NATIONAL PETROLEUM RESERVE IN ALASKA

STUDIES OF SELECTED WILDLIFE AND FISH AND THEIR USE OF HABITATS ON AND ADJACENT TO THE NATIONAL PETROLEUM RESERVE IN ALASKA 1977-1978

Volume 1

BY
NATIONAL PETROLEUM RESERVE IN ALASKA
WORK GROUP 3

FIELD STUDY 3

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PETROLEUM RESERVE IN ALASKA
105(c) LAND USE STUDY
ANCHORAGE, ALASKA
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CHAPTER 2

CARIBOU DISTRIBUTION, POPULATION CHARACTERISTICS, MORTALITY, AND RESPONSES TO DISTURBANCE IN NORTHWEST ALASKA

By

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INTRODUCTION

This report includes results of caribou studies undertaken by the Alaska Department of Fish and Game (ADF&G) in 1977 and 1978. These studies extended over the range of the Western Arctic Herd (WAH) caribou in northwestern Alaska. ADF&G caribou investigations during that period were, in part, aimed at providing information needed for the NPR-A 105(c) study purposes. A survey conducted in January 1977 was not financed with NPR-A 105(c) funds. Similarly, certain other field efforts, such as the calving grounds surveys in 1977 and 1978, were partly or wholly funded by Federal Aid in Wildlife Restoration project funds. Nevertheless, all movement and distribution data gathered in 1977 and 1978 have been included in this report.

OBJECTIVES

For the 105(c) study purposes, emphasis was placed on determining movements, distribution, seasonal patterns of habitat use, and patterns of mortality. Population size and composition data were obtained in part with 105(c) funding. Responses to disturbance were recorded incidental to other field activities.

METHODS

Aerial surveys were conducted from January 3 to 14, 1977, to determine the number of caribou wintering in the 14,130-mi^2 (36,172-km^2) area between the Utukok River delta on the west, the Colville River delta on the east, the Arctic Ocean on the north and lat 70° N on the south. Surveys were flown

between 1030 and 1400 local time when light was best. Pieces of tape on the wing struts served as reference points which allowed observers to determine a distance of one-half mile (0.8 km) on each side of the aircraft when 500 ft (160 m) above ground. For each mile (1.6 km) traveled, therefore, an area of one square mile (2.58 km^2) was surveyed. Two Cessna 180's and one Cessna 185 aircraft were utilized. Each aircraft had either three or four observers including the pilot. Four biologists, three protection officers and five local residents selected by the North Slope Borough participated in the survey.

The survey area was divided into seven sections, using identifiable landmarks, to facilitate navigation. In sections 1, 2, 3, 4 and 6, survey lines were spaced at approximately 12-mi (ca. 19-km) intervals and oriented in a north-south direction. In section 5, survey lines were run in an east-west direction to minimize sampling bias because caribou were clumped along rivers which generally run north-south. In Section 7 north-south surveys were used in part, supplemented by surveys around Teshekpuk Lake. Caribou density was calculated for each transect by dividing the number of caribou observed by the area encompassed in the transect. The mean density for all transects within each sector was calculated and applied to the total area in the sector to estimate the number of caribou present.

Composition counts to determine the survival rate of calves from fall to spring were conducted for the first time in April 1977. Although work was performed primarily south of the Brooks Range, for two days in late April a Bell 206 helicopter was used to conduct composition counts and to locate and autopsy dead animals in the general Umiat-Teshekpuk Lake area. Following this, a 9-hour survey was flown in a Super Cub across the Arctic coastal plain to count adult caribou, calves and dead caribou, and to determine the distribution of the caribou.

In April 1978 a transect survey of the Arctic coastal plain was conducted; it was similar to the one conducted in January 1977. A total of 1,226 mi (1,960 km) in 24 transect lines was flown. In contrast to the 1977 survey, the area was subdivided based on density of caribou. A Super Cub and a Bellanca Scout were used during the survey.

In late May and June 1977 and 1978, reconnaissance surveys were flown to delineate areas of calving activity and aggregations of cows with calves. All adult animals present were counted and calf, yearling and bull percentages in some groups were determined. During early June 1977, surveys using fixed wing planes were flown over most of the western Arctic Slope to search for outlying groups of calving animals.

Photocensus and reconnaissance flights were conducted in 1977 to thoroughly cover the southwestern portion of NPR-A. Two Piper Cubs, a Cessna 180 and a Cessna 402 photo plane were used. During the 1978 photocensus, the southwestern portion of NPR-A was again thoroughly reconnoitered using two Super Cubs, a Beaver DHC-2 and a Bellanca Scout. After the photocensus, attempts were made to survey the entire range of the WAH to look for caribou that were not in the post-calving aggregations. Fifteen randomly selected north-south transects that totaled 1,312 mi (2,099 km) were flown north of lat 69°30' N from the Chukchi Sea on the west to the Colville River on the east. In the area south of lat 69°30' N, north of the Yukon River, and west of the Itkillik River and trans-Alaska pipeline, 13 randomly selected quadrats of about 1,000 mi^2 (2,600 km^2) each were flown. Full results of 1978 population estimates are not available for this report. They will appear in a subsequent Pittman-Robertson report by the Alaska Department of Fish and Game.

After July 1978, information about caribou was obtained from various people working in NPR-A because no further distribution surveys were conducted during this period.

Whenever opportunities occurred, the visible responses of caribou to disturbance by light aircraft were recorded. For each observation the type of aircraft involved, sex and age composition of the group, group size, response to the disturbance, vertical distance of the aircraft above the caribou (and lateral distance in some cases) and the habitat type were also recorded. The observed reactions of caribou were classified as falling into one of five response classes based upon Calef et al. (1976), as follows:

Class 1. Panic response. Animals were completely out of control; they stumbled, collided with one another, and ran into obstacles such

as willow patches or trees. There was some subjectivity in distinguishing this class from the following one.

Class 2. Strong escape response. Animals trotted or ran, and usually continued running after the aircraft had passed.

Class 3. Mild escape response. Animals moved away from the aircraft or from the original direction of movement in the case of traveling animals. This class included only animals which walked or trotted a short distance.

Class 4. Stationary response. Animals stopped feeding, rose from resting position, or assumed alarm posture (Pruitt, 1960).

Class 5. No visible response. Animals continued feeding or resting or, if moving, continued at the same pace in the same direction.

When not all animals in a group elicited the same response, the reaction of the largest portion of the animals was recorded as representing that of the group.

In all cases, the collection of disturbance data was ancillary to other objectives and was limited to surveys in late winter and early spring when recording the data was compatible with major survey objectives.

RESULTS

Distribution and Movements

Winter - 1976-1977

During November 1976 it became apparent that a substantial number of caribou were wintering on the western Arctic Slope. In January 1977 spokesmen for the North Slope Borough claimed that 140,000 caribou were present between Wainwright and Nuiqsut and suggested that the WAH had not declined as the ADF&G reported. In response to these statements a winter census was conducted in January 1977. Detailed results of this

census are shown in table 2-1. The area surveyed is delineated in figure 2-1, and results are summarized in table 2-2. From the census it was estimated that 28,683 ± 6,076 [80 percent confidence interval (C.I.)] caribou were present in the area north of lat 70° N and between the Utukok River on the west and the Colville River on the east.

The caribou observed during the January census apparently did not move significantly between January and late April. The largest concentrations observed in April were southeast of Wainwright and southwest of Teshekpuk Lake. In April, large numbers of caribou probably occurred throughout most of the area north of lat 70° N between the Colville River delta and Kuk River, but poor weather precluded a complete survey. From January through early May, an area from the crest of the Brooks Range north to lat 70° N and from Driftwood airstrip on the west and the Anaktuvuk River on the east was nearly devoid of caribou; only a few small scattered groups of bulls were observed.

Spring - 1977

Some caribou that wintered south of the Brooks Range began to move northwestward by early March (fig. 2-2). Trails of many hundred migrating caribou were seen in several areas: 1) from Easter Creek westward to the Nigu River, 2) north across Walker Lake from areas to the south and 3) north across Selby Lake from areas to the south near the Kobuk River. Caribou in the latter migrations were observed about April 10 by residents of Walker and Selby Lakes. Caribou in the Selawik Flats began northward migrations as late as April 15 and probably headed toward the Kobuk River near Ambler. Migrating caribou were observed on May 3 crossing the Kobuk River between Ambler and Shungnak, and trails indicated that several thousand had already crossed the river. ADF&G biologist Pete Shepherd observed trails of caribou on May 12 which indicated that those seen near Ambler on May 3 had moved down the Cutler River, across the Noatak River, and up the Anisak River where the vanguard of the groups was located at the crest of the De Long Mountains. These caribou probably reached Noluck Lake by May 17 when a local air taxi operator observed 500 caribou there.

Table 2-1. Densities of caribou on transect lines and quadrats determined during surveys of the Western Arctic Herd.

Survey Date	Transect Line or Sector Number*	Caribou per mi^2
January 3-14, 1977	1	0.75
	2	1.20
	3	0.50
	4	1.88
	5	4.03
	6	1.32
	7	1.51
		Ave. 2.03 ± 0.43**
April 17-18, 1978	1	11.09
	2	7.83
	3	2.65
	4	7.32
	5	4.50
	6	2.72
	7	6.25
	8	4.70
	9	2.91
	10	3.90
		Ave. 4.82 ± 0.52**
	11	1.80
	12	1.30
	13	1.14
	14	2.56
	15	0.76
		Ave. 1.62 ± 0.42**
April 17-18, 1978	16	0.68
	17	1.10
	18	1.84
	19	0.82
	20	0.89
	21	0.34
	22	0.58
	23	0.23
	24	0.00
		Ave. 0.78 ± 0.19**
July 7-11, 1978	1	0.0085***
	2	0.5521
	3	0.2308
	4	1.9623

Table 2-1. Continued.

Survey Date	Transect Line or Sector Number*	Caribou per mi^2
	5	0.0270
	6	0.3889
	7	0.0615
	8	0.2703
	9	0.1094
	10	0.1356
	11	0.9556
	12	0.0880
	13	0.2308
	14	0.0588
	15	0.0449
		Ave 0.2965 ± 0.1415**
July 5 - August 9, 1978	16	0.0152
	19	0.0022
	21	0.0933
	31	0.0064
	36	0.0000
	38	0.0128
		Ave 0.0183 ± 0.229**
	54	0.0000
	66	0.0000
	76	0.0053
	88	0.0000
	101	0.0137
	115	0.0000
		Ave 0.0032 ± 0.0071**

* Refer to figures 2-1 and 2-4.

** All figures for the 80 percent C.I.

*** These figures are carried to four places to preclude listing zero caribou per mi^2 where some were observed.

Table 2-2. Summary of data from transect and quadrat sampling in the range of the Western Arctic Herd, January 1977-August 1978.

Type of Survey	Date of Survey	Area Surveyed (mi^2)	Area Sampled in survey (mi^2)	Weighted Mean Density (caribou per mi^2)	Number of Caribou Estimated $\bar{X} \pm$ (80 percent C.I.)
transect	Jan. 3-14, 1977	14,130	1,099	2.03	28,683 ± 6,076a
transect	Apr. 12-13, 1978	14,790	1,226		30,993 ± 5,034
	Stratum A	4,064	378	4.82	19,588 ± 2,129
	Stratum B	3,618	298	1.62	5,861 ± 1,536
	Stratum C	7,108	550	0.72	5,544 ± 1,369
transect	mid-July 1978	25,000	1,312	0.20	7,413 ± 3,513
quadrat	July 1978	113,867	12,507		920 ± 1,635b
	Brooks Range and north	36,825	6,542	0.018	665 ± 843
	Brooks Range and south	77,042	5,965	0.003	245 ± 547

[a] An erroneous calculation of the 80 percent C.I. appeared in a progress report by Davis and Valkenburg released for limited distribution in 1977.

[b] 120 caribou were seen during the surveys in the northern areas and 19 in the southern areas.

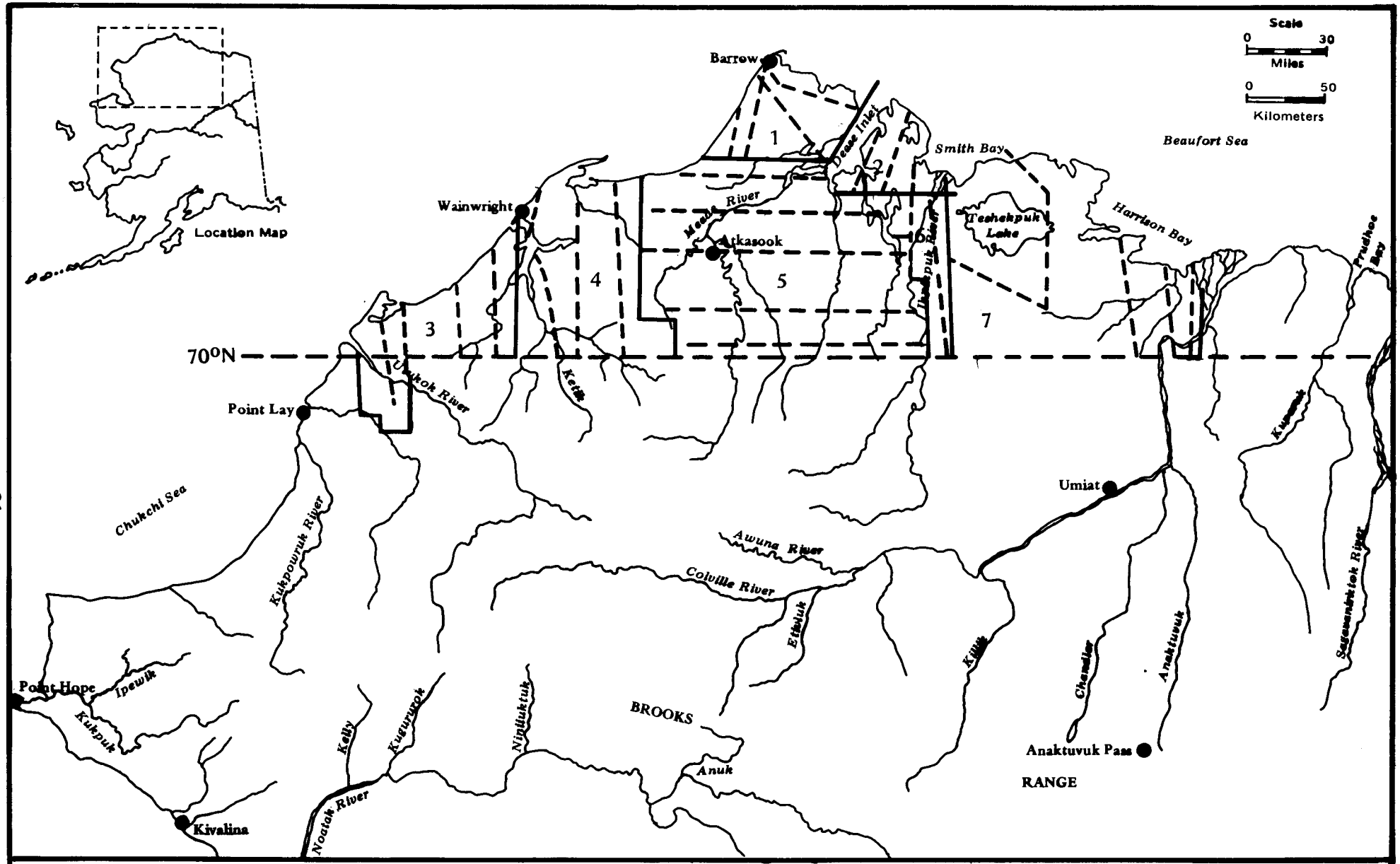

FIGURE 2-1. Location sectors and transect lines (broken lines) flown from 3-14 January 1977 to census caribou on Coastal Plain

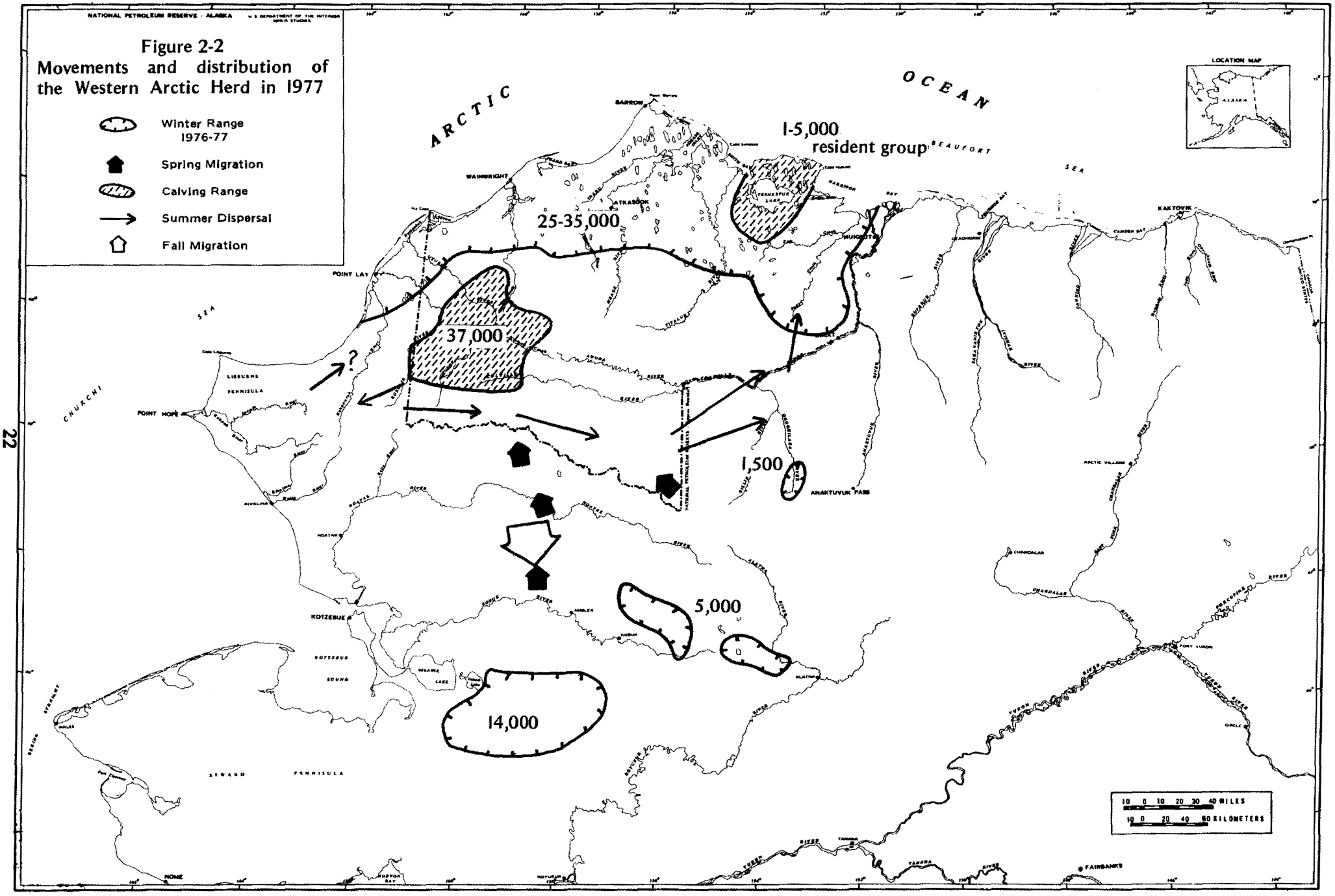
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Figure 2-2
Movements and distribution of the Western Arctic Herd in 1977
Winter Range 1976-77
Spring Migration
Calving Range
Summer Dispersal
Fall Migration
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
1-5,000 resident group
25-35,000
37,000
1,500
5,000
14,000
?
BARROW
WAINWRIGHT
ATKASOOK
POINT LAY
POINT HOPE
LISBURNE PENNSYLVANIA
KOTZEBUE
KOTZEBUE SOUND
SEWARD PENNSYLVANIA
NOME
ANAKTUVUK PASS
ARCTIC VILLAGE
KAKTOVIK
FAIRBANKS
LOCATION MAP
ALASKA
10 0 10 20 30 40 MILES
10 0 20 40 60 KILOMETERS

Smaller groups that wintered in the central Brooks Range migrated north along two routes. P. Shepherd (ADF&G) observed trails that indicated several hundred caribou moved from the upper Nigu River to the upper Etivluk River and then to Desperation Lake where they joined caribou migrating from the south in early May. Other caribou moved through Howard and Nigu Passes and then west along the northern foothills of the Brooks Range. It appeared that caribou taking this route would join those from the south shortly after May 12.

It was not possible to document movement routes to the calving area used by the caribou that wintered north of lat 70° N.

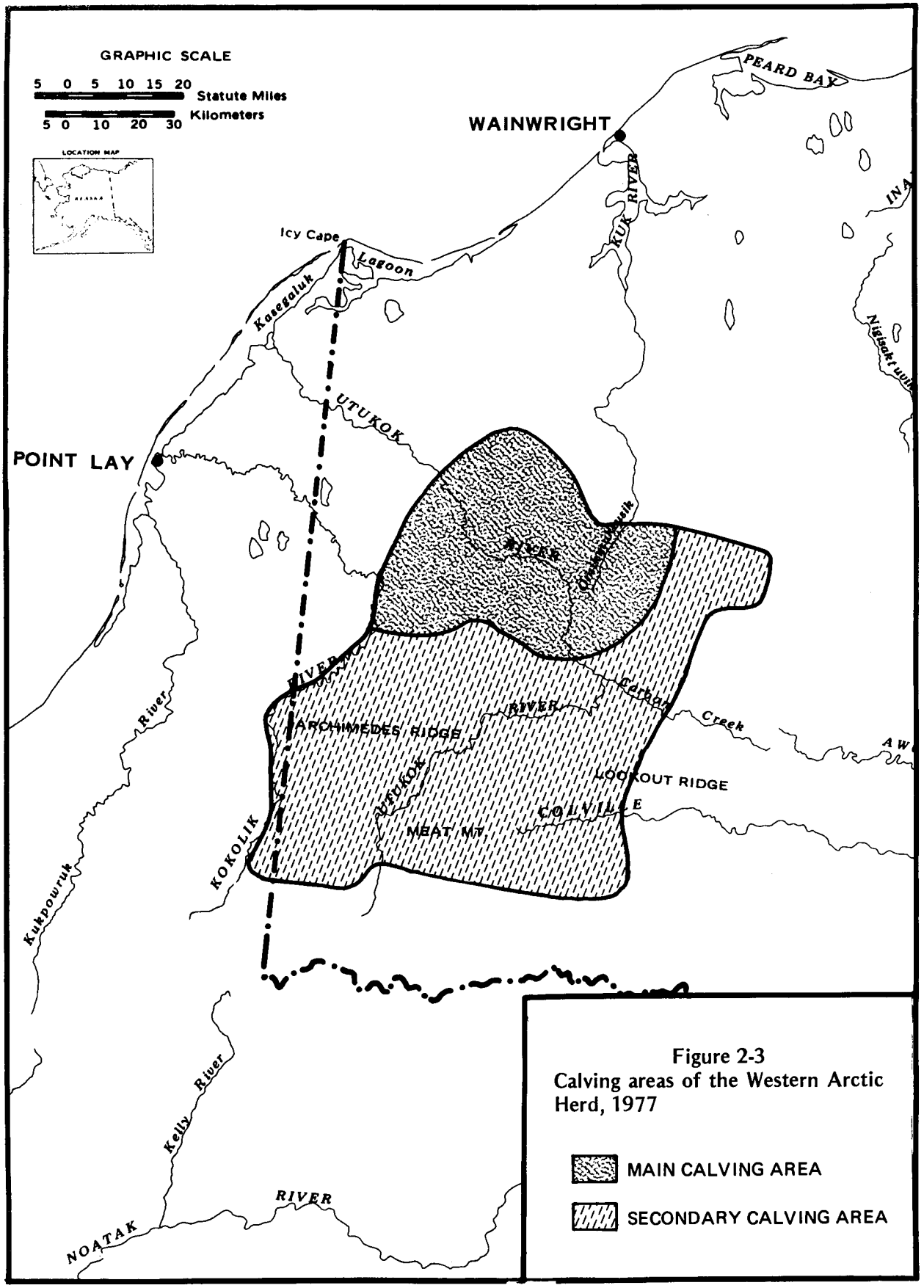
Calving - 1977

Caribou began passing Driftwood airstrip on the upper Utukok River about May 20. Trails in the snow indicated that many caribou moved north through the Brooks Range through three western tributaries of the Anisak River. From here, most caribou proceeded northwestward to the vicinity of Noluck Lake. From Noluck Lake trails spread out and continued in a more northerly direction.

Apparently most cows and yearlings segregated during the last week of May, and yearlings remained behind in the foothills. On May 31, 85 percent of the 2,000 caribou seen on the main calving area were antlered cows. One group of 30 yearlings and several other smaller groups composed entirely of yearlings were observed. Many yearlings were separated from the females on June 14 when an attempt was made to count caribou on the calving area. We observed 46.3 yearlings per 100 cows on the southern part of the calving area closest to the foothills, and an average of 9.1 per 100 in the central portion of the calving area were observed.

At Driftwood airstrip movement of cows and yearlings stopped on June 2 and most cows were probably in their calving area (fig. 2-3). Some groups of cows were still traveling northwest on June 2 in the area east of Driftwood where a heavier snow cover persisted.

A census of the calving area was carried out on June 14. The main calving


GRAPHIC SCALE
5 0 5 10 15 20
Statute Miles
5 0 10 20 30
Kilometers
LOCATION MAP
WAINWRIGHT
PEARD BAY
KUK RIVER
Icy Cape
Lagoon
Kasegaluk
UTUKOK
POINT LAY
ARCHIMEDES RIDGE
RIVER
Creek
LOOKOUT RIDGE
COLVILLE
MEAT MT
KOKOLIK
Kukpowruk
River
Kelly River
RIVER
NOATAK
Figure 2-3
Calving areas of the Western Arctic Herd, 1977
MAIN CALVING AREA
SECONDARY CALVING AREA

area encompassed 1,400 mi^2 (3,600 km^2) and secondary areas comprised 6,200 mi^2 (16,000 km^2). Density of caribou older than calves was 14.3 per mi^2 and 2.9 per mi^2 (5.5 per km^2 and 1.1 per km^2), respectively. The total number of caribou older than calves was 37,000. The excellent weather in 1977 allowed an especially thorough search. Therefore, the 1977 figures are probably more accurate than those of 1976 or 1978.

Post-Calving Movements - 1977

Definite directional movements and formation of larger groups began after June 10, the peak of calving. At this time caribou in the main calving area began moving southwestward. After June 14 the post-calving movement was not closely followed. Most caribou, including some bulls, were located between Mount Kelly, Windy Lake and Cape Sabine on June 28 when composition counts and a photocensus were initiated. Other caribou were located between Tupikchak Mountain and the Kukpowruk River.

During the first week of July, most caribou in the post-calving aggregation turned back eastward from the Kukpuk/Ipewik River area as they have traditionally done. R. Ritchie (USFWS, pers. comm.) estimated that 10,000 caribou crossed the upper Utukok River heading east in early July. On July 12, A. Springer (pers. comm.) saw approximately 1,000 caribou 5 mi (8 km) east of Cape Lisburne which indicated that not all the herd had started east. No large groups of caribou were seen in the Noatak Valley through July 20 or along the Colville River through August 2. By the first week of August, tracks and large groups were common along the Colville River near Umiat (T. Bendock, ADF&G, pers. comm.). We surveyed the coastal plain east of Barrow and the Meade River and found no large groups on August 3 and 4. Umiat residents and air taxi pilots reported that 3,000 caribou had been in the vicinity of Umiat. A major portion of the herd probably was in the general area but apparently moved southwestward from the Umiat area. On August 11, caribou were widely scattered over the coastal plain north and west of Umiat, and no large aggregations were reported. Caribou were most dense on the upper Ikpikpuk River (S. Young, Inst. for Northern Studies, Wolcott, VT, pers. comm.). Some bulls were also observed by S. Young at Cape Simpson in early to mid-August. M. Doxey (ADF&G, pers. comm.) reported that on August 30 several thousand caribou moved down

the Nigu and Etivluk Rivers; most were cows and calves. Caribou were common along the Colville River upstream from Umiat through the end of August.

Fall - 1977

The fall migration began shortly before mid-September. R. Ahgook (pers. comm.) from Anaktuvuk Pass estimated that 7,000-8,000 caribou traveled south through the pass about September 15 and another 3,000 about October 25. The upper Alatna, Killik, Nigu and John Rivers were surveyed on September 17 and only a few hundred caribou in small groups were found. These were generally traveling east.

During September, October and November weather was extremely poor north of the Brooks Range. The only report received from the Arctic Slope during this period was of several thousand caribou scattered in groups of 50 or so on the Tuluga River in mid-September.

On September 25 and 26 we counted about 23,000 caribou near Ambler. The animals were migrating south across the Kobuk River. D. Johnson, ADF&G Kotzebue Area Biologist, counted about 30,000 caribou a few days earlier before they had reached timbered areas. Because only about 1,500 caribou were located near Kivalina in addition to those that had passed through Anaktuvuk Pass and those located near Ambler, it was suspected that half the herd had remained on the North Slope as they had done the previous year. It was determined during a survey flown in November 1977 that caribou were indeed scattered across the Arctic coastal plain. However, visibility during the survey was so poor that an accurate picture of caribou locations and numbers could not be obtained.

Winter Distribution in NPR-A - 1978

From April 10-12, 24 transects were flown in the area north of lat 70° N and between the mouths of the Utukok and Colville Rivers (fig. 2-4). The surveys were flown with a pilot and one observer in a Bellanca Scout and a Piper Super Cub. A total of 1,226 transect mi (1,961 km) were flown which equated to 1,226 mi^2 (3,175 km^2) sampled (table 2-2). It was estimated that

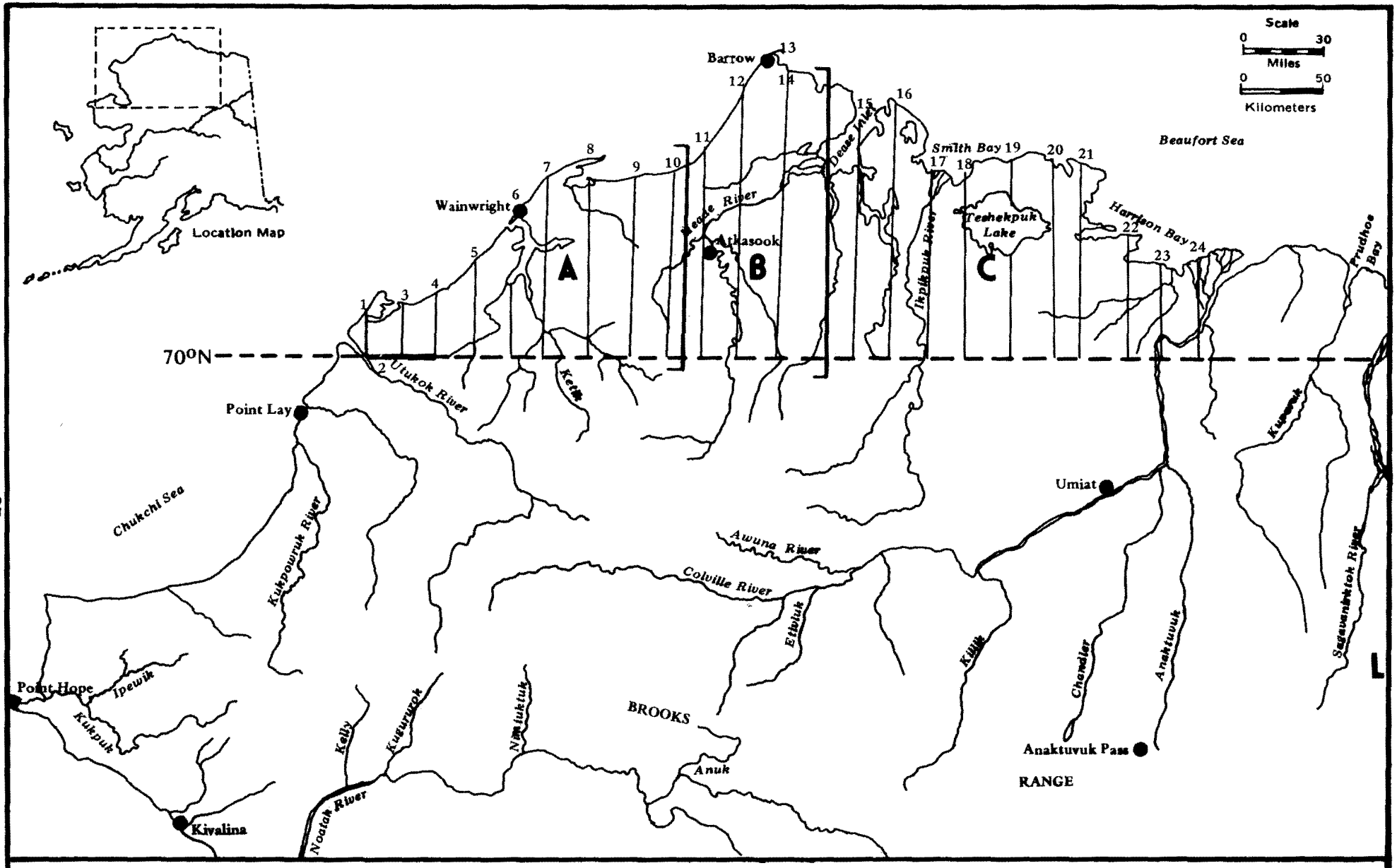
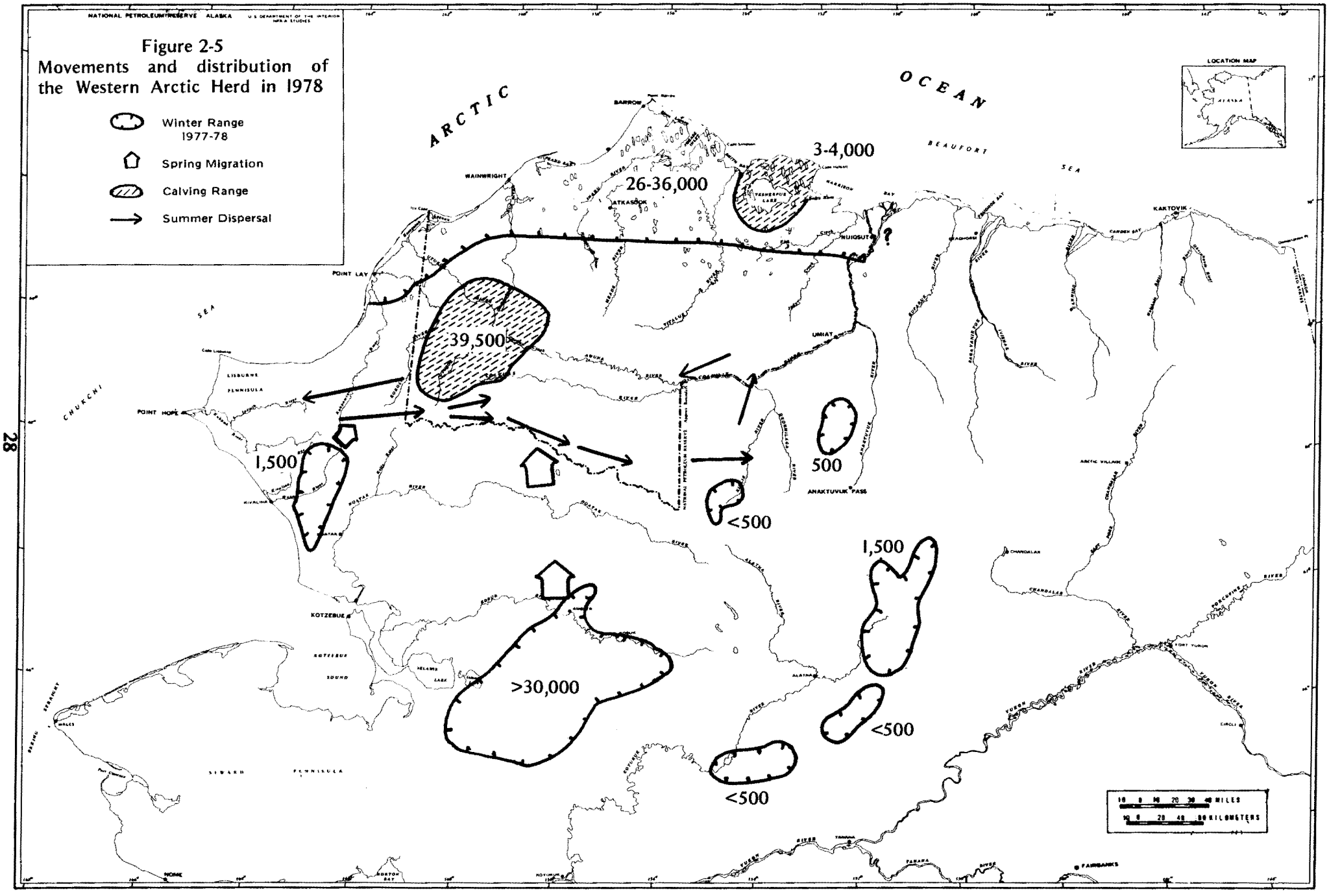


FIGURE 2-4. Transect lines flown during April 1978 to determine the number and distribution of caribou wintering on the western Arctic Slope. Transects 1-10 in Stratum A, 11-14 in Stratum B and 15-24 in Stratum C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U.S. DEPARTMENT OF THE INTERIOR
NPR-A STUDIES
Figure 2-5
Movements and distribution of the Western Arctic Herd in 1978
Winter Range 1977-78
Spring Migration
Calving Range
Summer Dispersal
LOCATION MAP
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
BARROW
WAINWRIGHT
ATKASOOK
3-4,000
26-36,000
NUIQSUT
?
KAKTOVIK
POINT LAY
39,500
UMIAT
POINT HOPE
LISBURNE PENNISULA
1,500
500
ANAKTUVUK PASS
<500
1,500
KOTZEBUE
>30,000
<500
<500
SEWARD PENNISULA
ARCTIC VILLAGE
FORT YUKON
CIRCLE
FAIRBANKS
10 0 10 20 30 40 MILES
10 0 20 40 60 KILOMETERS

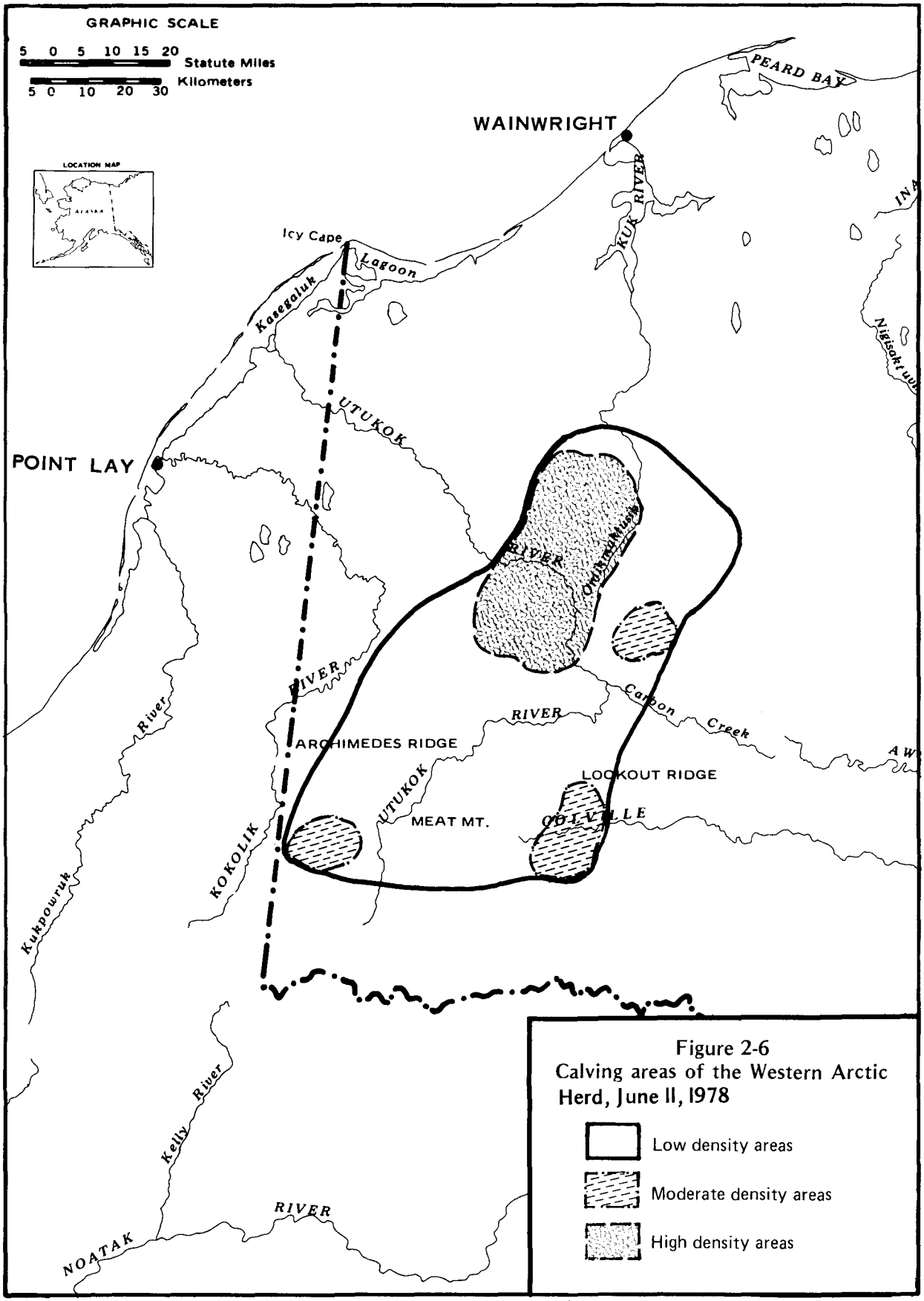

Figure 2-6
Calving areas of the Western Arctic Herd, June 11, 1978

there were 30,993 ± 5,034 (80 percent C.I.) present in the area, an average density of 2.10 +0.34 caribou per mi^2 (0.81 ± 0.13 per km^2). However, there was a density gradient from west to east; west of long 158° W the average density was 4.8 per mi^2 (1.8 per km^2) for stratum A compared to 1.6 and 0.8 per mi^2 (0.6 and 0.3 per km^2) for strata B and C, respectively (fig. 2-4). No caribou, feeding craters or trails were observed south of lat 70° N, except in the Point Lay vicinity where 2,000-3,000 caribou were distributed in the area from the coast to about 3 mi (about 5 km) inland and extending down the coast to about 30 mi (50 km) south of the village.

Spring - 1978

Little documentation exists on when the spring migration from southern wintering areas occurred, but most caribou apparently migrated in early May through the traditional middle Kobuk/Noatak Rivers route. The Hunt, Redstone and Anisak Rivers were heavily used, and few animals passed Noatak village. Some caribou arrived at Driftwood on the southern edge of the calving grounds by May 10, but most did not arrive until May 20. Caribou that wintered on the coastal plain in NPR-A apparently drifted into the calving area without any clear concentrated migration.

Calving - 1978

P. Lent and L. Anderson (USFWS, pers. comm.) surveyed the Teshekpuk Lake and Meade River areas in early June. They found calving caribou at Teshekpuk Lake, as had the investigators and others during the two previous summers (Davis and Valkenburg, 1978). They also found scattered groups near Wainwright and Point Lay which they considered were continuous with the caribou present on the Utukok calving grounds (fig. 2-5).

A reconnaissance survey on June 11 was flown to delineate areas used for calving. From the large number of calves observed, as well as the large proportion of cows without antlers, it was surmised that the peak of calving was around June 6-8. The depiction of the areas used for calving, therefore, may not precisely indicate which areas were most used during actual parturition. Figure 2-6 shows the distribution of calving caribou on June 11, and the direction of movement before and after that date.

The calving grounds were censused on June 15 and 40,000 caribou were counted, 38,637 of which were adult cows. The main calving area covered 624 mi^2 (1,616 km^2). Areas of moderate caribou density totaled 298 mi^2 (772 km^2). The total area used by calving caribou, with the exception of some scattered groups to the north and west, was 2,235 mi^2 (5,788 km^2). Calculated density of caribou on the main calving area was 50 per mi^2 (about 19 per km^2). Overall, calving density was 18 per mi^2 (about 7 per km^2). However, the calving ground was not censused until well after the peak of calving, and caribou were already aggregating and moving toward the southwest. Except for the earlier peak of calving, it appeared that the pattern of use of the calving ground was identical to that in 1977.

As in previous years the caribou in the calving area began moving toward the southwest about June 14 where they were joined by many bulls and yearlings on the upper Kokolik River. From June 20 to 25 an average of 200 bulls and yearlings per day were passing westward across the upper Utukok River near Driftwood. All animals were moving slowly and by June 27 it appeared that the post-calving aggregation would be late in forming. Surveys were not intensive between June 15 and July 4, but on July 5, in preparation for the aerial photocensus, the northern foothills of the Brooks Range between the Utukok River and Mt. Kelly were searched for caribou. Several large groups of caribou were located; the vanguard was just crossing the upper Utukok River heading east. Weather was warm and generally sunny on July 4 and 5 which may have precipitated the formation of large groups. Groups became larger and more consolidated and continued moving east until July 7 (fig. 2-7), when they were photographed for the aerial photocensus. Rapid eastward movement continued. On July 8 composition counts were conducted on two of the largest aggregations. From late afternoon on July 7 to late the following afternoon, the vanguard of the post-calving aggregation moved from the upper Colville River near Noluck Lake to the head of the Anisak River, a distance of about 16 mi (26 km).

From July 10-15, randomly selected transects and quadrats were flown throughout the range of the WAH to determine the number of caribou not present in the post-calving aggregation. From these surveys it was determined that 7,413 $\pm$ 3,513 (80 percent C.I.) caribou were present north

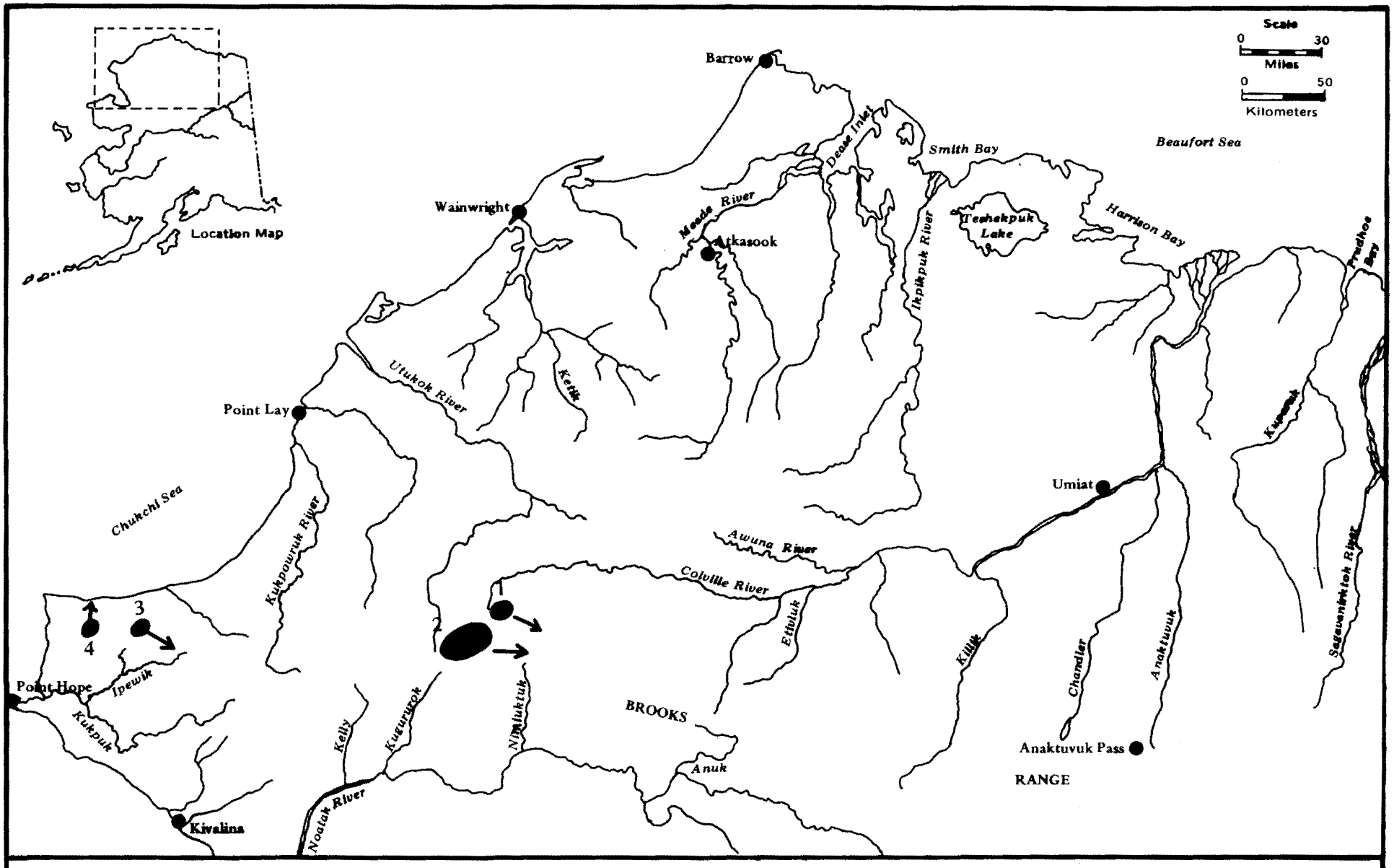

FIGURE 2-7. Location and direction of movement of post-calving aggregations on July 6, 1978

1. Estimated 20,000 in one group.
2. Four groups totaling about 30,000.
3. Estimated 5,000 in one group.
4. Estimated 20,000 in one group.

of lat 69°30' N. It should be noted that this included the approximately 4,000 animals in the Teshekpuk Lake Herd. Between the crest of the Brooks Range and lat 69°30' N, 665 ± 843 (80 percent C.I.) were present and south of the crest 245 ± 547 (80 percent C.I.) were present. Most cows found during these surveys were in areas occupied by small resident herds (i.e. the Ray Mountains and Teshekpuk Lake Herds).

Postcalving - 1978

After July 8, the large aggregations apparently continued eastward, except perhaps the two groups seen near Cape Lisburne on July 7, but their movement was not monitored. Reports from various people in NPR-A indicated that large numbers of caribou did not move as far east in summer 1978 as in 1977 (i.e. large numbers were not seen in the vicinity of Umiat in 1978). Herb Melchior (ADF&G, Barrow) reported that few caribou were accessible to Nuiqsut or Barrow in late August. Caribou were common on the Colville River between Knifeblade Ridge and the mouth of the Kiligwa River on August 26, but no estimate of total numbers was made. Caribou were also common in the Howard Pass/Nigu Pass area.

The Teshekpuk Lake Calving Area

Sappington (1976) reported about 2,000 caribou near Teshekpuk Lake in June and July 1976. In both 1976 and 1977 calving groups were apparently most common immediately south and west of the lake. U.S. Fish and Wildlife Service personnel stationed east of Teshekpuk reported that groups with a high proportion of calves, totalling an estimated 2,000 or more, passed by their camp in generally northerly movements between June 11 and July 1, 1977 (unpublished field report on file at USFWS, Anchorage). No adult bulls were observed in these groups prior to June 24. Starting on July 4, groups of similar size and composition were observed moving by generally in a southerly direction. An estimated 2,500 animals, including nearly 600 calves, were seen between that date and early August.

On June 3, 1978 a calving group was located by P. Lent and H.L. Anderson (USFWS) northeast of Teshekpuk Lake in the area from north of Kogru Inlet and south and east of Lonely. At this time 24 percent of approxi-

mately 250 cows observed had calves. On June 14 and 15 a systematic survey of the same area was accomplished. Based on low-level aerial transects sampling 8 percent of the area, an estimated 1,903 cows with 869 calves (46 percent) were present. Bulls were estimated to number 88, and the estimated total for the area was 3,100. This estimate may be compared with the estimate of 4,000 by ADF&G for the general Teshekpuk Lake area based on the surveys in mid-July. During extensive reconnaissance surveys from July 1 to 4, no other significant number of calves was observed on the coastal plain east of the Utukok River drainage to the Colville River. The significant number of bulls in the Teshekpuk calving group in 1978 suggests that calving occurred on or very close to the wintering area.

Population Size and Composition in 1977

Caribou were censused on the calving grounds on June 14, 1977, and it was estimated that 37,577 caribou older than calves were present. It was calculated that 32,464 were adult cows by extrapolating from the total using composition data (table 2-3) obtained during or before the census. By using the figure of 32,464 cows as the female base of the population and by using herd composition data obtained in fall 1977, a population estimate was extrapolated as follows:

Adult cows	=	32,464
Bulls (43.2/100 cows)	=	14,024
Yearlings (28.5/100 cows)	=	9,252
Calves (41.7/100 cows)	=	13,537
Total	=	69,277

However, after comparing the composition data from October 1976 and from April, late June and October 1977, it was concluded that this population estimate was probably low because of suspected bias in the October 1977 composition data. In April 1977, 43.9 calves (short yearlings) per 100 cows were counted, but in fall 1977 only 28.5 yearlings/100 cows were observed. Similarly, in fall 1976 58 bulls/100 cows were counted, but only 43.2 bulls/100 cows were counted in fall 1977. No evidence existed to suggest that the decline in the yearling ratios was due to summer mortality, and known or suspected harvest by humans would not account for the observed decline in bulls.

Table 2-3. Results of composition counts on calving grounds, mid-June 1977*

	Per 100 cows	Percent in sample
Cows	--	54.0
Bulls	0.4	0.2
Calves	68.0	36.7
Yearlings	18.0	9.1

* Based on a sample of 8,034 caribou, considered representative of 37,577 caribou on calving grounds.

Therefore, we believe it is probable that a number of yearlings were mistakenly classified as adult females in the fall 1977 composition counts. This error could have resulted from poor counting conditions and inexperienced observers relying upon gross morphology rather than genitalia to distinguish the sexes. Because body size and antler conformation of yearling bulls can be similar to cows, most misidentification likely results in the yearlings being classified as cows. The error was estimated as follows:

1. Assume 5 percent mortality of short yearlings and 2.5 percent mortality of cows from April 1977 to October 1977, so the expected October yearling/100 cows ratio would be:

   $43.9 - (43.9 \times .05)/100 - (100 \times .025) = 42.025$ yearlings/97.5 cows
   or approximately 43 yearlings/100 cows

2. Assume that the misidentified yearlings were added to the cows in the composition surveys of October 1977 and calculate that 10 yearlings must be subtracted from 100 cows and added to the observed yearling/100 cow ratio (28.5/100) to give the expected yearling/100 cow ratio calculated above (42.7/100) as illustrated below:

   $$\frac{28.5 + 10 \text{ yearlings}}{100 - 10 \text{ cows}} = \text{approximately 43 yearlings/100 cows}$$

By adjusting the calf/100 cow and bull/100 cow ratio proportionately (i.e. similarly) corrected ratios of 46.0 calves and 48 bulls/100 cows were calculated.

By extrapolating with these data, a "corrected" population estimate was derived as follows:

June 14, 1977, calving ground census, cow base	=	32,464
Bulls (48/100 cows)	=	15,583
Yearlings (43/100 cows)	=	13,960
Calves (46/100 cows)	=	14,933
Total	=	76,940

It is obvious from the above calculations that such misclassifications in fall composition counts lead to an underestimate of population numbers. The actual fall population was possibly somewhat larger than the adjusted estimate of 76,940. We believe the adjusted estimate of 76,940 animals was a minimum estimate of the fall population. Some of the sources of error discussed by Pegau and Hemming (1972) would also apply to the estimate of the 1977 population. In addition to these, if any significant groups of cows were not counted in early June 1977, the population estimates would be low. However, we believe that no significantly large groups (thousands) were missed because the weather during the calving period was excellent and extensive surveys were flown in the area adjacent to the main calving area.

Aerial Photo-Direct Count-Extrapolation (APDCE) Census

Several large post-calving aggregations were successfully photographed on June 28, 1977. However, when a fog bank began moving into the area of the caribou aggregations, the scale of the the photographs was reduced from the normal 1:3,000 to 1:7,000 to finish the photo coverage. Photo resolution was poor and no confidence was placed in the counts that were obtained from most photographs. On one photograph, three different counters obtained totals ranging from 1,100 to 1,400. During the counting it was expected that many calves would be missed. The final total from the photographs was 54,936.

In addition to the caribou counted on the photographs, another 13,203 were counted visually from aircraft. The total number of caribou seen, including those photographed and those counted visually was therefore 68,139. A population estimate was calculated from the observed caribou by extrapolating with the June (table 2-3) and October composition data, based on a sample of 6,881 animals. The results are as follows:

June 28, 1977, cow base = (68,139) x (0.5651)		= 38,505
October composition:	Cows	= 38,505
	Bulls (43.2/100 cows)	= 16,702
	Yearlings (28.5/100 cows)	= 11,025
	Calves (41.7/100 cows)	= 16,044
	Total	= 82,276

If it is assumed that many yearlings were misclassified as cows and the

October composition data are corrected accordingly, using the assumptions previously described, then the extrapolation results in a larger estimate:

Cows	= 38,505
Bulls (48/100 cows)	= 18,482
Yearlings (43/100 cows)	= 16,557
Calves (46/100 cows)	= 17,712
Total	= 91,256

Thus, the 1977 APDCE census, although not totally satisfactory because of reasons discussed above, provided an estimate within the range of 82,000 to 91,000 for caribou in the WAH. A more satisfactory APDCE census in 1978 (which is still being analyzed) suggests that the actual number of caribou present in 1977 did fall within that range.

Chronology of Calf Mortality, 1976-77

Initial calf production in the core calving area of the WAH was 76.9 calves/100 cows in mid-June 1976. Calf production in peripheral areas was approximately 60 calves/100 cows. A 26.3 percent reduction in the calf:cow ratio occurred from the peak of calving in mid-June to early July. Part of this reduction was probably due to nonparturient cows and groups of cows with lower proportions of calves immigrating from the peripheral calving areas to the core area. However, some loss of calves did occur, because instances of calf mortality were observed during this time. Also, many studies demonstrate that ungulates are most vulnerable to several mortality sources during the first days of life. Mortality rate of calves from early July to late October was apparently proportional to mortality rate of cows because the calf:cow ratio did not change appreciably during this time even though some calf mortality was known to have occurred. Findings from long-term life history studies of caribou in North America (Kelsall, 1968; Skoog, 1968; Bergerud, 1971) suggest that the adult female segment of a population normally incurs five or six percent annual mortality from natural causes when wolf predation is not excessive. We believe that wolf predation north of the Brooks Range is relatively low in most areas, particularly on the coastal plain. If the five or six percent mortality occurred evenly through the year, less than 1.5 percent of the adult cows would be lost from July to October. Because ungulate populations in temperate regions usually sustain heaviest natural mortality of adult females during late winter

and spring (during calving), and because predation was light, the natural mortality rate was probably very low from July to October. The mortality rate of calves was probably also low during this period.

Calf survival from late October 1976 to mid-April 1977 was calculated to be 94.1 percent, based only on comparison of calf:cow ratios and assuming that no mortality of cows occurred during this period, and that one half of the yearlings classified in October were females. The second assumption requires that observed ratios be adjusted as follows:

Observed ratios in October 1976 were:	13.2 female yearlings and 54.2 calves/100 cows
Observed ratios in April 1977 were:	44.3 calves/100 cows and female yearlings

Therefore, the April calf/cow plus female yearling ratio was corrected to calf/100 cows as follows:

$$\frac{44.3 \text{ calves}}{86.8 \text{ cows } (+13.2 \text{ F yrlgs})} = \frac{X \text{ calves}}{100 \text{ cows}}$$

$$X = \frac{100\ (44.3)}{86.8} = 51 \text{ calves/100 cows}$$

In October 1977 the yearling/cow ratio was estimated to be 26 per 100 cows, but due to the suspected bias in composition counts already discussed, the actual figure may be about 43 per 100 cows. If this is true calf survival from 1976 to fall 1977 was in excess of 50 percent.

June and July calf/cow ratios are representative of the entire WAH whereas the October and April values represent about 50 percent of the herd, or those wintering south of lat 69° N. The other 50 percent of the herd wintered on the Arctic coastal plain north of lat 69° N where no October calf/cow ratios were obtained. Calf/cow ratios were obtained from these animals in late April 1977, however. In April, 53.9 calves/100 cows (plus female yearlings) were observed in a sample of 1,245 animals classified between the Colville and Ikpikpuk Rivers north of lat 70° N. During a classification count from a fixed-wing aircraft southeast of Wainwright in April, 22 percent calves were identified in a sample of 1,195 animals. These

observations suggest that overwinter calf survival in areas north of lat 69° N equalled or surpassed that of areas south of lat 69° N in 1977.

Identification of Calf Mortality Factors

Eight calf carcasses were examined during March and April 1977. Of these, 4 (50 percent) were probably killed by wolves, 1 (12 percent) by illegal hunting and 3 (38 percent) by malnutrition. Three of 12 "winter-killed" or moribund caribou found were calves, and 4 of 26 (15 percent) wolf-killed caribou were calves.

Characteristics of Wolf-Killed Caribou

Although sample sizes are not large, some inferences can be made about wolf predation on WAH caribou during late winter 1977. As noted above, calves were killed approximately in proportion to their abundance in the population. In areas where snow was 18-36 inches (in) or 45 to 90 centimeters (cm) deep (i.e. all locations except Selawik Flats vicinity), wolves seemed to take animals of any sex or age class and all were apparently in good nutritional condition. Marrow percent fat averaged [64.6, standard deviation (s.d.) = 20.3, range = 96.9 - 27.2] for wolf-killed caribou. The degree of utilization of carcasses in these areas was less ($\bar{x}$ = 62.7 percent; range 5 percent to 100 percent) than in the Selawik Flats vicinity where snow depths ranged from about 0-10 in (0-25 cm). All carcasses in this area received 90 percent or more utilization, or wolves were still feeding when specimens were collected. Five of six (83 percent) of the wolf-killed caribou from this area were in poor condition (average femur marrow percent fat = 18.3, s.d. = 19.8, range 58.5 - 7.8). For comparison, six hunter-killed animals from the Selawik Flats had average percent marrow fat content of 84.4 (s.d. = 4.5, range = 88.4 - 76.1).

Characteristics of Caribou Dying from Malnutrition

Percent femur marrow fat was determined from seven "winter-killed" animals. Five with lowest values apparently died from malnutrition during late winter. The two with highest values included a moribund yearling

(16.0 percent marrow fat) that was shot. A necropsy revealed evidence of internal hemorrhaging. The other caribou (11.3 percent marrow fat) was a large adult bull with antlers, suggesting that it had died during early winter. The carcass was scavenged, and no necropsy was possible. Because the five caribou suspected of dying from malnutrition had a mean femur marrow fat content of 6.5 percent (s.d. = 1.20 and a range of 7.8 - 5.0), marrow fat values considerably greater than 6.5 may indicate that the proximate cause of death was from factors other than malnutrition under the environmental conditions existing in 1976-77. Although 12 probable "winter-killed" caribou were located, it is felt that malnutrition contributed little to overall mortality in the herd during the winter of 1976-77. All "winter-killed" caribou (except one moribund yearling) were found on the North Slope where carcasses probably remained visible for a longer period of time. Further, over 90 percent of these were old bulls and calves, and most were found within about 15 mi (or 25 km) of the Colville River where snow was about 24 in (about 60 cm) deep. This was deeper than in any other area visited on the North Slope. Fewer than 100 caribou were observed in this area, and most were bulls in poor condition. The only other "winterkilled" caribou were found near Teshekpuk Lake where several carcasses and moribund animals were observed. Less than 20 weak and dead animals were observed in this area, and these were probably animals lagging behind several thousand caribou that had wintered in that vicinity and were migrating west toward the calving area. More weak and dead animals were observed near Teshekpuk Lake than in areas farther west. No weak or dead animals were seen west of the Ikpikpuk River, although several thousand live animals were observed. We concluded that total loss from "winter kill" was no greater than would be expected for an ungulate population exposed to mild winter conditions.

Chronology of Calf Mortality, 1977-78

Ground counts were conducted in the "core" calving area in 1977, and aerial counts of adults and calves were flown in peripheral areas. The calves-to-cows ratio which was thought most representative of the population was 68 calves:100 cows. By the end of June, the ratio was reduced to 52.1:100, a decline of 23 percent compared with 26 percent the previous year. The ratio in October had declined to 41.7, or a 20 percent decline compared to

only 10 percent the previous year. About 30,000 caribou again remained on the Arctic Slope in fall, but we were unable to conduct composition counts there. Composition counts on both the Arctic coastal plain and the southern wintering areas were completed in mid-April 1978. The mean ratio (adjusted for yearlings as in 1977) from both the northern and southern areas was 28.7:100, a 31 percent decline from October. Calf survival on the Arctic coast near Point Lay was particularly poor; the adjusted ratio here was 19.5:100. The ratio on the south side of the Brooks Range was 35.2. If it is assumed that the fall ratio was the same on the Arctic Slope as in the Kobuk River-Selawik Flats area, the percent decline was 53.2 and 25.2, respectively. Possible biases in the composition counts have been discussed in previous sections. If the fall ratio is adjusted for possible error in the composition counts, the overwinter mortality is even higher.

A clue to the poor survival was our discovery of several dead and sick calves on the coastal plain near Point Lay, and a dead adult cow near the calving grounds in early June. These animals all had very heavy infestations of warble and/or nose bot larvae. The adult cow had about 100 nose bot larvae in the throat, and one of the dead calves had between 1,900 and 2,000 warble larvae on the back and upper legs. Subsequently, two other calves were examined that had similar unusually high loads of warble fly larvae. Temperature during the winter was probably not below normal on either the coastal plain or in the Selawik Flats, and snow depth was below normal.

No large predators were seen on the Arctic coastal plain, and no wolves were seen by ADF&G personnel in the major southern wintering areas. No wolves or wolf-killed caribou and only one set of wolf tracks were seen in the Selawik Flats, a very different situation from the previous year. However, ADF&G Area Biologist Peter Shepherd conducted aerial surveys for wolves in the central Brooks Range and saw almost 50 wolves and nearly 30 dead caribou in three days. Local residents of the Kobuk valley and Kotzebue who traditionally hunt wolves from aircraft took very few during the winter. Most were of the opinion that poor tracking conditions were responsible, not a shortage of wolves.

Despite the poor survival in 1977-78, recruitment may have been sufficient

to sustain the herd, especially in view of the moderate harvest level and possibly reduced wolf population.

Responses to Disturbance by Aircraft

During the study we recorded the reactions of 486 groups to fixed-wing aircraft (420 on the Arctic coastal plain and 66 south of the Brooks Range) and 21 groups to helicopters.

Many variables are involved in determining what a group's response will be (Klein, 1973; McCourt et al., 1974; Miller and Gunn, 1978). Because of the relatively small sample size, these data were analyzed only to compare group response to distance above ground level (AGL) of the aircraft (either fixed-wing or helicopter) and response by group size (table 2-4; fig. 2-8). Our basic goal was to see if these findings corresponded to reports in the literature to determine if extrapolating from the literature to NPR-A would be legitimate. We separated the data to determine if there were significant differences in responses between caribou on the Arctic coastal plain and those south of the Brooks Range.

As shown in figure 2-8, there was basically a direct relationship between how close the aircraft passed and the strength of the disturbance response. When the aircraft passed closer than 150 ft (50 m), over 70 percent of the groups exhibited a mild escape response (class 3) and conversely none of the groups failed to demonstrate some response (class 4). By contrast, when the aircraft passed 250-500 ft (80-160 m) overhead, only about 15 percent of the groups exhibited a class 3 response and over 40 percent exhibited no visible response (class 5). Description of the response classes appears in the Methods Section.

Inspection of the data in table 2-5 suggests that no clear-cut differences in response to aircraft can be directly attributed to group size. However, as others have concluded, it does appear that the larger the group size the more likely the group is to react strongly.

Table 2-4. Summary of observations of the reaction of Western Arctic Herd caribou to disturbance by "light" aircraft.

Dates	Location	Observers	Number of groups	Aircraft type
10 January 1977	Wainwright to Barrow	Reynolds & Davis	51	C-185
4 April 1978	N. Fk. Koyukuk R.	Davis & Valkenburg	11	Bellanca Scout
6 April 1978	Shungnak/Ambler	Valkenburg	16	Bellanca Scout
7 April 1978	Ambler River	Crain	11	Super Cub
8 April 1978	Selawik Flats	Davis	12	Helicopter 206B
9 April 1978	Buckland River	Davis	18	Super Cub
10 April 1978	Umiat-Teshekpuk L.	Davis & Valkenburg	68	Bellanca Scout
11 April 1978	Teshekpuk L.-Wainwright	Davis & Valkenburg	97	Bellanca Scout
13 April 1978	Pt. Lay vicinity	Davis	9	Helicopter 206B
18 April 1978	East of Wainwright	Davis & Valkenburg	204	Bellanca Scout

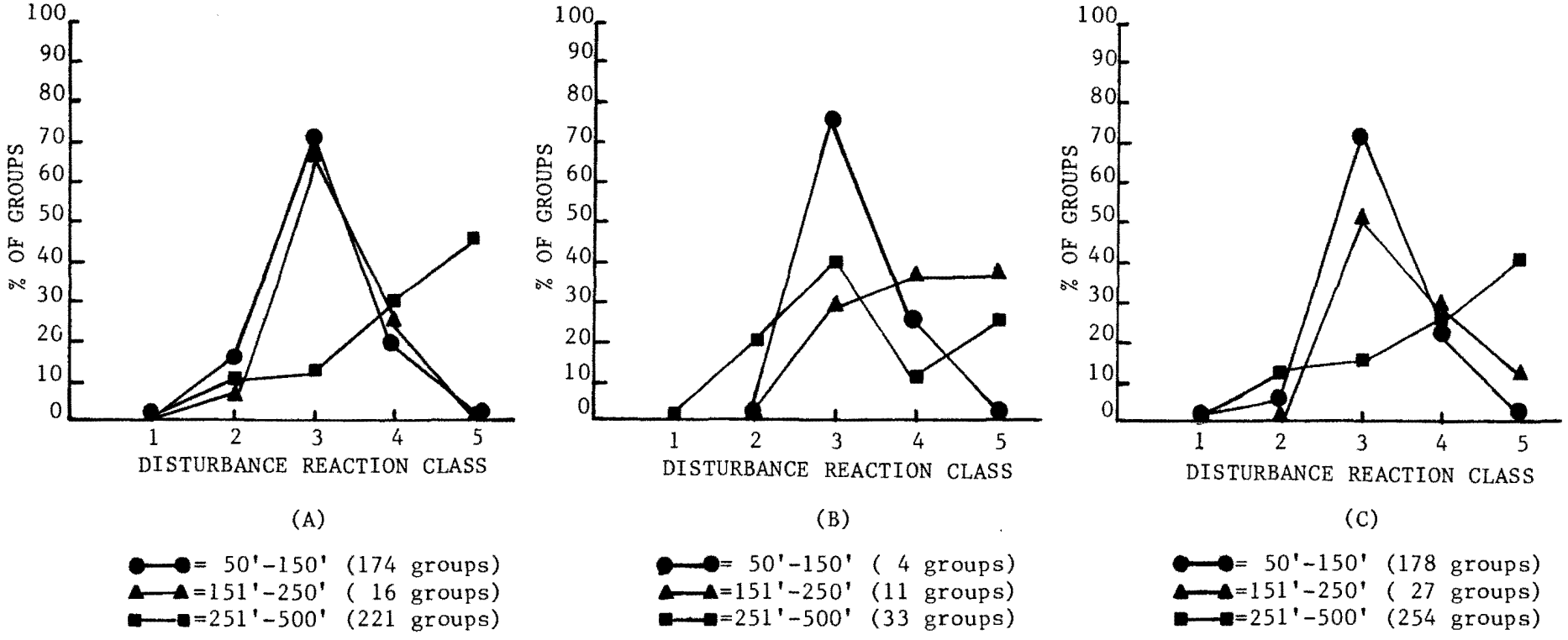

FIGURE 2-8. Graph depicting distribution of response classes by Western Arctic Caribou Herd to fixed wing aircraft passing overhead at various heights. In (A) NPR-A, (B) south of the Brooks Range, (C) all observations combined (1977-1978).

Table 2-5. Summary of reactions, by group size, of Western Arctic Herd caribou to disturbance by "light" aircraft. Response classes are described in Methods section.

Group Size	Number and percent of groups (in parentheses) in Response Class 1	2	3	4	5		Total Groups
			NPR-A				
1	0	9(13)	16(23)	26(38)	18(26)		69
2-5	0	15(7)	96(42)	58(25)	60(26)		229
6-10	0	10(11)	44(48)	19(21)	19(21)		92
11-30	0	3(10)	16(55)	7(24)	3(10)		29
31-100	0	0	1(100)	0	0		1
100	0	0	0	0	0		0
						Total	420
			South of Brooks Range				
1	0	0	1(100)	0	0		1
2-5	0	0	0	0	1(100)		1
6-10	0	0	1(50)	0	1(50)		2
11-30	0	2(6)	9(28)	4(13)	17(53)		32
31-100	0	2(22)	3(33)	3(33)	1(11)		9
100	0	3(14)	8(38)	7(33)	3(14)		21
						Total	66
			All Observations Combined				
1	0	9(13)	17(24)	26(37)	18(26)		70
2-5	0	15(7)	96(42)	58(25)	61(26)		230
6-10	0	10(11)	45(48)	19(20)	20(21)		94
11-30	0	5(8)	25(41)	11(18)	20(33)		61
31-100	0	2(20)	4(40)	3(30)	1(10)		10
100	0	3(14)	8(38)	7(33)	3(14)		21
						Total	486

DISCUSSION

The Calving Area as a Critical Habitat

"Traditional" calving occurs on the Arctic Slope west of the Colville River in two areas. A resident group of up to 4,000 caribou uses the area around Teshekpuk Lake for calving. The middle portion of the Utukok River and adjacent drainages (i.e. the Utukok uplands) has long been the major WAH calving area. This area has been used consistently since the 1800's (Lent, 1966). Hemming (1971) depicted more of the Ketik River drainage in use during calving than we have observed from 1975 through 1977. The herd was much larger in 1970, which may account for the difference. Delineating calving areas is a subjective process because of the continuous movement of caribou and the great variation in density of calving animals. The calving area for the WAH was delineated the week when most calves were born (June 8-14). Before June 8, some cows may still be enroute, and after June 14 many large cow/calf groups are moving in a southwesterly direction, away from the area where the calves were born. Thus, it is likely that not all calving took place in the areas delineated in the figures in this report. Scattered calving occurs in surrounding areas, and the number of cows using these outlying areas varies from year to year. The variations that occur from year to year cannot detract from the fact that the same general areas have been used year after year. This attests to the singular importance of these areas.

No published information is available which describes displacement of caribou from a calving area. The effects of industrial development on the calving grounds of the Central Arctic Herd are still being assessed, but it appears that the cows are avoiding areas where development is greatest (Cameron and Whitten, 1977, 1978). Because the WAH is an extremely valuable resource ecologically, economically and esthetically, it seems ill-advised to risk the viability of the herd in any way. Until more is known about the effects of development and disturbance of caribou on calving areas, and in view of Cameron's and Whitten's findings in the Central Arctic Herd, it seems wise to prohibit increased human activity and development on or adjacent to calving areas.

Calef et al. (1976) compared their findings with those of Klein (1973), McCourt et al. (1974) and McCourt and Horstman (1974). For the most part, the findings of Klein and Calef et al. were similar except Klein concluded that helicopters frightened caribou more during spring and summer while Calef et al. concluded that there was no difference in response to fixed-wing aircraft or helicopters.

Calef et al. (1976) concluded that, if aircraft operate at heights above 500 ft (160 m) in level flight during the spring or fall migration, most potentially injurious reactions by caribou will be avoided. This was based on the thinking that it is the panic and strong escape responses (response classes 1 and 2) which would result in caribou injuring or exhausting themselves. Further, they discussed seasonal differences in caribou response to aircraft disturbance and concluded that response is similar during spring and fall migrations and that caribou are generally more tolerant during these seasons than at other times. At both these times of year a high percentage of their groups exhibited class 1 and 2 responses when the aircraft was flying lower than 200 ft (about 70 m). Above this altitude, the aircraft caused these responses in less than 20 percent of all groups observed. Above 500 ft (160 m), no class 1 or 2 responses occurred, and class 3 responses dropped to a low level.

Caribou are generally more sensitive when disturbed by aircraft while on the calving grounds or during cold weather in early winter (i.e. November) than during spring and fall migration. At these times of year there is a high percentage of class 1 and 2 responses to aircraft flying at all altitudes up to 500 ft (160 m). Also, the likelihood of class 1 and 2 responses does not decline rapidly as aircraft altitude increases. Miller and Gunn (1978) conducted an exhaustive, if not definitive, study of the response of Peary caribou (R. t. pearyi) to turbo-helicopter harassment. Generally their conclusions, when under comparable conditions to the above studies, were similar.

The caribou responses to aircraft which would result in caribou exhausting themselves and injuring themselves are the panic (class 1) and strong escape

(class 2) categories. Although the other responses (class 3, 4 and 5) may contribute to long-term physiological or behavioral changes, these reactions are of a more subtle nature and would likely require recurrent disturbance during the year for the detrimental impact to be manifested.

The Soviets (Zhigunov, 1961, cited in Klein, 1973) have reported that disturbance of reindeer can cause loss of body weight, weakening of animals and increased susceptibility to diseases, and particularly emphysema during very cold weather, abortion of embryos through loss of maternal body weight or injury while running, desertion or trampling of newborn fawns, and displacement of fetuses at calving time leading to difficulties during delivery.

In theoretical discussions Geist (1971) further mentioned effects of disturbance as including decreased body weight of young at birth leading to increased mortality after birth, altered behavior of young as a result of stress of the pregnant females, neurosis among domestic sheep, increased susceptibility to predation, pulmonary edema among saiga antelope (Saiga tatarica) and abandonment of habitat.

Because our limited observations of caribou response to aircraft obtained from the WAH in NPR-A are basically consistent with those reported from the other studies reviewed, we believe that many of their conclusions should apply equally to caribou in NPR-A.

Based upon our own observations and review of available literature on the reaction of caribou to light aircraft, we have made the following conclusions:

1. It is evident that all aircraft passing over caribou at distances closer than 500 ft (about 160 m) cause undesirable disturbance to the caribou during all seasons of the year, and efforts should be made to minimize such disturbance.

2. Light fixed-wing aircraft (i.e. less than 300 horsepower) operating at distances over 1,000 ft (330 m) from caribou during most seasons of the year will not disturb caribou to a degree that

the caribou would injure or exhaust themselves. However, long-term physiological or behavioral changes might still result from repeated aircraft disturbance. This subject needs further research.

3. Although findings of several studies differ slightly, in general, light helicopters (i.e. 6-place or smaller) do not cause any conspicuously greater disturbance to caribou than do light fixed-wing aircraft at distances over 300 ft (100 m) . However, at distances less than 300 ft (100 m) they cause greater disturbance than light fixed-wing aircraft.

4. No information is available regarding disturbance of heavy aircraft on caribou.

5. In several studies no difference in reactivity to different light aircraft occurred for altitudes greater than 300 ft (100 m).

6. Threshold response levels should be determined for various visual and auditory stimuli.

7. Cows and calves are usually more responsive than other sex/age classes, and caribou bulls are usually the least responsive sex/age class.

8. Caribou in larger groups tend to be more responsive than individuals in small groups.

9. Caribou may respond more to people on the ground (by greater displacement from activity centers) than when exposed to aircraft. Ground crews and vehicles should not approach animals to within 3,000 ft (1,000 m).

10. Extra protection should be afforded during calving and post-calving periods (May-August) by increasing the minimal flying height to 2,000 ft (660 m) AGL to reduce the possibility of man-induced mortality to young of the year.

II. Helicopters have a greater potential for harassment of animals than do fixed-wing aircraft. If a helicopter stays behind caribou once they start to move in a given direction and keeps following, then extreme panic response will result. Persistent following of groups is the most dangerous form of harassment and is possible only with a helicopter.

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