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Dall's Sheep in Gates of the Arctic National Park and Preserve, Alaska

2010 Survey Report

Natural Resource Data Series NPS/GAAR/NRDS—2011/198

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Abstract

In 2009 and 2010, the National Park Service (NPS) Arctic and Central Alaska Networks tested aerial distance sampling and hierarchical modeling to estimate Dall's sheep (*Ovis dalli dalli*) abundance in Gates of the Arctic National Park and Preserve (GAAR). This report details the field methods and summarizes results for the 2010 survey. Further information regarding data analysis and interpretation for both surveys can be found in Schmidt et al. (2011). In 2010, we flew 318 20-km long contour transects generated on a 9-km grid across available sheep habitat in GAAR (26,921 km^2 survey area). We detected 220 groups totaling 557 individuals on 86 transects. Data were analyzed using spatially-explicit Bayesian modeling, and the estimates were adjusted for group size effects on detection. We estimated that there were 10,072 sheep (95% Bayesian credible interval of 8,081-12,520 sheep) in GAAR in 2010. The total and adult abundance estimates for GAAR, as well as an abundance estimate for the Itkillik Preserve subsection of GAAR, did not differ significantly between 2009 and 2010 and are comparable to the census conducted in GAAR from 1982-1984 (Singer 1984). Estimated lamb abundance was double in 2010 versus 2009 (19.3% versus 10% of total abundance). These surveys showed distance sampling and hierarchical modeling to be an efficient and precise means to estimate park-wide abundance of sheep in GAAR, and these methods will be adopted for monitoring long-term trends in Dall’s sheep abundance in GAAR and other NPS units in Alaska.

Acknowledgments

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Introduction

The primary goal of the Dall's sheep (*Ovis dalli dalli*) monitoring program with the National Park Service (NPS) Arctic Inventory and Monitoring Network (ARCN) is to detect long-term trends in the abundance and distribution of sheep in the parks and preserves which span the central and western Brooks Range using statistically robust methods (Lawler et al. 2009). This task is made difficult by the sheer size and remoteness of the region. Over 41,000 km^2 of potential Dall's sheep habitat have been delineated here, most of it within Gates of the Arctic National Park and Preserve (GAAR), Noatak National Preserve (NOAT), northern Kobuk Valley National Park (KOVA) and a small portion of Cape Krusenstern National Monument (CAKR). Based on past surveys (Singer 1984a, Singer 1984b, Singer et al. 1983) the region likely harbored >13% of the world's Dall's sheep population in the 1980s (~100,000 sheep, Valdez and Krausman 1999). However, there was a substantial decline in sheep numbers during the early 1990s that has been attributed to severe winter weather, which likely reduced access to forage and increased vulnerability to predation (Whitten 1997, Shults 2004). Localized surveys in small portions of the region have shown some recovery since then (e.g., western Baird Mountains of NOAT, Shults 2004), but little is known about park-wide and regional population trends.

Aerial minimum count surveys have been the primary method used to assess and manage Dall's sheep populations in Alaska (Singer 1984b, Udevitz et al. 2006, ADF&G 2008). However, minimum count surveys represent only the population available for sampling. They do not estimate uncertainty or detection bias (the proportion of animals not detected during a survey), and they are logistically unfeasible and costly for large survey areas such as the ARCN park units. These factors complicate analyses of spatial and temporal population trends. Previously proposed methods to estimate detection bias, such as double-sampling (McDonald et al. 1990, Whitten 1997), sight-resight (McDonald et al. 1990, Strickland et al. 1992), mark-resight (Neal et al. 1993, Udevitz et al. 2006), and the sightability-model approach (Udevitz et al. 2006), as well as sampling methods to estimate abundance and uncertainty (e.g., double sampling; stratified random sampling, Rattenbury and Lawler 2011), have likewise proven to be costly and inefficient for large areas.

In 2009 and 2010, ARCN collaborated with the Central Alaska Network (CAKN) to test the feasibility of using aerial distance sampling (Buckland et al. 2001, 2004) and hierarchical modeling (Royle et al. 2004, Royle and Dorazio 2008) to estimate Dall's sheep abundance across GAAR (Rattenbury et al. 2009, Schmidt and Rattenbury 2010, Schmidt et al. 2011). Aerial distance sampling has been used successfully to estimate density and abundance for wildlife species such as bears (*Ursus* spp.) in southwest Alaska (Quang and Becker 1999, Walsh et al. 2010). Distance sampling and hierarchical modeling were expected to create a more efficient and cost-effective survey tool for Dall's sheep than minimum count methods, produce unbiased estimates of abundance, account for detection probability, and provide density distribution maps for large park units. These methods will also be used to estimate abundance and sex and age composition of sheep in small reference areas (< 2500 km^2) that are important for harvest management, such as the Itkillik Preserve in GAAR and the western Baird Mountains in NOAT. The NPS will use these estimates to detect decadal-scale trends in the abundance and distribution of Dall's sheep and to focus management action in these park units. This information is also an important foundation for research concerning productivity relative to other sheep populations in the state; the relationship between sheep numbers and other ungulate and predator populations;

and the influence of available forage, stochastic weather events and climate change on sheep populations.

This report details the field methods and summarizes the results from the 2010 survey. Further information regarding data analysis and interpretation for both the 2009 and 2010 surveys can be found in Schmidt et al. (2011).

Study Area

The 2010 survey area included available Dall's sheep habitat within GAAR as well as small, contiguous areas containing historically surveyed areas (67°03'-68°40'N and 149° 22'-156°52'W; Figure 1). This area covers most of the central Brooks Range, which is characterized by the rugged Schwatka and Endicott Mountains reaching 2,500 m, and the headwater catchments for the Noatak, Nigu, Alatna, Killik, Chandler, Anaktuvuk, John, North Fork of the Koyukuk and Itkillik Rivers. Climate across the central Brooks Range is characterized by long, cold winters, and short, cool, wet summers (Lawler et al. 2009). Predominant vegetation communities at higher elevations are *Dryas*-sedge-lichen tundra and *Dryas*-mixed herb-lichen tundra with moist to wet tussock tundra in the valleys.

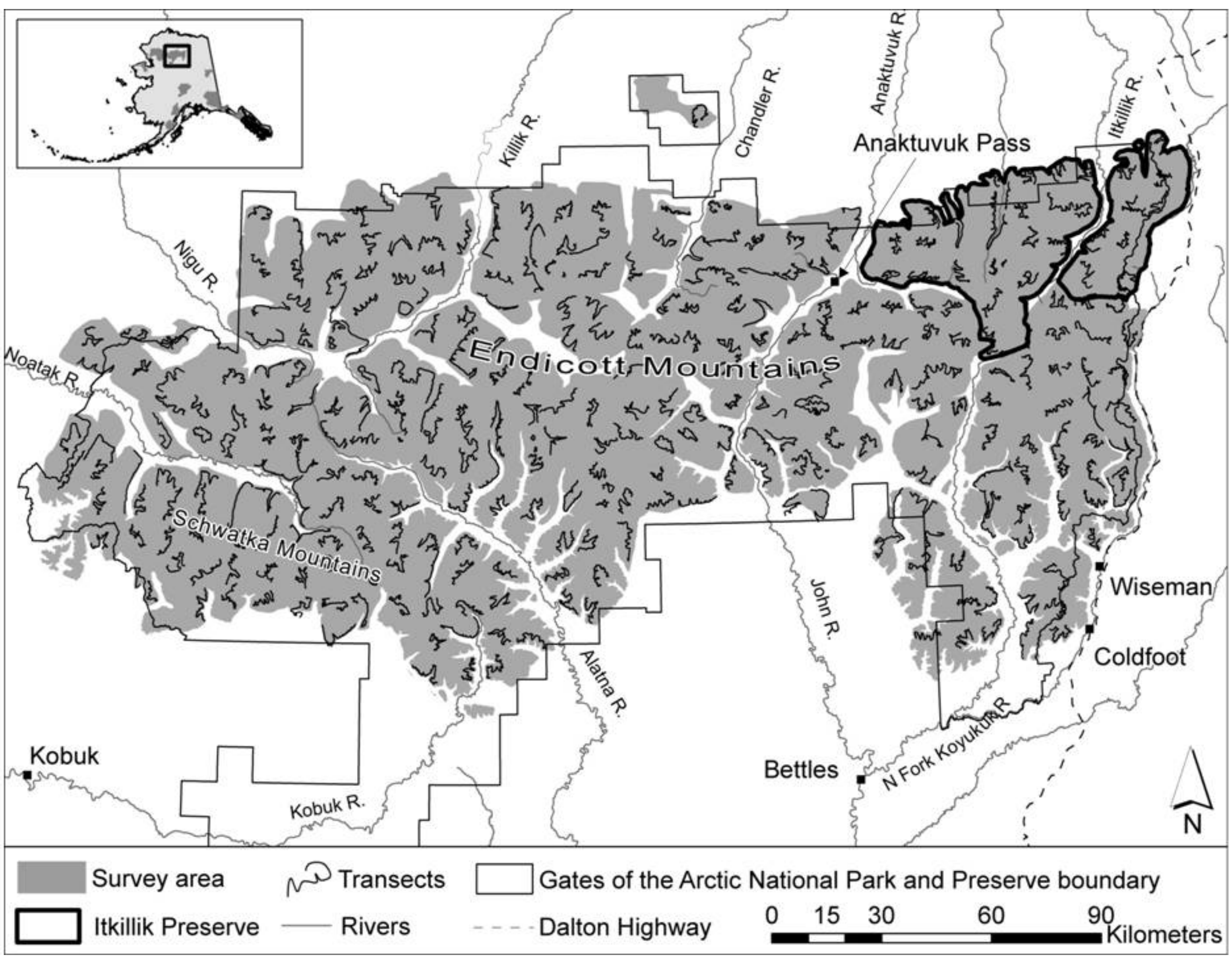

Figure 1. Survey area and transects, Dall's sheep distance sampling survey, Gates of the Arctic National Park and Preserve, Alaska, July 2010.

Methods

Transect Generation

We generated the 2010 survey area by merging survey units from Brubaker and Whitten (1998) and Rattenbury and Lawler (2011) using the ArcMap 9.3 Integrate tool with a 500-m cluster tolerance (ESRI, Redlands, CA), and removing from this all areas below 600 m within the ecotype areas classified 'Boreal (White Spruce)' and 'Boreal (Black Spruce)' but not 'Subalpine' by Jorgenson et al. (2009). The resulting survey area was 26,922 km^2 (Figure 1). We overlaid 2,221 locations of sheep observations from Singer (1984a), Brubaker and Whitten (1998), Rattenbury and Lawler (2010, 2011), and our 2009 data onto this area. Three historical sheep observations fell outside of this area; however this was within the standard error of the 2009 abundance estimate.

We generated 321 20-km transects (*n*=324) centered on a random-start, 9-km grid within the survey area using a custom ArcMap 9.3 (ESRI, Redlands, CA) extension created for contour transect surveys (NPS Animal Tracking Project v1.1.2 Transect Generation ArcMap Extension, GeoNorth, LLC, Anchorage, Alaska). The extension generated transects that followed mountain contours at the elevation of their respective center points, and straight transects in a random direction where center points fell in flat areas (0-7°) based on a 60-m digital elevation model (USGS National Elevation Dataset [NED]). Where transects could not be generated ≥ 15 km due to limited terrain at the specified elevation, we digitized the remaining transect length up to 20 km total at the same elevation on the nearest mountain to ensure that all elevations were sampled in proportion to availability (Walsh et al. 2010). This produced 16 two-part transects and 1 three-part transect. Sections of these multi-part transects were to be flown in consecutive order (Figure 2).

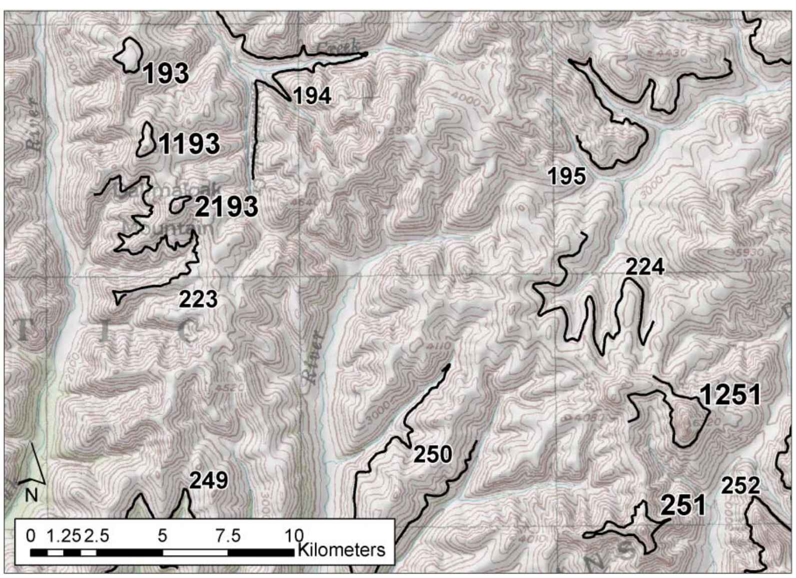

Figure 2. Examples of multi-part transects, Dall's sheep survey, Gates of the Arctic National Park and Preserve, Alaska, 2010. Lines 193, 1193 and 2193 compose a three-part transect at 1,400 m elevation, totaling 12 km in length. Lines 251 and 1251 compose a two-part transect at 1,400 m elevation, totaling 20 km in length. All other transects shown here are single-part transects of 15-20 km in length.

Survey Preparation and Procedures

A file geodatabase produced during transect generation was uploaded to portable tablet PCs (Xplore Technologies, Austin, TX) running a specialized ArcPad 7.1.1 (ESRI, Redlands, CA) application for data collection in the survey aircraft (NPS Animal Tracking Project v1.1.2 Animal Tracking ArcPad Applet, GeoNorth, LLC, Anchorage, Alaska). The tablet PCs were interfaced with GPS USB units (Garmin 18X, Olathe, KS) to display real-time GPS locations. Transect shapefiles were also uploaded to the pilots' GPS (Garmin 296/496, Olathe, KA) for navigation. We held training sessions prior to the aerial survey to familiarize pilots and observers with flight and data collection protocols and conducted mock surveys by car whereby the observers could practice using the ArcPad application on the table PCs.

We conducted the aerial survey from 6 to 13 July following the spring snowmelt but as close as possible to the post-lambing season when sheep are highly visible. Previous aerial surveys of Dall's sheep have been conducted in late June and early July for similar reasons (Singer 1984; Brubaker and Whitten 1998; Lawler 2004; Rattenbury and Lawler 2010, 2011). The survey was flown by five pilot-observer teams in tandem aircraft (four Piper Supercubs and one Aviat Husky), with three teams based in Bettles flying transects in southern GAAR and two teams based in Anaktuvuk Pass flying transects in northern GAAR (Figure 1).

The transects were flown at ~90 m above ground level and speeds of approximately 100-120 km/hr. The pilot and observer worked together to search for sheep uphill from the line. Teams were directed to thoroughly search areas nearest the line first to ensure that the assumption of complete detection on the line was met. When a group of sheep (≥ 1 individual) was detected, the pilot deviated from the transect line to fly over and record the initial location of the group. If groups were large and/or diffuse, the center of the group was recorded. Sheep > 100 m apart were considered to belong to separate groups. Before leaving the line to collect location information, the pilot continued past the group searching upcoming habitat to ensure that additional sheep were not detected after leaving the transect. Additional detections while flying off-transect would have violated the assumption of independence among detections. Observers did not mark an effective search distance (ESD) for each group as in Walsh et al. (2010), because it was not feasible to estimate this for transects not having sheep observations, and we did not use ESD to calculate detection probability.

After marking locations, each group was circled as necessary to confirm count and composition. The observer took digital photographs of groups with > 4 sheep to verify these data. The team classified all sheep into six composition classes: lambs, ewe-like sheep (ewes, yearlings and ≤ ¼-curl rams), sub-curl rams (> ¼-curl and < full-curl), ≥ full-curl rams, unclassified rams and unclassified sheep. The observer also recorded group activity (stationary, walking, or running, based on the initial observation); cloud cover (clear, < ½ scattered, > ½ broken, overcast); precipitation (none, rain, snow); turbulence intensity (none, light, moderate); turbulence duration (none, occasional, intermittent, constant); and air temperature. The ArcPad application automatically recorded the flight path, and the observer marked the start and end points of flown transects as well as the off- transect segments when the aircraft left the line to mark sheep locations. The pilot also collected a daily tracklog and waypoints for sheep groups and the transect start and end points for backup.

Data Processing and Analysis

At the end of each survey day, the observers downloaded the ArcPad data into the geodatabase on another laptop and compared transect and sheep locations with the pilots' tracklogs and waypoints for accuracy. We also compared the photographs with the recorded group count and composition data. We increased group size based on photo verification, but did not decrease the count if fewer sheep were found in a photograph compared with the observer-recorded data because it was often difficult to photograph large and/or scattered groups of sheep. Two observers having multiple years of experience with aerial Dall's sheep surveys verified and corrected sex and age classification data based on the photographs. All transect flight line and sheep location data were processed prior to data analysis to reduce the potential for errors using methods similar to those described by Walsh et al. (2010).

We used a spatially-explicit Bayesian modeling approach for analysis, allowing us to include covariates and random effects that may influence detection probability, group abundance, and group size, while allowing unbiased abundance estimation for smaller areas of specific management importance (Royle et al. 2004, Royle and Dorazio 2008, Johnson et al. 2010). The model-generated detection probabilities were used to estimate total abundance of Dall's sheep in GAAR, lamb and adult abundances in GAAR, and total abundance in the 2,542 km^2 Itkillik Preserve reference area (Figure 1). Data analyses for the 2009 and 2010 surveys are treated in greater detail in Schmidt et al. (2011).

Results and Discussion

We flew 110 survey hours in 2010 and completed 318 of 321 transects, effectively sampling ~11% of the total survey area. We detected 220 groups totaling 557 individual sheep on 86 transects. The detected groups averaged 2.5 sheep per group, and observed numbers per composition class were 297 ewe-like sheep, 98 lambs, 99 rams > ¼-curl and < full-curl, 50 rams ≥ full-curl, two unclassified rams and seven unclassified sheep.

We estimated that there were 10,072 sheep (95% Bayesian credible interval of 8,081 to 12,520 sheep; approximate CV of 11%) in GAAR, with 1,854 sheep (95% Bayesian credible interval of 1,342 to 2,488 sheep; approximate CV of 16%) in the Itkillik Preserve reference area in 2010. Adults and lambs composed 80.7% and 19.3% of the population, respectively. Total and adult abundance estimates for GAAR as well as the Itkillik estimate did not differ significantly between 2009 and 2010 (Schmidt et al. 2011). However, estimates of lamb abundance were 57% lower in 2009 (Schmidt et al. 2011). This contrasts with the estimate based on observed lamb-adult ratios not adjusted for group size bias, which shows a 40% difference between the two years (Schmidt et al. 2011). This suggests that there may be unaccounted bias in lamb numbers from previous surveys where the effects of group size on detection were not taken into account.

Total abundance estimates in 2009 and 2010 for GAAR (Figure 3) and the Itkillik Preserve reference area (Figure 4) did not differ substantially from previous surveys (except 1996), but historical data are sparse. A helicopter census conducted from 1982-1984 reported 10,939 Dall's sheep in GAAR, with 1,965 sheep in the Itkillik Preserve area (Singer 1984a). A stratified random sampling survey conducted in 2005 and 2006 estimated 8,406 sheep (95% confidence interval of 6,242-10,570) in GAAR (Rattenbury and Lawler 2011). However, the census and other minimum count surveys did not estimate uncertainty or detection, and the 2005-2006 survey did not estimate detection. The time, cost and logistics required of these earlier surveys is not sustainable in a long-term monitoring program. Considering the state-wide decline in Dall's sheep observed in the early 1990s and the lack of park-wide population data during that time, the NPS is adopting more frequent and more precise survey methods to monitor sheep populations.

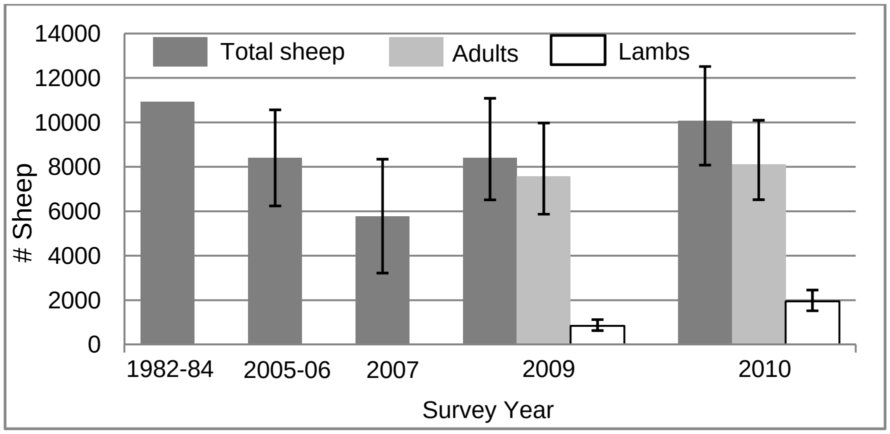

Figure 3. Dall's sheep survey results, Gates of the Arctic National Park and Preserve (GAAR), Alaska, 1982-2010. The 1982-1984 aerial census was conducted by helicopter; estimates of precision, accuracy and detection probability were not included in the methods (Singer 1984). The 2005-2006 and 2007 estimates were based on stratified random sampling surveys analyzed per Gasaway et al. (1986) and also do not include estimates of detection probability. The 2007 results are biased low. Error bars = 95% CI, and 95% Bayesian credible intervals in 2009 and 2010.

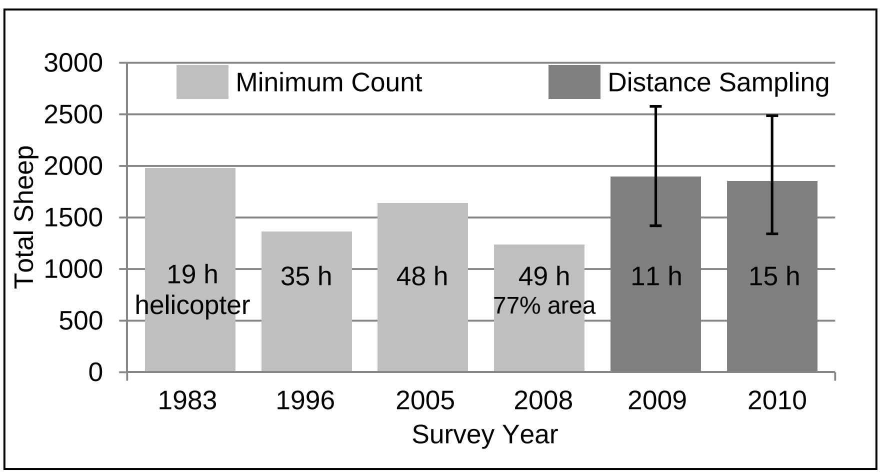

Figure 4. Dall's sheep survey results and flight times, Itkillik Preserve (2,542 km2), Gates of the Arctic National Park and Preserve, Alaska, 1983-2010. The 2009 and 2010 error bars are 95% Bayesian credible intervals. The 1983, 1996, 2005 and 2008 data do not have estimates of uncertainty or detection. Data are from Singer (1984), Brubaker and Whitten (1998), Rattenbury and Lawler (2010) and Schmidt et al. (2011).

A significant advantage of the distance sampling and hierarchical modeling approach is the generation of estimates of abundance, uncertainty and detection that are directly comparable among years and areas. Additionally, the time per transect is low, allowing for a 70-80% decrease in survey costs compared with minimum count methods and the ability to conduct large surveys under a greater variety of weather conditions. With Bayesian hierarchical modeling we are able to investigate non-random spatial effects (i.e., uneven distribution of sheep) and covariates affecting abundance and detection such as elevation, group size and weather. The model-based estimate is also more precise than a design-based variance estimator, with a 30% reduction in CV. Another benefit is the ability to produce abundance estimates for different sex-age classes (e.g., lambs, adults, large rams) and estimates in smaller reference areas (< 2500 km^2, e.g., Itkillik Preserve) by combining distance data from several areas and over time. We can thus estimate sheep abundance in places such as Denali National Park and Preserve (DENA) and Lake Clark National Park and Preserve (LACL), which have smaller populations (~800-2000) of sheep. These benefits outweigh any disadvantages associated with the additional time required for preparation and training and more complex data analyses. ARCN, CAKN and LACL plan to test and apply these methods to long-term Dall's sheep monitoring in GAAR, NOAT, KOVA, CAKR, LACL, DENA and WRST. Additional details about the 2009 and 2010 data analysis process and further discussion regarding the use of distance sampling and hierarchical modeling to estimate Dall's sheep abundance can be found in Schmidt et al. (2011).

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