

Demography of Dall's Sheep in Northwestern Alaska

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Dall's sheep in northwestern Alaska declined in the early 1990s following the severe 1989-90 and 1990-91 winters. In the Baird Mountains of Noatak National Preserve, estimates of adult sheep declined by 50% from 800 in 1989 to under 400 in 1991. Population counts remained low throughout 1991 to 1996, reaching a minimum of 244 adult sheep in 1996. Few lambs were observed during annual midsummer aerial surveys in 1991 to 1994. We suspect that these declines resulted from a combination of poorer nutritional condition and increased vulnerability of sheep to predation resulting from severe winter conditions.

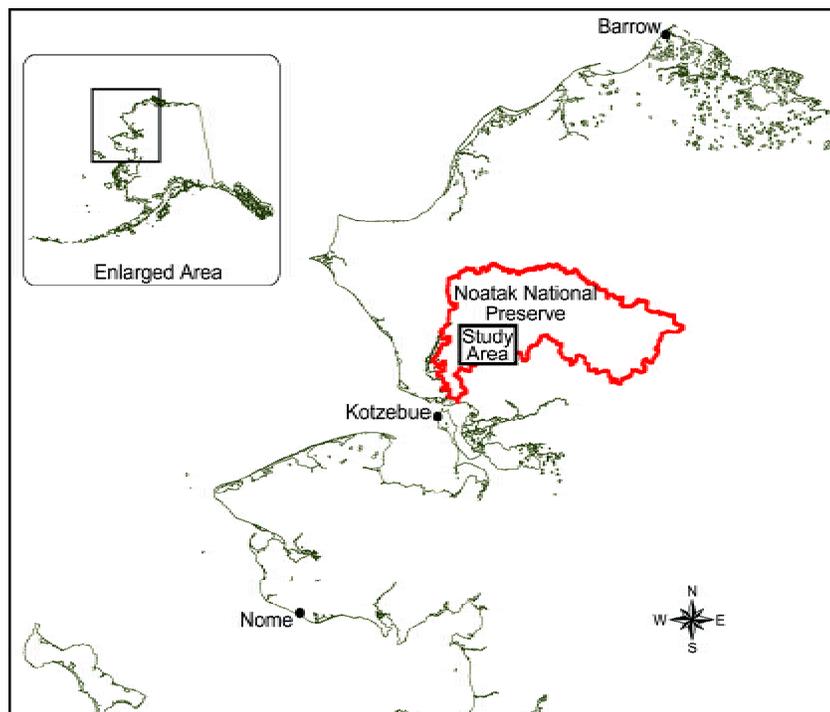
As a result of these declines, both subsistence and sport hunting seasons were closed by emergency order in 1991, resulting in substantial management controversy. The affected publics, although willing to accept the closures, questioned the validity of the sheep survey data and

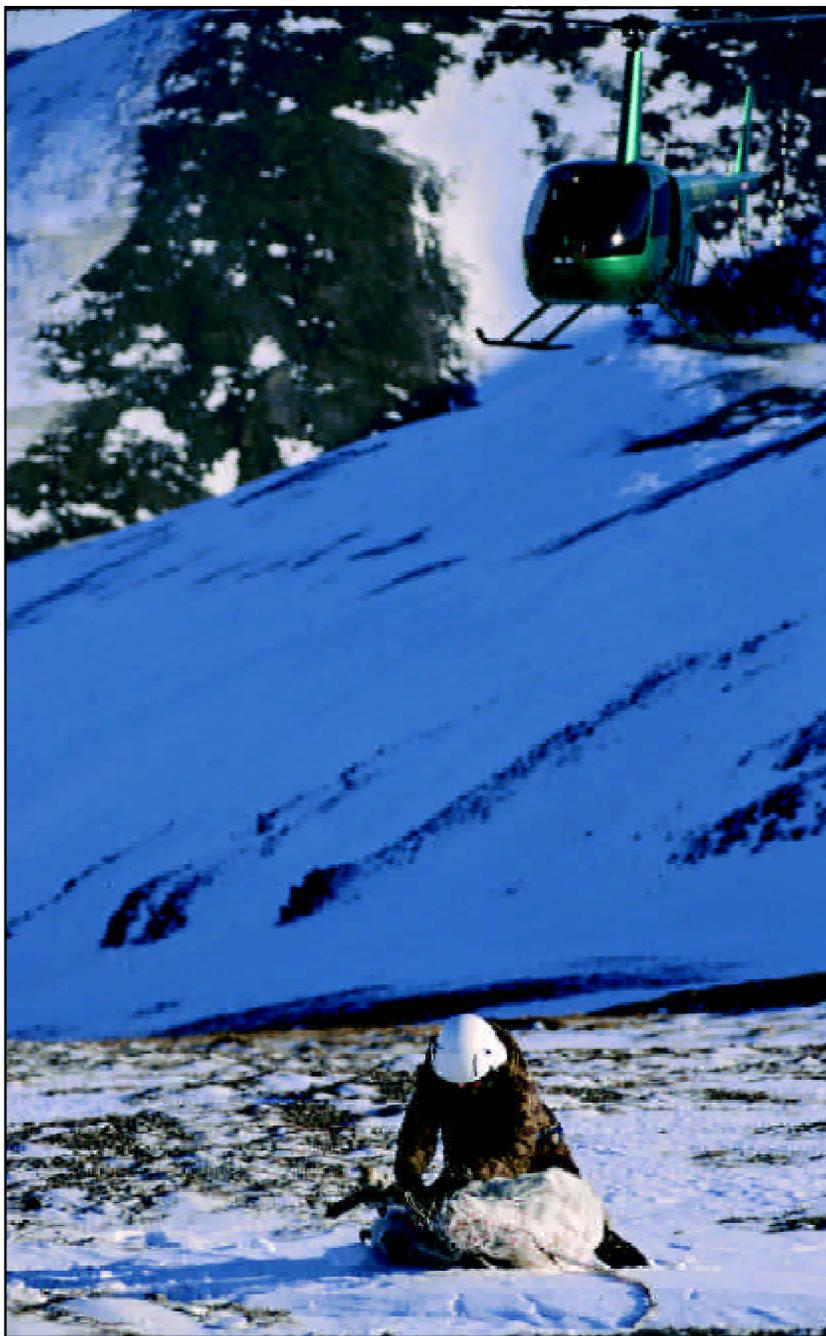
strongly emphasized their interest in restoring harvests as soon as populations increased sufficiently. In 1995 the Northwest Arctic Regional Advisory Council, the local advisory committee for the Federal Subsistence Board, passed a motion supporting efforts to initiate research on sheep populations in the region to better understand the factors limiting sheep populations and to evaluate sheep survey methodologies.

Currently estimates of Dall's sheep population size and composition in the western Brooks Range are based on intensive fixed-wing aerial surveys conducted annually since 1986 in areas including the Baird Mountains. The annual variation in recent Baird Mountains aerial counts cannot be explained with reasonable assumptions about reproduction and survival, suggesting that there is some variability in the proportion of the population observed each year or that a substantial number of sheep move during the survey. Prior to our research, no attempt had been made to estimate visibility bias or precision for these surveys.

Our understanding of Dall's sheep population biology comes largely from studies in central or southern Alaska and the southern Yukon. However, sheep in northwestern Alaska are at the northwestern extreme of their range and live in a less hospitable environment characterized by short growing seasons and long, severe winters. We expect patterns of productivity and survival for sheep in Noatak National Preserve to differ from the more southerly populations. To adequately manage sheep harvests in northwestern Alaska, we need a better understanding of sheep demography. Along with unbiased population estimates, understanding the dynamics of sheep populations in the region will allow population models to be developed that can provide focus for a useful dialog on management goals and strategies and facilitate a cooperative strategy for managing sheep harvests in northwestern Alaska.

Location of the Baird Mountains Study Area, Noatak National Preserve, Alaska.





Barry Minor hobbles a Dall's sheep. The sheep are captured from a helicopter with a shoulder-mounted netgun. Once a sheep is in a net, the net-gunner hobbles the sheep so that the biologist can collar and take samples from the animal.

In 2000 the U.S. Geological Survey's Alaska Science Center and the National Park Service's Western Arctic Parklands initiated a cooperative three-year study of Dall's sheep in the Baird Mountains. Our objectives are to investigate patterns of productivity, lamb recruitment, and adult survival of Dall's sheep; to compare aerial survey methods and assess the validity of their key assumptions; and to recommend a cost-effective procedure for monitoring Dall's sheep in the Baird Mountains.

Study Area

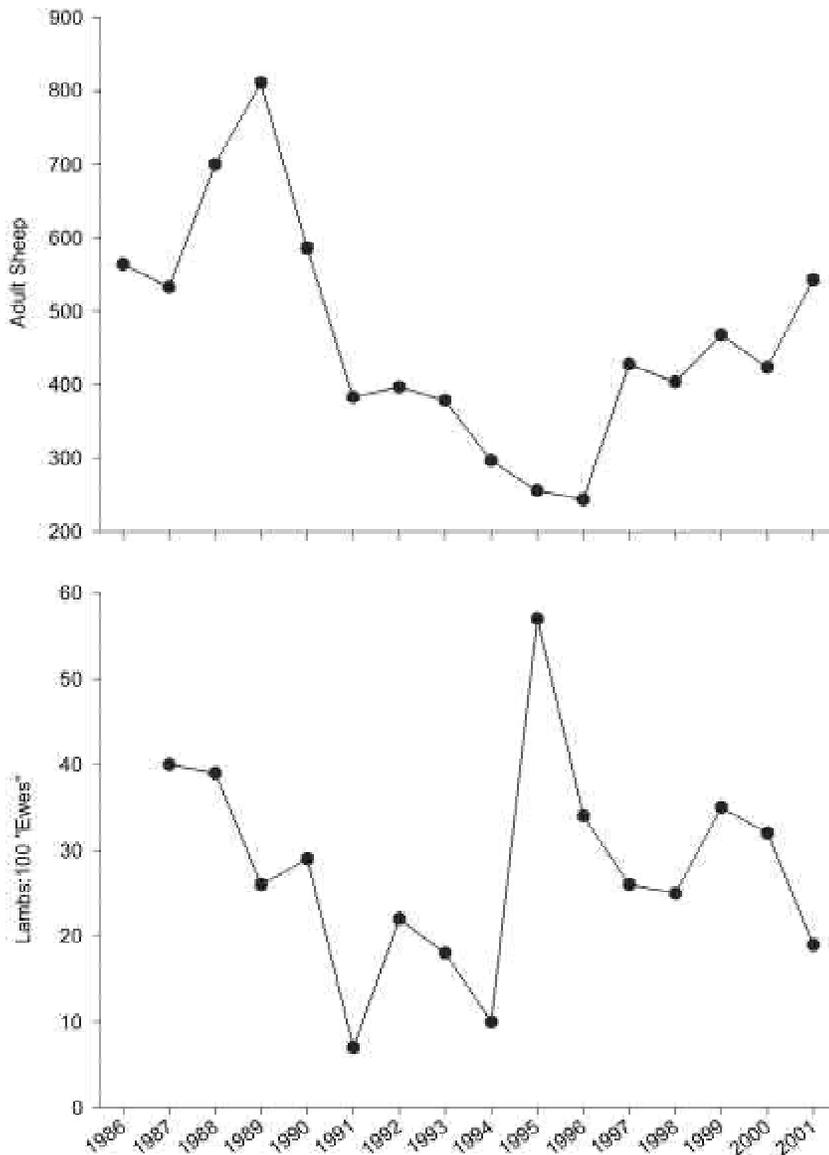
The Noatak National Preserve encompasses 26,600 square kilometers in the western Brooks Range and is bisected by the Noatak River valley. Dall's sheep inhabit most of the mountainous areas within the preserve. The Baird Mountains consist of approximately 2,000 square kilometers in the southern portion of the preserve and are characterized by rolling tussock tundra interspersed with ridges and knolls reaching 700 to 900 m in elevation. In addition to Dall's sheep, the area is inhabited by moose and is within the annual range of the large Western Arctic Caribou Herd. Predators in the area include gray wolves, grizzly bears, and wolverines.

Background

Population Demography

The published literature on Dall's sheep population dynamics is surprisingly sparse. The majority of information is derived from research conducted on Alaska's Kenai Peninsula, the central Alaska Range, and the southern Yukon Territory of Canada. Reports on the ages at which Dall's sheep ewes reach puberty are quite variable. A study on the Kenai Peninsula reported that three of four yearlings collected were pregnant, while a study in Kluane National Park in the Yukon Territory found that initial lamb production was delayed to as late as five years of age. Other studies have reported a minimum age for onset of reproduction at two years. If sheep are similar to other members of their family, we would expect that the variation in sexual maturation results largely from differences in nutrition, but other explanations are also possible.

Once they reach sexual maturity, ewes tend to be highly productive throughout the remainder of their lives. Estimates of pregnancy rates of sexually mature ewes derived from carcass analyses or intensive observations during lambing have varied from 78 to 87%. There is some evidence that productivity may decline for ewes greater than nine years old. These reproductive patterns are comparable to those reported for bighorn sheep. Many other studies have reported estimates of productivity based on mid-summer lamb:"ewe" ratios, but these counts are conducted after the period when lambs are highly vulnerable to predation and often include nonproductive yearling ewes and one- or two-year-old rams in the



Results of annual fixed-wing surveys of Dall's sheep in the Baird Mountains, Noatak National Preserve, Alaska, during July 1986 to 2001. The top graph shows the total number of adult sheep observed each year. The bottom graph shows annual lamb: "ewe" ratios. "Ewes" include all females more than one year old and young rams that have horn characteristics similar to females.

estimate of "ewes," resulting in underestimates of actual productivity.

Most published estimates of lamb survival are also based on comparisons of lamb:ewe and yearling:ewe ratios obtained during summer counts at licks or during aerial surveys. Lamb survival varies from year to year and is likely linked to the age and nutritional status of females and to winter severity.

Information on adult survival is also sparse. Wayne Heimer, formerly a researcher with the Alaska Department of Fish and Game, estimated adult survival for each sex based on observations of eartagged or visually collared individuals. Ewe survival averaged 94% for individuals greater than nine years old, then decreased to 82% for older ewes. Survival rates varied for rams depending on

horn curl restrictions, but they generally followed a similar pattern, with high survival until individuals began actively participating in the rut.

Research on Dall's sheep in Alaska has been limited. Compared to other ungulate species, sheep are primarily managed with conservative harvest strategies aimed at removing fully mature males, and the management controversies have been minimal. However, with the large decline in sheep numbers in northwestern Alaska and the associated concerns raised by subsistence and sport hunters, we require a more thorough understanding of sheep population dynamics.

Survey Methodologies

It is widely recognized that aerial surveys of wildlife are subject to visibility bias. Dall's sheep tend to occur in relatively exposed habitats and may be less subject to visibility bias than many species. However, a variety of factors can affect the detectability of mountain sheep, including size and composition of groups, activity, habitat, and light conditions.

Four approaches have been used to account for visibility bias in aerial surveys of North American mountain sheep, including single observer mark-resight, double observer sight-resight, double sampling ratio, and covariate-based modeling methods. Single observer mark-resight methods require animals to be marked before the survey, and detection probabilities are estimated based on the proportion of the marked animals observed during the survey. Double observer sight-resight methods require two observers but have the advantage of not requiring marked animals and may detect more animals, reducing the overall visibility bias that must be corrected. Detection probabilities are estimated from the proportion of sheep seen by one observer that were also seen by the other observer. Double sampling ratio methods require two surveys, with the first flown at a relatively low intensity and the second flown at a higher intensity on a subset of the units covered by the first survey. Detection probabilities for the low-intensity survey are estimated based on ratios of low-intensity to high-intensity counts from double-sampled units. Although modeling of covariates can be used with any of the above survey methods to account for heterogeneity of detection probabilities, visibility models may also be developed as a separate activity and then applied in future surveys conducted under similar conditions. A function that relates detection prob-

abilities to covariates such as group size and vegetation type is estimated during intensive preliminary surveys of radiocollared animals. This function is then used to adjust for effects of these covariates on detectability in subsequent surveys of uncollared sheep. We refer to those approaches that separate model development from application as covariate-based modeling methods.

All of the survey methods assume that the population is closed, with no movements between survey units during the survey. Sheep populations in the Noatak National Preserve are thought to be relatively discrete. However, little information is available about within-season movements for these populations. Surveys are usually designed to minimize the potential for movements among sampling units, but only a few studies

Netgunner Barry Minor hobbles a Dall's sheep ewe.



have been designed to directly assess movements by mountain sheep during surveys.

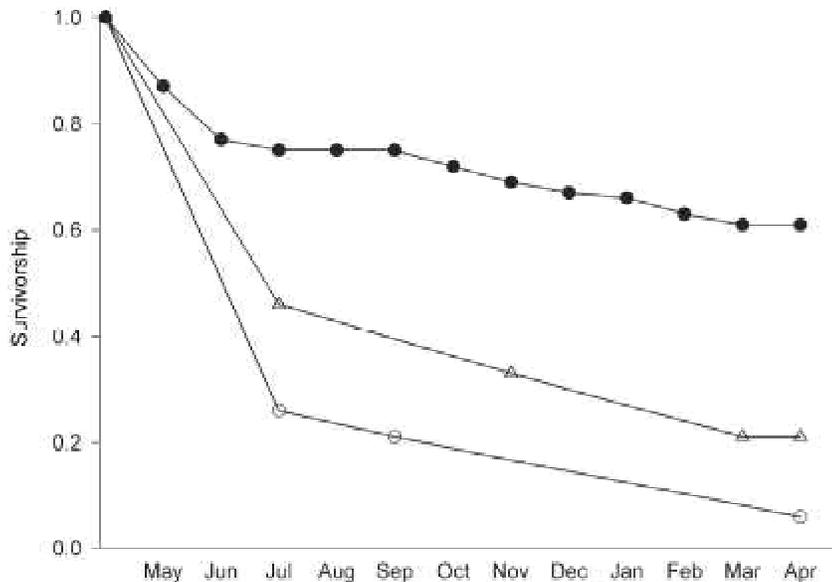
It is not clear which of these survey methods might be most appropriate for monitoring sheep populations in northwestern Alaska, or whether any would result in a cost-effective improvement over the unadjusted fixed-wing surveys currently in use. This study directly compares the basic aerial survey methods, using radiocollared sheep to assess the validity of key assumptions. Based on this evaluation, we will recommend a cost-effective monitoring protocol for the population.

Methods

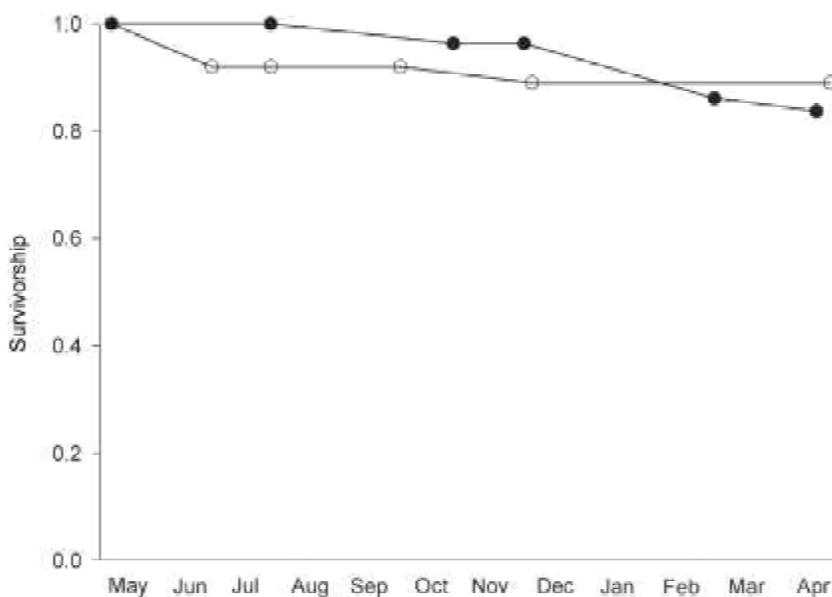
In March 2000 we captured 44 sheep by helicopter netgunning and fitted them with mortality-sensing radiocollars. The composition of the captured sheep—34 ewes and 10 rams—was representative of the population as determined from aerial surveys. While restrained, ewes were weighed and blood samples were taken to determine their reproductive status. We estimated each sheep's age by counting horn rings and, for ewes, by pulling a canine tooth for cementum analyses. In March 2001 and 2002, all surviving ewes were recaptured to be weighed and blood sampled for pregnancy detection. An additional 21 ewes and 6 rams were captured to maintain our sample size.

Currently, radiocollared sheep are located monthly, weather permitting, to determine their survival, group size and composition, and seasonal distribution. We are estimating lamb recruitment by monitoring the survival of lambs associated with radiomarked ewes known to have been pregnant. During summer aerial surveys, collared sheep are used to evaluate sightability and detect movements between survey units.

The annual aerial survey evaluation begins with a pre-survey period in late June to assess baseline movements and habitat selection of collared animals before any potential disturbance resulting from surveys. This is followed in early July by three simultaneous replicate surveys with Supercub airplanes, designed to provide the data for population estimation with each of the basic survey methods. Subsamples of units are surveyed by helicopter immediately following the fixed-wing surveys. During these surveys, collared sheep are monitored for movement between survey units. Survey fieldwork concludes each year with a post-survey period immediately following the aerial surveys to gather additional data on daily movements among survey units.



Estimates of lamb survivorship during May 2000–April 2001 (open triangles) and May 2001–April 2002 (open circles) for the Baird Mountains. Survivorship of lambs from a study by Brad Scotton is provided for comparison (solid circles). Scotton’s estimates of lamb survival are from a more southerly population in the Alaska Range, and they are substantially higher.



Survivorship of Dall’s sheep ewes during May 2000–April 2001 (solid circles) and May–April 2002 (open circles) for the Baird Mountains.

Results

Although our studies are ongoing and any conclusions at this point are preliminary, we have already made some interesting observations. The pregnancy rates of ewes were substantially different between the two years, with 90% of the ewes

pregnant in March 2000, but only 58% pregnant in March 2001. The body weights of ewes averaged 2.00 kg less in 2001 than 2000 (54.2 kg and 52.2 kg, respectively) indicating that the sheep were in poorer nutritional condition in 2001, when pregnancy rates were low.

Observations of collared ewes with lambs at heel are being used to estimate lamb survival. Lamb survival to one year was 21% in 2000–2001 and 6% in 2001–2002.

Adult survival rates are being estimated from observations of collared ewes. Five of the ewes died between May 2000 and April 2001, resulting in an estimate of 84% annual survival for ewes. Between May 2001 and April 2002, four ewe mortalities were recorded, resulting in a survival estimate for this period of 89%.

We were largely unsuccessful during our 2000 field evaluation of survey methods because of unfavorable weather throughout the survey period. However, we were able to more fully implement our study design in the summer of 2001. The proportion of groups containing marked sheep detected by Supercub survey teams varied from 72 to 100%, whereas the helicopter crew detected 94% of the marked groups in 2001. Sheep that were not detected tended to be in smaller groups than on occasions when they were detected. We also detected movements by 12 of 45 (27%) marked sheep among survey units during the 2001 survey. It appears that we could minimize the effects of these movements on population estimates by redesigning survey units and conducting surveys simultaneously in adjacent units where movements are likely.



Research wildlife biologist Chris Kleckner prepares to release a Dall’s sheep ewe as pilot Rick Swisher assists.



Research wildlife biologist
Chris Kleckner releases a
young Dall's sheep ram.

Summary

Our studies are well under way and will continue through April 2003. At that time, we expect to have gained a clearer view of vital rates that comprise the population dynamics of Dall's sheep in northwestern Alaska and to be able to provide recommendations for improving the annual monitoring of these sheep populations. We hope that by providing a better understanding of the status and trends of sheep populations in the region, we can help the public and wildlife managers develop reasonable strategies and goals for managing this important resource.

Suggestions for Further Reading

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