

# HABITAT USE BY GRIZZLY BEAR FAMILY GROUPS IN INTERIOR ALASKA

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**Abstract:** A study of grizzly bears (*Ursus arctos*) in 1984 and 1985 in Denali National Park investigated the differences between family and single bear habitat use patterns. Differences in family age, seasons, and years contributed to differences in habitat use patterns. Proportions of cub families seen in the spring were low but increased through the field season, whereas proportions of observed yearlings remained constant. Seasonal patterns of habitat use were generally consistent among cub and yearling families and single bears. Small but notable proportions of observations of families were made in more rugged, isolated terrain, especially in spring. Habitat use patterns between the years were significantly different and probably a result of a late spring and wetter weather in 1985. The 1984 habitat use pattern was more concentrated in extreme habitat combinations (high-rugged vs. low-flat) than was the 1985 pattern.

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Grizzly bears spend their 1st few years of life under the protection of their mother, and the success of females in raising their offspring to weaning age influences the long-term success of the population. Families, therefore, are an important segment of any brown bear population, and we need to identify important family use habitats where nutritious food and cover or escape terrain are easily available and in sufficient quantities for the family members. Identification of family areas could prevent some of the aggressive encounters between humans and family groups, because females with young are responsible for most defensive attacks on humans (Herrero 1970). Knowledge of family habitat could improve management of areas inhabited by brown bears.

Studies of habitat use, home range, food habits, and behavior using radiotelemetry, aerial surveys, and scat analysis have determined that brown bears use different habitats throughout the year to take advantage of seasonal food resources (Curatolo and Moore 1975, Pearson 1975, Reynolds and Hechtel 1980, Miller et al. 1982, Hamer 1985). These movements and diet changes have been observed for single bears and families. Differences in use between single bears and families have not been specifically addressed, although many studies present anecdotal reports of differences secondarily to major research conclusions. This apparent lack of investigation is primarily due to the tremendous amount of time, effort, and money required to monitor enough animals over a long period to provide a sufficient sample for statistical analyses.

The specific objective of this study was to investigate the concept of "nursery habitat" put forth by Sharafutdinov and Korotkov (1976). They suggested that families use different habitats than single bears because of higher requirements of females and young for nutrients, cover, and isolation. The 1st stage in an investigation of this sort must be to determine if

indeed there is a quantifiable difference in habitat use patterns between bear families and single bears. The 2nd stage must delineate characteristics of vegetation and physiographic combinations that comprise habitats used by families. The final stage is to compare the quality of habitats used by families with those used by single bears. This paper presents preliminary findings for the 1st and 2nd steps.

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## STUDY AREA

The study area was in Interior Alaska on the north side of the Alaska Range within the bounds of Denali National Park and Preserve. It consisted of a 10-km-wide corridor roughly centered on the Park road and stretching from the eastern Park boundary to the Eielson Visitors' Center, 105 km by road to the west.

The Park road winds through a broad glaciated region which is part of a major fault system between the Alaska Range and the Outside Range to the north. Elevation along the road varies from 488 m at the Park entrance to 1,220 m at Highway Pass (km 92); the surrounding mountain peaks range 1,200-1,800 m. The road crosses several braided, north- and northwest-flowing rivers that are characterized by wide, glacial gravel bars.

White spruce (*Picea glauca*) occurs in isolated patches below 900 m and is most extensive in the

major valleys in the eastern half of the study area. Low shrubs, especially birch (*Betula nana*) and some species of willow (*Salix* spp.) dominate most valleys and mountain slopes, but taller shrubs such as other willows and alder (*Alnus crispa*) usually border rivers, streams, and moist draws. Dryas (*Dryas octapetala*), mountain heather (*Cassiope tetragona*), and willow (*Salix reticulata*) are dominant at higher elevations and in the western one-third of the study area. Above about 1,400 m one finds mostly bare rock and ice.

Extensive descriptions of the physiography, vegetation, and climate are available in Alaska Planning Group (1974), Tracy (1977), Murie (1981), Stelmock (1981), and Heebner (1982).

## METHODS

### Data Collection

The research was conducted from mid-May to the end of August in 1984 and 1985. Ninety-minute scans were made of a series of 34 fixed plots ( $\leq 3$  km radius) straddling the Park road and 19 plots outside the road corridor. Plots were chosen using an incomplete systematic sampling design with daily randomized starting points. We supplemented data from the plot sample with similar data from incidental observations made along the road. Habitat use records were made for the location at which bears and bear groups were first seen to simulate aerial surveys or survey photos. Based on the rigor of the data collection scheme, all plot and incidental observations were considered independent. Details are available in Darling (1987).

Vegetation at each bear sighting was classified, if possible, to Level IV (primary species) of the 5-level hierarchy of Alaskan vegetation types proposed by Viereck et al. (1982). For many distant bear sightings, and some complex vegetation associations at closer range, it was impossible to determine plant species, but classification of vegetation to the 3rd level (community form) was possible. The vegetation component of the habitat was determined at 2 radii: (1) point vegetation within 1 bear length of the bear in question (approximately a 6-m-diameter circle) and (2) local vegetation, within 5 bear lengths (approximately 22-m-diameter). Differences between point and local vegetation suggest selection on a fine scale and were used to describe the level of diversity of a bear's habitat.

The following physiographic features were rec-

orded for the location of the initial sightings (field measurements were at a finer scale than noted below):

1. slope ( $< 10^\circ$ ,  $10^\circ\text{--}20^\circ$ ,  $> 20^\circ$ );
2. aspect (NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW);
3. elevation (msl) (1,050 m, 1,050–1,200 m,  $> 1,200$  m);
4. exposure (ridge, upper one-third of hillside, midslope or saddle, lower one-third of hillside, valley bottom);
5. terrain (flat, rolling, rugged);
6. distance to permanent and temporary water ( $< 50$  m, 50–500 m,  $> 500$  m);
7. distance to escape terrain ( $< 100$  m, 100–500 m,  $> 500$  m).

Escape terrain was a subjectively evaluated combination of terrain characteristics that observers believed would provide bears with a refuge or area of safety. In the open expanses of the Park, this often included areas high on hillsides away from travel routes, with panoramic views of valleys below. Some heavy brush and forested areas were also considered escape terrain. No attempt was made to differentiate between point and local physiographic characteristics because I assumed they would be similar at the 2 radii.

Observations of older families were pooled with single bears for all analyses because of (1) a decline in proportion of older families in the total sample as the season progressed, suggesting dissolution of these families (Table 1); (2) expected behavioral and physical similarities between adults, independent subadults, and older offspring still in family groups; and (3) few observations of older families ( $N = 13$ , Table 2).

### Data Analysis

Commercially available statistical computing packages were used to analyze the habitat data. SPSSx (SPSS Inc. 1983) was used in cross-tabulation problems, chi-square ( $X^2$ ) analyses, and to calculate Spearman rank correlation coefficients and their significance levels. BMDP (Dixon et al. 1981) was chosen for loglinear analysis of 3-way contingency tables.

Habitat variables were cross-tabulated with year, season, and status (cub families, yearling families, single bears plus older families) in 2-way contingency

Table 1. Percent of independent observations of bears and bear groups (*N*) in each status class through 3 seasons in 1984 and 1985 in Denali National Park, Alaska.

| Season | Year  | <i>N</i> | % single bears | % families |        |                    |
|--------|-------|----------|----------------|------------|--------|--------------------|
|        |       |          |                | Cub        | Yrlng. | Other <sup>a</sup> |
| Spring | 1984  | 51       | 66.7           | 19.6       | 11.8   | 2.0                |
|        | 1985  | 68       | 45.6           | 1.5        | 44.1   | 8.8                |
|        | Total | 119      | 54.6           | 9.2        | 30.3   | 5.9                |
| Summer | 1984  | 114      | 60.5           | 28.1       | 8.8    | 2.7                |
|        | 1985  | 163      | 41.7           | 11.7       | 45.4   | 1.2                |
|        | Total | 277      | 49.5           | 18.4       | 30.3   | 1.8                |
| Fall   | 1984  | 89       | 47.2           | 42.7       | 9.0    | 1.1                |
|        | 1985  | 65       | 38.5           | 10.8       | 50.8   | 0.0                |
|        | Total | 154      | 43.5           | 29.2       | 26.6   | 0.6                |

<sup>a</sup> Family groups consisting of offspring  $\geq 2$  years old.

tables, and  $X^2$  tests of independence were conducted. Although the  $X^2$  test itself is not a test of trend, important trends or patterns in the data are indicated by large cellwise contributions of observed values to the contingency table  $X^2$  statistic (i.e., large residual); they indicate substantial deviations of observed from expected values. Observed values greater or less than expected do not imply a comparison to availability but rather indicate possible trends or important relationships between the contingency table indices.

I chose the conservative level of  $P \leq 0.005$  for testing independence in 2-way contingency tables because multiple  $X^2$  tests on multivariate data such as this are complicated by the lack of variable independence and repeated testing of observations from the same data set. Actual probabilities of error in rejecting the null hypothesis are underrepresented by the  $P$  value. With a large enough sample this problem is minimized when only a few tests of independence are made and the acceptable  $P$  level is low (Zar 1984). For some cross-tabulations where the  $X^2$  was approaching significance (A.S.:  $0.005 < P < 0.05$ ), I document where trends in the data were evident.

Correlation coefficients were calculated for pairs of ordinal habitat and behavior variables. Coefficients were calculated from all data records that were complete for particular pairs of variables. Levels of significance varied according to the number of complete records for that variable pair.

Loglinear analysis, a multiway contingency table analysis (Fienberg 1980), was used on the combined plot and incidental data set to determine the relationship among 3 indices: individual habitat variables, year, and status. A series of nested models for each

habitat variable was examined in a stepwise manner to determine the importance of potential model terms in describing the relationship. Possible terms in the models are independent main effects (i.e., the indices year, status, or habitat variable, either alone or in any non-interacting combination with 1 or 2 of the other indices), interactions between main effects, or both. Inclusion of a term indicates its significance in describing the 3-way relationship among indices; interaction terms included in the model indicate lack of independence among those indices. The "best" model simply but adequately described the habitat-status-year relationship in terms of 2-factor or 3-factor interactions or main effects only. Details of model choice are described in Fienberg (1980).

## RESULTS

We collected 550 independent plot and incidental observations over the 2 field seasons, half of which were of families (Table 2). Thirteen families were identified each year in the study area, but not all yearling families seen in 1985 were positively identified as families seen the previous year as cubs. At least 10 cub families (8 in 1984, 2 in 1985) were readily identifiable by family size, color combinations, and location, and I was able to distinguish at least 3 yearling families in 1984 and 8 in 1985. The ratio of cub family observations to yearling family observations changed substantially from 80:24 in 1984 to 27:137 in 1985.

Seasonal shifts in feeding behavior that were used to indicate the change in seasons (Stelmock 1981, Darling 1987) occurred later in 1985 than in 1984

Table 2. Number of independent observations (plot and incidental) in the combined roadside and backcountry zones in the Denali study area, 1984–85.

| Status                           | 1984               | 1985   | Total  |
|----------------------------------|--------------------|--------|--------|
| Lone bears                       | 145                | 124    | 269    |
| All families                     | 109                | 172    | 281    |
| Cub families                     | 80(8) <sup>a</sup> | 27(2)  | 107    |
| Yearling families                | 24(3)              | 137(8) | 161    |
| Older families                   | 5(2)               | 8(3)   | 13     |
| Grand total                      | 254                | 296    | 550    |
| Sighting ratio (plot:incidental) | 49:205             | 25:271 | 74:476 |

<sup>a</sup> Minimum number of different families (identified by age, family size, pelage color combinations, location) that contributed to the total number of observations.

because a long winter with unusually heavy snowfall delayed plant development. Also, precipitation was greater in 1985 than in 1984 (National Park Service files, Denali National Park). The shift to summer grazing from spring root digging occurred during the weeks beginning 8 June 1984 and 15 June 1985. In 1984 the fall season started when berry feeding began in the 1st week of August but did not start until the 3rd week of August in 1985.

#### Influence of Year and Status on Habitat Use

I first conducted loglinear analyses on 3-way contingency tables (habitat-status-year) in which status described single bear or family observation. A “best” model describing the habitat-status-year relationship was derived for each habitat variable (Table 3, Model Set A), and in each case a year-status interaction term was required in the model. For all but 1 habitat variable (exposure), the best model also included the habitat-year interaction, but the habitat-status interaction often was not included. This process suggests that the habitat-year interaction was more important than the habitat-status interaction. The importance of the year index may have been caused by 2 factors. The 1st factor is phenological differences in food plants brought on by a late spring in 1985. This would be reflected in different habitat choice patterns between the 2 years, and contingency table analysis would show lack of independence between year and status. A 2nd reason why year played an important role in the model-building is the substantial difference between the 2 years in observed proportions of yearling and cub families (Table 2). Any age-specific habitat use by families would thus tend to be associated with years and would be masked when treating all families as a group.

To address the latter influence, status and each

habitat variable were evaluated in 2-way loglinear analyses with years pooled. In this analysis a 3-level index of status (cub families, yearling families, and single bears plus other families) was used and differences in year were confounded with the 3-level status index. Some habitat variables (slope, terrain, and distance to temporary water) were best described by a model that did not include the habitat-status interaction, although the model included the status main effect (Table 3, Model Set B). This analysis indicates that for some habitat variables, the habitat-status interaction must be included in the best model when differences between years are not explicit.

However, because of differences between 1984 and 1985 potentially caused by phenological differences, I conducted a 3rd series of loglinear analyses with differences in year explicit rather than confounded with the 3 levels of status (Table 3, Model Set C). If the influence of year was totally confounded in the 3 levels of status (as Model Set B assumes), and there was no phenological (year) influence, then in Set C models, habitat-status interaction terms should occur in models where habitat-year interactions are required, and visa versa. This was not the case. Those physiographic habitat variables requiring a habitat-year interaction in models of the 3rd analysis but no habitat-status interaction (slope, terrain, distance to temporary water) also exhibited no habitat-status interactions in the models of Model Set B. These results reinforce the conclusion that differences in year were more important than differences in status in explaining the observations of these habitat variables.

For the remaining 5 physiographic habitat variables (aspect, exposure, elevation, distance to permanent water, and distance to escape terrain) the habitat-status interaction is present in Model Sets B and C. This suggests that observations on these habitat variables are most influenced by the status of the

bear groups. Models for 3 of these 5 variables (aspect, elevation, and escape terrain) required the 3-way interaction; this is interpreted as lack of independence between a given variable and status and year. Therefore, for these 3 variables, although the influence of year is not expressed when it is hidden in the 3-level status of Model Set B, some influence of year is suggested in Set C models. In contrast, the best model for exposure does not include the exposure-year interaction in either the 2nd or 3rd analyses, suggesting that exposure and year are independent, conditional on the status level. Because this is the only variable in this scenario, it may be the most important in differentiating between the status levels because it is independent of year (but see Darling 1987 regarding indications of Principal Components Analysis).

The models for point and local vegetation suggest that both year and status influenced observations of these variables, although year may have a greater influence. When year was explicit (Model Sets A and C) the vegetation-year interaction was included in the models, but the vegetation-status interaction was not included. The latter interaction was important only when year was not explicitly stated (Model Set B). The influence of year on vegetation is expected if delayed phenology had an influence on habitat choice.

Interaction of habitat variables with other habitat variables, year, and status in 4-way and higher-order contingency tables could not be investigated using loglinear analysis because low cell frequencies made X<sup>2</sup> likelihood tests invalid.

Habitat Variable Correlations

Two-way correlations between habitat variables suggest different habitat use by the 3 status groups. A matrix of significant Spearman rank correlation coefficients (Table 4) illustrates that significant correlations between variables are not necessarily the same among the 3 groups. That is, the association between some habitat variables varies with the status group. Strong associations (significant correlations) may occur in 1, 2, or all status groups and suggest particular relationships between habitat variables that are more attractive or available for a given status group. For example, the terrain-vegetation correlations are only significant for single bears. Other terrain correlations are significant for at least single bears, and, in most cases, family groups as well. Because terrain-vegetation correlations are only significant for single bears, perhaps particular terrain-vegetation combinations are more attractive or available for singles than families. This is discussed elsewhere (Darling 1987), but for this discussion the important concept is the overall difference between the matrices for the 3 status groups.

Habitat Use Between Years and Seasons

Two-way contingency tables from X<sup>2</sup> tests of independence between habitat variables and year or season showed between-year and seasonal trends in habitat use for the whole population. Chi-square cell-wise residuals indicated that observations on steep

Table 3. Loglinear models<sup>a</sup> generated to describe relationships between habitat variables (Hab) and year (Yr) and status (St).<sup>b</sup>

| Habitat variable | Terms included in the models <sup>c</sup> |          |         |               |                   |          |             |          |         |               |
|------------------|---|----------|---------|---------------|-------------------|----------|-------------|----------|---------|---------------|
|                  | Model Set A                               |          |         |               | Model Set B       |          | Model Set C |          |         |               |
|                  | Hab × Yr                                  | Hab × St | Yr × St | Hab × Yr × St | Both main effects | Hab × St | Hab × Yr    | Hab × St | Yr × St | Hab × Yr × St |
| Slope            | x   |          | x       |               | x                 |          | x           |          | x       |               |
| Aspect           | x   | x        | x       | x             |                   | x        | x           | x        | x       | x             |
| Elevation        | x   | x        | x       | x             |                   | x        | x           | x        | x       | x             |
| Exposure         |   |          | x       |               |                   | x        |             | x        | x       |               |
| Terrain          | x   |          | x       |               | x                 |          | x           |          | x       |               |
| Perm. water      | x   |          | x       |               |                   | x        |             | x        | x       |               |
| Temp. water      | x   |          | x       |               | x                 |          | x           |          | x       |               |
| Escape terr.     | x   |          | x       |               |                   | x        |             | x        | x       | x             |
| Point veg.       | x   |          | x       |               |                   | x        | x           | x        | x       |               |
| Local veg.       | x   | x        | x       | x             |                   | x        | x           |          | x       |               |

<sup>a</sup> For example, in Model Set A, the model for slope includes main effects plus slope-year and year-status interactions. The 1st model for aspect includes, in addition to all main effects, all 2-way and 3-way interactions.

<sup>b</sup> In Model Set A the status index is family or single bear. In Model Set B the year index is implicit in 3 levels of status: cub family, yearling family, single bear. In Model Set C the year index is explicit with the 3 levels of status. An x indicates a term is included in the best model of the relationship.

<sup>c</sup> All main effects are included in Model Sets A and C.

Table 4. Combined matrices of significant Spearman rank correlations between habitat components for 3 status levels: cub families, yearling families, single bears (plus older families). Significant correlation\* denoted by C, Y, S, respectively. Significance for all 3 status levels denoted by ALL. Correlations on the diagonal equal 1.0.

|              | Year | Ptveg | Locveg | Slope | Aspect | Elev | Expos | Terr | Pwater | Twater |
|--------------|------|-------|--------|-------|--------|------|-------|------|--------|--------|
| Year         |      |       |        |       |        |      |       |      |        |        |
| Point veg.   |      |       |        |       |        |      |       |      |        |        |
| Local veg.   |      | ALL   |        |       |        |      |       |      |        |        |
| Slope        |      |       |        |       |        |      |       |      |        |        |
| Aspect       | S,Y  | S     | S      | S,C   |        |      |       |      |        |        |
| Elevation    |      | C,Y   | Y      | ALL   | S,C    |      |       |      |        |        |
| Exposure     |      |       |        | ALL   | ALL    | ALL  |       |      |        |        |
| Terrain      | S    | S     | S      | ALL   | S,C    | ALL  | ALL   |      |        |        |
| Perm. water  |      |       |        | ALL   | S,C    | ALL  | ALL   | S,C  |        |        |
| Temp. water  |      |       |        | S,C   | C      | ALL  | ALL   | S    | ALL    |        |
| Escape terr. | ALL  |       | Y,C    | ALL   | S      | S    | S,Y   | ALL  | S      | S      |

\*  $P \leq 0.05$ , 1-tailed test; level of significance of correlation takes into account sample size (complete records for the variable pair being considered), which varies because of incomplete data for some sightings (cub families, 100–106; yearling families, 155–160; single bears, 256–270).

slopes ( $> 20^\circ$ ) were greater than expected by the null hypothesis of similarity between years in 1985 than in 1984 ( $X^2$  A.S. at 0.005, but  $P \leq 0.05$ ), but use of steeper slopes was particularly evident in the spring season ( $H_0$ : similarity among seasons) in conjunction with fewer than expected observations on moderate ( $10^\circ$ – $20^\circ$ ) slopes ( $X^2 = 79.39$ ,  $P < 0.0001$ ). This pattern of use was also significant in 1985 alone ( $X^2 = 65.21$ ,  $P < 0.0001$ ). Trends in elevation were evident over the seasons with more use than expected of low sites ( $< 1,050$  m) in spring and fall and greater than expected use of middle elevations (1,050–1,200 m) and high sites ( $> 1,200$  m) in summer ( $X^2 = 128.61$ ,  $P < 0.0001$ ). This pattern of elevation use was also significant in 1984 alone ( $X^2 = 58.01$ ,  $P < 0.0001$ ). In both 1984 and 1985, spring use of ridges and valleys was greater than expected. Bears moved to upper and middle hillsides in summer and to low hillsides and valley bottoms in fall. The number of bears observed was greater than expected in 1985 on low hillsides in summer and middle hillsides in fall ( $X^2 = 52.67$ ,  $P < 0.0001$ ;  $X^2 = 28.17$ ,  $P = 0.0004$ ).

*General single bear trends.*—Two-way  $X^2$  tests of independence between habitat variables and status ( $H_0$ : similarity among status groups) showed trends in habitat use by each status group without regard to season. Chi-square cellwise residuals showed that observations of single bears were greater than expected on flat slopes ( $X^2$  A.S.), on middle and lower hillsides, and valley bottoms ( $X^2 = 23.05$ ,  $P = 0.0033$ ), and at distances greater than 500 m from escape terrain ( $X^2$  A.S.)

*Cub families.*—Cub families were observed more than expected ( $H_0$ : similarity among status groups) in the middle elevation class (1,050–1,200 m) and less than expected at low ( $< 1,050$  m) and high ( $> 1,200$  m) elevations ( $X^2 = 50.99$ ,  $P = 0.0001$ ). They were observed more than expected on rugged terrain ( $X^2$  A.S.), more than expected on ridges ( $X^2 = 23.05$ ,  $P = 0.0033$ ), and more than expected between 100–500 m from escape terrain but less than expected at distances greater than 500 m ( $X^2$  A.S.).

Cub families were not seen often in spring (Table 1), but observations of that age class increased through the field season, suggesting that they remained in less accessible (hence less visible), safer areas—presumably near their den sites—until after the mating season, when the cubs were slightly more mobile (Crook 1971; Pearson 1975, 1976; Russell et al. 1979; Glenn and Miller 1980; Miller et al. 1982; Reynolds and Hechtel 1984). The few cub families that were seen in spring ( $N = 11$ ) were using rugged terrain and ridges or flat and rolling terrain in and near valley bottoms, far from escape terrain. They were seen equally often at low ( $< 1,050$  m) and middle (1,050–1,200 m) elevations but were not seen more than 500 m from water in the spring. Repeated observations of 1 family were in open conifer forest, but vegetation at other cub family sightings varied from tall or low shrubs to herbaceous or open gravel bars. Comparisons with yearling families and single bears in spring were not made because of the small sample size of cub families.

With the coming of summer, cub families moved

off ridges and out of valleys onto rolling, moderately steep terrain, and mid-hillside habitats. Use of areas 100–500 m from escape terrain increased, although a small number of observations were made in rugged terrain, on upper slopes, and on ridges. Use of low shrubs was greater in summer than in spring but the spring sample size was small. Summer habitat use patterns of cub families were similar to patterns of single bear use, except that cub families used high elevations more than singles and were at greater distances from water. The proportion of sightings at higher elevations increased in summer, contrary to other trends that indicated movement away from steep, upper hillsides. But use of a particular category of 1 habitat variable does not imply use of a particular category of another variable. For, example, although one might think of sightings in rugged terrain as also being on ridges, 67% of ridgetop observations were actually recorded in rolling terrain.

In the summer of 1985, cub families retained the high-rugged vs. low-flat habitat use pattern that was evident in spring; however, observations of habitat use in 1984 were more evenly distributed throughout the categories of each habitat variable and were closer to the habitat use patterns of other status groups. In light of the small 1985 sample, the less extreme patterns of 1984 may be more truly representative of summer use by cub families.

In fall, cub families moved to lower slopes and valley bottoms, as did the other status groups; however, there was proportionately more use by cub families of middle elevations and lower slopes and less use of rolling terrain than by other status groups. Cub families were typically found on rolling or flat terrain, moderate to far distances from escape terrain, and moderate to near distances to water. As in spring, use of high elevations was minimal. Use of herbaceous habitats decreased in the fall, but use of open gravel bars increased.

Between-year differences in fall use were substantial. In 1984 cub family use was highest on flat terrain, lower elevations, valley bottoms, shrub vegetation, and open gravel bars. In contrast, cub families in 1985 were seen more often on moderately steep slopes, on lower hillsides, in rolling terrain, and in herbaceous vegetation.

*Yearling families.*—Yearling family habitat use differed from that of single bears and cub families. Over the whole sample period, yearling families were seen more than expected ( $H_0$ : similarity among status groups) on mid-steep ( $10^\circ$ – $20^\circ$ ) and steep slopes

( $> 20^\circ$ ) ( $X^2$  A.S.), at elevations  $> 1,200$  m ( $X^2 = 50.99$ ,  $P = 0.0001$ ), and on the upper half of hillsides ( $X^2 = 23.05$ ,  $P = 0.0033$ ).

Proportions of observations of yearling families were consistent throughout both field seasons, although the ratio of yearling to cub families was substantially greater in 1985 (Tables 1, 2). Spring habitat use by yearling families was concentrated in low shrub vegetation, low elevations, flat slopes, valley bottoms, and at moderate distances from water but far from escape terrain. In the spring of 1984 the limited sample of yearling family observations ( $N = 6$ ) was concentrated on moderately steep slopes and middle elevations, whereas in 1985 yearling families ( $N = 30$ ) were found more often on flatter slopes, at lower elevations, and in valley bottoms. Like cub families, some yearling families in spring used ridge exposures, rugged terrain, and dwarf shrub habitats near escape terrain, but this was particularly evident in the 1984 sample. Spring habitat use by yearling families resembled that of single bears except that yearlings chose lower elevations more frequently than singles. In contrast, there was more use by yearlings of upper hillsides and locations near escape terrain than singles, suggesting a small contingent of yearling families that were isolated from single bears. Yearlings also used relatively more tall shrub vegetation and less herbaceous or open gravel bar habitats than single bears.

Summer habitat use by yearling families paralleled the general pattern for other status groups as they moved out of the valleys and low hillsides to rolling hillsides and as use of herbaceous habitats increased substantially from spring. Nonetheless, observations were more equally distributed among categories of the elevation and exposure variables, a phenomenon not recorded for cub families or single bears. Proportions of observations far from escape terrain were intermediate between cub families and singles. As in spring, and similarly to cub families, summer patterns of habitat use by yearling families were less extreme in 1985 than in 1984. In the limited summer observations of 1984 ( $N = 10$ ), a greater proportion of yearling families were seen at higher elevations, near escape terrain and alpine vegetation, and far from water than in 1985, but these characteristics did not comprise a major portion of the sample.

Fall observations of yearling families indicated a movement to lower elevations, flat slopes, rolling terrain, and valley bottoms. This pattern was similar to that of single bears, except that yearling families

tended to be seen more at low elevations and in valley bottoms. Use of tall shrubs in summer changed to greater use of dwarf shrub vegetation and open gravel bars in the fall. Yearling families used fewer low shrub habitats and more open gravel bars than single bears, suggesting that yearlings, like cub families, were digging roots more or traveling more on the open bars than singles were. As with cub families, annual differences in fall habitat use by yearling families were considerable and indicated greater use of hillsides than valley bottoms in 1985 than 1984.

The majority of all observations in all seasons, both years, and for all status levels were made on north-facing slopes, especially the NNW- and NNE-facing slopes. This is consistent with the location and topography of the road corridor. Choice of hillside aspect was significantly different between years ( $X^2 = 91.69$ ,  $P \leq 0.0001$ ), with emphasis on NNE-facing slopes in 1984 and NNW-facing slopes in 1985 (see Darling 1987).

Despite biases toward observations on north-facing slopes, a  $X^2$  test indicated that the choice of aspect was not independent from status group ( $X^2 = 56.07$ ,  $P \leq 0.0001$ ). Differences in use of aspects among the 3 status groups were greatest between the 2 family categories. Chi-square cellwise residuals indicated that cub families were seen more often than expected on northeast-facing slopes and less than expected on northwest-facing slopes. Yearling families were just the opposite. Single bears used southeast-facing slopes more than expected and northwest-facing slopes less than expected.

Choice of aspect was not independent of season ( $X^2 = 36.80$ ,  $P = 0.008$ ), and distributions of observations of bears differed by season. Patterns of seasonal use of aspect classes over all observations suggest a general movement from northwest-facing slopes in spring and summer to northeast-facing slopes in fall. Observations of cub families and single bears generally followed this pattern, whereas yearling families showed more use than expected of southwest- and northeast-facing slopes in spring and southeast-facing slopes in summer.

## DISCUSSION

The study design provided an adequate sample size for analysis. The number of families seen each year was within the range observed by Murie (1981) and Dean (1976) and was close to that observed by Dean in 1983.

Seasonal shifts in feeding behavior occurred later in 1985 than in 1984, but the dates derived in this study are close to those of previous studies (Murie 1981; Stelmock 1981; F. Dean, pers. commun.).

This study indicates that differences in family age, seasons, and years contribute to differences in overall habitat use patterns exhibited by bears. The seasonal patterns of habitat use for all status groups followed patterns of habitat use reported for other studies in northern and alpine areas (Curatolo and Moore 1975, Pearson 1975, Hechtel 1978, Reynolds and Hechtel 1980, Murie 1981, Stelmock 1981, Hamer 1985). Single bears and family groups moved to areas that supported seasonally available foods as the plants emerged or ripened. In spring, bears were generally on low slopes and in valley bottoms, whereas in summer they were found on upper and middle hillsides. They moved back down to lower hillsides and valleys in fall but were less concentrated in valley bottoms than in spring. The general seasonal patterns were persistent over the 3 status levels, but subtle differences occurred among groups.

Fall habitat use patterns were substantially different between the 2 years. A relatively poor buffaloberry (*Shepherdia canadensis*) crop on the well-drained, stable gravel bars in 1985 or a relatively better huckleberry (*Vaccinium uliginosum*) crop on hillsides in 1985 could have resulted in more hillside use by bears and thus increased the number of hillside observations in the fall of 1985. Field records, however, indicate that berry production in the 2 years was not substantially different. Although a mid-August snowfall in 1984 resulted in early berry loss from buffaloberry bushes, use of valley gravel bars for root digging was not seen in the fall of that year.

Seasonal habitat use patterns of all status groups were less distinct in 1985 and bears were less concentrated in high-rugged or low-flat habitat types than in 1984. A combination of differences in timing of green-up, snowmelt patterns, levels of precipitation, and temperature between the 2 years could have resulted in drastically different temporal and spatial patterns of development of food plants. For example, if different foods were simultaneously available in sufficient quantities in a more random spatial pattern in 1985 than in 1984, the bears would have been less restricted to particular feeding areas, they might have wandered more freely, and random observations would have been less concentrated in particular habitat types in 1985. On the other hand, if production of food plants was lower or more restricted in 1985

and the bears had to wander farther to find sufficient forage, then observations would have been less concentrated in particular habitat types in 1985. It is also possible that bear habitat use is just not consistent year to year.

Family groups, especially cub families, reportedly choose more rugged, isolated terrain than lone bears (Pearson 1975, Sharafutdinov and Korotkov 1976, Stelmock 1981) and are found at higher elevations than lone bears (Russell et al. 1979, Glenn and Miller 1980). Similar differences between status levels were significant in this study. When habitat use was considered over the entire field season, observations of families were made in more rugged terrain, on ridges, in isolated locations, and on steeper slopes than were observations of single bears; however, only a small proportion of the total family data set illustrated this difference and, in fact, greater proportions of families were observed in flatter terrains and in habitats that single bears were using. A small proportion of single bear observations was also in rugged, upslope terrain; these bears may have been adults in transit between valleys or perhaps recently weaned subadults who, like family groups, sought to avoid other bears. Perhaps by using safer terrain, some families avoid at least the majority of lone bears, but it seems odd that this avoidance is not the strategy for more families if, indeed, avoidance is the key to successfully raising young.

Observations of families that were not on the more rugged terrain could have been of families using the edges of the areas that single bears were using. That is, a female may keep her family in the general locale of particular food resources and be recorded in habitat resembling that used by single bears, but she may not use that portion of the area more heavily used by single bears. If she chooses feeding areas on the basis of available safety areas, the proportion of time she spends in the latter (and is seen there) may be quite small, depending on the frequency of real and perceived threats from other bears.

The seasonal change in proportion of cub families observed compared to the consistency in the proportion of yearling families seen suggests that habitat use by the 2 groups differs. Differences in movements and habitat use patterns of older and younger families are widely reported. Family groups emerge from winter dens later than single bears, and cub families emerge later than older families (Pearson 1975, Glenn and Miller 1980, Hamer 1985). Cub families usually remaining longer near the den site after emergence

than older families, whereas lone bears tend to leave a den site immediately. Movements and home range sizes of families, especially cub families in the spring, are reported to be greatly restricted compared to older families and lone bears (Pearson 1975, Russell et al. 1979, Berns et al. 1980, Reynolds and Hechtel 1984, Hamer 1985), although some studies report no significant differences between cub and yearling family home range sizes (Curatolo and Moore 1975, Atwell et al. 1980, Ballard et al. 1981).

Loglinear model-building analyses indicated that habitat variables interacted differently with status and year variables. For some variables (aspect, elevation, exposure, distance to permanent water, distance to escape terrain) the habitat-status interaction appeared more important, and for others (slope, terrain, distance to temporary water), the habitat-year interaction appeared more important. That is, observations on the former set of variables may be substantially different for the status groups and are potentially useful in distinguishing among the groups. Conversely, the latter set of variables exhibit a stronger tie with differences between 1984 and 1985 and are probably not as important in distinguishing among groups. The habitat variables I recorded are themselves correlated and, as Table 4 illustrates, differences exist in the levels of correlation of these variables for different status groups. The conclusion to draw at this stage, then, is that there are differences in habitat use among cub families, yearling families, and single bears but that differences within a status group are complicated by differences between years. Therefore, studies of grizzly bear habitat use must address how results differ with the age of the family, rather than simply lumping all families together. Researchers must also address potential between-year differences when studies are conducted over several years, rather than assuming each year's results are the same and grouping them together indiscriminately.

#### LITERATURE CITED

- ALASKA PLANNING GROUP. 1974. Proposed Mount McKinley National Park additions, Alaska: final environmental impact statement. U.S. Dep. Int., Wash., D.C. 687pp.
- ATWELL, G., D. L. BOONE, J. GUSTAFSON, AND V. D. BERNs. 1980. Brown bear summer use of alpine habitat on the Kodiak National Wildlife Refuge. *Int. Conf. Bear Res. and Manage.* 4:297-305.
- BALLARD, W. B., S. D. MILLER, AND T. H. SPRAKER. 1981. Home range, daily movements, breeding and denning activity of brown bears in south-central

- Alaska. App. I. in T. H. Spraker, W. B. Ballard, and S. D. Miller. 1981. Game management unit 13 brown bear studies; feeding behavior of Interior brown bears. Alaska Dep. Fish and Game, Fed. Aid Wildl. Restor., Final Rep., Project W-17-10, W-17-11, W-21-1, Job 4.13R. 57pp.
- BERNS, V. D., G. C. ATWELL, AND D. L. BOONE. 1980. Brown bear movements and habitat use at Karluk Lake, Kodiak Island. Int. Conf. Bear Res. and Manage. 4:293-296.
- CROOK, J. L. 1971. Determination of abundance and distribution of brown bear (*Ursus arctos*) north of the Brooks Range, Alaska. M.S. Thesis, Univ. Alaska-Fairbanks. 78pp.
- CURATOLO, J. A., AND G. D. MOORE. 1975. Home range and population dynamics of grizzly bear (*Ursus arctos* L.) in the eastern Brooks Range, Alaska. Chap. 1 in Arctic Gas Biological Report Series, Vol. 32. Studies of large mammals along the proposed Mackenzie Valley gas pipeline route from Alaska to British Columbia. 71pp.
- DARLING, L. M. 1987. Grizzly bear nursery habitat in Denali National Park, Alaska. M.S. Thesis, Univ. Alaska-Fairbanks. 128pp.
- DEAN, F. C. 1976. Aspects of grizzly bear population ecology in Mount McKinley National Park. Int. Conf. Bear Res. and Manage. 3:111-119.
- DIXON, W. J., M. B. BROWN, L. ENGELMAN, J. W. FRANE, M. A. HILL, R. I. JENNRICH, AND J. D. TOPOREK. 1981. BMDP statistical software 1981. Univ. Calif. Press, Los Angeles. 727pp.
- FIENBERG, S. 1980. The analysis of cross-classified categorical data, 2nd ed. The MIT Press, Cambridge, Mass. 198pp.
- GLENN, L. P., AND L. H. MILLER. 1980. Seasonal movements of an Alaska Peninsula brown bear population. Int. Conf. Bear Res. and Manage. 4:307-312.
- HAMER, J. D. W. 1985. Feeding ecology of grizzly bears in the Cascade and Panther Valleys of Banff National Park, Alberta. Ph.D. Thesis, Univ. Calgary, Alberta. 247pp.
- HECHTEL, J. 1978. Behavioral ecology of a barren-ground grizzly bear female and her young in the National Petroleum Reserve—Alaska. Prelim. Rep. App. III in H. V. Reynolds and J. Hechtel. 1980. Structure, status, reproductive biology, movement, distribution and habitat utilization of a grizzly bear population. Alaska Dep. Fish and Game, Fed. Aid Wildl. Restor. Proj. W-17-11, Job 4.14R. 76pp.
- HEEBNER, D. K. 1982. The numerical analysis of vegetation plots in Denali National Park and Preserve. M.S. Thesis, Univ. Alaska-Fairbanks. 243pp.
- HERRERO, S. 1970. Human injury inflicted by grizzly bears. Science 170:593-598.
- MILLER, S. J., N. BARICHELLO, AND D. TAIT. 1982. The grizzly bears of the Mackenzie Mountains, Northwest Territories. Completion Rep. No. 3. Northwest Territ. Wildl. Serv., Yellowknife. 118pp.
- MURIE, A. 1981. The grizzlies of Mount McKinley. U.S. Dep. Int., Natl. Park Serv., Sci. Monogr. Ser. No. 14. 251pp.
- PEARSON, A. M. 1975. The northern interior grizzly bear *Ursus arctos* L. Can. Wildl. Serv. Rep. Series No. 34. 86pp.
- . 1976. Population characteristics of the arctic mountain grizzly bear. Int. Conf. Bear Res. and Manage. 3:247-260.
- REYNOLDS, H. V., AND J. HECHTEL. 1980. Structure, status, reproductive biology, movement, distribution, and habitat utilization of a grizzly bear population. Alaska Dep. Fish and Game, Fed. Aid Wildl. Restor. Proj. W-17-11, Job 4.14R. 76pp.
- , AND ———. 1984. Structure, status, reproductive biology, movement, distribution, and habitat utilization of a grizzly bear population. Alaska Dep. Fish and Game, Fed. Aid Wildl. Restor. Proj. W-21-1, W-21-2, W-22-1, W-22-2, Job 4.14R. 29pp.
- RUSSELL, R. H., J. W. NOLAN, N. G. WOODY, AND G. H. ANDERSON. 1979. A study of the grizzly bear in Jasper National Park, 1975-1978. Prep. for Parks Canada by Can. Wildl. Serv., Edmonton, Alberta. 136pp.
- SHARAFUTDINOV, I. Y., AND A. M. KOROTKOV. 1976. On the ecology of the brown bear in the southern Urals. Int. Conf. Bear Res. and Manage. 3:309-311.
- STELMOCK, J. J. 1981. Seasonal activities and habitat use patterns of brown bears in Denali National Park—1980. M.S. Thesis, Univ. Alaska-Fairbanks. 118pp.
- SPSS INC. 1983. SPSSx user's guide. McGraw-Hill Book Co., New York. 806pp.
- TRACY, D. M. 1977. Reactions of wildlife to human activity along Mount McKinley National Park road. M.S. Thesis, Univ. Alaska-Fairbanks. 260pp.
- VIERECK, L. A., C. T. DYRNESS, AND A. R. BATTEN. 1982. Revision of preliminary classification for vegetation of Alaska. U.S. Dep. Agric., For. Serv., Instit. North. For., Fairbanks, Alaska. 72pp. (unpubl. rep.)
- ZAR, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Inc., New Jersey. 718pp.