

**PROJECT TITLE:** DYNAMICS OF THE DENALI CARIBOU HERD, DENALI NATIONAL PARK, ALASKA: PROGRESS REPORT (OCTOBER 2003 - SEPTEMBER 2004)

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**DATE:** FEBRUARY 2005

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This progress report summarizes research and monitoring of the Denali Caribou Herd conducted during October 2003-September 2004 (FY04). The National Park Service has supported long-term research on the Denali Herd since 1983. During FY04 we resumed a full research effort after a year of lesser funding while park managers evaluated options for large mammal monitoring in the park and sought long-term funding. During the year, our objectives were:

- 1) Monitor herd size and composition, adult female survival, female age structure, and calf production and recruitment;
- 2) Maintain the age-structured sample of 60 radiocollared cows by adding calves of the 2003 cohort and additional adult females as necessary, as well as replacing collars on previously instrumented individuals; and
- 3) Relate caribou population characteristics to winter snowfall and wolf predation.

During FY04, I completed a manuscript, entitled "Effects of maternal characteristics and environmental variation on birth masses of Alaskan caribou" which was accepted for publication by the Journal of Mammalogy (Appendix 1, 2). I also presented 2 papers at the Tenth North American Caribou Workshop in May 2004, entitled "Persistent effects of severe winters during 1988-1994 on dynamics of the Denali Caribou Herd" and "Extraordinary movements of the Denali Caribou Herd following an unusual September storm". The second paper has been developed into a manuscript to be published in the conference proceedings (Appendix 1, 2).

## **BACKGROUND**

The National Park Service has supported intensive caribou research at Denali National Park since 1983. Since 1986, this research program has applied the same methodology to census the population annually and estimate calf production, calf recruitment, adult female survival, and herd composition, representing the longest and most consistent effort of its kind on caribou anywhere in North America. One unique aspect of the research design is that since 1986, a sample of approximately 50 radiocollared females representative of the herd's age structure has been maintained, thus providing annual

assessment of population vital rates faithful to the herd's age structure. Even with the general acceptance of the important influences of age on productivity and survival, this age-structured sample is the only one of its kind ever attempted in a wildlife population and has been maintained for 18 years.

To date, we have learned much about the interactions between predation and weather that drive the dynamics of the Denali Caribou Herd. When this study began, the caribou population was increasing at about 7%/year through a period of relatively mild winters in the mid-1980s. Winter survival of caribou cows was high (96%/year) and about 50% of the calves produced were recruited into the herd. With the onset of a period of severe winters in 1988, caribou numbers plateaued at about 3,200 in Autumn 1989 and then declined by a third over 2 years reach about 2,300 caribou by fall 1992. During the period of decline, adult cow winter survival dropped substantially (85%/year) and calf recruitment dropped to a mere 5%. Since 1992, winter snowfall has been moderate and the caribou herd has declined slowly at about 2% annually. Adult cow survival has been comparable to the mid-1980s, but calf recruitment has continued to be relatively low (35 calves:100 cows during Autumn 1984-89 vs. 14:100 during Autumn 1994-2002).

With the overall decline in calf recruitment since 1990, the female age structure became heavily weighted towards older females, a harbinger of impending population declines regardless of winter snowfall patterns. In May 2001, we estimated that 31% of the females in the herd were  $\geq 12$  years old. Between May 2001 and September 2002, half of those older cows died. Such high losses of cows can be expected to continue for the next couple of years as the remaining old cows are removed from the population.

## **FIELDWORK RESULTS**

As of 1 October 2003, 48 female caribou were radiocollared in the Denali Herd, including 38 from the age-structured sample. We conducted capture operations in late October 2003 and March 2004 to replace radiocollars on individuals ( $n = 21$ ); instrument additional adult females to bolster the age-structured sample ( $n = 21$ ); and to add female calves from the 2003 cohort to our sample ( $n = 8$ ). During the year, 12 radioed caribou died and on 30 September 2004, 66 female caribou, including 50 in the age-structured sample, carried radiocollars.

### **HERD SIZE**

I derived a tentative estimate of 2,030 caribou in the Denali Herd in late September 2004 (Table 1, Fig. 1) that was higher than expected. During 1993-2003, the caribou population declined by about 1.6% per year ( $\ln(N) = 38.68 - 0.016 \times \text{Year}$ ;  $r^2 = 0.432$ ). If that trend continued, the 2004 population estimate would have been about 1,770 caribou. However, in 2004, calf recruitment was  $> 20$  calves:100 cows for the first time since 1989

and bolstered population numbers. Although the additional calves boosted the fall herd estimate, adult cow numbers continued to decline at a rate of about 1.2% (1993-2004;  $\ln(N) = 31.89 - 0.012 \times \text{Year}$ ;  $r^2 = 0.358$ ).

#### ADULT SEX RATIO

In September 2004, the adult sex ratio was 40 bulls:100 cows (Table 1) indicative of continued increase from the low of 29-30 bulls:100 cows during 1995-1998. The bull segment of the herd was weighted toward large, fully-mature males which comprised 50% of the bulls tallied, while small bulls were relatively rare (19%) as a result of poor calf recruitment in 2003. The increasing bull:cow ratio is likely the result of poorer survival of cows because of the preponderance of old cows in the population and better recruitment of males compared to females. The recruitment rate for males is higher than it is for females, even with a skewed sex ratio of recruited calves, because of the lower number of adult males. For example, in Autumn 2002 (Table 1), approximately 9 female calves were recruited into a population of 100 females for a rate of 9%, while 7 male calves were recruited into a population of only 32 males for a rate of 22%.

#### CALF PRODUCTION AND SURVIVAL

Based on observations of radiocollared females of the age-structured sample near the peak of calving in May 2004, approximately 85% of the cows produced calves (Table 2). On 6 June 2004, I noted 35 calves:100 cows while conducting the annual census and post-calving composition survey (Table 3). This was the highest post-calving calf:cow ratio since 1994 and 59% higher than the average over the last decade (1995-2004;  $\bar{x} = 22$  calves:100 cows). By late September 2004, the calf:cow ratio was 28:100, indicative of 33% survival of calves of the 2004 cohort. Since 1990, fall calf:cow ratios have been chronically low, averaging 13.1 calves:100 cows. Given the calf sex ratio (Table 1), approximately 17 female calves were recruited per 100 older females.

#### ADULT FEMALE SURVIVAL

During October 2003 – September 2004, 12 radiocollared caribou died including 4 killed by wolves, 1 killed by an unknown predator, 2 that died of unknown causes, 2 that died in avalanches, and 3 that are still to be investigated. Eight of the cows that died were  $\geq 10$  years old.

Adult female winter survival (October 2003 – May 2004) was estimated at 85%, lower than the average of 90.6% for the 18 winters we have been monitoring survival of Denali cows. Overwinter survival has generally been low during the last 4 winters (Fig. 2) in spite of below average winter snowfall, as the preponderance of old females in the population have died out. Since 2001, the proportion of females in the herd that were  $\geq 13$  years old has declined from 25% to 11% (Fig. 3, 4).

## CONCLUSIONS

The increased calf recruitment in 2004 was somewhat of a surprise. It is too early to tell whether this is indicative of a trend toward better recruitment or a 1 year anomaly. However, because of the generally poor adult female survival, the improved level of recruitment of female calves will barely match the losses of adult females during the year. With the reduced proportion of the cow population made up of old females, we can expect adult survival to improve over the next couple of years. That increased survival coupled with the possibility of higher calf recruitment could result in an improved population trend for the herd.

## **PLANNED ACTIVITIES DURING OCTOBER 2004 - SEPTEMBER 2005**

In the upcoming year, we plan to continue efforts to assess population dynamics of the DCH and investigate influences of environmental variation and wolf abundance on those dynamics. Specifically, we plan to:

1. Capture and radiocollar caribou females as needed to maintain an age-structured sample of 60 individuals for estimation of calf production, age structure, survival patterns and seasonal distribution, and to aid in population monitoring. Instrumented caribou will be radiotracked in late November, late January, mid-March, late April, mid-May, early June, late July, and late September, or as needed to meet study objectives.
2. Conduct post-calving census and composition survey and the fall composition survey to determine herd size, calf recruitment, and adult sex ratio.

Table 1. Results of helicopter composition surveys in late September and fall population estimates for the Denali Caribou Herd, Denali National Park and Preserve, Alaska, 1984-2004.

| Date         | Fall Survey Results |        |       |                       |       |                   |                     |    |    | Fall<br>Herd Size  | Estimated Fall<br>Herd Composition |                  |                  |
|--------------|---------------------|--------|-------|-----------------------|-------|-------------------|---------------------|----|----|--------------------|------------------------------------|------------------|------------------|
|              | Cows <sup>a</sup>   | Calves | Bulls | Ratios<br>(:100 Cows) |       | Calf Sex          | Bulls% <sup>b</sup> |    |    |                    | Cows                               | Calves           | Bulls            |
|              |                     |        |       | Calves                | Bulls | Ratio<br>(m:100f) | S                   | M  | L  |                    |                                    |                  |                  |
| 9/27/1984    | 375                 | 154    | 184   | 41                    | 49    | --                | --                  | -- | -- | 2,200              | 1,158                              | 475              | 567              |
| 9/25-26/1985 | 654                 | 183    | 368   | 28                    | 56    | 72                | --                  | -- | -- | -                  | -                                  | -                | -                |
| 9/27/1986    | 547                 | 210    | 305   | 38                    | 56    | --                | --                  | -- | -- | 2,470              | 1,272                              | 488              | 709              |
| 9/25/1987    | 631                 | 234    | 356   | 37                    | 56    | 73                | 28                  | 39 | 33 | 2,430              | 1,256                              | 466              | 709              |
| 9/27-28/1988 | 678                 | 221    | 451   | 33                    | 67    | 70                | 27                  | 34 | 39 | 2,950              | 1,482                              | 483              | 986              |
| 9/28/1989    | 830                 | 246    | 428   | 30                    | 52    | 84                | 34                  | 34 | 32 | 3,210              | 1,771                              | 525              | 913              |
| 9/26-27/1990 | 777                 | 130    | 387   | 17                    | 50    | 59                | 39                  | 28 | 33 | 3,100              | 1,861                              | 311              | 927              |
| 9/26/1991    | 1,067               | 72     | 409   | 6.7                   | 38    | 112               | 32                  | 39 | 29 | 2,610              | 1,799                              | 121              | 690              |
| 9/25/1992    | 643                 | 103    | 282   | 16                    | 44    | 66                | 31                  | 40 | 29 | 2,340              | 1,464                              | 234              | 642              |
| 9/27/1993    | 849                 | 54     | 336   | 6.4                   | 40    | 74                | 26                  | 46 | 28 | 1,970              | 1,350                              | 86               | 534              |
| 9/27-28/1994 | 648                 | 128    | 253   | 20                    | 39    | 88                | 21                  | 38 | 41 | 2,140              | 1,348                              | 266              | 526              |
| 9/25/1995    | 685                 | 131    | 204   | 19                    | 30    | 75                | 29                  | 29 | 42 | 2,170              | 1,457                              | 279              | 434              |
| 9/29/1996    | 820                 | 103    | 243   | 13                    | 30    | 69                | 32                  | 26 | 42 | 2,060              | 1,449                              | 182              | 429              |
| 9/26/1997    | 777                 | 124    | 228   | 16                    | 29    | 110               | 38                  | 28 | 34 | 2,070              | 1,425                              | 227              | 418              |
| 9/26/1998    | 718                 | 87     | 205   | 12                    | 29    | 98                | 41                  | 27 | 32 | 1,790              | 1,272                              | 154              | 363              |
| 9/29/1999    | 667                 | 92     | 261   | 14                    | 39    | 51                | 30                  | 34 | 36 | 1,760              | 1,151                              | 159              | 450              |
| 9/24-26/2000 | 730                 | 52     | 257   | 7.1                   | 35    | 86                | 32                  | 31 | 37 | 1,930              | 1,356                              | 97               | 477              |
| 9/27/2001    | 778                 | 90     | 248   | 12                    | 32    | 64                | 22                  | 38 | 40 | 1,750              | 1,220                              | 141              | 389              |
| 9/29/2002    | 453                 | 72     | 145   | 16                    | 32    | 76                | 22                  | 17 | 61 | 1,960              | 1,325                              | 211              | 424              |
| 9/30/2003    | 743                 | 58     | 264   | 7.8                   | 36    | 71                | 23                  | 23 | 54 | 1,810              | 1,263                              | 99               | 449              |
| 9/27/2004    | 774                 | 214    | 309   | 28                    | 40    | 69                | 19                  | 30 | 50 | 2,030 <sup>c</sup> | 1,211 <sup>c</sup>                 | 335 <sup>c</sup> | 484 <sup>c</sup> |

Footnotes for Table 1.

- <sup>a</sup> Cows  $\geq$  1 year old.
- <sup>b</sup> S = small: antlers indistinguishable from those of adult cows, body size comparable to cows.  
M= medium: antlers larger than adult cows, but having smaller beam diameter, fewer points, and/or shorter antler length than the large bull class.  
L = large: antlers fully developed with large diameter beams, many points, and long antler length.
- <sup>c</sup> 2003 herd size estimate and composition is tentative.

Table 2. Estimated natality rates for the Denali Caribou Herd, Denali National Park and Preserve, Alaska during 1987-2004. Rates are based on observations a sample of radiocollared females  $\geq 1$  year old, designed to approximate the age structure of the population, during the calving season.

| Year | n  | Pregnant | Not<br>Pregnant. | Natality<br>Rate<br>% (95% CI) |
|------|----|----------|------------------|--------------------------------|
| 1987 | 37 | 26       | 11               | 70.3 (53.0-84.1)               |
| 1988 | 46 | 33       | 13               | 71.7 (56.5-84.0)               |
| 1989 | 55 | 37       | 18               | 67.3 (53.3-79.3)               |
| 1990 | 49 | 29       | 20               | 59.2 (44.2-73.0)               |
| 1991 | 44 | 29       | 15               | 65.9 (50.1-79.5)               |
| 1992 | 46 | 41       | 5                | 89.1 (76.4-96.4)               |
| 1993 | 41 | 27       | 14               | 65.9 (49.4-79.9)               |
| 1994 | 47 | 43       | 4                | 91.5 (79.6-97.6)               |
| 1995 | 50 | 43       | 7                | 86.0 (73.3-94.2)               |
| 1996 | 53 | 46       | 7                | 86.8 (74.7-94.5)               |
| 1997 | 53 | 42       | 11               | 79.3 (65.9-89.2)               |
| 1998 | 46 | 39       | 7                | 84.8 (71.1-93.7)               |
| 1999 | 48 | 43       | 5                | 89.6 (77.3-96.5)               |
| 2000 | 55 | 46       | 9                | 84.6 (71.2-92.2)               |
| 2001 | 52 | 43       | 9                | 82.7 (69.7-91.8)               |
| 2002 | 45 | 38       | 7                | 84.4 (70.5-93.5)               |
| 2003 | 42 | 31       | 10               | 73.8 (58.0-86.1)               |
| 2004 | 53 | 45       | 8                | 84.9 (72.4-93.3)               |

Table 3. Results of post-calving composition surveys of the Denali Caribou Herd, Alaska, 1984-2004.

| Date             | Cows<br>> 1 YO | Calves    | Calf:Cow<br>Ratio |
|------------------|----------------|-----------|-------------------|
| 5/30,31,6/3/1984 | 519            | 201       | 39:100            |
| 1985             |                | NO SURVEY |                   |
| 5/28/1986        | 335            | 134       | 40:100            |
| 5/29-30/1987     | 1124           | 487       | 43:100            |
| 5/27-29/1988     | 1002           | 435       | 43:100            |
| 5/30/1989        | 1263           | 500       | 40:100            |
| 6/1/1990         | 1402           | 512       | 37:100            |
| 6/4-5/1991       | 1213           | 220       | 18:100            |
| 6/1/1992         | 909            | 278       | 31:100            |
| 6/2-3/1993       | 822            | 177       | 22:100            |
| 6/1-2/1994       | 985            | 376       | 38:100            |
| 5/30/1995        | 693            | 238       | 34:100            |
| 5/29/1996        | 682            | 139       | 20:100            |
| 5/31/1997        | 759            | 101       | 13:100            |
| 5/29-30/1998     | 624            | 141       | 23:100            |
| 5/29/1999        | 522            | 108       | 21:100            |
| 6/7/2000         | 665            | 68        | 10:100            |
| 6/6/2001         | 736            | 140       | 19:100            |
| 6/8/2002         | 431            | 120       | 28:100            |
| 6/8/2003         | 613            | 104       | 17:100            |
| 6/6/2004         | 673            | 236       | 35:100            |

Fig. 1. Population estimates for the Denali Caribou Herd, Denali National Park, Alaska, late September, 1986-2004. Estimate for 2004 is tentative.

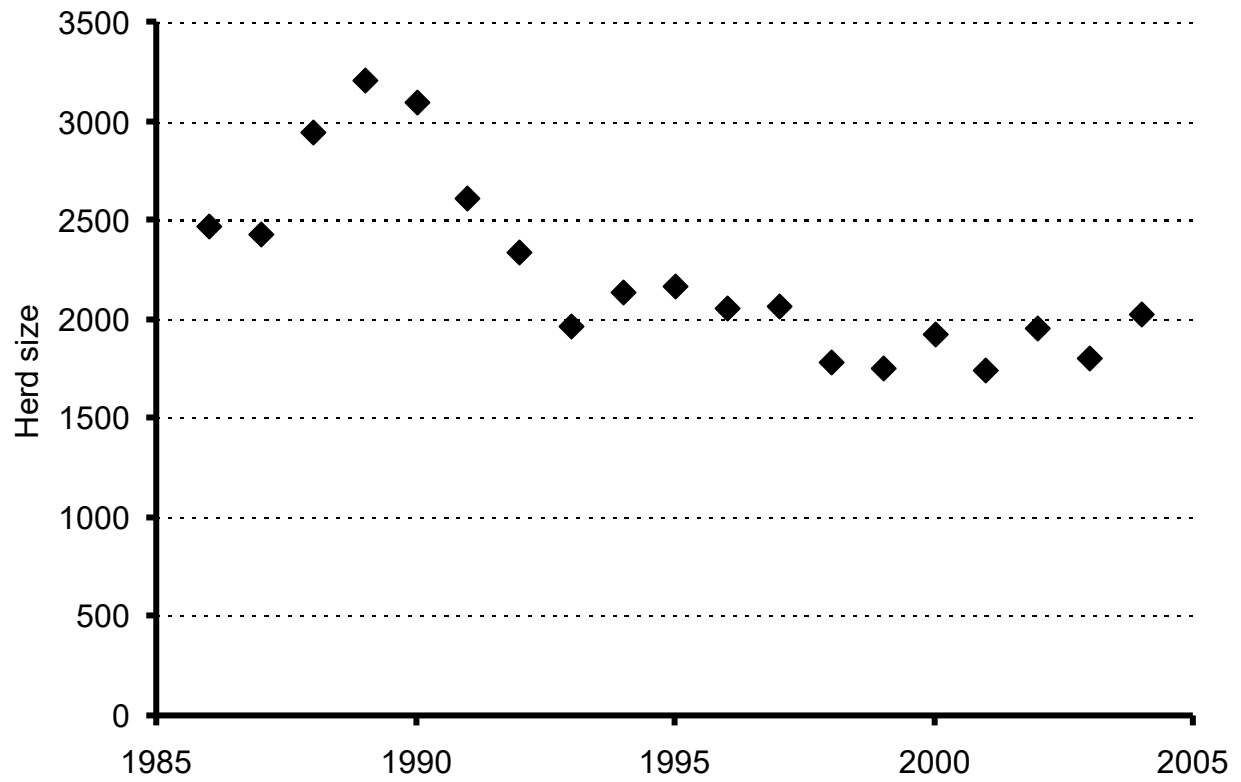


Fig. 2. Estimated winter survival rates (October –May) of caribou cows in the Denali Caribou Herd, Alaska relative to winter snowfall during 1987-2004.

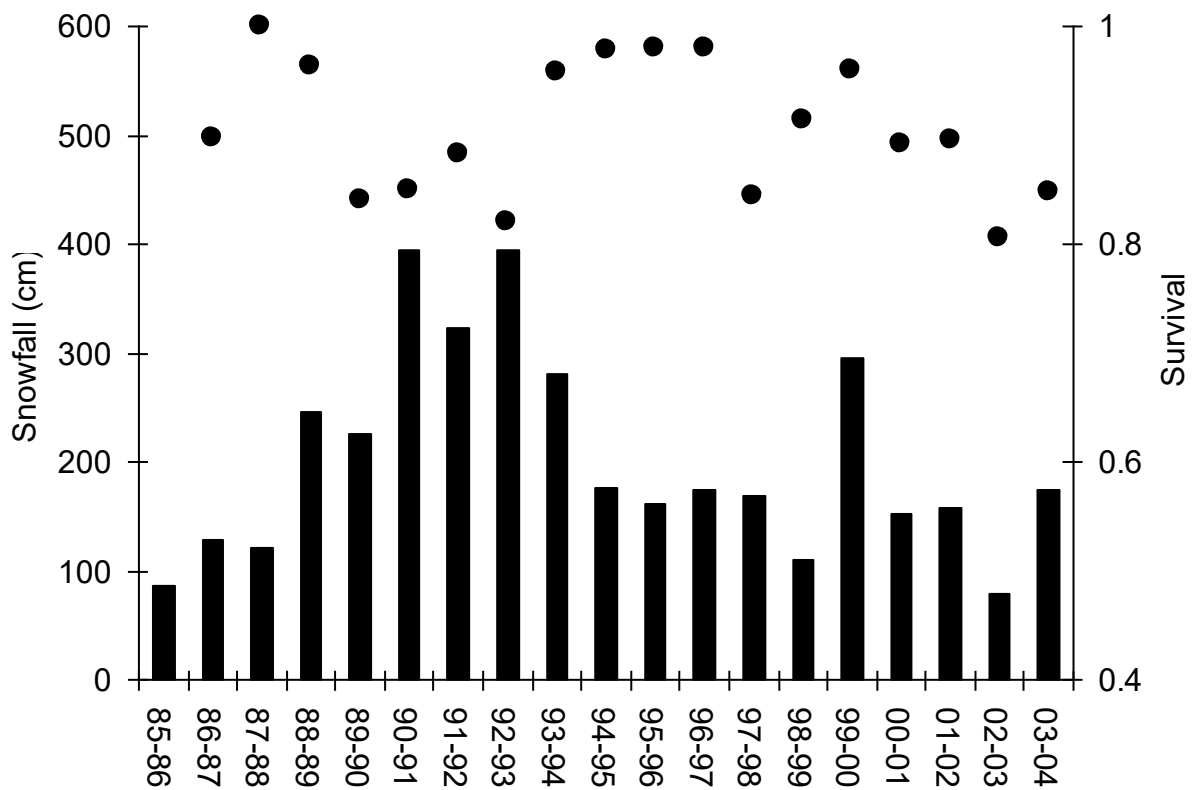


Fig. 3. Estimated age structure of the female segment of the Denali Caribou Herd on 1 May 2004 ( $n = 56$  cows).

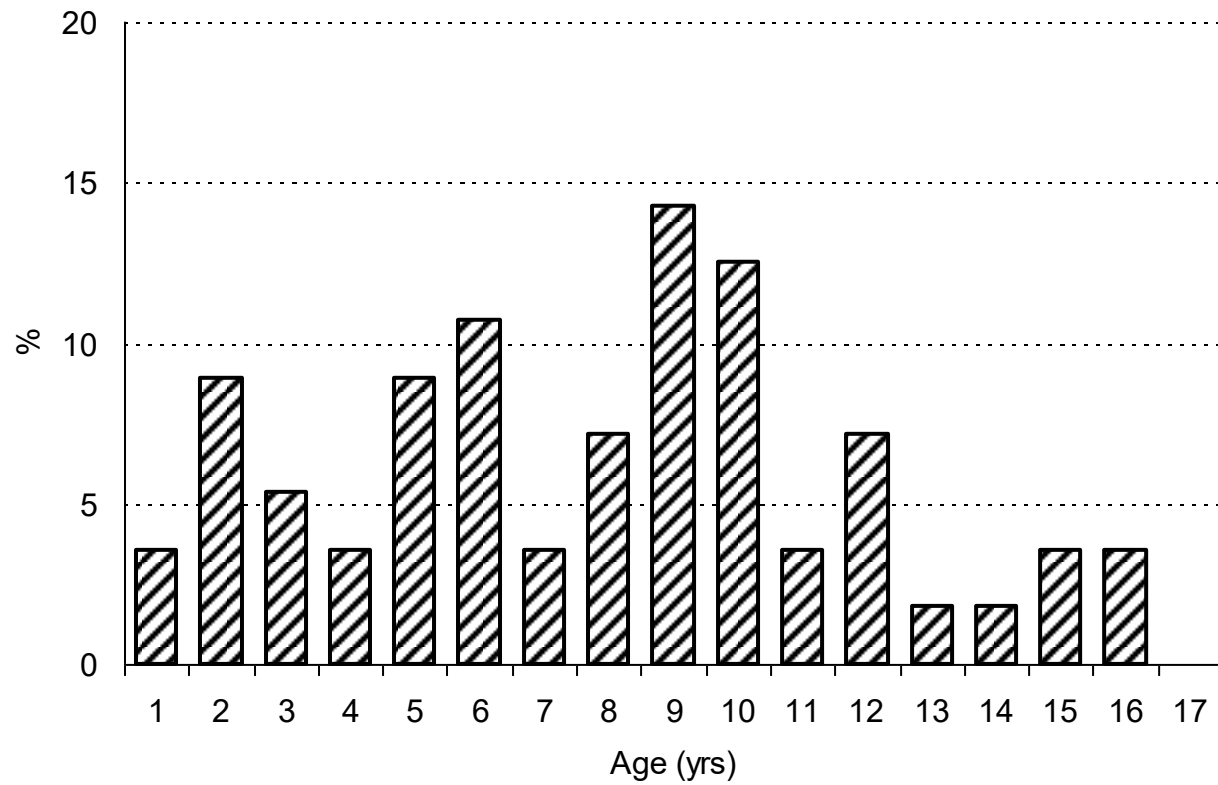
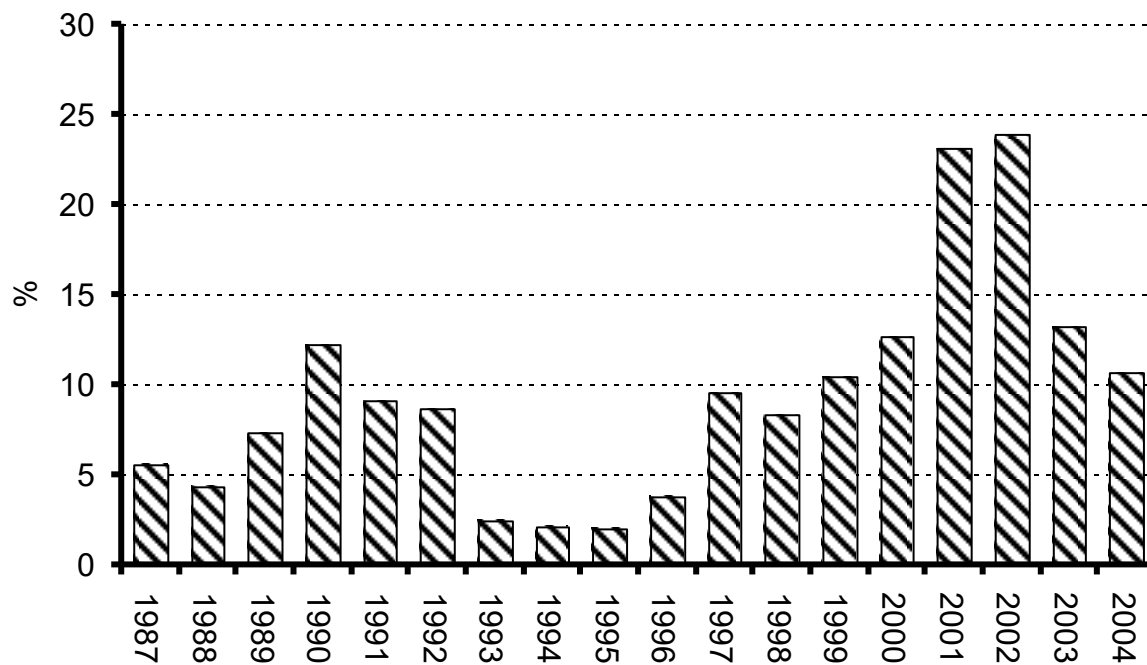


Fig. 4. Proportion of the adult female segment of the Denali Caribou Herd  $\geq 13$  years old on 1 May 1987-2004.



Appendix 1. Products of the Denali Caribou research program during 1986-2003.

- Publication - Adams, L.G., B.W. Dale, and G.H. Roffler. 2006. Extraordinary movements of the Denali Caribou Herd following the perfect storm. Rangifer Special Issue. In press.
- Publication - Adams, L.G. 2005. Effects of maternal characteristics and environmental variation on birth masses of Alaskan caribou. Journal of Mammalogy. In press.
- Report - Adams, L. G. 2004. Dynamics of the Denali Caribou Herd, Denali National Park, Alaska: progress report (October 2002 – September 2003).
- Publication - Adams, L.G. 2003. Marrow fat deposition and skeletal growth in caribou calves. Journal of Wildlife Management 67:20-24.
- Report - Adams, L.G. 2002. Population dynamics of wolves and their prey in Denali National Park, Alaska: progress report (May 2000 - April 2001). USGS Alaska Biological Science Center, Anchorage, AK. 26pp. + appendices.
- Publication - Ben-David, M., E. Shochat, and L.G. Adams. 2001. The utility of stable isotope analysis in studying foraging ecology of herbivores: examples from moose and caribou. Alces 37:421-434.
- Report - Adams, L.G. 2001. Population dynamics of wolves and their prey in Denali National Park, Alaska: progress report (May 1998 - April 2000). USGS Alaska Biological Science Center, Anchorage, AK. 26pp. + appendices.
- Report - Adams, L.G. 1999. Population dynamics of wolves and their prey in Denali National Park, Alaska: progress report. USGS Alaska Biological Science Center, Anchorage, AK. 17pp. + appendices.
- Publication - Adams, L.G., and B.W. Dale. 1998. Reproductive performance of female Alaskan caribou. Journal of Wildlife Management 62:1184-1195.
- Book - Mech, L.D., L.G. Adams, T.J. Meier, J.W. Burch, and B.W. Dale. 1998. The wolves of Denali. University of Minnesota Press. 238pp.
- Publication - Adams, L.G., and B.W. Dale. 1998. Timing and synchrony of parturition in Alaska caribou. Journal of Mammalogy 79:287-294.
- Thesis - Adams, L.G. 1996. Calf production and survival in the Denali Caribou Herd, Alaska. Ph.D. Thesis. University of Minnesota, St. Paul. 152pp.
- Publication - Adams, L.G., F.J. Singer, and B.W. Dale. 1995. Caribou calf mortality in Denali National Park, Alaska. Journal of Wildlife Management 59(3):584-594.
- Publication - Adams, L.G., B.W. Dale, and L.D. Mech. 1995. Wolf predation on caribou calves in Denali National Park, Alaska. Pages 245-260 in L.N. Carbyn, S.H. Fritts, and D.R. Seip, eds. Ecology and conservation of wolves in a changing world - proceedings of the second North American symposium on wolves. Canadian Circumpolar Institute Occasional Paper 35. University of Alberta, Edmonton. 642pp.
- Publication - Adams, L.G., and L.D. Mech. 1995. Population trends of wolves and caribou in Denali National Park, Alaska. Pages 347-348 in E.T. LaRoe, G.S. Farris,

C.E. Puckett, P.D. Doran, and M.J. Mac, eds. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals and ecosystems. U.S. Department of Interior, National. Biological Service, Washington, DC. 530pp.

Popular article - Adams, L.G. 1992. Snowfall tips the balance of wolf-caribou relationships in Denali National Park. Pages 56-57 in Highlights of natural resource management. U.S. Department of Interior, National Park Service, Washington, DC. 67pp.

Publication - Davis, J.L., L.G. Adams, P. Valkenburg, and D.J. Reed. 1991. The relationship between caribou body weight and age and cohort specific reproduction. Pages 115-142 in Butler, C.E. and S.P. Mahoney (eds.). Proceedings of the fourth North American caribou workshop. Newfoundland and Labrador Wildlife Division, St. John's, Newfoundland. 529pp.

Report - Adams, L.G., B.W. Dale, and B. Shults. 1989. Population status and calf mortality of the Denali Caribou Herd, Denali National Park and Preserve, Alaska - 1984-1988. U.S. National Park Service Natural Resources Progress Report AR-89/13. Anchorage, AK. 131pp.

Publication - Adams, L.G., B.W. Dale, and F.J. Singer. 1988. Neonatal mortality in the Denali Caribou Herd. Proceedings of the third North American caribou workshop. Alaska Department of Fish and Game Wildlife Technical Bulletin 8:33-34.

Publication - Adams, L.G., P. Valkenburg, and J.L. Davis. 1988. Efficacy of carfentanil citrate and naloxone for field immobilization of Alaskan caribou. Proceedings of the third North American caribou workshop. Alaska Department of Fish and Game Wildlife Technical Bulletin 8:167-168.

Popular article - Adams, L.G. 1987. Fate of caribou calves studied in Denali. Page 16 in Highlights of natural resource management. U.S. Department of Interior, National Park Service, Washington, DC. 53pp.

Report - Adams, L.G. 1986. Population status and neonatal mortality of the Denali Caribou Herd-progress report. U.S. National Park Service Natural Resources Progress Report AR-86/05. Anchorage, AK. 13pp.

Appendix 2. Abstracts of papers in press.

A. Accepted for publication in Journal of Mammalogy 2005.

## **EFFECTS OF MATERNAL CHARACTERISTICS AND CLIMATIC VARIATION ON BIRTH MASSES OF ALASKAN CARIBOU**

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*Abstract:* Understanding factors that influence birth mass of mammals provides insights to nutritional tradeoffs made by females to optimize their reproduction, growth, and survival. I evaluated variation in birth mass of caribou (*Rangifer tarandus*) in central Alaska relative to maternal characteristics (age, body mass, cohort, and nutritional condition as influenced by winter severity) during 11 years with substantial variation in winter snowfall. Snowfall during gestation was the predominant factor explaining variation in birth masses, influencing birth mass inversely and through interactions with maternal age and lactation status. Maternal age effects were noted for females  $\leq 5$  years old, declining in magnitude with each successive age class. Birth mass as a proportion of autumn maternal mass was inversely related to winter snowfall, even though there was no decrease in adult female masses in late winter associated with severe winters. I found no evidence of a hypothesized intergenerational effect of lower birth masses for offspring of females born following severe winters. Caribou produce relatively small offspring but provide exceptional lactation support for those that survive. Conservative maternal investment prior to parturition may represent an optimal reproductive strategy given that caribou experience stochastic variation in winter severity during gestation, uncertainty of environmental conditions surrounding the birth season, and intense predation on neonates.

B. Accepted for publication in Rangifer 2006.

## **EXTRAORDINARY MOVEMENTS OF THE DENALI CARIBOU HERD FOLLOWING THE PERFECT STORM**

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*Abstract:* Although historic literature is replete with anecdotes about atypical and far-reaching movements of caribou herds in Alaska, very few such events have been

described since the late 1970s proliferation of radiotelemetry studies in the region. In September 1992, several herds in Alaska made unusual movements away from their typical year-round ranges as a result of highly unusual weather conditions that affected a broad swath of the state. We describe the movements of 113 radiocollared caribou from the Denali Caribou Herd during this phenomenon and the subsequent year. The majority of caribou in the Denali Herd left their typical range during 26-28 September 1992, traveling distances up to 221 km and remained out of the area through much of the winter. While the outmigration was highly consolidated and easily noticed, the return was protracted with caribou drifting back to their typical range from October 1992 to early September 1993. All radiocollared caribou that survived the 1992-93 winter ultimately returned to their typical year-round range.