

**Habitat Use by
Parturient and Nonparturient Caribou
of the Mentasta Caribou Herd**

A Thesis
for the Degree of
Master of Science

by
Neil L. Barten, B.A.

University of Alaska Fairbanks
Fairbanks, Alaska

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CARIBOU OF THE MENTASTA CARIBOU HERD

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Presented to the faculty
of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements
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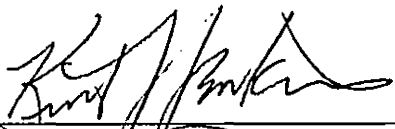
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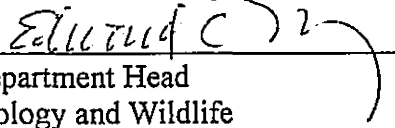
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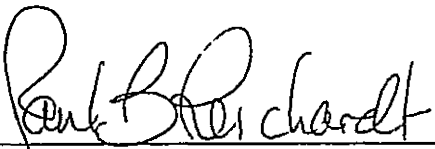


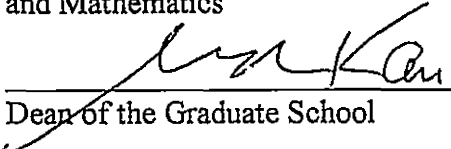
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ABSTRACT

I compared habitat use and diet characteristics among preparturient female caribou (Rangifer tarandus), and between parturient and nonparturient caribou during and after parturition, in the Mentasta Caribou Herd, Alaska, to explain movements by parturient females just prior to giving birth. I monitored 39 radio-collared females in 1994 and 40 animals in 1995. I estimated forage biomass, collected forage for determination of nitrogen and in-vitro dry matter digestibility (IVDMD), and collected fecal pellets to calculate indices of diet composition and diet quality at sites used by caribou. I also recorded sightings of predators throughout the study area. During peak parturition, females with young used habitat with fewer predator sightings, a lower abundance of forage species, but with nearly equal forage quality as that used by females without young. I hypothesized that parturient females used birth sites that lowered the risk of predation, and did so at little cost nutritionally.

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INTRODUCTION

Acquiring the resources necessary to survive and reproduce is a major component of fitness and constrains the types of habitats used by mammals (Bowyer et al., 1998; Fryxell and Sinclair, 1988; Langvatn and Hanley, 1993; White et al., 1997). Among herbivores, habitat selection often is related to the availability and quality of forage (Albon and Langvatn, 1992; Bowyer, 1986; Klein, 1970; Skogland, 1980), but also can depend on other factors, such as mineral requirements (Belovsky and Jordan, 1981; Hebert and Cowan, 1971), insect harassment (Russell et. al., 1993), exposure to adverse weather conditions (Belovsky, 1981; Ion and Kershaw, 1989; Miller and Gunn, 1985), and predation (Bergerud et al., 1984; Bleich et al., 1997; Festa-Bianchet, 1988; Kohlmann et al., 1996).

Constraints on foraging are magnified for females at parturition because neonates are vulnerable to predation, and lactation increases nutrient demands (Bowyer, 1991; Rachlow and Bowyer, 1994; White and Luick, 1984). Requirements for nitrogen and phosphorus by female caribou (Rangifer tarandus) increase around the time of parturition (Klein, 1970; McEwan and Whitehead, 1970), both to meet the costs of gestation and lactation (Klein, 1970; Robbins, 1983) and to replenish body reserves expended during winter (McEwan, 1968). These nutritional demands on caribou coincide with early phenological stages of vegetative growth (Albon and Langvatn, 1992; Klein, 1990; Kuropat and Bryant, 1980), which are typically high in nitrogen, phosphorus, and digestible energy, and low in structural carbohydrates and toxic or secondary metabolites

that reduce digestibility (Bryant et al., 1983; Launchbaugh et al., 1993).

Minimizing risk of predation may result in ungulates selecting habitats that compromise their ability to optimize foraging (Berger, 1978; Bowyer et al., 1998; Edwards, 1983; Molvar and Bowyer, 1994). Mountain ungulates often seek steep, rugged terrain to reduce risks of predation, especially when accompanied by neonates (Bleich et al., 1997, Festa-Bianchet, 1988). During migration, mule deer (Odocoileus hemionus) made tradeoffs between using habitats containing high-quality forage and those with less risk of predation (Nicholson et al., 1997). Bergerud et al. (1984) noted that female caribou with young were separated spatially from those without young during parturition, and hypothesized that predation was the controlling factor; however, the role of nutrient selection was not investigated. No studies have examined in detail the nutritional tradeoffs of habitat use by caribou inhabiting mountainous terrain during parturition.

Our objective was to determine the relative importance of nutrient acquisition and predator avoidance in the use of sites for parturition by female caribou. If caribou follow a phenological gradient of vegetation to maximize their intake of high-quality forage, diet quality should be similar throughout the season of parturition for parturient and nonparturient females. If habitat use differed between parturient and nonparturient females at parturition, we considered three hypotheses to explain this outcome: 1) parturient females use habitat that maximizes forage intake and forage quality to accommodate the increased cost of gestation and lactation; 2) parturient females use sites with a lower risk of predation to themselves and their neonates, and 3) females make

tradeoffs between forage and risk of predation.

To distinguish among these three hypotheses, we compared forage characteristics between sites used by parturient and nonparturient females immediately before, during, and after the birthing season. If nutrient acquisition was the driving force influencing the use of sites for parturition, we predicted that: 1) forage abundance and quality would be equal or greater at sites used by females with young just after parturition than that at sites used by pregnant females before parturition; 2) forage abundance and quality would be equal or greater at sites used by females with young than that at sites used by females without young; 3) forage abundance and quality would be equal or greater at high-elevation sites used for birthing than at low-elevation sites following parturition.

Alternatively, if predator avoidance was the primary factor determining habitat use, we predicted that: 1) forage abundance and quality would be lower at sites used by females with young than at sites used by females without young; 2) parturient females would spatially segregate themselves from concentrations of predators, and 3) this tradeoff between avoiding predators and acquiring nutrients would be most evident immediately following parturition when neonates are most vulnerable to predators (Adams et al., 1995; Bleich et al., 1997), and the energetic demands on females increase because of the high costs of lactation (Adamczewski et al., 1987; Skogland, 1984).

MATERIALS AND METHODS

Study area.--We studied habitat use and diets of female caribou around the time of parturition in Wrangell St. Elias National Park and Preserve in south-central Alaska (Fig. 1). The range of the Mentasta herd during parturition encompassed ca. 2,100 km², and ranged in elevation from ca. 600 m along the Copper River, to 2,200 m on the slopes of Mt. Drum and Mt. Sanford, and reached 4,800 m at the summit of Mt. Sanford.

Approximately 10-15% of the area was > 2,200 m in elevation, which was above the elevation of habitat typically used by caribou in the Mentasta herd (K. J. Jenkins, in litt.).

The topography of this area ranged from nearly flat in low-lying areas, to steep, precipitous terrain in the mountains. Vegetation at < 800 m was composed primarily of forests of white and black spruce (Picea glauca and P. mariana, respectively) interspersed with wetlands and tussock tundra that was dominated by cotton grass (Eriophorum vaginatum). Vegetation was characterized by shrub communities of willow (Salix) and shrub birch (Betula glandulosa) at elevations between 800-1,200 m, by extensive areas dominated by sedge-tundra communities between 1,200-1,700 m, and alpine tundra, typified by lichens (e.g., Cetraria, Cladina, and Cladonia) from 1,700 to 2,200 m. Permanent snow, ice, and rock generally prevail above 2,200 m.

Female caribou of the Mentasta herd (ca. 600 females in 1994) arrived on ranges where they gave birth (62° 20' N, 144° 20' W) on the western and northern slopes of Mt. Drum and Mt. Sanford in late April, where they remained until migration in October. Caribou begin giving birth in mid-May, with peak parturition usually occurring 1 week

later. Parturition was nearly complete by the beginning of June (K. J. Jenkins, in litt.).

The first snowfall typically occurred in late September and snow persisted until early May. The weather at >1,500 m was harsher than at lower elevations, with higher winds, colder temperatures, and snow flurries developing occasionally throughout May (K. J. Jenkins, in litt.). Approximately 35 cm of snow fell on the calving grounds on 25 May 1994, and again on 16 May 1995. As a result of these snowfalls, much of the habitat above 1,500 m that had become snow-free, was again completely covered by snow.

The study area contained numerous predators of young caribou. We observed wolves (Canis lupus), grizzly bears (Ursus arctos), black bears (U. americanus), wolverines (Gulo gulo), coyotes (Canis latrans), golden eagles (Aquila haliaetus), and bald eagles (Haliaeetus leucocephalus) on the study area. We located five dens of wolves in this area in 1996.

Insect abundance was low on the study area during both years of the study. We routinely worked at elevations ranging from 800 to 2,000 m daily throughout the calving season in the same habitats occupied by caribou. Although we did not quantify insect abundance, we noticed few mosquitoes (Culicidae) during that period.

Sampling procedures.--In autumn 1992 and spring 1993, we captured 44 adult (≥ 2 years old), female caribou with a skid-mounted net gun attached to a Hughes-500D helicopter using the methods of Krausman et al. (1985). Each female we captured was fitted with a radio collar and was radio-tracked daily from 18 May-10 June in 1994 and 1995, as weather permitted, using a small fixed-wing aircraft. We monitored whether

each female was pregnant by searching daily for presence or absence of hard antlers or a young at heel, and less frequently for indications of a distended udder. At peak parturition, we categorized each radio-collared female as parturient or nonparturient based on antler and udder characteristics or presence of a young at heel (Whitten, 1995). All aspects of our research were approved by the Institutional Animal Care and Use Committee at the University of Alaska Fairbanks.

We sampled characteristics of habitats and recorded group sizes of caribou during three sampling periods based on focal females: 1) preparturition (3-5 days before the first young was born); 2) peak parturition (1-3 days after a focal female gave birth); and 3) post parturition (10-12 days after a focal female gave birth). Parturient status was defined as one of the following: 1) preparturient (before parturition began); 2) parturient (pregnant or with young); 3) nonparturient (not pregnant and without young). The size of groups was determined by the total number of animals present (i.e., a female with a young was scored as a group of 2). We attempted to sample sites used by 20 females before parturition, 40 females during peak parturition (20 with young and 20 without young), and 40 females after parturition (20 with young and 20 without young) each year. We marked all sampling sites by dropping a radio-transmitter beacon at the locations of the caribou from a fixed-wing aircraft or helicopter, or by recording the location with a global positioning system (GPS) from the airplane. Because the GPS was only accurate to within 100 m, these locations often were accompanied with written descriptions and drawings of the site, which allowed us to relocate the position of the neonate. We then

used a helicopter equipped with a GPS unit to return to the locations for sampling, usually within 24-48 h of their initial location.

Just prior to parturition in 1995, we randomly selected 20 radio-collared females, without regard to their status of pregnancy, for sampling habitat use during preparturition. Nonparturient females were probably under-represented in this sample because 84-86% of the females were pregnant each year (K. J. Jenkins, in litt.). Unfortunately, parturition began 1 week earlier than expected in 1994 (K. J. Jenkins, in litt.), which prevented us from sampling habitat used during preparturition in that year.

We then sampled habitat use by females at peak parturition by randomly selecting 20 radio-collared females that were parturient from the sample of 44 radio-collared individuals. We located these females each day via fixed-wing aircraft, and sampled habitats where each female was first seen with a young at heel, usually within 24-48 h of the birth of young. We obtained comparable samples of habitats used by nonparturient females at peak parturition by using all radio-collared females that were nonparturient. Nonetheless, because of the high rate of pregnancy in this herd, we had to rely on noncollared females ($n = 15$, in both 1994 and 1995) to achieve our quota of nonparturient animals. Thus, we identified additional females as nonparturient by antler and udder characteristics (Whitten, 1995) and based the selection of noncollared females on random sightings of caribou (groups or individuals) during telemetry flights made each day. We synchronized the timing of sampling for parturient and nonparturient females within each period to control for the effects of date on values of forage quality

and abundance.

We sampled habitat use during post parturition in the same manner as at the peak of parturition. We sampled the same parturient females that we had used for the sample at peak parturition ca. 10 days after they gave birth, providing they still had a young at heel. Females selected during peak parturition but that lost their young before post parturition were omitted from our sample, because they no longer had a young at heel. We replaced these females with other randomly selected females with radio collars that had young of known age. We also resampled nonparturient females that we had sampled during peak parturition (those with radio collars), and again relied on noncollared females that were without young to complete our sample of nonparturient females. To increase our sample of nonparturient females with radio collars, we considered any female that had lost a young at least 5 days prior to the post-parturition period to be nonparturient. We based this decision on data from previous years, which indicated that females moved from their birth sites to areas occupied by nonparturient females within 36-48 h after losing a neonate (K. J. Jenkins, in litt.). For our purposes then, we assumed that these females were behaving similar to nonparturient animals.

We sampled the distribution of predators on the study area by recording all sightings of predators we observed while radio-tracking collared female caribou and recorded the locations of predators using a GPS unit. During field seasons from 1993 to 1996, we logged a total of ca. 180 h of flight time in a helicopter, and ca. 600 h in a fixed-wing aircraft flying at ca. 175-m above ground level while monitoring radio-collared caribou

throughout the study area. There were typically four people in the helicopter, and two in the fixed-wing aircraft; all acted as observers.

Descriptions of sites.--We described the habitat at each site using the vegetation classification system of Viereck et al. (1992; Table 1). Topography was recorded as the dominant features of terrain within 1 ha of the site (i.e., flat, gentle slope, steep slope, drainage bottom, ridge, or hills). We estimated the slope of the site to be one of six categories (0° , $1-10^{\circ}$, $11-20^{\circ}$, $21-30^{\circ}$, $31-45^{\circ}$, and $> 45^{\circ}$). We recorded elevation using the altimeter mounted in the helicopter after landing at the site. Cover of tree and shrub canopy was estimated visually within 1 ha of the site. Slope of aspect was recorded using one of eight categories (N, NE, E, SE, S, SW, W, and NW).

At each site we sampled vegetation at each 1-m point along a 50-m transect (i.e., 50 points/transect). We oriented the 50-m tape in a N-S or E-W direction based on the flip of a coin. The tape was centered at the location of the radio beacon that had been dropped at the site, or by randomly selecting a midpoint at the GPS location. This midpoint was located by throwing a marker from the location of the helicopter in a randomly selected direction. At each 1-m point along the transect, we sampled the first intercept (hit) and recorded one of the following categories: deciduous shrub, evergreen shrub, graminoid, forb, lichen, moss, rock, bare ground, snow, water, or litter. Plants were identified to species in nearly all instances, except for dead or newly emergent graminoids. In shrub communities, the canopy of vegetation overhanging the point also was recorded, using line-intercept sampling (Bonham, 1989). We estimated forage

biomass with the double-sampling method (Ahmed et al., 1983), using six 20 by 50-cm quadrats spaced at 10-m intervals along the transect, which we pooled into a single sample of 0.6 m². We began by estimating the biomass of each species in one quadrat, and then immediately clipped and weighed that vegetation to the nearest 0.01 g. This weight allowed us to calibrate our estimate of biomass on each transect, and was used as a correction factor for the remaining five quadrats. By regressing measured versus estimated weights on the clipped plots, we developed regression equations for each forage class, and converted estimated weights to dry weights.

At each site, we recorded the phenological stage of plant species thought to be important forages for caribou during spring, based on previous studies (Boertje, 1984; Klein, 1990; Whitten and Cameron, 1980), and on the results of microhistological analysis of fecal pellets collected on the study area in 1993. We divided phenology into stages based on >50% of the individuals of a species in a sample. We described leaves of deciduous shrubs as: 1) buds swelling; 2) leaves unfolding, or 3) full leaves. We recorded phenological stages of grasses and sedges as: 1) dead leaves only; 2) green vegetation < 5 cm in height; 3) green vegetation ≥ 5 cm in height, or 4) flowering. Eriophorum was categorized as: 1) bud head in sheath; 2) early flower; 3) full flower, or 4) flower seeding. Forbs were described as: 1) early green-up; 2) mid-growth; 3) flowering, or 4) petals senescing.

To assess the effect of elevation on the timing of green-up for graminoids (based on percent live versus dead material), we divided the study area into three elevation

categories; < 1,200 m, 1,200-1,500 m, and > 1,500 m, with nearly equal numbers of sites at each elevation ($n = 55, 51, \text{ and } 57$ respectively). We then divided the birthing season into five 5-day periods, and determined the percent of live graminoids at each of the elevations throughout the season of births. The percent of live graminoids at each site was calculated from the clipped plot on each transect.

We collected ca. 40 g wet biomass of each forage species at each site, on or adjacent to the transect, for subsequent analysis of nutrients. For deciduous shrubs, we collected only new growth. We collected the entire plant for forbs, while for graminoids we collected available biomass, which ranged from entirely dead to entirely live material, but samples were usually a mixture of the two.

We collected fecal samples from groups of caribou during pre, peak, and post parturition to compare indices of diet composition and quality. Each sample consisted of 10-15 fresh pellets, typically collected within minutes of deposition. In 1993 and 1994, we collected samples during pre, peak, and post parturition without regard to the maternal status of a particular group, because of difficulty in obtaining feces from individuals of known parturient status. In 1995, we divided our sampling during parturition into high elevation (> 1,700 m--typically parturient females and nursery groups) and lower-elevation (< 1,450 m--females of any parturient status; Table 3). Thus, we sampled feces as an index of diet composition based on elevation differences of groups, in lieu of knowing status of individual females.

Laboratory analysis.--We dried forage samples at 50⁰ C to a constant weight and

ground them in a Wiley Mill using a 40-mesh screen (ca. 0.5 mm). We analyzed each sample for nitrogen content (N) and in-vitro dry matter digestibility (IVDMD). Nitrogen content was measured at the Forest Soils Laboratory at the University of Alaska Fairbanks using a LECO CNS 2000 carbon, nitrogen, and sulphur analyzer. IVDMD was determined at the University of Alaska Fairbanks, Institute of Arctic Biology using the Tilley and Terry technique (Tilley and Terry, 1963). Rumen liquor for the digestibility trials was obtained from a fistulated reindeer at the Large Animal Research Station at the University of Alaska Fairbanks (elevation = 270 m). Prior to collection of the rumen fluid, the reindeer was taken off pelleted rations and allowed to graze on newly emergent grasses and forbs, and on new growth of deciduous shrubs, which more closely mimicked the diet of caribou on our study area.

Botanical composition of feces was determined from epidermal fragments of plants identified from microhistological characteristics (Dearden et al., 1975) at the Wildlife Habitat Laboratory at Washington State University. Density values for fragments in feces were calculated from 100 microscope views for each group identified to forage class, and from 150 microscope views for each composite of groups identified to species. We did not use correction factors for digestibility in our dietary analysis and thus may underestimate the occurrence of more digestible species. We also analyzed fecal pellets for dry matter, fecal nitrogen (FN), and neutral detergent fiber (NDF) as indices of diet quality (Holechek et al., 1982).

Statistical analysis.--All statistical comparisons were conducted with SAS statistical

software (SAS Institute Inc., 1988). Tests were considered significant at $P \leq 0.05$. We compared use of the three major habitat types on the study area (i.e., shrubs, sedge tundra, lichen tundra) by females with and without young during peak and post parturition using chi-square analysis (Conover, 1980). We pooled all observations in shrub habitats into “shrubs” because of the basic habitat similarities (Table 2), and to meet the assumptions of chi-square analysis. We omitted 12% of the observations from this analysis because they did not fall into any of these three habitat types. Subsequently, we used stepwise logistic regression (Agresti, 1990) to determine which habitat variables best differentiated between sites used by parturient and nonparturient female caribou at parturition. We controlled for multicollinearity by eliminating one of any pair of variables with $r \geq |0.50|$. We used the log-odds ratio to determine the importance of individual variables in discriminating between sites used by female caribou of differing reproductive status. To test the hypotheses that habitat use would not differ between parturient and nonparturient females and within periods of parturition, the following comparisons were made: 1) preparturition vs. peak parturition with young; 2) preparturition versus peak parturition without young; 3) peak parturition with young versus peak parturition without young, and 4) post parturition with young versus post parturition without young.

We tested for differences of group size using analysis of variance (ANOVA), with group size as the dependent variable, and parturient status, year, and their interaction as main effects. Elevation was highly correlated with many other variables; consequently we omitted this variable from logistic models. Thus we tested for differences in

elevations of sites used by females with and without young using ANOVA (Wonnacott, 1990). Elevation was the dependent variable, with parturient status, year, and their interaction as main effects.

We further investigated the importance of forage biomass by evaluating differences in biomass among sites used by preparturient females, and females with and without young using multivariate analysis of covariance (MANCOVA; Johnson and Wichern, 1982). Dry weights of each forage class (g/m^2) were used as the dependent variables, with parturient status, year, and their interaction as main effects, and Julian date as a covariate.

Measures of forage quality (N and IVDMD) could not be included in the logistic-regression model because that analysis requires no missing data, and we were unable to collect comparable forage samples at all sites because of either the absence of forage or deep snow that prevented such collections. We used MANCOVA for the analysis of N and IVDMD (dependent variables), with parturient status and forage class as the main effects, and Julian date as a covariate.

We tested for temporal changes in indices of diet quality (FN and NDF) throughout the parturition period for groups of females with and without young using a t -test (Wonnacott, 1990). Botanical composition of feces was analyzed by testing percent occurrence of each forage class separately using ANOVA, with forage class as the dependent variable, and parturition period or elevation class as the main effects. We used a sequential Bonferroni procedure to correct for making multiple comparisons (Rice,

1989).

We examined differences in elevations of sites used by female caribou with and without young during peak and post parturition, and elevations of predator observations using a Wilcoxon test of medians (Conover, 1980).

RESULTS

Group size.--Preparturient females were in significantly larger groups ($\bar{X} = 10.3$, $SD = 10.6$, $n = 20$) than females with young at peak parturition ($\bar{X} = 4.0$, $SD = 4.5$, $n = 36$; $F = 5.46$, $d.f. = 2, 53$, $P = 0.007$), but not different from females without young at peak parturition ($\bar{X} = 9.9$, $SD = 13.5$, $n = 30$; $F = 0.71$, $d.f. = 2, 46$, $P = 0.50$). During peak parturition, females with young were in significantly smaller groups ($\bar{X} = 4.0$, $SD = 4.5$, $n = 36$) than females without young ($\bar{X} = 9.9$, $SD = 13.5$, $n = 30$; $F = 3.10$, $d.f. = 3, 61$, $P = 0.03$). At post parturition, however, females with young ($\bar{X} = 35.0$, $SD = 39.2$, $n = 40$) and those without young ($\bar{X} = 18.5$, $SD = 17.9$, $n = 37$) were in groups that did not differ significantly in size ($F = 1.75$, $d.f. = 3, 71$, $P = 0.17$).

Habitat use.--Use of habitat (Fig. 2) differed between females at preparturition and females with young at peak parturition ($X^2 = 17.93$, $d.f. = 2$, $P = 0.001$), but not between females at preparturition and females without young at peak parturition ($X^2 = 4.87$, $d.f. = 2$, $P = 0.09$). Patterns of habitat use differed between females with and without young during peak parturition ($X^2 = 18.17$, $d.f. = 2$, $P = 0.001$). Females with young used lichen-tundra habitat predominantly, whereas nonparturient females used mostly sedge tundra and shrubs (Fig. 2). During post parturition, patterns of habitat use did not differ

significantly between females with and without young ($\chi^2 = 4.67$, d.f. = 2, P = 0.097).

Data for 1994 and 1995 were pooled in all logistic regressions because year failed to enter any of the models (P > 0.15). Logistic regression identified three variables, low-shrub habitat, sedge-tundra habitat and bare ground, that best discriminated between sites females used during preparturition (n = 20), versus sites used by females with young at peak parturition (n = 36; P < 0.05; Table 4). This model correctly classified 80.1% of 56 sites used by these categories of caribou. At peak parturition, females with young used habitats that had a higher proportion of bare ground, and a lower occurrence of sedge tundra and low shrubs than sites used by females at preparturition (Table 4).

Logistic regression identified three variables, dry weight of all graminoids, dry weight of live graminoids, and a terrain slope of $<30^\circ$, that best discriminated between sites females used during preparturition versus sites used at peak parturition by females without young (n = 30; P < 0.05; Table 4). This model correctly classified 83.5 % of 50 sites used by these females. At peak parturition females without young used habitats with steeper slopes and a greater amount of live biomass of graminoids biomass than did females at preparturition.

During peak parturition, logistic regression identified three variables, low-shrub habitat, sedge-tundra habitat, and dry weight of the new growth of deciduous shrubs, that best discriminated between sites used by females with and without young (Table 4). This model correctly classified 79% of 66 sites. Females with young used sites with less low-

shrub and sedge-meadow habitat than those sites used by females without young ($P \leq 0.05$).

During post parturition, logistic regression identified three variables, low shrub habitat, wet weight of lichens, and percent cover of *Vaccinium vitis idaea*, that collectively best discriminated between sites used by females with young ($n = 40$) and those without young ($n = 37$). Only low-shrub habitat was significant ($P \leq 0.05$; Table 4). This model only classified 66% of 77 sites correctly. Females with young used areas with less cover of shrubs than did females without young.

At peak parturition, females with young used higher-elevation sites than those used by females without young ($F = 3.23$, $d.f. = 3, 61$, $P = 0.03$). That difference no longer existed at post parturition, when females with young and those without young used sites at similar elevations ($F = 2.48$, $d.f. = 3, 73$, $P = 0.07$; Fig. 3).

Forage biomass differed between sites used by female caribou during preparturition and by females with young at peak parturition ($F = 2.58$, $d.f. = 4, 49$, $P = 0.05$). Most of that difference occurred because of a greater biomass of graminoids at sites used by females during preparturition ($F = 5.97$, $d.f. = 3, 52$, $P = 0.0002$). Forage biomass did not differ between sites used by females without young at peak parturition and those sites used by females during preparturition ($F = 0.15$, $d.f. = 4, 44$, $P = 0.96$). During peak parturition, females with young used sites with less available biomass of forbs, graminoids, and deciduous shrubs, than used by females without young ($F = 3.39$, $d.f. = 4, 61$, $P = 0.02$). By post parturition, biomass of forages did not differ significantly

between sites used by females with and without young ($F = 0.58$, $d.f. = 4, 72$, $P = 0.68$; Fig. 4).

We examined differences in forage quality among periods of parturition and parturiency classes separately in 1994 and 1995, because there was a significant year by parturient-class interaction (MANCOVA; $P < 0.05$). In 1994, levels of N and IVDMD of forage species differed between sites used by females with and without young during peak parturition ($F = 4.91$, $d.f. = 2, 48$, $P = 0.01$). Nitrogen content of forages was higher at sites used by females without young, but levels of IVDMD were lower at those sites (Figs. 5, 6). During post parturition, forage quality was not significantly different between sites used by females with and without young ($F = 1.14$, $d.f. = 2, 130$, $P = 0.32$).

In 1995, N and IVDMD of forages at sites used by females with and without young during peak parturition differed significantly ($F = 6.51$, $d.f. = 2, 113$, $P = 0.002$; Figs. 5 and 6). A posteriori comparisons indicated both N and IVDMD were higher at sites used by females without young ($P = 0.001$ and $P = 0.009$, respectively). Those differences no longer existed at post parturition ($F = 0.88$, $d.f. = 2, 169$, $P = 0.42$).

The percent live material in our samples of graminoids was negatively related to elevation. That is, when comparing the percentage of live graminoids at low-elevation sites versus high-elevation sites within the same 5-day periods, the low elevation sites had a higher percentage of live material. Graminoids reached 20% live material during 26-30 May at $< 1,200$ m, 31 May - 4 June at 1,200-1,500 m, and 5-9 June at $> 5,000$ m.

Diet characteristics.-- Fecal nitrogen (FN) and NDF did not differ between

preparturition and peak parturition in 1993-1995 (years pooled; $t = 0.38$, $d.f. = 9.1$, $P < 0.71$, and $t = 0.31$, $d.f. = 10.3$, $P < 0.76$, respectively; Table 6). Fecal nitrogen was significantly higher at post parturition than preparturition ($t = 3.61$, $d.f. = 8.1$, $P < 0.007$), but NDF was not significantly different ($t = 1.83$, $d.f. = 10.5$, $P < 0.096$). Fecal nitrogen also was higher at post parturition than peak parturition ($t = 3.53$, $d.f. = 10.5$, $P < 0.005$), but NDF was not significantly different ($t = 2.09$, $d.f. = 9.8$, $P < 0.06$). In 1995, composition of fecal pellets did not differ in FN or NDF between post-parturition sites at high elevation, and post-parturition sites at low elevation ($t = 0.53$, $d.f. = 5.7$, $P < 0.62$, and $t = 0.49$, $d.f. = 4.5$, $P < 0.64$, respectively; Table 6).

The botanical composition of the fecal pellets was similar across periods of parturition in 1993 (Table 5), but differed somewhat in 1994, when fecal pellets contained more deciduous shrubs ($P = 0.04$) and fewer mosses ($P = 0.006$) during post parturition than during peak parturition or preparturition. Further, fecal pellets collected during peak and post parturition in 1994 contained a lower percent of grasses than those collected during preparturition. In 1995 the botanical composition of fecal pellets collected at high elevation and low elevation sites did not differ significantly for any of the forage classes listed in Table 5.

Distribution of predators.--We pooled sightings of grizzly bears and wolves from 1993-1996 to increase sample size, and because the elevations at which we observed predators did not differ between years (ANOVA; $F = 1.92$, $d.f. = 7, 103$, $P = 0.073$). During peak parturition, females with young were at significantly higher elevations

(median = 1,515 m, interquartile distance = 518 m, $n = 36$) than both grizzly bears (median = 1,333 m, interquartile distance = 485 m, $n = 87$) and wolves (median = 1,151 m, interquartile distance = 545 m, $n = 24$; Wilcoxon test, $Z = 2.03$, $P = 0.042$, and $Z = 2.61$, $P = 0.009$, respectively). Females without young (median = 1,043 m, interquartile distance = 431 m, $n = 30$), were not at significantly different elevations than those predators ($Z = 1.63$, $P = 0.10$, and $Z = 0.54$, $P = 0.59$, respectively; Figure 7). At post parturition females with young ($n = 40$) were at similar elevations as grizzly bears and wolves ($Z = 0.97$, $P = 0.332$, and $Z = 1.48$, $P = 0.14$, respectively), as were females without young ($n = 37$; $Z = 1.37$, $P = 0.17$, and $Z = 0.94$, $P = 0.35$, respectively). In addition, the five wolf dens discovered in 1996 were all at $< 1,000$ m in elevation.

DISCUSSION

We rejected the overall hypothesis that females with and without young used similar habitats at parturition; patterns of habitat use for nonparturient females did not change through the period of parturition, whereas females with neonates sought higher-elevation sites during the period of peak-parturition period (Fig. 3). This pattern is consistent with other studies involving caribou herds inhabiting mountains, where parturient females disperse to higher-elevation sites just prior to giving birth (Bergerud et al., 1984; Bergerud and Page, 1987).

Our data were inconsistent with the hypothesis that parturient females segregated from nonparturient females in response to increased nutrient demands at parturition. We observed no evidence that parturient females used sites with equal or greater abundance

of forage than sites used by nonparturient females, indeed the opposite occurred (Fig. 4). During peak parturition we observed nearly 50% less biomass of deciduous shrubs, total graminoids, and live graminoids at sites used by females with young than at sites used by females without young, although forb abundance was nearly the same (Fig. 4). This difference in biomass was substantiated by cover data from our line transects, which indicated lower cover of graminoids and deciduous shrubs, and nearly equal cover of forbs at sites used by females with young compared to sites used by females without young (Table 3).

Biomass we measured across periods of parturition appeared to be low when compared with that reported by White and Trudell (1980a) on reindeer range in early summer. These authors recorded from 54-387 g/m², while we recorded much lower biomass of forage at sites (i.e., 3-22 g/m²; Fig. 4). This difference between studies likely related to seasonal differences as well as the scales at which biomass was measured. White and Trudell (1980a) sampled forage in a small area immediately surrounding a tethered reindeer. Our subsamples, however, were spread across a 50-m transect; vegetation along transects often was distributed into small patches, and quadrats did not always sample such patches. Although not directly comparable with data from White and Trudell (1980a), our samples do provide valid measures for testing among sites on our study area.

In 1994 during peak parturition, no significant differences in N or IVDMD occurred between sites used by females with and without young for the three forage classes we

measured (i.e., deciduous shrubs, total graminoids, or forbs). During peak parturition in 1995, however, N and IVDMD were lower for graminoids and forbs at sites used by females with young, than at sites used by females without young. No differences were detected for deciduous shrubs (Figs. 5, 6). Although somewhat ambiguous because of between-year variation, those data indicate that sites used by females with young at peak parturition did not support forage of higher quality.

Although female caribou with young used plant communities of lower biomass than females without young at peak parturition, we were unable to document significant effects of this altitudinal separation on the nutrient qualities of the diets they consumed. Our analysis of caribou feces indicated that females at high elevations had similar diet composition to females at lower elevations, although forage abundance was generally lower at high-elevation sites (Table 4; Fig. 4). In spite of the lower abundance of forage, caribou may be able to feed in a highly selective manner at those sites, and increase their intake of forage higher in quality than our process for collecting forage revealed. White and Trudell (1980b) documented an increase of 10 % in the dry matter digestibility of forage acquired through selective grazing by reindeer, compared with the digestibility of forage collected based on availability.

Although caribou frequently ascend in elevation to take advantage of early phenological stages of vegetation (Oosenbrug and Theberge, 1980), the timing of vertical movements of parturient caribou in the Wrangell Mountains preceded this green-up, as evidenced by the later green-up dates of graminoids at higher elevations. Higher-

elevation sites used by females with young consisted mostly of lichen-tundra communities (Fig. 2), with colder temperatures (K. J. Jenkins, in litt.) and snow persisting later than at lower elevations (Table 3). These harsher climatic conditions limit new growth of plants (Chapin, 1983; Kudo, 1991), which are high in N, and thought to be important nutritionally to caribou at parturition (Albon and Langvatn, 1992; Klein, 1990; Kuropat and Bryant, 1980). Lichens also can be an important forage at parturition, especially in combination with newly emergent vegetation that can enhance their digestibility (Klein, 1983). Our analysis of fecal pellets indicated that lichens were an important component of the diet at parturition (Table 5), but lichens were more abundant at lower than at higher elevations (Table 3); caribou probably did not move to higher sites to gain access to this forage. This pattern of behavior by which parturient females move to high-elevation sites before green-up, has been described previously for caribou (Bergerud et al., 1984) and bighorn sheep (Festa-Bianchet, 1988). Avoidance of predation was hypothesized to be the driving factor underlying movements in those studies.

Our data also are consistent with the hypothesis that habitat selection by parturient females reflected a response to minimizing the effects of predation on neonates, because we could find no obvious nutritional benefits at sites used at parturition by pregnant and lactating females. Additionally, sites where caribou gave birth were higher in elevation than most locations where we observed predators (Fig. 7). We believe the distribution of predators may have been more concentrated at lower elevations than what we observed,

because forest and shrub communities likely obscured bears and wolves from our view. This argument is further substantiated by the discovery of five wolf dens on the study area in 1996, all of which were well below the mean elevation of sites used by caribou for giving birth (mean elevations; 1,000 m and 1,465 m, respectively). A female and her young could lower the chance of a predator encounter by “spacing away” to higher elevation sites as reported in other studies of mountain caribou (Bergerud et al., 1984; Bergerud and Page, 1987).

Other studies have suggested high elevations may offer other additional protection from predation we did not measure. Sites consisting of heterogeneous terrain and snow patches can offer a cryptic background for a female and her neonate, which can greatly enhance their ability to escape detection by predators (Eastland et. al., 1989). Indeed, at peak parturition there was a higher occurrence of snow at sites used by parturient females, than at sites used by nonparturient females in our study (Table 3). Bergerud and Page (1987) suggested that movements upward in elevation by caribou could decrease the likelihood of encountering a predator by spacing away from alternate prey sources such as moose (Alces alces), while at the same time removing themselves from travel corridors of predators along valley bottoms. Although we did not quantify the distribution of moose during caribou parturition, most sightings of moose were <1,100 m (pers. obs.), well below the parturition sites of most caribou we monitored (Table 3). Bergerud and Page (1987) also observed that parturient females at higher elevations were in smaller groups, making them less conspicuous to predators. Parturient females consistently

occurred in smaller groups than nonparturient females at peak parturition. High-elevation sites also could enhance the ability of caribou to detect and avoid predators, as has been suggested previously for other ungulates (Jarman, 1974). This increased ease in vigilance afforded by being above most approach routes of predators could allow a female and young an opportunity to escape by moving away from an approaching predator. This method of predator avoidance, however, would be less effective in eluding golden eagles, which were common on the study area. Nevertheless, few incidents of eagle predation on neonates occurred on this study area (K. J. Jenkins, in litt.).

If minimizing the risk of predation to offspring is the deciding factor in habitat use by parturient females, we would expect substantial differences between sites used by females with neonates and those without a young at heel. Those differences did exist as indicated by the elevational differences in sites used (Fig. 3), and the differential habitat use revealed with logistic regression (Table 4). We also predicted that after the loss of their neonate, parturient females would behave as nonparturient female caribou in their use of habitat, because the risk of predation had lessened. Indeed, when females in high-elevation sites lost young to predation, they usually descended to sites occupied by females without young within 24-36 h (K. J. Jenkins, in litt.). We also observed the use of lower-elevation sites by females when their young were at or near 10 days old, compared with the elevation of sites used just after they gave birth (Fig. 3). This period coincides with increased mobility of young, and a decreased vulnerability to predators (Miller et. al., 1985), especially to bears (Adams et. al., 1995; K. J. Jenkins, in litt.).

Females that had moved to lower elevations were in larger groups, which could be advantageous to a female caribou and her young by lessening the chance that she or her neonate would be selected from the group by a predator (*sensu* Hamilton, 1971). The period 10 days after parturition also coincides with greatest energetic demands on female caribou because of the costs associated with lactation, which could be responsible for movements to low-elevations sites that supported a greater biomass of forage (Fig. 4). Indeed, White and Trudell (1980b) suggested that low biomass of forage combined with a high percentage of that forage being dead material, could limit the rate of forage intake by caribou. Both these conditions existed at high elevation sites in our study area for graminoids (Fig. 4), which were the most abundant forage class we measured, and may have limited the intake of forage by caribou. Other studies have shown similar behavioral changes by parturient females in caribou (Bergerud et al., 1984), mountain sheep (*Ovis canadensis*; Festa-Bianchet, 1988), and moose (Edwards, 1983; Molvar and Bowyer, 1994), which balanced the need for resources with the risk of predation to young. In each of these instances, females with young either foraged less efficiently because of increased surveillance for predators, or used habitats with lower biomass of forage, and often lower quality of forage than did nonparturient females. In Nubian ibex (*Capra ibex*), females accompanied by young foraged less efficiently, and used poorer habitat than females that left their young behind during feeding bouts (Kohlmann et. al., 1996). The presence of a neonate caused the female ibex to balance foraging efficiency with predator vigilance, whereas females without accompanying young could forage

without the concern for safety of their neonates.

The effectiveness of this strategy of spacing away could be dependent on the number of caribou in the herd, and consequently on the intraspecific competition between parturient females for forage at high-elevation sites. At a higher density of caribou, high-elevation sites used for parturition may not be able to support an increase in grazing pressure, and there likely would be resulting costs to females that choose this strategy. Thus, female caribou occurring at low density may be able to minimize risk of predation at little or no cost in acquiring nutrients. Whether a tradeoff between avoiding predation and acquiring essential nutrients to meet the high cost of lactation would occur at higher densities of caribou warrants further study.

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Table 1.--Habitat characteristics sampled at sites used by female caribou, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995.

Variable	Code	Description
Topographical		
Topography	0	Flat
	1	Gentle sideslope < 30 deg.
	2	Steep slope \geq 30 deg.
	3	Drainage bottom-flat
	4	Ridge
	5	Hills
Aspect		Direction of slope of 1 ha surrounding transect.
Slope (degrees)	0=0 ⁰	Degree of slope at transect site, 0-5.
	1=1-10 ⁰	
	2=11-20 ⁰	
	3=21-30 ⁰	
	4=31-45 ⁰	
	5= > 45 ⁰	
Elevation (m)		Elevation of site in meters.
Climatic		
Julian date		Date transect was categorized.
Snow cover (%)	0=0%	Percent of transect covered in snow, 0-6.
	1=1-5%	
	2=6-25%	
	3=26-50%	
	4=51-75%	
	5=76-95%	
	6=96-100%	
Forage characteristics		
Tree canopy (%)		Percent of 1 ha surrounding the transect that was covered by tree canopy, ranked 0-6, (0=none, 6= > 95%).
Shrub canopy (%)		Percent of 1 ha surrounding the transect that was covered by shrub canopy, 0-6, (0=none, 6= > 95%).
Biomass weight (g/m ²)		Estimated dry weight of each forage (deciduous, forb, total graminoid, live graminoid, lichen, and evergreen) at each site.
Percent cover		Percent cover by forage class or substrate, along a 50 m transect at each site.

Table 2.--Habitat types and predominant species associated with each habitat, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995.

Habitat types	Description	Dominant species
Conifer forest	> 3 m tall > 10% tree canopy cover > 75% conifers	(<u>Picea glauca</u> , <u>Picea mariana</u>)
Deciduous forest	> 3 m tall > 10% tree canopy cover > 75% deciduous	(<u>Betula papyrifera</u> , <u>Populus tremuloides</u>)
Mixed forest	> 3m tall > 10% tree canopy cover > 75% conifers/deciduous	(<u>Picea glauca</u> , <u>Picea mariana</u> , <u>Betula papyrifera</u> , <u>Populus tremuloides</u>)
Forest shrub	> 3 m tall > 10% tree canopy cover	(<u>Picea mariana</u> , <u>Betula glandulosa</u>)
Tall shrub	< 10% tree cover > 25% shrub cover > 1.5m tall	(<u>Betula glandulosa</u> , <u>Alnus crispa</u>)
Low shrub	< 10% tree cover > 25% shrub cover 0.0-1.5m tall	(<u>Betula glandulosa</u> , <u>Vaccinium uliginosum</u> , <u>Salix pulchra</u>)
Riparian shrub	< 10% trees > 25% shrub predominantly willow	(<u>Salix pulchra</u> , <u>Salix alaxensis</u> , <u>Alnus crispa</u>)
Tussock tundra	< 10% tree cover < 25% shrub cover tussocks predominate	(<u>Eriophorum vaginatum</u> , <u>Carex aquatilis</u> , <u>Ledum palustris</u>)
Sedge tundra	< 10% tree cover < 25% shrub cover grasses, sedges predominate	(<u>Carex bigelowii</u> , <u>Carex aquatilis</u> , <u>Salix reticulata</u>)
Lichen tundra	10% tree cover < 25% shrub cover lichen, rocks, sedges, predominate	(<u>Cladina sp.</u> , <u>Cladonia sp.</u> , <u>Cassiope sp.</u> , <u>Dryas</u> , <u>Vaccinium vitis-idaea</u>)
Wet meadow	< 10% tree cover < 25% shrub cover bog, fen, marsh	(<u>Trichosporum caespitosum</u> , <u>Carex aquatilis</u> , <u>Equisetum</u>)
Ice-glacier		
Rock-scree		
Frozen lake		
Glacier moraine		

Table 3.--Summary statistics (Mean and SD) for habitat characteristics of sites used by female caribou, separated by period of parturition and parturient status, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995.

Habitat characteristics ^a	<u>Preparturition</u>		<u>Peak parturition</u>				<u>Post parturition</u>			
	<u>(n = 20)</u>		<u>with young</u>		<u>without young</u>		<u>with young</u>		<u>without young</u>	
	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>
<u>Topographical</u>										
Elevation (m)	1432	221	1465	356	1175	371	1373	333	1253	259
Sin aspect (E-W)	-0.15	0.81	-0.08	0.67	-0.31	0.56	-0.11	0.71	-0.22	0.66
Cos aspect (N-S)	-0.14	0.54	-0.06	0.67	-0.05	0.64	-0.05	0.55	0.16	0.64
Slope (°)	0.95	0.22	1.11	0.67	0.90	0.66	1.05	0.64	1.05	0.47
<u>Climatic</u>										
Julian date	136.8	1.63	146.5	4.70	146.7	4.97	155.9	3.22	155.1	2.89
Snow cover (0-6)	1.80	2.73	1.42	1.84	0.50	1.43	0.45	0.88	0.24	0.55
<u>Vegetation (Dry wts.)</u>										
<u>Deciduous</u>										
weight (g/m ²)	4.53	5.58	3.92	4.82	8.32	7.68	8.31	6.68	10.52	7.53
<u>Forb</u>										
weight (g/m ²)	0.95	1.13	2.23	2.65	3.20	2.99	5.54	5.12	5.94	5.41
<u>Graminoid</u>										
weight (g/m ²)	25.22	17.74	9.58	14.49	21.41	20.80	21.52	19.10	24.52	15.97
<u>Green gram.</u>										
weight (g/m ²)	1.15	0.78	1.11	1.34	2.57	2.26	3.45	3.67	3.88	3.32
<u>Lichen</u>										
weight (g/m ²)	4.01	10.89	1.54	1.93	4.28	8.15	2.04	2.47	1.67	1.69
<u>Evergreen</u>										
weight (g/m ²)	4.26	2.66	1.06	2.35	2.42	3.71	3.05	4.95	2.97	4.16

Table 3. continued.

Habitat characteristics ^a	Preparturition		Peak parturition				Post parturition			
	(n = 20)		with young (n = 36)		without young (n = 30)		with young (n = 40)		without young (n = 37)	
	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>	<u>X</u>	<u>SD</u>
Cover (%)										
Graminoid	50.3	30.28	17.5	21.28	36.5	28.52	38.0	27.54	45.5	24.98
Deciduous	3.0	4.38	2.5	3.98	6.5	7.10	5.0	8.04	6.5	10.06
Forb	0.2	0.62	1.0	2.36	1.0	2.90	1.0	1.92	1.0	1.46
Lichen	7.0	6.86	8.0	7.82	7.5	7.80	7.0	7.66	8.5	7.78
Evergreen	8.0	7.42	10.5	11.34	15.0	16.34	12.5	10.02	13.0	10.98
Moss	13.5	9.64	12.5	11.16	9.0	6.24	10.0	8.26	11.0	8.50
Rock	9.5	16.12	23.5	27.88	10.0	16.58	7.5	10.78	4.5	11.56
Bare ground	3.0	3.28	7.5	8.36	4.5	8.26	7.5	10.48	4.0	5.66
Leaf litter	2.5	2.94	3.0	4.34	4.5	9.06	5.0	6.38	4.0	5.96
Snow	1.0	2.38	13.5	27.34	3.5	16.84	5.0	13.82	1.5	6.22
Water	2.0	3.70	0.5	2.40	2.0	4.28	1.5	4.06	0.5	1.52

^a Habitat variables are described in Table 1.

Table 4.--Logistic regression models: coefficient, (SE), and odds ratio for sites used by female caribou at parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995.

Model	Variable	Coefficient*	SE	Odds ratio	P
Preparturition (1) vs.					
Peak parturition (0) (with young)	Low shrub	-2.2345	0.9868	0.107	0.024
	Sedge tundra	-3.2679	1.0448	0.038	0.002
	Bare ground	0.2928	0.1449	1.340	0.043
Preparturition (1) vs.					
Peak parturition (0) (without young)	Gentle slope	-1.4574	0.7253	0.233	0.045
	Wt. of green graminoids	1.5530	0.5890	4.726	0.008
	Wt. of total graminoids	-0.0662	0.0352	0.936	0.059
Peak parturition (1) (with young) vs.					
Peak parturition (0) (without young)	Low shrub	2.8858	1.1236	17.917	0.010
	Sedge tundra	2.5553	0.8788	12.875	0.004
	Deciduous Wt. (dry)	0.1605	0.0838	1.174	0.055
Post parturition (0) (with young) vs.					
Post parturition (1) (without young)	Low shrub	1.6392	0.7801	5.151	0.036
	Lichen weight (wet)	-0.3933	0.2477	0.675	0.112
	<u>Vaccinium</u> <u>vitis-idae</u> ^a	0.4722	0.3265	1.604	0.148

* The coefficient signifies the direction (+ or -) of relative use of the habitat variable by caribou that are coded 0.

^a Percent cover along 50-m line transects/50 intercepts (Table 3).

Table 5.--Percent occurrence (Mean and SE) of forage classes in fecal pellets of female caribou collected during pre, peak, and post parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1993-1995.

Year	Parturition period	(n)	Forage classes											
			Mosses		Lichens		Forbs		Shrubs		Sedges		Grasses	
			X	SE	X	SE	X	SE	X	SE	X	SE	X	SE
1993	Preparturition	(2)	35.5	5.3	17.9	6.0	9.4	5.4	4.7	-	29.4	15.7	3.1	0.9
	Post parturition	(4)	17.5	5.6	14.4	6.4	12.4	4.2	24.8	5.2	29.3	11.9	1.6	0.6
			**											
1994	Preparturition	(1)	38.9	- ^A	33.1	-	8.9	-	12.0	-	3.0	-	4.1	-
	Peak parturition	(7)	45.4	3.8 ^A	26.4	1.9	8.9	1.3	8.3	2.0	10.2	2.2	0.8	1.3
	Post parturition	(4)	18.2	4.9 ^B	22.9	9.4	5.4	1.3	38.3	13.1	13.8	3.9	1.4	0.5
1995	Post parturition (low elevation)	(4)	19.5	4.8	29.8	6.1	8.2	0.9	30.5	8.6	10.2	2.7	1.8	0.4
	Post parturition (high elevation)	(4)	19.8	4.9	25.1	11.5	21.8	8.9	17.8	4.5	13.3	4.8	2.2	1.1

- No variance due to single sample.

* * Percent of forage classes differed between parturition periods, ANOVA ($P < 0.05$).
Numbers with matching letters are not significantly different.

Table 6.--Percent (Mean and SE) of nitrogen (N) and neutral detergent fiber (NDF) in fecal pellets of female caribou during pre, peak, and post parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1993-1995.

Year	Parturition period	(n)	Nitrogen ^a		Neutral detergent fiber ^a	
			<u>X</u>	<u>SE</u>	<u>X</u>	<u>SE</u>
1993- 1995	Preparturition	(6)	1.56	0.09 [^]	65.24	0.87 [^]
	Peak parturition	(7)	1.48	0.18 [^]	65.59	0.73 [^]
	Post parturition	(8)	2.82	0.34 ^B	61.94	1.58 [^]
1995:	Elevation					
	Post parturition (Low)	(4)	2.44	0.55	65.07	2.83
	Post parturition (High)	(4)	2.07	0.43	66.66	1.48

^a Different letters represent significant differences (t-tests; $P < 0.05$)

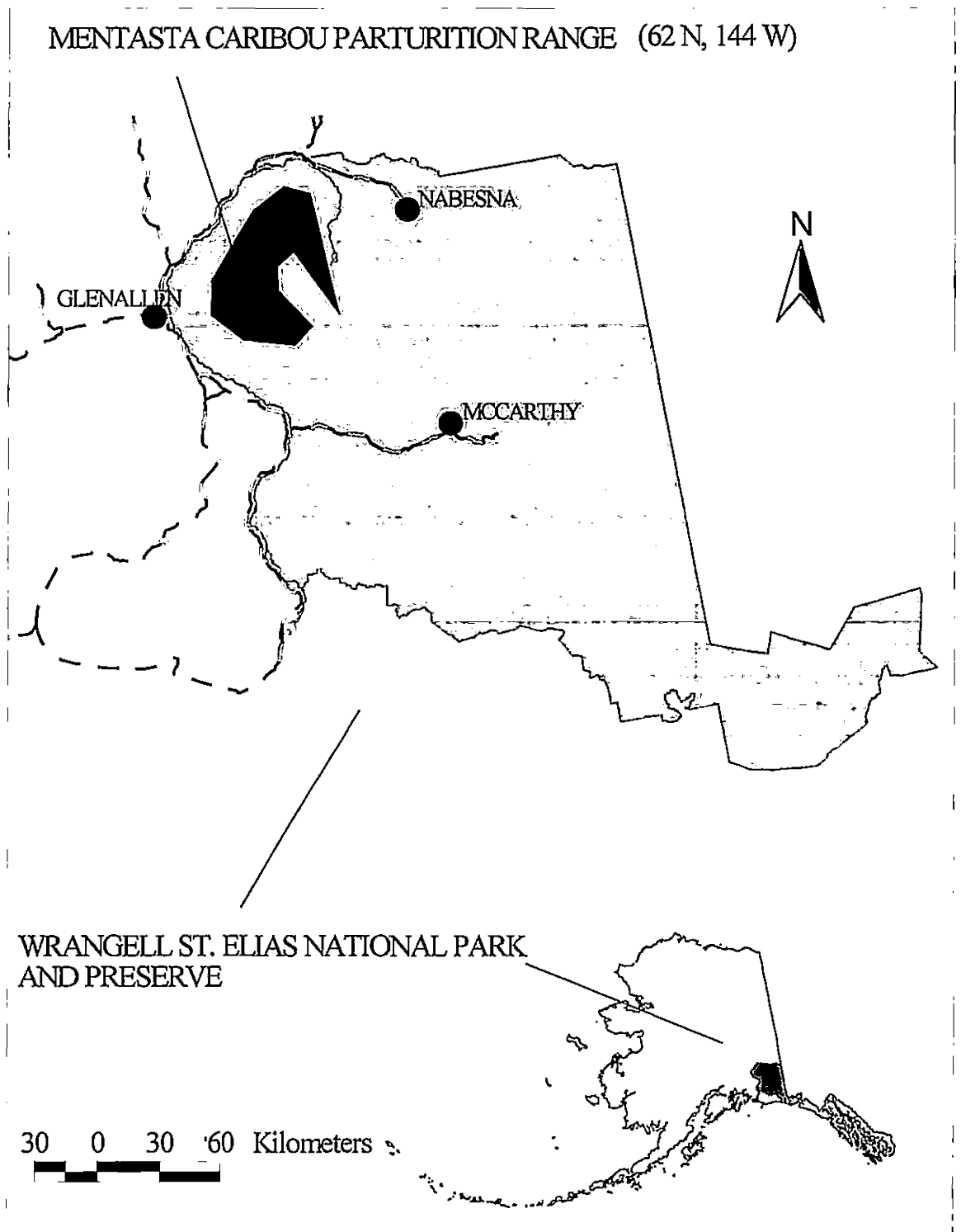


Figure 1. Location of the range used for parturition by the Mentasta Caribou Herd, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995.

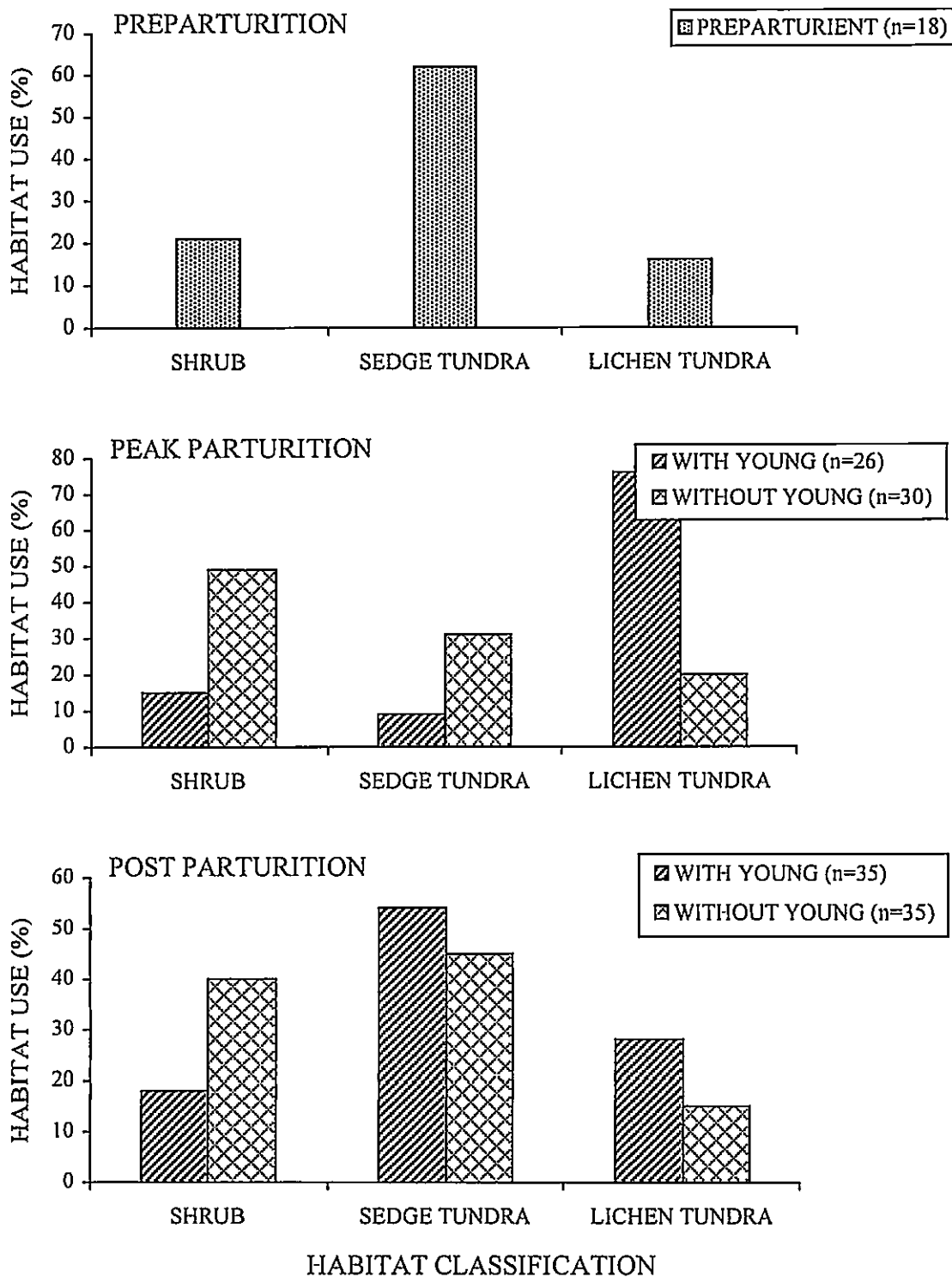


Figure 2.--Percent of major habitat types used by female caribou during pre, peak, and post parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995. Some habitat types are not shown.

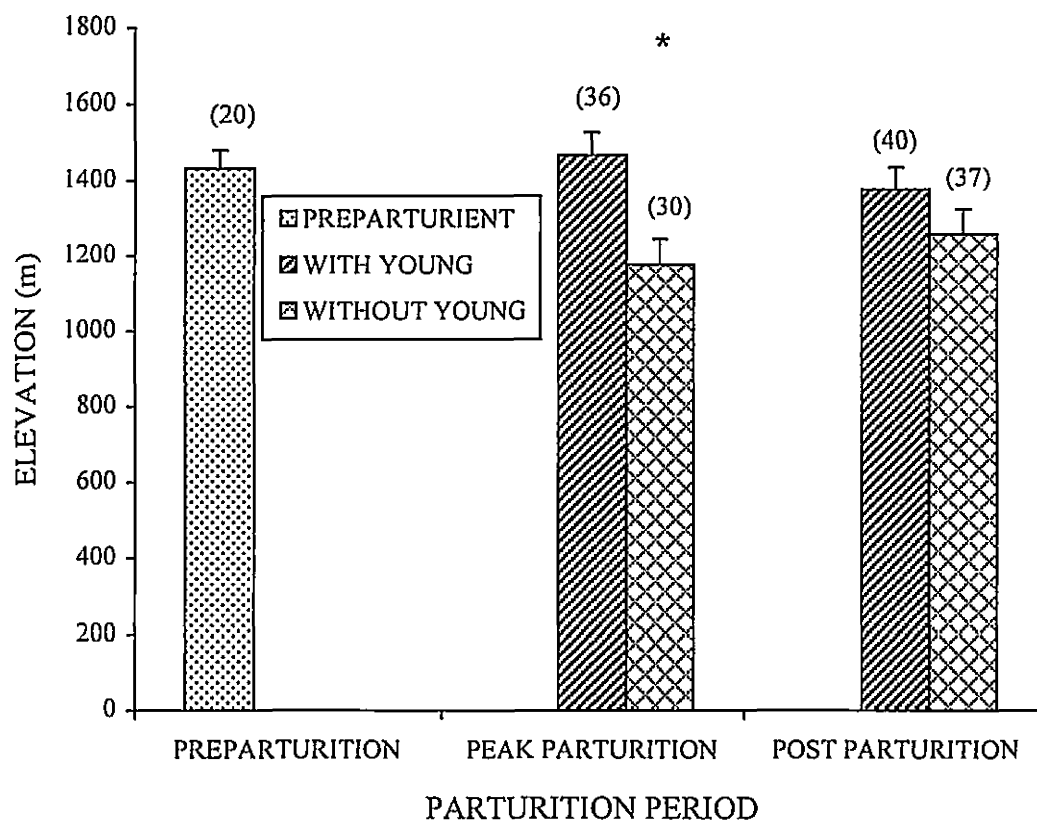


Figure 3.--Mean elevation and (SE) of sites used by female caribou during pre, peak, and post parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995. Sample sizes are provided above error bars (* = $P < 0.05$).

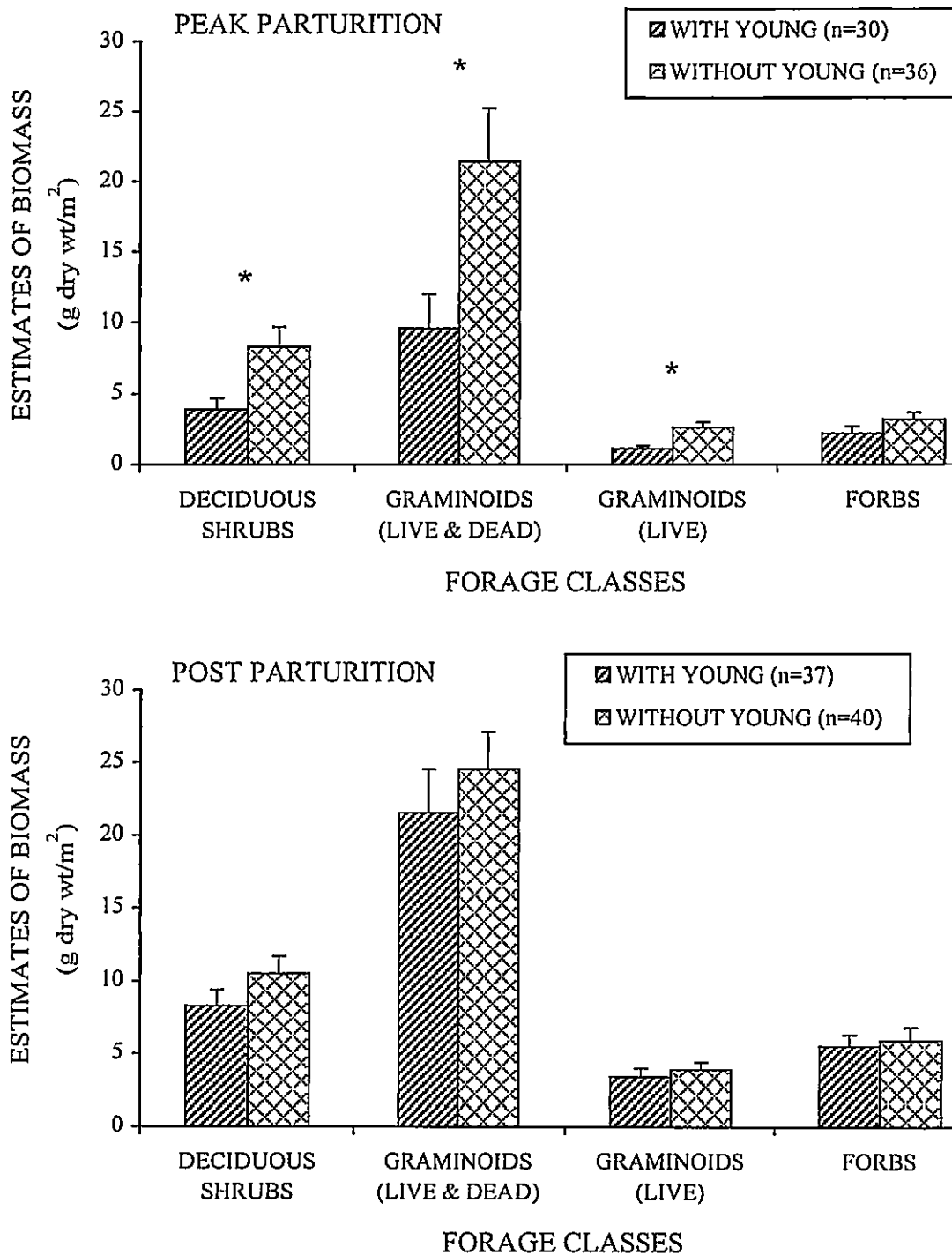


Figure 4.--Mean biomass and (SE) of major forage classes at sites used by female caribou with and without young during peak and post-parturition periods, Wrangell St. Elias National Park and Preserve, 1994-1995. Sample sizes are provided above error bars (* = $P < 0.05$).

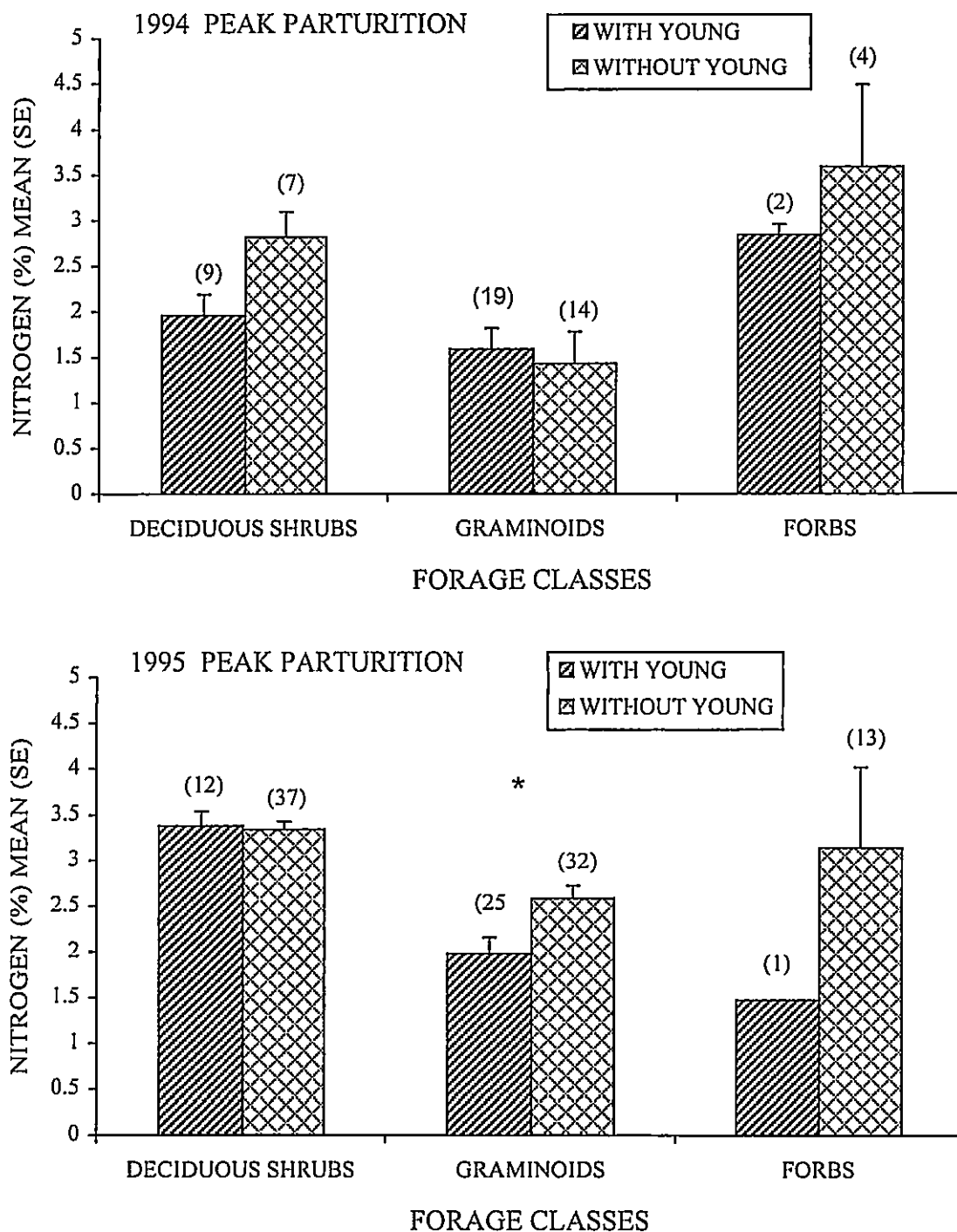


Figure 5.--Mean percent nitrogen and (SE) of forage collected at sites used by female caribou with and without young at peak parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995 (* = $P < 0.05$).

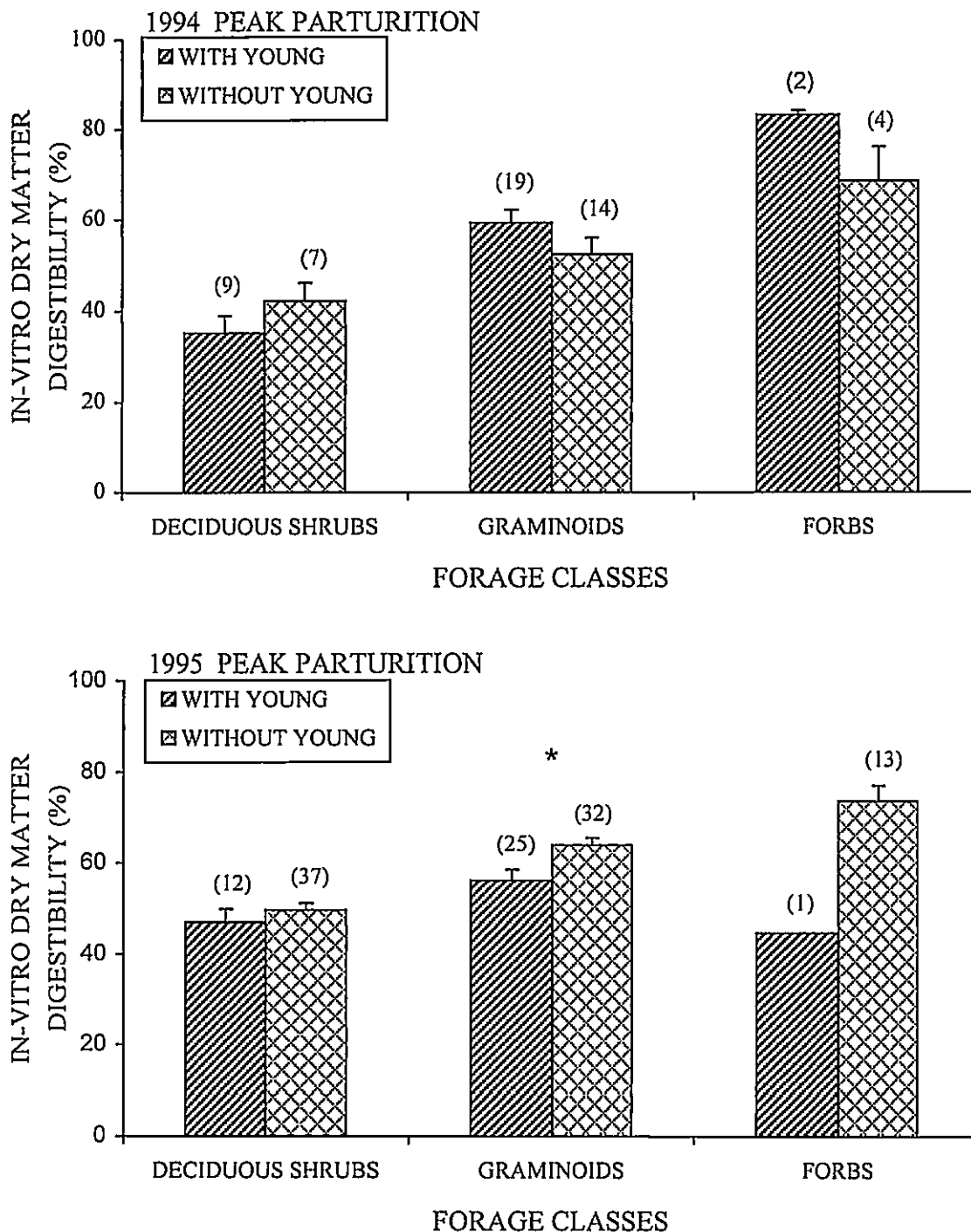


Figure 6.--Mean In-vitro dry matter digestibility and (SE) of major forage classes collected at sites used by female caribou with and without young at peak parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1994-1995. Sample sizes are provided above error bars (* = $P < 0.05$).

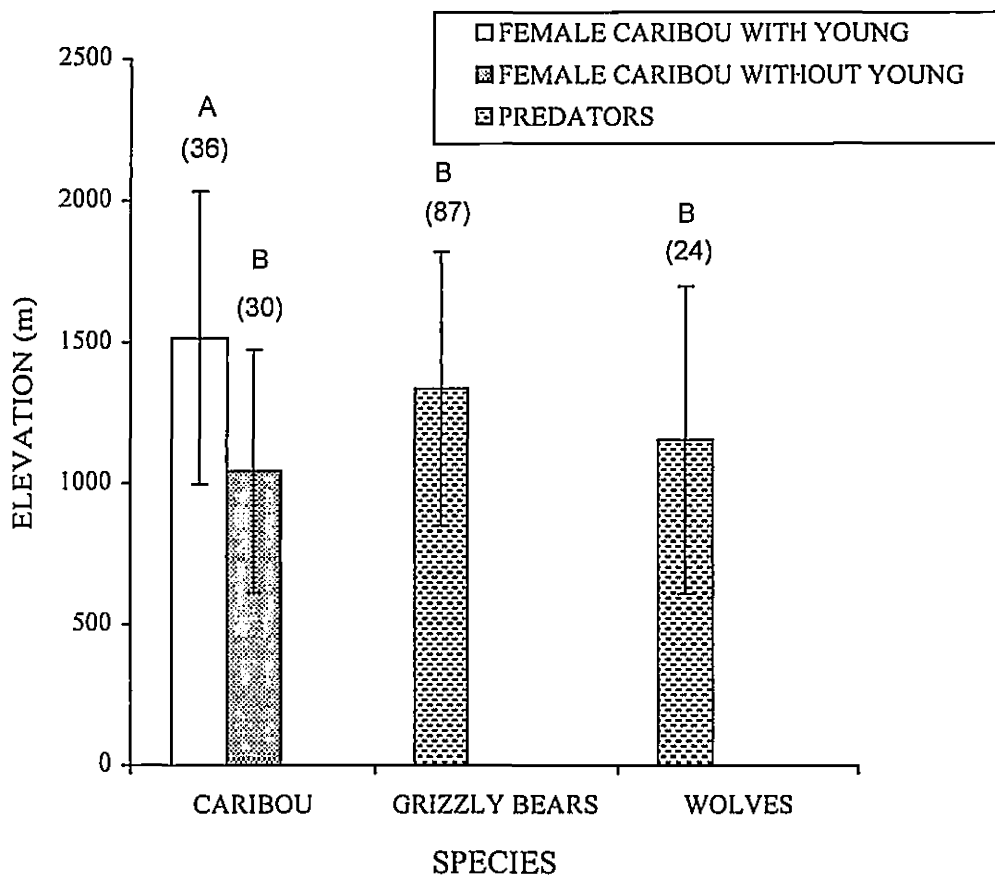


Figure 7.--Median elevation and interquartile distance of sites where female caribou, grizzly bears, and wolves were observed during peak parturition, Wrangell St. Elias National Park and Preserve, Alaska, 1993-1996. Sample sizes are provided above interquartile bars. Sites labeled with different letters are significantly different in elevation ($P < 0.05$).