcupine Herd has probably increased in numbers and has established (or reestablished) the patterns of distribution and movements currently observed.

Two occurrences in the 1950-1970 period merit special note: (1) repeated ingress of animals from the Fortymile Herd and, (2) occasional wintering and rutting in the eastcentral Brooks Range. In 1957 and again in 1964, substantial numbers of Fortymile Herd caribou migrated north from the northwestern Ogilvie Mountains with the Porcupine Herd (Olson 1958, Skoog 1964). The latter interchange was well documented and involved about 20,000 animals. It is unknown whether any of these animals rejoined the Fortymile Herd in succeeding springs. Olson (1957, 1959) reported that, in 1956 and 1958, many caribou migrated southward past the headwaters of the Ivishak and Sagavanirktok Rivers to winter in the Big Lake-Chandalar area. This may have been an atavistic distribution from days of more westerly distribution, or might continue to occur periodically. A similar winter distribution, resulting from a very different migration pattern, occurred in 1972-73 and is described in this report.

Subsistence utilization of caribou in the range of the Porcupine Herd has varied in magnitude and nature during recorded history. The resource apparently was either too small or too unreliable to play a crucial role in the lives of Arctic coastal peoples. Several writers have remarked that there were no permanent settlements north of the Brooks Range between Barrow and Herschel Island (U.S. Census Office 1893, as cited by Skoog 1968; Leffingwell 1919). Temporary coastal settlements were common, however. Permanent Eskimo settlements did exist at the eastern edge of the herd's range (Inuvik, Aklavik, Herschel) and their residents probably relied at least partially on caribou. Further south, many Athapascan villages utilized caribou to a greater or lesser extent (e.g. Arctic Village, Rampart, Fort Yukon, Venetie, Chandalar, Chalkyitsik, Old Crow, Eagle, Beaver, Stevens Village), but in all cases had alternate sources of food and materials in fish, moose (*Alces alces*) and/or Dall sheep (*Ovis dalli*).

The earliest white users of Porcupine Herd caribou were whaling crews on the Arctic Ocean. In the last half of the 19th century, whaling ships landed on the coast to shoot caribou in summer, and not infrequently

wintered near Herschel Island. Stone (1900) estimated that 15 ships wintering there one year consumed more than 300,000 pounds of caribou, mostly hindquarters. This might represent a harvest of as many as 4,000-6,000 caribou.

Whaling declined in the north by the early 1900's, at about the time white trappers, gold-seekers and traders began to invade the upper and middle Yukon basin. These new users probably never became as significant as the whalers were to the herd, and use by whites was practically nonexistent by the 1930's. Subsistence harvest of the herd probably peaked in the late 1960's, before dog teams were replaced by snow machines. Contemporary subsistence harvest is probably fewer than 2,500 animals in most years.

Pending proposals for natural gas pipelines from Prudhoe Bay and the Mackenzie delta to Alberta have created a resurgence of interest in the Porcupine Herd since 1970-71. Renewable Resources Consulting Service, Ltd. and Interdisciplinary Systems, Ltd. began studies of the herd in spring 1971. Their studies were expanded in 1972, when the Canadian Wildlife Service and the Alaska Department of Fish and Game also initiated major projects. Much has been learned in the intervening two years and information from these sources is summarized in this report.

Four major construction projects proposed to date occur within the current range of the Porcupine Herd; the Trans-Alaska (Alyeska) oil pipeline, the El Paso Natural gas pipeline, the Gas-Arctic natural gas pipeline and the Dempster Highway.

1. The Trans-Alaska oil pipeline has been under construction since spring 1974. It will be a 48-inch hot oil line from Prudhoe Bay to Valdez, passing through the western part of the herd's contemporary range. According to the latest designs available, approximately 50 percent of the line will be above ground in this area. A gravel road will follow the pipeline at various distances throughout its length.

2. The El Paso natural gas line would follow approximately the route of the TAP oil line but would likely be completely buried, with compressor-pumping stations each 60-100 km. No firm design proposals have been made for this pipeline.

3. The Gas-Arctic natural gas line would take one of three alternate routes from Prudhoe Bay to the Mackenzie Valley. It would be a 48-inch buried pipe with compressor-pumping stations approximately each 80 km. Applications are expected in early 1974, probably for the northern (foothills) route.

4. The Dempster Highway will link Inuvik with Dawson, and thereby with the contiguous highway system. This highway will be an all-weather, two-lane gravel road.

Whether these new developments will directly or indirectly influence movements, size and productivity of the Porcupine subpopulation remains to be seen. Information presented in this and related reports will serve as baseline data necessary to assess any changes that might occur in the next decade.

OBJECTIVES

1. To determine size, composition and productivity of the Porcupine Caribou Herd.

2. To determine movements, distribution and traditional migration routes of the Porcupine Caribou Herd in Alaska.

3. To delineate, characterize and map habitat used by the Porcupine Caribou Herd in Alaska.

PROCEDURES

Aerial Photo-Census

The method used was Hemming's "aerial photo-direct count-extrapolation technique" (APDCE), as described by Pegau and Hemming (1972). The technique involves four steps in the field: precensus reconnaissance, aerial photography, classification of animals in the post-calving concentration and classification of animals during rut. A final minimum estimate of animals in the herd is calculated from this information.

1. Precensus reconnaissance was carried out over the entire area east of the Kavik and west of the Babbage Rivers and north of Arctic Village and Old Crow. Our reconnaissance began June 20, 1972 and continued daily (weather permitting) through the date of the aerial photography (July 3). The entire area was covered in good weather conditions on June 29 and 30 and July 1,2 and 3 by our three aircraft (DHC-2, PA18-150, FH-1100) and a C-185 of Renewable Resources.

2. Aerial photography of the post-calving segment of the herd (comprising three groups at the time was accomplished on July 3 by a USBLM photogrammetric aircraft flying at 1,500 feet (ca. 500 m) AMT and providing stereo photographs at a scale of approximately 1:3,000. Animals not photographed were counted from the Beaver and Supercub aircraft.

3. A sample of 11,721 caribou was classified in the post-calving group on July 4 near the Jago River. Four crews, transported by helicopter, did the classifications from the ground with spotting scopes; segregating cows, calves, bulls and yearlings on the basis of body size and conformation, antler size and conformation and genital characteristics.

4. Grant M. Lortie (Interdisciplinary Systems, Ltd.) classified 2,979 caribou in the vicinity of Parkin Strip near the Dempster Highway on October 17, 1972. This is the only composition information available from the rutting period because of the scattered distribution of the caribou below timberline.

Trail Mapping

During June-August 1972 we mapped caribou trails in the described area at the same time we monitored caribou movements in the area. We flew over the area at approximately 80 km/hr. in a PA18-150 (Supercub) aircraft, at altitudes between 180 and 300 m aboveground. When unsure whether ground patterns represented caribou trails we flew as low as 10-20 m to enhance visibility. We often circled ground patterns at varying altitudes to take advantage of differences in lighting and reflections so attained. Trails were immediately mapped as they were observed on USGS 1:63,360 quadrangles (1 inch=1 mile).

Trail patterns were placed in one of three categories: narrow, heavy trails; wide, heavy trails; or light trails. The categories represent visual classification of trail patterns and result from a combination of factors including number of animals using the route, frequency of use of the route, recentness of use of the route and substrate characteristics. The categories are defined as:

1. Narrow, heavy trails: very obvious trails forming one "path", which may be as wide as 100 m, but is not an obvious series of individual, parallel or braided trails.

2. Wide, heavy trails: very obvious trails composed of a series of parallel or braided, narrow trails. Some trails in this category are 5-8 km wide.

3. Light trails: few or scattered indistinct trails either single, paralleled or braided.

Habitat Mapping

Wet meadow, tussock and riparian willow (*Salix* sp.) habitats were mapped on 1:63,360 scale maps during trail-mapping flights.

Habitat Characteristics

Ground cover was analyzed in $0.25m^2$ (0.5 m x 0.5 m) areas in wet meadow, tussock and riparian willow habitats north of the Brooks Range. Proportion of the area covered by each species or species group was recorded using the modified Hult-Sernander scale (Hanson 1958, Pegau and Hemming 1972) and converted to percent cover. Plant species were identified after Hultane (1968) and Hale (1969). Specific areas were chosen as representative of a habitat type and a spike was thrown to mark a starting point. A cord was stretched true east from the starting point and a quadrat was taken each 20 m along the north side of the cord. Eight transects were run and 125- 0.25 m^2 quadrats were sampled.

Aerial transects were flown on August 27,28 and 29, when autumnal colors helped in designating vegetation types. The area in Alaska east of 147°E longitude (roughly the Canning River) and north of 69°05'N (roughly the continental divide) was divided into quadrats 32 km (20 mi.) on a side. Each quadrat was gridded by 20 equidistant north-south and 20 equidistant east-west lines. One north-south line and one east-west line within each quadrat was chosen randomly and flown in a PA18-150 aircraft. The aircraft was flown at approximately 130km/hr. (80 mph) at an altitude of about 200 m (600 ft.) AMT. The observer in the rear seat watched the ground pass under a point marked on the wing strut and the pilot tapped the observer's shin each 10 seconds. The observer recorded the plant community under the marked point at the moment he was tapped by punching one of 7 buttons on a multiple counter. Flight time was recorded between each of two or three checkpoints on each transect and for each complete transect. Twenty-four transects were completed, including 1,822 separate "hits", or ground points recorded. Communities (or cover types) designated were: water, bare ground, tussocks, wet meadow, emergent *Carex, Dryas* fell-field and willow.

FINDINGS

Herd Size

Minimum size of the Porcupine subpopulation was 100,000 animals in October 1972. This estimate was derived as follows:

1. Number of caribou (including calves) counted on aerial photographs of post-calving concentration:
   82,680

2. Number of caribou (including calves) counted in peripheral (unphotographed) groups and estimated by interpolation to be present between non-overlapping photographs:
   10,080

3. Total caribou in postcalving concentration group:
   (1)+(2) = 92,760

4. Composition of post-calving group:

	No. Counted	Percent of Total
a) Cows	6,157	52.5
b) Calves	3,052	26.0
c) Bulls	1,433	12.2
d) Yearlings	1,079	9.2
	11,721	99.9

5. Number of cows in post-calving group (and therefore minimum number of cows in entire subpopulation):
   (4a)x(3) = 48,727

6. Composition of entire herd, as determined by Lortie during rut (assuming random mixing at that time) (Calef and Lortie 1973):

		No. Counted	Percent of Total
a)	Cows	1,461	48.7
b)	Calves	443	14.8
c)	Bulls	836	27.9
d)	Yearlings	257	8.6
		2,997	100.0

7. Minimum size of entire herd, assuming 48,726 cows (step 5) represents 48.7 percent (step 6) of the herd:

$$\frac{(5)}{(6a)} = 99,959 \text{ (or } 100,000 \text{ to the nearest } 100)$$

Previous rough estimates of the size of the Porcupine Herd made since 1949 by Scott et al. (1950), Munro (1953), Skoog (1963a, 1963b), Lentfer (1965), Renewable Resources (1972) and Calef and Lortie (1972) suggest a population low in the early 1950's, a peak in the mid-1960's of 500-700 percent the low number and a subsequent decline of 30 percent in the ensuing eight years. I feel it is unlikely fluctuations of this magnitude occurred and that we have no sound basis for any conclusions concerning population trends. Our present estimate is the first done by the rigorous aerial photograph-extrapolàtion method.

Scott et al. (1950) estimated the size of a group observed in late winter near Chandalar. It likely was but one segment of the Porcupine Herd; relationships between wintering groups and true "herds" were not understood until later. Munro (1953) estimated 30,000 caribou during spring migration. Estimates during this time of year are extremely difficult and are almost certain to be low. During spring 1972 (before the post-calving concentration), we pooled our survey data with those of Renewable Resources biologists and estimated a maximum of 35,000-40,000 caribou were in the herd. Our error became apparent when the concentration of 93,000 animals occurred in July. Without seeing this concentration, we would have estimated a herd size similar to that estimated by Munro, even though our aerial surveys were much more thorough and prolonged. Skoog (1963a), discussing Munro's figures in retrospect, felt the true 1953 population was about 55,000.

Skoog (1963a) attempted to extrapolate from numbers in the calving concentration, when he estimated a herd size of 110,000 (excluding calves) caribou in 1961. His method was a transect-sample, count-plus, estimate of the calving group, extrapolated by an aerial composition count (with fixed-wing aircraft) and demographic information known for the Nelchina Herd. The tenuous assumptions used in such a procedure are obvious; yet, this was the most rigorous estimate made until 1972. It was the first estimate to consider and use new knowledge of seasonal segregation, aggregation and distribution patterns. Skoog himself (1963a) felt the errors involved all tended toward underestimation.

Estimates made in 1963 and 1964 (Skoog 1963b and Lentfer 1965) were not based on any reported observations of the herd. The 1963 estimate was roughly the 1961 estimate including calves, and the 1964 estimate was the 1963 estimate plus the approximately 20,000 Fortymile Herd caribou that apparently joined the Porcupine Herd in spring 1964. Both estimates were extrapolations from an original crude estimate and thus cannot be evaluated retrospectively.

Renewable Resources (1972) estimated a herd of 60,000 animals from estimates of wintering groups in spring 1971. Calef and Lortie (1972) estimated 21,000-30,000 caribou by transects during spring migration, but believed their estimate was low. They estimated 60,000 in post-calving concentration, using aerial photographs of part of the aggregation counted by a sampling technique. Their photographs contained an estimated 40,000 caribou (including calves), which was estimated to represent two-thirds of the entire group.

Both Interdisciplinary Systems (Calef and Lortie 1973) and Renewable Resources (1973a, b) assisted in our census in spring 1972 and both now accept the resulting estimate of 100,000 for the Porcupine subpopulation.

Possible Errors in Estimating Herd Size

Because the aerial photography extrapolation method results in only a minimum estimate, statistical confidence limits have little meaning. Nevertheless, it is instructive to review potential sources of error in the method and assess their possible magnitude as best we can. Potential error sources include: (1) failure to photograph and/or count the entire post-calving concentration and "peripheral groups," (2) invalidity of the assumption that all adult females in the herd are present in post-calving groups, (3) failure to secure a classification of the post-calving group that represents the true proportion of adult females among the caribou photographed and counted and (4) failure to derive an accurate estimate of herd composition during autumn classification counts.

All these errors are primarily dependent upon whether the caribou are distributed and segregated as we think they are. Classification errors also depend upon sampling intensity.

Spring Photography/Counting Errors

These errors may stem from a failure to locate all post-calving groups in the herd, a failure to correctly count or estimate numbers of caribou in "peripheral" groups not photographed or incorrect interpretation of aerial photographs. I feel these errors were minimal in the 1972 census of the Porcupine Herd.

As described in "METHODS", intensive aerial surveillance was performed of the entire area where post-calving groups might reasonably have occurred. This coverage began a month before aerial photography was undertaken and continued (by Renewable Resources, Ltd.) for a month afterward. No observations during this period suggested that any post-

calving groups were unobserved on July 3, when we photographed the major concentrations and counted peripheral groups.

All peripheral groups but one were small enough to allow accurate total counts by helicopter or Supercub. The one exception was a group just east of Jago River, estimated by two observers in a helicopter and two in the photographic plane at between 3,000 and 4,000 animals. This group was taken at its minimum estimated size (3,000) for purposes of the final estimate (page 6, item 2). It is reasonable to assume we estimated within 33 percent of the true total of a group of this size, and we were certain there were no fewer than 3,000 animals, the final estimate for the entire herd would be increased by 1,078 (1.1%), using the method of extrapolation outlined above.

Aerial photograph interpretation was straightforward and almost certainly quite accurate, due to the quality of photographs and distribution of caribou. The technician who interpreted the photographs had previously interpreted photographs of the western Arctic Herd (1970) and the Nelchina Herd (1972). I spot-checked approximately 10 percent of the 1,500 photographs and found the counting of caribou accurate.

Due to gaps in photographic coverage, it was necessary to interpolate caribou present in approximately 7 percent of the area we attempted to photograph. Unphotographed areas were never more than one photograph wide, and were usually narrower. Interpolation was done on a per area basis, photograph by photograph. That is, if an unphotographed area 100 m wide occurred between two photographs, the number of caribou present in it was estimated as the mean of those present in adjacent 100 m strips in the photographs to either side of the "gap". Twenty-four unphotographed areas were estimated to contain 6,500 caribou. Caribou estimated in each unphotographed area ranged fron none to 1,592. There is no way to determine the accuracy of these interpolations, but breaking up each unphotographed area into the smallest units possible (one single photograph - approximately 750 m x 750 m maximum area on either side of the gap) achieved maximum possible accuracy. If it can be reasonably assumed that the number of caribou estimated to be in unphotographed areas was within 20 percent of the true number present, the final estimate of herd size could be raised or lowered by .20 x 6,500 females, or 1,401 animals extrapolated.

Invalid Assumption That all Females Were Present in the Post-calving Concentration

It is impossible to evaluate this source of error, except by noting that the proportion of adult females in the post-calving concentration (page 6, item 4) was similar to that found for the western Arctic Herd in 1970 (Pegau and Hemming 1972) and that few animals that could possibly have been adult females were observed outside of the concentrations. Hemming estimated that adult females comprised 51.2 percent of the 190,226 caribou in the post-calving concentration of the western Arctic Herd in 1970. Our estimate is that adult females comprised 52.5 percent of the caribou present in the 1972 post-calving concentration of the Porcupine Herd. This suggests that our estimate is reasonable if behavior and demography and classification of the herds were similar and if

virtually all adult females were present in the post-calving concentration of the Arctic Herd. More convincing is the fact that "bull-yearling" groups seen away from the post-calving concentrations contained virtually no caribou that resembled adult females and virtually no calves. No classifications were made of these groups from the ground, but a significant number of cows would not have gone undetected.

It is very unlikely that as many as 10 percent of the adult females in the herd were absent from the post-calving concentration. If this were the case, however, 5,414 cows would have been missed and the herd would have been underestimated by $\frac{5,414}{0.487}$ = 8,884 caribou (8.9%).

Inaccurate Estimate of Composition of Post-calving Group:

These errors may have arisen from improper sampling of the co centrations due to low sample size or non-random selection of animals to classify, or to inaccurate classification of animals observed.

Our sample of 11,721 animals classified represented 12.6 percent of the animals present, and thus represents reasonable sampling intensity. It was obvious at the time of classification that caribou were not randomly distributed within the concentration. There was but one large group. Bulls and yearlings seemed concentrated in the east and west portions of the group (ahead and behind) and were clumped where they were present in the central part of the concentration. We attempted to sample representative parts of the concentration, but could not formally stratify due to the fluid nature of the migrating group.

Classifications of animals at individual observation points by various observers give some estimation of the precision of the classifications. This is confounded by differences in observer accuracy, which cannot be corrected for, however.

Significant ($P < .001$; x^2) differences occurred both between the composition of groups of caribou classified by the same observers and between those classified by different observers. Contingency coefficients were 0.39 within counter pair 1, 0.47 within counter pair 2 and 0.34 between counter groups, suggesting that non-random distribution of cows, calves, bulls and yearlings was more important than differences between counters' techniques.

Applying standard statistical methods to the proportions of adult females observed in each of the eight groups classified results in 90 percent confidence limits of 52.5±10.9 percent, or 41.6-65.4 percent cows in the postcalving concentration. Since there were 92,760 caribou in the concentration, the estimate of the total number of adult females (considering only this classification error) is 38,588-60,665, at the 90 percent confidence level. Ignoring other possible errors, this range extrapolates to a minimum herd size of 92,760-124,659.

Accuracy of classification during July is probably reasonably high, with the possible confusion of adult females and young males. Skoog (1968) tabulated criteria for field identification of caribou during

spring and autumn and we used the identifying characters he described in large part. In addition, we employed genital characteristics as a criterion when uncertainty remained after employing other criteria.

The estimate of age/sex structure derived for the post-calving group met rough expectations, so there is no compelling reason to doubt its accuracy. It is, nevertheless, instructive to calculate the potential effects of confusion of cows and young males. For example, if 10 percent of those animals classified as "adult females" in spring were indeed young males, final estimate of herd size would decline to:

$$\frac{(.525 - .053) \times 92{,}760}{.487} = 89{,}903$$

This would represent a decrease in estimated herd size of 10,056 caribou (10%). The resulting bull:cow relationship in the post-calving concentration

$$\frac{.122 + .053}{.525 - .053} = 37:100$$

would be suspiciously high for a herd segregated as we know it was at the time, with substantial "bull groups" present away from the concentration.

Conversely, if 10 percent of those animals identified as young bulls (and thus placed in the "bulls" category) were actually adult females, the estimate of herd size would have increased. Calef and Lortie (1973) estimated that 48 percent of bulls older than yearlings were "immature" or less than three years old. If this were true in the post-calving group, and if 10 percent of these were actually misidentified adult females, the final estimate for the herd would have been:

$$\frac{.525 + (.10 \times .48 \times .122) \times 92{,}760}{.487} = 101{,}114$$

This represents an increase of 1,155 caribou, or 1.2 percent. An error of this magnitude is certainly more likely to have occurred than the preceding error and a confidence range of $\pm$ 1,155 for inaccurate classifications is reasonable.

Inaccurate Estimation of Autumn Composition of Entire Herd

The census method is most vulnerable to this error, for final herd size is extrapolated on the basis of the assumptions that 1) the entire herd is randomly mixed during the autumn rutting period and 2) that it is possible to distinguish accurately between adult females and other caribou in a representative sample of the herd at this time of year.

The problems encountered in spring classifications - possible non-random distribution and difficulty in accurately distinguishing adult females and young males - are amplified in autumn composition counts. The herd is invariably more widely dispersed in autumn and is often within the boreal zone where it is more difficult to observe animals as they pass. Because of these difficulties, only one reasonably good fall classification of the Porcupine herd has ever been accomplished: that done by Lortie from October 12-14, 1972 (Calef and Lortie 1973). Even this classification was considered representative only of a portion of the herd totaling about 15,000 animals (Calef and Lortie 1973). It remains the best information we have, however.

The 2,997 animals classified represent approximately 3 percent of the herd. The five groups classified by Lortie differed significantly from one another ($P < .001$; $\chi^2 = 41.16$, 12 df); however, the contingency

coefficient (C = 0.12) was smaller than that associating caribou groups with composition in spring (0.34). This indicates that mixing was more homogeneous in autumn and that the classification counts may have been more precise despite the smaller sample sizes.

Confidence intervals (90%) for the proportion of cows present in the autumn classifications are 44.4 percent-53.0 percent, using Lortie's five groups as individual samples. Using the uncorrected estimate of total number of cows in the herd (48,727 from spring photographs and classifications item 5, page 6), total animals in the herd can be estimated at between $\frac{48,727}{0.530}$ and $\frac{48,727}{0.444}$, or 91,938-109,746. Estimated sampling error (90% confidence level) in autumn, thus affects the final estimate by $\pm$ 8,904 animals.

Inaccuracy resulting from confusing yearling males with adult females in autumn may have occurred in Lortie's classifications. However, Lortie (*Viva voce*) used gential characteristics wherever there was a question and the error was probably minimal, if it existed at all. Calculating from a possible error of 10 percent, as for spring classifications, causes a change of +11,290 or 719 animals in the final herd estimate.

Cumulative Effects of All Errors

It is unlikely that all the errors listed actually occurred, but calculation of their cumulative effect on the estimate of herd size is instructive.

The minimum number of animals in the herd is at least 86,260, for that many were counted in photographs and peripheral groups. If all seven types of errors occurred to the maximum extent discussed, the corrected estimate of herd size is 170,448, or 1.7 times the uncorrected estimate. As described above, it is improbable that any one error occurred to the maximum extent considered. The probability of all seven errors occurring maximally and in the same direction (i.e. toward deflating the estimate) is thus infinitesimally small.

Considering the method used, the thoroughness of aerial surveys accomplished, the physiographic features of the area of post-calving concentration and the distribution of the caribou during the critical phases of the census, there is little compelling reason to doubt the final estimate of 100,000 animals in the herd. Nevertheless, perhaps the most important information derived from the census procedure is the incontrovertible fact that at least 86,260 caribou were present in spring 1972. This is within 14 percent of the final extrapolated estimate of 100,000 and is subject to no possibility of error (except in the extremely unlikely event that the number of caribou on the photographs was over-counted). It is thus a certainty that there were no fewer than 86,260 caribou in the Porcupine Herd in July 1972.

Population Dynamics

Calf Production and Survival

Calf production and survival were assessed during calving, post-calving concentration and autumn. Initial calf production was a minimum of 55 calves:100 cows ($\frac{987}{1167+469}$) as estimated on June 8, 1972. It was almost surely higher, for the animals were classified by helicopter and yearlings and bulls were indistinguishable from cows. Furthermore, some calves were likely born after this date. Maximum calf proportion present at this time can be estimated by assuming all adult females, and only adult females, carried hard antlers at this time. If this were the case, the calf proportion would have been $\frac{897}{1167}$, or 77 calves:100 cows. This is almost certainly an overestimation, for some cows had surely shed their antlers by this date, which was at least 1-3 days after the calving peak. Thus, calf "crop," within the first week after parturition, was 55-77 calves:100 adult females.

By July 4, 1972 the calf:cow proportion had declined slightly to 50 calves:100 adult females, indicating only light to moderate calf loss during the first 3 weeks after parturition.

Classifications obtained in October by Lortie (see above) suggest only 15 percent calves in the herd, or a calf:cow ratio of 30:100. This represents a decline of 45 percent from early June and of 40 percent from July calf numbers, assuming a stable number of cows.

These estimates, if reasonably accurate, indicate that the Porcupine Herd was moderately productive for a northern caribou population, that summer calf losses were about "normal" and that fall calf proportion in the herd was indicative of a stable or slightly increasing population.

Lent (1966), estimated calf production of 73, 42 and 53 calves:100 cows in three separate years in the Arctic Herd, which he felt was stable or slowly increasing. Our estimate of 55:100 falls very near the mean of these three years' productivity.

Calef and Lortie (1973) suggested that most calf mortality occurring between spring and autumn took place during July when post-calving aggregations were most dense and daily movements greatest. Estimates for the Porcupine Herd in 1972 are consistent with this and it is evident that this pattern might occur in other herds (e.g. Fortymile Herd, LeResche and Curtolo, unpublished data).

Kelsall (1968) calculated that, over 14 years, spring calf ("short yearling") proportions in central Canadian Arctic caribou populations averaged 15-16 percent. Lent (1966) had similar estimates for the western Arctic (Alaska) Herd. Calef and Lortie (1973) suggested from these sources and the present data that caribou populations decline

when autumn calf proportions are less than 15 percent and expand when they exceed 15 percent. I concur with their conclusion that productivity estimates from 1972 suggest the Porcupine Herd is a roughly stable population at this time.

Sex and Age Composition

Bull:cow proportions, estimated at 57:100, suggest that 28 percent of the population was adult bulls. This is similar to Hemming's (Pegau and Hemming 1972) estimate of 64 bulls:100 cows in the western (Alaska) Arctic Herd (1970), Kelsall's (1968) most confident estimates (44-64 bulls:100 cows) for central Canadian Arctic populations and Skoog's (1968) estimates for the Nelchina population (Alaska) in the late 1950's and early 1960's. All these herds were only lightly to moderately hunted. Decline in bull:cow proportion has been reported in heavily hunted populations. Bergerud (1971) reported that 9 years of bulls-only hunting in Newfoundland reduced the proportion of males in the herd from 32 percent to 23 percent. Bos (1974) estimated the Nelchina Herd contained 53 adult bulls:100 cows in the early 1960's and only 31 bulls:100 cows in the early 1970's after nearly a decade of moderate to heavy hunting. In this case, as in all Alaskan herds, kill is not legally restricted to bulls, but bulls are selected by hunters. Our estimate of the Porcupine population of 28 percent adult bulls (57:100 cows) suggests, as do harvest estimates, that the Porcupine Herd has been little affected by hunting to date.

Harvest and Hunting Pressure

Estimated harvests from the Porcupine Herd from spring 1972 through spring 1973 were:

Alaska	
Arctic Village	1,000
Kaktovik	300
Venetie, Chalkyitsik, Ft. Yukon	100
Other	100
	1,500
Canada	
Aklavik, Inuvik, Ft. MacPherson, Arctic Red River, Tuktoyaktuk	2,000
Old Crow	600
Dempster Highway & misc.	75
	2,675
Total Alaska and Canada	4,175

These are very crude estimates derived from personal observations and interviews with resident hunters, biologists and others. Distribution of kill during this period was unusual due to the fact that most of the herd wintered near Arctic Village rather than near the Dempster Highway in the Richardson and Ogilvie Mountains. Kill in the McKenzie Delta region (Aklavik, etc.) was probably a little above normal.

The present liberal seasons and bag limits in Alaska remain appropriate to this large and usually isolated herd. There is no conflict between present levels of subsistence use and sustaining the resource. Legal "commercial" utilization of this herd within Game Management Units 22-26 has been negligible to date, but several hundred caribou were used as barter currency or gifts by people in the Arctic Village-Fort Yukon area. This use is appropriate at present levels, but should be watched closely in the future if caribou numbers or level of "commercial" use change.

Movements and Aggregations

Movement patterns of the Porcupine Herd have been reported in great detail by Calef and Lortie (1972,1973), Renewable Resources (1971, 1972, 1973) and others (e.g. DeBock, in press and LeResche, 1974) and will not be repeated here. In general, 1971-73 movements can be summarized as follows:

The herd wintered (1971-72) in four major groups, all in Canada, as reported by Calef and Lortie. Most of the herd wintered south of the Peel River in the Ogilvie, Knoor and Trevor Mountains. Another large group wintered in the southwest and west-central Richardson Mountains (and Caribou Mountain area) and a smaller group used the Eagle Plains. A few caribou from the Porcupine Herd were also scattered in Alaska south of the Brooks Range from the border as far west as the eastern Kanuti Flats.

Beginning in late April 1972, caribou migrated northward along the Richardson Mountains and across the Old Crow Flats. Most reached the coastal plain in Canada, but many traversed the Brooks Range through passes in Alaska. Animals from as far west as Deitrich Pass turned east to the calving grounds of the Porcupine Herd.

Calving occurred in the Brooks Range foothills at elevations from 1,000-3,500 feet, from the Babbage River on the east to the Hulahula or Canning on the west. Most calving occurred east of the Jago River. Peak of calving probably occurred on June 5-7. Post-calving concentrations formed in late June and by July 4 the entire post-calving group was in one mass, moving eastward on the coastal plain just east of the Jago River. About 30 percent of the herd entered Canada in early July and the rest swung back northwestward along the Alaska coastal plain as far as Camden Bay, then proceeded southeast to enter Canada in August.

The herd crossed the Porcupine River near Driftwood River in late September. By the first week of November, the vanguard had reached the Dempster Highway and Ogilvie River and about two-thirds of the herd had turned northwest, recrossed the Porcupine near the mouth of the Colleen and proceeded northwest as far as Sheenjek Lake. About 60-65,000 caribou wintered in Alaska, primarily in the south foothills of the Brooks Range between the Colleen River and Chandalar. Major concentrations used the East Fork Chandalar River throughout the winter of 1972-73.

The remainder of the herd (30-35,000 animals) remained just north of the Yukon River in the western Ogilvie Mountains, using the upper Tatonduk and nearby drainages.

Four facts are especially noteworthy concerning present movement patterns of the Porcupine Herd:

First, the calving area must be defined as the Arctic foothills and coastal plain from the Canning River to the Babbage River. Skoog (1962) and later workers felt the calving grounds did not extend eastwead of the Kongakert River. Calef and Lortie (1973) also stressed the importance of the Canadian portion of the calving ground, especially the Spring River to Clarence River segment of the coastal plain.

Second, the Porcupine and Arctic populations overlap on winter range (e.g. Kanuti Flats) and spring migration routes (Deitrich-Atigun area) and animals from the Porcupine population cross the Trans-Alaska Oil Pipeline Corridor. LeResche (1974) discusses this overlap.

Third, significant numbers of caribou from the Porcupine population sometimes winter in the east-central Brooks Range, from the Colleen River to Chandalar. Although small numbers always winter in Alaska, Olson (1957, 1959) was the last to report such a winter distribution (in 1956 and 1958 at Big Lake-Chandalar). In these winters, however, caribou arrived at their winter area from the north (i.e. via the Ivishak and Sagavanirktok Rivers) rather than from the southeast.

Fourth, the winter distribution of a large part of the Porcupine Herd very near the Yukon River made an interchange with the Fortymile Herd very possible. Such an exchange did not occur, but such movements suggest the possibility for an interchange remains high.

Trail Patterns

The general pattern of summer movements observed from 1971 to 1973 is illustrated by the trail patterns mapped, but other patterns less easily explained by recent observations are also present.

During the past two years, caribou have arrived on the mapped area in late May from the south and east, using the Kongakut and Aichilik River valleys and the foothills just south of the coastal plain. After calving in early June they have moved westward in the foothills, generally following contours from 800-1,500 feet (275-500 m) elevation. Some animals have traveled as far west as the Canning River before forming large post-calving concentrations. Concentrations of 30-60,000 animals have formed on the flat benches along the upper Okpirourak River and in the northern foothills of the Sadlerochit Mountains. These concentrations have then moved northwest and northeast to join on the coastal plain just south of Camden Bay in a tremendous concentration of miles. On July 3 in both 1972 and 1973 the concentration moved eastward in a broad-front extending from the intertidal zone of the Arctic Ocean inland 25-30 km (15-20 miles). The animals trended southeast after crossing the Jago River and crossed Aichilik and Egaksrak Rivers on a broad-front. Animals reaching the mouth of the Kongakut River swung south, funnelling together with those from farther inland. The entire herd crossed the Kongakut north of the Plulaluk River, proceeding eastward into Canada by mid-July.

These movements are well indicated by trails which show north-south movement through the Brooks Range, east-west movement in narrow fronts in the foothills, northerly movement of the concentrations toward Camden Bay and extensive broad-front east-west movement along the coastal plain.

Large-scale maps of trail systems show important facets of terrain-following and natural-feature diversions by caribou. Trail direction and nature (i.e. single line or broad-front) vary with steepness, nature of slopes and with features such as lakes, rivers and cut-banks. These interactions occur often enough to allow some prediction of routes caribou trails will take, but are not so rigidly fixed to make field checks unnecessary.

Several principles appear to hold generally true both from examination of trail systems and observations of caribou:

1) Caribou follow contours in hilly terrain. They traverse side hills rather than travelling perpendicularly to, or across, contours. This tendency is especially evident in the northern foothills of the Brooks Range, where east-west trail systems follow the 750-1,200 foot (250-400 m) contours and through mountain passes where caribou often use slide slopes as well as valley bottoms.

2) When traversing hilly terrain caribou usually use ridgelines, lowest passes and most gentle slopes, however, animals occasionally use steeper terrain for unknown reasons.

3) Caribou tend to travel in narrower lanes when in steep areas and to spread out on a broader front when in flat areas.

4) Caribou tend to course natural features (i.e. rivers, steep slopes, cut-banks) for some distance before crossing them. This appears true regardless of how easily they might be crossed at the point of first encounter.

5) Caribou trails themselves are important terrain features and affect caribou movements. That is, caribou will tend to follow nearly the exact path of a preceeding group of animals, even in areas of almost featureless terrain. The more recent the preceeding movement, the more likely the succeeding group is to follow it. As a result, precise routes travelled by groups of caribou vary more from year to year than within a given year.

6) The above factors combine to "funnel" caribou between or along terrain features that are obstacles or are below optimum travel routes for caribou. These areas of funnelling thus become critical areas for caribou movements.

DISCUSSION

Trail patterns in the eastern North Slope and Brooks Range demonstrate almost total use of this area by caribou in the past. Animals of the Porcupine Caribou Herd currently use this area for calving grounds and summer range: therefore, trail maps in this particular area disclose little new information regarding general presence of caribou. Trail maps do, however, provide insight into specific routes used as specific sites and may thus be useful in planning any structures that may be considered in the future. In addition, they do show specific routes used in the past but not used during the past two years.

For example, were a barrier of some sort (e.g. a road, a railroad, an elevated pipeline or a powerline) to be built in an east-west direction across the area mapped, caribou movements would be least affected were it built in certain locations. Generally, a route north or south of the major zone of caribou trails would be preferable (i.e. along the coast or in the foothills above 1,000 m [3,000 ft.] elevation). Once the general route was chosen, specific routings could take into account specific trail patterns. An optimum design would parallel trails where possible and provide crossing features where trails and structure intersected. It would avoid entirely areas where caribou from a broad-front funnelled into a narrow trail. Further, building the structure to follow features that are natural barriers ordinarily coursed by caribou (i.e. cut-banks, swift parts of large rivers, steep hillsides) would minimize its additional blocking effects, provided crossings were constructed where natural crossings occur.

We expect that this technique and modifications of it (e.g. mapping trails from aerial photographs) will be used in the future where man-made structures must be designed to accomodate caribou movement. We have used caribou and moose trail patterns to evaluate design for the Trans-Alaska Oil Pipeline and to comment upon development plans for the Prudhoe Bay oil field. Since long-term intensive studies of large mammal behavior are impossible over areas as large as those affected by these projects, trail maps are often the only means we have to estimate

movement patterns. In addition, some areas (e.g. east-central Alaska, western Alaska) are not presently fully used by caribou, but have been in the past and could be in the future. Trail patterns in these areas are especially useful in reconstructing movement patterns.

The technique is basically a subjective recording of signs left by past events on a very variable and unstable substrate. As such, it involves two major problems: 1) caribou leave visible trails in some places more readily than in others and 2) caribou trails persist in some areas longer than they do in others. The type of trails that will appear, and how long they persist are products of soil type, slope, aspect, water content, number of caribou, frequency of use, caribou behavior (e.g. milling, walking), time of year and probably other factors (Benninghoff 1952, Hok 1969, Pegau 1970). As such, our technique cannot hope to indicate frequency of use, recentness of use or intensity of use of a given caribou trail. In fact, absence of trails is not sure proof the area is unimportant to caribou, although consideration of general soil and vegetation types and general seasonal movements in the area provide indications in most cases. What the technique does show is where caribou have been in the past. For this reason alone it is a valuable tool in evaluating construction plans in areas where intensive or long-term study has not been possible.

Characteristics of Calving Grounds and Summer Habitat

The calving-summer ranges of the Porcupine Herd include predominately the Arctic foothills and Arctic coastal plain provinces of Wahrhaftig (1965). These are dominated by *Eriophorum* tussock communities (foothills) and damp meadows and wetter *Carex* communities (coastal plain) (Spetzman 1959, Britton 1967). Significant areas of riparian willow (*Salix*) communities occur along many drainages (LeResche et al. 1974). In addition, caribou use the Brooks Range (Arctic Mountains) province occasionally during summer, occupying *Dryas* fell-field habitats.

LITERATURE CITED

Benninghoff, W.S. 1952. Interaction of vegetation and soil frost phenomena. Arctic. 5:34-44.

Bergerud, A.T. 1971. The role of the environment in the aggregation, movement and disturbance behavior of caribou. Proc. 1st. Int. Symp. on Behavior of Ungulates and Its Rel. to Mgmt. Calgary. 47pp.

Dease and Simpson. 1838. Account of the recent arctic discoveries by Messrs. Dease and Simpson, with maps. Royal Geog. Soc. J. 8:213-225.

Franklin, J. 1828. Narrative of a second expedition to the shores of the polar sea, in the years 1825, 1926 and 1827. J. Murray, London. 320pp.

Funston, F. 1896. Along Alaska's eastern boundary. Harper's Weekly. 40(2041): 103-104.

Hanson, H.C. 1958. Analysis of Nelchina caribou range. U.S. Fish & Wildl. Serv. Fed. Aid in Wildl. Rest. Alaska. Proj. W-3-R, Job Compl. Repts. 12(4):1-68.

Hemming, J.E. 1971. The distribution and movement patterns of caribou in Alaska. ADF&G Tech. Bull. No. 1. 60pp.

_____ and R.E. Pegau. 1970. Caribou Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. Proj. W-17-1 and W-17-2. Juneau. 42pp.

Hultén, E. 1968. Flora of Alaska and neighboring territories; a manual of the vascular plants. Stanford Univ. Press. 1008pp.

Isbister, A.K. 1845. Some account of Peel River, N. America. Royal Geog. Soc. J. 14:332-345.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Queen's Printer. Ottowa. 340pp.

Leffingwell, E.deK. 1919. The Canning River region, northern Alaska. U.S. Geol. Survey. Prof. Paper. 109:251pp.

Lent, P.C. 1966. The caribou of northwestern Alaska. p. 481-517, In N.J. Wilimovsky and J.N. Wolfe (Eds.), Envir. of the Cape Thompson Region, Alaska. U.S. Atomic Energy Comm. Wash.D.C. 1250pp.

Lentfer, J. 1965. Caribou Report. Alaska Dept. Fish and Game, Fed. Aid in Wildl. Rest. Prog. Rept. Proj. W-6-R-5-6. Juneau. 20pp.

Munro, D.A. 1953. A preliminary report on the caribou of northern Yukon Territory. Can. Wildl. Serv. unpubl. rept. Ottowa. 36pp.

Murie, O.J. 1935. Alaska-Yukon caribou. N. Am. Fauna. No. 54. U.S. Dept. of Agr. 93pp.

Olson, S.T. 1957. Management studies of Alaskan caribou movements, distribution and numbers - Steese-Fortymile herd. P. 45-48. In U.S. Fish and Wildl. Serv. Fed. Aid in Wildl. Rest. Job Comp. Rept. 11(4):1-132.

_____. 1958. Movements, distribution and numbers -Steese-Fortymile herd. P. 41-46, In U.S. Fish and Wildl. Serv. Fed. Aid in Wildl. Rest. Job Comp. Rept. 12(3):1-118.

_____. 1959. Movements, distribution and numbers - Arctic caribou and other herds. P. 58-70, In U.S. Fish and Wildl. Serv. Fed. Aid in Wildl. Rest. Job Comp. Rept. 13(2):1-125.

Pike, W. 1892. The barren ground of northern Canada. MacMillan and Co. New York. 300pp.

Porsild, A.E. 1945. Mammals of the Mackenzie Delta. Can. Field Nat. 59(1):4-22.

Russell, F. 1898. Explorations in the far north. State Univ. Iowa, Iowa City. 290pp.

Scott, R.F., E.F. Chatelain and W.A. Elkins. 1950. The status of the dall sheep and caribou in Alaska. Trans. N.Am. Wildl. Conf. 15:612-626.

Simpson, T. 1843. Narrative of the discoveries on the north coast of America; effected by the officers of the Hudson's Bay Company during the years 1836-39. Richard Bently. London. 419pp.

Skoog, R.O. 1962. A gross method for estimating size and status of caribou herds. Alaskan Sci. Conf. Proc. 13:37-39.

_____. 1963a. Alaska Wildlife investigations; caribou investigations. Alaska Dept. Fish and Game. Fed Aid in Wildl. Rest. Proj. W-6-R, Ann. Prog. Rept. 89pp.

_____. 1963b. Alaska wildlife investigations; caribou investigations. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. Proj. W-6-R, Ann. Prog. Rept. 31pp.

_____. 1964. Alaska wildlife investigations; caribou investigations. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. Proj. W-6-R, Ann. Prog. Rept. 44pp.

_____. 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. PhD. Thesis. Univ. Calif., Berkeley. 699pp.

Spetzmann. L.A. 1959. Vegetation of the arctic slope of Alaska. U.S. Geol. Survey. Prof. Paper 302-B: 58pp.

Stone, A.J. 1900. Some results of a natural history journey to northern British Columbia, Alaska and the Northwest Territory, in the interest of the American Museum of Natural History. Am. Museum Nat. Hist. Bull. 13(5):31-62.

Wahrhoftig, C. 1965. Physiographic divisions of Alaska. Geol. Surv. Prof. Paper. 482. U.S. Gov. Printing Office. Wash. D.C. 52pp.

PREPARED AND SUBMITTED BY:

Robert E. LeResche
Game Biologist

APPROVED BY:

_____
Director, Division of Game

_____
Research Chief, Division of Game