AN EVALUATION OF CALF SURVIVAL IN THE AISHIHIK CARIBOU HERD, SOUTHWESTERN YUKON

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D. Toews, Acting Director

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The Problem

In recent years, some woodland caribou (*Rangifer tarandus tarandus*) herds have declined to low numbers in the Yukon. These declines are associated with low calf recruitment. The Aishihik caribou herd fell from about 1,200 animals in 1981 to 700 animals by 1990. The neighboring Kluane herd declined from about 400 to 200 animals in the same period. Similar evidence has accumulated for moose in many Yukon areas. Moose (*Alces alces*) in the Aishihik area declined sharply to 60-120 moose:1,000 km^2, one of the lowest densities in the Yukon.

It was clear that unless some measures were taken to reverse these trends, both ungulates could decline further. Historical evidence for other parts of Canada shows that when woodland caribou herds reach very low numbers, their chance of recolonizing is greatly reduced. Where timber wolf (*Canis lupus*) numbers are sustained by moose, small caribou herds can be eliminated by wolf predation (Seip 1991).

Overhunting was believed to have contributed to both caribou and moose declines (Yukon Fish and Wildl. Br., YFWB,1992). Both species are important to the subsistence economies of two Yukon First Nations who first called for a recovery program in the Aishihik area. In 1991, all caribou hunting was closed in the range of the Aishihik and Kluane herds. In 1992, the Wolf Conservation and Management Plan (Yukon Wolf Management Planning Team 1992) set out conditions for conducting aerial wolf reduction programs. In December 1992, an experiment was designed to conserve caribou and moose in the Aishihik area (YFWB 1992). In 1993, moose permits were closed in accessible areas where densities were lowest.

The Objective

The objective of the present management program, in the short term, is to prevent caribou herds from declining further for the conservation of biodiversity, and the continued subsistence use by people. Caribou are the primary objective because they form discrete herds, are range specific, and are less capable of recolonizing than moose.

Hypothesis for the Cause of the Decline

There are many possible reasons why animal populations decline rapidly. Some of these are: excessive natural predation, loss of habitat, overhunting, decline in food supply and climate change. Not all of these factors can be addressed simultaneously for obvious practical reasons. On the basis of prior information (Gauthier and Theberge 1985, YFWB 1992), we hypothesized that wolf predation was the most probable cause of recent declines in the Aishihik and Kluane caribou herds. Thus, we chose to investigate the '*Wolf Predation Hypothesis*' first (YFWB 1992). The other ideas were subsumed into the alternate null hypothesis '*Non-wolf Predation Hypothesis*'.

Predictions

The predictions of the wolf predation hypothesis are:
(i) In the area where wolf numbers are reduced (Aishihik) there should be a substantial increase in calf survival as indexed by the autumn calf:cow ratios, relative to the period before wolf reductions.
(ii) The increase in calf survival should be greater than simultaneous changes in areas (the controls) where no wolf reductions have taken place.
(iii) The absolute values of Aishihik caribou calf survival before and after wolf reduction should be consistent with other areas where wolves were present then reduced to similar levels.

Conditions of the Two Year Preliminary Evaluation

The Yukon Wolf Conservation and Management Plan (Wolf Planning Team 1992) includes a condition (9.3.4) that requires evaluating calf survival rates in the first two years of wolf reduction:

> '*If calf survival of the target ungulate species in the area has not increased significantly (at least doubled) during the first two years of wolf reduction, the program should be suspended and the situation re-evaluated.*'

This condition is a safety to ensure that wolf reduction does not continue if there is no immediate response in calf survival. This paper examines Aishihik caribou calf responses in relation to condition 9.3.4 and another condition set out in the experimental design of this project (YFWB 1992, page 36):

> *'If other factors besides wolves strongly depress recruitment, and (caribou) calf ratios remain below 30-35:100 females after two years of wolf control, then the reduction program should be suspended...'.*

We set this calf survival level because caribou herds usually increase when ratios exceed 30 calves:100 cows in autumn (R. Farnell YFWB unpubl.data).

This evaluation does *not* test whether wolf reduction has *caused* any change in caribou calf survival. It will merely examine the predictions outlined above. If there is reasonable evidence in support of the predictions then wolf reduction can continue for three more years when the next assessment is required (9.3.5):

> *'If the population level of the target ungulate species fails to meet the predictions of the experimental design after five years, the reduction program should be suspended and the situation and experimental design re-evaluated.'*

To infer any relationship between wolf numbers and caribou response requires a series of annual replications across a number of 'untreated' or control herds, which began in 1993 (YFWB 1992). Statistical comparison of responses among herds at this time is necessarily weak because there are only two years of replicated data.

METHODS

The Herds

One treatment herd, Aishihik, was chosen for the wolf reduction and for testing prediction i. There were three consecutive years of calf survival data before wolf reduction (1990 through 1992) and two years during reduction (1993 and 1994). We tested prediction ii using different combinations of six control herds (Fig. 1), depending on available data and statistical models. The control herds are the Ibex and Kluane herds with three years of data before

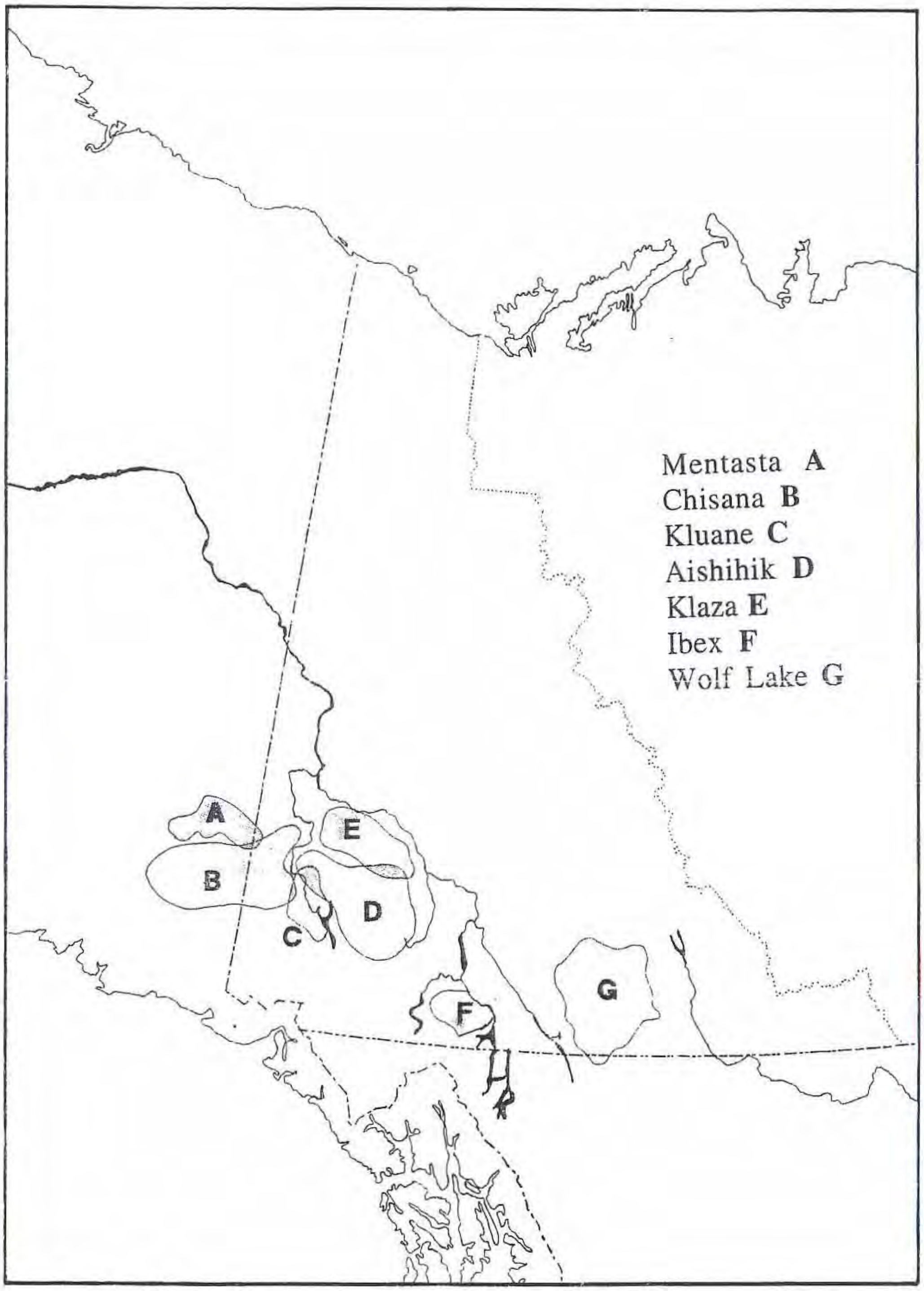

Figure 1. The location of seven woodland caribou herds that we compared calf:cow ratios among.

the experiment; the Mentasta and Chisana with two years of pre-experiment data; and the Wolf Lake and Klaza with data starting in March 1993 when the experiment began. Part of the Kluane herd's range falls inside the boundary of the experimental area, confounding the herd as a control.

Information from the Finlayson (Farnell and Hayes, unpubl. ms.) and Delta caribou herds (Gasaway et al. 1983) were used to test prediction iii. Both herds experienced similar levels of wolf reduction as Aishihik did in this study.

Caribou Data Collection

Caribou were separated into age and sex classes during autumn in seven herds. Caribou were in mixed sex bands, and methods for classifying age and sex were consistent in all herds. Crews in fixed-wing aircraft first located radio-collared caribou, then a helicopter crew flew to the area and classified bands. The crew flew to the next nearest radiotelemetry location, counting bands found along the way. There was little chance of double counting groups because caribou were mainly in the alpine where they were easily seen. Crews classified adjacent bands on the same day, reducing the chance of duplication. Survey periods lasted from one to three days depending on herd size and weather.

Wolf Reduction

In both winters we reduced wolf numbers to about 30% (2.8-3.0 wolves:1,000 km^2) of their pre-reduction densities (10 wolves:1,000 km^2) by helicopter shooting (YFWB 1994, YFWB in prep.). There was a decline of 52 (32%) wolves between March 1992 and February 1993 that was not due to the aerial program. Nine wolves were killed from one pack by hunters and reported this year (R. Quock, Council for Yukon Indians, pers. commun.). We do not know if the other wolves dispersed, died naturally or were illegally poisoned (YFWB 1994).

Statistical Analysis

We consulted with Dr. R. Routledge of the Department of Mathematics and Statistics, Simon Fraser University, on the model for comparing caribou calf:cow ratios. We tested for annual differences within herds by comparing Bonferroni-adjusted t values where:

$$t = \frac{\hat{R}_i - \hat{R}_j}{\sqrt{[\hat{SE}(\hat{R}_i)]^2 + [\hat{SE}(\hat{R}_j)]^2}}$$

and $\hat{R}_i$ is the estimated ratio of calf:cow in $year_i$ and $\hat{R}_j$ is the ratio in $year_j$. We selected the model because it was the most conservative and reduced the probability of observing differences due to chance error. Results from t-tests were compared to critical values for $t_{\alpha/2\mathcal{L}}$, d.f.= n_i+n_j-2, where α =0.05, and $\mathcal{L}$= the number of paired ratio comparisons/2. The number of paired comparisons was k (k-1), where k=the number of ratios being compared. The calf: cow ratios were viewed as a general ratio estimate where:

y_i=	number of calves in cluster i,
x_i=	number of cows in cluster i,
$\hat{R}$=	$(\Sigma y_i)/(\Sigma x_i)$,
n=	number of sampled clusters, and
f=	estimated fraction of clusters sampled.

Residuals in the form of y-$\hat{R}$x were plotted against x (cows) for each year. There was no serious problem with lack of normality in the distributions. The standard error of $\hat{R}$ follows Cochran (1977:pages 153-155):

$$\hat{SE}(\hat{R}) = \sqrt{\left(\frac{1-f}{n\bar{x}^2}\right)\left(\frac{\Sigma (y_i - \hat{R}x_i)^2}{N-1}\right)}$$

where $\bar{x}$ is the average number of cows in $_i$ clusters, N is the estimated total number of cow clusters in the herd, and f is the estimated proportion of cow groups sampled from each herd. We estimated N by dividing the total number of cows in the herd by the average size of cow groups. The total number of cows was based on the best estimate of herd size and adult bull:cow ratio each year. We used Bonferroni-adjusted comparisons of Aishihik annual ratios to test prediction i, and compared results with three control herds to test prediction ii.

For prediction ii, we also used a nested ANOVA to test for significant changes in calf:cow ratios between periods (before and after wolf reduction), and among years within periods. We used an arcsine modification to normalize ratios (Anscombe 1948: cited in Krebs 1989). F ratios were calculated using Type III sums of squares of the ANOVA, with the treatment effects fixed and the year effects random.

RESULTS

Changes in Calf Survival over Time

A summary of annual calf:cow ratios from the seven caribou herds are shown in Table 1. From Bonferroni-adjusted comparisons we found all herds showed significantly different ratios among some years (Table 2). We found the Aishihik herd had significantly different ratios in both years after wolf reduction (1993 and 1994) compared to all three years before reduction (1990, 1991 and 1992).

The 1992 calf:cow ratio in the Kluane herd was different from all years (Table 2), but other years were not different from each other. Changes in the Chisana and Ibex herd ratios were significant but the absolute changes were small and did not alter population trends of either herd (Table 2, Fig. 2). Chisana ratios increased after the experiment, but remained well below levels that would indicate herd growth. Calf survival was annually highest in the Ibex herd, ranging between 41 and 60 calves:100 cows. The Ibex ratios have been high since 1983, (R. Farnell, YFWB unpubl. data), but in spite of this the herd has not increased. This is probably because excessive subsistence hunting is removing too many adults (D. Cresswell, Council for Yukon Indians, pers. commun.). Hayes et al. (1991) found no wolf predation on Ibex caribou during three winters in the 1980s, despite high wolf densities on the herd's range. They believed the herd was unimportant prey because moose and Dall sheep *(Ovis* *dalli*) were much more abundant, and the small number of caribou had caused wolves to shift predation to more available ungulates.

ANOVA results (Table 3A) showed that calf survival only differed in the Aishihik and Chisana herds between pre and post-experiment periods. All herds except the Chisana showed insignificant differences among years nested within periods (Table 3A). Aishihik calf survival averaged 15 calves:100 cows before reduction compared to 38.5: 100 after wolves were reduced, more than a doubling - but the difference was not significant (P=0.080). Average annual ratios for all other herds were not significantly different between periods (Table 3B).

Table 1. The number of calves and cows observed in October counts and the average number of calves:100 cows (bold parentheses) for seven caribou herds. The vertical double line indicates when wolf reduction began in the Aishihik area. Herds tested with Bonferroni-adjusted multiple comparisons and nested ANOVA are underlined.

Herd	1990	1991	1992	1993	1994
Aishihik	100:347	42:486	30:409	119:305	107:284
	(28.8)	**(8.6)**	**(7.3)**	**(39.0)**	**(37.7)**
Kluane	25:79	29:98	0:46	23:123	26:118
	(31.7)	**(29.6)**	**(0)**	**(18.7)**	**(22)**
Wolf Lake			a	76:340	103:337
				(22.4)	**(30.9)**
Chisana		6:339	1:870	13:628	43:393
		(1.7)	**(0.02)**	**(2.1)**	**(10.9)**
Klaza			b	36:151	29:98
				(23.8)	**(29.6)**
Ibex	42:70	18:32	29:55	35:62	25:57
	(60)	**(56.3)**	**(52.7)**	**(56.5)**	**(43.9)**
Mentasta		*	19:345	17:474	*
		(2.2)	**(5.5)**	**(3.6)**	**(11.0)**

[a] No rut survey. Data from March 1993: 80 calves:641 cows(12.48).

[b] No rut survey. Data from March 1993: 6 calves:69 cows (8.7).

* Ratios could not be separated by cow groups in 1991 and 1994 due to survey methods (B. Tobey, ADFG, pers. commun.).

Table 2. Bonferroni-adjusted t values for pairwise comparison of calves:cow ratios for Aishihik, Kluane, Ibex, and Chisana herds.

Critical values were interpolated from Zar (1984, Table B3). Years with significantly different ratios are in bold.

Aishihik (Double line indicates when wolf reduction began).

Year		1990	1991	1992	1993
	R	0.29	0.09	0.07	0.39
1991	0.09	**13.16**			
1992	0.07	**13.06**	1.38		
1993	0.39	**4.32**	**15.63**	**15.63**	
1994	0.38	**3.06**	**11.34**	**11.53**	0.43

Kluane

Year		1990	1991	1992	1993
	R	0.31	0.29	0.00	0.19
1991	0.29	0.23			
1992	0.00	**6.71**	**3.90**		
1993	0.19	2.68	1.42	**18.75**	
1994	0.22	1.98	0.98	**19.68**	2.22

Ibex

Year		1990	1991	1992	1993
	R	0.60	0.56	0.53	0.56
1991	0.56	1.48			
1992	0.53	2.89	1.18		
1993	0.56	1.74	0.08	1.44	
1994	0.44	**5.12**	**3.513**	2.52	**3.94**

Chisana

Year		1991	1992	1993
	R	0.02	0.001	0.02
1992	0.001	**4.06**		
1993	0.02	0.68	**11.00**	
1994	0.10	**13.44**	**19.77**	**15.41**

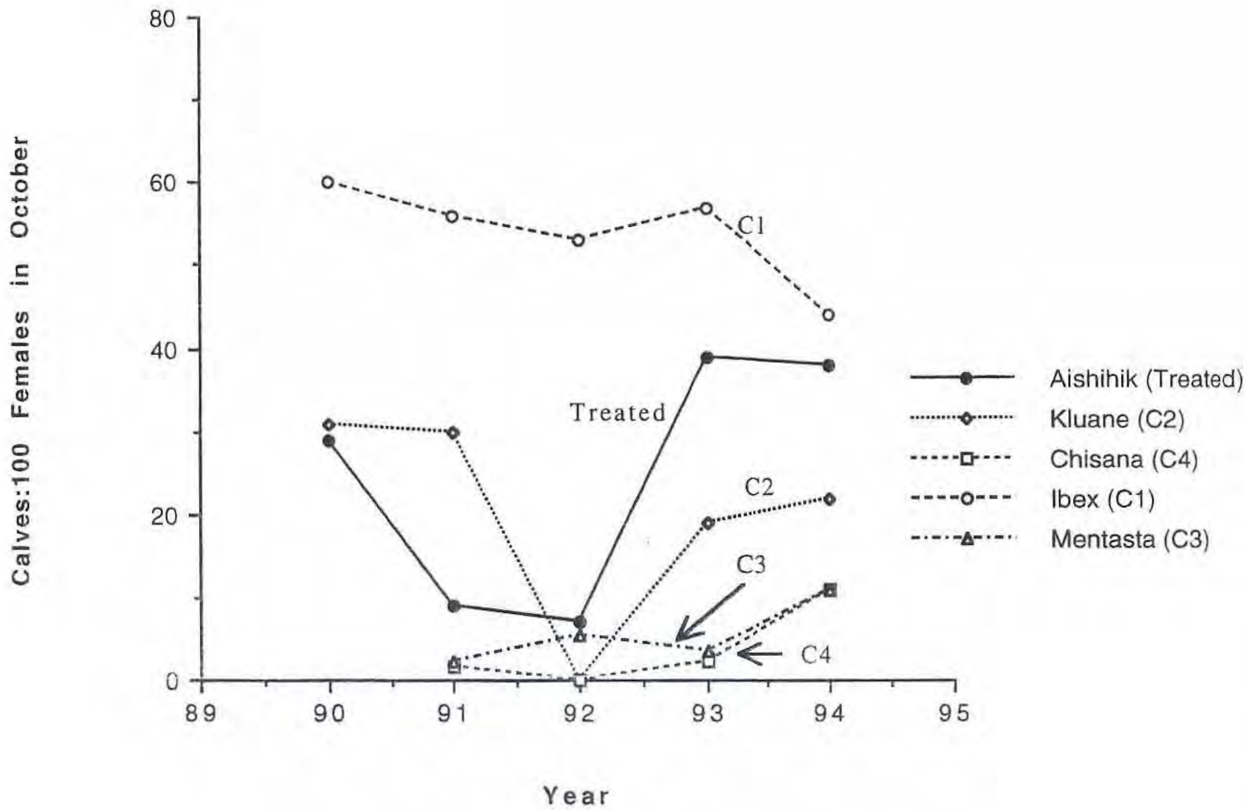

Figure 2. Calf:cow ratio in autumn for the treated Aishihik herd and four control herds in the southern Yukon and Alaska, 1990 through 1994. Refer to Table 1 for ratio values.

Changes in Calf Survival by Herd

In the above section we establish there has been a significant increase in calf survival over time in the Aishihik herd, and there is reasonable evidence of doubling, coincident with the reduction of wolves. For other herds, there is no evidence of similar changes among years, or between pre and post-experiment periods.

We now address the question whether the large increase in survival between 1992 and 1993 happened by chance, and had little or nothing to do with fewer wolves in the area. Because there is only one experimental area and the data in the control areas are unbalanced, it was not possible to perform any meaningful ANOVA.

Table 3. Results from nested ANOVA (A) and independent t-tests (B) for Aishihik and control herds. ANOVA results were calculated using transformed cluster ratio data, t-tests used mean number of calves:100 cows each year.

A (Nested ANOVA)

Herd	F Ratio for Period	P*	F Ratio for Year within Period	d.f.	P
Aishihik	19.85	0.001	2.12	3	0.102
Kluane	0.05	0.821	2.52	3	0.073
Chisana	19.81	0.0001	8.32	2	0.0005
Ibex	0.86	0.357	1.67	3	0.184

* d.f.=1

B (Independent t test)

	Mean No. Calves:100 Cows				
Herd	Before	After	T	d.f.	P
Aishihik	15	38.5	-3.37	3	0.078
Kluane	20	20	-0.01	3	0.99
Chisana	0.86	6.5	-1.259	2	0.33
Ibex	56	50	1.22	3	0.31
Mentasta	2.9	7.3	-0.85	2	0.28

Thus, we must replace the question: Does the single value of 31.7 calves:100 cows representing the increase in Aishihik survival following wolf reduction (Table 4, 1992 to 1993) fall outside the 95% confidence limits of the standard deviation of the changes shown by all control herds in the same interval? The mean change in survival from 1992 to 1993 over all six control herds (Table 4) was 7.95 calves:100 cows with a standard deviation of 8.00. This gives a 95% confidence limit range for the distribution of between -12.59 and 28.49 calves:100 cows. Thus, the 31.7 value for the Aishihik herd falls outside (i.e., above) this range, and there is less than a 5% probability that the observed result was due to chance events. Using the more conservative Grubbs Test Statistic (GTS), we found that 31.7 was a significant outlier (GTS=2.97, n=6, $P<0.005$). These results are conservative because: (a) they accept the Kluane herd as a control, and if the herd is removed the confidence range is even narrower; and (b) the 1992 Wolf Lake and Klaza ratio values in Table 1 are actually from March 1993 counts. The October 1992 data was not available, but those values are probably higher because caribou calf mortality from October to March in the Yukon is about 5.5 calves:100 cows.

Table 4. Annual changes in autumn calf survival (calves:100 cows) between each year among seven caribou herds in the southern Yukon and eastern Alaska.

Herd	1990→91	91→92	92→93	93→94
Aishihik	-20.2	-1.3	31.7	-1.3
Kluane	-2.1	-29.6	18.7	3.3
Chisana	—	-1.7	2.1	8.8
Mentasta	—	3.3	-1.9	7.4
Ibex	-3.7	-3.6	3.8	-12.6
Wolf Lake	—	—	*9.9 (4.4)	8.5
Klaza	—	—	*15.1 (9.6)	5.8

* These values are liberal estimates because they are calculated by subtracting March 1993 from October 1993 ratios. Estimated changes from October 1992 are in parentheses, but those values were not used in statistical comparisons.

We can also examine the idea that any herd, from time to time, can show sudden changes in survival, and that by chance it was the Aishihik herd showing this change between 1992 and 1993. We can test this by asking whether the 31.7 calves:100 cows change in Aishihik falls outside the range of normal variation shown by all herds among all years that there are data. The 95% confidence limit range lies between -22.6 and 23.43 calves:100 cows. Grubb's test statistic confirmed that the 31.7 value was an outlier compared to all herds in all other years (GTS=2.83, n=21, p=0.025). From these results, we conclude that there is less than a 1 in 50 probability that the increase in Aishihik calf survival between 1992 and 1993 was due to random chance events.

Could some environmental change explain the increase in calf survival in the Aishihik herd in 1993 and 1994? Calf survival was lowest in 1992 among four of the herds (Table 1, Fig. 2) and environmental conditions probably influenced the generally low survival. In winter 1991-92 there was higher than normal snow depth, and snow cover was extensive on calving ranges in June 1992 (YFWB, unpubl. data). However, the change in absolute values of calf survival between 1992 and 1993 was significantly greater in the Aishihik herd compared to all controls, and there was low probability it could be explained by random chance.

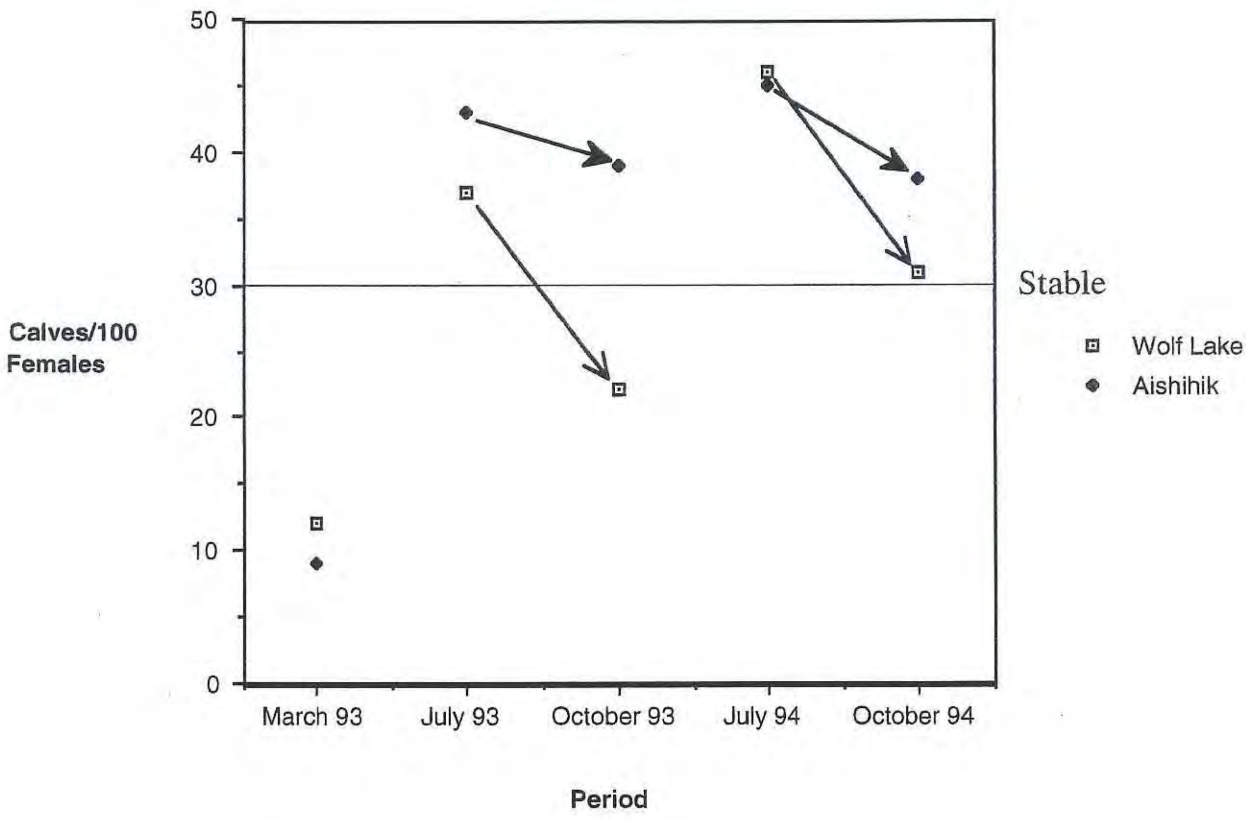

Figure 3. Calf:100 cow ratio between July and October in the Aishihik and Wolf Lake caribou herds, 1993 and 1994. March 1993 data points are included to show ratios when wolf reduction began in the Aishihik herd range.

We monitored differences in calf:cow ratios from July through October in 1993 and 1994 to compare over summer mortality rates in the Aishihik herd and Wolf Lake control herd. The rate of calf loss was significantly lower in the Aishihik herd (t =8.5, d.f.=2, P =0.032), declining by a rate of 6-8 calves:100 cows between July and October (Fig. 3), compared to 15-16 calves:100 cows in the Wolf Lake herd. Farnell and Hayes (unpubl. ms.) found that calf survival to autumn increased sharply after wolves were reduced on the summer range of the Finlayson herd.

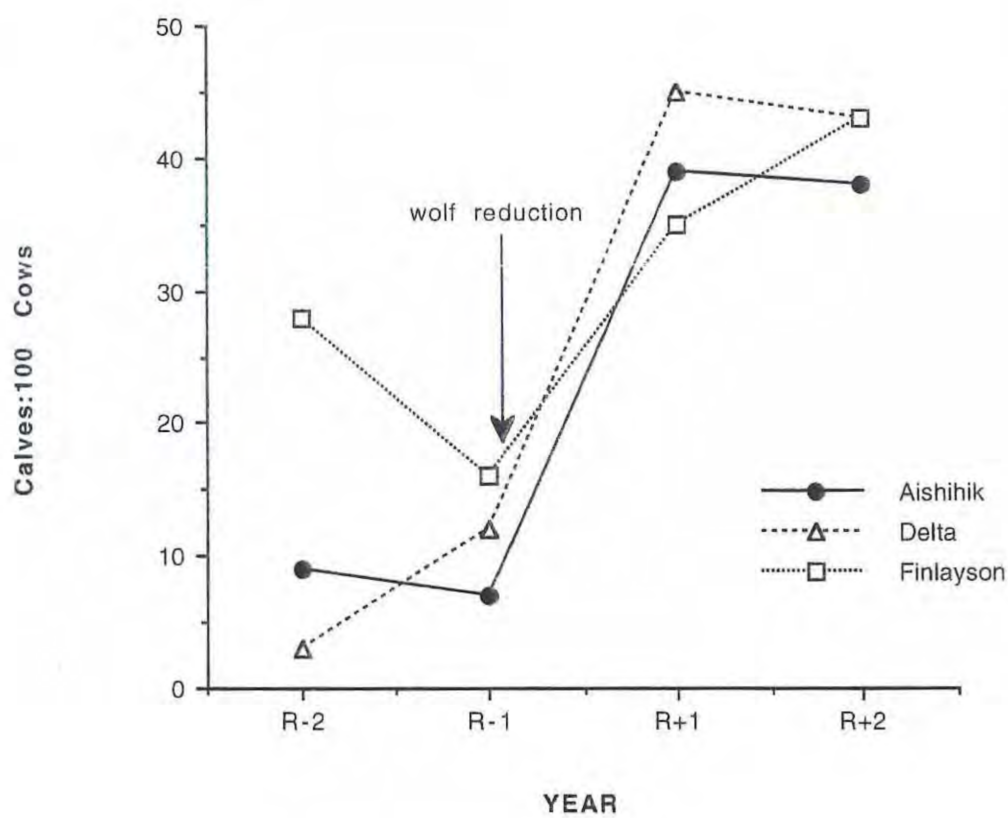

Figure 4. Changes in calf survival (calves:100 cows) in the Aishihik, Finlayson and Delta caribou herds two years before wolf reduction began and during the first two years of reduction. R-1 is ratio in autumn before reduction began, R+1 is autumn after first reduction.

Changes in Absolute Values of Calf Survival

In this section we test prediction iii to determine whether calf survival in the Aishihik herd after wolf reduction is comparable to the Finlayson and Delta caribou herds. Both herds experienced similar (60-80%) levels of wolf reduction (Gasaway et al. 1983, Farnell and Hayes unpubl. ms.). Figure 4 shows that the absolute values of Aishihik calf survival before and after wolf reduction were similar to the Finlayson and Delta herds. We used nested ANOVA to test for differences in mean ratios for the three herds in the two years before reduction (Period 1) vs. the two years after reduction (Period 2). There was a significant difference between periods ($F=53.9$, d.f.=1, $P<0.001$) but no difference among herds nested within periods ($F=1.25$, d.f.=2, $P=0.33$). We conclude that the absolute values of Aishihik calf survival were similar to other caribou herds before and after wolf reduction.

DISCUSSION

Test of Predictions

We now compare the results with predictions stated in the Introduction. Prediction (i) states there should be a significant increase in calf survival in the Aishihik herd when wolves are reduced. The observed results demonstrate a significant increase after reduction, and there is evidence of calf survival doubling. Prediction (ii) states that the increase be significantly greater than changes shown in control areas where wolves were not reduced. Results show the large increase in Aishihik calf survival from 1992 to 1993 was significantly greater than shown by all control herds. Prediction (iii) states that the absolute values of calf survival in the Aishihik herd before and after wolf reduction are consistent with values in other herds. We observed changes in calf survival responses in the Aishihik herd values that are consistent with two other herds that experienced wolf reduction. In summary, the results from the first two years of the wolf reduction experiment are consistent with the three predictions of the wolf predation hypothesis.

Data Quality

Control herds were included because they were near the Aishihik herd range (Fig. 1) and there was available data. They covered a range of habitats and environmental conditions. There is no reason to expect the herds produced biased data, except perhaps the Kluane herd which has confounding treatment effects. The variability in the control herds was an asset because it allowed us to assess whether the Aishihik results were unusually different.

Some control herds are experiencing different ecological and environmental conditions. The Kluane and Ibex are the smallest of the herds, numbering less than 200 caribou each. Gauthier and Theberge (1985) found that wolf predation was the most important factor limiting the Kluane herd in the early 1980s. The Ibex herd was not preyed on by radio-tagged wolves during three winters in the mid 1980s (Hayes et al. 1991). It has consistently shown the highest calf survival rates in autumn of any naturally regulated herd in the Yukon. The Chisana herd (n=1,000 animals) was probably natality-limited in 1992, based on low udder counts during calving (P. Valkenburg, Alaska Dept. of Fish and Game, ADFG, pers. commun.). The neighboring Klaza (500 animals) herd shared a small portion of Aishihik late winter range in 1994. The Wolf Lake herd (1,200) is furthest from Aishihik (250 km) and probably experiences the most different environmental conditions.

We identified the Pelly and Tatchun herds as potential controls in the experimental design. Studies were not initiated on the Pelly herd and research on the Tatchun herd was incomplete. We included the Mentasta herd as a control because it had available data, it was nearby and about the same size as Aishihik (1,000 animals), it was also in decline and there is no evidence it is natality-limited (K. Jenkins, National Biological Survey, pers. commun.).

The reported calf:cow ratios for all herds were not adjusted to exclude non-breeding yearlings. This limits the accuracy of ratios as true measures of calf survival rates. Non-breeding female yearlings enter the cow population but are not separated from breeding cows (two years and older). In rapidly increasing herds, high yearling recruitment will decrease the calf:cow ratio in the next year, more than in stable or declining herds. This is because the inclusion of numerous non-parous yearlings as adult cows will increase the ratio denominator. This will cause a lower than actual calf:breeding cow ratio during the second year of wolf reduction. This probably happened in the Aishihik herd in 1994. We used March 1994 data to estimate about 22 yearling cows:100 adult cows survived to October. These Aishihik yearlings were included as adults in the October 1994 count; subtracting them increases the 1994 ratio from 38 to 48 calves:100 cows.

SUMMARY

There is evidence that Aishihik calf survival rates increased to levels required in the Yukon Wolf Conservation and Management Plan and the experimental design. The herd could be increasing based on high calf survival after 1992. No other herds show the same responses as Aishihik since 1990. Only the Aishihik and Ibex herds show recruitment rates that are high enough for substantial herd growth. There is evidence that calf survival from July to October in 1993 and 1994 is higher in the Aishihik herd compared to the Wolf Lake control herd. The increase in Aishihik calf survival values after wolf reduction is not different than values observed in two other caribou herds where similar levels of wolf reductions were applied.

Most regional herds experienced their lowest calf survival in 1992, probably due to severe winter and spring calving conditions. Improved conditions in 1993 could explain part of the increase in calf survival observed in control herds and Aishihik that year. However, the increase in Aishihik calf survival from 1992 to 1993 is significantly greater than the changes shown by all other herds in the same period. There is a low probability the increase was due to chance events.

- Continue the program as planned in the experimental design.
- Collect additional calf:cow data from the Aishihik, Wolf Lake, Klaza, Ibex and Mentasta herds in March, July and October. We can then compare seasonal calf mortality rates until 1997.
- Measure moose calf survival in March 1995 to enable future assessment of the moose response model described in the experimental design. A moose population increase is important for the long term stability of the Aishihik wolf-ungulate system, and for caribou conservation.
- Monitor and minimize the impacts of resource exploration and extraction in the important caribou post-calving and rutting areas in the Ruby Range. Caribou responses could be negatively affected by these activities.

LITERATURE CITED

Cochran, W.G. 1977. Sampling Techniques, Wiley and Sons, Toronto, Ontario.

Farnell, R. and R. Hayes. unpubl. ms. Results of wolf removal on wolves and caribou in the Finlayson study area, Yukon, 1983-1994.

Hayes, R.D., A.M. Baer and D.G. Larsen. 1991. Population dynamics and prey relationships of an exploited and recovering wolf population in the southern Yukon. Yukon Fish and Wildl. Br. Rep. TR 91-1. 67pp.

Gauthier, D. and J. Theberge. 1985. Wolf predation in the Burwash caribou herd, southwest Yukon. Rangifer Spec. Issue. No. 1: 137-144.

Gasaway, W.C, R.O. Stephenson, , J.L. Davis, P.E.K. Sheperd and O.E. Burris. 1983. Interrelationships of wolves, prey and man in interior Alaska. Wildl. Monogr. 84. 50pp.

Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York. 654 pp.

Seip, D. 1991. Predation and caribou populations. Rangifer. Spec. Issue No. 7:46-52.

Yukon Fish and Wildl. Br. 1992. An experimental design to test wolf regulation of ungulates in the Aishihik area, southwest Yukon. Yukon Fish and Wildl. Br. Rep. TR-92-6. Whitehorse, Yukon. 54 pp.

Yukon Fish and Wildl. Br. 1994. Aishihik and Kluane caribou recovery program. Prog. Rep. Yukon Fish and Wildl. Br. PR 94-2. Whitehorse, Yukon.

Yukon Wolf Management Planning Team. 1992. The Yukon Wolf Conservation and Management Plan. (Available from Yukon Fish and Wildl. Br., Box 2703, Whitehorse, Yukon. Y1A 2C6).

Zar, J.H. 1984. Biological Statistics. Prentice Hall, New Jersey. Second Edition. 718 pp.