Beaver Cache Surveys on the Kanuti National Wildlife Refuge

Tim Craig
Wildlife Biologist
Kanuti National Wildlife Refuge
US Fish and Wildlife Service

Lisa Saperstein
Regional Fire Ecologist
Alaska Region

Abstract

Aerial surveys of beaver (Castor canadensis) food caches were conducted on the Kanuti National Wildlife Refuge (NWR) in north-central Alaska, in 2002, 2003 and 2010. Survey design and analysis were based on the GeoSpatial Population Estimator (GSPE) method originally designed for moose population surveys. The Refuge was divided into 508 survey units delineated by longitude and latitude, 80% of these units were considered beaver habitat and thus were included in the final survey area. Each survey unit was approximately 13.7 km^2 in size. Units were stratified as having either high or low beaver density based on water quantity and previously collected beaver cache data. A random sample of high density and low density units at an approximate ratio of 60:40 was selected for the surveys, although the actual number of units surveyed varied due to weather and other factors. The GSPE analysis provided estimates that ranged from 1104 to 1337 beaver caches on the Refuge, although the confidence intervals for all three surveys overlapped. Predicted changes in climate in Alaska are likely to result in concomitant changes in habitat for wildlife. One of Kanuti NWR's goals is to monitor the beaver population on the Refuge. Because the Refuge is very remote, aerial surveys are the only practical way to monitor these aquatic mammals. The GSPE method as adapted to beaver has shown to be a reliable, randomized, and repeatable sampling technique.

Introduction

Beaver (*Castor canadensis*) are an important subsistence resource throughout interior Alaska, both for food and fur. The Alaska Department of Fish and Game (ADF&G) stopped "sealing" beaver in 2002, so current harvest data are unavailable. That year, ADF&G estimated that 221 beaver were harvested throughout Game Management Unit 24 (Hollis 2007). In 1983, the last year that ADF&G did household surveys in the villages of Allakaket and Alatna (human population <130), 230 beaver were harvested by village residents (Marcotte and Haynes 1985). In addition to their economic and subsistence value, beaver are considered a "keystone species" because of their important ecological effects (Baker and Hill 2003) including modifying plant communities by removing woody vegetation (Brzyski and Schulte 2009), and influencing hydrologic processes (Woo and Waddington 2003; Reeves 2007). Beaver are also an important source of prey for large carnivores (Andersone 1999). Despite their recognized importance, management strategies for beaver in Alaska are largely based on anecdotal information rather than systematic field surveys (Alaska Department of Fish and Game 2007).

Beaver populations are difficult to assess, particularly in remote locations. Beaver food caches (fresh, deciduous branches that beavers pile in water-bodies near active lodges) are an important component of beaver ecology at northern latitudes where surface water remains frozen for months each year. Aerial surveys of these caches have been used since the 1940's to monitor beaver abundance because they are visible from the air after leaf-fall (Swank and Glover 1948, Hay 1958, Payne 1981, Swenson et al. 1983, Saperstein 2001). Unfortunately, reports of the relationship between the number/size of caches and the number of beaver in a colony vary. Novak (1977) reported that the average colony size in a study area in Ontario was 7.59 beaver based on sex, age, and breeding data from trapped animals. Hay (1958) found that the colony sizes in three Colorado study areas ranged from 2 – 11 beaver, and that each colony was associated with one food cache. Other studies have estimated colony size at around five beaver (Swank and Grover 1948, Swenson et al. 1983). In Alaska, Boyce (1974) estimated there to be an average of five beavers per lodge, and Koontz (1968) suggested there to be 4-6 animals in each active lodge in interior Alaska. Because of this ambiguity, cache survey data are best used as indices of trends in the relative abundance of beaver.

Several National Wildlife Refuges in interior Alaska conduct periodic aerial beaver cache surveys. Aerial cache surveys are used for two reasons: they are achievable in very remote settings, and caches are contemporary, i.e. they are evidence of the current presence by beaver. Koyukuk and Nowitna NWRs have established several trend areas, each a township in size (93.2 km^2), that are surveyed at three year intervals (Jenny Bryant, personal communication). Trend areas on the Yukon Flats NWR range in size from 93 - 259 km^2, and at least some are surveyed annually. These survey transects are not selected randomly but are located where beaver were abundant. While the results of the transects are indicative of the beaver population in the transect areas, they are not indices of Refuge-wide beaver abundance.

Prior to 2002, Kanuti NWR also conducted two non-random surveys of large areas. The survey areas were located in three different parts of the Refuge and were each between 100 and 989 km^2 (Saperstein 2001). Unfortunately, it was difficult to maintain consistent survey effort among years because the surveyed areas were large, and included numerous, complex wetlands (Saperstein 2001). This prompted Kanuti NWR to develop an alternative method for surveying caches that provided a reliable, random, and repeatable index of the beaver population for the entire Refuge. Beginning in 2002, a new protocol was developed to survey beaver caches on Kanuti NWR that uses the GeoSpatial Probability Estimator (GSPE; Kellie and DeLong 2006; Ver Hoef 2001, 2002, 2008), a technique that was developed to survey moose populations in Alaska, and the Yukon Territories.

Study Area

Kanuti NWR lies on the Arctic Circle in north-central Alaska, approximately 161 km south of the Brooks Range (Fig. 1). It is 6,625 km^2 in size and occupies a basin formed by the Koyukuk and Kanuti Rivers. The climate is cold and continental with low and high temperatures ranging between -56°C and 34° C. The Refuge landscape consists of rolling hills, river floodplains, wetlands, and streams. Vegetation is typical of the boreal forest: large expanses of black spruce (*Picea mariana*) muskeg, rolling hills with mixed forest of black and white spruce (*P. glauca*) and paper birch (*Betlula papyrifera*) and wetland, and riparian areas typically bordered by willows (*Salix* spp.) and alders (*Alnus* spp.).

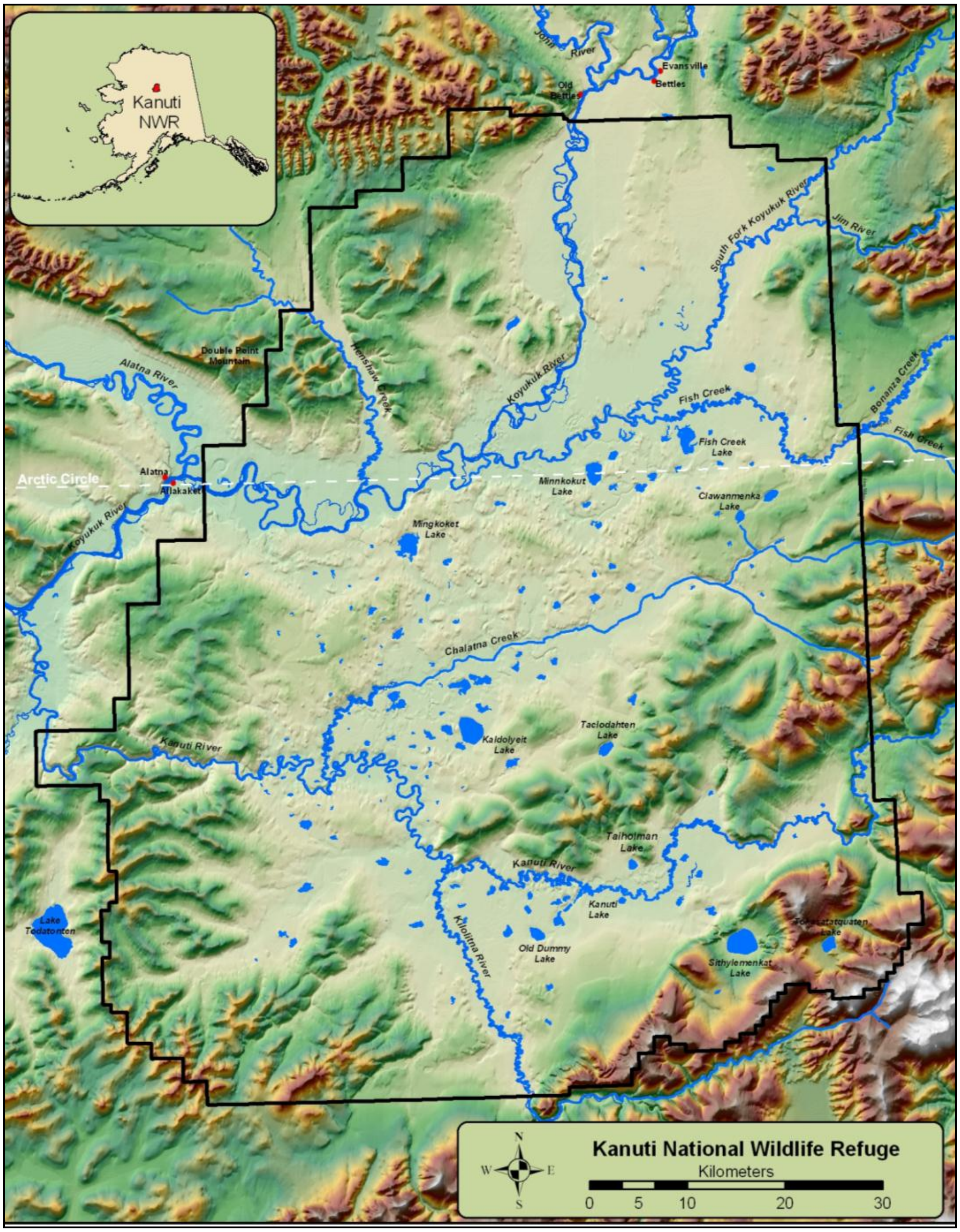

Figure 1. Location of Kanuti National Wildlife Refuge, Alaska.

Methods

The GeoSpatial Probability Estimator method utilizes a grid of survey units (SU) that are delineated by latitude/longitude coordinates spaced at intervals of 2 min. of latitude and 5 min. of longitude. In north-central Alaska, these SU are approximately 13.7 km^2 each. Kanuti NWR is covered by 508 of these survey units, 80% of which contain beaver habitat (we excluded 102 units without water-bodies, that had only one or two small pothole ponds, or that had a small stream segment less than 3 km in length) and constituted the survey area. Each survey unit was classified as having a high or low potential for occurrence of beaver based on habitat characteristics like size of streams, lakes, and wetlands; the complexity of lakeshore habitat was determined from maps and our experience during surveys in 1995 and 2001 (Saperstein 2001). This stratification resulted in 112 high beaver density, and 294 low beaver density SUs (Figs. 2, 3, and 4). A random sample of units was drawn from the two strata (about 60% highs and 40% lows) each survey year so that a total of about 100 units were selected for each survey. The locations of these units were downloaded into the GPS units on survey aircraft and used for navigation to, and within, each SU.

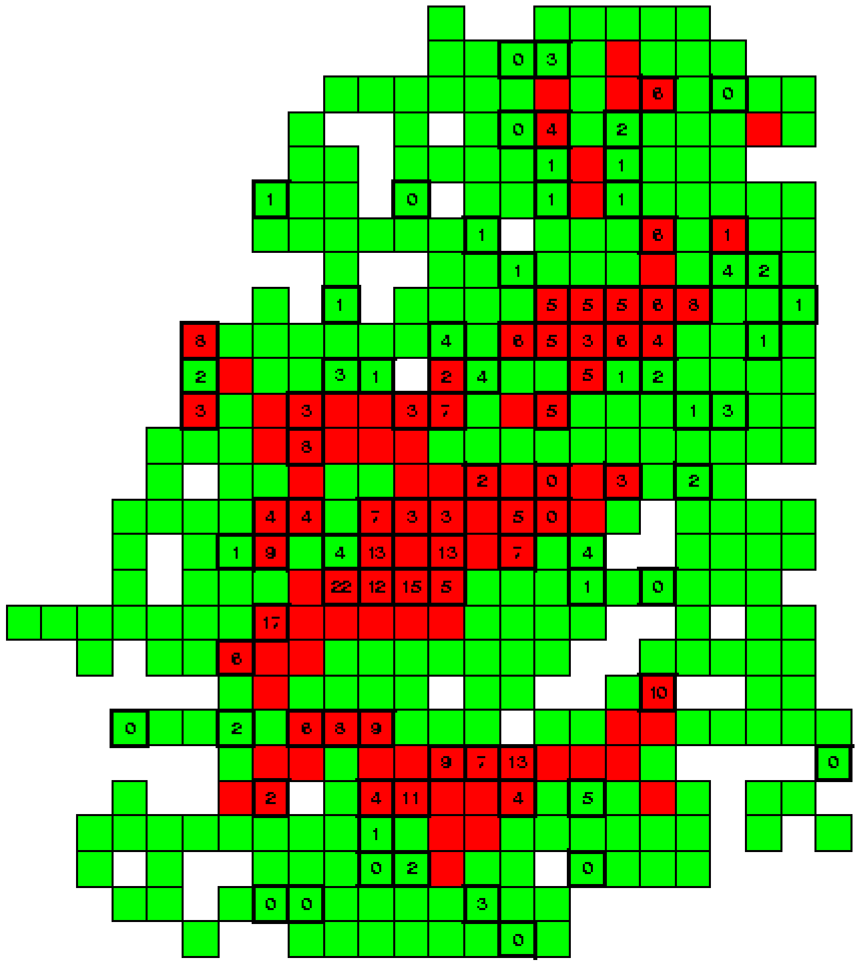

Figure 2. Stratification and number of caches counted per survey unit on Kanuti National Wildlife Refuge, Alaska during a beaver cache survey in 2002. Green units are low density, red units are high density. Gaps indicate units classified as non-habitat.

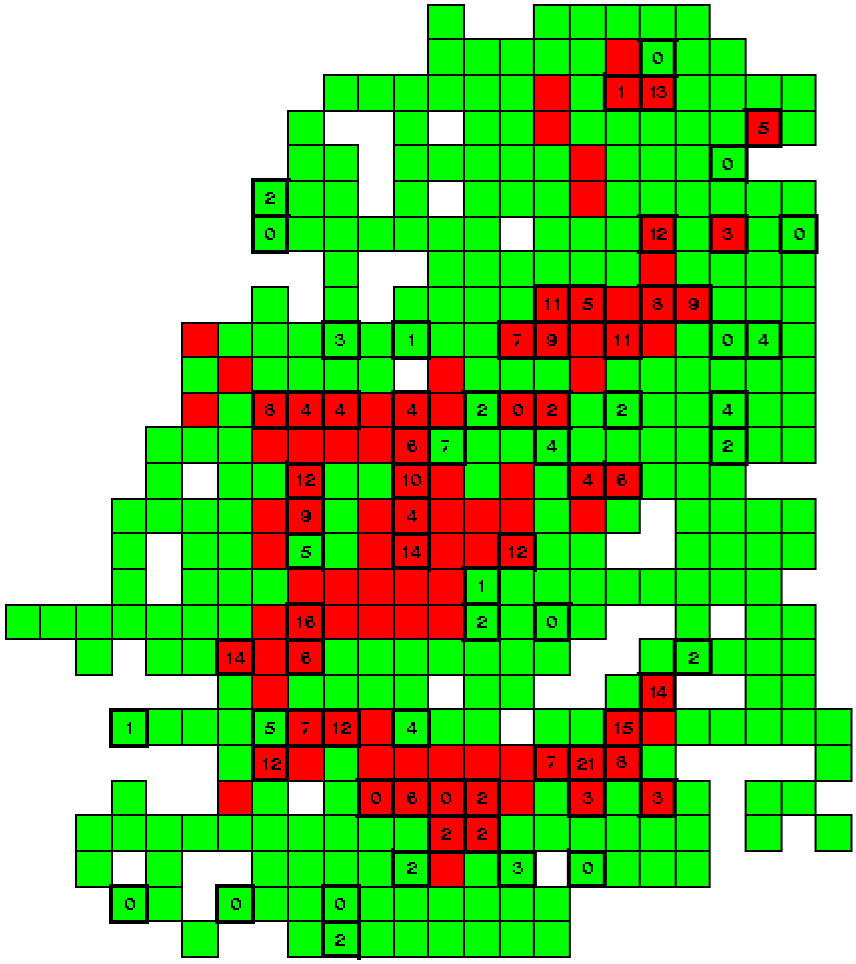

Figure 3. Stratification and number of caches counted per survey unit on Kanuti National Wildlife Refuge, Alaska during a beaver cache survey in 2003. Green units are low density, red units are high density. Gaps indicate units classified as non-habitat.

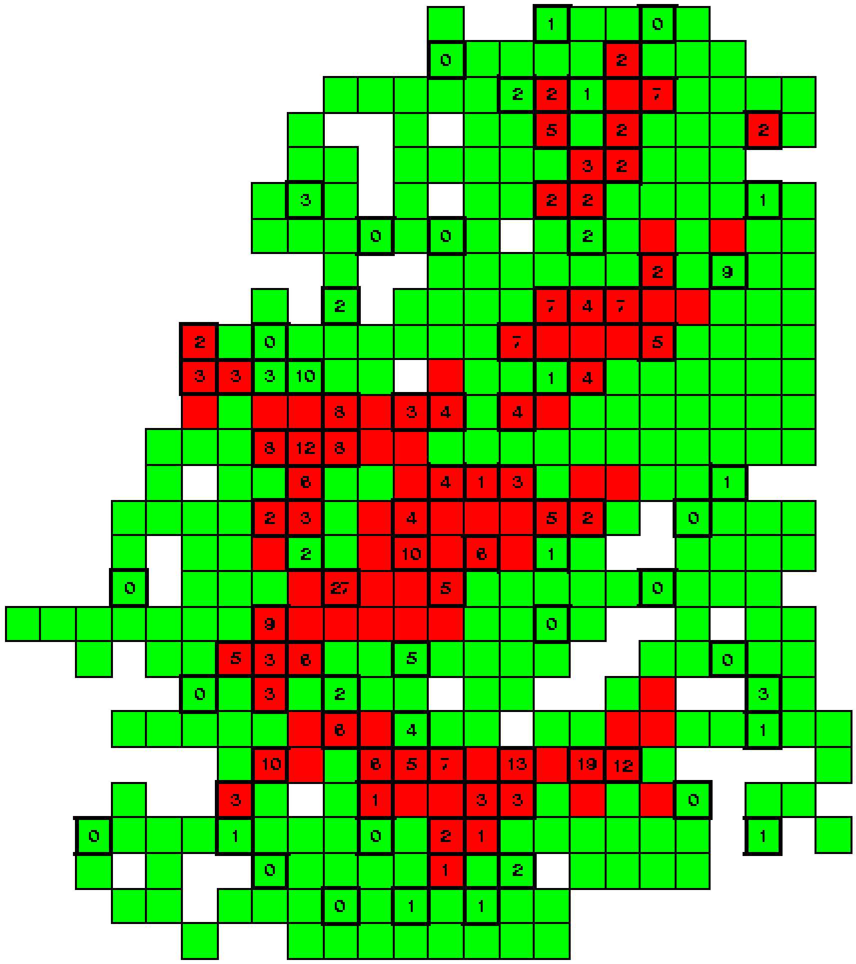

Figure 4. Stratification and number of caches counted per survey unit on Kanuti National Wildlife Refuge, Alaska during a beaver cache survey in 2010. Green units are low density, red units are high density. Gaps indicate units classified as non-habitat.

Because food caches are largest and most visible in late fall, we conducted our surveys around freeze-up, just after most leaves had fallen from deciduous plants. Units were surveyed in two-place, fixed- wing aircraft (Bellanca Scout, Avait Husky, and Piper PA-18). The exact survey pattern in each unit was based on the distribution of appropriate habitat in the unit. However, the goal was complete coverage of beaver habitat in each SU, and that is assumed in our analysis. Both the pilot and a passenger acted as observers and the passenger recorded data, as well. Aircraft were flown about 150 – 244 m AGL and at about 128 km/h. The observers searched opposite sides of the aircraft simultaneously for contemporary beaver caches, as evidenced by fresh, leafy, branches. In addition to the location of each cache and survey time/unit effort, factors affecting the quality of the search were recorded for each SU (e.g. foliage cover, light quality, and overall conditions). Incidental observations of lodges and other wildlife were also recorded. Location observations were archived as GPS coordinates in each plane's GPS as waypoints, or, in two years in one survey plane, via a computerized mapping system linked to a

GPS unit that allowed voice recordings of observations (software developed by John I. Hodges, USFWS R7 Migratory Bird Management Office, Juneau, Alaska).

Data were analyzed using automated, web-based software developed by the Alaska Department of Fish and Game for moose surveys that use the GSPE (Kellie and DeLong 2006). Initial surveys were conducted in 2002 and 2003 to refine methods, and then repeated in 2010. The Kanuti NWR Comprehensive Conservation Plan (U.S. Fish and Wildlife Service 2008) suggests as a possible management action that this survey be conducted at 5 year intervals.

Results

Surveys took place between 23 September and 10 October each fall. Conditions for all three surveys were characterized as "good" to "excellent". The total number of flight hours expended to conduct the surveys varied because up to 3 different planes were used in a given survey year and their performance characteristics, and ferry distances were different (Table 1). The mean time it took to survey units also varied in different years. More time was spent searching units in 2010 than in either 2002 or 2003 when the search effort was nearly identical (12.2 and 12.3 min./unit, respectively). Nonetheless, because the confidence intervals for survey effort, as measured in minutes surveyed /unit for all three years, overlapped the differences may not be significant.

Table 1. Survey parameters of aerial beaver cache surveys on Kanuti National Wildlife Refuge, Alaska in 2002, 2003 and 2010.

Survey year	Survey dates	Total* flight time (Hr.)	Mean Survey effort (Min./unit±SD)	Range (Min./ unit)	90%CI for effort	# of units used in calculating effort
2002	23-26 September	45.3	12.2 ± 6.2	4 – 50	10.9 – 13.5	65**
2003	8-10 October	35.7	12.3 ± 5.5	1 – 28	12.3 – 13.5	76
2010	27-29 September	39.2	14.8± 7.9	3- 41	13.5 – 16.1	100

*The total flight time includes ferry-time

** Fewer units used in calculations in 2002 because some effort data was lost for voice recordings.

Although each of the different surveys was completed in three days, the number of units surveyed each survey year varied. About 100 units were surveyed in 2002 and 2010 (Table 2). Fewer units were surveyed in 2003 because of weather constraints and mechanical problems.

Table 2. Units surveyed, number of caches counted, and cache densities observed during beaver cache surveys on Kanuti NWR, Alaska, 2002, 2003, and 2010.

	Units Surveyed by Stratum			Cache Count by Stratum		
Year	High	Low	Total	High	Low	Total (#/km^2)
2002	54	45	99	347	67	414 (0.26)
2003	46	30	76	343	58	401 (0.33)
2010	60	40	100	316	60	376 (0.24)

The estimated number of caches as determined by the GSPE method ranged from 1104 to 1337 in the three survey years (Table 3). However, the confidence intervals for all three years overlapped despite the reduced number of sample units searched in 2003, and the increased survey effort in 2010 (Fig. 5).

Table 3. Summary statistics resulting from using GeoSpatial Probability Estimator software to analyze beaver cache survey results on Kanuti NWR, Alaska, 2002, 2003, and 2010.

Summary Statistics			
Year	Estimated Beaver Caches	Standard Deviation	90% Confidence Interval
2002	1,135	68.4	1,023 – 1,248
2003	1,337	112.1	1,153 – 1,521
2010	1,104	103.7	933- 1274

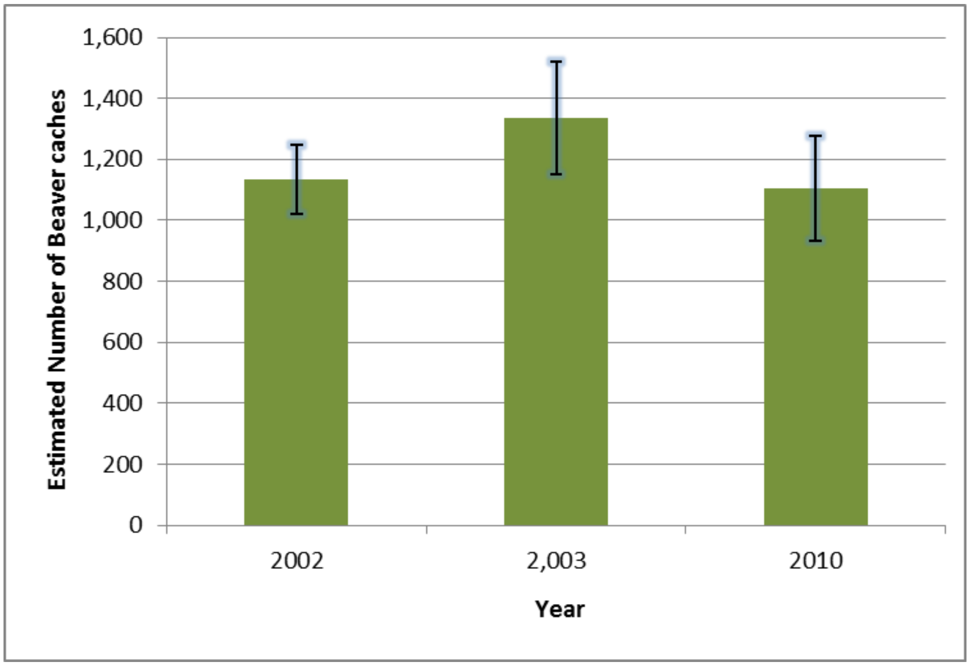

Figure 5. Estimated number of beaver caches with 90% Confidence Interval error bars resulting from using GeoSpatial Probability Estimator software to analyze beaver cache survey results on Kanuti NWR, Alaska, 2002, 2003, and 2010.

Discussion

Aerial surveys have been identified as a practical monitoring technique for beaver populations elsewhere (Kafcas 1987). Because Kanuti NWR is remote, and roadless, aerial cache surveys are the only feasible way to assess the beaver population on the Refuge, as well. Unfortunately, aerial beaver cache surveys have an inherent problem. The detectability of different types of beaver food caches from aircraft varies because caches in small, winding streams are difficult to see, as are caches associated with bank lodges. This has been identified as a weakness of the survey technique since its inception (Swank and Glover 1948). Payne (1981) compared results of aerial surveys to the number of caches reported by trappers on the ground. He found that ground counts exceeded counts from aircraft by 39% and counts from helicopters by 19%; overall, the aerial survey missed 30% of the colonies. Most of the lodges in that study were against banks and so were more difficult to see than those surrounded by water. During our surveys we noticed lodges both in open water and against the banks of lakes, creeks, and rivers. Unfortunately, the detectability of these different types of caches is unknown on Kanuti NWR. Developing a sightability correction factor for caches that are associated with both bank and open-water lodges would allow us to calculate more accurate estimates of the cache population on the Refuge.

Others have observed that the relationship between the number of caches and the number of beavers per colony in an area must be known to estimate a beaver population from cache survey data (Swank and Glover 1948). That relationship has been found to vary. Swenson et al. (1983) reported that aerial surveys on two rivers in Montana resulted in high accuracy and repeatability in locating caches, but that there was high annual variability in colony size in one of the areas surveyed over two consecutive years. Using a formula developed by Novak (1977), they calculated the average colony sizes based on age and breeding information obtained by trappers, and found a 34% decrease in population between years. They concluded that while cache surveys may detect gross changes in population size, they could not be used to distinguish smaller ones. Cache size (volume) has also been used as a predictor of beaver colony size in conjunction with nocturnal counts, again with mixed results (Kafcas 1987, Osmundson 1990, Easter-Pilcher 1990). The number and age structure of beaver associated with cache numbers or volume has not been determined for Kanuti NWR, nor does our current protocol include estimating cache volume. Therefore, the beaver cache surveys on KNWR can only be used as indices of trends in the relative abundance of beaver on the Refuge, and only by cautious extension, the beaver population. If baseline information correlating the number/size of caches and the number of beavers in a colony is determined on Kanuti NWR in the future, these data could be used to draw more informed inferences about the size of the beaver population on the Refuge.

Beaver density estimates in North America are often expressed as colonies per unit of stream length, or area. In three places in Canada the density of beaver colonies ranged between 0.38 colonies/ km^2 to 0.76 km^2 (Hill 1982). In Alaska Koontz (1968) found a density of 0.49 beaver colonies/km^2 in the upper Yukon River Drainage. In some studies, beaver were found to construct one cache per colony (Hay 1958), although Baker and Hill (2003) indicate the beaver do sometimes build more than one cache in a colony. If it is assumed that one cache is associated with each lodge on Kanuti NWR, the beaver colony density on the Refuge (0.30 beaver/km^2), while somewhat lower than more southerly populations, is comparable to northern populations reported in the literature. Furthermore, if we assume that an average of 5 beaver are associated with each lodge (Boyce 1981) on Kanuti NWR, the beaver population on the Refuge may have ranged from as low as 4665 beaver (2010) to as high as 7605 beaver (2003) during our surveys. It is tempting to attribute the ostensive decline in the number of beaver caches we observed in 2010 to environmental factors (e.g. an incremental decline in beaver habitat on the Refuge due to hydrologic changes). However, it should be noted that because the confidence intervals among all years overlap, the observed decrease in caches may be an artifact of sampling rather than an actual change in the abundance of beavers on the Refuge.

Summary

GSPE methodology proved to be an efficient, randomized and repeatable survey technique to measure beaver activity on KNWR by estimating the number of contemporary beaver caches on the Refuge. It produced a refuge-wide estimate of the number of beaver caches with relatively tight confidence intervals, and at a comparatively low cost. The GSPE technique has several advantages over the trend survey techniques that were used on Kanuti NWR in the past.

- The earlier trend surveys were censuses of discrete areas and did not provide a refuge-wide estimate of beaver caches with statistical measures of variability.
- The trend surveys covered large areas of complex wetlands, but did not specify a flight route. This made it difficult for pilots to ensure full coverage of wetlands and streams and to replicate effort among surveys.

- GSPE protocol utilizes small units which allow observers a high degree of confidence that they have surveyed all appropriate habitat in a given unit, enhancing detection of caches.
- Survey units are stratified, easily relocated, and randomly selected.
- After a number of surveys are completed, the GSPE design will allow temporal/spatial analysis of beaver distribution and fluctuation in relation to environmental changes.

The climate at northern latitudes has been changing (Euskirchen et al 2010). Riordan et al. (2006) used remotely sensed imagery to demonstrate that the surface area of ponds in interior Alaska declined between the 1950s and 2002. Similarly, there has been a 15% decline in the water-covered area at Lake Todatonten on the Refuge's southwestern boundary (Hamfler 2008). There is anecdotal evidence from local residents of Allakaket and Alatna that this trend is occurring on Kanuti NWR, as well (Unpublished report, Kanuti National Wildlife Refuge).

Most of Alaska is predicted to become appreciably drier by the end of this century (SNAP 2009), including Interior Alaska (Rupp and Springsteen 2009a). It has been noted that:

> "Changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fires risk, and contribute to the likelihood of wetlands, streams, and lakes drying (Rupp and Springsteen 2009b)."

If these prognostications are fulfilled, changes in habitat will likely occur in interior Alaska in the future, including on Kanuti NWR, and there will be commensurate changes in wildlife populations, particularly those of aquatic mammals like beaver.

Acknowledgements
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Literature Cited

Alaska Department of Fish and Game. 2007. Furbearer management report of survey-inventory activities. 1 July 2003 - 30 June 2006. P. Harper, editor, Juneau, Alaska

Andersone, Z. 1999. Beaver: A new prey of wolves in Latvia? Comparison of winter and summer diet of *Canus lupus* Linnaeus, 1758. Pages 103-108 *In* P.E. Busher and R.M. Dzieciolowski, eds. Beaver protection, management, and utilization in Europe and North America. Kluwer Academic/Plenum Publishers, NY.

Baker, B. W., and E. P. Hill. 2003. Beaver (Castor canadensis). Pages 288-310 *In:* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. Wild Mammals of North America: Biology, Management, and Conservation. Second Edition. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Boyce, M.S. 1974. Beaver population ecology in interior Alaska. M.S. Thesis, University of Alaska Fairbanks. 161 pp.

Boyce, M.S. 1981. Habitat ecology of an unexploited population of beaver in Interior Alaska. Page 155-186. *IN:* J. A. Chapman and D. Pursley, Ed. Proceeding of the Worldwide Furbearer Conference. Frostburg, Maryland, USA.

Brzyski, J. R. and B. Schulte. 2009. Beaver (Castor canadensis) impacts on herbaceous and woody vegetation in southeastern Georgia. Am. Midl. Nat. 162:74–86

Easter-Pilcher, A. 1990. Cache size as an index to beaver colony size in Northwestern Montana. Wildl. Soc. Bull. 18:110-113.

Euskirchen, E.S.; McGuire, A.D.; Chapin, F.S.; Rupp, T.S. 2010. The changing effects of Alaska's boreal forests on the climate system. Can. J. of Forest Res. 40: 1336-1346.

Hamfler, C. 2008. The shrinking of Lake Todatonten. Report to Kanuti National Wildlife Refuge, US Fish and Wildlife Service, Fairbanks, Alaska. 4pp.

Hay, K. G. 1958. Beaver census methods in the Rocky Mountain Region. J. of Wildl. Manage. 22:395-402

Hill, E. P. 1982. Beaver (*Castor canadensis*). Pages 256–81 *In:* J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. Johns Hopkins University Press, Baltimore. 1147 pp.

Hollis, A. L. 2007. Unit 24 furbearer. Pages 301-312 *in* P. Harper, editor. Furbearer management report of survey and inventory activities 1 July 2003 – 30 June 2006. Alaska Department to Fish and Game. Project 7.0 Juneau, Alaska, USA.

Kafcas, E. N. 1987. Census and Exploitation of a discrete beaver population in Michigan. M. S. Thesis. Central Michigan University. 78 pp.

U.S. Fish and Wildlife Service. 2008. Kanuti National Wildlife Refuge Revised Comprehensive Conservation Plan. U. S. Fish and Wildlife Service, Anchorage, Alaska.

Kellie, K.A. and R.A. DeLong 2006. GeoSpatial survey operations manual. Alaska Department of Fish and Game. Fairbanks, Alaska, 55 pp.

Koontz, K.C. 1968. Small game and furbearers of the Rampart Dam impoundment area. M.S. Thesis, University of Alaska Fairbanks. 165 pp.

Marcotte, J.R. and T. L. Haynes. 1985. Contemporary resource use patterns in the Upper Koyukuk Region, Alaska. Technical Paper # 93. Alaska Department of Fish and Game, Division of Subsistence. Fairbanks, Alaska. 122pp.

Novak, M. Determining the average size and composition of beaver families. 1977. J. Wildl. Manage. 41:751-754

Osmundson, C.L. 1990. Dynamics of beaver food caches and cache size as a predictor of colony size in Wyoming. M.S. Thesis. University of Wyoming, Laramie, Wyoming. 69 pp.

Payne, N. F. 1981. Accuracy of aerial censusing for beaver colonies in Newfoundland. J.of Wildl. Manage. 45:1014-1016.

Reeves, G. 2007. Beaver ecology on the West Copper River Delta, Alaska. M.S. Thesis. Oregon State University, Corvallis Oregon. 96 pp.

Riordan, B., D. Verbyla, and A. D. McGuire (2006), Shrinking ponds in subarctic Alaska based on 1950–2002 remotely sensed images, *J. Geophys. Res.*, 111: G04002, doi:10.1029/2005JG000150

Rupp, T. S. and A. Springsteen. 2009a. Projected climate change scenarios for the Bureau of Land Management Eastern Interior Management Area, Alaska, 2001 – 2099. Report prepared for the Bureau of Land Management. University of Alaska, Fairbanks, Alaska. 10pp.

Rupp, T.S and A. Springsteen. 2009b. Summary Report for Kanuti National Wildlife Refuge: Projected Vegetation and Fire Regime Response to Future Climate Change in Alaska. May 15th 2009.

Saperstein, L. 2001. Kanuti National Wildlife Refuge, 2001 Beaver Cache Survey. Unpublished trip report. Kanuti National Wildlife Refuge, Fairbanks, Alaska.11 pp.

SNAP [Scenarios Network for Alaska Planning]. 2009. Climate change impacts on water availability in Alaska. University of Alaska, School of Natural Resources and Agriculture Sciences. http://www.snap.uaf.edu/projects/climate-change-impacts-water-availability-alaska

Swank, W. G. and F. A. Glover. 1948. Beaver censusing by airplane. J. of Wildl. Manage. 12:214

Swenson, J.E., S.J. Knapp, P.R. Martin, and T.C. Hinz. 1983. Reliability of aerial cache surveys to monitor beaver population trends on prairie rivers in Montana. J.of Wildl. Manage. 47: 697-703.

Ver Hoef, J.M. 2001. Predicting finite populations from spatially correlated data. 2000 Proceedings of the Section on Statistics and the Environment of the American Statistical Association, pp. 93-98.

Ver Hoef, J.M. 2002. Sampling and geostatistics for spatial data. Ecoscience 9:152-161.

Ver Hoef, J. M. 2008. Spatial methods for plot-based sampling of wildlife populations. Environ. Ecol. Stat. 15:3– 13.

Woo, M and J. M. Waddington 2003. Effects of Beaver Dams on Subarctic Wetland Hydrology. Arctic **43: 223-230.**

Appendix 1

Survey: KANUTIBEAVER
Year: 2002
Season: Fall

REQUEST PARAMETERS	
Analysis Column:	[TOTAL_CACHE]
Analysis Area:	InTotSurvey
Strata Column:	StratName
Counted Column:	Counted
Unit Area Column:	AreaMi

RESULTS

Estimate	
Population Estimate:	1135.974
Standard Error:	68.3676

Confidence Intervals		
Confidence	Interval (Beaver)	Interval (proportion of the mean)
80%	1048.358 1223.591	0.07712905
90%	1023.520 1248.429	0.09899406
95%	1001.976 1269.972	0.1179587

SAMPLE DETAILS

Total Samples	Stratum N 1 HIGH 104 2 LOW 301 3 TOTAL 405	Total Area	Stratum Area 1 HIGH 555.654 2 LOW 1606.642 3 TOTAL 2162.296
Sample Sizes	Stratum n 1 HIGH 54 2 LOW 45 3 TOTAL 99	Area Sampled	Stratum Area 1 HIGH 288.221 2 LOW 239.806 3 TOTAL 528.027
Beaver Counted	Stratum Counted 1 HIGH 347 2 LOW 67 3 TOTAL 414		

ESTIMATE DETAILS		
Stratum	HIGH	LOW
Empirical Semi-Variogram	distance gamma np 1 4.348378 0.3767230 122 2 9.677226 0.5517994 312 3 15.908526 0.6765060 356 4 21.994248 0.8099665 464 5 28.038067 0.6404395 376 6 34.213060 0.6979147 374 7 40.656378 0.5396222 286 8 47.032864 0.5907820 236	distance gamma np 1 4.328264 0.04393732 40 2 9.706362 0.06265421 114 3 15.910331 0.05470053 150 4 21.862401 0.06999589 202 5 28.296971 0.05994834 178 6 34.470063 0.08185403 224 7 40.240861 0.07740433 180 8 46.998817 0.06795290 148
Parameter Estimates	nugget parsil range 1 0.2205106 0.4419198 10.46093	nugget parsil range 1 0.06338955 0.005685945 18.53162

Survey: Beaver Cache
Year: 2003
Season: Spring

REQUEST PARAMETERS	
Analysis Column:	[TOTAL_CACHE]
Analysis Area:	InTotSurvey
Strata Column:	StratName
Counted Column:	Counted
Unit Area Column:	AreaMi

RESULTS

Estimate	
Population Estimate:	1337.087
Standard Error:	112.0907

Confidence Intervals		
Confidence	Interval (Beaver)	Interval (proportion of the mean)
80%	1193.437 1480.737	0.1074350
90%	1152.714 1521.460	0.1378914
95%	1117.393 1556.781	0.1643077

SAMPLE DETAILS			
Total Samples	Stratum N 1 HIGH 101 2 LOW 304 3 TOTAL 405	Total Area	Stratum Area 1 HIGH 539.642 2 LOW 1622.654 3 TOTAL 2162.296
Sample Sizes	Stratum n 1 HIGH 46 2 LOW 30 3 TOTAL 76	Area Sampled	Stratum Area 1 HIGH 245.824 2 LOW 160.410 3 TOTAL 406.234
Beaver Counted	Stratum Counted 1 HIGH 343 2 LOW 58 3 TOTAL 401		

ESTIMATE DETAILS		
Stratum	HIGH	LOW
Empirical Semi-Variogram	distance gamma np 1 4.238416 0.6891379 78 2 9.827266 0.6885743 188 3 15.905018 0.9066762 192 4 22.094796 0.9359846 230 5 28.197090 0.9443090 250 6 34.490290 0.9288224 254 7 40.678911 0.7021104 266 8 46.892341 0.7624629 222	distance gamma np 1 3.970489 0.15868018 12 2 9.967008 0.09542133 46 3 16.363296 0.11099051 54 4 21.706705 0.15224936 86 5 28.221333 0.11312635 98 6 34.659603 0.15563879 92 7 40.878472 0.13746630 82 8 46.929939 0.15045787 92
Parameter Estimates	nugget parsil range 1 0.5132366 0.3497272 8.149778	nugget parsil range 1 0.09124615 0.04659552 22.69680

Survey: BEAVER CACHE SURVEY
Year: 2010
Season: Fall

REQUEST PARAMETERS	
Analysis Column:	[TOTAL_CACHE]
Analysis Area:	InTotSurvey
Strata Column:	StratName
Counted Column:	Counted
Unit Area Column:	AreaMi

RESULTS

Estimate	
Population Estimate:	1103.719
Standard Error:	103.6572

Confidence Intervals		
Confidence	Interval (Beaver)	Interval (proportion of the mean)
80%	970.8769 1236.5611	0.1203586
90%	933.218 1274.220	0.1544786
95%	900.5545 1306.8834	0.1840726

SAMPLE DETAILS			
Total Samples	Stratum N 1 HIGH 107 2 LOW 299 3 TOTAL 406	Total Area	Stratum Area 1 HIGH 571.446 2 LOW 1596.228 3 TOTAL 2167.674
Sample Sizes	Stratum n 1 HIGH 60 2 LOW 40 3 TOTAL 100	Area Sampled	Stratum Area 1 HIGH 320.206 2 LOW 213.686 3 TOTAL 533.892
Beaver Counted	Stratum Counted 1 HIGH 316 2 LOW 60 3 TOTAL 376		

Stratum	HIGH	LOW
Empirical Semi-Variogram	distance gamma np 1 4.450987 0.2162352 126 2 9.674408 0.8021136 316 3 15.969605 0.7921687 360 4 21.910547 0.8304182 396 5 28.220675 0.8056772 430 6 34.312825 0.5386220 450 7 40.662063 0.6825738 372 8 46.776321 0.5669339 348	distance gamma np 1 4.684468 0.38440735 16 2 9.262915 0.09809618 70 3 16.220251 0.15437687 100 4 21.738271 0.15336900 120 5 28.106491 0.19467865 132 6 34.694948 0.28148959 158 7 40.477015 0.17891069 152 8 46.774616 0.18369790 154
Parameter Estimates	nugget parsil range 1 2.694694e-10 0.823968 7.294802	nugget parsil range 1 0.1760758 1.638822e-08 57.48418