

1996 Dall Sheep (*Ovis dalli dalli*) Survey,
Gates of the Arctic National Park and Preserve, Alaska.

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Abstract

A Dall sheep (*Ovis dalli dalli*) survey was conducted in the northern portion of Gates of the Arctic National Park and Preserve during 7 - 17 July 1996. Approximately 2242 mi² of sheep habitat was divided into 92 sampling units: 79 were surveyed at relatively low-intensity with Supercub aircraft; 34 of those units were randomly selected to re-survey at a higher intensity with a Robinson R-22 helicopter; 11 units were surveyed only with the Robinson R-22 helicopter because of poor weather conditions; and 2 units with historically low sheep numbers were not surveyed. The sightability correction factor (SCI) for the low-intensity counts was 1.10. A total of 2758 Dall sheep \pm 8% (90% CI) were estimated for the survey area, with an average density of 1.2 sheep/ mi². The estimated lamb:ewe ratio was 47:100 \pm 9%, the yearling:ewe ratio was 25:100 \pm 16%, and the ram:ewe ratio was 43 \pm 17% (all at the 90% CI). Comparison of population estimates from previous surveys (Singer 1984a, Adams 1987) indicate a substantial decline during the past 10-15 years. However, the ratio of lambs is high relative to other sheep populations, and suggests that reproduction is not likely to limit population growth. Subsistence harvest at levels seen in recent years is not likely to limit population growth.

INTRODUCTION

National Park Service (NPS) is mandated by the Alaska National Interest Lands Conservation Act (ANILCA) (Section 201(4)(a)) to protect...populations of...Dall sheep (Section 201(4)(a)), to provide the opportunity for continued subsistence uses (Section 801(4)), and [to conserve] natural and healthy populations (Section 815(1)).

Between 1993 and 1996, residents of Anaktuvuk Pass and Bettles and commercial and private small aircraft pilots who regularly fly over the park and preserve expressed concern about the declining Dall sheep population. Recent surveys in northern Alaska indicate widespread declines in Dall sheep (*Ovis dalli dalli*) populations in the Brooks Range both east and west of Gates of the Arctic National Park and Preserve (Ayres, in press; Mauer, pers. comm.). These declines are being attributed to a series of hard winters, which made the Dall sheep more vulnerable to predation.

Dall sheep can be legally hunted throughout the park and preserve by qualified subsistence users and in the preserve units by sport hunters. The natural variability in caribou migration patterns has created recent local shortages of caribou, the primary food source for Anaktuvuk Pass residents. These shortages necessitate a periodic shift of subsistence harvest to Dall sheep. An emergency subsistence Dall sheep hunt, two weeks earlier than the regular season, was opened in the park for local residents in July 1995.

Several Dall sheep population assessments have been conducted within Gates of the Arctic National Park and Preserve over the past 25 years. The studies have varied greatly in scope and effort. Dall sheep population assessments were conducted by the Alaska Department of Fish and Game (ADF&G) in the central Brooks Range before the park was established. During 1982-1984, a population survey was conducted across the park covering all potential Dall sheep habitat (Singer 1984a). The study was on-going for three years and was the most extensive Dall sheep survey conducted in the park to date. This estimate serves as the baseline for current efforts. An additional survey was conducted in a portion of the Singer (1984) survey in the Anaktuvuk Pass area in 1987 (Adams 1988). Additional small surveys were conducted in 1992 (Faber) and 1993 (Osborne), both of which were aborted early due to inclement weather.

The increased emphasis on Dall sheep as a subsistence species, combined with the large population declines in the eastern and western Brooks Range, lead the park to conduct a Dall sheep population survey in 1996. This survey was conducted to provide current information to manage and protect the Dall sheep population in Gates of the Arctic National Park and Preserve.

The goal of this project was to assess the general health of the Dall sheep population in areas where the heaviest harvest pressure occurs. The objectives

that were developed to meet this goal were to 1) estimate Dall sheep abundance and 2) determine sex and age ratios of Dall sheep populations in the Anaktuvuk Pass and Itkillik Preserve areas.

Funding was provided by the National Park Service, Alaska Regional Office. ADF&G and NPS cooperated in conducting the 1996 survey. N. Demma, B. Dale, K. Whitten, Sverre Pederson, J. M. Ver Hoef, J. Woolington, and B. D. Scotton acted as fixed-wing and/or helicopter observers. J. M. Ver Hoef provided statistical advice. T.M. Webb of Tundra Limited, J. Rood of Northwest Aviation, and D. Miller of Caribou Air Service piloted Supercub aircraft. R. Swisher of Quicksilver Aviation and T. Cambier of Pollux Aviation flew the helicopters. B. Ahgook, B. Hopson, and P. Hugo of Anaktuvuk Pass assisted in defining survey strata. D. DiFolco digitized the maps into a geographical information system and prepared the figures. S. Arthur reviewed the report and provided helpful comments.

STUDY AREA

The survey was conducted in the Endicott Mountains in the central Brooks Range of Alaska, between 149°30' and 153°30'W longitude, and 67° 45' and 68° 30'N latitude. Most of the study area lies within the boundary of Gates of the Arctic National Park and Preserve and is within ADF&G game management units (GMU's) 24, 26A and 26B. (Figure 1).

Maximum elevation in the study area is 7,600' above sea level and valley bottoms are at 2000' to 3500' above sea level. The climate north of the Continental Divide is primarily arctic and subarctic south of the divide (NPS 1987). The entire region is characterized by long, cold winters and short, warm summers. Yearly precipitation ranges from 5 to 18 inches and yearly snowfall from 35 to 79 inches. Average minimum and maximum temperatures are -29°F to 70°F, respectively (NPS 1986).

The landscape is characterized by wide river valleys formed by glaciers and steep rugged mountains. Vegetation around Anaktuvuk Pass (Spetzman 1959) and elsewhere in the Brooks Range, outside the study area has been described (Ayres 1982, Cooper 1983, Murray 1974). Vegetation consists predominantly of arctic alpine tundra communities at high elevations and moist tundra at lower elevations. Permanent snow fields remain in some high altitude north-facing valleys. Large areas are characterized by rock outcrops and large fields of rock rubble with vegetation of only lichens. Boreal forest or taiga occurs in small patches at lower elevations in river valleys south of the continental divide.

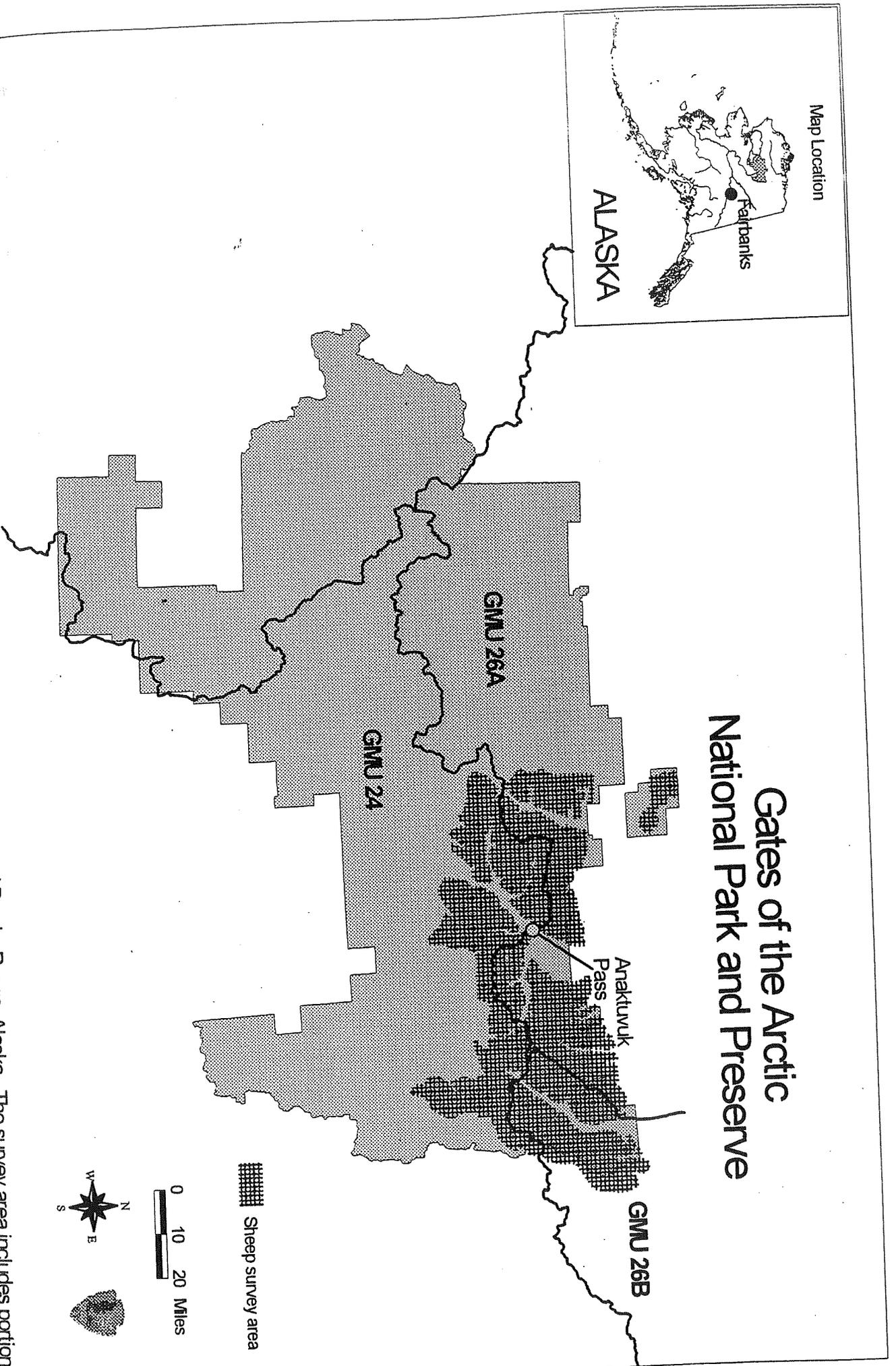


Fig. 1. Dall sheep survey area in Gates of the Arctic National Park and Preserve in the the central Brooks Range, Alaska. The survey area includes portions of State Game Management Units 24, 26A and 26B.

METHODS

The survey was conducted from July 7 to 17, 1996. Pilots and observers with extensive experience with Dall sheep surveys were selected for the project. Three fixed-wing Piper PA-18 super cubs, two Robinson R-22 helicopters, and 6 observers were used in the survey. Operations were based out of Galbraith Lake and Anaktuvuk Pass.

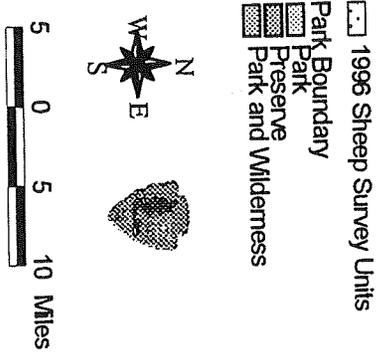
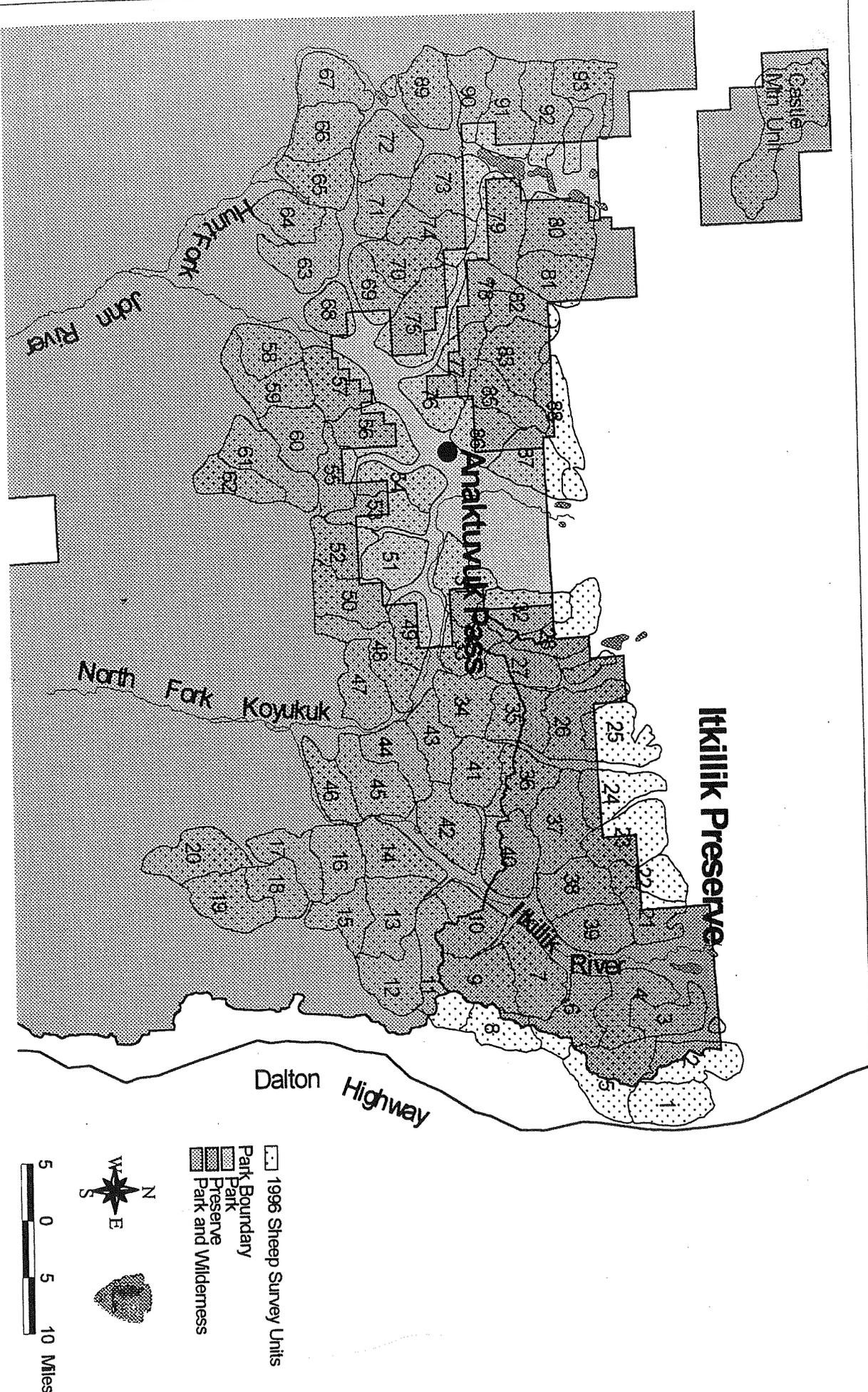
The study focused on the Itkillik Preserve unit and the area around Anaktuvuk Pass. A small amount of the survey area included Dall sheep habitat outside the park and preserve, but adjacent to the Itkillik Preserve boundary, which was defined by ridgetops. Dall sheep hunters in Anaktuvuk Pass were interviewed to identify areas that were important for subsistence harvest so they could be included in the survey (Appendix 1).

The survey area was divided into 92 sample units ranging in size from 24 to 60 mi² each (Figure 2). Unit boundaries were drawn to allow each unit to be surveyed within one hour. Sample units from previous surveys (Adams 1988, Singer 1984a) were too large to accomplish this, so the original boundaries were retained and the units were sub-divided (Appendix 2). Survey unit boundaries were defined based on Dall sheep movement patterns. Dall sheep are usually found on ridges during midsummer, so river and creek valleys defined the boundaries to reduce the chance of counting Dall sheep on or moving across boundaries during the survey. Ridge lines were used only when necessary to constrain the size of survey units, and snowfields were used as much as possible to define ridge line boundaries. Survey units were numbered from 1 to 93, but sample unit # 84 was not included in the final survey area.

Seventy-nine of the 92 sample units were surveyed at relatively low-intensity with Supercub aircraft. The pilot and observer searched for Dall sheep by following contour lines and flying as many contours as necessary to carefully examine the terrain. Aircraft circled over groups of Dall sheep only as necessary to obtain accurate counts. Dall sheep were classified as adults (≥ 1 year) or lambs (< 1 year). Locations of Dall sheep were marked on 1:63,360-scale USGS maps, and numbers and age classifications were recorded on a data sheet (Appendix 3). Survey effort was intentionally varied among units, with the objective that this will reduce (or eliminate) differences in probability of sighting sheep in units that differ in complexity of terrain.

Some randomly selected units were then re-surveyed at a higher intensity with a Robinson R-22 helicopter with pilot and 1 observer. High-intensity counts were usually initiated in a unit within 30 minutes of the completion of the low-intensity search. During high-intensity searches, the helicopter circled over rough or broken terrain and spent as much time in each sample unit as the observer felt necessary to thoroughly search for all Dall sheep. Dall sheep were counted and

Fig. 2. Location of the 93 survey units in 1996 Dall sheep survey, Gates of the Arctic National Park and Preserve.



mapped as in the low-intensity counts, but were also classified as lamb, ewe, yearling, and Class I, II, III, or IV rams (after Geist 1971).

During the survey, a computer model was used to allocate survey effort between high intensity and low intensity surveys. The model took into account variance estimates from previous sheep surveys in other parts of the state, operating costs of the two types of aircraft, and the amount of money available for the survey. (It was assumed that the variance estimates would remain similar between areas of the state.) Data were analyzed regularly and the proportion of high intensity surveys relative to low intensity surveys was calculated and adjusted to optimize cost-effectiveness and statistical results of the survey.

Seventy-nine of the 92 sample units were surveyed at relatively low-intensity with Supercub aircraft; 34 of those units were randomly selected to re-survey at a higher intensity with a Robinson R-22 helicopter; 11 units were surveyed only with the Robinson R-22 helicopter because of poor weather conditions for fixed-wing aircraft; and 2 units (# 29 and #30) with historically low sheep numbers were not surveyed. The Castle Mountain unit was not included in the analysis because it is geographically isolated from the rest of the survey area (Appendix IV). Mean search time for the low-intensity survey was 2.07 min/mi². Mean search time for the high-intensity survey was 2.51 min/mi².

After completion of the counts, data from the low- and high-intensity counts were entered into the computer program MOOSEPOP (DeLong and Reed 1991) to estimate a sightability correction factor (SCI) for the low-intensity counts (Gasaway et al. 1986). MOOSEPOP used the SCI to estimate the Dall sheep population for the entire area covered by the low-intensity survey. The resulting population estimate was the number of Dall sheep surveyors should have seen if the high-intensity helicopter survey had covered the entire area. MOOSEPOP was also used to estimate composition of the Dall sheep population, based only on high-intensity survey data.

The survey area was divided into three strata: "subsistence harvest", "sport harvest", and "low harvest" areas (Figure 3) for comparison of Dall sheep population characteristics between different use areas in the park and preserve. The "sport harvest" stratum included survey units where a sport harvest is permitted. Sport harvest is permitted in the Ikillik Preserve and outside the park and preserve boundary. The "subsistence harvest" stratum included all survey units where important subsistence harvest areas were located. The important subsistence harvest areas were defined by subsistence hunters and an elder from Anaktuvuk Pass. The "low harvest" stratum included the survey units outside the defined "subsistence harvest" stratum, and where a sport harvest is not permitted. For those survey units where both sport and subsistence harvest occur, it was determined which group probably contributed the highest hunting pressure, and the unit was assigned to that stratum. Hunting pressure

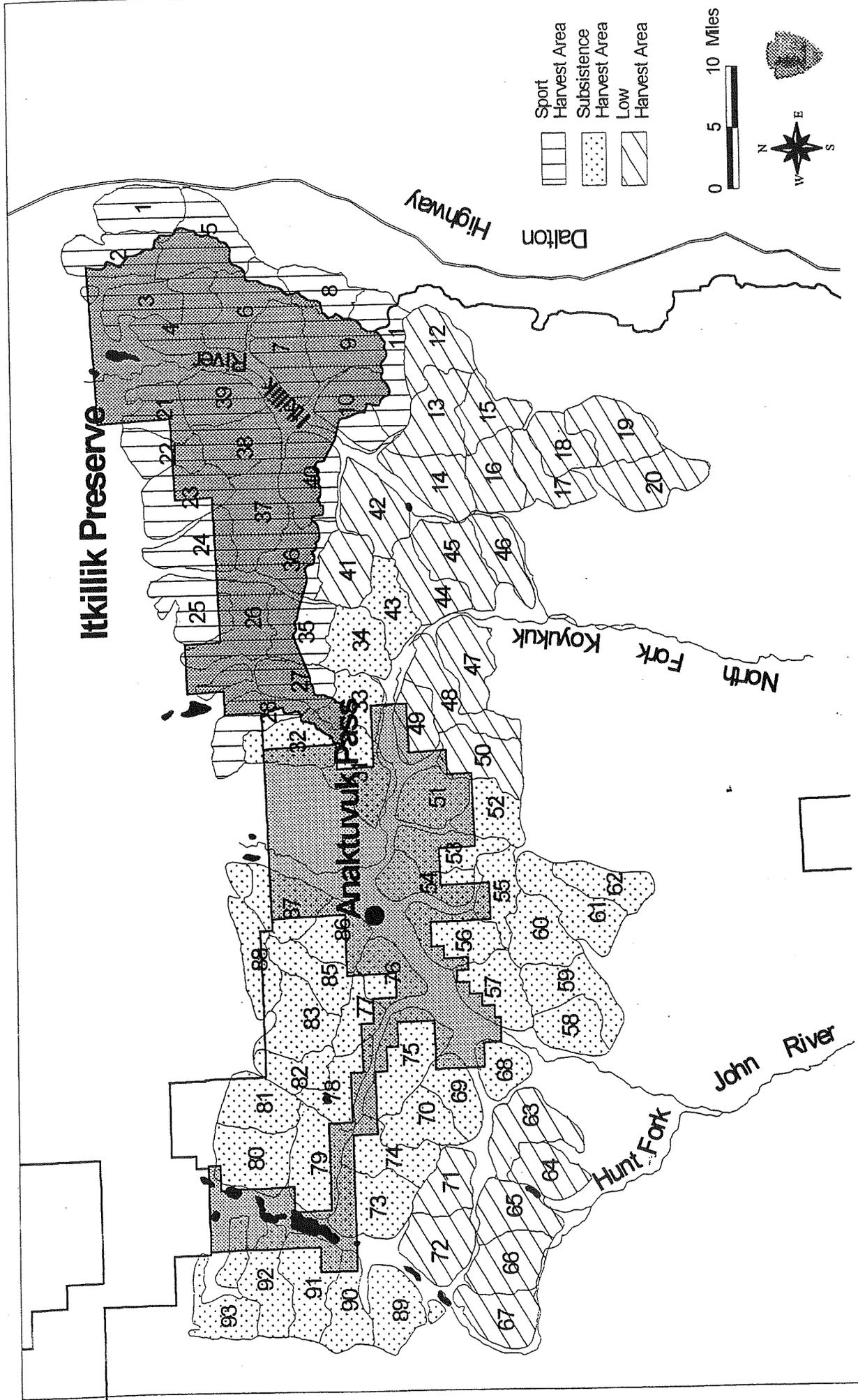


Fig. 3. The 1996 Dall sheep survey units, Gates of the Arctic National Park and Preserve, Alaska. Survey units were divided into three strata, defined by use patterns: sport harvest, subsistence harvest, and low harvest units.

contribution was determined by the type of access typically used by the different hunting groups and access available in the survey unit.

Seasonal Dall sheep movements between strata were not considered for the survey stratification because Dall sheep movement information was not available. During the hunting seasons, it was assumed that sheep move into rutting areas and then into their winter ranges. Some sheep in the "low harvest" areas may be subject to sport and/or subsistence harvest, and some sheep in "sport" and "subsistence" areas may be subject to both types of harvest, while some are not subject to any harvest. The survey was conducted shortly before the subsistence season opened and several weeks before the sport season opened.

RESULTS

In the 34 units which were counted at both intensities, observers counted 620 Dall sheep during the low-intensity searches and 666 Dall sheep during the high-intensity searches (Appendix V). The SCI calculated from MOOSEPOP for the low-intensity count was 1.10 (Appendix VI). A total of $2758 \pm 8\%$ (90% CI) Dall sheep were estimated in the study area, with an average density of 1.2 sheep/mi². The estimated lamb:ewe ratio was $47:100 \pm 9\%$, the yearling:ewe ratio was $25:100 \pm 16\%$, and the ram:ewe ratio was $43:100 \pm 17\%$ (all at the 90% CI).

Dall sheep densities varied among harvest strata, with a much higher sheep density in the "sport harvest" area (Table 1). There were also noticeable differences in composition between strata, with fewer lambs, yearlings, and rams per 100 ewes in the "sport harvest" area. No statistically valid analyses of these differences were computed because the differences between areas fall within the error bounds computed for the total area and because the lack of information on sheep movements preclude anything other than anecdotal conjecture. While sheep densities differ between areas, cause-and-effect relationships between harvest practices and Dall sheep population characteristic differences cannot be assigned based only on this survey. For example, the Ikillik Preserve, which is where all sport hunting and very little subsistence hunting occurs, has been historically known for high sheep densities (Singer 1984b).

Because the estimate is the number of sheep which would have been seen if the entire survey area had been conducted by helicopter, an alternate analysis was possible: we could have used the helicopter survey units as a total count. Then we could have estimated the number of sheep which would have been seen if they had been surveyed by helicopter in the 45 units that were surveyed only by fixed-wing. This analysis would probably have reduced the confidence interval.

Table 1. Data from the 1996 sheep survey in Gates of the Arctic NP were divided into three strata, defined by harvest practices in the survey units. Data were summarized for each strata.

	Harvest Strata			Total survey area
	Subsistence	Sport	Low	
stratum area (mi ²)	977	662	629	2268
population estimate (90% CI)	811±11%	1277±19%	681±20%	2758 ± 8%
density (sheep/mi ²) ^a	0.8	1.6	1.1	1.2
Lambs:100 Ewes ^a	56	35	61	47 ± 9%
Yrlgs:100 Ewes ^a	25	19	26	25 ± 16%
Rams:100 Ewes ^a	44	39	57	43 ± 17%

^a Densities and composition ratios were calculated by simple addition in each age class from the helicopter surveys; error bounds were not calculated because all ratios are within the error bounds of the ratios for the total survey area.

DISCUSSION

Comparison with previous surveys is not straight forward because count areas, survey intensities, seasonal timing and methodologies varied among years. The Dall sheep survey method used in the present survey was being developed by the State of Alaska to reduce the high survey costs. A complete discussion of comparison of the methods is described in Whitten (1997). The survey area in the present survey included portions of the 1982-84 (Singer) survey and of the 1987 (Adams) survey area. Singer's (1984) and Adams (1987) surveys were conducted entirely by a Bell 206 Jet Ranger helicopter; a piston engine Robinson 22 helicopter and supercubs were used in the present survey. The Singer (1984) and Adams (1988) surveys provided minimum sheep counts of the entire survey areas. The present survey provided a population estimate with less bias than uncorrected estimates. However a SCI of 1.10 suggests little bias, i.e., difference between fixed-wing counts and helicopter counts. In all the surveys, 1982-84 (Singer), 1987 (Adams), and the present survey, it was assumed that, from the helicopter, all sheep were seen and counted. There was no correction factor for the helicopter to estimate sheep count accuracy relative to the actual population.

Search intensity for the different methods varied and must be considered when attempting to compare survey results between years. Densities and survey intensities from previous sheep surveys in the park are summarized in Table 2. In 1982, 4605 Dall sheep were counted, with densities ranging from 1.1 to 2.8 sheep/mi², compared with the present survey estimate of 2537-2979 Dall sheep (90%CI) at densities of 0.3 to 1.6 sheep/mi² in the same area. A portion of the survey area was surveyed in 1982, 1984, 1987, and in the present survey. In

this portion, 888 sheep were counted in 1982, 1079 were counted in 1984, 1043 were counted in 1987, and 358 sheep were estimated in 1996.

Table 2. Densities of Dall sheep (mi^2) in the 1996 sheep survey in Gates of the Arctic NP are compared with previous surveys conducted in the same areas.

Survey Unit Nos.	1982		1987		1996	
	Search intensity (min/mi^2)	density (sheep/mi^2)	Search intensity (min/mi^2)	density (sheep/mi^2)	Search intensity (min/mi^2)	density (sheep/mi^2)
1-11	1.4	1.7	N/A	--	2.5	1.6
12-20	1.8	2.4	N/A	--	2.4	1.1
21-46	1.5	2.8	N/A	--	3.4	1.0
47-52	1.6	2.3	N/A	--	2.7	1.3
53-62	1.6	2.0	N/A	--	2.4	1.0
63-67	1.4	1.7	1.7	0.9	1.8	0.4
68-75	1.1	1.1	2.1	1.3	1.4	0.3
76-88	1.6	1.8	2.6	2.6	2.4	0.7
89-93	1.3	2.6	N/A	--	2.2	1.1

The evidence suggests that sheep are now far less abundant than they were 10 to 15 years ago. The decrease in the number of sheep observed cannot be explained by differences in search intensity. Singer (1984) searched at 1.1-1.8 min/mi^2 ; Adams (1988) searched at 1.7-2.6 min/mi^2 ; search intensity during this survey was 1.4-3.4 min/mi^2 . Dall sheep in the Hulahula drainage in the eastern Brooks Range in Arctic National Wildlife Refuge showed a similar trend. The sheep population increased during 1976 through 1986, and then declined by more than 50% by 1993 (Mauer, pers commun).

MANAGEMENT IMPLICATIONS

1. Dall sheep in Gates of the Arctic National Park and Preserve and throughout the state have decreased in number during the early 1990's, irrespective of hunting patterns or level of predation. This widespread pattern suggests a widespread cause, such as mortality and/or low reproductive rates due to severe winters (Whitten 1997). The ratio of lambs is high relative to other sheep populations, and suggests that reproduction is not limiting this population.
2. Subsistence harvest in recent years has been 10 sheep in 1995-96, 26 sheep in 1994-95, 15 sheep in 1993-94, 22 sheep in 1992-93, 23 sheep in 1991-92, 22 sheep in 1990-91, and 27 sheep in 1989-90 (Osborne 1996). Harvest at these levels is not likely to limit population growth, providing the harvest is not too localized in an area and is not primarily ewes.

3. Annual trend surveys should be conducted to more closely monitor the population. In order to define a trend survey area, seasonal sheep movements must be known. It is important to know if the groups of sheep being monitored in the trend surveys are also subject to harvest.

4. Historical local knowledge and previous surveys suggest that sheep densities are normally greater in the Itkillik Preserve area than in the immediate vicinity of Anaktuvuk Pass. The pattern was repeated in this population survey. A somewhat lower sheep population around Anaktuvuk Pass must not be automatically attributed to the subsistence harvest. Dall sheep habitat requirements and habitat quality across the park and preserve must be better understood before cause-and-effect assignments are made.

5. Subsistence harvests include some ewes, while sport harvest includes only large rams. Traditional population composition counts, based on lambs: yearlings:rams:100 ewes, are more difficult to interpret when the females are harvested. Periodic population estimates and harvest reporting are essential to monitor the population status.

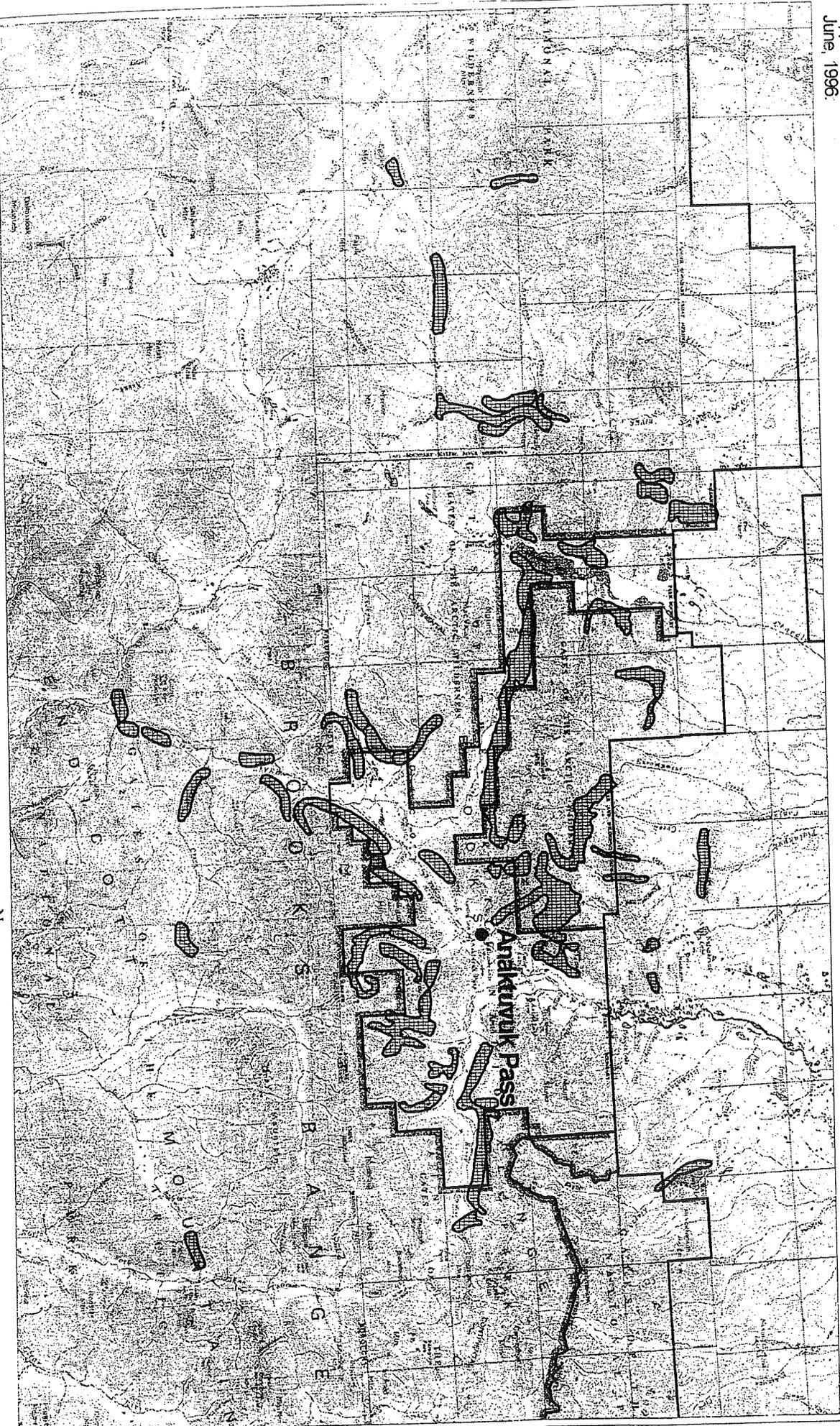
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Appendix I.
June, 1996.

Locations of traditional Dall sheep harvest in Gates of the Arctic National Park and Preserve, Alaska. Information was provided by Anaktuvuk Pass sheep hunters and elders in



Traditional subsistence
harvest areas



National Park Service
Natural Resources

Appendix II. Sample unit numbers, showing sub-divisions between three Dall sheep surveys in Gates of the Arctic National Park and Preserve (Adams 1988; Singer 1984).

1996 Survey	Adams (1987)	Singer (1982)
1-11	no survey	17
12-20	no survey	16
21-46	no survey	18
47-59	no survey	1/2 of 9
60-62	no survey	6
63,64	5B	
65-67	5A	
68	2E	
69	2D	
70		
71,72	2C	5
73,74	2B	
75	2A	2
76,77	1E	
78,79	1D	
80	1H	
81	1C	
82	1I	
83*	1B + 1/2 1G	
85, 86	1A	
87,88	1F + 1/2 1G	
89-95	no survey	
96-100	no survey	3

* there is no survey unit numbered 84.

Appendix III. Sample of a data map and data form from a high intensity survey unit. Locations of sheep were marked on 1:63,360 scale USGS maps, and numbers and age classifications were recorded on a data sheet during a sheep survey in Gates of the Arctic National Park and Preserve, 1996.

Sheep Count Form – Helicopter

Pg. _____ of _____
 Sample Unit 43 Date 7/15/96
 Pilot Swisher Observer Whitten
 Acft type R22

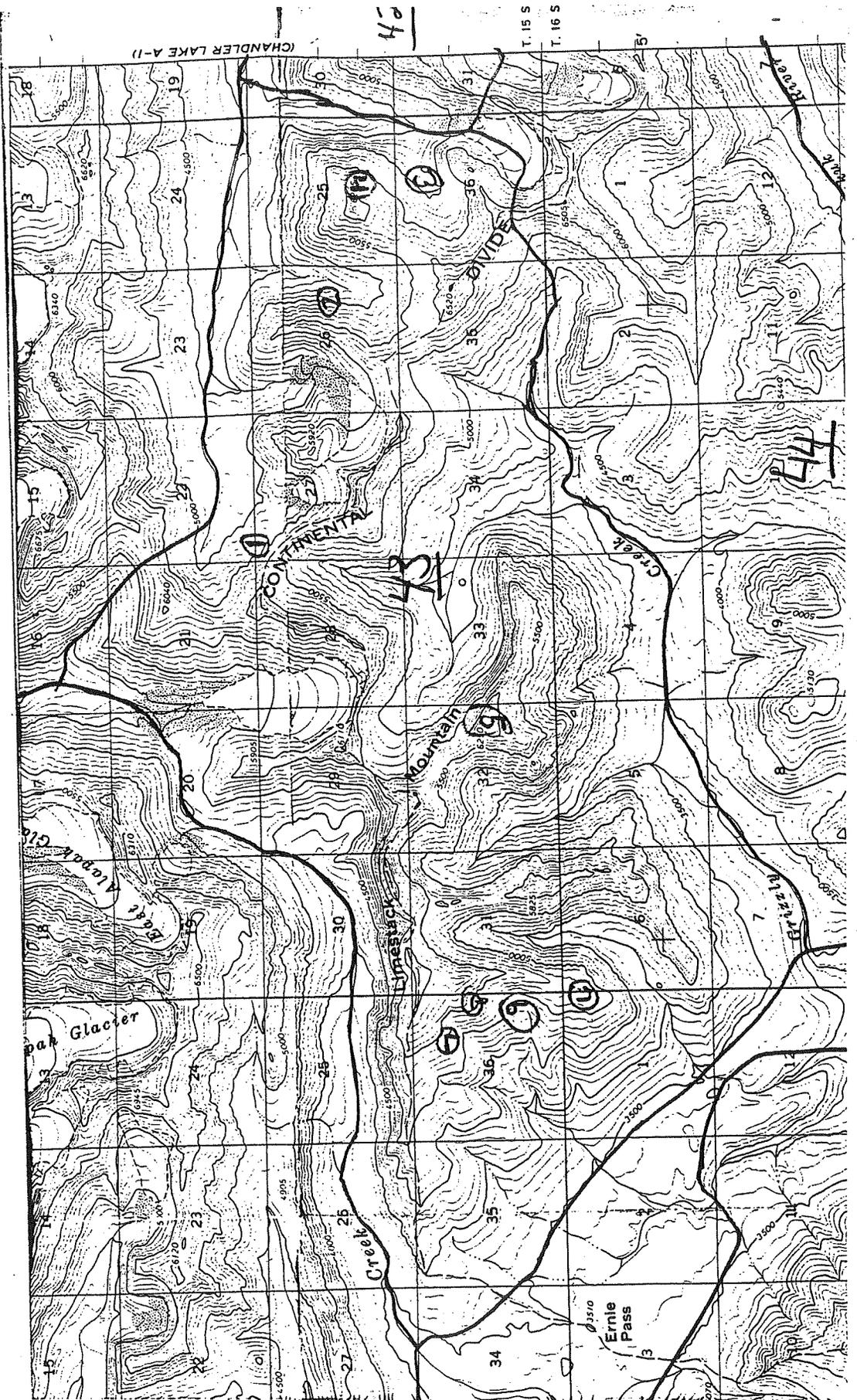
Time Spent Searching
 Stop @ 19 | 11
 Start @ 17 | 22
 Elapsed 1 | 49 min
-17
1h32

Comments, conditions that may have affected data quality:

Ref. nos.	Ewes	Lambs	YrIs.	Rams				Total	Comments
				I <1/2	II 1/2-3/4	III 3/4-7/8	IV full-curl		
1					1	1		2	
2							2	2	
3	5	1	3					9	
4	1							1	
5	1	1						2	
6	6	5	1					12	
7	10	6	2					18	
8	2	2	1					5	
9	1	1						2	
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									

Survey Summary

1-23	27	16	7		1	1	2	54	
24-59									
Total									



Appendix IV. Weather conditions varied during the Dall sheep survey in Gates of the Arctic National Park and Preserve, 1996. Survey efforts were curtailed if low clouds obscured the survey area, high winds made surveying unsafe, or rain obscured visibility through the windshield. The survey stretched through a longer period of time than had been initially estimated because of the unfavorable weather. A summary of daily conditions is as follows:

7 July 1996: Galbraith Lake. Rapidly moving clouds and occasional moderate turbulence. Within a unit, crews surveyed peaks and ridges as they cleared, and moved to other peaks as clouds moved in to obscure a peak. Rain and clouds remained on some peaks and ridges above 6500'. Units surveyed: 1-7

8 July 1996: Galbraith Lake. Rapidly moving clouds and occasional moderate turbulence. Within a unit, crews surveyed peaks and ridges as they cleared, and moved to other peaks as clouds moved in to obscure a peak. Rain and clouds remained on some peaks and ridges above 6500'. Units surveyed: 8,9,11-17,20

9 July 1996: Galbraith Lake. Overcast, fog. Units surveyed: No surveys

10 July 1996: Galbraith Lake. Early fog, then rapidly moving clouds and occasional moderate turbulence. Units surveyed: 14,18, 19,21-24,37,40

11 July 1996: Anaktuvuk Pass. Clouds obscuring some peaks and ridges. Units surveyed: 10,25,36-39,41-46,70

12 July 1996: Anaktuvuk Pass. Lots of rain and rapidly moving low clouds, fog building on some peaks. Clearing later in the day. Units surveyed: 31,33,34,51,52,54,56-59,62,69,70,72,80,86-88

13 July 1996: Anaktuvuk Pass. Sunshine and lots of shadows. Downdrafts on north-facing cliffs. Units surveyed: 50,63-65,68,71,74-83

14 July 1996: Anaktuvuk Pass. High winds. Units surveyed: 85

15 July 1996: Anaktuvuk Pass. High winds. Units surveyed (most by helicopter only): 26,43,53,55,73,93

16 July 1996: Anaktuvuk Pass. High winds. Units surveyed: 28, Castle Mtn.

17 July 1996: Anaktuvuk Pass. Sunshine and lots of shadows. Downdrafts on north-facing cliffs. Units surveyed: 27,32, 35,47-49,90,92

Appendix V. Counts per unit, by fixed wing and by helicopter in the Dall sheep survey in Gates of the Arctic National Park and Preserve, 1996. Composition counts were conducted from the helicopter. Eleven survey units were surveyed only by helicopter because of inclement weather and are denoted with a *.

Unit Nos.		Area (mi ²)	Harv. Class	Fixed-wing		Helicopter composition			
'96	'82-			Adults	Lambs	Ewes	Lambs	Yrags	Rams
1	17	24.60	Sport	7	0	-	-	-	-
2	17	26.41	Sport	0	0	0	0	0	0
3	17	21.03	Sport	9	5	-	-	-	-
4	17	27.67	Sport	36	10	48	16	7	7
5	17	36.51	Sport	19	2	-	-	-	-
6	17	29.25	Sport	8	0	0	0	0	15
7	17	29.37	Sport	26	7	-	-	-	-
8	17	19.03	Sport	43	4	33	8	2	11
9	17	27.66	Sport	38	13	-	-	-	-
10	17	27.23	Sport	9	1	-	-	-	-
11	17	29.05	Sport	83	30	-	-	-	-
12	16	27.28	Low	9	1	1	1	0	9
13	16	31.59	Low	45	17	-	-	-	-
14	16	26.80	Low	20	3	13	8	5	11
15	16	20.47	Low	5	2	-	-	-	-
16	16	24.37	Low	17	6	-	-	-	-
17	16	20.83	Low	10	7	4	2	2	-
18	16	20.12	Low	52	19	27	16	8	1
19	16	28.45	Low	12	0	-	-	-	-
20	16	29.46	Low	2	0	-	-	-	-
21	18	18.63	Sport	39	3	-	-	-	-
22	18	18.93	Sport	14	4	9	4	2	0
23	18	31.40	Sport	51	18	-	-	-	-
24	18	24.31	Sport	31	7	11	4	3	12
25	18	27.46	Sport	1	0	-	-	-	-
*26	18	28.08	Sport	-	-	43	13	6	9
27	18	25.88	Sport	16	4	-	-	-	-
28	18	25.52	Sport	1	0	-	-	-	-
29	18	22.28	No survey	-	-	-	-	-	-
30	18	29.05	No survey	-	-	-	-	-	-
31	18	24.95	Subst	11	0	-	-	-	-
32	18	27.60	Subst	0	0	-	-	-	-
33	18	19.51	Subst	25	5	23	11	6	3
34	18	24.97	Subst	6	3	-	-	-	-
*35	18	25.40	Sport	-	-	10	8	4	14
36	18	24.46	Sport	51	15	-	-	-	-
37	18	32.02	Sport	47	4	33	13	5	28
38	18	26.10	Sport	104	19	-	-	-	-
39	18	24.60	Sport	115	24	93	27	13	7
40	18	31.33	Sport	35	10	20	13	16	15
41	18	24.03	Low	19	4	8	2	1	9
42	18	29.51	Low	19	8	-	-	-	-
*43	18	20.93	Subst	-	-	27	16	7	4
44	18	22.64	Low	47	12	-	-	-	-

Unit Nos.		Area (mi ²)	Harv. Class	Fixed-wing		Helicopter composition			
'96	'82-			Adults	Lambs	Ewes	Lambs	Yrlgs	Rams
45	18	30.53	Low	42	13	-	-	-	-
46	18	19.07	Low	21	6	-	-	-	-
47	9a	25.64	Low	48	18	30	12	5	0
48	9a	27.42	Low	40	17	26	21	6	15
*49	9a	19.17	Low	-	-	9	5	2	0
*50	9a	27.47	Low	-	-	4	2	1	9
51	9a	22.26	Subst	2	1	2	1	1	0
52	9a	21.25	Subst	23	9	-	-	-	-
*53	6	22.54	Subst	-	-	2	1	3	3
54	6	21.32	Subst	2	1	0	0	0	0
*55	6	19.81	Subst	-	-	3	3	1	7
*56	6	27.73	Subst	-	-	13	9	3	0
57	6	27.98	Subst	32	8	-	-	-	-
58	6	20.94	Subst	19	9	19	10	5	-
59	6	27.81	Subst	8	1	-	-	-	-
60	6	25.73	Subst	76	21	34	21	6	37
61	6	30.83	Subst	18	0	-	-	-	-
62	6	19.83	Subst	6	2	-	-	-	-
63	5	28.93	Low	6	1	-	-	-	-
64	5	20.02	Low	4	0	-	-	-	-
65	5	25.12	Low	12	4	-	-	-	-
66	5	27.50	Low	12	2	-	-	-	-
67	5	24.90	Low	4	1	6	5	3	3
68	2	16.02	Subst	4	0	-	-	-	-
69	2	19.47	Subst	6	0	-	-	-	-
70	2	21.81	Subst	4	2	-	-	-	-
71	2	19.90	Low	15	7	-	-	-	-
72	2	27.91	Low	7	1	-	-	-	-
*73	2	31.92	Subst	-	-	10	7	2	2
74	2	23.79	Subst	5	2	4	3	1	1
75	2	37.57	Subst	1	0	-	-	-	-
76	1	20.74	Subst	15	1	-	-	-	-
77	1	15.32	Subst	29	14	-	-	-	-
78	1	20.66	Subst	13	3	-	-	-	-
79	1	31.86	Subst	29	11	24	9	5	7
80	1	30.21	Subst	3	1	1	1	0	2
81	1	24.34	Subst	0	0	-	-	-	-
82	1	16.59	Subst	8	4	3	2	2	0
83	1	27.82	Subst	15	6	10	8	1	0
85	1	20.80	Subst	19	12	-	-	-	-
86	1	21.63	Subst	20	3	7	6	5	3
87	1	26.83	Subst	0	0	-	-	-	-
88	1	26.72	Subst	1	0	-	-	-	-
89	3	27.27	Subst	24	6	-	-	-	-
90	3	22.32	Subst	15	4	5	1	2	1
*91	3	30.64	Subst	-	-	22	12	4	11
92	3	26.25	Subst	10	0	3	0	0	9
*93	3	29.95	Subst	-	-	14	5	3	6
Cst	4		None	17	1	-	-	-	-

Appendix VI. MOOSEPOP sheep survey analysis printouts for a Dall sheep survey in Gates of the Arctic National Park and Preserve, 1996. The analysis included a total population estimate, and estimates for three strata: subsistence harvest area, sport harvest area, and low harvest area.

Sheep 96 data for MOOSEPOP

* * * * ESTIMATED POPULATION SIZE * * * *

Sheep 96 data for MOOSEPOP

PAR/STRAT	ALL	TOTAL
N	79	79
Tot area	5100.01	5100.01
n	79	79
Area sur	5100.01	5100.01
# seen	2158	2158
Density	0.4231	0.4660
To	2158.0	
V(To)	0.00	
SCFo	1.101390	
V(SCFo)	0.0036408	
SCF df	33	
To df	78	

Te = 2376.8 V(Te) = 16955.05 df(Te) = 33
 80% CI around Te = (2206.5, 2547.1) is +/- 7.16%
 90% CI around Te = (2156.4, 2597.2) is +/- 9.27%
 95% CI around Te = (2111.8, 2641.8) is +/- 11.15%

Te = 2376.8
 + 381*

 2757.8

Add 381* to all estimate figures.

2758 ± 7.99% @ 90%

± 9.61% @ 95%

* Total number of sheep counted in helicopter-only survey units = 381. The sightability correction factor should not be applied to these units, so they were added on after the SCI was applied.

Dumpst2

Sheep 96 data for MOOSEPOP
 * * * * ESTIMATED POPULATION SIZE * * * *

Sheep 96 data for MOOSEPOP

PAR/STRAT	Subsiste	TOTAL
N	40	40
Tot area	976.52	976.52
n	40	40
Area sur	976.52	976.52
# seen	778	778
Density	0.7967	0.8305
To	778.0	
V(To)	0.00	
SCFo	1.042447	
V(SCFo)	0.0040563	
SCF df	13	
To df	39	

Te=	.811.0	V(Te)=	2455.19	df(Te)=	13
80% CI around Te =	(744.1,	877.9)	is +/-	8.25%	
90% CI around Te =	(723.3,	898.8)	is +/-	10.82%	
95% CI around Te =	(704.0,	918.1)	is +/-	13.20%	

Dumpst1

Sheep 96 data for MOOSEPOP
 * * * * ESTIMATED POPULATION SIZE * * * *

Sheep 96 data for MOOSEPOP

PAR/STRAT	Sport	TOTAL
N	25	25
Tot area	661.93	661.93
n	25	25
Area sur	661.93	661.93
# seen	1070	1070
Density	1.6165	1.9297
To	1070.0	
V(To)	0.00	
SCFo	1.193775	
V(SCFo)	0.0142894	
SCF df	8	
To df	24	

Te=	1277.3	V(Te)=	16359.88	df(Te)=	8
80% CI around Te =	(1098.7,	1456.0)	is +/-	13.99%	
90% CI around Te =	(1039.4,	1515.2)	is +/-	18.63%	
95% CI around Te =	(982.4,	1572.3)	is +/-	23.09%	

Sheep 96 data for MOOSEPOP
 * * * * ESTIMATED POPULATION SIZE * * * *
 Sheep 96 data for MOOSEPOP

PAR/STRAT	None	TOTAL
N	25	25
Tot area	629.13	629.13
n	24	24
Area sur	601.22	601.22
# seen	641	641
Density	1.0662	1.0820
To	670.8	
V(To)	504.90	
SCFo	1.014899	
V(SCFo)	0.0113392	
SCF df	10	
To df	23	

Te = 680.8	V(Te) =	5616.01	df(Te) = 10
80% CI around Te = (577.9,	783.6)	is +/- 15.10%
90% CI around Te = (545.0,	816.5)	is +/- 19.95%
95% CI around Te = (513.8,	847.7)	is +/- 24.53%