Grizzly bear food habits in the northern Yukon, Canada

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Abstract: We documented seasonal food habits of grizzly bears (*Ursus arctos*) in the Firth River Valley, Ivvavik National Park (INP), northern Yukon, Canada, 1993–1995 using: (1) analysis of 176 scats, (2) 222 hours of direct observation, and (3) 99 feeding site investigations. In spring, the primary grizzly bear food plants were alpine hedysarum (*Hedysarum alpinum*) roots and over-wintered berries such as crowberry (*Empetrum nigrum*). The main food plants in summer were common horsetail (*Equisetum arvense*) and bearflower (*Boykinia richardsonii*). Bears fed primarily on bog blueberries (*Vaccinium uliginosum*), crowberries, horsetail, and bearflower in fall. When blueberries were not available, grizzly bears dug for alpine hedysarum roots. In addition to eating plants, grizzly bears killed or scavenged caribou (*Rangifer tarandus*) and hunted Arctic ground squirrels (*Spermophilus parryii*) and microtines when available. Well used grizzly bear food plants in INP have similar nutritional quality as food plants from southern Canada. However, the northern growing season is short, and suitable growing sites and diversity of major foods are generally less than in the south, so food plant availability is lower.

Key words: Canada, diet, food habits, grizzly bear, *Ursus arctos*, Yukon

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Food and the search for it influence most behavior of grizzly bears during their non-denning period. Nutritional status has a strong influence on population dynamics; the availability and quality of foods can affect a grizzly bear's mean age of reproduction, mean litter size, and breeding interval (Stringham 1986, Blanchard 1987, Stringham 1990). Understanding food habits is also important for understanding grizzly bear seasonal distribution and habitat use. Grizzly bears living in northern Canada and Alaska must contend with a short season of food availability, lack of protective cover, and extremes in weather unlike bears living in southern Canada or the contiguous United States. Northern bears may be particularly vulnerable to changes in food availability because of the short time they have to acquire energy necessary for maintenance, growth, reproduction, and winter denning. Understanding seasonal food habits of grizzly bears in the north may provide insight into how they adapt to this environment and may be helpful for assessing the potential effects of human activities, such as oil and gas exploration and increasing tourism, on bears in these areas (MacHutchon 2001).

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As part of a larger research project investigating grizzly bear seasonal habitat use, activity, and movements for Ivvavik National Park (MacHutchon 1996, 2001), we quantified grizzly bear food habits. The intent was to provide baseline documentation of bear ecology for the park's use in planning for increases in human visitors to the park in the future and to better understand grizzly bear ecology in northern environments.

Study area

Ivvavik National Park (INP) encompasses 10,170 km^2 at the northwestern tip of Yukon Territory, Canada, bordering the Arctic National Wildlife Refuge (ANWR), Alaska, USA, to the west and Beaufort Sea to the north (Fig. 1). The British Mountains occupy the central and southern two-thirds of INP and rise to elevations of 1675 m. A band of flat to rolling topography 10–30 km wide forms the coastal plain between the British Mountains and the Beaufort Sea. This study was primarily conducted in the British Mountains of the Firth River Valley, but extended to other parts of the British Mountains in INP. The Firth River (69°10′N, 140°05′W) flows northward for 160 km from its headwaters in Alaska to the Beaufort Sea. INP is characterized by short, cool summers and long, cold winters. Mean

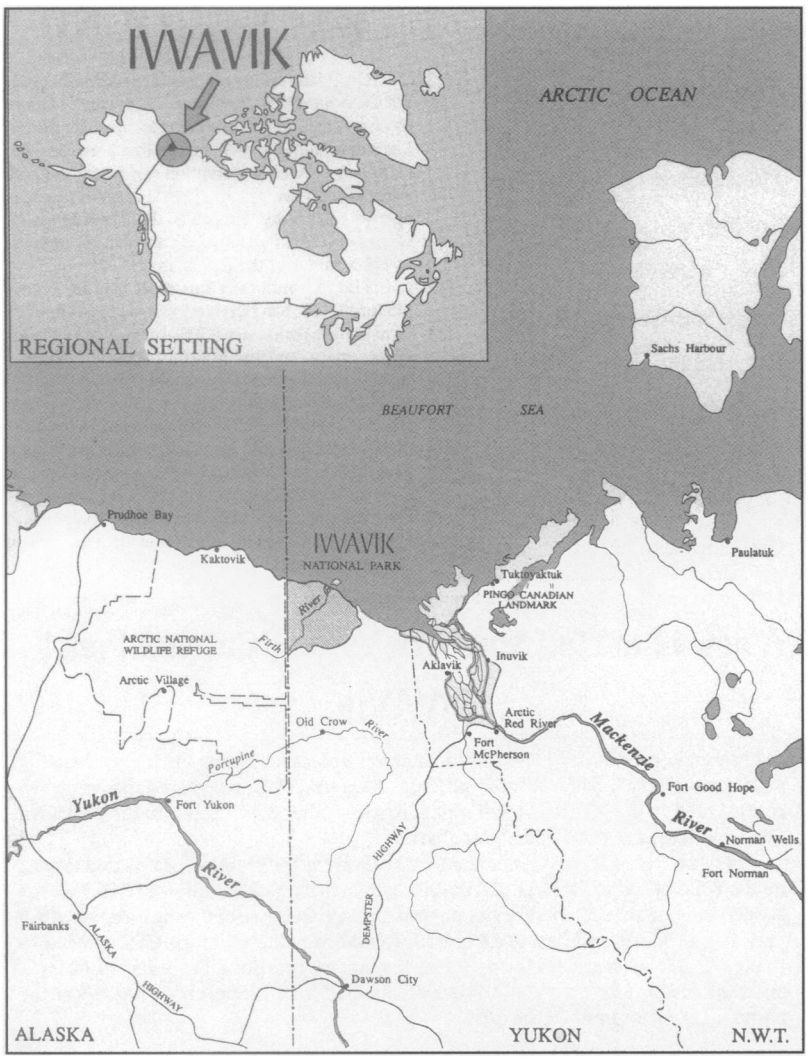

Fig. 1. Location for the study of food habits of grizzly bears in Ivvavik National Park showing the Firth River Valley in northern Yukon, Canada.

annual temperature is −10°C (6.5°C in summer, −25°C in winter) and mean annual precipitation is 300 mm.

Vegetation of the British Mountains includes open-forest subarctic taiga, treeless arctic tundra, and the broad transition zone between the 2 referred to as treeline (Pielou 1994). Trees become smaller and more scattered with increasing latitude, and white spruce (*Picea glauca*) and balsam poplar (*Populus balsamifera*) reach their northern limit within the British Mountains along the lower Firth River Valley. Forests are most common on valley bottoms and southern-facing slopes and are replaced by shrub communities with increasing latitude. There is an elevation transition from well vegetated valley bottoms through low shrub-dominated communities to alpine tundra. Slopes above 500 m are sparsely vegetated. Cotton-grass (*Eriophorum* spp.) and sedge (*Carex* spp.) tussocks typically dominate low-angle slopes or pediments.

Mammals of INP include caribou of the Porcupine caribou herd, moose (*Alces alces*), muskox (*Ovibos moschatus*), Arctic ground squirrels, collared (*Dicrostonyx torquatus*) and brown lemmings (*Lemmus sibiricus*), and northern red-backed (*Clethrionomys rutilus*) and singing voles (*Microtus miurus*). Anadromous and non-anadromous Dolly Varden char (*Salvelinus malma*) occur in the Firth River as well as other major rivers of INP.

Methods

We documented grizzly bear diet using a combination of (1) scat analysis, (2) direct observation, and (3) feeding site investigations to reduce biases associated with each technique. We collected scats of known age during capture, ground investigations of radio-collared grizzly bear locations, or after observing unmarked bears. We collected some scats opportunistically and aged them by considering local bear activity, the moisture content of the scat, condition of vegetation under the scat, decomposition, and recent rainfall (Holcroft and Herrero 1991). No American black bears (*Ursus americanus*) were in our study area.

We used only scats ≤14 days old for analysis following the methods of MacHutchon (1989). Scats were rinsed on sieves to remove fruit dye and fine digested material, then suspended in water. The percent volume of each diet item was visually estimated from three to five 10-ml samples, then averaged. Diet items were identified to the finest taxonomic level possible. Most plants were identified to species using reference plants collected in the field, but grasses and sedges were recorded as graminoids. Mammal hair was identified using the methods of Weir (1995). Most mammals were identified to species, but voles and lemmings were recorded as microtines. Percent occurrence was the number of scats with a diet item divided by the total number

of scats. Percent volume was the mean volume of a diet item among all scats.

During June 1993, we fitted 5 adult female and 3 adult male grizzly bears with radiocollars (Telonics, Mesa, Arizona, USA). In late August 1995, we recaptured all radiocollared bears and removed collars. MacHutchon (2001) described methods for focal bear observation. We located radiocollared bears from aircraft; then 1–2 backpacking crews of 2–3 people each were flown by helicopter to locations where they could watch individual bears. We chose bears for observation based on the number of previous observation sessions for each bear each season, its location inside or outside the study area, and the feasibility of maintaining a good vantage without disturbing the bear. Unmarked bears were observed opportunistically, but data were not included in our food habits analysis. Bears were followed if they moved, and we continued to observe as long as possible (up to 35 hours). We recorded foods eaten by bears during observations whenever possible. Frequently, however, a bear was too far away or viewing conditions were such that foods could not be distinguished. The most common food plants in a patch were often easiest to see; therefore, less common plants may have been eaten but not seen. If two common foods occurred in a patch and the observer could not tell which was being eaten, the food was recorded as unknown forb, root, or berry.

We identified foods eaten by grizzly bears at feeding sites during ground investigations. Only feeding sites documented independently of focal bear observations were included in this analysis to maintain independence between the two methods. Some evidence of feeding was more obvious and persisted longer; therefore, it may have been recorded more often (such as alpine hedysarum root digging). Percent frequency of use was the number of sites where a food was eaten divided by the total number of feeding sites. We recorded up to 3 foods at each site so the total of percent frequencies was not 100%.

Common horsetail shoots, bearflower leaves and flowers, alpine hedysarum roots, and bog blueberries were collected at a location in the central part of the Firth River Valley every 2–3 weeks during June–August 1994. Each sample was a collection of several individual plants and bearflower leaves, and flowers were combined during analysis. Proximate analyses of plant samples were done at the Department of Animal Science, University of British Columbia, Vancouver, British Columbia, Canada. Gross energy was determined with a bomb calorimeter and nitrogen content was estimated by the macro-Kjeldahl technique. Percent crude protein was estimated as percent nitrogen multiplied by 6.25. Neutral detergent fiber (NDF) was estimated using a modified Van Soest method (Robbins 1993). Similar analysis methods were used for samples from the Flathead River Valley, British Columbia, Canada (McLellan and Hovey 1995). Regressions of crude protein levels of plant species collected in INP and the Flathead River Valley during 2-week sampling periods were compared using equations in Zar (1996).

We delineated grizzly bear seasons of activity by general shifts in diet as determined from scat analysis and observations of bears and by the phenological development of food plants (MacHutchon 1996). Spring lasted from 26 May to 15 June, summer from 16 June to 31 July and fall from 1 August to 4 September. The start of spring and end of fall were based on the start and end of data collection. The change from spring to summer corresponded with the widespread availability of common horsetail shoots and the general shift in diet from roots to horsetail and forbs. The change from summer to fall corresponded with the widespread availability of bog blueberries and the general shift in diet to berries. Phenology was faster in the southern part of the study area than the northern part because of the influence of the cold Arctic Ocean, and there were slight differences in dates among years. The specific dates used to delineate seasons generally reflected plant phenology in the central part of the study area where food plants were collected for nutrient analysis.

Results

Grizzly bear diet items in INP were placed into 8 of the 11 major food categories used by Mattson et al. (1991) and were the same 8 used by McLellan and Hovey (1995; Table 1). Additional categories in this study were "unidentified animal" and "other." Other included debris collected incidentally with scats, grizzly bear hair, and unidentified material.

In spring, alpine hedysarum roots, over-wintered crowberries, and horsetail shoots, primarily common horsetail, were dominant food plants in scats. Alpine hedysarum root was the most frequently eaten food during focal observations and the most common food at feeding sites. We did not often see bears feeding on crowberries, but they were common at feeding sites. Graminoids and caribou occurred frequently in scats but in small volumes. Caribou was the most frequent mammal eaten during observations and at feeding sites.

In summer, horsetail shoots and bearflower leaves were dominant food plants in scats, during focal

observations, and at feeding sites. Bears were observed feeding on the flowers and leaves of bearflower, but flowers were rarely detected in scats. Graminoids were frequently found in scats, but usually in small quantities. Bog blueberries started to show up in scats and at feeding sites in late summer. Adult and larval wasps (family Vespidae) or bumblebees (*Bombus polaris*, *B. hyperboreus*) were found in a number of scats, but they made up a small volume. Arctic ground squirrels were the most frequent mammal in scat samples during summer. Caribou meat scats were rarely collected when found, so caribou was under represented.

In fall, bog blueberry, alpine hedysarum, bearflower, and horsetail were dominant food plants in scats. Blueberries and alpine hedysarum roots were the most common foods during focal observations and at feeding sites. Bearflower and horsetail were primarily eaten in early fall, and blueberries and alpine hedysarum were eaten throughout fall. Crowberries occurred often at feeding sites, but were never recorded during observations likely because they often grew with bog blueberry and it was hard to distinguish between the two. Arctic ground squirrels were the most frequent mammal in scats and at feeding sites during fall. We ceased collecting scats and making ground observations in early September, but observations of radiocollared grizzly bears during aerial locations in late fall suggested feeding on alpine hedysarum roots and Arctic ground squirrels increased as bog blueberry availability decreased when frost damage caused them to drop. On two occasions grizzly bears were seen from the air feeding on caribou carcasses in late fall. No moose remains were identified in fall scats; however, a radiocollared female grizzly bear was observed feeding on an adult bull moose carcass in early fall 1995, and moose remains were found at 2 feeding sites. On two occasions MacHutchon (1996) documented grizzly bears feeding on Dolly Varden char in INP.

There was some variation among years in grizzly bear food use in INP. In 1993, wasps occurred much more frequently in scats than in 1994 or 1995. Microtine populations peaked in 1995 (MacHutchon 1996) and grizzly bears fed on them more than in 1993 or 1994. Bog blueberry production was reduced in 1995, apparently because of late spring frost (MacHutchon 1996); consequently, grizzly bear use of alpine hedysarum roots was higher in fall 1995 than in 1993 or 1994.

One scat collected at a radiocollared adult female's den site not included in Table 1 was entirely grizzly bear hair with 4 cub claws. The female was observed breeding the previous spring, but she was without cubs when first seen after denning. We do not know whether the cub died from natural causes and was consumed or was preyed on.

Alpine hedysarum roots were highest in crude protein in spring and early summer (Fig. 2). When horsetail and bearflower shoots first emerged, they had higher levels of crude protein than alpine hedysarum roots, but crude protein in horsetail and bearflower steadily declined over summer. Fiber was lower in bearflower than horsetail and both were lower than alpine hedysarum roots.

We found no difference in the regression of crude protein to date of common horsetail between the Firth River Valley, INP and the Flathead River Valley, southeast British Columbia, Canada (Fig. 3; B. McLellan, British Columbia Ministry of Forests, Revelstoke, British Columbia, Canada, unpublished data; slope: $t = 0.236$, $v = 10$, $P > 0.05$, elevation: $t = -0.278$, $v = 11$, $P > 0.05$). Alpine hedysarum roots had higher crude protein than yellow hedysarum (*Hedysarum sulphurescens*) roots from the Flathead River Valley in spring, but they were similar in summer through fall, so there was no significant difference in regressions (slope: $t = -0.472$, $v = 6$, $P > 0.05$, elevation: $t = 1.674$, $v = 7$, $P > 0.05$). We included bearflower from the Firth River Valley and cow-parsnip (*Heracleum maximum*) from the Flathead River Valley together because they were the most commonly eaten summer forb in their respective ranges. These plants had the same rate of decline in crude protein ($t = -0.759$, $v = 9$, $P > 0.05$), but the amount of crude protein was significantly higher in cow-parsnip in late summer and fall ($t = -5.001$, $v = 10$, $P < 0.05$). Small sample sizes precluded testing for differences in crude protein between bog blueberry and black huckleberry (*Vaccinium membranaceum*).

Discussion

Scat analysis data is commonly presented as percent volume of food items (Hamer and Herrero 1987, Mattson et al. 1991, McLellan and Hovey 1995). However, volume data can be misleading because of differences in digestibility among foods. Poorly digested foods such as roots and graminoids can be over represented, and highly digested foods such as meat can be under represented (Hechtel 1985, McLellan and Hovey 1995). Our bear observation and feeding site data were different measures of food use in our study and compensated for some scat data bias. However, sample sizes were small and observation and feeding site data

Table 1. Percent volume (% V) and percent occurrence (% O) of diet items in scats, the proportion of time grizzly bears fed on foods during observations, and the percent of feeding sites where foods were used, Ivvavik National Park, Yukon, Canada, 1993–95. A dash indicates the item was not identified for that period.

	Scat analysis						Focal observations			Feeding sites		
	Spring[a] (*n* = 29)		Summer[a] (*n* = 87)		Fall[a] (*n* = 60)		Spring (19 hrs)	Summer (103 hrs)	Fall (100 hrs)	Spring (*n* = 29)	Summer (*n* = 28)	Fall (*n* = 42)
Food items	**% V**	**% O**	**% V**	**% O**	**% V**	**% O**	**%**	**%**	**%**	**%**	**%**	**%**
Roots												
Alpine hedysarum	44.8	65.5	1.6	6.9	12.4	43.3	79.1	0.5	25.8	72.4	17.9	38.1
Unidentified root	—	—	0.9	3.4	—	—	0.1	0.1	0.4	—	—	2.4
Graminoids	1.6	34.5	2.9	62.1	4.1	56.7	0.0	1.9	0.1	—	3.6	—
Horsetail	20.7	34.5	44.2	83.9	13.4	78.3	2.0	43.6	7.1	3.4	53.6	7.1
Forbs												
Bearflower	5.2	6.9	41.7	77.0	31.1	75.0	—	41.3	2.8	3.4	32.1	7.1
Mountain sorrel (*Oxyria digyna*)	—	—	0.3	12.6	2.2	18.3	—	0.1	2.8	—	—	—
Unidentified forb	0.1	3.4	0.8	10.3	1.2	8.3	10.2	3.7	1.4	—	—	—
Fruit												
Bearberry (*Arctostaphylos* spp.)	0.2	6.9	—	—	—	—	—	—	—	3.4	3.6	—
Kinnikinnick (*Arctostaphylos uva-ursi*)	0.2	3.4	0.1	1.1	0.0	1.7	—	—	—	3.4	—	—
Crowberry	23.8	44.8	0.0	3.4	1.7	26.7	1.3	0.1	—	17.2	—	26.2
Red currant (*Ribes triste*)	—	—	—	—	0.0	1.7	—	—	—	—	—	—
Soopolallie (*Shepherdia canadensis*)	—	—	—	—	2.5	10.0	—	—	—	—	—	2.4
Bog blueberry	0.0	3.4	2.3	16.1	29.7	86.7	—	4.5	30.4	—	3.6	47.6
Lingonberry (*Vaccinium vitis-idaea*)	0.0	3.4	0.0	2.3	—	—	—	—	—	—	—	—
Unidentified berry	0.1	6.9	0.0	2.3	0.0	1.7	5.0	1.3	25.6	3.4	—	—
Insects	—	—	1.6	9.2	0.0	3.3	—	—	—	—	3.6	—
Rodents												
Microtines	1.9	6.9	0.0	5.7	—	—	—	—	—	3.4	—	—
Ground squirrel	0.6	6.9	0.9	11.5	0.5	15.0	—	0.0	0.0	—	10.7	19.0
Ungulates												
Caribou	0.6	13.8	1.6	5.7	0.0	1.7	1.2	2.9	0.4	13.8	3.6	—
Moose	—	—	—	—	—	—	—	—	3.3	—	3.6	2.4
Unidentified animal	0.0	3.4	0.1	3.4	1.1	3.3	0.9	0.1	0.0	3.4	3.6	—
Other	0.0	3.4	1.0	8.0	0.0	5.0	—	—	—	—	—	—

[a]Spring = 26 May to 15 Jun; Summer = 16 Jun to 31 Jul; Fall = 1 Aug to 4 Sep.

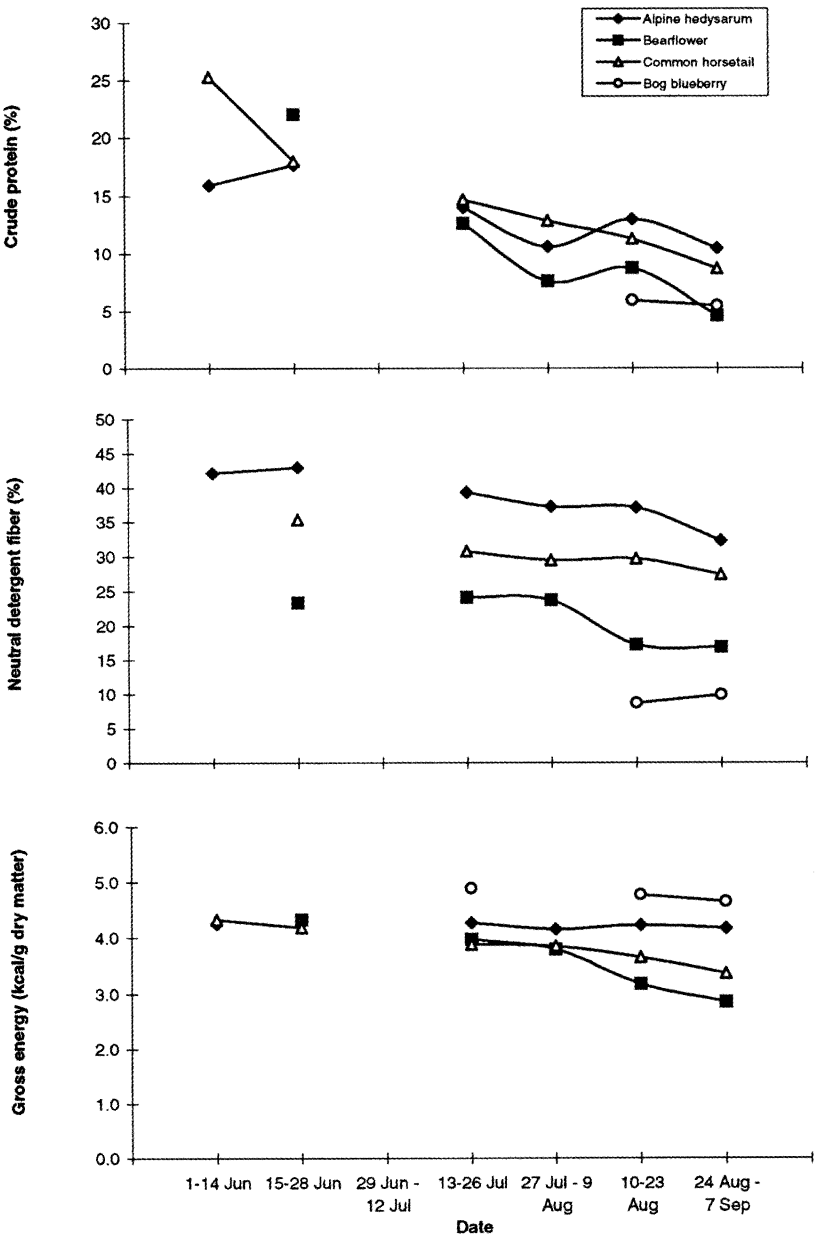

Fig. 2. Percent crude protein, percent neutral detergent fiber, and gross energy of 4 grizzly bear food plants from the central Firth River Valley, Ivvavik National Park, Yukon, Canada, June–August 1994.

were only from 5 grizzly bears. One other radiocollared bear dropped his collar early in the study and 2 others frequently were not observed because they were off the habitat-mapped portion of the study area. Individual variation in bear behavior may have biased observation data (MacHutchon 2001). In addition, 72% of scat samples came from the 5 grizzly bears used for focal observation and feeding site data. For these reasons, our methods may not be entirely independent and our results may not represent the population as a whole. Nevertheless, there are fewer major foods in the north than the south (McLellan and Hovey 1995), so there is less chance we missed any common ones.

Grizzly bear food habits have been described for other mountainous areas of northern Alaska and Yukon, including the western Brooks Range, Alaska (Hechtel 1985), British Mountains of ANWR, Alaska west of INP (Phillips 1987), and Barn Range, Yukon east of INP (Nagy et al. 1983*a*). Similar to this study, a common spring food in all studies was alpine hedysarum roots. However, during one year bears more frequently dug *Oxytropis viscida* (also called *Oxytropis borealis*) roots in the western Brooks Range (Hechtel 1985). Over-wintered berries were well used in 2 studies. In the Barn Range, crowberries were the most used (Nagy et al. 1983*a*), but in the western Brooks Range bearberries (*Arctostaphylos rubra* or *A. alpina*) were most used (Hechtel 1985). Over-wintered berries are likely important spring foods because they are high in carbohydrates (Hamer and Herrero 1987). As in our study, caribou were a well used spring food in ANWR (Phillips 1987). In the western Brooks Range cotton-grass (*Eriophorum vaginatum*) flowers were eaten extensively by one family group one year (Hechtel 1985). Cotton-grass was abundant in INP, but we found no evidence it was eaten, nor did Phillips (1987) in ANWR.

Grizzly bears in INP had a similar summer diet to bears in the western Brooks Range (Hechtel 1985) and ANWR (Phillips 1987). In the Barn Range, however, grizzly bears fed almost entirely on grass in summer, even though horsetail and bearflower were available (Nagy et al. 1983*a*). Grizzly bears in INP and in southern populations feed on insects during summer (Hamilton and Bunnell 1987, Hamer et

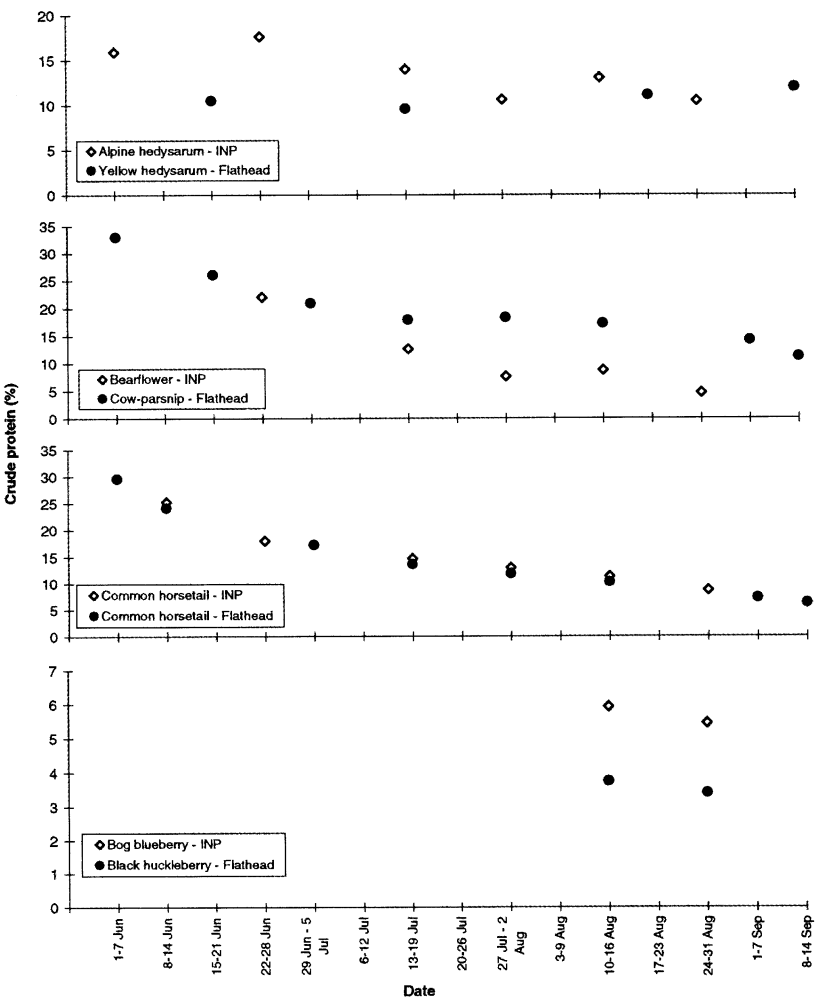

Fig. 3. Seasonal crude protein of the same (or similar) grizzly bear food plants from the Firth River Valley, Ivvavik National Park, Yukon, Canada (INP) and the Flathead River Valley, south-east British Columbia, Canada (Flathead; B. McLellan, British Columbia Ministry of Forests, Revelstoke, British Columbia, Canada, unpublished data).

al. 1991, Mattson et al. 1991, McLellan and Hovey 1995). Hechtel (1985) found only a few instances of insect feeding and Nagy et al. (1983*a*) found none.

Alpine hedysarum roots, bearberries, and Arctic ground squirrels were the most common fall grizzly bear foods in the western Brooks Range (Hechtel 1985). Crowberries, bog blueberries, and bearberries were commonly eaten in early fall in ANWR and alpine hedysarum roots, Arctic ground squirrels, and microtines were more commonly eaten as fall progressed (Phillips 1987). Grasses, crowberry, and some soopolallie (*Shepherdia canadensis*) were the most common fall foods in the Barn Range, but alpine hedysarum roots and Arctic ground squirrels were also used (Nagy et al. 1983*a*). Nagy et al. (1983*a*) suggested the scarcity of bog blueberry use during their study was due to poor blueberry production. Bearberries and soopolallie were present in INP; however, bog blueberry and crowberry were much more widespread and abundant. Similar to other studies, use of alpine hedysarum roots and Arctic ground squirrels increased through fall in our study, and alpine hedysarum roots were more frequently used when bog blueberry production was reduced.

Mammals are likely the highest quality food throughout the year (McLellan and Hovey 1995, Hilderbrand et al. 1999), but their ease of capture and relative availability in INP varied among seasons (MacHutchon 2001). Radiocollared grizzly bears spent considerable time pursuing Arctic ground squirrels or microtines during summer and fall (called "foraging" in MacHutchon 1996, 2001), but feeding time in Table 1 is low because they were quickly consumed. Caribou were primarily available for a short time in spring when migrating northwest through INP to calving grounds on the Arctic Ocean coast and in summer when large groups with calves migrated southeast through INP to summer range (Russell et al. 1993). When available, grizzly bears focused considerable effort on obtaining caribou (MacHutchon 2001). We observed or found evidence that caribou were obtained in a number of ways. Caribou were surprised and killed by grizzly bears as they moved down tree or shrub draws toward major rivers. Caribou calves separated from their mothers at aggregations beside rivers or during river crossings became prey to wolves (*Canis lupus*) and grizzly bears. Caribou of all ages died or were injured crossing rivers and were scavenged or killed. Grizzly bears occasionally caught and killed adult caribou in open country chases and took over carcasses killed by wolves. Grizzly bears in east central Alaska killed about 4 times more moose

and caribou biomass than they scavenged, and appropriated and consumed more carcasses of animals killed by wolves than they lost to wolves (Boertje et al. 1988).

Abundant meat resources positively affect body size, reproductive success, and population density of grizzly bears and therefore positively influence habitat quality (Hilderbrand et al. 1999). Northern grizzly bears that feed on caribou on a regular basis have higher densities and productivity than populations that do not feed on caribou (Reynolds and Garner 1987). MacHutchon (2001) suggested the availability of mammalian prey, such as caribou, Arctic ground squirrels, and other small mammals, may compensate for the constraints of latitude in northern bear populations. Hechtel (1985) and Nagy et al. (1983*a*) found only small amounts of caribou in scats, but suggested caribou were under represented in scats and actually were a more common food. Caribou were the primary food of grizzly bears in the central Canadian Arctic during most of their active season (Gau et al. 2002). Arctic ground squirrels were commonly eaten by grizzly bears on the northern coastal plain of the Prudhoe Bay oil fields, Alaska (Shideler and Hechtel 2000) and the Tuktoyaktuk Peninsula and Richards Island, Northwest Territories (Nagy et al. 1983*b*). R. Shideler (Alaska Department of Fish and Game, Fairbanks, Alaska, USA, personal communication, 2003) suggested small mammals, particularly Arctic ground squirrels, may compensate for the lower predation rates on caribou seen in the Prudhoe Bay region than other northern areas.

Variation in grizzly bear food habits among years is common (Hechtel 1985, Stemlock and Dean 1986, Hamer and Herrero 1987, Mattson et al. 1991, McLellan and Hovey 1995). In Denali National Park, Alaska, (Stemlock and Dean 1986) and the Prudhoe Bay oil fields (Shideler and Hechtel 2000), Arctic ground squirrel populations were relatively stable and consistently available to bears, but microtine and large mammals were less predictable prey items. This relative availability of mammalian prey was true for our study area as well. During years of abundant microtines in the Prudhoe Bay region, Shideler and Hechtel (2000) observed a relatively high proportion of grizzly bears feeding on microtine adults and young in nests, but also on the caches of rhizomes collected by adult microtines. Hamer and Herrero (1987) also found that grizzly bear use of alpine hedysarum roots increased in Banff National Park, Alberta, during years of low berry production. Weather and microclimate can influence berry production by affecting pollinators and flower buds (Martin 1983, Stemlock and Dean 1986).

The amount of digestible protein available to grizzly bears is positively correlated with the amount of crude protein in a food item (Pritchard and Robbins 1990). NDF measures the amount of insoluble fiber in plants (hemicellulose, cellulose, lignin, and cutin), but it does not measure soluble fiber, such as pectins and gums, that are not digestible by grizzly bears (Pritchard and Robbins 1990, Robbins 1993). Total dietary fiber is a better measure of all nondigestible dietary fibers; however, we used NDF because the cost of total dietary fiber analysis was prohibitive. Our NDF values, therefore, are not a true measure of nondigestible plant fiber, but they do reflect relative differences in fiber over time. Pritchard and Robbins (1990) found that as total dietary fiber increased, dry matter digestibility and digestible energy decreased.

Bunnell and Hamilton (1983) suggested grizzly bears change food plants with seasons in response to changes in digestibility to optimize their energy and protein intake. McLellan and Hovey (1995) suggested availability (distribution and abundance) and handling time may have a greater influence on forage selection by grizzly bears than quality (digestible energy and protein). We suggest grizzly bears of INP changed their diet seasonally based on trade-off between food quality and digestibility, as well as availability and handling time. We focus our discussion on frequently eaten foods that provide digestible energy and protein, but recognize that some foods eaten in small quantities or infrequently may be important in providing essential vitamins and minerals.

Grizzly bears fed on alpine hedysarum roots in spring when roots were highest in crude protein. They also fed on alpine hedysarum roots in fall when protein levels were lower, but fiber was also lower, which likely meant a higher proportion of crude protein and energy was digestible. In addition, there were few aboveground vegetation alternatives to alpine hedysarum roots in early spring and late fall. Hamer and Herrero (1987) also found crude protein of alpine hedysarum roots and grizzly bear use was highest in spring and lowest in summer.

Grizzly bears in INP used horsetail and bearflower as soon as they were available above ground, even in small amounts, but made a more significant switch to these plants from alpine hedysarum roots in early summer. At that time, horsetail and bearflower were much more widespread and abundant, so handling time was shorter (MacHutchon 2001) with correspondingly higher intake rates (Rode et al. 2001). In addition, protein stored in alpine hedysarum roots was immobilized for stem and leaf growth and flowering in late spring, thereby reducing the amount available to bears. The protein and energy content of horsetail and bearflower in early

summer was not that different than alpine hedysarum roots, but fiber was lower in the former so digestibility likely higher. By mid-August feeding on horsetail and bearflower had declined and there was an increase in feeding on alpine hedysarum roots again. This corresponded to a period when nutrient quality of horsetail and bearflower was lower than for alpine hedysarum. Protein content of horsetail and forbs commonly declines over summer (Hamer and Herrero 1987, McLellan and Hovey 1995, Rode et al. 2001), but some areas with drifted snow have delayed phenology and therefore may have high quality horsetail and forbs available into fall (Shideler and Hechtel 2000).

Newly ripened berries were eaten only in fall, the only time they were available. Bog blueberries likely were preferred over other berries because plants were widespread and abundant, therefore intake rates were high (Welch et al. 1997), particularly in years of good berry production. Blueberries also were low in fiber and high in gross energy (i.e., carbohydrates), which can be important for fat deposition prior to denning (Hamer and Herrero 1987, Welch et al. 1997, Rode and Robbins 2000). Bears can not significantly increase their fat stores on foliage alone because they are non-cecal monogastrics that cannot digest fiber efficiently (Bunnell and Hamilton 1983, Welch et al. 1997). Hamer and Herrero (1987) also found grizzly bears used blueberries more frequently than alpine hedysarum roots when both were available. In the absence of easily obtained meat, however, some alpine hedysarum root or late developing forb in the diet may provide protein and other minerals to offset the limitations of a largely fruit diet (Rode and Robbins 2000). Decreased use of blueberries in late fall was likely because they dropped off plants and were no longer readily available (Welch et al. 1997). Arctic ground squirrels can be an especially important food in late fall when other foods such as berries and vegetation are not available (Shideler and Hechtel 2000).

Grizzly bears' food plants in INP were as nutritious as those from southern Canada; however, the northern growing season is short and suitable growing sites and diversity of major foods are generally less than in the south (McLellan and Hovey 1995), so overall food plant availability is lower. Availability appears to have a greater influence on diet selection in the north than the south because of these constraints (McLellan and Hovey 1995).

Management implications

Grizzly bears, in the north have a short growing season to feed, so repeated disruptions may adversely affect the time available to acquire energy necessary for maintenance, growth, reproduction, and hibernation (MacHutchon 2001). Constraints on their ability to forage, particularly on meat sources, could have individual or long-term population implications (Hilderbrand et al. 1999). Grizzly bears in INP appear to fear humans and generally have not habituated to human activity; they can be easily displaced from important habitats or prey (MacHutchon 1996, 2001). Grizzly bears in the north have limited vegetative security cover and no darkness during most of their non-denning period to reduce the displacement effects of human activity (McLellan 1990). This suggests a need to carefully manage human activities to minimize their effects on bears or their important foods, particularly mammalian prey.

Tourists can disrupt grizzly bear feeding on caribou when people travel on northern rivers in summer. During this time, caribou herds cross rivers between calving grounds and summer ranges and are killed by bears or scavenged when they die during the crossing. For example, in July 2002 more than 20 adult bull caribou died while swimming across the lower Firth River in high water and an almost equal number of bears moved in to feed on the carcasses. Parks Canada staff temporarily closed the lower river to rafting to minimize disturbance of the bears and to ensure human safety (S. Travis, Parks Canada, Inuvik, Northwest Territories, Canada, personal communication, 2002). Travelers should be encouraged to be cautious about where they camp and hike during the summer caribou migration to avoid displacing bears from carcasses and to avoid potentially dangerous encounters. Riverbanks and alluvial deposits along rivers are common places for ground squirrel colonies (MacHutchon 1996, Shideler and Hechtel 2000), so travelers should be encouraged to avoid these areas if possible. If people hike on sparsely vegetated mountain ridges and stay away from vegetated mountain slopes and valley bottoms, they can avoid areas where caribou kills are often made as well as important growing sites of alpine hedysarum, horsetail, bearflower, and bog blueberry.

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