MONITORING BEAVER CACHE ABUNDANCE ON TOGIAK NATIONAL WILDLIFE REFUGE

Annual Report

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ABSTRACT

The Alaska Department of Fish and Game conducted aerial beaver cache surveys on four southwest Alaska rivers from 1975-1987 to monitor beaver abundance. Togiak National Wildlife Refuge reinstated aerial beaver cache surveys in 2002 along thirteen rivers, including the four rivers previously surveyed. From 2002-2006, the average number of caches per river mile (with 95% confidence limits) was 0.87 (0.82, 0.92) for Unit 17A, 1.30 (1.10, 1.49) for Unit 17C and 1.20 (1.14, 1.27) for Unit 18. Over all survey years, there was significant variation in food cache rates among rivers and no significant trends in food cache rates over time except the Togiak, Ongivinuk, and Kanektok rivers.

INTRODUCTION

Beaver (*Castor canadensis*) are one of the most important furbearers in the northern Bristol Bay region of Alaska. Beaver are valuable as a source of income and food to residents in the region (Taylor 1983, Woolington 2004). The region has experienced some of the highest recorded beaver population densities in the state (Taylor 1983). Over 4,000 beavers were annually harvested in the region in the late 1950's (Taylor 1983). However, harvest numbers declined to less than 500 annually by the late 1990's (Woolington 2004). Commercial fishing is presently the primary economic activity in the region (Alaska Department of Commerce 2005). Variation in the region's commercial fishing prosperity dictated the beaver harvest effort in the past, with the secondary trapping income having greater importance during poor commercial fishing years (Taylor 1983, Woolington 2004). The decreased trapping effort experienced in the region in the late 1990's is primarily due to low fur prices, high fuel costs, and adverse weather conditions (Woolington 2004).

Beaver populations in the northern Bristol Bay region appear to be healthy. Long-time residents have reportedly observed an increased abundance in beaver over the last half century (La Vine and Lisac 2003). Primary sources of mortality for regional beaver populations are trapping, inclement winter weather conditions, and predation (Woolington 2004). Natural mortality can be elevated in winters with low temperatures and low snowfall. Such conditions can freeze shallow waters causing food caches to become ice-bound, resulting in more above ice movement for beaver, poorer body condition and increased susceptibility to predation (Smith and Peterson 1991, Woolington 2004).

Food caches are the primary winter food source for beaver colonies, generally with one cache associated with one colony (Hay 1958). However, instances occur where two food caches are adjacent to one lodge (Collins 2002). Aerial cache counts have been used throughout North America, and have proven to be an inexpensive monitoring method that provides a reliable index to the number of active beaver colonies (Swank and Glover 1948, Hay 1958, Bergerud and Miller 1977, Brown and Parsons 1979, Payne 1981, Swenson *et al.* 1983, Easter-Pilcher 1990). Aerial food cache surveys assume that all possible habitats within the sampling area are surveyed and that all food caches in the sampling area are detected. Cache counts provide information on gross changes in beaver populations, though this method cannot determine

annual variation in colony size or precise beaver population estimates (Swenson *et al.* 1983, Easter-Pilcher 1990). Predation rates may also factor into annual variation of cache numbers. Beavers act as an alternative prey source for wolves and other predators when primary prey populations have decreased (Novak 1987). The moose population in the northern Bristol Bay region is steadily increasing (Aderman and Woolington 2003), and caribou numbers, although they have increased since 1980, are currently declining (Collins et al. 2001, Valkenburg et al. 2001).

In order to maintain beaver populations and understand the dynamics of this resource, beaver populations in southwest Alaska have been monitored since the 1950's. Aerial cache surveys were conducted by the Alaska Department of Fish and Game in 1954 (Libby 1955) and the mid-1970's through 1987 (Collins 2002). Togiak National Wildlife Refuge (Togiak Refuge) reinstated aerial surveys on thirteen refuge rivers in 2002 (Collins 2002).

OBJECTIVES

Monitor beaver abundance on the Togiak, Ongivinuk, Weary, North Fork Goodnews, Middle Fork Goodnews, Kanektok, Tuklung, Gechiak, Pungokepuk, Quigmy, Osviak, Kulukak, and Arolik rivers.

STUDY AREA

Togiak Refuge, established in 1980, encompasses approximately 4.7 million acres of land at the confluence of Kuskokwim and Bristol Bays in southwestern Alaska. The Refuge includes portions of State Game Management Units (GMU) 17 and 18 (Figure 1).

There are over 1,500 miles of stream and river habitat within Togiak Refuge. Cottonwoods (*Populus* spp.) dominate the overstory on surveyed rivers, with willow (*Salix* spp.), alder (*Alnus* spp.), and birch (*Betula* spp.) in the understory. Dwarf shrubs are found near riverine systems, including Labrador tea (*Ledum palustre*), crowberry (*Empetrum nigrum*), dwarf birch (*Betula nana*), lowbrush blueberry (*Vaccinium uliginosum*), cranberry (*Oxycoccus microcarpus* and *V. vitus-idea*), and bearberry (*Arctostaphylos alpina*).

Togiak Refuge experiences both subarctic maritime climate near the coast and subarctic continental climate towards the interior (USFWS 1990, Walsh *et al.* 2006). Consequently, temperature and precipitation vary by location within the refuge. For example, respective mean maximum and minimum temperatures in Dillingham located at the southeastern edge of the refuge, are 15.8 and 7.6°C during summer, and -5.6 and -12.6°C during winter. Mean maximum and minimum temperatures at Cape Newenham, located at the southwestern edge of the refuge, are 11.1 and 7.1°C for summer, and -4.6 and -9.5°C during winter (National Climatic Data Center 2006). Average annual precipitation at Dillingham and Cape Newenham is 64.7cm and 90.1cm, respectively. Annual coastal snowfall averages 152-178cm, but snowfall in the mountains can be greater than 381cm (USFWS 1990).

Figure 1. Surveyed rivers on Togiak Refuge, 2002-2006.

METHODS

Aerial food cache surveys were conducted from 1975-1987 and 2002-2006 on the Togiak, Kanektok, Ongivinuk and Weary Rivers. Additional rivers surveyed from 2002-2006 include North Fork Goodnews, Middle Fork Goodnews, Tuklung, Gechiak, Pungokepuk, Quigmy, Osviak, Kulukak, and Arolik rivers.

Surveys were conducted after complete leaf fall and prior to snow cover for optimal visibility of food caches. The surveyed area of each river included the main river channels and adjacent side channels within the flood plain. Braided areas or wide channels were circled repeatedly to ensure that all caches were detected. Detected food caches were tallied and locations were recorded. Multiple caches directly adjoining a single lodge were counted as a single cache. A relative abundance index was then calculated as (total number of caches) / (total number of surveyed river miles) for each river system.

Food cache surveys conducted from 2002 through 2006 occurred on the same sections of each river. Surveys conducted 1975-1987 of the Kanektok and Togiak Rivers differed from the 2002-2006 surveys (Table 1). The 1975-1987 surveys of the Kanektok River were 53 miles in length, 27 miles shorter than current surveys. The start and end points of those surveys is not known. Current surveys cover the entire Kanektok River. The 1975-1987 surveys for the

Togiak River were 60 miles, 12 miles longer than the current survey section initiated in 2002. Current surveys do not include the lower 12 miles of the river. Future surveys will cover the entire 60 miles of the Togiak River for comparison to past surveys. Compared to the upper 48 miles of the Togiak River, the lower 12 miles is larger and more complex with many side channels. Spatial data of beaver caches was not collected from 1975-1987 surveys, and data from specific river sections cannot be compared. The surveyed stretch for the Ongivinuk and Weary Rivers during 1975-1987 surveys is identical to the current surveys.

An analysis of covariance (ANCOVA) model was used to investigate differences among rivers in mean number of food caches/mile and in temporal trends in mean number of food caches/mile. The ANCOVA model used cache/mile rates as the dependent variable and year and river as covariates, to detect differences in mean number of cache/mile; and interaction effects between year and river to detect differences in temporal trends. Annual food cache trends were determined by calculating the slope of the line with 95% confidence for each river over time. Directional trends were indicated when slopes were significantly different than zero. A Tukey's HSD was used to test differences among mean cache/mile rates of the rivers.

The ANCOVA and Tukey's HSD were conducted in the statistical freeware package R v. 2.4.0 (R Development Core Team 2005). The ANCOVA included all data from 1975-2006 and the Tukey's HSD included all data from 2002-2006 surveys.

RESULTS

Surveys were conducted from 1975-1987 and from 2002-2006. Surveys occurred September through November. Average cache/mile rates have ranged from 0.5 to 1.6 (Table 1, Figure 2).

Table 1. Beaver cache/mile, Togiak National Wildlife Refuge, 1975-1987[a], and 2002-2006.

		Caches per Mile															
River	**Miles**	**1975**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**2002**	**2003**	**2005**	**2006**
Kanektok[b]	53[c]							2.4		1.8				2.1	1.66	1.9	1.6
Ongivinuk[b]	32	0.8	1.5	1.4	1	1.7	2	1.7	1.5	1.1	1.3	1.9	1.6	1.1	1.07	1.3	1.2
Togiak[b]	60[d]	0.4	0.9	1.1	0.6	0.8	1		1	0.6	0.7	1		1	1.13	0.8	0.5
Weary[b]	22					1.5								2.3	0.91	1.8	1.7
Arolik	40													1.5	1.18	1.3	1.1
Gechiak	10													0.6	0.8	0.6	0.6
Goodnews – MF	30													0.4	0.41	0.4	0.3
Goodnews – NF	30													1	0.96	0.8	0.9
Kulukak	40													1.5	1.43	1.2	1.4
Osviak	30													0.7	0.52	0.6	0.6
Pungokepuk	10													0.2	0.21	0.4	0.5
Quigmy	29													0.5	0.52	0.7	0.7
Tuklung	20													0.8	0.82	1.4	0.6
Total Caches		49	102	111	90	132	124	127	108	166	84	121	51	598	508	462	413
Total Miles		92	92	92	92	114	92	85	92	145	92	92	32	421	421	421	421
Average Cache / Mile		0.5	1.1	1.2	1.0	1.2	1.3	1.5	1.2	1.1	0.9	1.3	1.6	1.4	1.2	1.1	1.0

a Taylor 1984; Machida 1986; ADFG Unpublished data
b Rivers historically surveyed that were reinstated within Togiak National Wildlife Refuge
c 2002-2006 distance surveyed measured as 80 miles
d 2002-2006 distance surveyed measured as 48 miles

Rivers differed significantly ($p<0.0001$) in mean number of food caches/mile (Table 2). Surveyed rivers also varied ($p = 0.047$) in temporal trends in number of food caches/mile

(Table 2). The ANCOVA model accounted for approximately 85% of the total variability in food cache/mile ($r^2 = 0.8550$, $p<0.0001$), with differences in means across rivers accounting for approximately 77% of the total variation.

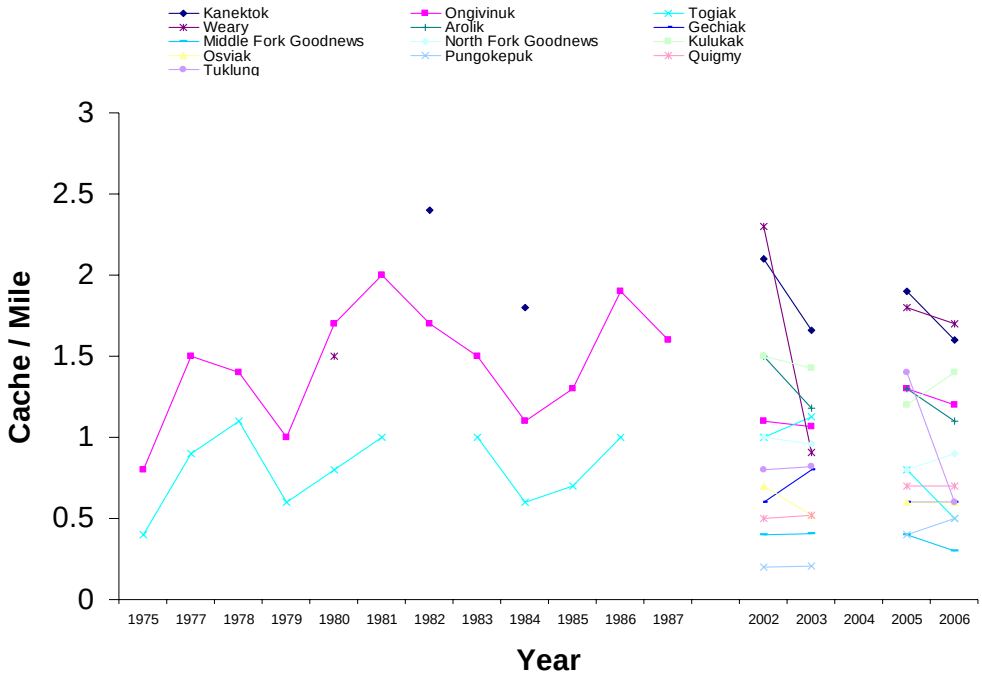

Figure 2. Beaver cache abundance on surveyed rivers from 1975-1987 and 2002-2006.

Three rivers demonstrated temporal trends in beaver cache rates that were significantly different than zero (Table 3, Figure 3). The only river exhibiting a statistically significant positive annual trend estimate was the Togiak River (slope of line = 0.00185), while the Ongivinuk River and Kanektok River exhibited a statistically significant negative annual trend (slope = -0.0129 and -0.04355, respectively). The trend estimates of these three rivers were all of very small magnitude. The estimated annual trends of all other rivers were not significantly different than zero. Tukey's HSD test of mean cache rates for rivers resulted in the Kanektok and Weary Rivers showing clearly higher cache abundance than remaining rivers (Figure 4). The remaining rivers fell into a continuum of food cache/mile rates, overlapping with groups of both higher and lower cache abundance.

Table 2. Results of ANCOVA model evaluating the relationship of cache rate with year and rivers for surveys conducted in 1975-2006.

Comparison Source	df	SS	MS	*F*	*P*
River	12	17.0588	1.4216	22.6666	<.0001
Year	1	0.3087	0.3087	4.9214	0.031
Interaction	12	1.4863	0.1239	1.9749	0.04655
Residuals	51	3.1985	0.0627		

Table 3. Results of ANCOVA annual beaver cache trend estimates (slope) for rivers surveyed between 1975-2006.

River	Slope	Lower Confidence Limit	Upper Confidence Limit
Pungokepuk	0.11	-0.04711	0.26711
Goodnews MF	0.0734	-0.08371	0.23051
Quigmy	0.0414	-0.11571	0.19851
Weary	0.01696	-0.00553	0.03945
Tuklung	0.015	-0.14211	0.17211
Togiak	0.00185	0.00138	0.00232
Osviak	-0.0065	-0.16361	0.15061
Ongivinuk	-0.0129	-0.01337	-0.01243
Gechiak	-0.04	-0.19711	0.11711
Kanektok	-0.04355	-0.06599	-0.02111
Kulukak	-0.045	-0.20211	0.11211
Arolik	-0.0625	-0.22026	0.09526
Goodnews NF	-0.13	-0.28711	0.02711

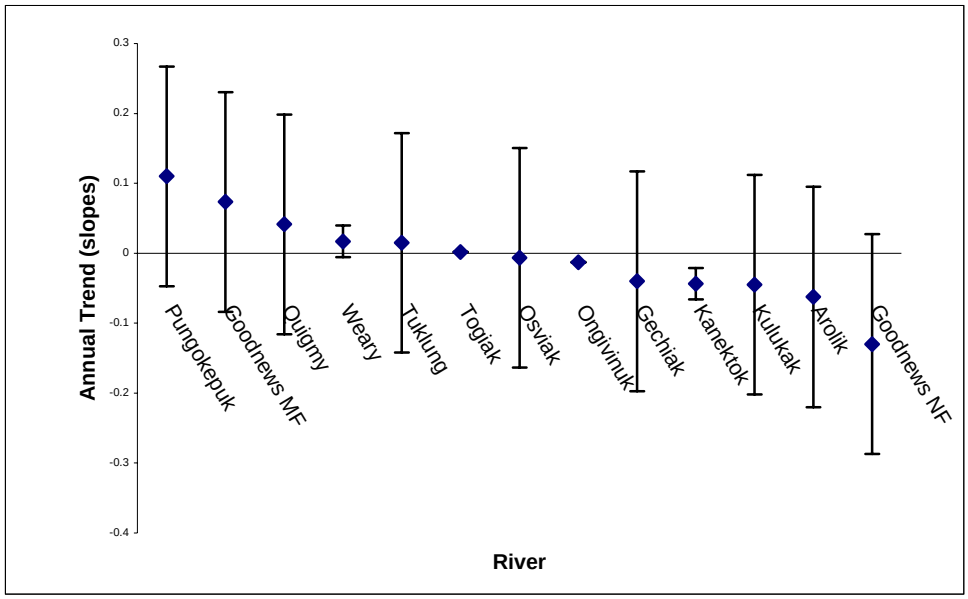

Figure 3. Beaver cache annual trend (slope) estimates by river, with 95% confidence limits (1975-2006).

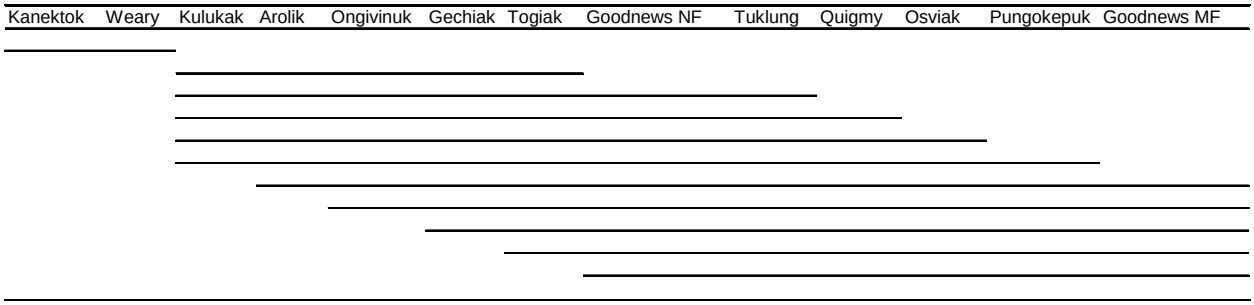

Figure 4. Tukey's HSD comparisons of mean cache/mile rates with 95% family-wise confidence level (2002-2006 surveys).

DISCUSSION

Temporal trends in abundance were only detected on rivers with data collected from six or more years, which includes the Togiak, Ongivinuk, and Kanektok Rivers (Table 3, Figure 3). Because these trends were weak, we are uncertain if they represent biologically significant change. Rivers with data limited to surveys from 2002-2006 demonstrated no significant temporal trends; however, this analysis likely has low power to detect these trends due to low sample size.

These results do not support local perceptions of an increased beaver population in the region. Yet traditional ecological knowledge suggests beaver populations have increased in the region over the past five decades (La Vine and Lisac 2003). Libby's (1955) beaver cache survey in 1954 corroborates such observations; only eleven caches were counted on a single survey of the Togiak River. The 1954 survey results were low compared to more recent surveys; though the specific survey methods used in 1954 are unknown,

Beaver populations may have increased prior to surveys occurring in the mid-1970's as a result of management actions (Taylor 1983). Periodic seasonal trapping closures were imposed in portions of Unit 17 since 1900 to allow beaver populations to recover. Results from early aerial surveys in Bristol Bay indicated that it was advisable to limit the numbers of beaver harvested (Libby 1955). Low beaver population densities have also been mentioned to typically occur near villages and along portions of major winter trails (Van Daele 1995), and management efforts in northern Bristol Bay between 1968 and 1978 were intended to avoid overharvest in those areas by shortening trapping season length and decreasing bag limits (Taylor 1983).

State population objectives for beaver in GMU 17A is an average stream index of 1.0 cache per river mile, while objectives for GMU's 17B and 17C are 1.2 caches per river mile (Woolington 2004). Average cache per mile rates from 2002-2006 surveys in 17C and 18 meet management objectives. However, cache per mile rates for the same time period in 17A are lower than management objectives (Table 5).

Table 5. Beaver cache densities from 2002-2006 in Game Management Units 17 and 18.

Game Management Unit	Mean	Upper limit	Lower limit	Management Objectives
17A	0.87	0.92	0.82	1
17C	1.30	1.49	1.10	1.2
18	1.20	1.27	1.14	1.2

An important assumption of aerial food cache surveys is that all caches in the study area are detected. In most cases, however, perfect detection of food caches does not occur (Novak 1987). Factors, such as survey protocols, observer error, and weather and lighting conditions can affect results of food cache surveys (Novak 1987, Popko *et al.* 2002). Incorporating multiple surveys of rivers into the monitoring protocol can address imperfect cache detection and allow for estimation of food cache rates and associated error estimates. Implementing a food cache monitoring program outside of refuge river corridors would provide valuable information on active beaver lodge densities in the region. Aerial beaver cache surveys based on the GeoSpatial Population Estimator (GSPE) method have been conducted in interior Alaska (Saperstein 2006). However, this method would require more flight hours and result in higher cost compared to current survey methods, though surveys using the GSPE method do not need to occur annually. Another method used in the Northwest Territories is the monitoring of established study areas (Popko *et al.* 2002). Surveys result in active beaver lodge density estimates from the study blocks. Similar to the GSPE method, this protocol is more intensive than river surveys and should occur in multi-year intervals (Popko *et al.* 2002). Beaver cache surveys on Togiak Refuge river systems should continue to be conducted annually to better determine temporal trends of surveyed rivers. Cache counts are variable, and continuing annual surveys would strengthen trend analyses among rivers.

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