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Research Progress Report

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Job 3.33R
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(Includes data through December 1986)

SUMMARY

This study is an expansion of, and is complementary to, Projects W-21-2 and W-22-1 through W-22-4, Job 3.27R, for which a final report was printed in 1985. Background and histories are presented for radio-collared caribou (Rangifer tarandus granti) that were available for this study. Distribution of the Delta Caribou Herd (DCH) and Yanert Caribou Herd (YCH) overlapped during censuses of post-calving aggregations in both 1985 and 1986. The 1985 census estimated 8,083 caribou in the DCH and YCH combined and the combined 1986 census estimate was 7,804. Natality data were obtained primarily from monitoring radio-collared females from the DCH and YCH. Natality in the DCH and YCH remained relatively high, and natality data from 1981 through 1986 are compared with natality data from the Fortymile and Western Arctic Caribou Herds.

A fixed-wing survey suggested excellent short yearling (survival to 11 mos) recruitment in the DCH in 1985--51 short yearlings:100 caribou older than short yearlings. In 1986, sampling short yearling recruitment in the DCH was designed to evaluate bias and to allow calculation of a confidence interval. The unadjusted ratio of short yearlings:100 cows was 31.4 ± 9.8 (95% CI), and an adjusted ratio was 38:100. We estimated 49 short yearlings:100 cows in the YCH during spring 1986. Between 1979 and 1985, both total annual mortality rates and wolf-induced (Canis lupus) annual mortality rates increased for radio-collared adult females in the DCH and YCH. The wolf-induced mortality rate in 1985-86 was 11% and the

total mortality rate was 22%; however, both rates could be biased overestimates.

Predator:prey ratios were calculated for the DCH, the YCH, and for all of Game Management Subunit (GMU) 20A. In 1975 there was 1 wolf:41-44 caribou "equivalents" in GMU 20A compared with 1 wolf:172 caribou equivalents in 1985. The wolf population size in GMU 20A during fall 1985 was estimated at 195 compared with 239 in 1975.

A University of Alaska Master of Science project by Steve Fleischman complements our study; his project outline appears as an appendix. A manuscript discussing calving ground fidelity was published following our last report. The abstract appears as an appendix and the citation follows: Davis, J. L., P. Valkenburg, and R. D. Boertje. 1986. Empirical and theoretical considerations toward a model for caribou socioecology. Rangifer, Spec. Issue No. 1, 1986:103-109.

Key Words: caribou, census, Delta Herd, demography, grizzly bear, mortality, population dynamics, *Rangifer*, recruitment, wolf, Yanert Herd.

CONTENTS

BACKGROUND

Few caribou (*Rangifer tarandus granti*) herds in Alaska have remained stable for more than a few years; it has been particularly rare for a heavily harvested herd to remain stable.

The Alaska Department of Fish and Game's (ADF&G) goal for some caribou herds, as stated in various Draft Wildlife Management Plans, is to stabilize some herds at specific levels and to ensure that others do not decline below set minimum sizes. If these goals are to be accomplished, and if any caribou management program is to be successful, understanding of the mechanics of caribou population dynamics is essential. The factors that determine population dynamics for all wildlife species are the same: births, deaths, and emigration/immigration. However, the specific variables affecting these 3 factors can differ greatly.

A good quantitative assessment of the demography of an Alaska caribou herd has never been conducted over a period of greatly varying rates of natural mortality and human harvest. In a recent workshop (Klein and White 1978) attended by leading caribou researchers in North America, a need for intensive demographic study of 1 or more caribou herds in Alaska was identified.

Proximity of the Delta Caribou Herd (DCH) to Fairbanks, our considerable background information on the herd, and options for intensively managing (i.e., manipulating) the herd make it ideal for long-term demographic study. Hypotheses may be more feasibly tested on the DCH than on larger herds, such as the Western Arctic and Porcupine Herds, regarding many aspects of general caribou ecology. (A recent study of the DCH [Davis and Preston 1980] revealed that herd demography was misunderstood from 1975 through 1979.) The DCH will continue to be intensively managed, so a thorough understanding of its demography is essential.

Davis and Neiland (1975) reviewed and compiled all available data for the DCH in 1974. Additional background information has been presented by Davis and Preston (1980), Davis and Valkenburg (1981, 1983, 1985), and Davis et al. (1982, 1983). During the past 16 years, the DCH has declined dramatically (from 5,000 in 1969 to ca. 2,000 in 1975) and increased even more dramatically (from ca. 2,000 in 1975 to >7,000 in 1982). Since 1982, herd growth has been slowed by hunting. During the past 16 years, high and low levels of both natural mortality and harvest have occurred, and much has been learned about caribou population dynamics (Davis et al. 1983). More importantly, much has been learned about the interrelationships between large predators, prey, and man in Game Management Subunit (GMU) 20A (Gasaway et al. 1983).

By continuing to study the DCH's demography, and by simultaneously intensifying study of the herd's behavior, nutrition, energetics, and interaction with the biotic (including predators) and abiotic environment, we should ultimately understand caribou ecology to the degree presently demanded by the growing pressures on caribou and their habitat.

Since study of the DCH was intensified in 1979, considerable data on herd movements and distribution have been collected incidental to fulfilling major objectives. Skoog (1968:202, 655) and Bergerud (1974a) discussed movements and distribution mechanisms of caribou as they affect herd demography. As populations increase, caribou travel more widely and may increase their use of marginal ranges. Use of marginal ranges could result in lower natality and increased mortality due to greater energy expenditures, poorer quality forage, and greater vulnerability to predation.

Implications of movements and distribution of caribou herds to population demography are sufficient to warrant collation and analysis of existing movement and distribution data. If the DCH continues to increase, any change in movements and distribution will be better interpreted if earlier patterns are well documented.

Opposing views are emerging among caribou biologists regarding basic social organization of caribou, including questions of herd identity, herd definition, and fidelity to calving areas and seasonal ranges (Bergerud et al. 1984, Carruthers 1985, Martell and Russell 1985). The known histories of radio-collared caribou in the DCH and the Yanert Herd (YCH) could prove invaluable in contributing empirical evidence about the social organization of caribou (Davis et al. 1986).

The use of aerial photography for estimating population size of caribou herds is becoming more popular. The assumption that all caribou that are photographed (including calves) can be counted from photos has not been validated. Many other caribou management/research techniques that are presently employed require validation. For example, the reliability of conducting herd composition counts in April as an indication of "yearling recruitment" has not been critically examined. Also, using a small cohort of radio-collared cows to estimate herd natality and calf survival has not been critically evaluated.

This project is an expansion of, and is complementary to, work conducted under Projects W-21-2 and W-22-1 through W-22-4, Job 3.27R, for which a final report (Davis and Valkenburg 1985) has been published. Availability of radio-collared caribou with known histories is requisite for several objectives of the current study. Fortunately, caribou that were collared for Job 3.27R still have functioning radio collars and are available for study (Table 1).

GOAL

To estimate population parameters (birth, death, and dispersal) of the DCH and YCH, and to evaluate field procedures for estimating those parameters.

OBJECTIVES AND PROCEDURES

1. Objectives 1a through 1g will be worked toward over a 5-year period (1986-90). Procedures for 1a through 1g have been described or cited in a prior Federal Aid report (Davis and Valkenburg 1985). The following objectives will be accomplished by the ADF&G Survey and Inventory program and/or by this research project.

   a. To census the DCH and the YCH in 1986, 1987, 1988, 1989, and 1990. We will use the modified aerial photo-direct count-extrapolation (APDCE) technique, a radio-search technique, or a total-count technique (using 2 helicopters) to annually census the 2 herds.

   b. To determine the annual natality rates and calving chronologies of the 2 herds. Monitoring about 50 radio-collared cows and sampling the herd at large will enable us to determine the natality rate. Other supporting information will be obtained by using a helicopter to aid in obtaining composition counts and udder counts. Documenting annual calving distribution is a priority.

   c. To determine yearling recruitment in the DCH and the YCH. We will monitor the radio-collared cows to determine their natality rate and subsequent calf survival. Composition counts will be conducted during April on the herd at large. On 20 April 1986, Doug Heard, Northwest Territories Government biologist, assisted us in sampling sex and age composition in the DCH, with the goal of reducing bias in our estimate of the short yearling:100 cows ratio (i.e., an index of yearling recruitment). We attempted to obtain random, even-sized subsamples to facilitate evaluation of bias and for calculation of a confidence interval for the data. Our sample design required classifying approximately (to ensure classification of entire groups) 100 caribou closest to each radio-collared caribou. This rationale for sampling assumes that the basic social structure of caribou consists of "temporary tenuous association(s) of individuals" (Lent 1965) or "open social units" (Bergerud 1974b) which has been validated for some Alaskan caribou herds through radiotelemetry studies (Valkenburg et al. 1983).

d. Measure harvest by hunters. The existing Survey and Inventory program will collect harvest data through various reporting procedures.

e. To determine when major mortality occurs to both calves and adults, and to characterize caribou dying from natural causes. Data from radio-collared caribou and composition counts will determine the chronology of calf mortality. Survival rates of adult caribou will be calculated from the radio-collared caribou. Carcasses of caribou dying from natural causes will be collected and examined.

f. To determine caribou:predator ratios in the range of the DCH and YCH. These ratios will be determined using data from the annual caribou censuses, from the caribou distribution surveys of radio-collared caribou, from results of wolf (*Canis lupus*) surveys conducted in GMU 20A by the management staff, (augmented by our surveys when required), and from the results of a concurrent ADF&G study of grizzly bears (*Ursus arctos*) (Reynolds and Hechtel, in press).

g. To determine the seasonal movements, distribution, and fidelity to respective calving grounds of radio-collared caribou. We will locate all radio-collared caribou monthly and monitor all female radio-collared caribou daily, or once every 2 days during the calving period.

2. Objectives 2a through 2k will be addressed by collecting data during 1 or more years of this 5-year study.

a. To determine if bearing a calf when a cow is 24-36 months old, or for several successive years, influences the probability of calving in subsequent years. We will keep active radio collars on about 50 cows to determine their reproductive history.

b. To determine if there are any differing cohort-specific pregnancy probabilities for cows 24 or 36 months old. Same procedure as 2a.

c. To determine if the natality rate of 24- and 36-month-old cows is determined by their weight at the time of the rut. We will collar 10 12-month-old females in each cohort to determine natality rate at 24 months. We will weigh 16-month-old females and correlate weight with subsequent natality.

d. To determine if caribou killed by predators are taken in proportion to their representation in the population in terms of sex and age. We will compare the sex and age data of radio-collared caribou killed by predators with data from the total radio-collared sample. We will do likewise for caribou in the population at large.

e. To determine the correlation between wolf abundance and the number of caribou killed by wolves. Estimates of caribou population size and distribution and estimates of wolf abundance and distribution, coupled with caribou mortality rates from wolf predation, will allow this correlation to be tested.

f. To determine if DCH and YCH caribou are faithful to their respective calving grounds. We will determine this by monitoring radio-collared cows and by conducting aerial surveys of the respective calving areas.

g. To determine if dispersal is important to the population dynamics of the DCH and YCH. We and workers on concurrent studies will monitor radio-collared caribou in the Delta, Yanert, Denali, Nelchina, Macomb, and Fortymile Herds. Also, annual censuses should identify inexplicable major increases or declines that suggest immigration or emigration has occurred.

h. To compare food habits of the Delta, Yanert, Denali, and Fortymile Herds. Monthly fecal pellet collections will be made for herds where data are currently unavailable.

i. To determine if all caribou photographed during censuses appear as discrete images and are enumerated during photo interpretation. Ground counts will be made to determine the exact number of calves and older caribou in groups that will subsequently be photographed at the scale used during censuses. Different scales (altitude), photo angles, and film will be evaluated.

j. To determine if yearling recruitment is precisely and accurately estimated by conducting herd composition surveys in April. Precision will be tested by conducting serial counts of the same sample area (e.g., on successive days, weeks, or months). Evaluating accuracy will involve modeling for cross-checking recruitment data.

k. To identify the limits of validity in using a small sample of radio-collared cows to estimate herd natality and recruitment. Modeling results will be compared with empirical data from the herd at large and from the radio-collared cohort. The validity of judging calf recruitment by monitoring radio-collared females will be evaluated by determining when the cow-calf bond breaks and by determining the sex and age of caribou that unbonded calves associate with.

STUDY AREA

Skoog (1968) originally described the range of the DCH. Based on subsequent study, Hemming (1971) modified Skoog's description and described the physical environment. Little has changed since Hemming's revision. The DCH currently ranges over about 9,600 km^2 on the northern slopes of the Alaska Range, between the Nenana River on the west and the Delta River on the east (Fig. 1). The area lies approximately 110 km south of Fairbanks. The Alaska Range rises abruptly from its foothills and consists of rugged, glaciated ridges 1,830-2,740 m in elevation interspersed with glacier-capped mountains exceeding 3,660 m. The northern foothills of the Alaska Range are flat-topped ridges 610-1,370 m in elevation separated by rolling tussock tundra, muskegs, and spruce (*Picea* spp.)-covered lowlands. North of the foothills lies the predominantly spruce-covered Tanana Flats. The entire area is drained by the Tanana River.

The transition is abrupt from the foothills to the Tanana Flats. The Flats have little relief and elevations range from 130 to 300 m. The Flats are underlain by permafrost and drainage is poor, resulting in numerous shallow ponds and extensive bogs.

Fire has greatly influenced the lowland vegetation. The result has been the creation of a mosaic of shrub and young forest-dominated seres, climax bogs, and mature black spruce (*P. mariana*) forest (LeResche et al. 1974). Fires have also occurred on the calving area and adjacent tundra and uplands (Davis et al. 1985). Vegetation in the hills, foothills, and mountains grades from taiga of white spruce (*P. glauca*), black spruce, paper birch (*Betula papyrifera*), and quaking aspen (*Populus tremuloides*) into shrub communities of willow (*Salix* spp.), and dwarf birch (*B. glandulosa* and *B. nana*) at low elevations, with alpine tundra at high elevations (LeResche et al. 1974).

The study area is largely snow-free from May until October. Annual temperature range is approximately 29 C to -51 C. Annual precipitation averages about 30 cm; snow accumulation averages 0-50 cm and rarely exceeds 80 cm. Ground vegetation in the foothills and mountains is frequently exposed during winter because of strong winds. Although the DCH is widely distributed from the mountains to the flats during winter, foothills appear most used.

As calving time approaches, cows and many short yearlings move into the upper portion of the Little Delta River and Delta Creek to the traditional core calving areas (Fig. 1), which have been used since before the 1950's. Most calves are born in tussock tundra, but many others are born in the low shrub and sparse spruce-dominated areas. Most bulls and some short yearlings remain widely scattered throughout the herd's entire range during calving.

In this report, all references to the DCH prior to 1980 include the Delta and Yanert Herds.

RESULTS AND DISCUSSION

1a. Censuses of the DCH and YCH

All census results from the DCH and YCH through 1984 have been reported previously (Davis and Valkenburg 1985). Since our last Federal Aid report (Davis and Valkenburg 1985), 2 censuses of the DCH and YCH have been conducted, one each in 1985 and 1986. The 1985 census was conducted on 16 July, the latest census date on record. Very late snowmelt in spring 1985 retarded the phenology of post-calving aggregation for the DCH and YCH. We monitored the 2 herds from late May until 16 July before they were aggregated suitably for censusing. D. Miller and K. Whitten used a Super Cub to locate, respectively, 8 and 47 YCH and DCH caribou with radio collars. P. Valkenburg used a U.S. Army 206 helicopter to photograph all aggregations with 35mm color print film (Kodak VRG, ASA 100).

The 1985 census located 8,083 caribou in association with the radio-collared DCH and YCH caribou. Hence, 8,083 is a minimum estimate for the combined size of the DCH and YCH (Appendix A).

During the 1985 census, 2 of 47 radio-collared DCH caribou overlapped with the distribution of YCH caribou, which made it difficult to estimate the number of caribou in either the DCH or YCH. Also, the caribou associated with radio-collared YCH caribou were in small groups and were not well aggregated. Groups 8-19 (Appendix A) totaled 335 caribou, were distributed in the range of the YCH, and included all radio-collared YCH caribou. If we assume 335 is a reasonable estimate of the YCH population size, then this estimate would imply a substantial decline from past estimates of >500 for the YCH's population. Also, since 2 of 47 radio-collared DCH caribou were present in groups 8-19, obviously some DCH caribou were included in the 335 caribou in the range of the YCH. Although fewer than 335 YCH caribou were accounted for in the range of the YCH, little visual searching was done in conjunction with locating aggregations containing the radio-collared caribou.

Davis and Valkenburg (1983) reported that a census of caribou associated with 7 radio-collared YCH caribou in 1982 counted 244 caribou. In contrast, a census consisting of an intensive visual search of the entire range of the YCH located 680 caribou (it is possible that the 1982 visual search located some DCH caribou in the range of the YCH). Two possible conclusions from the above discussion are: (1) that an intensive visual search of the YCH's range during the 1985 census would have located more than 335 caribou in the YCH's range, which would imply a larger minimum population estimate for both the YCH alone and the DCH and YCH combined; and (2) that the YCH population size could have exceeded 335 because some YCH caribou were located with DCH caribou outside the range of the YCH and were widely separated from the radio-collared YCH caribou. The latter would imply a larger minimum population for the YCH but probably no change in the combined population size of the DCH and YCH. We believe the 2nd option is less likely.

In 1986 we used a Bellanca Scout (P. Valkenburg and E. Crain) and a Piper Super Cub (M. McNay and J. Davis) to census the DCH and YCH on 26 and 27 June. All groups containing more than 50 caribou were photographed with 35mm SLR cameras using color print film (Kodak VRG, 100 ASA). Both aircraft combined radio tracking and visual searches to cover the entire Yanert River watershed and the adjacent Wood River drainage. The Bellanca Scout was used on 27 June to search areas peripheral to where caribou were located on 26 June.

The DCH and YCH were aggregated in the same general area, and distribution overlapped for radio-collared DCH and YCH caribou (Appendix B). The only population estimate available, 7,804, was for the 2 herds combined.

When we compared the 1985 and 1986 census results, the data suggested a minimum decline of 279 (8,083 vs. 7,804) in combined DCH and YCH size. However, past experience has shown that we cannot accurately detect population size trends by comparing 2 consecutive herd-size estimates. For example, Davis and Valkenburg (1985) reviewed census data which suggested a lower combined herd size in 1984 (6,260) than in 1983 (6,800-7,229) and 1982 (7,335). For the 1984 population to have increased to 8,083 in 1985 is inconsistent with recruitment and harvest data. In retrospect, the most plausible explanation is that the 1983 census underestimated the population.

It is premature to infer that herd growth has ceased or become negative from 1985 to 1986 solely on the basis of the 1985 and 1986 census results. Census results from 1987 and population modeling using empirical harvest, recruitment, and natural mortality data should clarify the current trend in herd growth. Our census methodology is insufficiently refined to permit calculating a statistical confidence interval for each of the census estimates; we acknowledge that "realistic" confidence intervals would probably be sufficiently broad to preclude demonstrating population size change between any 2 consecutive years.

When we considered just the YCH alone, the June 1986 census contributed little to an improved estimate of population size. However, on 22 October 1986, 570 caribou were classified as to sex and age in the YCH's range. The area sampled contained all radio-collared Yanert caribou, except one which was in the range of the Nelchina Caribou Herd, and no radio-collared DCH caribou, so we believe that 570 constitutes a known minimum estimate of the YCH's size. A critical reexamination of past estimates of the size of the YCH, which included estimates ranging up to 900, suggests little concrete evidence that the YCH ever contained more than 600 caribou. Insights about seasonal mixing of the DCH and YCH in recent years has caused us to suspect that DCH caribou may have been present on the few occasions in the past when we estimated more than 600 caribou present in the range of the YCH. We will expand on this reanalysis of YCH size estimates in future reports.

1b. Natality Rate

During this reporting period, natality data were obtained primarily from radio-collared DCH caribou. Natality data for 1981 through 1986 and comparisons with the Fortymile and Western Arctic Herds are summarized in Table 2.

1c. Yearling Recruitment in the DCH and YCH

In 1985, funding was insufficient to charter a helicopter to estimate yearling recruitment in April. However, J. Davis (observer) and W. Lentsch (pilot) flew a 2.1-hr sex and age composition survey of the DCH in a PA-18-150 Super Cub on 3 May 1985. They classified 759 caribou, including 256 short yearlings and 503 older than short yearlings (only 5 obvious bulls were present in the 503 "older than short yearlings" category). The ratio of 51 short yearlings:100 older than short yearlings suggests excellent overwinter calf survival. However, the entire sample was obtained near Iowa Ridge and may have contained the portion of the herd with the highest short yearling:100 older ratio. No late-winter herd composition data were obtained for the YCH in 1985.

The 20 April 1986 composition survey of the DCH obtained 11 subsamples (n = 998) totaling 649 cows, 145 bulls, and 204 short yearlings (i.e., 11 mos old) (Appendix C). The observed short yearling:cow ratio was 31:100 (but was biased). Although we attempted to obtain a representative sample based on locating radio-collared caribou, we clearly did not obtain unbiased data. For example, radio collars were not proportionately distributed among all sex and age components of the DCH. No radio-collared males or short yearlings were present in the herd, and we believe that male short yearlings were underrepresented among the caribou associated with the adult females. The short yearling sex ratio in our sample was 39% males and 61% females (79:123). We expected a 50:50 sex ratio, so we concluded that we undersampled male short yearlings. When we adjusted our observed short yearling:100 cow ratio (assuming a 50:50 sex ratio of short yearlings), the ratio was elevated from 31:100 to 38:100.

To test the precision of our unadjusted short yearling:100 cows ratio, we used Cochran's (1977) ratio estimation formula to calculate a 95% confidence interval.

$\bar{x}$ ratio	=	31.4 short yearlings:100 cows
Variance	=	19.3
SE	=	4.4
df	=	10
95% CI	=	31.4 ± 9.8 short yearlings:100 cows (i.e.,
	=	21.6 - 41.2 short yearlings:100 cows)

In subsequent reports we will further evaluate the "goodness" of estimates from composition data.

On 2 May 1986, J. Davis located all radio-collared YCH caribou from a Bellanca Scout aircraft, and M. McNay and R. Bishop (from a 206B helicopter) classified all associated caribou. All caribou observed were classified as male or female short yearlings (11.5 mos old), cows, or bulls (Table 3). The observed ratio of short yearlings:100 cows was 49:100 (n = 182).

1d. Harvest by Hunters.

Historical harvest data for the DCH and YCH are summarized in Table 4. Historical hunting seasons and bag limits through 1985-86 are summarized in Table 5 for the YCH and Table 6 for the DCH. During regulatory year 1986-87, M. McNay manned a hunter check station near the main access route for hunters hunting YCH caribou and contacted several hundred DCH hunters while they were in the field. McNay's field checks will ultimately be used to determine the rate of reporting by successful and unsuccessful hunters via the hunter report card/harvest ticket system presently in use. The hunter reporting data will appear in the 1986-87 S&I report for the DCH and YCH.

1e. Causes and Chronology of Mortality in Calves and Adults

Serial herd composition surveys at the end of calving, during fall, and during late winter in 1985 and 1986 (Table 7) were our principal means of determining the timing of calf mortality. The composition surveys, however, gave little insight into principal sources of mortality on calves.

Causes and timing of death for adult radio-collared caribou are summarized in Tables 8 and 9.

Mortality of Female Radio-collared Caribou:

All discussion of caribou mortality rates under this heading considers combined data from the DCH and YCH, and we define a radio-caribou month (r-cm) after Trent and Rongstad (1974). For example, if a radio-collared caribou survives through 1 calendar month, it accumulates 1 r-cm. Visual inspection of mortality rates from Table 8 suggests 3 distinct periods of differing total mortality from 1979 through 1986. No mortality occurred from 1 January 1979 through 30 September 1982 (784 r-cm); a 6% mean annual mortality rate, weighted by r-cm, occurred between 1 October 1982 and 30 September 1985 (1,638 r-cm); a r-cm weighted mean annual mortality rate of 22% occurred from 1 October 1985 through 30 September 1986 (498 r-cm).

The differences in observed total mortality rates from 1979 through 30 September 1986 were significantly different (χ^2 = 13.04, df = 4; 0.01 < $\underline{P}$ <0.02). Pooling mortality data from 1 October 1982 through 1985 into 1 set and comparing with the pooled 1979 through 30 September 1982 data showed no significant difference (χ^2 = 1.95, df = 1; 0.10 < $\underline{P}$ < 0.20). When we pooled 1979 through 30 September 1985 data and compared it with 1 October 1985-30 September 1986 data, the results showed a highly significant difference (χ^2 = 11.68, df = 1; $\underline{P}$ < 0.001).

The apparent and statistically significant increase in total mortality rate for female caribou in the DCH and YCH from 1979 to the present has major implications for (1) population dynamics of the caribou, (2) caribou management strategy, and (3) identifying limiting factors.

It is instructive to divide total mortality into categories of man-induced or natural mortality when drawing inferences that relate to the implications of (1) through (3) above. In this report natural mortality is that portion of total mortality which is not man-induced (includes caribou that died of unknown cause because there was no evidence that people were implicated in those deaths).

We tested for differences in the rate of wolf-induced mortality to female caribou from 1979 through 1986 and found the results instructive for examining implications of increased total mortality. The increased wolf-induced mortality rate in 1985-86 vs. 1979-85 was highly significant ($\chi^2 = 13.5$, df = 1; $\underline{P} < 0.001$).

We found it essential to identify assumptions inherent in our data collection and analysis when we interpreted the 1979-86 mortality data. The 2 broadest assumptions are that (1) the radio-collared sample is representative of the population, and (2) a radio-collared caribou has the same probability of surviving (or dying) as an uncollared caribou. For this report we are assuming a priori that assumption 2 is valid. We acknowledge that assumption 1 is invalid because of our experimental design. It is beyond the scope of this report to compare sample vs. population sex and age structure on a year-by-year basis. In early years (1979, 1980, etc.), the mean age of our radio-collared sample undoubtedly was younger than the population at large. The mean age of our sample has increased over time and if age-specific mortality increases with age, mortality rates for the later years (1985, 1986, etc.) could be biased upward.

However, even though the mean age of female radio-collared caribou increased during this study, the mean age of the radio-collared females is still probably not older than the mean for the population at large. In 1985-86, no more than 10 of 46 radio-collared female caribou could have been older than 8 years. Four of the 10 turned 8 in May 1986, but the precise ages of the remaining 6 were unknown. We believe that the calculated natural mortality rate of female radio-collared caribou is a reasonable estimate of the natural mortality rate of female caribou in the entire population.

Qualifications inherent in the mortality data, that should be recognized, can be illustrated by discussing the wolf-induced mortality. For example, on 1 extreme, 2 of the 5 radio-collared females killed in 1985-86 were old and one more was drugged 1-2 weeks before being killed. This implies the small sample could be greatly influenced by bias, which might overestimate mortality.

Alternately, it is likely that many of the radio-collared caribou listed as dying from unknown causes may, in fact, have been killed by wolves.

If all radio-collared female caribou dying from unknown causes were actually killed by wolves, then the maximum wolf predation rate becomes 4% for the period 1979-85 and 16% for 1985-86. If none of those dying of unknown cause were killed by wolves, then the minimum wolf predation rate was 1% for 1979-85 and 12% for 1985-86.

Mortality Rates of Male Radio-collared Caribou:

We have insufficient data to make conclusions about mortality rates of male DCH or YCH caribou. Monitoring radio-collared males has been a lower priority than monitoring females for most past objectives, and keeping collars from dropping off males has been a problem. However, radio-collared males experienced substantially higher mortality than females (Tables 8 and 9), albeit most male mortality has been man-induced.

1f. Wolf:Caribou and Grizzly Bear:Caribou Ratios

R. Boertje (ADF&G files) compiled available information on the distribution and abundance of wolves in GMU 20A (includes an area larger than the combined ranges of the DCH and YCH) for fall 1985 and spring 1986. The data suggested a fall wolf population of 195 wolves in 24 packs (plus 10% singles) (Fig. 2, Table 10). Juxtaposition of the range of the DCH and YCH and wolf pack distribution in GMU 20A can be depicted by overlaying Figs. 1 and 2. The GMU 20A wolf population ranges over about 16,500 km^2 compared with minimum herd ranges of 9,650 km^2 and 1,409 km^2 for the DCH and YCH, respectively.

In fall 1985, there were at least 15 wolves in 3 packs in the range of the YCH, which contained 600-700 caribou. The wolf:caribou ratio, therefore, was 1:40-47 (15:600-700). There were probably $\geq$600 moose in the range of the YCH in fall 1985 (W. Gasaway, pers. commun.). If we assume 1 moose = 3 caribou equivalents (Keith 1983) for the purposes of calculating ratios predator:caribou equivalents, the probable wolf:caribou equivalents ratio in fall 1985 was 1 wolf:160-167 caribou equivalents. This calculated ratio should be considered a minimum estimate on the prey side of the ratio because Dall sheep (Ovis dalli) are also abundant in the Yanert River drainage. W. Heimer, ADF&G sheep biologist (pers. commun.) estimates there are ≥800 sheep in the Yanert River drainage. Available data suggest wolves infrequently prey on sheep in GMU 20A (Gasaway et al. 1983), but because of their relative abundance they must be acknowledged as potential alternate prey for wolves.

In 1986, Reynolds and Hechtel (in press) estimated minimum grizzly bear density in their GMU 20A study area at 1.27 bears/100 km² or 1.04 bears ≥2 years old/100 km². There is no reason to believe grizzly bear density is lower in the range of the YCH than in Reynolds and Hechtel's study area. So assuming a density of 1.27 bears/100 km² in the 1,409-km² YCH range, we calculate a minimum grizzly bear population of 18 in the YCH's range. The calculated grizzly bear:caribou ratio in the range of the YCH then is 1:33-39 (18:600-700); the grizzly:caribou equivalents for the caribou and moose combined ratio is 1 grizzly:133-139 caribou equivalents.

Similar calculations of wolf:caribou and grizzly bear:caribou ratios for the DCH follow. The distribution of wolf packs in GMU 20A suggests that caribou are probably not important prey for packs 1, 2, 4, 5, and 10 (Fig. 2). Excluding packs 1, 2, 4, 5, and 10 (and packs 18, 19, and 20 from the range of the YCH), we conclude that 150 (includes prorating to include single wolves) of the 195 wolves in GMU 20A in fall 1985 were potential predators of DCH caribou. In fall 1985, the wolf:caribou ratio for the DCH therefore was 1 wolf:50 caribou (150:7,500).

The GMU 20A moose population in fall 1985 was about 8,000-8,500. About 5,000 of these moose were distributed in the DCH's range so a wolf:caribou equivalent for the DCH's range would be 150:22,500 caribou equivalents or 1 wolf:150 caribou equivalents. The DCH range of 9,650 km² probably contains about 123 grizzly bears (extrapolated based on data in Reynolds and Hechtel, in press), a ratio of 1 grizzly:61 caribou, and a ratio of 1 grizzly:183 caribou equivalents when caribou and moose are combined as prey.

The range of the DCH also contains 4,000-5,000 Dall sheep (W. Heimer, pers. commun.), including the Yanert drainage. Available data (Gasaway et al. 1983) suggest wolves infrequently prey on sheep in GMU 20A, but because of their relative abundance, they must be acknowledged as potential alternate prey for wolves.

The wolf:caribou and wolf:caribou equivalents ratios for the YCH and DCH are similar enough to justify considering the 2 herds as 1 entity to simplify further iterations regarding predator:prey ratios. A comparison of the wolf:caribou equivalents ratio for all of GMU 20A prior to wolf control in 1976, with the comparable ratio in fall 1985 follows:

1975: 239 wolves, 2,900 moose, 2,000 caribou = 1 wolf:45 caribou equivalents

1985: 195 wolves, 8,500 moose, 8,000 caribou = 1 wolf:172 caribou equivalents

Keith (1983) presented a model (i.e., equation), that allows calculation of the annual ungulate kill per wolf that would stabilize an unhunted ungulate population, as follows:

$K = N\ (\lambda - 1)$

where, K = ungulate kill per wolf annually

N = ungulate numbers per wolf in spring before births

λ = finite rate of ungulate increase annually (assuming no wolf predation)

For the DCH and YCH combined, assume:

N = 40-44 (for caribou only)

λ = 1.20 to 1.25

therefore, best case scenario is $K = 44\ (1.25-1)$; or $K = 11.0$

therefore, worst case scenario is $K = 40\ (1.20-1)$; or $K = 8.0$

The above calculations suggest that if all wolves in the range of the YCH and DCH each killed 8 caribou annually, then wolf predation would stabilize the size of the DCH and YCH. This conclusion assumes no hunting of the caribou and no predation by other predator species. Another way of looking at this calculation is that 150 wolves, each killing 8 caribou per year, would kill 1,200 caribou annually.

If we assume that each wolf in the range of the DCH and YCH eats an average of 8 caribou per year, this equates to an assumption that one-third of the wolves' annual diet consisted of caribou (Kuyt 1972). Gasaway et al. (1983) reported that the stomach contents of 156 wolves taken from 1975 through 1979 throughout GMU 20A revealed frequencies of occurrence as follows: 55% for moose and 12% for caribou. It is difficult to equate the frequency of occurrence data to differential rates of consumption between moose and caribou for reasons such as differences in size of prey, and caribou not being present in much of the area where the 156 wolves were killed. Also, when the 156 wolves were collected, GMU 20A contained a mean of about 3,300 moose (the 1977 level) and about 2,000 caribou, a ratio of 0.61 caribou:moose. In 1985 the ratio was about 1 caribou:1 moose (8,000 caribou:8,500 moose). It seems reasonable to expect a higher proportion of the wolves' diet to be caribou in 1985 than in 1976.

Clearly, there is a priority need to ascertain the specifics of wolf/caribou interactions in GMU 20A and we will focus efforts in that direction in coming years. The role of predation on GMU 20A caribou by grizzly bears and predators other than wolves is not well understood. However, our long-term study of mortality rates of radio-collared caribou and the ongoing grizzly bear research (Reynolds and Hechtel, in press) should elucidate the relative importance of predation by grizzlies and wolves.

1g. Seasonal Movements, Distribution, and Fidelity to Calving Grounds

Throughout the study period we monitored radio-collared caribou to document seasonal movements and distribution. A University of Alaska, Cooperative Wildlife Research Unit Master of Science project by Steve Fleischman is contributing toward collation, analysis, and interpretation of movements and distribution data (Appendix D).

One of our manuscripts discussing calving ground fidelity has been published since our last report (Davis and Valkenburg 1985). Davis and Valkenburg (1985) presented an abstract of a paper titled, "Calving Ground Fidelity and Herd Identity of the Delta and Yanert Caribou, Alaska." The paper was presented at the 4th International Reindeer/Caribou Symposium, Whitehorse, Yukon in August 1985. The paper was subsequently revised and published in Rangifer with a revised title and abstract. The revised abstract appears in Appendix E; the literature citation follows:

Davis, J. L., P. Valkenburg, and R. D. Boertje. 1986. Empirical and theoretical considerations toward a model of caribou socioecology. Rangifer, Spec. Issue No. 1, 1986:103-109.

2a-k. Data to be Collected During 1 or More Years to Test Hypotheses

Some field data pertaining to several of the 2a-k objectives (see Objectives and Procedures) were collected. However, no in-depth analysis was conducted, so reporting will occur in subsequent reports.

Other Progress During This Reporting Period

Project personnel assisted in radio-collaring 4 wolf packs in GMU 20A in cooperation with other studies. P. Valkenburg transferred our data on capture of radio-collared caribou and related information to dBase III computer files for storage and analysis with ADF&G's IBM-PC system.

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PREPARED BY:

James L. Davis
Game Biologist III

Patrick Valkenburg
Game Biologist II

Mark E. McNay
Game Biologist III

SUBMITTED BY:

Wayne L. Regelin
Regional Research Coordinator

APPROVED BY:

W. Lewis Pamplin, Jr. /bt

W. Lewis Pamplin, Jr.
Director, Game Divsion

SRPeterson

Steven R. Peterson
Chief of Research, Game Division

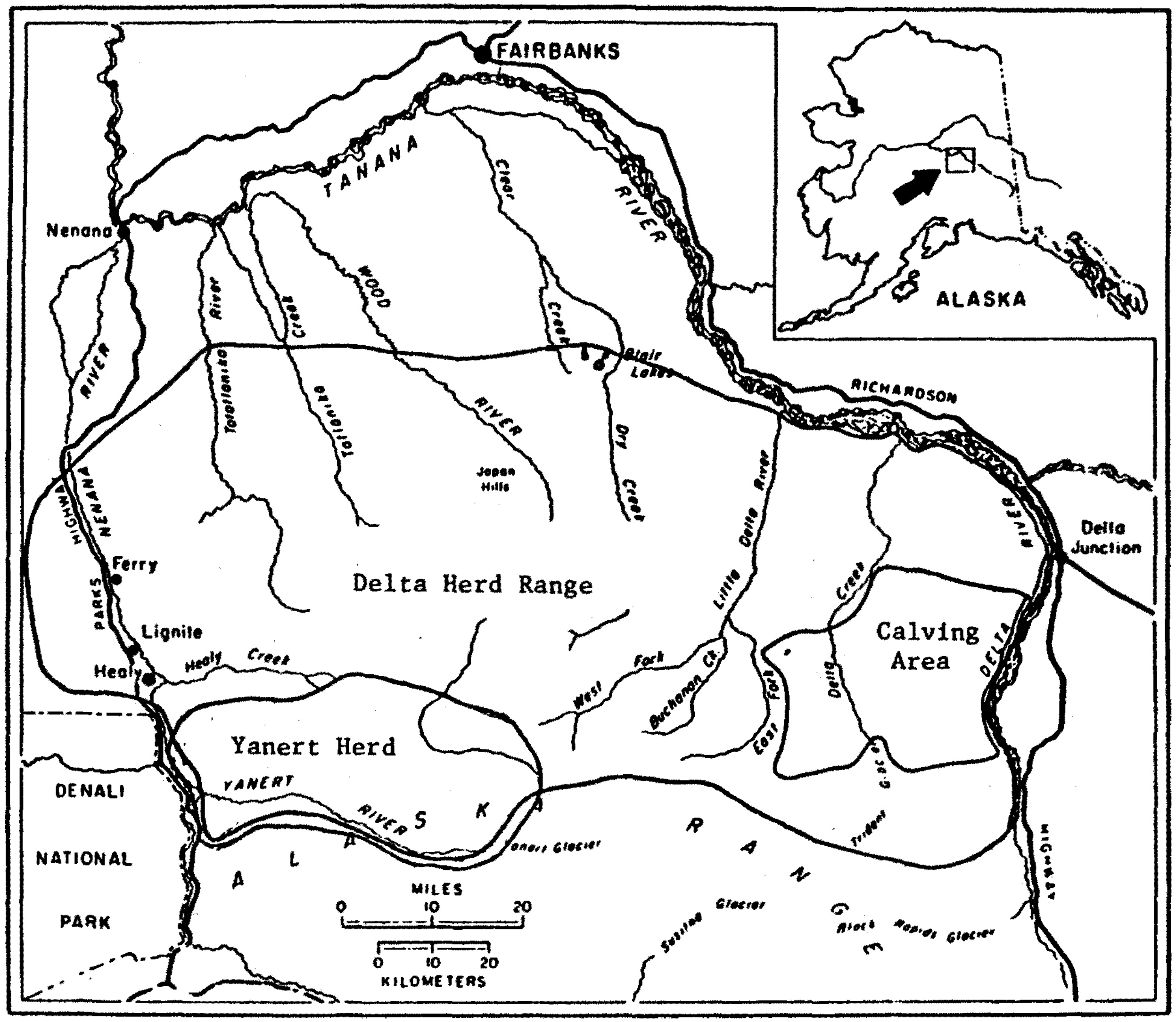

Fig. 1. Study area, ranges of the Delta and Yanert Caribou Herds, and Delta Herd calving area.

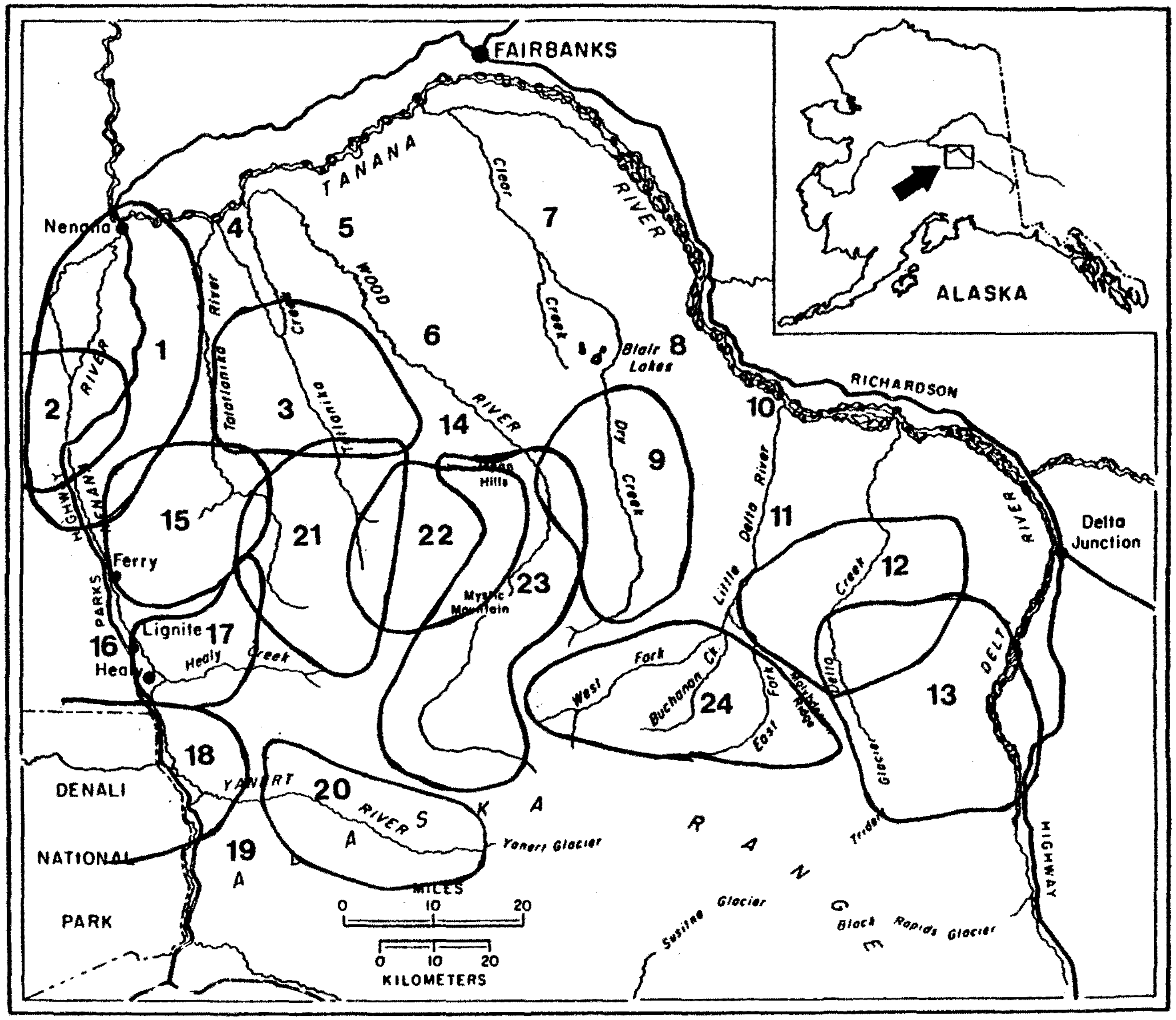

Fig. 2. Distribution of wolf packs in GMU 20A during 1985-86. Numbers correspond to pack numbers in Table 9; home ranges were delineated only for packs whose sign or members were observed in ≥ 3 locations and/or where tracking of the pack was extensive. Packs 3, 15, 17, 18, and 23 contained radio-collared wolves.

Table 1. Permanent accession numbers and other pertinent information for radio-collared Delta and Yanert Herd caribou, 1979-86.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
101972	R57	1978	F	01/04/79	D	Recollared 2/11/82
101972	Y36	1978	F	02/11/82	D	Dead unknown cause 9/84
101973	R53	1978	F	01/04/79	D	Recollared 2/11/82
101973	Y28	1978	F	02/11/82	D	Possible bear kill 9/11/85
101974	R88	1978	F	01/08/79	D	Recollared 2/11/82
101974	Y37	1978	F	02/11/82	D	Recollared 11/21/85
101974	B 3	1978	F	11/21/85	D	
101975	Y52	1978	M	01/09/79	D	Probable wolf kill 16-19 Feb 79
101976	Y17	1978	M	01/09/79	D	Missing after 4/79
101977	R78	1978	F	01/09/79	D	Recollared 2/26/82
101977	Y49	1978	F	02/26/82	D	Probable capture mortality 3/82
101978	Y57	1978	M	01/09/79	D	Died unknown cause 3/79
101979	Y18	1978	M	01/04/79	D	Shot 11/80
101980	Y58	1978	M	01/10/79	D	Missing after 2/79
101981	Y59	1978	F	01/10/79	D	Recollared 5/30/81
101981	Y20	1978	F	05/30/81	D	Capture mortality
101982	R52	1978	F	01/10/79	D	Recollared 2/11/82
101982	Y78	1978	F	02/11/82	D	Collar failed 5/27/85
101983	Y59	1978	M	01/10/79	D	Bear kill 8/80
101984	R54	1978	F	01/11/79	D	Recollared 2/26/82
101984	Y47	1978	F	02/26/82	D	Recollared 11/21/85
101984	O57	1978	F	11/21/85	D	
101985	Y56	1978	M	01/11/79	D	Recollared 2/11/82
101985	Y79	1978	F	02/11/82	D	Shot 10/3/83
101986	Y69	1978	M	01/11/79	D	Missing after 2/79
101987	Y19	1978	M	01/08/79	D	Shed collar 1/79

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
101988	R56	1978	F	01/04/79	D	Recollared 2/26/82
101988	Y25	1978	F	02/26/82	D	Recollared 11/22/85
101988	B91	1978	F	11/22/85	D	
101989	Y47	1978	M	01/11/79	D	Dropped collar 6/79
101990	Y58	1978	F	01/08/79	D	Capture mortality 1/08/79
101991	Y79	1978	M	01/10/79	D	Radio failed 9/80
101992	Y63	1978	M	01/11/79	D	Radio failed 3/79
101993	R76	1978	F	03/30/79	D	Recollared 2/26/82
101993	Y26	1978	F	02/26/82	D	Probably shot 8/84
101994	R79	1978	F	03/30/79	D	Radio failed fall 1980
101995	Y67	1978	M	03/30/79	D	Missing after 7/17/79
101996	Y62	1978	M	03/30/79	D	Radio failed 3/79
101997	R77	1978	F	03/30/79	D	Recollared 2/26/82
101997	Y20	1978	F	02/26/82	D	Recollared 11/20/85
101997	O69	1978	F	11/20/85	D	
102341	Y15	1980	F	02/08/81	D	Recollared 11/03/84
102341	Y53	1980	F	11/03/84	D	
102342	Y86	1979	M	02/08/81	D	Probable wolf kill 2/81
102343	Y13	1980	F	02/08/81	D	Recollared 11/3/84
102343	Y54	1980	F	11/03/84	D	Wolf kill 4/15/86
102348	Y14	1980	F	02/27/81	D	Recollared 10/30/84
102348	Y68	1980	F	10/30/84	D	
102349	Y12	1979	F	02/27/81	D	Battery died 11/84
102350	Y22	1978	F	02/27/81	D	Recollared 4/22/86
102350	O47	1978	F	04/22/86	D	Missing after 5/86
102360	Y16	1980	F	03/22/81	D	Recollared 10/12/85
102360	O62	1980	F	10/12/85	D	Killed by wolves after collaring

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102361	Y21	1980	M	03/22/81	D	Recollared 11/2/84
102361	O46	1980	M	11/02/84	D	Dropped collar 3/85
102362	Y18	0	F	03/22/81	D	Recollared 11/3/84
102362	O74	0	F	11/03/84	D	Killed by wolves 7/22/86
102363	Y29	0	F	04/17/81	Y	Recollared 11/2/84
102363	O49	0	F	11/02/84	Y	Killed by predator 6/86
102364	Y30	0	F	04/18/81	Y	Recollared 10/31/84
102364	O51	0	F	10/31/84	Y	
102365	Y31	0	F	04/18/81	Y	Recollared 10/31/84
102365	O64	0	F	10/31/84	Y	
102366	Y32	0	F	04/18/81	Y	Recollared 11/2/84
102366	O61	0	F	11/02/84	Y	
102367	Y33	0	F	04/18/81	Y	Recollared 10/30/84
102367	O60	0	F	10/31/84	Y	
102368	Y34	0	F	04/18/81	Y	Recollared 11/2/84
102368	Y11	0	F	11/02/84	Y	
102369	Y35	0	F	04/18/81	Y	Recollared 11/22/85
102369	B 7	0	F	11/22/85	Y	Wolf kill 11/25/85
102370	Y70	0	F	04/18/81	Y	Recollared 11/2/84
102370	O65	0	F	11/02/84	Y	
102411	Y19	1980	F	05/30/81	D	Recollared 11/3/84
102411	O66	1980	F	11/03/84	D	Died unknown cause 8/86
102412	Y23	1980	F	05/30/81	D	Recollared 10/30/84
102412	O63	1980	F	10/30/84	D	
102413	Y27	1980	F	05/30/81	D	Recollared 10/30/84
102413	Y51	1980	F	10/30/84	D	
102546	Y 9	1981	F	05/03/82	D	Died unknown cause 8/83
102547	Y10	1981	F	05/03/82	D	Possible bear kill 5/5/82

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102548	Y 7	1981	F	05/03/82	D	Recollared 11/21/85
102548	Y52	1981	F	11/21/85	D	
102549	Y 6	1981	F	05/03/82	D	Recollared 10/20/85
102549	O47	1981	F	10/20/85	D	Snared 1/26/86
102560	Y 1	1981	F	05/03/82	D	Recollared 10/20/85
102560	O52	1981	F	10/20/85	D	
102561	Y 4	1981	F	05/03/82	D	Recollared 12/13/85
102561	B 6	1981	F	12/13/85	D	
102562	Y 2	1981	F	05/03/82	D	Recollared 11/21/85
102562	B 5	1981	F	11/21/85	D	Shot 9/86
102563	Y 5	1981	F	05/03/82	D	Recollared 11/21/85
102563	O44	1981	F	11/21/85	D	Capture mortality ca. 11/25/85
102564	Y 3	1981	F	05/03/82	D	Died unknown cause ca. 10/82
102565	Y 0	1981	F	05/03/82	D	Recollared 11/21/85
102565	B 4	1981	F	11/21/85	D	Probable wolf kill 3/86
102566	Y 8	1981	F	05/03/82	D	Recollared 11/20/85
102566	O53	1981	F	11/20/85	D	
102803	Y40	1982	F	04/01/83	D	Recollared 4/7/86
102803	O43	1982	F	04/07/86	D	
102804	Y43	1982	F	04/01/83	D	Recollared 4/7/86
102804	B10	1982	F	04/07/86	D	
102805	Y41	1982	F	04/01/83	D	Recollared 4/22/86
102805	B 0	1982	F	04/22/86	D	
102806	Y42	1982	F	04/01/83	D	Recollared 4/21/86
102806	O21	1982	F	04/21/86	D	
102807	Y39	1982	F	04/01/83	D	Died unknown cause ca. 8/83
102808	Y48	1982	F	04/01/83	D	Recollared 4/21/86
102808	O23	1982	F	04/21/86	D	

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102809	Y10	1982	F	04/01/83	D	Recollared 4/22/86
102809	B11	1982	F	04/22/86	D	
102810	Y45	1982	F	04/01/83	D	Recollared 4/21/86
102810	B 8	1982	F	04/21/86	D	
102811	Y44	1982	F	04/01/83	D	Died unknown cause 5/85
102812	Y17	1982	F	04/01/83	D	Recollared 4/7/86
102812	O25	1982	F	04/07/86	D	Hunter kill 9/9/86
102813		1982	F	04/01/83	D	
102814	Y46	1982	F	04/01/83	D	Recollared 4/7/86
102814	O24	1982	F	04/07/86	D	
102815	Y 3	1982	F	04/01/83	D	Recollared 4/21/86
102815	B 1	1982	F	04/21/86	D	Seen 5/24/86, not heard
102816		1982	F	04/01/83	D	Capture mortality
102982	O76	1983	F	03/30/84	D	
102983	O74	1983	F	03/30/84	D	Capture mortality
102984	O75	1983	F	03/30/84	D	
102985	O79	1983	F	03/30/84	D	
102986	Y49	1983	F	03/30/84	D	Dropped collar ca. 4/1/84
102987	O71	1983	F	03/30/84	D	Wolf kill 2/86
102988	O78	1983	F	03/30/84	D	
102989	O72	1983	F	03/30/84	D	
102990	O70	1983	F	03/30/84	D	
102991	O67	1983	F	03/30/84	D	
102992	O77	1983	F	03/30/84	D	

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102993	Y50	1983	F	03/30/84	D	
102994	Y49	1983	M	04/13/84	D	Hunter kill 9/84
103042	Y62	0	M	10/30/84	D	Dropped collar 11/84
103043	Y63	0	M	10/30/84	D	Dropped collar 3/85
103044	Y66	0	M	10/30/84	D	
103045	Y64	0	M	10/30/84	D	Dropped collar 11/1/84
103046	Y61	0	M	10/30/84	D	Dropped collar 4/85
103047	Y67	0	M	10/30/84	D	Dropped collar ca. 1/85
103048	Y60	0	M	10/31/84	Y	
103049	Y65	0	M	10/31/84	Y	Dropped collar 3/85
103050	Y52	0	M	10/31/84	D	Dropped collar 12/84
103051	Y59	0	M	10/31/84	D	
103052	Y55	0	M	10/31/84	D	Hunter kill 9/10/86
103054	O59	0	M	11/02/84	Y	Hunter kill 09/03/85
103055	O50	0	M	11/02/84	Y	Hunter kill 9/9/86
103074	Y66	0	M	11/21/85	D	

Table 2. Comparison of natality rate of Delta, Western Arctic, and Fortymile Caribou Herds based on counts of calves and proportions of pregnant radio-collared females ≥ 2 years old, 1981-86.

	Calf counts (late May or early June)			Radio-collared caribou ≥ 36 mos.		
Herd and year	No. calves counted	No. cows counted	Calves: 100 cows	No. pregnant	Total	Natality rate (%)
Delta 1981	--	--	--	10	13	77
Delta 1982	108	151	72	7	10	70
Delta 1983	1,629	2,052	80	17	22	77
Delta 1984	395	482[a]	82	28	31	90
Delta 1985	--	--	--	38	41	93
Delta 1986	--	--	82	33[b]	40	83
Western Arctic 1981	885	1,079	82	31	37	84
Western Arctic 1982	1,380	1,764	78	24	29	83
Fortymile 1984	1,072	1,478	72	20	23	87
Fortymile 1985	--	--	--	19	19	100
Fortymile 1986	--	--	--	20[c]	21	95

[a] Includes some yearlings.

[b] Twenty-six had distended udders, 7 had hard antlers (indicating pregnancy but udder was not seen), 5 had no distended udder, and 2 were antlerless (udder was not seen, but neither one was a naturally polled animal).

[c] Sixteen had distended udders, 3 had hard antlers during calving, and 1 was seen in August and September with a calf following her.

Table 3. Sex and age composition of Alaska's Yanert Caribou Herd, 1982-86.

Date	Bulls: 100 cows	Calves: 100 cows	Calf % in herd	No. calves	Cow % in herd	No. cows	Bull % in herd	No. bulls	Sample size
11/26/82	59	36	18	56	51	156	30	92	304
4/13/84	22	44	26	44	60	101	13	22	167
10/12/85	65	40	19	152	49	383	32	252	787[a]
5/2/86	21	49	29	53	59	107	12	22	182
10/22/86	70	38	18	105	48	274	34	191	570

[a] Some Delta Herd caribou were apparently present because $\geq$1 radio-collared Delta caribou were present.

Table 4. Harvest from the Delta Caribou Herd and Yanert Caribou Herd, 1968-86.[a]

Year	Males N (%)	Females N (%)	Sex unk N (%)	Total	Extrapolated total
1968-69	119 (81)	25 (17)	3 (2)	147[b]	160
	--	--	--	205[c]	NA
1969-70	169 (75)	54 (24)	2 (1)	225	324
1970-71	198 (72)	68 (25)	9 (3)	275	428
1971-72	387 (62)	226 (36)	12 (2)	624	740
1972-73	372 (72)	132 (25)	13 (3)	517	NA
1973-74	158 (70)	67 (30)	8	233	301
1974-75 through 1979-80, No open season					
1980-81	104 (100)			104	
1981-82 (fall)	78	9		87	
1981-82 (winter)	113	64	4	181	
1981-82 (total)	191	73	4	268	
1982-83 (fall)	92	11	1	104	
1982-83 (winter)	101	65	3	169	
1982-83 (total)	193	77	4	274	
Delta 1983-84	576	98	20	694	
Yanert 1983-84	40	12	2	54	
Delta 1984-85	258	153	2	413	
Yanert 1984-85	77	22	0	99	130
Delta 1985-86	250	67	15	332	
Yanert 1985-86	52	12	0	64	

[a] Harvest from Subunit 20A and part of 20C.
[b] From 1969 Alaska Department of Fish and Game Survey and Inventory Progress Report.
[c] From J. Sexton memo 3 December 1970.

Table 5. Hunting seasons and bag limits for Alaska's Yanert Caribou Herd, 1984-87.[a]

Year	Season	Bag limit
1984-85[b]	10 Aug-31 Mar Unit 20(A), that portion within the Yanert River drainage	1 caribou
1985-86	1 Sep-28 Feb Unit 20(A) within the Yanert Controlled Use Area	1 caribou
1986-87	1 Sep-28 Feb Unit 20(A) within the Yanert Controlled Use Area	1 caribou

[a] The 1st year that the Yanert Herd caribou season was not included as part of the Delta Herd season was 1984-85.

[b] Amended by emergency announcement to close the Yanert River drainage on 8 February 1985.

Table 6. Hunting seasons and bag limits for Alaska's Delta Caribou Herd, 1968-86.[a]

Year	Season	Bag limit
1968-69	10 Aug-31 Mar	3 caribou
1969-70	10 Aug-31 Mar	3 caribou
1970-71	10 Aug-31 Mar	3 caribou
1971-72	10 Aug-31 Mar	3 caribou
1972-73	10 Aug-31 Mar	3 caribou
1973-74[b]	10 Aug-31 Dec	1 caribou
1974-75[c]	10 Aug-20 Sep	1 caribou
1975-76 through 1979-80	No open season	
1980-81	1 Sep-30 Sep	1 male by drawing permit. 200 permits issued.
1981-82	10 Aug-30 Sep 15 Nov-31 Dec	1 caribou by drawing permit from 10 Aug-30 Sep; 150 permits issued, up to 25 will be issued to nonresidents. Antlered caribou may be taken from 15 Nov-31 Dec by registration permit. A total of 400 caribou may be taken.
1982-83	10 Aug-30 Sep 1 Dec-31 Mar	1 caribou by drawing permit from 10 Aug-30 Sep; 175 permits issued, up to 30 will be issued to non-residents. Antlered caribou may be taken from 1 Dec-31 Mar by registration permit. A total of 500 caribou may be taken.
1983-84[d]	10 Aug-31 Mar	1 caribou

Table 6. Continued.

Year	Season	Bag limit
1984-85[e,f]	20 Aug-20 Sep	1 caribou by registration permit only. 600 caribou may be taken. The 20 Aug-20 Sep season will be closed when 300 caribou have been taken; the 1 Feb-31 Mar season will be closed when the total harvest reaches 600 caribou.
	10 Aug-31 Mar	1 caribou.
1985-86[g] Alaskan Residents	10 Aug-31 Dec Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	1 caribou by Tier II hunting permit only. 200 permits will be issued.
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou
1985-86 Nonresidents	No Open Season Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou
1986-87	6 Sep-31 Dec Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	1 caribou by drawing permit only. 200 permits will be issued.
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou

Table 6. Continued.

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[a] Subunit 20A and part of 20C.

[b] Amended by emergency announcement to close 20 September.

[c] Amended by emergency announcement to No Open Season.

[d] Amended by emergency announcement to close 28 October, except the Yanert River drainage which remained open through 31 March.

[e] Amended by emergency announcement to close 5 September, except the Yanert River drainage.

[f] Amended by emergency announcement to close the Yanert River drainage on 8 February 1985.

[g] The 1985-86 seasons and bag limits which for the 1st time (at least since 1968) differentiated between residents of Alaska and nonresidents was the result of a judicial ruling which said the State Subsistence Bill had not been properly implemented.

Table 7. Sex and age composition of Alaska's Delta Caribou Herd, 1969-86.

Date	Bulls: 100 cows	Yrlgs: 100 cows	Calves: 100 cows	Yrlg % in herd	No. yrlg	Calf % in herd	No. calves	Cow % in herd	No. cows	Bull % in herd	No. bulls	Sample size
10/13-15/69	40	21	28	11	85	15	116	53	410	21	166	777
10/21-23/70	77	23	34	9	88	14	129	42	383	33	296	896
10/29-11/1/71	29	11	16	7	78	9	109	64	738	18	214	1,139
10/27-31/72	32	6	10	4	46	7	85	67	795	21	259	1,185
10/23-24/73	28	4	10	3	29	7	76	70	735	20	210	1,050
10/23-25/74	27	2	2	1	16	1	17	76	868	21	240	1,141
6/11-12/75	3	<1	12	<1	3	11	108	86	839	2	26	976
Fall 1975	No counts conducted											
6/3/76	1	--	41	--	--	28	395	70	955	1	15	1,365
6/6-22/76	1	--	55	--	--	35	390	63	699	0	10	1,099
10/29-11/1/76	38	1	45	<1	5	24	258	54	572	20	220	1,055
6/16-19/77	9	12	34	8	95	22	269	64	784	6	76	1,224
10/26-11/2/77	32	6	42	3	44	23	319	55	756	18	246	1,365
6/13-14/78	12	8	23	6	52	16	157	69	661	8	81	951
10/26/78	75	10	39	5	33	17	126	44	324	33	242	725
6/23/79	11	18	44	10	76	25	189	57	424	6	49	738
12/7/79	39	--	65	--	--	32	115	49	177	19	69	361
6/14/80	18	--	43	--	--	26	324	61	748	11	137	1,209
10/15-11/3/80	85	--	49	--	--	21	288	42	585	36	496	1,369
6/17/81	12	16	33	9	87	21	182	62	543	8	68	880
10/2/81	59	--	41	--	--	20	319	50	776	29	458	1,553
5/23/82	--	--	72	--	--	42	108	58	151	0	0	259
10/8/82	54	--	29	--	--	16	215	55	736	30	398	1,349
11/26/82	60	--	38	--	--	19	65	51	173	30	104	342
4/20/83	23	--	29	--	--	19	205	66	708	15	166	1,079
6/15/83	4	--	51[a]	--	--	33	522	64	1,021	3	44	1,587
10/4/83	54	--	46	--	--	23	307	50	665	39	139	1,333
4/10/84	10	--	49	--	--	31	194	63	396	--	--	628

Table 7. Continued.

Date	Bulls: 100 cows	Yrlgs: 100 cows	Calves: 100 cows	Yrlg % in herd	No. yrlg	Calf % in herd	No. calves	Cow % in herd	No. cows	Bull % in herd	No. bulls	Sample size
4/13/84[b]	22	--	44	--	--	26	44	60	101	--	--	167
5/20/84	--	--	82[a]	--	--	--	--	--	482	--	--	877
6/22/84	17	--	56	--	--	32	837	58	1,508	--	--	2,604
10/17/84	42	--	36	--	--	20	222	56	613	24	258	1,093
5/3/85	--	--	--	--	--	34	256	66	503	--	--	759
10/9-12/85	49	--	36	--	--	20	228	54	630	26	306	1,164
4/20/86	22	--	31	--	--	20	204	65	649	15	145	998
10/6/86	43	--	29	--	--	17	354	58	1,222	25	522	2,098

[a] Eighty-two calves:100 cows is a maximum ratio as it is actually 82% cows with calf or still pregnant (Bergerud and Butler data).

[b] Yearlings were not segregated.

Table 8. Calculated mortality rates for 63 radio-collared female caribou from the Delta Herd, 1979-86 (after Trent and Rongstad 1974).

Time period	No. of caribou with active collars (No. collar-mos.)	Deaths from wolf predation (% annual mortality)	Man-caused deaths (% annual mortality)	Deaths from unknown cause[a] (% annual mortality)	Total deaths (% annual mortality)
1 Jan-30 Sep 1979	11(90)	0	0	0	0
1 Oct 1979-30 Sep 1980	11(127)	0	0	0	0
1 Oct 1980-30 Sep 1981	29(209)	0	0	0	0
1 Oct 1981-30 Sep 1982	39(358)	0	0	0	0
1 Oct 1982-30 Sep 1983	47(476)	0	0	3(7)	3(7)
1 Oct 1983-30 Sep 1984	55(568)	1(2)	1(2)	1(2)	3(6)
1 Oct 1984-30 Sep 1985	50(594)	0	0	2(4)	2(4)
1 Oct 1985-30 Sep 1986	48(498)	5(11)[b]	3(7)	2(5)[c]	10(22)
Jan 1979-Sep 1986	63(2,920)	6(2)	4(2)	8(3)	18(7)

[a] These deaths are most likely from causes other than man.

[b] Two of these wolf-killed caribou were very old and 1 additional caribou was killed within a week after capture; its death could have been capture related. If these 3 are excluded from the calculation, then annual wolf-induced mortality would have been 5% and total annual mortality would have been 16%.

[c] One of these 2 was killed by a predator of some kind.

Table 9. Calculated mortality rates for 27 male radio-collared caribou from the Delta Herd, 1979-86 (after Trent and Rongstad 1974).

Time period	No. of caribou with active collars (No. collar-mos.)	Deaths from wolf predation (% annual mortality)	Man-caused deaths (% annual mortality)	Deaths from unknown cause[a] (% annual mortality)	Total deaths (% annual mortality)
1 Jan-30 Sep 1979	12(55)	1(20)[b]	0	1(20)	2(36)
1 Oct 1979-30 Sep 1980	4(47)	0	0	1(23)[c]	1(23)
1 Oct 1980-30 Sep 1981	4(21)	1(44)	1(44)	0	2(70)
1 Oct 1981-30 Sep 1982	2(24)	0	0	0	0
Subtotal (1 Jan 1979-30 Sep 1982)	14(147)	2(15)	1(8)	2(15)	5(34)
1 Oct 1982-30 Sep 1983	2(24)	0	0	0	0
1 Oct 1983-30 Sep 1984	3(17)	0	2(78)	0	2(78)
1 Oct 1984-30 Sep 1985	11(86)	0	1(13)	0	1(13)
1 Oct 1985-30 Sep 1986	5(56)	0	2(35)	0	2(35)
1 Jan 1979-30 Sep 1986	27(330)	2(7)	6(20)	2(7)	10(31)

[a] Most likely to be natural mortality rather than man-induced.

[b] This individual had been captured and released a few days before being killed by the wolf.

[c] Probably killed by a grizzly bear.

Table 10. Wolf survey data for Subunit 20A[a], Alaska, fall 1985 and spring 1986 (ADF&G files, data compiled by R. Boertje).

Pack name	Estimated numbers fall 1985	Estimated numbers spring 1986	Number harvested	Colors of wolves if seen	Evidence	Observers
Tanana Flats						
1 Nenana	8	8	0	6 grays, 2 blacks	Seen	Karczmarczyk-ADF&G; Myers, Carter, Lord-public
2 Clear	3	2	1[b]	2 blacks	Seen	Morris, Myers-public
3 Lower Tatlanika River	9	8	1	6 blacks, 2 grays	Seen spring 1985, tracks 1986	Valkenburg-ADF&G
4 Lower Wood River	8	0	8[c]	7 grays, 1 black	Seen	Hodnik-public
5 Crooked Creek	4	3	1	--	Tracks seen	Crain-ADF&G; Argall-public
6 Wood River Buttes	6	6	0	--	Tracks seen	Grangaard, Valkenburg-ADF&G
7 Clear Creek Buttes	3	3	0	--	Tracks seen	Long-public
8 Blair Lakes	16	14	2	--	Tracks seen	Long, Nystrom, Thompson-public
9 Dry Creek	6	6	0	--	Tracks seen	Grangaard, Quimby-ADF&G
10 Harding Lake	3	2	1	--	Tracks seen	Parrish-public
11 Little Delta Creek	7	4	3	--	Tracks seen	Bares, Thompson-public
12 Delta Creek	14	6	8	--	Tracks seen	Dorhorst, Thompson-public
13 100-mile Creek	6	5	1	4 grays, 1 black	Seen	Bunselmier-F&WP
14 Lower Bonnifield Creek	6	3	3	--	Tracks seen	Stephenson-ADF&G; Smith, Boltz-public
Subtotal	99+10[d] =109	70+7[d] =77	29			

Table 10. Continued.

Pack name	Estimated numbers fall 1985	Estimated numbers spring 1986	Number harvested	Colors of wolves if seen	Evidence	Observers
Foothills						
15 Rex Dome	6	6	0	6 blacks	Seen	Myers, Dabney-public
16 Healy	2	2	0	1 silver, 1 black	Seen	Winkleman, Sorenson-public
17 Lignite	7	6	1	5 grays, 2 blacks	Seen; 2 radio-collared	Davis, Grangaard, Valkenburg-ADF&G
18 Lower Yanert River	6	5	1[e]	6 grays	Seen; 2 radio-collared	National Park Service
19 Revine Creek	2	2	0	--	Tracks seen	Grangaard-ADF&G
20 Upper Yanert River	7	7	0	6 grays, 1 black	Seen fall and spring	Karczmarczyk, Grangaard-ADF&G
21 Upper Tatlanika	24	22	2	15 grays, 9 blacks	Seen fall and spring	Valkenburg-ADF&G; Grahm, Smith-public
22 Gold King Creek	8	6	2	--	Tracks seen	Boertje-ADF&G; Smith-public
23 Snow Mountain	9	9	0	5 grays, 4 blacks	Seen; 2 radio-collared	Davis, Grangaard-ADF&G
24 Buchanan Creek	7	5	2	7 grays	Seen fall and spring	Bunselmier-F&WP; Quimby-ADF&G
Subtotals	78+8[d] =86	70+7[d] =77	8			
Totals	195	154	37[f]			
Percent change = -21[g]						

Table 10. Continued.

[a] Data collected prior to July 1984 were collected in part from a portion of Subunit 20C, since included in Subunit 20A. Also, some wolf packs spend less than 50% of their time outside Subunit 20A.

[b] Wolf was trapped in Subunit 20C.

[c] Wolves were snared in Subunit 20B.

[d] Added 10% for single wolves.

[e] Wolf was killed by 1 or more wolves in Subunit 20C.

[f] Only 27 wolves were harvested in Subunit 20A; 10 additional wolves (that were apparently part-time residents of 20A) were harvested in Subunits 20C and 20B adjacent to Subunit 20A.

[g] This change assumes natural mortality, dispersal, and/or unreported harvest totals 10% of reported harvest.

Appendix A. Distribution and size of caribou groups and distribution of radio-collared caribou from the Delta and Yanert Caribou Herds during the 16 July 1985 census (see attached map).

Group No.	Number of caribou	Number of radio collars in group
1	3011	19
2	1,309	7
3	987	9
4	958	6
5	709	2
6	498	1
7	276	1
8	100[a]	0
9	85	1
10	51	0
11	40	1
12	39	1 (Y)[b]
13	5	1 (Y)
14	5	1 (Y)
15	3	1 (Y)
16	2	1 (Y)
17	2	0
18	1	1 (Y)
19	1	1 (Y)
20	1	1 (Y)
Total	8,083[c]	55

[a] This group was estimated.

[b] (Y) indicates a radio collar on a Yanert Herd caribou.

[c] Bulls were mixed in throughout most groups.

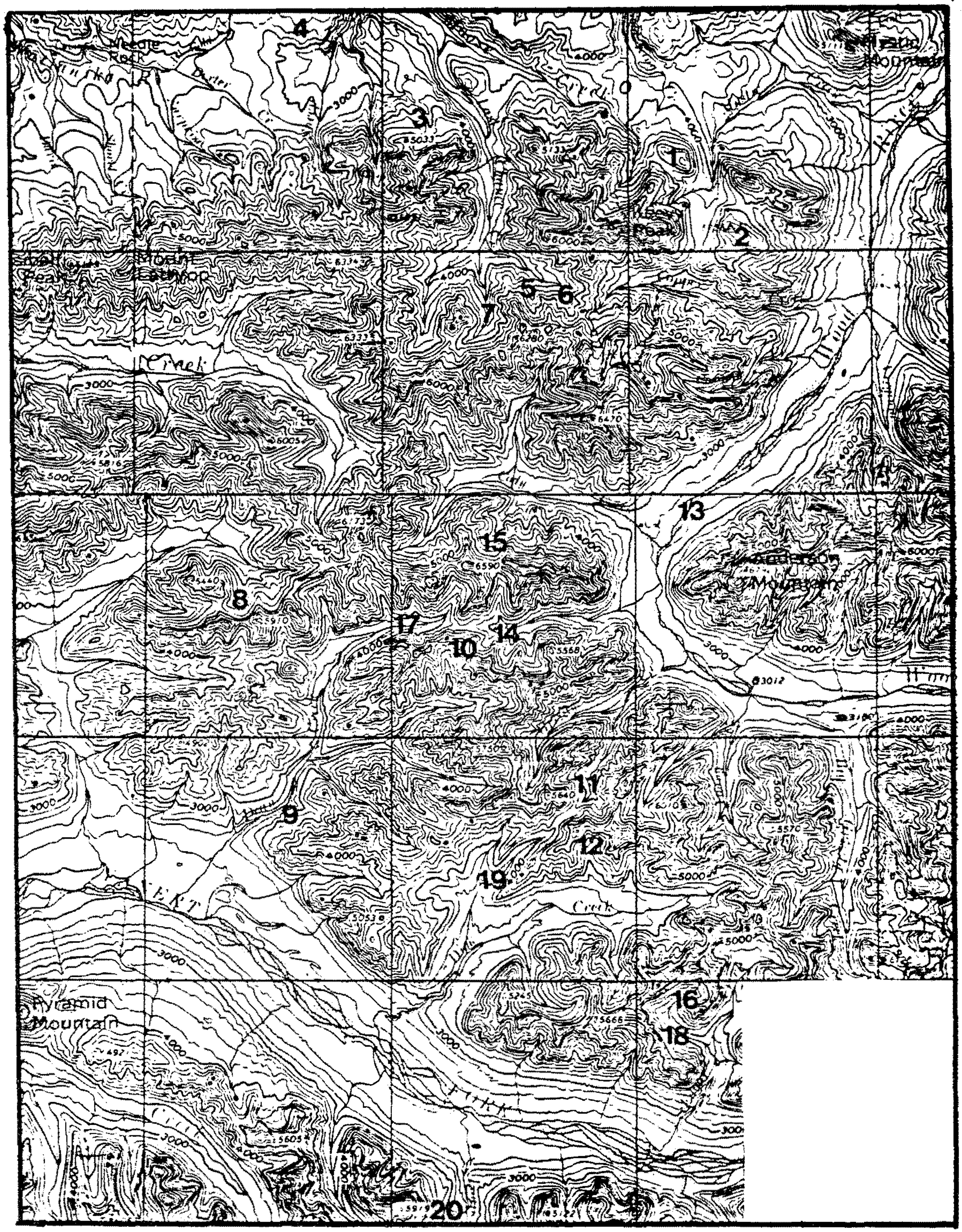

Fig. A-1. Locations of Delta and Yanert Herd caribou during the census, 16 July 1985.

Appendix B. Distribution, size, and composition of caribou groups and distribution of radio-collared caribou from the Delta and Yanert Caribou Herds during the 26 and 27 June 1986 census (see attached map).

Group No.	No. of caribou	No. of radio collars in group	Group composition
1	1,972	12	Cows and calves
2	1,344	9	Bulls, cows, and calves
3	1,143	1	Bulls, cows, and calves
4	765	1	Bulls
5	533	4	Cows and calves
6	467	5	Cows and calves
7	402	1	Cows and calves
8	344	1	Cows and calves
9	338	2	Cows and calves
10[a]	179	2	Cows and calves
11	131	0	Bulls, cows, and calves
12	91	0	Bulls
13	87	3	Bulls, cows, and calves
14	8	1	Cows and calves
Total	7,804	42	

[a] Many small groups.

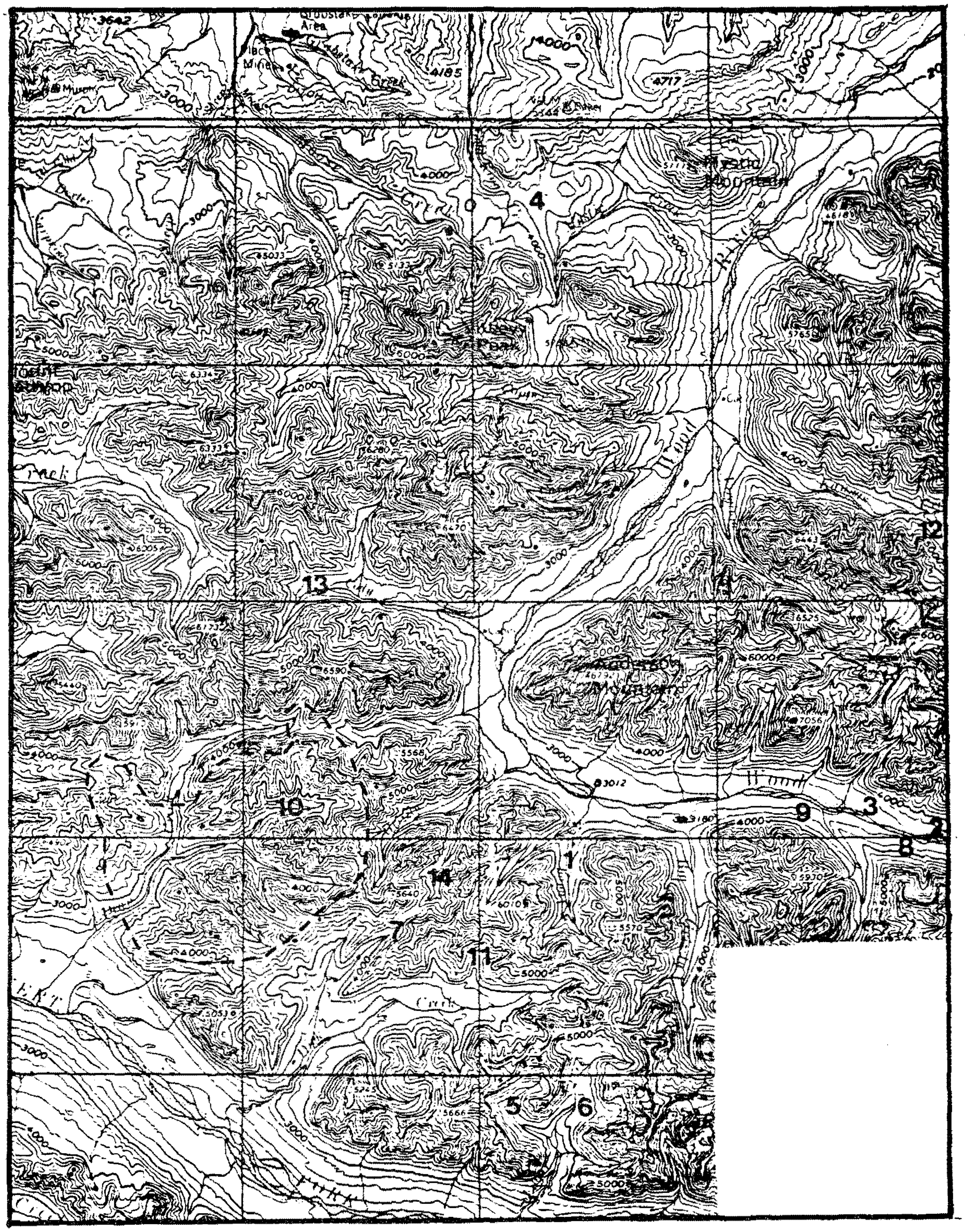

Fig. B-1. Locations of Delta and Yanert Herd caribou during the census, 26 and 27 June 1986.

Appendix C. Sex and age composition of 11 caribou sample units, and identity of radio-collared female caribou present in each sample, surveyed to estimate the ratio of 11-month-old calves:100 cows in the Delta Caribou Herd, 20 April 1986.

Sample unit	Cows	Calves Male	Calves Female	Unknown	Total	Males	Total	Radio-collared caribou present
1	11	--	3	--	3	1	15	072
2	34	13	20	--	33	38	105	074
3	79	8	12	--	20	20	119	076
4	86	11	11	1	23	28	137	Y45[a], Y50[a]
5	14	1	0	--	1	1	16	079[a], 075[a]
6	65	10	16	--	26	20	111	066
7	45	2	6	--	8	1	54	Y10
8	88	11	14	--	25	7	120	067
9	79	7	14	--	21	4	104	B5
10	80	11	5	1	17	14	111	Y41, 057
11	68	5	22	--	27	11	106	B9, 053
Total	649	79	123	2	204	145	998	

[a] All 4 of these radio-collared caribou were present in a "loose" aggregation encompassing sample units 4 and 5.

Appendix D. Draft study plan for Master of Science thesis project, Delta Caribou Herd, 24 December 1986.[a]

Study Title: Forage Availability and Winter Range Use by the Delta Caribou Herd

Investigator: Steve Fleischman, University of Alaska, Cooperative Wildlife Research Unit, Fairbanks

Advisor: Dr. David Klein, University of Alaska, Cooperative Wildlife Research Unit, Fairbanks

Introduction/Justification

The Delta Caribou Herd (DCH) has been increasing in size since the mid-1970's and presently numbers about 8,000 animals. Large body size and early reproduction indicate that the nutritional status of the herd has been high, suggesting that forage has not been limiting up to the present time. However, forage resources in a given area are finite, and if population growth continues, there is the potential for expansion of range and/or density dependent food limitation, either of which would have important implications for management.

Population dynamics of the herd are being investigated by the Alaska Department of Fish and Game; however, complementary information on the foraging ecology of the DCH is needed to thoroughly understand the factors that influence the herd. Winter is the time of the year when food is most likely to be limiting to caribou populations due to poor forage quality and restricted forage availability. Knowledge of (1) winter forage abundance and availability, (2) winter range use patterns, and (3) composition of the winter diet will provide valuable baseline information on an expanding herd and may also prove useful in assessing the probability of future food limitation and/or range expansion. It is these 3 aspects of foraging ecology which will be addressed by this study; they are discussed briefly here in turn.

Forage abundance and availability:

Lichens, due to their high digestibility and energy content, are highly preferred by wintering caribou and reindeer and are the primary winter forage of *Rangifer* at this latitude. As a consequence of their slow growth and their fragility when dry, however, lichen stands are easily impacted by grazing and trampling; therefore, lichen abundance is commonly used as an indicator of winter range condition. An estimate of lichen standing crop would therefore be useful in comparing the Delta Herd winter range with those of other herds. However, a more meaningful

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assessment of winter range condition should include some measure of relative forage availability as influenced by ice and snow. It has been demonstrated that caribou show a preference for feeding sites where snow conditions are favorable for cratering, that the energetic expense of obtaining forage is related to snow characteristics, and that the presence of an ice layer in the snow can affect even the ability of caribou and reindeer to detect the presence of forage. Lichen biomass and snow characteristics have been measured on several Rangifer ranges, but very few studies have related snow measurements directly to vegetation.

Range use patterns:

Information on the distribution of the herd, based on relocations of animals radio-collared by ADF&G, is available for the past 7 years. General patterns of winter range use are as follows. The rut occurs in October in the western foothills and during early winter the herd remains largely in the western half of the range. During midwinter there is a general tendency for females and young to drift eastward. A dissected plateau in the central part of the range has received much midwinter use in the past although the herd has shown a tendency to be more dispersed in recent years. By March or April many of the cow-calf groups are found in the eastern foothills and occasionally in the flats to the north. Mature bulls remain largely in the western half of the range and are segregated from females and young during much of the winter. A comparison of past and present distribution with information on winter range characteristics would provide data on habitat selection in relation to snow, vegetation, and land types, and would allow an appraisal of the rate and extent of range expansion. Sex segregation in winter has been observed in many herds. Differential selection pressures on males vs. females have been hypothesized to account for differential range use in other cervids. Comparison of male and female distribution data with range characteristics obtained during this study might address the applicability of theories on sexual selection to caribou.

Winter diet:

Diet composition has been hypothesized to be an indicator of range condition and nutritional status. Crude indices of diet composition are relatively easily obtained (through fecal analysis) and would provide a means of comparison with other herds for which similar information is available. Other indices of winter diet composition (see procedures 11 and 12) may also be available, and any such information provides good baseline data on the DCH for this point in time.

Objectives/Hypotheses/Procedures

Objective I. To estimate lichen biomass on the winter range of the DCH and the relative availability of forage as influenced by snow conditions.

Central Hypothesis I: A substantial portion of the total lichen biomass on the study area is energetically expensive to obtain due to adverse snow conditions.

Procedures:

1. Three areas of the winter range, selected as representative of the western, central, and eastern foothills, have been sampled for plant species composition. Fifteen by one hundred-fifty meter plots (111 total) were located randomly within each area, and each plot was subsampled with an average of 8, 20 x 50 cm quadrats. Cover class was recorded for all plant species present except lichens, for which cover and height were recorded.

In a portion of the quadrats (103 total) all fruticose lichens were picked and later sorted, oven dried, and weighed, allowing an estimate of biomass to be obtained by regression of weight on cover and height data. Depending on the precision of the overall estimate of lichen biomass obtained with the present data, additional plots may be sampled during summer 1987.

2. Vegetation plots will be revisited in winter during periods when caribou are utilizing each respective area of the range; and cover, depth, density, and hardness of the snow cover will be recorded at each plot. Revisiting plots during periods of caribou use will allow for efficient collecting of fecal samples (see Objective III), as well as allowing for measurement of snow characteristics at caribou feeding sites.

3. Marked stakes have been placed on 24 of the plots with substantial lichen biovolume, and snow depth and cover will be read from the air at 1-month intervals during winter. Snow stake readings will allow calibration and standardization of snow measurements made at different periods during winter and provide an index of temporal changes in snow depth.

4. A model of the energetic cost of cratering in different snow types will be developed from the literature on cratering dynamics and energetics. Estimates of energy costs will be subtracted from energy available from the lichens to assess the net energy gain to be expected from cratering in different vegetation/snow types.

Related hypotheses:

A. Lichen biomass of the DCH winter range is greater than has been estimated for other *Rangifer* ranges in North America.

B. The eastern, central, and western portions of the range differ with respect to lichen biomass and/or proportion of vegetation/land types.

C. Snow characteristics vary among areas and vegetation/land types. Procedures:

5. An estimate of lichen biomass based on regression analysis of cover and height data will be compared with other forage biomass studies from the literature.

6. A sample of points on aerial photos will be classified according to vegetation and topographic criteria to estimate the proportion of vegetation/land types within the study area.

7. Topographic parameters and vegetation type will be recorded for all lichen/snow plots, allowing comparison of lichen biomass and snow characteristics among areas and vegetation/land types.

8. Landsat imagery will be investigated as a possible means of comparing snow cover on a regional basis.

Objective II. To document past and present patterns of winter range use.

Central Hypothesis II: Caribou use of range partially reflects patterns of forage availability. Additional hypotheses:

D. Mature bulls are segregated from cows, calves, and yearlings during much of the winter.

E. Cow, calf, and yearling groups prefer open, windswept areas with convex slopes at relatively high elevations, with possible sacrifice of lichen abundance for shallower snow and good escape terrain.

F. Mature bulls exhibit more use of low-elevation forested areas with deeper snow and higher lichen abundance.

G. Patterns of range use shift as snow accumulates over the course of a winter.

H. Winter range use has expanded during the past 7 years. Procedures for D-H:

9. Radio-collared animals will be located monthly during the winter by plane; vegetation type, topographic parameters, and snow depth will be recorded and locations plotted on maps or aerial photos. All of the radio-collared males will be tracked as well as a sample of the 40+ radio-collared females.

10. Present and past data on distribution of radio-collared caribou will be digitized to allow efficient analysis.

11. Number of pellet groups on vegetation plots has been recorded and will be investigated as a possible index of relative habitat use among areas.

Objective III. To obtain indices of the botanical composition of the winter diet of DCH caribou.

Central Hypothesis III: Dietary composition of DCH caribou is indicative of a relatively high nutritional status when compared with other North American herds. Specific hypotheses:

J. Lichens compose a large portion of the winter diet of DCH caribou.

K. Mosses and evergreen shrubs (both considered to be dietary indicators of poor range quality in caribou at these latitudes) compose a very small portion of the diet.

L. Lichens compose a larger portion of the diet of males than of females. Procedures:

11. Fecal pellets and rumen samples (when available) will be collected and analyzed for composition of lichens, graminoids, shrubs, and mosses. Results will be compared with similar studies of adjacent and other North American herds.

12. If tissue samples become available from DCH caribou in late winter, a radiocesium technique will be used to obtain an index of absolute lichen intake.

Appendix E. Abstract of a paper presented at the 4th International Reindeer/Caribou Symposium, Whitehorse, Yukon, in August 1985, and subsequently revised and published in the journal Rangifer.

Empirical and theoretical considerations toward a model for caribou socioecology

James L. Davis[1], Patrick Valkenburg[1], and Rodney D. Boertje[1]

Abstract: The Delta and Yanert caribou (*Rangifer tarandus granti*) herds apparently maintained discrete calving areas from 1979 through 1983 (as determined by radiotelemetry studies), even though substantial intermixing occurred during other seasons. Also, the Delta herd apparently used a single traditional calving area from the 1950's through 1983, based on results of aerial surveys and 1979-83 telemetry studies. Calving distribution in 1984 changed dramatically; 5 of 25 radio-collared Delta herd cows ≥3 years old and 5 of 24 radio-collared Delta herd cows <3 years old were located in the calving area of the Yanert herd, 72 km west-southwest of the traditional Delta herd calving area. Use of traditional, separate calving areas resumed for the two herds in 1985. One implication of these data is that the current definition of a caribou herd may not always apply. A second implication is that current models of caribou socioecology, based largely on the concepts of traditional use of calving grounds, herd identity/fidelity, and dispersal, inadequately predict or explain all empirical observations. An evolving model of optimal and dynamic use of space can help refine current models of caribou socioecology.

Key words: calving, caribou, conceptual model, dispersal, herd identity, socioecology.

[1] Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701.

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