

this report and in the 1987 Final Legislative Environmental Impact Statement (Clough et al. 1987).

### Nutritional Importance of the Calving Groundy

Spring arrival on the calving ground is the time of minimum body reserves for parturient females (those about to give birth or accompanied by very young calves) (Chan-McLeod et al. 1999). Thereafter, their energy and protein requirements reach the highest level of the year during peak lactation in the first 3 weeks of June (White and Luick 1984, Parker et al. 1990). The females' appetites are high and forage intake rates can match lactation demands where primary production is high (White et al. 1975, 1981). Small changes in nutritional content and digestibility of forage, however, can have substantial multiplier effects on digestible energy and protein intake (White 1983), and thus may influence nutritional performance of Porcupine Caribou herd females on the calving ground.

Recent advances in identifying the basis of selection of food by ungulates demonstrate that forage intake is a function of ungulate morphology, plant architecture, and biomass of acceptable forage (White et al. 1975, Trudell and White 1981, Spalinger et al. 1988, Shipley and Spalinger 1992, Gross et al. 1993, Langvatn and Hanley 1993, Wilmshurst and Fryxell 1995). Because ungulates select forage with high digestible energy and high digestible protein (Langvatn and Hanley 1993, Wilmshurst and Fryxell 1995), these properties are the relevant measure of forage value of habitats at any spatial scale (White et al. 1975, White and Trudell 1980a,b). Thus, the forage currency for ungulates is primarily a function of digestibility of acceptable foods and is not simply plant biomass or gross energy (Fryxell 1991).

The source of protein for fetal growth comes almost exclusively from body protein of female caribou entering winter (Gerhart et al. 1996). Females with high body protein in late winter produce the largest calves (Allayef-Chan 1991). Early weaning of calves occurs when habitat conditions do not support a protein intake sufficient to meet a minimal rate of body protein deposition; milk synthesis then ceases (Russell and White 1998). The protein:energy ratio of forage consumed during lactation increases the milk protein intake by calves (Chan-McLeod et al. 1994), the most important milk nutrient affecting calf growth rate at all calf ages (White 1992).

When forage biomass is low at calving, Porcupine caribou herd females might be expected to use microhabitats of highest biomass of acceptable foods and to select the most digestible forages from within them, as has been documented for caribou of the Central Arctic herd (White et al. 1975) and the Western Arctic herd (White and Trudell 1980). This change in the basis of selection, from forage biomass to forage digestibility,

constitutes scale-dependent selection (cf. Wiens 1989, O'Neil and King 1998). We pursued this issue of scale dependency in habitat selection by the Porcupine caribou herd at the larger scales of the annual calving grounds and concentrated calving areas.

Because the inability to meet lactation demands may lower the performance (i.e., weight-gain, survival) of calves, calving ground habitats may be important. They may be important because they can contribute substantially to the female and calf protein budgets during the calving season, when maternal protein reserves can be low (Gerhart et al. 1996, Chan-McLeod et al. 1999).

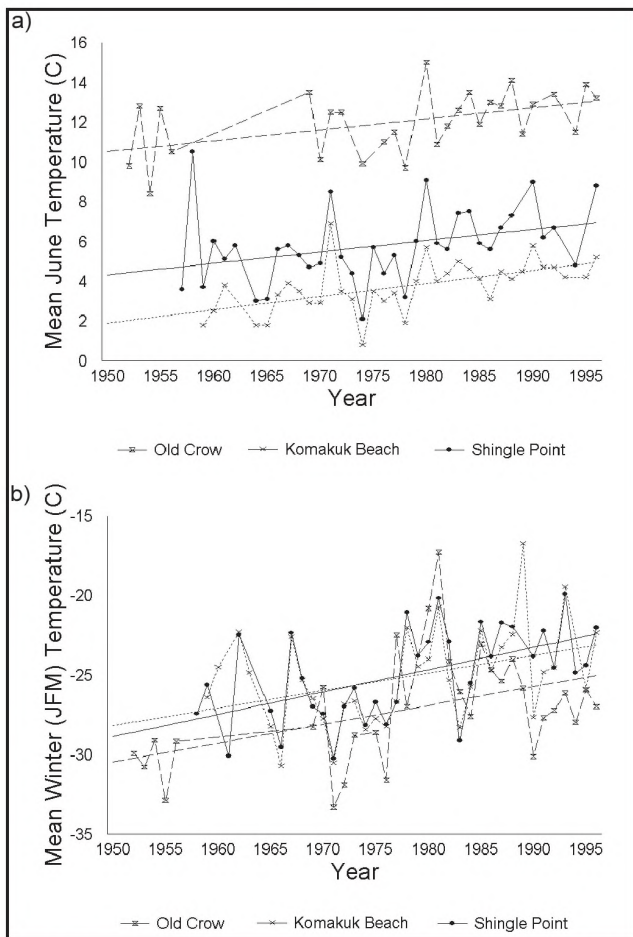
### Habitat Trends During the Study Periody

The climate of the Arctic has been warming in both summer and winter during recent decades (Chapman and Walsh 1993, Groisman et al. 1994, Houghton et al. 1995). Temperature increases have been greatest in winter. The warming has been heterogeneous across the Arctic (Chapman and Walsh 1993, Serreze 2000), but was evident in spring (Fig. 3.3a) and winter (Fig. 3.3f) temperatures within the northern part of the annual range of the Porcupine Caribou herd.

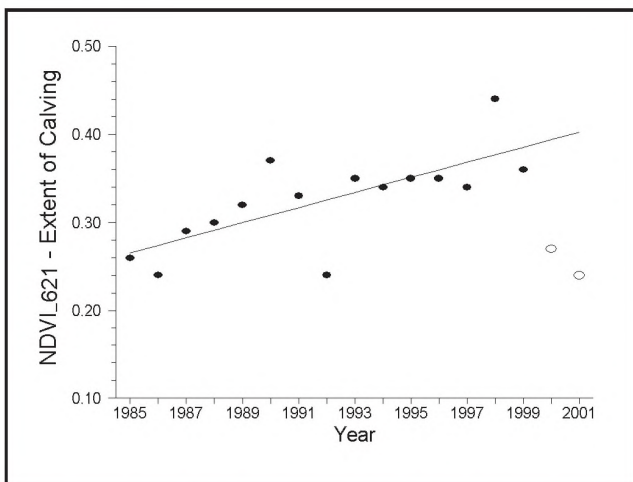
An earlier greening and later senescence of green plant biomass in areas north of 40°N (Myneni et al. 1997, 1998; Zhou et al. 2001) have been detected with NDVI and associated with the warming trend. The earlier greening was evident locally within the extent of calving (Fig. 3.2) of the Porcupine Caribou herd in the form of an increasing relative amount of green plant biomass on 21 June (NDVI\_621,  $r^2 = 0.50$ ,  $P = 0.002$ ) during 1985-1999 (Fig. 3.4).

A very low value for NDVI\_621 was observed in 1992, the year that stratospheric aerosols from the 1991 eruption of Mount Pinatubo in the Philippines reached the Arctic in spring (Minnis et al. 1993). Both 2001 and 2000 were substantial outliers (RSudent = -2.49, -2.86, respectively) from the relationship between NDVI\_621 and year, 1985-1999 (Fig. 3.4). Both 2001 and 2000 had exceptionally late springs with high snowcover at calving. We do not yet know if these outliers indicate a change in the trend observed during 1985-1999.

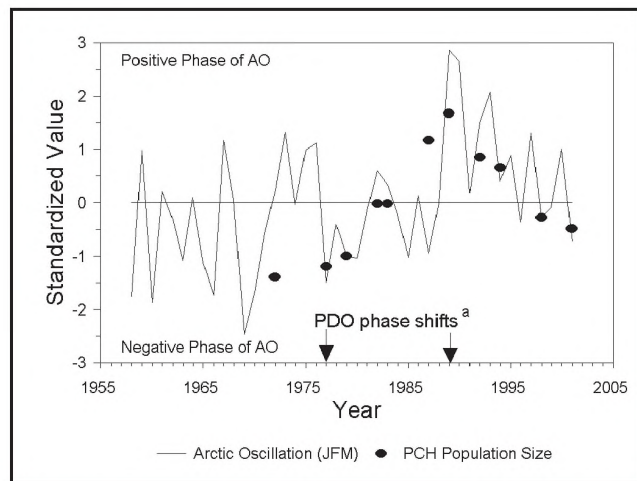
The Arctic Oscillation (Fig. 3.5) is centered over the high Arctic and is one of a number of correlated indices of large-scale atmospheric pressure differentials (e.g., North Atlantic Oscillation, Northern Hemispheric Annular Mode) (Thompson and Wallace 1998, 2001). The Arctic Oscillation is the height of the level of one-half atmosphere of pressure above the surface of the Earth and is weakly correlated with surface temperatures (Thompson and Wallace 1998). The Arctic Oscillation has a warm positive phase when surface pressures are low and warm North Atlantic water enters the Arctic Ocean,



**Figure 3.3.** Mean temperatures for 2 stations within the Porcupinez caribou herd's aggregate extent of calving (Komakuk Beach and Shingle Point, Yukon Territory, Canada) and 1 station within its winter range (Old Crow, Yukon Territory) for a) June, and b) winter (January, February, March), 1950-1995.



**Figure 3.4.** Median Normalized Difference Vegetation Index (NDVI) on June 21 within the aggregate extent of calving for the Porcupinez caribou herd, 1983-2001. Values for 2000 and 2001 were outliers ( $R_{Student} = -2.49, -2.86$ , respectively) and excluded from the displayed regression line,  $r^2 = 0.496, P = 0.002$ .



**Figure 3.5.** Standardized values of the Arctic Oscillation (AO) for winter (January, February, March) and population size of the Porcupinez caribou herd, 1958-2001. Mean value indicated by solid horizontal line. <sup>a</sup> PDO is the Pacific Decadal Oscillation (Hare and Matuna, 2000).

and a cool negative phase when surface pressures are relatively high.

Initiation of increasing and decreasing trends in the Arctic Oscillation has been coincident with phase shifts in the Pacific Decadal Oscillation in 1977 and 1989 (Hare and Matuna, 2000) (Fig. 3.5). Correlations between the closely related North Atlantic Oscillation and a number of vegetative and ungulate population characteristics have been reported for Northern Europe (Post et al. 1997, Post and Fensholt 1999).

Median annual NDVI at calving (NDVI\_calving) within the extent of calving of the Porcupine caribou herd was positively correlated with the Arctic Oscillation from the winter (January, February, March) of the previous calendar year (~15 month lag,  $F^2 = 0.32, P = 0.011$ ) (Fig. 3.6). This suggested that early forage availability for lactating females was influenced by weather patterns on a hemispheric scale.

Further, the suspected phase shift in the Arctic Oscillation at the end of the 1980s (Fig. 3.5) was coincident with an increase in the frequency of daily temperature excursions above freezing in both the spring (Fig. 3.7a) and fall (Fig. 3.7f) on the transitional ranges of the Porcupine caribou herd during the 1990s. There has been a decrease in the depth and extent of snowcover in Northwestern Canada near the wintering grounds of the Porcupine caribou herd during this latter period as well (Brown and Braaten 1998).

Thus, forage biomass during peak lactation demand (NDVI\_621) increased during the period of study, 1985-1999 (Fig. 3.4), and this positive trend was coincident with summer warming on the calving ground (Fig. 3.3a). In addition, forage availability at calving (NDVI\_calving) has been positively correlated with hemispheric-scale