
GAME REPORT

**POPULATION SURVEYS, SURVIVAL, AND REPRODUCTION OF
RESIDENT AND TRANSLOCATED (2006/2007) MOUNTAIN GOATS IN THE
BLACK HILLS OF SOUTH DAKOTA**

Completion Report

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ABSTRACT

POPULATION SURVEYS, SURVIVAL, AND REPRODUCTION OF RESIDENT AND TRANSLOCATED (2006/2007) MOUNTAIN GOATS IN THE BLACK HILLS OF SOUTH DAKOTA

Mountain goat (*Oreamnos americanus*) populations within the Black Hills of South Dakota originated from a single transplant of six animals from Canada in the 1920s. As an effort to counter potential genetic depression, in 2006 and 2007 the mountain goat population in the Black Hills was supplemented with 18 mountain goats transplanted from Colorado. All transplanted animals, and an additional 23 resident mountain goats, were tagged and/or radio-collared. The transplanted animals experienced high mortality the first year after release, with an annual survival rate of 36%. Survival for the second, third, and fourth year was high (100%). Annual survival of resident animals ranged from 70-100%. Reproduction for the transplanted mountain goats for the first three years was also low compared to reproduction of resident animals (15% and 57 %, respectively). Home range estimates for all radio-collared animals averaged 5.6 km².

Radio-collared individuals provided opportunity for aerial mark-resight population estimates to be conducted. The mean detection probability for radio collared mountain goats from 2007 to 2012 was 18.9%. Population estimates from 2007-2013, utilizing the mean detection rate, ranged from 55-111 animals.

PREFACE

This report summarizes results of research conducted by South Dakota Department of Game, Fish and Parks personnel(Study No. XXX under Pittman-Robertson project W-75-R).

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INTRODUCTION

Mountain Goats (*Oreamnos americanus*) were introduced into the Black Hills during the 1920's. By the late 1940's herd size was estimated at 300-400 animals and remained stable throughout the early 1970's. During the 1980's the population appeared to be declining and in 1987 following a comprehensive study the pre-kidding population size was estimated to be approximately 125 animals (Benzon and Rice 1987). Managers hypothesized that the decline was due to increased human recreational activity, pine encroachment, overharvest, and/or genetic depression as a result of the founder effect.

In the early 2000's population estimates were around 160. From 2003 through 2006 estimates declined to around 70. The mountain goat season was closed in 2007 and has remained closed through 2013.

Substantial die-off of trees has taken place in and around the Black Elk Wilderness area in the primary mountain goat range due to mountain pine beetle (*Dendroctonus ponderosae*). Approximately 50% of the wilderness is affected. It is believed that this will eventually lead to an improvement in habitat conditions for mountain goat but as of 2013 most of the affected trees are still standing.

METHODS

Capture and Marking

Mountain goats transplanted from Colorado were equipped with VHF (very high frequency) radio collars. Collars had colored jackets to assist in individual identification. Two individuals received ear tags instead of radio collars.

Additional non-transplanted resident mountain goats were captured by hand-held net guns or clover traps over several years before and after the transplant took place. Net gunning was done primarily at Mount Rushmore National Memorial where mountain goats were accustomed to vehicles and people. Clover trapping was done primarily in the Battle Creek area using salt blocks as bait. Resident mountain goats were marked with VHF radio collars (with or without a colored jacket) and ear tags, or an ear tag only. A study area map showing general sub-herd boundaries and the locations of transplanted and resident mountain goats can be found in Figure 1. Sub-herd boundaries were delineated by anecdotal observations and represent groups that typically did not interact with each other.

Animal Movements

Radio collared animals were located once every two to three weeks during 2007 to 2009. Recorded locations included visual sightings of marked individuals, often from a distance with locations calculated by triangulation using a compass and ArcPad 7.1 or by finding the location on a topographic map of a GPS unit.

Recorded locations also included locations based on telemetry only when visual triangulation was not possible. An estimate of location accuracy was recorded with each observation. The accuracy estimate varied from 10 meters when the observer was at the exact location the animal was observed, to 200 meters when the observer viewed the animal from a distance with limited terrain reference. Additional observations with an estimated accuracy of > 200 meters were censored from analysis.

Home ranges were calculated for animals that had at least 10 locations using 95% minimum convex polygons. Home range sizes were obtained using statistical package R with adehabitatHR (R Core Team 2012).

Survival

Radio collared animals were monitored for mortality two to five days per week. Program Mark was used to estimate weekly survival rates using the Kaplan-Meier known-fate model (White and Burnham 1999). Confidence intervals were derived using the maximum likelihood estimator. Two male mountain goats that left the study area were censored from analyses.

Reproduction

Radio collared animals were monitored for kidding production in June and July of 2007 through 2009. Reproductive rates for transplanted and resident mountain goats were compared using chi-squared tests combining all three years. Sample size did not allow comparison on an annual basis.

Population Size Estimation

From 2007 to 2012, population size estimation was done using mark-resight methodology from a helicopter. The entire mountain goat range was surveyed three times each year during the last week of May and/or the first two weeks of June. From 2007 to 2011, Robinson 44 helicopters were used to conduct the survey. Approximate half-mile width transects were flown at an altitude of 100-200 meters above ground level. Deviations from transects and above ground level altitudes were flown to circle higher quality habitats. From 2012 to 2013 a McDonnell Douglas 500 aircraft was used with the doors removed. A separate mark-resight estimate was calculated for each of the three days and the average was taken. Due to the small number of marked animals and one survey that resulted in observing zero marked animals, the Chapman mark-resight method was necessary. Standard Lincoln-Peterson mark-recapture is biased to overestimate population sizes with small sample sizes and it has no mechanism for observing zero marked animals (Chapman 1951). Since kidding is underway during the survey period, the number of kids sighted during the flights was not used to estimate the total number of kids. The year-round average ratio of kids to adults from 2007 to 2009 of all ground observations was used to estimate the number of kids.

During the 2013 survey, many of the collar batteries had expired and therefore we estimated population size using the mean detection rate from the 18 flights conducted from 2007 to 2012 combined.

RESULTS

Capture and Marking

In 2006 and 2007, a total of 18 mountain goats (10 females, 8 males) were captured in Colorado and released in South Dakota near Camp Remington. Two of the transplanted mountain goats received ear tags instead of radio collars (Table 1).

From 2005 to 2009, 16 resident mountain goats (13 females, 3 males) were captured and radio collared. Additionally, seven resident mountain goats too young to collar were captured and ear tagged (Table 2).

Animal Movements

The mean multi-year home range size from 2007 to 2009 was 2.65 km² (SE = 0.90, n = 13). Male home range size was 5.5 km² (SE = 1.32, n = 4) and females was 1.4 km² (SE = 0.35, n = 9), but the difference was not significant (P = 0.18). Transplanted female home range size (2.2 km²; SE = 1.0, n = 3) was not significantly different than resident females (1.0 km², SE = 0.3, n = 6; P = 0.13). Due to limited sample size, no analysis was performed comparing home range size of transplanted males and resident males (n = 2 and n = 2). A list of mountain goats with home range sizes and number of locations can be found in Table 3.

Transplanted goats were rarely observed interacting with resident goats, or in groups larger than three. One transplanted nanny and one transplanted billy were often seen together. There was, however, ample opportunity for unobserved interactions between transplanted and resident mountain goats. Uncollared resident mountain goats were observed throughout the home ranges of transplanted goats. Overlap between the transplanted and resident animals can be seen in Figure 1.

One transplanted male dispersed out of the Black Hills and remained in the Cheyenne River valley to the east until it was lost. Another transplanted male's collar failed, and later its carcass was found in Wyoming just west of the South Dakota boarder near Deerfield Lake.

Survival

Annual survival rates ranged from 0.36 – 1.00 for transplanted mountain goats and 0.70 -1.00 for resident mountain goats (Table 4. Survival rates of resident and transplanted mountain goats from 2007 – 2011. Table 4). The transplanted individuals experienced very low survival (0.36, $n = 14$, $SE = 0.12$, 95% $CI = 0.16$ to 0.61) during the first year after being released. Causes of death during the first year for transplanted animals included mountain lion (*Puma concolor*) predation (44%, $n = 4$), falling, drowning, and other unknown causes. Annual survival rates were quantified for five resident individuals the same year of the release and were 0.70 ($SE = 0.24$, 95%, $CI = 0.18$ to 0.96); however, small sample size did not allow for statistical comparison to the transplanted group.

Survival for the transplanted group for the following three years was 1.00 (SE = 0.00). A complete list of all causes of death and dates can be found in Table 4 and Table 2.

Reproduction

Throughout the duration of the study there was a total of 13 opportunities for transplanted nannies to have kids during the three year period (7 in 2007, 3 in 2008 and 3 in 2009). Nannies were observed with kids two times, thus an overall reproductive rate of 15.4%. In both cases where transplanted nannies gave birth, the kids died by July. In one case both the nanny and kid were predated upon by a mountain lion, in the other case the kid carcass was not found and no cause of death could be determined.

During the same three years there was a total of 21 opportunities for collared resident nannies to have kids (4 in 2007, 6 in 2007 and 11 in 2009). They were observed having kids 12 times, giving them an overall reproductive rate of 57.1%. One kid was known to have died by July from unknown causes.

The proportion of collared transplanted goats that gave birth to kids was significantly lower than that of resident mountain goats (chi-square = 5.781, df = 1, $p = 0.016$).

Population Size Estimation

From 2007 to 2012, the adult population estimate using Chapman mark-resight methodology ranged from 34 to 164 (Table 5 and Figure 2). Indicated in Table 5, the year-round average ratio of kids to adults from 2007 to 2009 of 0.22, (SE = 0.015, n = 936 individuals in 346 groups) was used to estimate the number of kids. Observations from the flights including the number of animals sighted and the number of marks available and re-sighted can be found in Table 6.

The mean detection rate from 18 flights was 0.189 (SE = 0.0239, n = 270 individuals over 18 flights). This rate was similar to the 0.165 rate reported by Benzon and Rice (1987) which was based on six spring helicopter flights in 1986 and 1987. Population estimates using the mean detection rate ranged from 55 to 104 (Table 7 and Figure 3). Using the mean detection rate results in population estimates with less variation when compared to mark-resight estimates (Table 8).

MANAGEMENT IMPLICATIONS

Population Estimation

Population size estimates vary less dramatically when using mean detection rate estimates versus mark-resight estimates (Table 8). Mark-resight estimates were derived using an average sample size of 15 marked individuals. We expect populations of mountain goats do not fluctuate drastically from one

year to the next, therefore we recommend using the mean detection rate (18.9%) for estimating the population size to mitigate this effect.

When utilizing the mean detection rate, caution should be used when interpreting the results of any single year's estimate. It would be recommended to use a running average of three years to determine trends in population growth or decline.

Beginning in 2012, a McDonnell Douglas 500 aircraft was used with the doors removed for better viewing. As a result, it is possible that this may have increased detection rates causing the population estimates in 2012 and 2013 to be biased high.

Future Research

In September 2013, SDGFP plans on obtaining 20-30 mountain goats from Utah and then releasing them into the Black Elk Wilderness Area. All captured individuals will be radio-collared prior to being released and monitored for survival. Attempts will also be made to collar additional residents using salt licks and Clover traps. The goal of future research will be to use all collared individuals for refining the mean detection rate using the McDonnell Douglas 500 aircraft.

Table 1. Mountain Goats transplanted from Colorado, 2006-2007.

Number	Mark Type	Sex	Age at Capture	Capture Date	Death Date	Death Cause	Comment
1	Collar	F	4.4+	11/01/2006	10/29/2010	Lion	
2	Collar	M	4.4+	11/01/2006	**	**	Lost contact
3	Collar	F	4.4+	11/01/2006			
4	Collar	F	3.4	11/01/2006	10/29/2010	Unknown	
5	Collar	F	4.4+	11/01/2006	07/09/2007	Lion	
6	Eartag	F	1.4	11/01/2006	**	**	
7	Collar	M	4.4+	11/02/2006			
8	Collar	M	3.4	11/02/2006	08/30/2007	Lion	
9	Collar	M	8.4	11/02/2006	04/15/2009	Unknown	Lost contact*
10	Collar	F	10.4	11/02/2006	12/15/2006	Old Age	
11	Collar	M	4.4+	11/02/2006	09/27/2007	Unknown	
12	Collar	M	4.4+	11/02/2006	03/16/2007	Fall	
13	Collar	F	3.4	11/02/2006	12/15/2006	Drowned	
14	Eartag	M	1.4	11/02/2006	**	**	
15	Collar	F	4.7+	02/21/2007	03/16/2007	Lion	
16	Collar	F	4.7+	02/21/2007	07/31/2007	Lion	
17	Collar	F	2.7	02/21/2007	07/02/2007	Unknown	
18	Collar	M	6.7	02/22/2007			

*Left study area with non-functioning collar. Carcass found in WY. **Status not known as of May 2012 due to not having a collar or leaving the study area. Three, seven, and 18 were alive as of May 2012.

Table 2. Resident mountain goats captured in South Dakota, 2004-2009.

Number	Mark Type	Sex	Age at Capture	Capture Date	Death Date	Death Cause	Comment
1	Collar	F	1.2	08/11/2004	11/11/2004	Lion	
2	Collar	F	6.2	08/17/2004	06/12/2007	Lion	
3	Eartag	M	1.2	08/17/2004	-	-	
4	Collar	F	7.1	07/14/2005	10/29/2010	Fence at Rushmore	
5	Collar	F	8.2	08/25/2005	09/19/2011	Fence at Rushmore	
6	Collar	F	3.4	10/30/2007			
7	Collar	M	5.4	10/30/2007			
8	Collar	F	4.9	05/07/2008			
9	Collar	F	2.9	05/09/2008			
10	Collar	F	3.9	05/12/2008			
11	Eartag	F	1.0	05/21/2008	-	-	
12	Eartag	F	1.0	05/21/2008	-	-	
13	Collar	M	2.0	05/30/2008			
14	Collar	M	3.3	09/11/2008	-	-	Lost contact
15	Collar	F	4.1	07/15/2009			
16	Eartag	F	1.1	07/15/2009	-	-	
17	Collar	F	4.1	07/16/2009			
18	Collar	F	3.1	07/21/2009			
19	Eartag	M	1.1	07/21/2009	-	-	
20	Collar	F	4.2	07/30/2009	-	-	Lost contact
21	Eartag	M	0.2	07/30/2009	-	-	
22	Collar	F	2.2	08/07/2009	-	-	Lost contact
23	Eartag	M	1.2	08/07/2009	-	-	

Table 3. Home range estimates and sample sizes of mountain goats in the Black Hills, 2007-2009.

Source	Sex	Total	Home Range	Locations Used in
CO	F	15		
CO	F	29	3.90	22
CO	F	24	0.39	20
CO	F	19	2.43	13
CO	F	6		
CO	F	11		
CO	F	4		
CO	F	4		
CO	M	21	0.97	14
CO	M	6		
CO	M	29	10.74	18
CO	M	5		
SD	F	19	0.55	14
SD	F	4		
SD	F	24	0.48	19
SD	F	24	0.62	20
SD	F	24	0.79	19
SD	F	1		
SD	F	19	2.54	14
SD	F	24	0.90	19
SD	F	1		
SD	F	1		
SD	F	3		
SD	M	13	1.94	10
SD	M	21	8.24	14

Table 4. Survival rates of resident and transplanted mountain goats from 2007 – 2011.

	Transplants			Residents		
	Survival	n	SE	Survival	n	SE
2007	0.36	14	0.12	0.70	5	0.25
2008	1.00	5	0.00	1.00	9	0.00
2009	1.00	5	0.00	1.00	14	0.00
2010	1.00	5	0.00	0.93	14	0.07
2011	0.52	5	0.24	0.85	13	0.10

Table 5. Mark-resight Chapman population estimates of mountain goats in the Black Hills.

Year	Mark-Resight Chapman Population Estimate (and with 22% added for kids)	SE	Confidence Interval (95%)
2007	42 (52)	11.5	20 - 65
2008	58 (71)	12.5	34 - 83
2009	34 (41)	5.5	23 - 44
2010	68 (83)	13.4	42 - 94
2011	65 (79)	16.8	32 - 98
2012	164 (200)	57.7	51 - 277

Table 6. Observations of mountain goats from aerial survey flights, 2007-2013.

Flight Date	Adults (1yrs+)	Kids	Marked	Available Marked
05/26/2007	9	0	1	13
05/27/2007	12	1	5	13
05/28/2007	14	1	6	13
06/02/2008	9	2	2	13
06/03/2008	12	1	2	13
06/04/2008	19	4	3	13
06/01/2009	5	0	3	14
06/04/2009	11	3	3	14
06/05/2009	16	4	6	14
06/08/2010	17	4	3	19
06/09/2010	20	3	5	19
06/10/2010	6	3	2	19
06/06/2011	17	1	4	16
06/08/2011	9	1	1	16
06/13/2011	5	2	1	16
06/08/2012	19	5	1	15
06/09/2012	13	3	0	15
06/10/2012	27	7	3	15
06/20/2013	23	10	2	NA
06/23/2013	23	14	3	NA
06/24/2013	17	5	4	NA

Table 7. Mean sightability population estimate of mountain goats in the Black Hills.

Year	Mean Sightability Population Estimate (and with 22% added for kids)	SE	Confidence Interval (95%)
2007	62 (75)	4.6	53 - 71
2008	71 (86)	5.4	60 - 81
2009	56 (69)	4.5	48 - 65
2010	76 (93)	6.0	64 - 88
2011	55 (67)	4.4	46 - 63
2012	104 (127)	7.9	89 - 120
2013	111 (136)	8.2	95 - 127

Table 8. Comparison of mountain goat population estimation techniques.

Method	Six-Year Mean Population Estimate	Six-Year Mean Population Range (min-max)
Mean Sightability	71	55 - 111
Mark-Resight	72	34 - 164

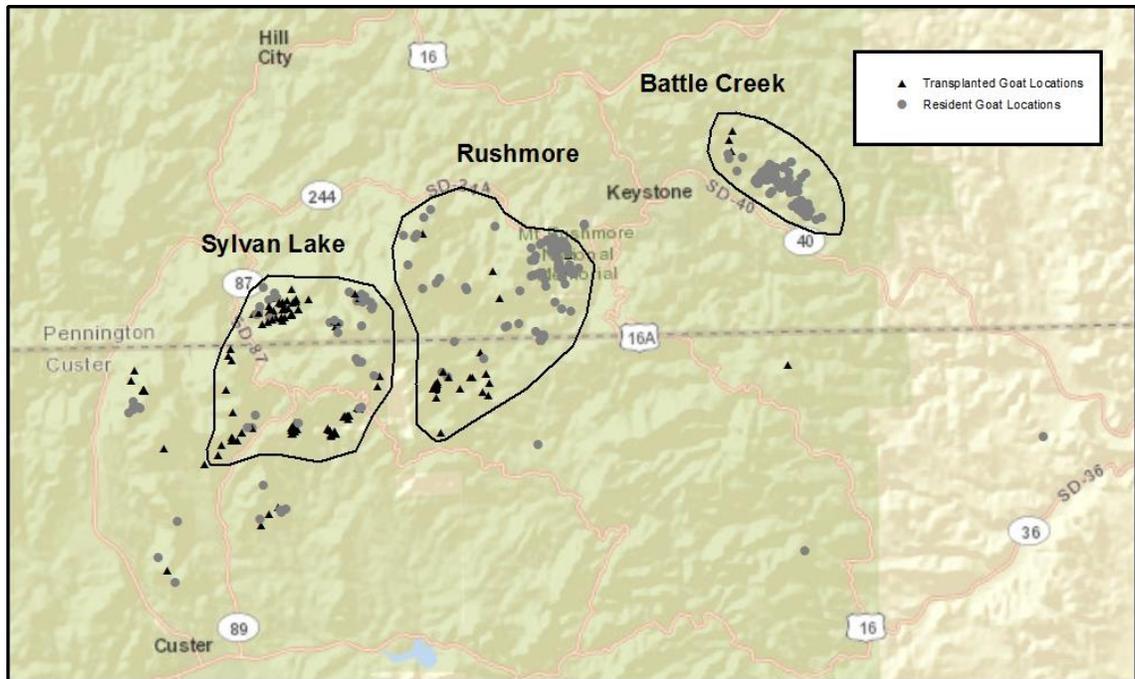


Figure 1. Locations of radio-collared mountain goats in the Black Hills from 2007-2009, and delineation of general sub-herd boundaries

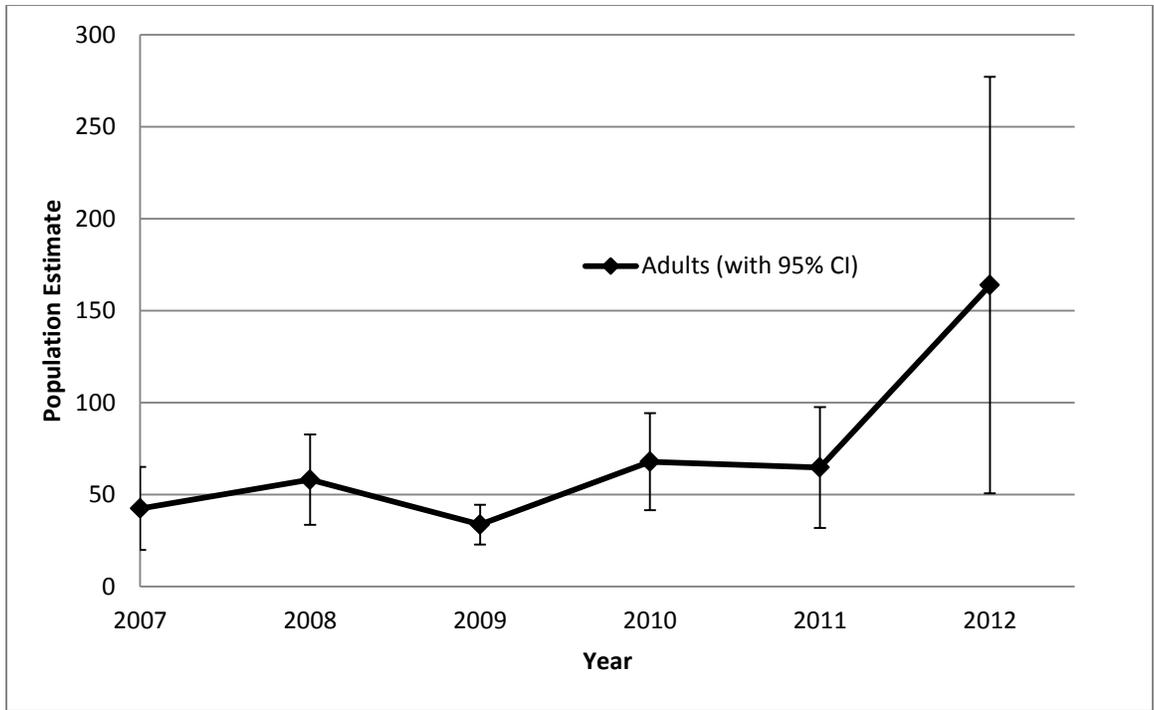


Figure 2. Chapman Mark-resight population estimates of mountain goats in the Black Hills.

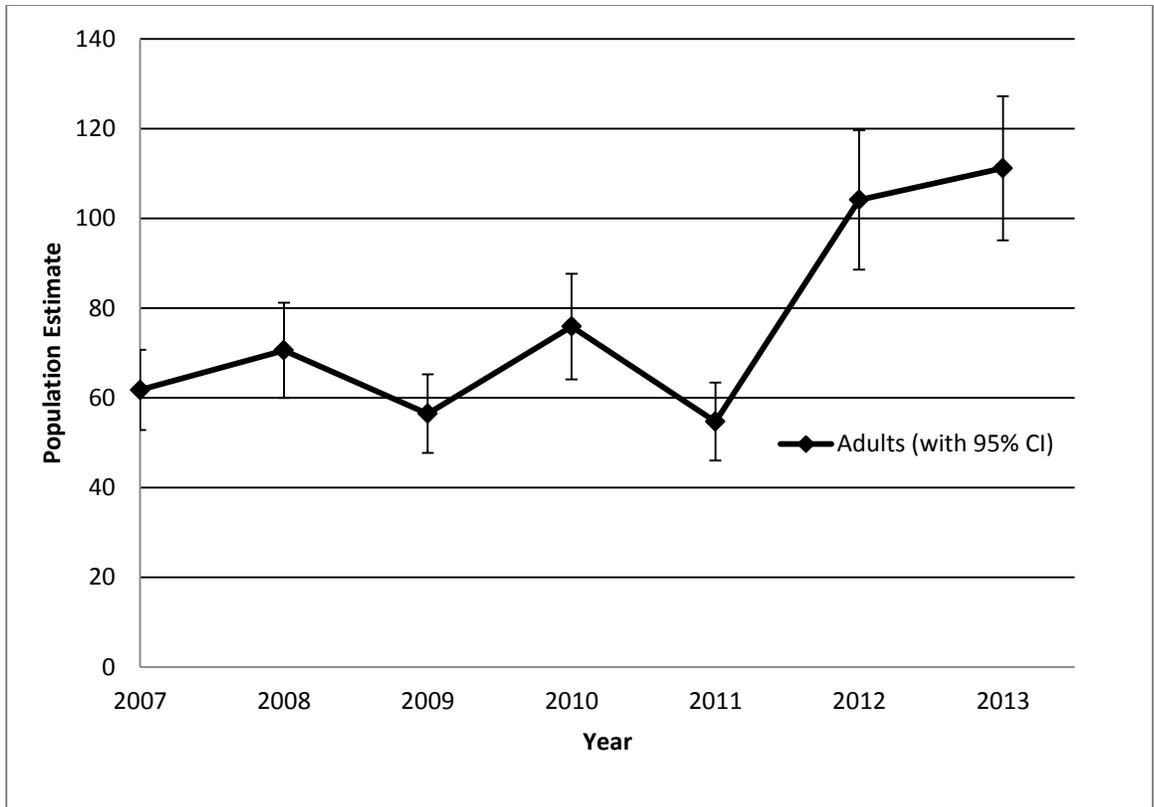


Figure 3. Mean sightability rate population estimates of mountain goats in the Black Hills.

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