

the coastal plain with lower suspected density of wolves, eagles and bears; and greater (8.3%, $P = 0.026$) if born in the 1002 Area.

The survival advantage of high density calving for individual calves tended to be greater when calves were born in the foothills and mountains than when they were born on the coastal plain (14.3% advantage vs. 7.9% advantage, respectively).

Individual calf survival was not related ($P = 0.160$) to the frequency of use of its birth site as a portion of the concentrated calving area, 1983-1994, but calf survival was lower (9.9%, $P = 0.026$) if the birth site was in an area never used as a concentrated calving area. In a stepwise logistic regression analysis that simultaneously considered calving density, time of birth, zone of birth (coastal plain or foothills), and in or out of the 1002 Area, only calving density ($P = 0.004$), time period of birth (early, middle, late; $P = 0.012$), and zone ($P = 0.008$) entered the model that predicted individual calf survival, 1983-1994.

The survival advantage of both high calving density and being born near the middle of the calving period may have been due to predator swamping where high spatial and temporal densities of calves may make it difficult for predators to capture individual calves (Hamilton 1971). Bears tended to be less successful at capturing calves in the concentrated calving areas of the Porcupine caribou herd (Young and McCabe 1997).

When assessing the proportion of the annual population of calves that survived during June, the timing of birth in relation to other calves was not applicable, but median calving date, 1983-1996, was available. In addition, we could consider the relative amount of food (NDVI_calving, NDVI_rate, and NDVI_621), winter range conditions prior to calf birth (snow properties), and the proportion of calves born in coastal plain or foothill zones.

Analyses of the proportion of calves surviving in relation to these independent variables were conducted separately at 2 scales: a) the extent of calving and b) the annual calving grounds.

Within the extent of calving, the relative amount of forage available to females during peak lactation (NDVI_621) provided the best model of calf survival during June ($r^2 = 0.85$, $P < 0.001$) (Fig. 3.26). No other independent variable that was considered added significant explanatory power.

This model (Fig. 3.26) (Percent June Calf Survival = $[0.107 + (2.05 \times \text{NDVI}_621 \text{ in the extent of calving})] \times 100$) was the best available estimate of survival of calves during June for the Porcupine caribou herd under undisturbed conditions during the past 2 decades. This model of calf survival was independent of annual calving ground location and, if the 1002 Area is developed, the

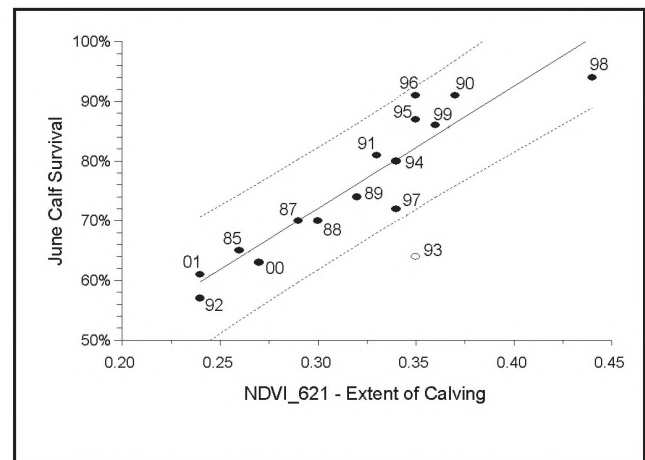


Figure 3.26. Calf survival through June for the Porcupine caribou herd, 1985-2001, in relation to median Normalized Difference Vegetation Index on 21 June (NDVI_621) within the aggregate extent of calving (EC). Legends identify the year of the estimate. Calf survival was not estimated in 1986 because inclement weather prevented a complete sample in late June. Calf survival for 1993 was a significant outlier (RStudent = 3.84, see text for biological justification) and was excluded from the estimated regression line ($r^2 = 0.85$, $P < 0.0001$). Upper and lower dashed lines indicate 95% confidence intervals on the predicted observations.

model can be used to assess whether calf survival during June is affected by development.

Calf survival for 1993 was an outlier (RStudent = 3.84) and excluded from the estimated relationship between NDVI_621 in the extent of calving and calf survival (Fig. 3.26) and from all subsequent models of calf survival. During 1992, atmospheric aerosols from the eruption of Mt. Pinatubo in the Philippines reached the Arctic in the spring (Stone et al. 1993). This resulted in a late spring, cool summer, early and heavy snow deposition in the fall, and near catastrophic conditions for caribou.

We surmise that the consistently bad weather conditions during 1992 and early 1993 resulted in a carry-over effect that reduced calf survival in 1993 to levels much lower than would have been expected on the basis of NDVI_621 alone. It was likely that this suspected additional mortality in 1993 affected calves within the first day or two of life; perhaps many calves were of very low birth weight. We draw this conclusion because 0- to 3-week weight-gain of calves that survived to be radio-collared in 1993 was as high as any other year (Fig. 3.23) and the weights of parturient females that were caught with their live calves on ~21 June in 1993 were as high as any weights we observed, 1992-1994 (Fig. 3.25).

At the smaller scale of the annual calving grounds, the proportion of Porcupine caribou herd calves that survived through June was positively related to both NDVI_621 in the annual calving grounds and to the proportion of calves that were born on the coastal plain (assumed lower

predation risk) ($r^2 = 0.70$, $P < 0.001$). No other variable added significant explanatory power. Median NDVI_621f in the annual calving grounds and the proportion of calves born on the coastal plain were not correlated ($P > 0.94$). Forage in the annual calving ground accounted for approximately 75% of the total variance explained by this model and assumed predation risk accounted for the remainder (Fig. 3.27).f

Thus, in addition to scale dependency in the functional response of caribou to habitats (selection of NDVIs within the extent of calving and within the annual calving grounds), there was scale dependency in the numerical response of calf survival to calving ground location and habitat conditions. Only forage was related to calf survival at the largest spatial scale (extent of calving) that we analyzed.f

At the intermediate scale (annual calving ground), forage dominated calf survival, but predation risk added substantial explanatory power. At the smallest scale (individuals within the population of calves), spatial and temporal variance in calf density (indirect predation risk) and direct predation risk most effectively explained calf survival.f

This scale dependency in calf survival likely occurred because the annual variance in habitat conditions in both the extent of calving and in the annual calving grounds far exceeded the annual variance in predation risk within the extent of calving and within the annual calving grounds.f The scale dependency in calf survival made it impossible to extrapolate across scales. Thus, to develop an understanding of the relative influence of forage and

predation on calf survival, it is imperative to specify the scale of analysis, and assess multiple scales simultaneously.f

The temporal increase in forage during peak lactation (NDVI_621) (Fig. 3.4) was coincident with local climate warming (Fig. 3.3a). Forage at calving (NDVI_calving) was positively associated with the Arctic Oscillation (Fig. 3.6). There were also positive relationships between climate and NDVI_calving, between percent of females calving in the 1002 Area and NDVI_calving, and between calf survival and NDVI_calving [$r^2 = 0.33$, $P = 0.011$ (annual calving ground); $r^2 = 0.60$, $P < 0.001$ (extent of calving)]. As a result, June calf survival was weakly correlated ($r^2 = 0.22$, $P = 0.029$) with the proportion of cows that calved in the 1002 Area. Further, because climate affected calving ground location (e.g., Porcupine caribou herd females were more likely to use the western portion of the extent of calving following winters with a positive Arctic Oscillation), both forage availability and predation risk were implicitly related to climate.f

In years with substantial snowcover on the coastal plain (Fig. 3.18) and relatively low NDVI_621 in the extent of calving, average calf survival (66%, $n = 7$, SE = 6%) was 19% less ($P = 0.008$) than when there was little snowcover at calving and NDVI_621 was high (85%, $n = 6$, SE = 11%). Thus, climate was an important influence on habitat conditions, on the likely use of the Alaska coastal plain and 1002 Area for calving, and on calf survival during June, 1983-2001, under undisturbed conditions.f

Potential Effects of Development on June Calf Survival

In order to assess the potential effects of development of the 1002 Area on the Porcupine caribou herd during calving, we needed a model of caribou behavioral response to oil field infrastructures. The adjacent Central Arctic herd (Fig. 3.2), which calved in the vicinity of Prudhoe Bay - Kuparuk complex of petroleum development areas, provided the only available model of caribou behavioral response to petroleum development during calving.f

Parturient female caribou (i.e., those about to give birth or accompanied by very young calves) of the Central Arctic herd repeatedly demonstrated their sensitivity to disturbance during the first few weeks of life of their calves (Smith and Cameron 1983, Whitten and Cameron 1983, Dau and Cameron 1986; Cameron et al. 1992; Nellemann and Cameron 1996, 1998).f

Parturient females avoided, or were less likely to cross, *infrastructures* (roads and pipelines) during the calving season (Cameron and Whitten 1979, Dau and Cameron 1986, Murphy and Curatolo 1987, Lawhead 1988, Cameron et al. 1992). In addition, densities of

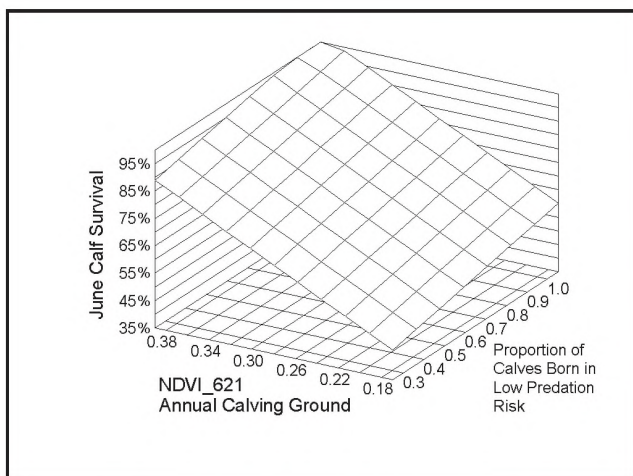


Figure 3.27. Predicted calf survival for the Porcupine caribou herd, 1985-2001, in relation to median Normalized Difference Vegetation Index on 21 June (NDVI_621) within the annual calving ground and to the proportion of calves born on the Arctic National Wildlife Refuge coastal plain physiographic zone where predator density was lower than in the foothill-mountain physiographic zone ($r^2 = 0.696$, $P < 0.001$). Calf survival was not estimated in 1986 because inclement weather prevented a complete sample in late June.z