CHARACTERISTICS OF SUMMER BEDS OF EUROPEAN BROWN BEARS IN NORWAY

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Abstract: One hundred and nineteen European brown bear (*Ursus arctos arctos*) daybeds and their surroundings were studied in Hedmark County, Norway, in 1974 – 77. In addition to bed type and size, the following parameters were measured or estimated: slope, aspect, altitude, type and age of vegetation, cover, distance to close objects, and distance from the site to farms and roads. Abiotic exposure avoidance, concealment, defense/safety, and construction behavior are discussed as elements of bed site selection. Bed studies based on field signs met with difficulties such as distinguishing daybeds from dens, and problems of bed classification are discussed.

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Terrestrial mammals exhibit 3 major sleeping and resting positions, the curled, the stretched, and the sitting posture. In certain species these basic postures have been greatly modified, and some may rest in both standing and recumbent positions (Hafez 1975). In general, brown bears rest in the loosely curled posture, and the term bed is used here for any spot where an animal curls up on a substrate leaving body prints or other signs identifying the site. Bedding behavior as studied here was based on beds as field signs only, and not by direct observation.

Judging from the amount of time spent bedding, this behavior is important for bears during the whole annual cycle, both summer and winter. A radio-marked Alaskan grizzly bear (*U. a. horribilis*) spent 31% of its time feeding, 10% travelling, and 59% bedding during May–June (S. Linderman, pers. commun.). Although we have no comparable investigation of the closely related European brown bear, numerous beds seen during the Hedmark bear study indicate that bedding is of similar importance in their activity patterns.

During winter it is well known that the bears bed down for a prolonged period inside a den (Vroom et al. 1980). While den bedding during winter has been extensively studied, summer bedding has not. Except for the data on daybeds for the grizzly bear in the Yellowstone area, USA, collected by the Interagency Study Team (R.R. Knight et al., unpubl. rep., U.S. Dep. Inter. Natl. Park Serv., 1978), summer bed characteristics for bears have been little considered.

The aim of the present study was 2-fold. It was intended as an investigation of typical summer and autumn daybeds, for the identification of as many behavioral elements associated with bedding as possible, and also for a description of the parameters usable for predicting the potential of varying structural forest stands as bedding locations. Information on bedding preferences in forests treated according to modern silvicultural practices is needed for management.

Beds were used for varying periods and purposes, and thus had different characteristics. The other aim of the study was to suggest a general scheme for bed type and to discuss bed classification problems of the whole annual bedding cycle.

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STUDY AREA

The study was part of an investigation of sheep-killing bears in Hedmark County in southeastern Norway, chosen for its level of bear depredation. The county has an area of 27,388 km^2; most beds were located in the central and eastern part (latitude 60° 45′ to 60° 55′ N and 11° 11′ to 12° 50′ E) (Fig. 1). Boreal coniferous forest on

Precambrian bedrock or Sparagmitic material characterized the area (Abrahamsen et al. 1977). In the northern part of the study area the forest was broken by isolated mountain barrens with premontane conditions (Fig. 2), maximum altitude in Hedmark being 2183 m.

Norway spruce (*Picea abies*), the most important cover species in the area, also formed the timberline at 800–850 m. Spruce was mixed with birch (*Betula pubescens*) and Scotch pine (*Pinus silvestris*) in dry areas or those poor in nutrients. Pure pine stands have often been developed on glacifluvial deposits. Soils were podzols or histosols (Abrahamsen et al. 1977). Selective logging has been undertaken in the area for hundreds of years, and from the 1940's a network of forest roads has been constructed and large clearcutting operations undertaken. In 1978 the roads in Trysil municipality and Hedmark County (public and Forest Service total) averaged 0.6 and 0.8 km/km^2, respectively (Hedmark Forest Service unpubl. data). Fire control has been practiced during the past 115 years (I. Pedersen, pers. commun.). The present forest can be characterized as a forestry-dominated taiga habitat complex, a mosaic of age classes and stand structures.

Human settlement was sparse and concentrated in valleys (Fig. 2), although isolated farms, some disused, or groups of farms in small communities were scattered throughout the area.

The climate may be generally classified as semicontinental, radiation-influenced, with warm summers and cold winters without drought (Lystad 1978). Mean annual temperatures recorded at Trysil weather station during January and July were −10.1 and 14.4 C, respectively; average total precipitation was 716 mm.

METHODS

Results reported are for the period 29 June 1974 to 22 September 1977. Beds were located by observing signs, by tracking bears with a Carelian bear dog, and by investigating bear activities in areas reported by residents. The method of locating beds in this study was subject to certain biases, as bears tracked after being involved in sheep predation incidents usually turned out to be males.

Data were recorded for 119 beds distributed in Trysil (93), Elverum (16), Åmot (5), Våler (1),

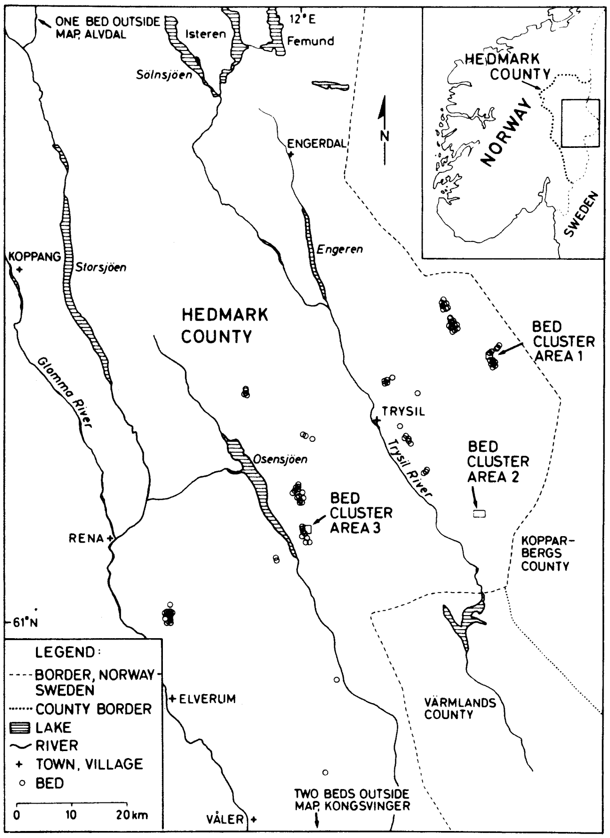

Fig. 1. Central study area and brown bear bed locations in Hedmark County, South Norway, 1974–77 (3 beds, 2 in Kongsvinger and 1 in Alvdal municipalities were located outside the map). The 3 clusters of bed sites were traditional summer daybed areas.

Åsnes (1), Kongsvinger (2), and Alvdal (1) within Hedmark County (Fig. 1); 83 beds were located close to sheep carcasses. The numbers of bed discoveries per month were June (4), July (21), August (8), September (79), and October (7).

Bear beds were classified as natural contour beds or constructed beds. Each series was divided into 4 stages, based on degree of structural complexity. If a natural contour bed ranged between 0 and 24 cm in depth it was termed a "surface depression;" if deeper than 25 cm, a "soil pit." Constructed beds were classified as "humus surface scratch" if they were surface depressions 0–24 cm in depth scooped out in the litter strata, as "shallow mineral soil diggings" if dug more than 25 cm down in mineral soil. The other 2 stages were sheltered daybeds and beds occasionally located inside sheltered, chambered

Fig. 2. General view of Trysil mountain barrens, timberline, and forested valleys typical of the eastern part of the study area in Hedmark, South Norway.

dens; data on these will be omitted here and treated in a separate paper on denning.

Length, breadth, depth, site altitude, and slope angle of each bed were recorded. Altitudes to the nearest 10 m were taken from contour maps. Slope inclination and aspect were measured with a clinometer compass (Silva 15T). Bed surroundings were noted, and distance to nearest vertical objects such as trees, stumps, and boulders measured. If the vertical object was a tree, the species was registered as well as dbh. Shortest distance from bed site to nearest forest road, public road, and inhabited farm were estimated from maps.

Cover and visibility characteristics of bed sites were assessed from measurements of distances visible from beds. The distances visible 1 m above the forest floor from the center of the bed were measured in 4 compass directions, V_N = 0/400°, V_E = 100°, V_S = 200°, and V_W = 300°, by moving away from the bed center to the point where a bear lying on the bed was judged to be more or less completely concealed. The bear's impression of the cover when standing in bed center at a height of 1 m was estimated. A cover index $V_i = (V_N + V_E + V_S + V_W)/4$ was calculated from these 4 visibility measurements, which were made using a steel tape.

Three areas containing clusters of reused beds (Fig. 1) were thoroughly searched for any bear signs, and plotted.

Vegetation association and forest type in the bed habitat were classified, and forest floor vegetation around beds and material within beds noted. Seral stages in forest stand development were described using the classification system of

Landskogstakseringen (1961). The succession of the stand was divided into 5 "Cutting Classes," from the clearcut stage to mature timber, based on age and development criteria. Cutting Class availability was estimated from forestry statistics, and evaluation of beds on each Cutting Class were calculated according to the following index:

$$I = nA/Na$$

where n = number of beds in a given Cutting Class, N = total number of beds, a = area covered by a given Cutting Class, and A = total area of Cutting Classes. $I < 1$ denotes that numbers of beds found were fewer than expected; $I = 1$, as expected; and $I > 1$, more numerous than expected in a given class.

For evaluating the availability of each of the site parameters (elevation, aspect, slope, topography, and distance to farms, public roads, and forestry roads), 1,000 grid points were collected at random by placing 10 10×10 grids on contour maps and similar measurements made. Distances between individual points in the grid were 1 km. For the parameter "slope," distances between neighboring height contour lines were first measured, and an additional calculation carried out to estimate slope angle β:

$$\beta = \arctan(\Delta h / 500s)$$

where Δh = contour interval (20 m) on the map (map scale 1:50,000), and s = measured distance (cm) between neighboring height contour lines on the map.

Procedure characteristics made it reasonable to assume a multinomial distribution of the data samples, and a standard test was used: Consider n groups of a selected bed site habitat parameter (elevation, aspect, etc.). Let

X_i = No. of "bed sites" in group i, $i = 1, 2, \ldots, n$.

We assumed $(X_1, X_2, \ldots, X_n)$ to be multinomially distributed

$(119, p_1, p_2, \ldots, p_n)$; then

$$\Pr\{X_1 = x_1, X_2 = x_2, \ldots, X_n = x_n\} =$$

$$\frac{119!}{x_1! x_2! \ldots x_n!} \cdot \prod_{i=1}^{n} p_i^{x_i}, \sum_{i=1}^{n} x_i = 119, \sum_{i=1}^{n} p_i = 1$$

We tested $p_1/a_1 \geq p_2/a_2$ against $p_1/a_1 < p_2/a_2$, where a_1 = number of grid points in group 1 and a_2 = number of grid points in group 2.

Table 1. Dimensions (cm) of 119 brown bear daybeds, Hedmark County, Norway, 1974–77.

Length	N	Width	N	Depth	N
50.5–75	6	30.5–50	6	0–5	9
75.5–100	28	50.5–75	32	5.5–10	23
100.5–125	42	75.5–100	57	10.5–15	12
125.5–150	34	100.5–125	17	15.5–20	28
150.5–175	4	125.5–150	5	20.5–25	13
175.5–200	3	150.5–175	2	25.5–30	18
200.5–225	1			30.5–35	6
225.5–250	1			35.5–40	7
				40.5–45	2
				45.5–50	1

Significance probability was calculated as

$$\alpha\% = 100 \cdot B_{x_1+x_2}(x_1, \frac{a_1}{a_1+a_2}),$$

where x_1 and x_2 were observed values of X_1 and X_2, respectively, and

$$B_{x_1+x_2}(x_1, \frac{a_1}{a_1+a_2}) =$$

$$\sum_{i=0}^{x_1} \binom{x_1+x_2}{i} \left(\frac{a_1}{a_1+a_2}\right)^i \left(1-\frac{a_1}{a_1+a_2}\right)^{(x_1+x_2-i)}.$$

RESULTS

Bed Types and Dimensions

Measurements of 119 beds are shown in Table 1. Mean and SD were, for length, $\bar{x} = 1.19 \pm 0.29$ m; width, $\bar{x} = 0.88 \pm 0.24$ m; and depth, $\bar{x} = 0.21 \pm 0.10$ m. Beds were roundish or oval in form, always with a concave shape permitting comfortable resting.

Fifteen beds had a convex-formed crest at the front, formed from root outlets, round stones, or earth. These made it possible for the bear to rest its head in an elevated position.

Ninety-six were natural contour beds (65 in surface depressions, 31 in soil pits) and 23 were constructed (8 scratched in surface humus, 15 dug in shallow mineral soil). The natural contour beds varied from nearly flat, even spots, to shallow, roundish or oval depressions and superbly shaped concave bowls or pits in the ground. When beds were shaped by scratching or digging by the bear, they always simulated natural contour bed forms.

Bed substrates were shrub, moss, grass, duff, and/or combinations of materials from the surface layer of the forest floor (Table 2). Five beds

Table 2. Substratum and lining material of 119 brown bear daybeds, 1974–77. In lined beds materials have been actively collected by the bear and brought to the bed; in unlined beds they rested on the surface material present.

Bed substratum materials	Number of beds		
	Unlined	Line	Total
Shrub	14		14
Shrub and moss	21	1	22
Shrub and duff	14		14
Shrub and grass	4		4
Shrub, moss, and lichens		1	1
Shrub and ferns	1		1
Shrub, moss, and duff		1	1
Moss	6	2	8
Moss and *Carex*	7		7
Moss and lichens	2		2
Moss and grass	1		1
Moss and torn log		1	1
Grass	1		1
Grass and lichens	1		1
Lichens	1		1
Carex	1		1
Ferns and herbs	1		1
Duff	19	1	20
Duff and moss	1	3	4
Duff and grass	1		1
Duff and ferns	1		1
Duff and torn log	1	3	4
Duff, removed from carcass cache mounds		5	5
Torn log		2	2
Dead spruce needles removed from anthill		1	1
Total	98	21	119

were situated on material scraped for food caching, while 1 was on material raked from an anthill. Twenty-one beds, or 18%, had been actively lined with duff or plant material from the immediate vicinity. The material was either scraped straight into the bed with the forepaws, or raked together in clumps a short distance away and carried to the bed. Some beds located during September–October were covered with a significant layer of rotten wood raked from logs or stumps. In one case during October, dry moss for bed insulation had been stolen from a badger's (*Meles meles*) den in an anthill, after destruction of the den wall.

Habitat Characteristics

Statistical testing of bed sites against aspect availability showed that more beds than expected were found on locations facing either east or west (Table 3). The beds were found at elevations between 230 and 760 m. Bedding was completely avoided in mountainous areas above timberline at 800 m, while more beds than expected were located in the upper part of the boreal coniferous forest areas at heights of 450–800 m. Average altitude of 119 beds was 593 m. Most bed sites were located on level or moderately sloping ground, and the median slope of the 119 beds was 8°. Statistical testing against slope availability, however, showed that there was less bedding than expected on slopes of less than 20° and a preference for steeper areas above 20°. Forest slopes rather than flat landscape were preferred for bed sites.

Vegetation and Forest Types

Forest types containing bed sites were as follows. Nomenclature is based on a vegetation mapping system described by O. Hesjedahl (unpubl. rep., Landbruksbokhandelen, Ås, 1973).

Boreal pine forest. — Bed sites were found in the A3 Berry–Shrub–Mixed Coniferous Forest subassociation (Hesjedahl I.1, Group A, subassociation A3). The tree cover was Scotch pine, Norway spruce, and occasionally birch; most often pine was best developed. Forest floor vegetation was mostly shrub/moss/lichens or tolerant grasses/herbs. The stand structure varied from stands with small openings through varying degrees of thinned or selectively cut stands to dense timber.

The pine component usually makes the stand more transparent than spruce forest associations. All bed site stands, however, had a considerable amount of spruce intermingled with the pines, and none was found in pure pine stands. Thirteen bed sites (10.9% of the total) were found in this subassociation. Based on the forest floor vegetation, 3 variants of this habitat type were represented: (a) Homogeneous *Vaccinium myrtillus,* in which the vegetation carpet of the forest floor was more or less homogenous V. myrtillus shrubs and associated mosses, mainly *Hylocomium splendens, Pleurozium schreberi,* and *Dicranum* spp. (8 bed sites). (b) *Vaccinium vitis–idaea* patches, in which the *V. myrtillus* shrub layer was mixed with, or broken by, large or small patches of *V. vitis–idaea* shrubs; this indicated a slightly drier type than the (a) variant (4 bed sites). (c) *Empetrum–Calluna–Cladonia* patches, in which the *V. myrtillus* shrub layer was broken by,

Table 3. Distribution, by topographic features, of 119 brown bear daybeds. Overall availability of corresponding features, recorded for 1,000 grid points at random by placing 10 10×10 grids on contour maps, was statistically compared with bed site distribution.[a]

	Number of			Number of	
Feature	Bed sites	Grid points	Feature	Bed sites	Grid points
Elevation (m)[b]			Aspect[c]		
150–190		3	North	4	104
200–240	1	6	South	15	151
150–290	1	15	East	43	204
300–340	10	55	West	33	156
350–390	1	80	Flat	24	385
400–440	1	93			
450–490	10	145	Slope (degrees)[d]		
500–540	6	171	0–10	82	855
550–590	14	142	11–20	22	100
600–640	13	82	21–30	9	35
650–690	40	59	31–40	0	7
700–740	18	41	41–50	6	1
750–790	4	27	51–60		1
800–840		28	61–70		1
850–890		19			
900–940		19	Topography[e]		
950–990		11	Flat	24	466
1000–1040		3	Slope	91	531
1050–1090		0	Knoll top	4	3
1100–1140		1			

[a] In the following footnotes, α_{r},s denotes the significance probability for the data group *r* tested against group *s* (example: $\alpha_{N,S}$ denotes the significance probability when the number of beds located with northern aspect N is tested against the subset located with southern aspect S).

[b] $\alpha_{150-440,450-790}$=0.01%; $\alpha_{800-1140,150-790}$=0.11%.

[c] $\alpha_{N,S}$=7%, n.s.; $\alpha_{N,E}$=0.03%; $\alpha_{N,W}$=0.03%; $\alpha_{N,Flat}$=25%, n.s.; $\alpha_{S,E}$=0.75%; $\alpha_{S,W}$=0.97%; $\alpha_{Flat,S}$=11%, n.s.; $\alpha_{Flat,E}$<0.01%; $\alpha_{Flat,W}$<0.01%.

[d] $\alpha_{0-10°,11-20°}$=0.04%; $\alpha_{0-20°,21-70°}$<0.01.

[e] $\alpha_{Flat,Slope}$<0.01%.

or partly replaced by, large or small patches of *Empetrum* spp. shrubs, *Calluna vulgaris* shrubs, and/or *Cladonia* spp. lichens; this indicated variable conditions, poor in nutrients and in general drier than the (a) variant (1 bed site).

Boreal spruce forest. — Bed sites were found in 3 spruce forest associations:

(B) The blueberry–fern–spruce forest association (Hesjedahl I.1, Group B, subassociations B2–B4) constituted the main bedding habitat, with 75 bed sites (63.0% of the total). The trees were Norway spruce, often with birch; forest floor vegetation was dominated by shrub/moss/lichens or tolerant grasses/herbs. The stand structure varied from stands with small openings through varying degrees of thinned or selectively cut stands to old and dense timber. This association was the most common in the study area and in the 1960's and 70's large clearcuts had been made in such stands. Bed sites were found in 3 Group B subassociations (subdivisions based on ground vegetation composition: (B2) Blueberry–spruce forest subassociation, in which the ground vegetation is characterized by homogenous *V. myrtillus* shrub carpets and associated mosses, particularly *Hylocomium splendens, Pleurozium schreberi,* and *Dicranum* spp. (53 bed sites, or 44.5% of the total). (B3) Small fern–spruce forest subassociation, in which the *V. myrtillus* shrubs were mixed with small ferns such as *Dryopteris assimilis*; this was indicative of better soil conditions than for the B2 subassociation (3 bed sites, 2.6%). (B4) Large fern–spruce forest subassociation, in which the *V. myrtillus* shrubs were mixed with large ferns such as *Athyrium* spp. indicative of excellent moisture and soil conditions (20 bed sites, 16.8%).

(C) The large and small herb–spruce forest association (Hesjedahl I.2, Group C) is a complex association including many plant species which were more nutrient and heat demanding. A bed site was found in 1 of this group's 4 subassociations: (C4) Large herb–spruce forest subassociation, in which the tree cover was as described for Group B, while ground vegetation was a luxuriant mixture of large herbs and flowering plants. This subassociation constituted only a minor part of the forest in the study area (1 bed site).

Table 4. Distribution, by forest Cutting Class, and bed visibility of 112 brown bear daybeds found inside forest stands.

Cutting Class	Classification of forest type[a]			Cutting Class distribution[b]		Distribution of beds		Index (I): beds vs. availability[c]	Distance (m) visible from bed	
	Age (years)			Area						
	Range	Mean	Seral stage	(km^2)	%	No.	%		Mean	SD
I	0	Newly clearcut	330	7.2	0	0	0			
II	1–30	15	Early regeneration, inc. thickets up to 6–8 m high	955	20.9	9	8.0	0.38	6.31	3.69
III	30–80	45	Young forest, 8–10 m and up	400	8.8	21	18.8	2.14	3.67	1.24
IV	40–100	80	Medium-age forest	1010	22.1	17	15.2	0.69	7.71	3.78
V	80–160	120	Mature forest	780	17.1	55	49.1	2.87	6.70	3.66
LP			Low-production forest	1090[d]	23.9	10	8.9	0.37	16.02	12.49
Total, all classes				4565	100	112	100		7.08	5.66

[a] Age and type classification of Cutting Classes as used by the Norwegian Forestry Valuation (Landskogstakseringen 1961). Ages vary considerably; those given represent estimated ages in the blueberry spruce forest, Trysil and Engerdal municipalities.
[b] Distribution (availability) estimated from 1970 forest statistics, rough Cutting Class figures for Åmot, Trysil and Elverum municipalities combined (based on unpubl. data, Norw. Inst. For. Res. 1964–76).
[c] Distribution of beds compared with availability of Cutting Classes: $I = nA/Na$.
[d] Total figure for low-production forest.

(G) Swamp forests and forested bogs (Hesjedahl I.4, Group G) is an association characterized by bog soil profiles and high groundwater levels with very variable nutrient conditions. Bed sites were found in 1 of this group's 9 subassociations: (G3) Blueberry–spruce–bog forest subassociation, in which the tree cover was Norway spruce and birch. The stands were mostly developed on level or nearly flat ground with stagnant water conditions. As a rule the stands had a fairly uniform structure. Ground shrub vegetation could be broken by larger or smaller patches of *Sphagnum* spp. mosses (15 bed sites, 12.6%).

Unclassified areas—One bed site was located in an unclassified forested bog, but with a stand consisting of spruce and pine. Three beds were situated in *Carex rostrata* bogs, 1 in a *Carex* bog edge, and 2 in *Sphagnum* spp. bogs. One bed was located in a meadow in a chalet area, and 6 beds were in seral stages in unclassified vegetation.

Forest Seral Stages

Evaluation of the distribution of bed sites in different seral stages showed that more beds than expected were found inside Cutting Classes III and V closed timber stands (Table 4). No bed was located in Cutting Class I, open, newly cutover area. Only brush beds in extremely dense, young thickets were found.

Five beds, not included in Table 4, were located on the edges of 2 seral stages. These were between Cutting Classes II–IV (1 bed), II–III (1), III–IV (1), and IV–LP (2). One additional bed was located in partly open bog and 1 in a meadow.

The dense Cutting Class III offered the darkest spots and best cover of all seral stages, but provided less passability than the class V stands. Thus open seral stages were avoided, and a well-developed Cutting Class II regeneration stand seems to be the minimum requirement for bedding. There was a preference for medium-aged dense stands in bed site selection.

Distance from Human Structures

Bear beds were never observed on sites less than 0.55 km from inhabited farms, and the greatest distance noted from a farm to a bed site was 6.50 km (Table 5). The shortest distance from a bed site to a disused farm was 0.05 km. Occasionally a bear had bedded in a meadow in an old chalet area, only 4 m from the wall of an empty cabin.

The shortest distance measured from a bed site to a public road was 0.45 km; the maximum distance was 6.80 km. Statistical testing of site distance against road availability showed a zone of 0.50 km where bedding was completely avoided

Table 5. Distribution, by distance to farms, to public roads, and to forestry roads, of 119 brown bear daybeds. Overall availability of corresponding distances, recorded for 1,000 grid points at random by placing 10 10×10 grids on contour maps, was statistically compared with bed site distribution.[a]

	Farms[b]		Public roads[c]		Forestry roads[d]	
Distance (km)	Bed sites *N*	Grid points *N*	Bed sites *N*	Grid points *N*	Bed sites *N*	Grid points *N*
0.0–0.4	0	158	0	268	62	373
0.5–0.9	16	228	11	209	47	248
1.0–1.4	17	197	13	142	4	177
1.5–1.9	15	150	29	105	4	79
2.0–2.4	29	108	23	76	2	51
2.5–2.9	17	60	6	57		30
3.0–3.4	5	44	11	45		14
3.5–3.9	0	14	3	30		12
4.0–4.4	2	13	8	27		6
4.5–4.9	1	11	12	19		2
5.0–5.4	2	8	1	10		3
5.5–5.9	4	3	0	7		1
6.0–6.4	11	2	1	3		3
6.5–6.9		1	1	1		0
7.0–7.4		1		1		1

[a] In the following footnotes, denotations are as described in footnote a, Table 3.

[b] $\alpha_{0.0-0.4,0.5-1.4} = 0.05\%$; $\alpha_{0.0-0.4,1.5-2.4} < 0.01\%$; $\alpha_{0.0-0.4,0.5-7.4} < 0.01\%$; $\alpha_{0.5-1.4,1.5-2.4} < 0.01\%$; $\alpha_{0.5-1.4,1.5-7.4} = 0.08\%$.

[c] $\alpha_{0.0-0.4,0.5-1.4} < 0.01\%$; $\alpha_{0.0-0.4,1.5-2.4} < 0.01\%$; $\alpha_{0.0-0.4,0.5-7.4} < 0.01\%$; $\alpha_{0.5-1.4,1.5-2.4} < 0.01\%$; $\alpha_{0.5-1.4,1.5-7.4} < 0.01\%$.

[d] $\alpha_{0.0-0.4,0.5-0.9} = 28\%$, n.s.; $\alpha_{1.0-2.4,0.0-0.9} < 0.01\%$; $\alpha_{1.0-7.4,0.0-0.9} < 0.01\%$.

around inhabited farms and along public roads, and there was an avoidance tendency within 1.50 km of both.

The shortest distance from a bed site to a forestry road was 0.02 km, and no bed was situated more than 2.40 km from a forestry road. No avoidance zone near forestry roads was observed. On the contrary, testing showed more bedding than expected within a 1.00 km zone along these roads, which varied in quality and had varying vehicle frequencies.

Surrounding Vertical Objects

Most bed sites selected were close to one or several vertical objects; the most common were spruce trunks (Fig. 3). Trunks or collections of objects including trunks were seen in 93 beds; objects of some kind were seen in 113 beds (Table 6). Fourteen beds were situated inside a ring of large and small spruce trunks; in such cases very little free space was left around the body of the bear. Some of the beds were protected by branches, but the lower part of the bed trunks were usually without branches. Holes in the ground, referred to as soil pits in Table 6, were

Table 6. Classification of 119 brown bear daybeds according to type of surrounding objects.

Objects	No. of beds
Tree trunks, alone or in combination	
Trunk	66
Trunk and boulder	7
Trunk and stump	2
Trunk and anthill	2
Trunk and soil pit	1
Ring of trunks	12
Ring of trunks and soil pit	2
Trunk, stump, and fallen tree	1
Total beds near trunks	93
Other objects	
Stump	11
Stump and soil pit	2
Stump and boulder	1
Boulder	2
Boulder and soil pit	1
Two fallen trees	1
Soil pit	2
Total beds near other objects	20
Areas without close objects	
Brush	1
Carex bog	1
Grassfield, chalet area	1
Carcass cache mound	3
Total beds without close objects	6

holes caused by blown-down trees. Measurements of bed edges to vertical objects showed that 70 bed objects were so close as to be part of the bed wall. Of the 119 beds, 112 had vertical objects closer than 120 cm to the bed edge (Fig. 4).

Only 6 beds had the nearest objects more than 200 cm from the bed edge. Of these, 3 were from a sow and 2 cubs which had bedded on top of a heap of material scraped for caching on a carcass site. A similar case of bedding on an actual covered carcass has been described for the grizzly bear (Craighead and Craighead 1972*a*). Another aberrant bedding, combined with rolling, was seen on a wet spot in an open *Carex rostrata* bog. One bed was located in extremely dense, young brush without objects other than a wall of brush stems. A final deviant bed was in a meadow in a chalet area, on a site which provided a view of the area.

Quality of Cover

The degree of cover of beds ranged from extremely well-hidden, to average, and a few relatively open. Some beds with a fairly high V_i and visibility ranging from 10 to 25 m often had 1

Fig. 3. Closeup photo of typical trunk bed at base of spruce trunk in depression between root outlets, surrounded by dense *Vaccinium myrtillus* shrubs offering excellent cover. The bear's head and forepart have rested on the root outlet (arrow) in foreground. Trysil, Hedmark, July 1974.

blind side which offered complete cover from that direction. The shortest single-direction visibility was 0–5 m for most beds and never exceeded 16 m.

The cover value V_i for 119 beds is shown in Fig. 5. V_i values for 109 beds with good cover ranged from 1.5 to 12.0 m. Minimum V_i values

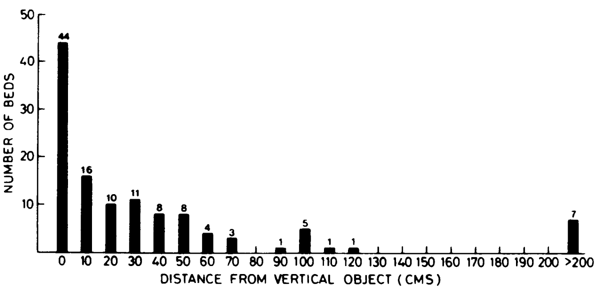

Fig. 4. Distance between bed and edge of nearest vertical object for 119 brown bear daybeds.

for beds utilized by an adult male killer bear in Elverum municipality in 1977 were 1.5 and 1.8 m. This bear resided mainly near carcasses and always rested inside extremely dense patches in Cutting Class III. Maximum V_i values for beds in wet *Carex* bog utilized for cooling purposes were 32.5, 33.3, and 33.8 m.

V_i plotted against various stand age groups (Table 4) showed that a bear can locate well-hidden bed sites in every Cutting Class from II to V. Particularly well-hidden beds were found inside Cutting Class III; here every bed had excellent cover. At 2 sites young spruce trees were broken above the bed to provide additional cover. The bed sites in medium-aged (IV) and old (V) timber had a more varied quality of cover.

The beds were in general judged to be almost as well hidden as the cover permitted, and quality and quantity of cover constituted an important factor in the Hedmark brown bear's selection of bed sites in its summer feeding areas.

Use of Traditional Daybed Areas

Usually each site contained only 1 bed. However, the bear tended to bed down at different sites inside a particular area which was repeatedly visited, such as for instance around carcasses (Mysterud 1973). In 3 cases clusters of reused daybeds were located in what were judged to be traditional summer daybed areas (Figs. 1,6). The clusters consisted of 4, 6, and 8 different beds, respectively. Topographic site selection, difference in soil characteristics, and varying degree of cover indicated that sites were selected and beds constructed for different purposes in each daybed area.

One type of bed, termed *hidebed,* was located in dry and sheltered spots under extreme cover. Some were, based on signs of wear and amount of hair left, seemingly used repeatedly for deep rests for extended periods of the season. These sites were blind spots, and appeared selected for safe retreats.

The 2nd type was termed *watchbed.* They were located on topographical sites offering excellent hearing range and scent control. The position was exactly what one would select if one lay alert and wanted to survey the surroundings.

The 3rd type was termed *coolbed.* These were pits excavated in wet, sandy soil on shady and well-sheltered sites, in 1 case secluded by a blown-down tree. They were assumed used for cooling purposes during hot, dry weather.

These 3 different bed types were distinct and easily identifiable, but the clusters also contained beds which were not easily classified, probably selected for occasionally resting without any additional requirements.

One cluster was located on a small knoll, and 2 on slopes, all sites with a marked diversity in topography, soil, and vegetation. Details of forest stand characteristics show a mosaic structure of mature forest and patches of dense regeneration (Fig. 6).

The beds were interconnected by paths, and additional paths led into surrounding areas. Three scats but few other signs of activity were noted in the areas, which seemed to be used only for bedding. In clusters 2 and 3 some beds had been constructed in earlier years. Such sites presumably belong to a system of permanent bed areas scattered throughout brown bear home ranges being reused during periods of residence or on travels.

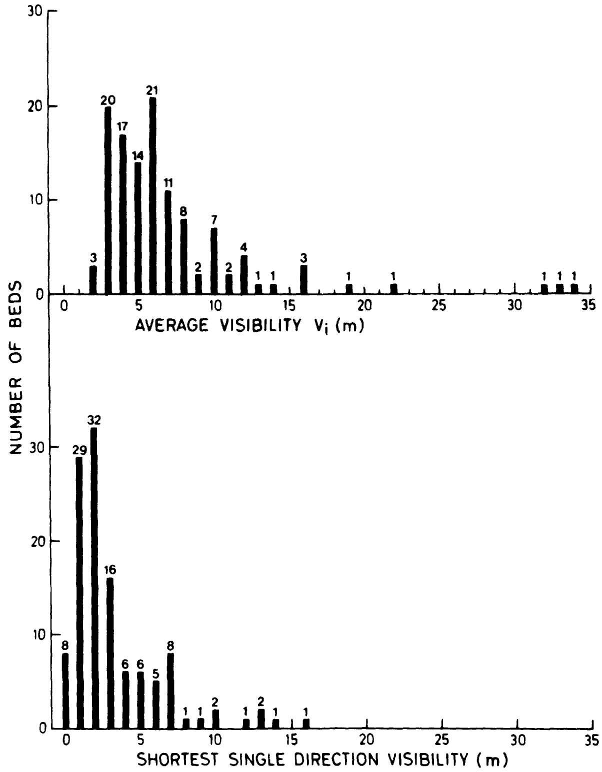

Fig. 5. Quality of cover measured as average visibility (V_i) from center of 119 brown bear daybeds (upper column). Lower column shows the shortest single-direction visibility.

DISCUSSION

A "typical summer bed" site for brown bears in Hedmark was inside a patch of dark and shady medium-aged spruce thicket or timber stand. Daybed sites were often located where the forest floor varied microtopographically with soil pits and mounds, hillocks, boulders, fallen trees, or a complex of stumps from previously selected cuttings. In such environments bears bedded down in a soil pit or near a trunk or other vertical object under excellent cover provided by the objects themselves or associated shrub carpets and overstorey vegetation.

For unknown reasons bedding habitats in the upper part of the coniferous forest in the height zone between 450 and 800 m were preferred. The same preference has been found during postdenning activity in another habitat study from South Norway (Elgmork et al. 1977). The

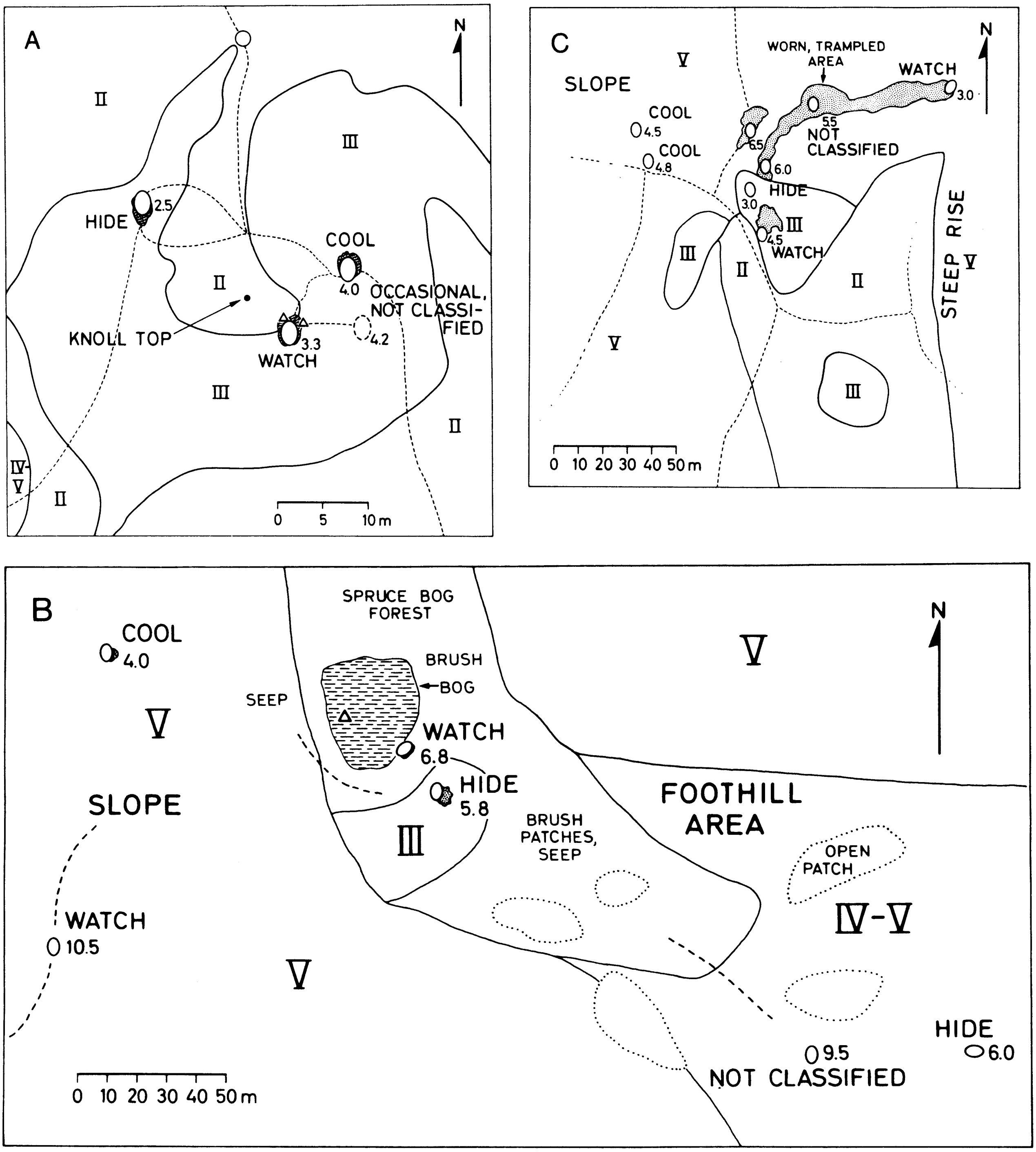

Fig. 6. Spatial distribution of hide-, cool- and watch-beds in 3 traditional summer daybed areas used by brown bears. (A) Four beds on a small hillock in Ljørdalen, Trysil, in July 1975. They were all constructed and used during 1975 by an adult male preying on sheep in the area. (B) Six beds on an eastern slope and adjacent foothill area in Galåsen, Trysil, in October 1975. The beds were constructed by an adult male preying on sheep, some in 1975, some in previous years. (C) Eight beds on a slope in Søre Osen, Trysil, in September 1976. Judging from tracks, the area was recently visited by at least 3 different bears. Some beds were from previous years.

reason for more beds than expected being found on locations facing east or west is also unknown. Both may be connected with food factors not considered here.

Spatial selection of sites within 3 traditional summer bed areas used repeatedly showed significant differences in bed requirements; i.e., some particularly well-hidden beds were selected for deep rests, some shady sites and wet soil for cooling, and some suitable topographic positions for watching. Some bed surroundings made it easy to assess the site choice; on other sites this was difficult. Such differential use of bed area space for alternative purposes, as seen in the clusters, indicates that the single beds described in this study were a mixture of general resting, hide-, cool-, and watch-beds. This has stressed the need for more precise identification and measurement of factors significant for bed site selection in field studies.

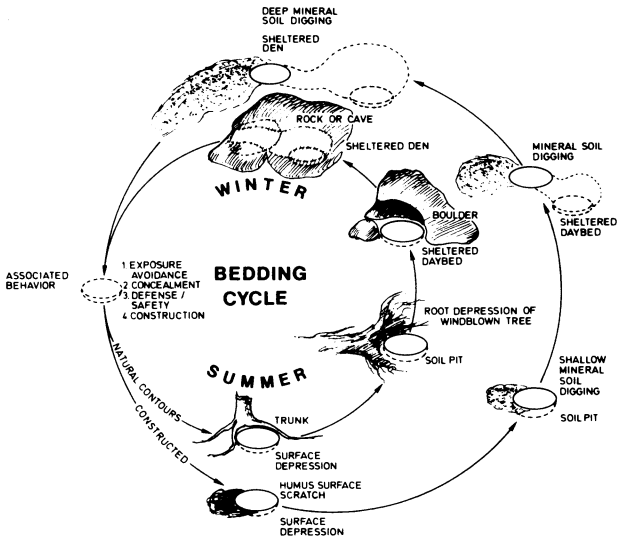

Fig. 7. Relationship between natural contour beds and constructed beds used by brown bears during their annual cycle. Progression of natural contour beds shown in inner circle, constructed beds in outer circle.

The Annual Bedding Cycle

Although this paper describes beds from summer and autumn only, denning is here regarded as no more than a winter bedding, adapted to a long stay on a bed requiring concealment, shelter, and construction adapted to winter rather than summer exposure factors.

Most summer beds utilized in Hedmark were natural contour beds, demanding no active shaping from bears prior to bedding. Constructed summer beds were formed by scratching superficial duff or by shallow digging in mineral soil. Sheltered beds constructed by deeper digging have been located, but as no information was available as to the season in which they were used, they have been omitted from the present material and will be treated in a separate paper on denning. The reason was simply that from structural characteristics it was virtually impossible to ascertain whether they were used for denning or not. During denning studies of the grizzly bear some investigators do not report difficulty in identifying dens (Vroom et al. 1980), while others do (Craighead and Craighead 1972*a*). There has been some controversy regarding the separation of sheltered daybeds from winter dens (Herrero 1972). Den-like burrows dug 3 or 4 feet into slopes or under windfallen trees were reported used by Yellowstone grizzlies (Craighead and Craighead 1972*a*). These burrows were cooler than surface beds and might simply have been sheltered coolbeds. There is no reason to assume any distinct difference between the construction of sheltered daybeds and dens. The physical digging capacity of brown bears is considerable, and the motor coordination patterns involved in construction are so simple that den-like, sheltered beds could quickly be constructed at small cost. Problems of differentiating daybeds from denbeds are, however, not restricted to excavated, sheltered structures.

In a sample of 148 European brown bear dens in the Leningrad area of Russia, all construction stages from shallow depression beds to sheltered den beds were represented; sheltered dens excavated in mineral soil were characterized as very rare (Novikov et al. 1969). Of 35 dens in the Darwin Reserve, 300 km north of Moscow, the majority were open surface beds (Kaleckaja 1973). Kaal (1976) reported from Estonia that the structure of winter dens varied greatly, ranging from simple surface beds in the open to carefully prepared caves.

Bed structures used in bears' annual bedding cycle (Fig. 7) may be divided into 2 series: natural contour beds (inner circle), and constructed beds (outer circle). Both series may be divided into 4 different stages: (1) surface depression, (2) soil pit, (3) sheltered daybed, and (4) sheltered denbed. Literature information suggests that beds in any of these stages might be used for denning.

Behavior Associated with Bedding

Four sets of behavioral elements were associated with bedding in Hedmark brown bears.

Avoidance of exposure.—During hot and dry summer periods, wet spots were selected for bedding, and signs from bear rolling were occasionally seen at such sites. Some spots in each cluster definitely appeared to have been selected for cooling purposes in the traditional summer bed areas. During late summer and autumn some beds were insulated. Such observations indicated that bears respond to abiotic exposure and that meteorological and radiation environment factors may influence their site selection. Temperatures and light intensity at summer bed sites were not measured, but 95% of the beds were judged to be situated in cool and shady spots in the stands. All sites selected inside Cutting Class III stands were extremely dark even during sunny summer days.

Forest stands modify extremes in temperatures, wind, and precipitation (Spurr and Barnes 1980), and as density of timber increases the amount of incident radiation to the ground decreases (Beall 1974). The tendency to avoid the open, and the need for timber stands to bed in, as described here, can be explained as the avoidance of exposure. The occurrence of vertical objects such as boulders close to beds offered additional shelter and comfort, and trunkbeds in particular provided excellent protection against rainfall beneath the ceiling of branches.

Radiation arguments have been used by Beall (1974) to explain winter bed selection by elk (*Cervus elaphus*), where a similar occurrence of beds near large trees has been described. Large trees have a great surface area and give mass reflection and energy emission, creating a more uniform site temperature (Beall 1974), a characteristic which could well be of significance also for bear summer bedding.

Abiotic factors suggested in other studies of significance for den bed site selection by grizzly bears during winter were prevaling wind direction, snow conditions, and possibly temperature inversion (Vroom et al. 1980). Sheltered den bed chambers have been suggested to function as heat traps (Craighead and Craighead 1972*b*).

However, extensive and complicated measurements will be needed to verify that bedding sites are selected to avoid exposure. Selection of summer bedding sites in timber stands can well be a demand for security cover (see the following discussion of concealment), and shade or low light intensity cannot be merely viewed as an exposure factor (see defense/safety).

Concealment.—Cover was provided by a combination of vegetative and topographical features, but the general quality and availability of cover in different Hedmark stands was not measured. Site visibility measurements showed that beds were usually well concealed. Some hidebeds were definitely selected in blind spots, where the bear got maximum concealment from existing vegetation and objects on the forest floor.

Avoidance of bedding in open, subalpine habitat above 800 m suggested a preference for forest stands, selected for concealment and security reasons. Security arguments may also explain the preference for steep areas; these include those bear habitats most inaccessible to man.

In the 3 bed cluster areas, some sites selected indicated an active topographical orientation towards watch-sites commanding the best view of the surroundings. Quality of cover and concealment behavior were probably among the most important factors in site selection, due to the heavy shooting pressure on remaining European brown bear populations (Mysterud 1977). Optimum grizzly habitat also included extensive timbered areas, suggested to provide security cover (Craighead and Craighead 1972*b*; R.R. Knight et al., unpubl. rep., U.S. Dep. Inter. Natl. Park Serv., 1976).

Vertical objects such as trunks, boulders, stumps, and varied microtopography prevent scent spread from resting animals by creating pockets of stagnant air. Bedded bears are much easier to locate when scent is carried directly by the wind. Avoiding detection by predators such as wolf (*Canis lupus*) packs and man's hunting dogs may be important.

The areas around inhabited farms and close to public roads, where summer bedding was avoided, are suggested as representing a security zone from human activity. More pronounced security zones seem to exist during the more critical winter den bedding, for which sites may be selected in the most inaccessibly parts of the bears' range (Mysterud unpubl. data). Locations of grizzly bear dens in avalanche areas seldom frequented by man may provide another example (Vroom et al. 1980).

The reason for more summer bedding than expected in the zone close to forestry roads is unknown. Bed sites described in this paper, however, were usually selected by bears preying on sheep, a high proportion of beds being located near sheep carcasses. Such bears, probably attracted to grazing sheep for hunting purposes, may operate close to pastures in clearcuts, chalets, and other important sheep grazing areas near a forestry road.

Defense/safety. — The Hedmark brown bears rested inside timbered stands, preferably close to trunks, and were definitely forest-adapted bears. Grizzly bears spend most of their time in timbered areas, at least when not feeding (S.P. Mealey, pers. commun.), and an identical ability to bed near trunks has been described from Yellowstone, USA (R.R. Knight et al., unpubl. rep., U.S. Dep. Inter. Natl. Park Serv., 1978).

Can vertical objects, particularly trunks at bedding sites, offer protection by giving the opportunity for a rapid escape climb? If so, closeness to trees is a defensive characteristic of brown/grizzly bears as suggested by Herrero (1972) for the black bear (*Ursus americanus*).

Conflicting arguments stem from the fact that bedding close to trunks has been seen in nonclimbing species, such as the wolf (pictured in Haglund 1968, p. 277). Although Beall (1974) suggested trunks as stabilizers of bed site radiation environment in elk, he did not rule out the possibility that bedding close to large trees reflects the psychological need to be near an object. Moen (1968) has suggested the same for white-tailed deer (*Odocoileus virginianus*).

An alternative hypothesis to climbing to escape concerns psychological imprinting. Imprinting depends on an object's size, shape, position, and length of exposure (Bateson 1966). It was here regarded as a more general part of the learning process including habitat imprinting (see Fichter 1974). The significance of imprinting "the type of environment first perceived" (Thorpe 1963) should be stressed for bear cubs, which are born in sheltered dens and bed there until up to 3 months of age during their most formative period. The 2 dominating den environment factors are closeness to vertical walls and darkness.

The cubs are born into a more or less closed system, and vertical walls are the only objects available for defence display against competitive and/or aggressive littermates, the sow, or intruding males trying to enter the den. Cubs thus use the vertical den or alcove wall for survival, and cubs active in dens always relax against the wall close at hand, presumably achieving a sense of security there. This means that vertical structure closeness may be imprinted to satisfy some basic neural demands necessary for relaxation. During adult resting behavior, object closeness may psychologically represent safety by a repetition of being close to the vertical den walls, to which they were exposed as cubs.

Vertical objects may in addition well have survival value in defense displays during adult life. A vertical object at its back prevents the bear from being encircled and killed by predators attacking in groups or packs, such as wolves or hunting dogs. The opportunity to escape by climbing could be just one part of defensive displays in bed environments.

The other den environment factor is darkness. During studies of black bear cubs, a preference for dark places was noted (Burghardt and Burghardt 1972). This preference may represent behavioral traits from dark dens imprinted at an early age and developing into a permanent part of behavior.

Construction. — Specific construction behaviors were identified during the Hedmark studies. A few beds at each stage in both series were insulated by adding debris and plant material to construct the bed into a type of nest. This type of construction behavior was assumed to be more important to bedding outside the summer season. Another construction behavior was the breaking of young trees to provide better daybed cover. In Russian populations this has been reported as an important construction feature during denning on above-ground beds (Novikov et al. 1969, Kaleckaja 1973).

The general bed construction behavior was the site shaping carried out by stereotyped scratching or digging. Bed construction was interpreted as different stages of structural complexity formed by a continuous succession of digging elements from superficial scratching to sheltered den bed excavation. Varying degrees of bed construction should simply be viewed as behavioral elements in the ancient mammal coordination pattern connected with the construction of burrows. It is not difficult to see the relevance of such construction behavior to natural selection, as winter bedding for pregnant females is directly related to survival of offspring.

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