Global Information Systems (GIS) are an important tool for research conducted on mammals in arctic environments. Researchers are currently learning a great deal about animal movements, distribution patterns, habitat selection, and responses to disturbance. Many of the findings produced from mammal research would not have been possible without the use of GIS technologies. In a sense, research in the arctic is well behind research being conducted in the conterminous United States primarily because of the difficult conditions that exist there. The remote and expansive nature of arctic regions make remotely collected data ideal. Most recent research projects have to do with satellite telemetry and the analysis of distribution patterns of animals. However, studies that are being conducted are largely guided by the unique conditions present in the arctic.

A benefit to working on mammal species in arctic regions and especially tundra environments is that the open horizon and little forest overstory allow for successful use of satellite telemetry systems (Service Argos). Satellite telemetry is most successfully used with large animals because the size and weight of the platform transmitter terminals (PTT's) that must be attached to the animals. As Bergmann’s Rule suggests, most species in northern latitudes tend to be large because of the decrease in surface to area ratio; an evolutionary adaptation to cold climates. This makes the use of satellite telemetry successful for many of the mammals that occur in the arctic, such as caribou (Rangifer tarandus), polar bears (Ursus maritimus), and muskoxen (Ovibos moschatus). Satellite telemetry is a beneficial tool for determining movement patterns over large areas because the system is only accurate to within 200-900 meters. The use of satellite telemetry in mammal studies in the arctic underlines the fact that little is known about many wildlife populations that exist there. Recent literature has focused on determining population boundaries of polar bears (Armstrup et al. 2004) and identifying shifts in winter ranges of caribou (Ferguson and Messier 2000). Both studies were interested in coarse scale movements of the study species making satellite telemetry a logical choice. However, not every species is an ideal candidate, such as the case with male polar bears, which have necks that are larger than their heads and thus easily shed telemetry collars. To rectify this problem one research group used implantable telemetry equipment on male polar bears to determine whether movement patterns of males and females were similar (Armstrup 2001). This study determined that male and female movement patterns were similar to one another, but monthly distances traveled were greater for male bears. An equally important outcome of this study was the finding that implanted PTT’s need to be refined before widespread use. The authors found that the average life of implanted transmitters was 97 days, which is much shorter than the expected duration of 20-24 months. Reasons for transmitter failure could be
due to problems with electronics, removal or expulsion by bears, and antenna breakage.

Remote areas such as the arctic of North America benefit from data that is collected remotely, such as location information collected from satellite telemetry and sent directly to the user. Fieldwork that is conducted in the arctic is logistically difficult requiring airplane and helicopter travel to get to field sites. The result of the high cost of fieldwork and the massive acreage is that there are few GIS products available for the entire state. One of the datasets that does exist is digital elevation models (DEM’s), which proved to be a useful parameter in a GIS model of muskoxen habitat (Danks and Klein 2002). Satellite imagery and aerial photographs are important sources of data used in GIS studies. I found that many researchers in the arctic use aerial photographs frequently in replace of orthophotos. The use of aerial photos was adequate for the purposes of the papers, but would have been easier to accomplish and more accurate with planimetrically correct base maps if they were available. In replace of using orthophotos some researchers plot locations directly onto topographic maps later to be digitized for use in a GIS (Yost and Wright 2001). Another study used a stereoscope to delineate polar bear denning habitat on aerial photographs, then visually transferred the locations to topographic maps, which were then digitized for use with a GIS (Durner et al 2001). Although the process would have been much more accurate with a planimetrically correct base map, the authors calculated and incorporated the possible error of 135 meters into the final product. The limited amount of existing data requires researchers to make due with available data or to create their own datasets.

Generally, studies that work at finer scales tend to be the same studies that create their own datasets (James and Stuart-Smith 2000, Durner et al 2001, Yost and Wright 2001). The ability to create GIS coverages is an important skill for researchers in remote areas. Another common analytical procedure used for large-scale studies was to measure distances from animal locations to landscape features, such as linear corridors resulting from industrial development (James and Stuart-Smith 2000). Although the automation of distance measurements using GIS software is a basic procedure, it becomes a very important tool when the number of measurements is greater than 10,000 (James and Stuart-Smith 2000). Both fine and coarse scale studies frequently use GIS to map locations of animals and describe the conditions around the animal locations. Complex data models and analytical procedures were not replete in the body of literature reviewed, likely because of the rather basic knowledge that still needs to be collected for most species and limited data available to create GIS models.

The future of GIS in the arctic is promising. Tools that allow for remote data collection will help to minimize the costs associated with working in such a remote and expansive area. Researchers will likely embrace the use of telemetry equipment incorporating Global Positioning Systems (GPS) to track animal movements. There was only one study found that used GPS telemetry collars (Danks and Klein 2002). Because of the accurate location information obtained from GPS telemetry the
researchers were able to build more complex models and conduct more detailed analysis of local conditions. It seems reasonable to assume that increasingly detailed datasets on land-use and vegetation types will be needed once GPS telemetry becomes commonplace. Overall, GIS studies of mammals in the arctic are largely driven by the availability of datasets. As different types of data become more prevalent and when data is created at finer resolutions researchers will have the necessary tools to answer more complex research questions.

Annotated Bibliography


This paper discusses how telemetry data on animal locations can be used to predict where animals will occur in the future instead of using the location information to describe where the animals have been in the past. Although the study focuses on polar bears (*Ursus maritimus*) from northern Canada and Alaska the techniques presented in this paper can be applied to other species of wildlife. The purpose of this paper was to determine polar bear population boundaries so that managers have the best available information to protect the species. Location information was collected from platform transmitter terminals (PTT’s) and the Argos Data Collection and Location System. Analysis of location data showed that population boundaries used in the past were not entirely correct. The methods employed by the authors may be more important than their findings. They used bootstrapped estimates of error with utilization distributions to show the relative probability of occurrence of bears across the study area. The methods employed are a significant contribution to researchers working with telemetry data because estimated errors can now be used to map occurrence probabilities as contour lines on maps.


A significant problem with studying the distribution of polar bears (*Ursus maritimus*) is that female polar bears are the only sex that can be outfitted with radiotelemetry collars. Male polar bears have necks that are larger than their heads and because of this they can easily shed collars. Researchers have identified that there could be a potential problem using only female bears to describe the entire population. Female bears establish home ranges to secure food resources while male bears establish home ranges to maximize the overlap with female bears. This study used platform transmitter terminals (PTT’s) and the Argos Data Collection and Location System to follow both female and male polar bears to determine if their movement patterns
were different. The methods of this paper were unique because PTT’s were surgically implanted in male bears (n=7). This study determined that male and female movement patterns were similar to one another, but monthly distances traveled were greater for male bears. An equally important outcome of this study was the finding that implanted PTT’s need to be refined before widespread use. The authors found that the average life of implanted transmitters was 97 days, which is much shorter than the expected duration of 20-24 months. Reasons for transmitter failure could be due to problems with electronics, removal or expulsion by bears, and antenna breakage.


This study was conducted to determine the feasibility of using GIS as a practical tool in wildlife habitat assessment. The specific focus of the study was to model current muskoxen (Ovibos moschatus) habitat suitability and extrapolate their findings to the National Petroleum Reserve - Alaska (NPR-A) for use in future land-use planning. This study highlights some problems that researchers in remote locations face when using GIS. Muskoxen were reintroduced in 1969 and there has not been much research conducted on the species, which means that little is known about habitat preferences. The arctic environment is difficult to model because it is expansive and there are not many existing geospatial datasets to work with. The authors used a combination of aerial surveys and GPS radio-collars to acquire location data. The location data were then used with satellite-based vegetation maps, digital elevation models, and terrain data to create their muskoxen habitat model. All base maps were in raster format and because cell sizes varied they were standardized to the coarsest scale (50 meters). The final habitat model showed that there is a difference between summer and winter muskoxen habitat and both habitats are present in adequate amounts in the NPR-A if muskoxen populations increase and expand their range. This is an important finding because future management scenarios can be updated to include potential impacts on muskoxen habitat even though the species is not currently present.


The purpose of this study was to document the most probable areas of polar bear (Ursus maritimus) den sites along the coastal plain of northern Alaska. Because the coastal plain is high quality denning habitat and also important for oil recovery operations there is a potential conflict. The authors visited known den sites located from telemetry studies to document micro and macro habitat components. Aerial photographs were examined (n=3000) to identify areas of the coastal plain that had similar features as the known denning areas. Once potential denning sites had been located on aerial photographs they were visually transferred to topographic maps, which is a process that immediately raises suspicion for any reader knowledgeable
about GIS error. However, error was controlled for by visiting every digitized node and buffering the potential denning sites by a distance of 135 meters. The process of transferring locations from aerial photographs to spatially accurate topographic maps could have been avoided if digital orthophotos were available, but the authors made due with available resources. Overall, this was a substantial study that contributes a great deal to mitigation attempts between polar bear conservation and industrial development in the coastal plains of Alaska.


This paper is a good example of how GIS technology can be used to address management questions in a clear-cut and simple manner. The purpose of the paper was to identify how corridors affect the distribution, movements, and population dynamics of woodland caribou (*Rangifer tarandus*) and wolves (*Canis lupus*). It was hypothesized that linear corridors created by industrial development could be one of the causes of the decline in the population of caribou in Alberta Canada. The authors posit that corridors could increase hunting pressure by both humans and wolves because corridors are easy travel lanes. They compared VHF derived telemetry locations from wolves and caribou to a population of randomly generated points (*n*=10,000) to test whether: 1) caribou telemetry locations are farther from corridors than random points, 2) wolf telemetry locations are closer to corridors than random points, 3) caribou mortality sites are closer to corridors than the random points, and 4) wolf predation sites are closer to corridors than random points. The authors digitized linear corridors from recent aerial photographs and reported a location error of 50 meters, which may be higher than if they had used orthophotos. The authors determined perpendicular distance of the telemetry locations and random points to the nearest linear corridor using GIS software. The authors found that different individuals respond in different ways to corridors, but on average caribou avoid corridors. They also discovered that sites where caribou were killed by wolves were closer to corridors than the randomly generated points. The analysis suggests that the effects of continued industrial expansion should include estimates of habitat that is lost due to avoidance of corridors by caribou.


This study is a perfect example of the benefits of using satellite telemetry to document major shifts in the distribution patterns of wildlife. The authors attached satellite telemetry collars (Service Argos) to 92 caribou between 1987 and 1992. The purpose of the study was to determine whether caribou shift winter ranges because of forage depletion caused by long-term overgrazing. This study reported on the percentage of the caribou population that altered their winter ranges and the subsequent increase in body condition after shifting ranges. The increased fitness of caribou after the range shift shows that forage depletion was the likely cause of the
range shift. This is a significant study because it identifies the need to focus management on areas that are much larger than static geographic range boundaries. Overall, this study may not have been feasible without the use of satellite telemetry equipment because there would be no way to locate animals that had moved far away from the study area when using classic VHF telemetry.


This paper is a good example of how a study can incorporate GIS technology to aid in management of mammal populations. Although this study could have been conducted using analog maps, repetitive tasks such as distance measurements were automated to save time and reduce human error. The study itself is relatively basic, but the study design is thorough and follows recent advances in methods to determine density estimates from detection functions. The purpose of the study was to determine whether the recent increase in vehicular traffic in Denali National Park decreases the opportunity for visitors to see wildlife. The authors sampled 19 viewsheds along road corridors and mapped the occurrence of moose (*Alces alces*) caribou (*Rangifer tarandus*), and grizzly bears (*Ursus arctos*) in these viewsheds. The locations where these three species were observed were placed on topographic maps in the field and then used to create a GIS point coverage. Distances to the animal locations from the road corridor were calculated using the NEAR command in ARC/INFO. Distance measurements were used to determine the detection function for density estimates of viewsheds versus sampling points in the backcountry. The authors conclude that there is no evidence to suggest that moose, caribou, or grizzly bears avoid using viewsheds near road corridors except in areas where road traffic is the greatest.