Section 5: Forage Quantity and Quality

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The Porcupine caribou herd has traditionally used the coastal plain of the Arctic National Wildlife Refuge, Alaska, for calving. Availability of nutritious forage has been hypothesized as one of the reasons the Porcupine caribou herd migrates hundreds of kilometers to reach the coastal plain for calving (Kuropat and Bryant 1980, Russell et al. 1993).

Forage quantity and quality and the chronology of snowmelt (which determines availability and phenological stages of forage) have been suggested as important habitat attributes that lead calving caribou to select one area over another (Lent 1980, White and Trudell 1980, Eastland et al. 1989). A major question when considering the impact of petroleum development is whether potential displacement of the caribou from the 1002 Area to alternate calving habitat will limit access to high quantity and quality forage.

Our study had the following objectives: 1) quantify snowmelt patterns by area; 2) quantify relationships among phenology, biomass, and nutrient content of principal forage species by vegetation type; and 3) determine if traditional concentrated calving areas differ from adjacent areas with lower calving densities in terms of vegetation characteristics.

We investigated caribou forage in 2 areas: an historically traditional calving area entirely within the 1002 Area and an adjacent displacement area entirely outside of the 1002 Area (Fig. 5.1).

The traditional calving area was defined during the 1002 Area baseline biological studies as the area of intensive calving use during 10 of the 14 years studied from 1972 to 1985. Importance of this area was upheld by data on calving locations from later years.

Availability of potential displacement areas is limited here because the coastal plain narrows as the rugged Brooks Range mountains approach the Beaufort Sea. The displacement area chosen for comparison was located to the south and east of the 1002 Area in the only part of Alaska's North Slope that is a designated Wilderness Area.

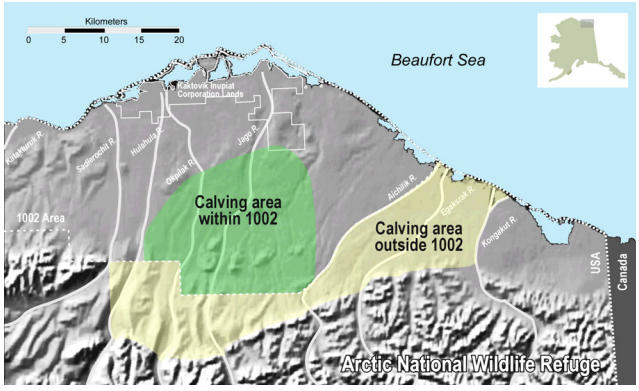

Figure 5.1. Map of caribou forage study area, Porcupine caribou herd, on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

The displacement area had topography similar to the traditional area: a mix of rolling foothills and coastal plains. It lay along the spring migration route typically traversed by the Porcupine caribou herd. Female caribou have calved in this area, especially during years when snow melted late (Fig. 3.18).

We gathered data at both study areas during the caribou calving period in early June of 1990 and 1991. Fifty-five 30m x 30m study sites in 1990, and 45 in 1991, were located at the intersections of grids positioned randomly over the entire study area. We sampled during 3 periods in 1990 (31 May-3 June, 8-12 June, and 19-22 June), and 2 periods in 1991 (4-6 June and 9-13 June).

Data were collected on 4 prevalent plant species identified in the literature as important forage for caribou on Alaska's North Slope: *Eriophorum vaginatum* (tussock cottongrass), *E. angustifolium* (tall cottongrass), *Carex aquatilis* (aquatic sedge), and *Salix planifolia* ssp. *pulchra* (diamond-leaf willow) (Thompson and McCourt 1981, Russell et al. 1993).

At each study site, forage quantity data were collected in 14 1-m^2 quadrats along 2 randomly-located transects. Phenology data were collected at the same 14 quadrats, plus 20 3-m^2 quadrats located on 2 additional random transects. Tussock cottongrass inflorescences and diamond-leaf willow leaves were collected on transects for analyses of nutrient and fiber content at a random subsample of sites during 1990 only.

We compared the traditional and displacement calving areas by measuring the following characteristics: distributions of vegetation types, snowcover, plant biomass, nutrient and fiber content, and phenology.

Non-parametric analysis of variance using a repeated measures design was used to test for differences between the calving areas and between sampling periods (time). Analyses were conducted individually for each parameter in each year.

Interactions between area and time were tested with Mann-Whitney tests (Conover 1980) of area differences for each time contrast in a full orthogonal set. If interactions were insignificant ($P > 0.05$), area differences were tested with Mann-Whitney tests based on the mean value for all sampling periods. The differences between the first and last sampling periods were tested with the sign test using data from both areas. If any interactions were significant, tests for differences between areas were conducted separately for each sampling period, and sign tests were conducted separately for each area.

Forage Comparisons Within and Outside the 1002 Area

Spring snowmelt was very early in 1990 and was nearly complete before the calving period. Snowmelt in 1991 was slightly earlier than normal. In 1991, we found the traditional calving area had more area with partial snowcover remaining during the calving period than the displacement area (40% vs. 33%, $P = 0.02$). Some plants were in earlier phenological stages in the traditional area (Table 5.1).

The quantity of new green forage was low throughout both study areas during the calving period in both years even though snow melted earlier than normal (Table 5.2). Only tussock cottongrass flowers appeared to be readily available for forage during the peak of calving. The 2 other sedges had very little new growth. The willow, which is the major forage species later in the summer, leafed out only at the end of the calving period. The tundra appeared brown and no other plant species were producing abundant new growth during the calving period.

Four forage species were quantified (Table 5.3). Tussock cottongrass flowers had much higher biomass in the traditional calving area than in the displacement area in both years, although the difference was statistically significant only in 1991. Tussock cottongrass was uncommon at the displacement area sites. The 2 other sedges had very low cover and no significant differences. Diamond-leaf willow did not leaf out during the study period in 1991, but in 1990 willow leaves had greater biomass in the traditional calving area when they leafed out.

Tussock cottongrass flowers and diamond-leaf willow leaves were tested for forage quality throughout the study period in 1990 (Table 5.4). Higher nutrient concentrations increase forage quality, while higher fiber and lignin concentrations decrease digestibility. Both plant species tended to have greater forage quality in earlier phenological stages than in later stages. Tussock cottongrass flowers had greater forage quality in the traditional calving area than in the displacement area.

Distributions of vegetation types were distinctly different between the 2 areas (Table 5.5). The traditional calving area had greater cover of 2 vegetation types important for caribou forage: tussock tundra and moist sedge-willow tundra. The displacement area had greater cover of early succession vegetation types such as Dryas river terraces and barren or partially vegetated ground due to the greater extent of floodplains in that area. Tussock tundra is a late-succession vegetation type and is nearly absent from floodplain terrain (Jorgenson et al. 1994).

The displacement area also included the highest elevation foothills where development of tussocks is

Table 5.1. Median phenological stages[a] of major forage species in the Porcupine caribou herd's traditional caribou calving area (C) and potential displacement area (D) on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

1990	31 May– 03 June		08 – 12 June		19 – 22 June			
	C	D	C	D	C	D	Area[b]	Time[c]
Tussock cottongrass	3	3**[d]	3	3**[d]	3	4**	$P < 0.01$	*
Tall cottongrass	1	1	2	2	2	2	$P = 0.60$	ns
Aquatic sedge	1	1	2	1	2	2	$P = 0.44$	*
Diamond-leaf willow	1	2	1	2**	2	3**	$P = 0.01$	*
1991	**04 – 06 June**		**09 – 13 June**		**(no sampling)**			
	C	D	C	D			Area[b]	Time[c]
Tussock cottongrass	2	2	3	3			$P = 0.85$	*
Tall cottongrass	1	2*	1	2*			$P = 0.04$	ns
Aquatic sedge	1	2	2	1			$P = 0.83$	ns
Diamond-leaf willow	0	0**[d]	0	1**			$P < 0.01$	*

* $P < 0.05$, ** $P < 0.01$, ns = no significant difference.

a Phenological stages: Tussock cottongrass, 1 = boot stage, 2 = early flower, 3 = full flower, 4 = seed; Tall cottongrass and Aquatic sedge, 1 = vegetative < 5cm, 2 = vegetative > 5cm, 3 = early flower, 4 = full flower; Diamond-leaf willow, 0 = no new growth, 1 = bud swollen, 2 = leaf unfolding, 3 = full leaf.

b Significance level for difference between areas averaged over all periods.

c Significance level for change between first and last sampling period.

d Phenological stage significantly advanced, although median values were the same.

Table 5.2. Median[a] biomass (g/m^2) and percent cover of 4 major caribou forage species in the 5 most common vegetation types on the coastal plain of the Arctic National Wildlife Refuge, Alaska, during the Porcupine caribou herd's calving period, June 1990.

	Vegetation Types[b]				
Species	WG	MS	MSD	TT	ST
Tussock cottongrass					
g/m^2	0.00^{A}	$< 0.01^{AB}$	$< 0.01^{AB}$	0.04^{C}	0.03^{BC}
Tall cottongrass					
% cover	1.2^{AB}	1.4^{A}	0.5^{C}	0.4^{C}	0.5^{BC}
Aquatic sedge					
% cover	0.9^{A}	0.7^{A}	0.0^{B}	0.0^{B}	0.0^{B}
Diamond-leaf willow					
g/m^2	0.00^{A}	0.88^{BC}	0.00^{AB}	0.83^{C}	3.25^{C}

a Values are medians for all sites, with site values obtained as means for 3 times. Medians with the same superscript were not significantly different ($P < 0.05$).
b Vegetation types: WG = wet graminoid tundra, MS = moist sedge-willow tundra, MSD = moist sedge-Dryas tundra, TT = tussock tundra, ST = low shrub tundra.

poorer than in the lower foothills of the traditional calving area. Glacial lobes covered about one-fifth of the foothills in the displacement area during the most recent glaciation that ended ~10,000 years ago. These recently deglaciated areas have very little tussock tundra (Jorgenson 1984).

Different distributions of vegetation types may explain most of the differences found in forage quantity and quality between the traditional and displacement areas. Tussock cottongrass flowers had greater biomass and forage quality in the tussock tundra type compared with other vegetation types (Tables 5.2 and 5.6). The greater biomass of flowers in the traditional area mainly resulted from the greater extent of tussock tundra. No consistent differences in flower quantity or quality between tussock tundra in the traditional calving area and tussock tundra in the displacement area were observed.

The location of the Porcupine caribou herd traditional calving area is greatly influenced by vegetation type distributions and snowmelt patterns across the Arctic Refuge coastal plain. These factors appear to determine the quantity and quality of forage available to the caribou during calving.

Because of the low amount of forage available during the calving period, the differences in vegetation

Table 5.3. Median density (no/m^2), biomass (g/m^2), and percent cover of major forage species in the Porcupine caribou herd's traditional caribou calving area (C) and potential displacement area (D) on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

1990	31 May– 03 June		08 – 12 June		19 – 22 June			
	C	D	C	D	C	D	Area[a]	Time[b]
Tussock cottongrass flowers								
no/m^2	0.6	0	0.5	0.2	0.2	0	$P = 0.87$	ns
g/m^2	0.02	0	0.01	< 0.01	0.01	0	$P = 1.00$	ns
Tall cottongrass								
% cover	0.4	0.4	0.6	0.3	0.6	0.2	$P = 0.93$	ns
Aquatic sedge								
% cover	0	0	0	0	0	0	$P = 0.72$	*[c]
Diamond-leaf willow leaves								
g/m^2	0	0	0	0	2.0	0.3	$P = 0.10$	*
1991	**04 – 06 June**		**09 – 13 June**		**(no sampling)**			
	C	D	C	D	C	D	Area[a]	Time[b]
Tussock cottongrass flowers								
no/m^2	2.7	0.0**	3.5	0.0**			$P < 0.01$	ns
g/m^2	0.09	0.00**	0.11	0.00**			$P < 0.01$	ns
Tall cottongrass								
% cover	0.2	0.3	0.3	0			$P = 0.68$	ns
Aquatic sedge								
% cover	0	0	0	0			$P = 0.08$	*[c]

* $P < 0.05$, ** $P < 0.01$, ns = no significant difference.
a Significance level for difference between areas averaged over all periods.
b Significance level for change between first and last time periods. If the significance levels differed between areas, both are shown (C/D).
c Last sampling period with significantly higher cover, although median values were the same.

Table 5.4. Median nutrient and fiber concentrations (percent of dry weight) of 2 major forage species in different phenological stages in the Porcupine caribou herd's traditional caribou calving area (C) and potential displacement area (D) on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

	Early Flower		Full Flower		Seed			
Tussock cottongrass	C	D	C	D	C	D	Area[a]	Time[b]
Nitrogen	2.8	2.6	2.5	2.2**	2.4	2.2**	$P = 0.01$	ns
Phosphorus	0.49	0.45	0.46	0.38*	0.38	0.36*	$P = 0.03$	*/ns
Calcium	0.18	0.16	0.13	0.12	0.14	0.11	$P = 0.25$	ns
Neutral detergent fiber	55.8	58.0	58.2	62.7	66.8	65.9	$P = 0.07$	*
Acid detergent fiber	16.5	18.4	19.0	20.4**	22.8	23.2**	$P = 0.01$	*
Lignin	2.3	2.6	2.5	2.3	1.9	1.9	$P = 0.43$	ns
n (# of sites)	6	7	8	15	8	14		
	Leaf Unfolding		Full Leaf					
Diamond-leaf willow	C	D	C	D				
Nitrogen	3.7	3.4	2.2	2.2			$P = 0.27$	*
Phosphorus	0.50	0.47	0.18	0.17			$P = 0.79$	*
Calcium	0.51	0.49	0.62	0.59			$P = 0.34$	*
Neutral detergent fiber	22.2	22.4	25.0	25.6			$P = 0.71$	*
Acid detergent fiber	16.3	15.6	17.0	17.7			$P = 0.71$	*
Lignin	10.3	9.4	8.8	9.4			$P = 0.43$	*
n (# of sites)	8	8	8	8				

* $P < 0.05$, ** $P < 0.01$, ns = no significant difference.

a Significance level for difference between areas averaged over all periods.

b Significance level for change between first and last time periods. If the significance levels differed between areas, both are shown (C/D). All tests for tussock cottongrass inflorescences were of full flower and seed stages only.

Table 5.5. Distribution of vegetation types (percent of area) in the caribou habitat study area (Fig. 5.1) based on an independent sample of 756 systematically-located vegetation plots on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

Vegetation Type	Entire Coastal Plain	Calving Habitat Study Area	Traditional Calving Area	Displacement Calving Area
Tussock Tundra	22	30	39	21
Moist Sedge-Willow Tundra	30	25	31	19
Low Shrub Tundra	7	11	8	13
Moist Sedge-Dryas Tundra	12	9	7	12
Wet Graminoid Tundra	13	8	8	7
Dryas River Terrace	3	7	1	13
Riparian Shrublands	2	3	3	3
Barren	2	3	3	4
Partially Vegetated	2	2	<1	5
Water	<1	2	<1	4

Table 5.6. Median nutrient and fiber concentrations (percent of dry weight) of tussock cottongrass inflorescences in different phenological stages compared between tussock tundra and other vegetation types on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

	Full Flower		Seed		
	TT [a]	Other	TT	Other	Stage
Nitrogen	2.4	2.0**	2.4	2.1**	$P < 0.01$
Phosphorus	0.43	0.34**	0.39	0.35**	$P < 0.01$
Neutral detergent fiber	60.0	63.6	66.2	66.7	$P = 0.25$
Acid detergent fiber	19.7	21.8*	22.8	23.6*	$P = 0.04$
Lignin	2.6	1.1**	1.9	1.9	$P = 0.03$
n (# of sites)	17	6	16	6	

* $P < 0.05$, ** $P < 0.01$

a TT = tussock tundra; Other = all other vegetation types that had tussock cottongrass inflorescences including moist sedge-willow tundra, moist sedge-Dryas tundra, and shrub-dominated tundra.

characteristics found between the 2 areas studied are probably biologically important and could affect calving success of the herd if petroleum development causes the displacement of calving caribou out of the 1002 Area into adjacent areas with lower forage value.

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