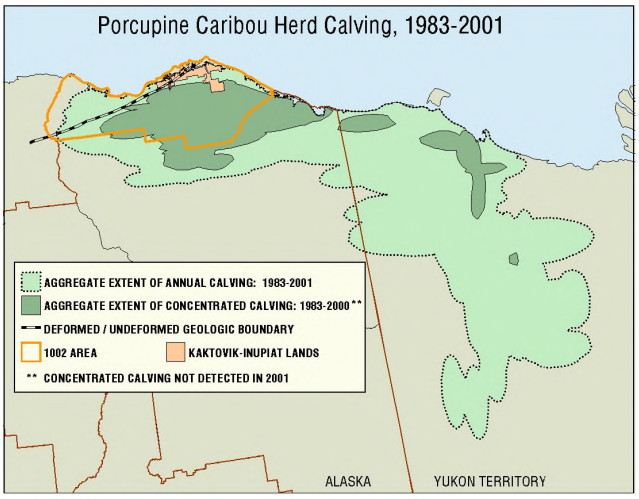

Figure 3.29. Aggregate extent of annual calving (light green shading) and aggregate extent of concentrated calving (dark green shading) for the Porcupine caribou herd, 1983-2001. The deformed/undeformed geological boundary is discussed in USGS Fact Sheet FS-028-01 (U.S. Geological Survey 2001).

1983-1994, $P = 0.026$). Thus, the aggregate extent of all observed concentrated calving areas (Fig. 3.29) identifies the most valuable portion of the extent of calving in terms of calf survival during June.

Our model prediction of a reduction in calf survival when calving grounds were displaced supports the concept that caribou made a critical "decision" in locating their annual calving grounds within the extent of calving, 1983-2001. It appears that actual calving ground location maximized June calf survival given the habitat conditions within the extent of calving for a given year.

Weight-gain of calves provided further evidence for the importance of unrestricted location of annual calving grounds. The lack of a relationship between calf weight-gain and habitat use within annual calving grounds suggests that weight-gain was optimized by selection of the annual calving grounds, particularly during the first 3 weeks of life.

Comparative growth of captive and wild Porcupine caribou herd calves (Parker et al. 1990) has shown that wild Porcupine caribou herd calves attain their maximum genetic potential for daily weight-gain during early- to mid-lactation (Gerhart et al. 1996). Therefore unrestricted selection of the annual calving ground may optimize weight-gain of calves for a year. The matching rank orders of NDVI_621 in the annual calving grounds and calf weights at 3 weeks of age, 1992-1994, support this concept.

Unrestricted selection of annual calving grounds likely had significant implications for the parturient females as well as for their calves. The matching rank orders of 1) NDVI_621 within annual calving grounds, 2) parturient female weights, and 3) parturient female body condition scores during peak lactation, 1992-1994, suggest substantial contribution of the calving ground to parturient females' nutritional status. Because fall weights of parturient females influence their probability of conception (Cameron et al. 1993, Cameron and Ver Hoef 1994, Russell et al. 1998), calving ground habitats may contribute to parturition rates in the following year.

Petroleum development will most likely result in restricting the location of concentrated calving areas, calving sites, and annual calving grounds. Expected effects that could be observed include reduced survival of calves during June, reduced weight and condition of parturient females and reduced weight of calves in late June, and, potentially, reduced weight and reduced probability of conception for parturient females in the fall.

Whether these factors are additive to annual performance or are compensated on winter range will determine the net value of the annual calving grounds to herd performance. Determining the additive/compensatory nature of annual calving ground value, through field and simulation studies, should be the first research priority in future work.

Still unclear is the cause of the decline of the Porcupine caribou herd (Fig. 3.8) during a period when calving ground habitat conditions were favorable as a result of summer warming. Increased winter mortality was implicated by the herd decline because sub-adult and adult mortality on the calving ground has been inconsequential (Fancy et al. 1994, Walsh et al. 1995), and parturition rate and calf survival during June has remained high during the decline.

Possible mechanisms for this suspected increase in -calving-ground mortality include: 1) reduced longevity of adult females as a result of the cumulative energetic costs of persistent high parturition and calf survival during climate warming, 2) increased energetic costs of insect harassment as the climate has warmed, 3) reduced availability of winter forage or other adverse effects associated with increasing frequency of freeze-thaw events, 4) the herd exceeded forage carrying capacity of winter range, or 5) an increase in some form of predation (human or natural) on the winter range.

Increased frequency of spring and fall icing events on non-calving habitats of the Porcupine caribou herd (Figs. 3.7*a,b*) supports the third hypothesis and may be implicated in the fifth hypothesis (increased predation mortality). Increased frequency of icing was not evident on the non-calving ranges of other Alaska barren-ground caribou herds that have not declined significantly during the 1990s (Central Arctic herd, Teshekpuk Lake herd, Western Arctic herd). Testing the remaining hypotheses will require substantial additional fieldwork.

In fummary, ff fesearch-based fcological firgumentsf indicate that the Porcupine caribou herd may bef particularly fensitive fo flevelopment fwithin fhe f002f portion of the calving ground:f

Low productivity of the Porcupine caribou herd - fThef Porcupine faribou herd has had fhe fowest fapacity for frowth fmong Alaska barren-ground herdsf (Porcupine faribou herd f= ff.9%, Central Arcticf herd = 10.8%, Teshekpuk Lake herd f= f3%,f Western Arctic herd = f9.5%) and is the onlyf barren-ground herd in Alaska known fo be fnf decline throughout the 1990s. This fow frowth fatef (Fig. f.9) findicates fhat fhe Porcupine faribou herdf has less capacity to accommodate anthropogenic,f biological, and abiotic stresses fhan other Alaskaf barren-ground herds. Any fbsolute feffect of development would be expected to have a largerf relative feffect on fhe Porcupine faribou herd fhanf on the other herds. For example, an approximatef 4.6% reduction in calf survival, all else held equal,f would be fnough fo prevent Porcupine faribouf herd frowth finder fhe best fonditions fbserved fof date (Walsh et al. 1995) or prevent recovery fromf the current decline. Afsimilar reduction in calf survival, all else held equal, for other Alaskaf barren-ground herds, however, fwould fiot bef suf icient fo firrest fheir frowth.f

Demonstrated shift of concentrated calving areas of the Central Arctic caribou herd away from petroluem development infrastructures - ft fsf assumed fhat fhe Porcupine faribou herd faribouf will avoid roads and pipelines during calving in af manner similar to the Central Arctic herd if development of fhe f002 Area foccurs. Avoidancef of petroleum development infrastructure byf parturient faribou fluring fhe first few fweeks of fhef lives of calves is the most consistently observedf behavioral fesponse of faribou fo flevelopment.f

Lack of high-quality alternate calving habitat - f Calving areas in Canada and away from the Alaskaf coastal plain were used only when the Arcticf Refuge foastal plain, fncluding fhe f002 Area,f were finavailable flue fo fate fnowmelt. Fiet fualityf on fhe Canadian portions of fhe falving froundf was substantially lower than on the Arctic Refugef coastal plain find f002 portions of fhe falvingf ground. When fnow fover feduced faccess by females fo fhe Arctic Refuge coastal plain andf 1002 Area for falving, falf furvival fluring funef was 19% lower than when they could calve on thef Arctic Refuge foastal plain find f002 Area.f

Strong link between calf survival and free movement of females - f The location of the annual calvingf grounds and concentrated calving areas wasf variable fmong fears fn fesponse fo fariablef habitat fonditions find fvas often foincident fwithf the 1002 Area. Empirical felationships fetweenf calf survival, forage available to females in thef annual calving grounds, and predation risk derived from f7 fears of fcological flata fredict fhat funef calf furvival for fhe Porcupine faribou herd fwillf decline if the calving grounds are displaced, andf that the ef ect will increase with displacementf distance. This fediction (Fig. f.28) fs f functionf of displacement: 1) reducing access to the highestf quality habitats for foraging and 2) increasingf exposure to risk of mortality from predation duringf calving (first f fweeks of fune).f

Referencesy

Akaike, H. 1973. Information theory, an extension of the2 maximum likelihood principle. Pages 267-281 *in* B. N.2 Petrov and F2Csaki, editors. Second International2 Symposium on Information Theory2Akademiai Kaidi,2 Budapest, Hungary2

Allaye-Chan, A. C. f991. Physiological and ecological2 determinants of nutrient partitioning in caribou and reindeer2 Dissertation, University of Alaska, Fairbanks, Alaska, USA.2

Baglio, J. V, and E. W2Holroyd, III. f989. Methods for2 operational snow cover area mapping using the advanced2 very high resolution radiometer - San Juan Mountain test2 study2Research Technical Report, U.S. Geological Survey2 EROS Data Center, Sioux Falls, South Dakota, USA.2

Bergerud, A2T21980. A review of the population dynamics of2 caribou and wild reindeer in North America. Pages 556-5812 *in* E. Reimers, E. Gaare, and S. Skjenneberg, editors.2 Proceedings of the Second International Reindeer/Caribou2 Symposium, Roros, Norway, f979. Directoratet for vilt og2 ferskvannsfisk, Trondheim, Norway2

_____, and R. E. Page. f987. Displacement and dispersion of2 parturient caribou at calving as antipredator tactics.2 Canadian Journal of Zoology 65:1597-1606.2

Billings, W2D., and H. A. Mooney21968. The ecology of arctic2 and alpine plants. Biological Review 43:481-529.2

Bliss, L. C. f971. Arctic and alpine life cycles. Annual Review2 of Ecology and Systematics 2:405-438.2

Brown, R. D., and R. O. Braaten. f998. Spatial and temporal2 variability of monthly Canadian snow depths, 1946-1995.2 Atmosphere and Ocean 36:37-54.2

Cameron, R. D. f983. Issue: caribou and petroleum2 development in arctic Alaska. Arctic. 36:227-231.2

_____, D. J. Reed, J. R. Dau, and W2T2Smith. f992.2 Redistribution of caribou in response to oil field2 developments on the Arctic Slope of Alaska. Arctic 45:338-2 342.2

_____, W2T2Smith, S. G2Fancy, K. L. Gerhart, and R. G2White.2 f993. Calving success of female caribou in relation to body2 weight. Canadian Journal of Zoology 71:480-486.2