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BROWN BEAR HABITAT PREFERENCES AND BROWN BEAR LOGGING AND MINING RELATIONSHIPS IN SOUTHEAST ALASKA

by
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and
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Project W-22-5
Job 4.17R
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SUMMARY

Twenty-two bears were captured or recaptured during this report period, bringing the total number captured since 1981 to 82 (55 on Admiralty Island and 27 on Chichagof Island). During the 1985 field season, we obtained 668 relocations of radio-collared bears. At the end of this reporting period, 36 bears were carrying functional transmitters.

Seasonal habitat use is presented as the percentage occurrence of relocations for 15 landscape variables. Habitat types used most frequently included old-growth forest, riparian old growth, avalanche slopes, and alpine/subalpine. Only 2% of the relocations occurred in early successional clearcuts. In late summer almost 50% of the relocations occurred in riparian forest habitat. During the same period, over 50% of the relocations occurred within 0.2 km of anadromous salmon streams. Home ranges of males and females averaged about 100 km² and 35 km², respectively. A capture/recapture density estimate of bears on northern Admiralty was 0.46 bears/km².

From fall 1981 through fall 1985, we followed 58 radio-collared brown bears to their winter dens and classified the habitat characteristics of 121 den sites. The mean elevation and slope of these dens were 640 m and 35 degrees. The mean dates of den entrance and emergence were 30 October and 2 May. These dates varied according to gender and among years. On Admiralty Island, rock caves were the most frequent den type, while on Chichagof, bears excavated dens--most frequently under large-diameter conifers or in the bases of large snags.

A paper on the den ecology of Admiralty and Chichagof brown bears was prepared for the International Conference on Bear Research and Management; this paper is included in Appendix A.

Key words: Admiralty Island, brown bear, Chichagof Island, density estimates, forestry, habitat use, home range, mining, reproduction, southeast Alaska, *Ursus arctos*.

CONTENTS

BACKGROUND

Once widely distributed across western North America, the current range of the brown/grizzly bear (*Ursus arctos*) is significantly reduced. This is particularly true in the United States (south of Canada) where the grizzly bear was declared threatened in 1975. In North America today, the largest population of brown/grizzly bears (hereafter called brown bears) occurs in Alaska.

In southeast Alaska, logging, mining, and outdoor recreation are rapidly expanding throughout the range of the brown bear. To avoid or minimize population declines of this valuable resource (identified as a "management indicator species" by the U. S. Forest Service), it is imperative that managers develop techniques to monitor brown bear population trends, and develop management guidelines for protection of habitat and regulation of human activity in brown bear country.

Currently, our understanding of brown bear/forestry and mining relationships is inadequate for development of rigorous management guidelines. This is particularly so in southeast Alaska where relatively little research has been conducted on these relationships. This study, which began in 1981 (Schoen 1982), was designed to provide baseline ecological data on brown bear seasonal movements and habitat utilization, den site selection, home range characteristics, food habits, and reproductive rates. Particular emphasis has been placed on developing an understanding of the relationships of mining and logging to bear populations. Preliminary data have been presented in Schoen and Beier (1983, 1985, 1986) and Schoen et al. (in press; *a*,*b*). Additional literature and problem analyses are provided in Schoen (ADF&G files).

OBJECTIVES

To determine weekly and seasonal movement patterns and habitat utilization by brown bears in southeast Alaska, particularly in respect to activities associated with mining and/or logging; and to locate and describe denning sites, determine reproductive rates, and relate these factors to habitat and harvest levels.

STUDY AREA

The study area is located in the Alexander Archipelago of southeast Alaska. Specific sites have been selected on Admiralty and Chichagof Islands. On northern Admiralty, our specific objective relates to monitoring the relationship of radio-collared bears to the Greens Creek mine development. On southeastern Chichagof, we are assessing bear/logging relationships. Additional study site description is included in Schoen (1982) and Schoen and Beier (1983).

METHODS

Detailed methodology has been described in Schoen (1982). A brief summary follows.

We captured bears in the alpine by shooting them with darts from a helicopter. Along beaches and salmon streams, Aldrich leg-hold snares were used. Etorphine hydrochloride (M99, Lemmmon Co., Sellersville, Pa.) and its antagonist, diprenorphine hydrochloride (M50-50, Lemmon Co., Sellersville, Pa.), were used to immobilize most bears. Sernylan (phencyclidine hydrochloride, Bioceutic Laboratories, St. Joseph, Mo. [no longer manufactured]) was used in a few cases. Movements, home range patterns, and habitat use were determined by relocating instrumented bears through aerial radiotelemetry.

RESULTS AND DISCUSSION

This report summarizes data collected during the 1985 field season, from spring den emergence to fall denning. Also summarized are data on the capture and status of instrumented bears, and reproductive data from fall 1981 through June 1986 (Tables 1 and 2). During this reporting period, 22 bears were captured or recaptured. This number included 9 new bears and 7 recaptures on Admiralty Island, and 2 new bears and 4 recaptures on Chichagof Island. To date, 82 bears have been captured: 55 on Admiralty and 27 on Chichagof.

At the completion of this reporting period, 12 males and 10 females on Admiralty and 4 males and 10 females on Chichagof had functional radios. During this period, we recorded 668 relocations: 413 from Admiralty and 261 from Chichagof. This brings the study's total number of relocations to 2,301.

Since fall of 1981, 4 radio-collared bears have been harvested by hunters; 1 bear was killed in defense of life or property; 4 bears died during capture; and 1 female was killed and eaten by a male bear before she recovered from immobilization. Thirty-six bears are still transmitting, and 36 bears are unaccounted for, probably because batteries ran down or transmitters failed.

Seasonal Distribution and Habitat Use

We have divided the year into 5 seasons: spring (den emergence-15 May), early summer (16 May-15 July), late summer (16 July-15 September), fall (16 September-den entrance), and winter (den entrance-den emergence). These are biologically meaningful periods in terms of bear distribution and activities. The seasonal distribution of our bear relocation efforts in 1985 was as follows:

Season	Admiralty	Chichagof
Spring	22	7
Early summer	170	62
Late summer	147	133
Fall	62	56

Only 1 location for each bear was used during winter to classify the den habitat. These locations were not included in the analysis of seasonal habitat use. A separate paper on the denning ecology of brown bears on Admiralty and Chichagof Islands, prepared for the International Conference on Bear Research and Mangagement in Williamsburg, Virginia is presented in Appendix A.

The 1985 seasonal distribution of radio-collared bears, relative to topographic variables (Tables 3-6), was similar to the 1984 distribution. The most obvious difference, however, was an increased use of lower elevations during early summer of 1985. This difference was probably a response to a late spring which caused higher-than-average snowpack at elevations above 600 m.

Seasonal distribution of radio-collared bears, relative to habitat types, is presented in Table 7. Compared with the distribution for 1984, there was an increased use of old-growth forest, and reduced use of avalanche slopes and alpine/subalpine areas during early summer. Again, this difference probably reflected greater snow accumulation in open, high-elevation habitats than in forested habitats. As in previous years, the highest proportion of bear habitat use occurred in riparian old growth, particularly high-volume spruce stands (Tables 8-9).

On Chichagof Island, where extensive logging occurs, radio-collared bears continued to make little use of clearcuts (Table 7). Only 3 relocations occurred in clearcuts during the 1985 season, representing 2% of bear habitat use in early summer, late summer, and fall. Since the 1983 field season, 16 of 653 relocations (2%) of radio-collared bears have occurred in clearcuts and 4 relocations have occurred in even-aged regrowth.

Seasonal distribution of radio-collared bears, relative to canopy cover and soil drainage, are presented in Tables 10 and 11. These data are similar to those of previous years.

The seasonal distribution of radio-collared bears, relative to the nearest distance to the coast, the alpine, an anadromous salmon stream, cover, a road, or a clearcut, is presented in Tables 13 through 17. The most significant trend is the high level of bear use of habitat along anadromous salmon streams during late summer (Table 14). From mid-July through mid-September, 50% and 68% of all relocations occurred within 0.2 km of these streams on Admiralty and Chichagof Islands, respectively. This was over twice the use these areas received at any other time of the year.

We surveyed bears' day beds along salmon streams in an attempt to develop an index of bear use in the Greens Creek drainage on northern Admiralty Island prior to major road development scheduled for 1986. In November 1985, we counted the number of beds and their locations along a 1.6-km strip (approximately 120 m wide) on both sides of lower Zinc Creek and the east side of lower Greens Creek. Of 83 day beds which had been used that year, 57 were located along Zinc Creek. Most of the bear beds along Zinc Creek occurred on the uphill side to the east. The mean distance to the stream, for all day beds, was 52 m (SE = 3.1) and ranged from 2 to 120 m. Eighty-eight percent of the beds were associated with live Sitka spruce (Picea sitchensis) or western hemlock (Tsuga heterophylla) trees. The mean dbh of these trees was 110 cm. We will again survey this area in 1986 and assess any change in distribution.

Home Range and Movements

The 1985 mean annual home range sizes of radio-collared bears on Admiralty and Chichagof Islands, as determined from convex polygons, were as follows:

Admiralty Island

	Male	Female
$\bar{x}$ =	72.0 km² (27.8 mi²)	38.6 km² (14.9 mi²)
SE =	31.2	17.7
n =	8	17

Chichagof Island

	Male	Female
$\bar{x}$ =	125.6 km² (48.5 mi²)	31.1 km² (12.0 mi²)
SE =	45.2	7.9
n =	3	10

As in prior years, we continued to see substantial overlap between years in the home ranges of individual bears that had been followed for several years. Subadult individuals (especially males) moved some of the longest distances and were more likely to move into new areas. Four radio-collared females (Nos. 60, 6, 14, and 99) continued to remain in upland and interior regions of the island throughout the year. For the 4th consecutive year, none of these bears moved down to coastal areas to feed on anadromous salmon.

Alpine Trend Counts and Density Estimates

Because of weather and logistical problems, only 1 alpine survey was flown in 1985. On 15 July we flew the north Admiralty study area for 1.5 hours and observed 36 bears, of which 4 were marked (Table 18). The sightability of marked bears was 20%. When we used this figure and corrected for cubs, we estimated there were 180 bears in the 390 km² area, or 0.46 bears per km² (1.2 bears/mi²). This density falls between estimates from 1983 and 1984 (Table 18) and represents a high-density brown bear population.

Reproduction

A summary of the reproductive history of radio-collared bears on Admiralty and Chichagof Islands is presented in Tables 19 and 20. The mean known age of 1st breeding for 5 marked bears was 7 years. For a larger sample of 14 marked bears (including the 5 above), for which oldest age before production of young is known, the mean age was 6.4 years (SE = 0.4, range = 5-9). However, this average is likely an underestimate of the age of 1st breeding, because some of these bears have still not produced any cubs. Thus, it appears most females probably do not breed for the 1st time until they are at least 7 years of age.

One of the Admiralty females (No. 62) lost her litter of 2 cubs sometime during the fall of 1985 or the spring of 1986. Cub mortality continues to be very high on Admiralty Island. We suspect that infanticidal behavior of adult bears contributes significantly to this high mortality. During the spring of 1986, our oldest marked bear (No. 38) died, presumably of natural causes, at age 27. She did not produce offspring during the last 5 years of her life.

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Table 1. Summary and status of brown bears captured on Admiralty Island, Alaska, fall 1981 through 30 June, 1986.

Bear No.	Location	Sex	Capture (recapture) Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Current status (30 June 1986)
51	Greens Cr.	M	1	60	8-28-81	s	radio lost 9-81
60	Greens Cr.	F	20	160(135)[d]	9-21-81(7-2-82) (7-8-85)	h	transmitting
59	Greens Cr.	M	3	80(113)[d]	9-21-81(8-8-82)	h	mortality (5-1-83)
58	Eagle Peak	M	4	180(194)	9-21-81(8-8-82)	h	last located 9-84 Hood Bay
36	Mansfield Pen.	F	14	230	9-26-81	h	radio lost 5-82
50	Greens Cr.	M	3	120(146)	9-26-85(6-17-83)	h	radio lost 7-85
14	Greens Cr.	F	7	120(90) (95)[d]	9-26-81(7-2-82) (7-5-85)	h	transmitting
43	King Salmon	F	15	250	9-27-81	h	radio lost 5-82
6	King Salmon	F	8	150(153)	9-27-81(6-14-83)	h	radio lost 5-86
62	Admiralty Cove	F	14	150	6-16-82	s	transmitting
B-14	King Salmon	F	2	100[d]	9-26-81	h	mortality
10	Greens Cr.	M	11	280[d](288)[d] (315)	7-2-82(7-6-84) (6-9-86)	h	transmitting
38	Greens Cr.	F	23	280(180)[d]	7-2-82(7-8-85)	h	mortality 5-86
99	Greens Cr.	F	17	200(158)	7-8-82(6-21-84)	h	radio lost 9-85
95	Mansfield Pen.	F	8	170	7-8-82	h	radio dead 6-86
72	Eagle Peak	M	6	200	7-8-82	h	transmitting
34	Mansfield Pen.	F	2	70	7-8-82	h	hunter kill 9-83
63	Greens Cr.	F	17	160	7-8-82	h	radio stationary 10-84
20	Greens Cr.	M	5	100(135)[d]	7-30-85(5-1-83)	s/h	mortality 5-1-83
56	Greens Cr.	F	13(14)	170(158)[d]	7-30-82(7-8-85)	s	transmitting
48	Greens Cr.	M	adult	300	8-3-82	s	radio lost 6-83
39	Mansfield Pen.	F	9(9)	270(171)[d]	8-7-82(7-9-85)	s/h	transmitting
37	Mansfield Pen.	F	10	270	8-3-82	s	hunter kill 10-83
67	Greens Cr.	F	2	60	8-2-82	s	no radio, sighted 9-82 Lake Florence, 6-85 Pack Cr.

Table 1. Continued.

Bear No.	Location	Sex	Capture (recapture) Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Current status (30 June 1986)
7	Pack Cr.	F	11	150	8-26-82	d	no radio, sighted 6-85 Pack Cr.
11	Pack Cr.	M	4	120	8-28-82	t	hunter kill 5-83
8	Pack Cr.	F	10	150	8-26-82	t	transmitting
9	Pack Cr.	F	1	54	8-26-82	d	no radio, sighted 6-85 Pack Cr.
91	Pack Cr.	F	19	162[d]	6-21-83	h	?
92	Pack Cr.	F	16	158[d]	6-21-83	h	radio lost 5-86
93	Pack Cr.	M	5	158[d]	6-21-83	h	transmitting
94	Pack Cr.	F	10	156[d]	7-13-83	t	transmitting
40	Greens Cr.	M	10	180	6-21-83	h	? last located 8-85
45	Greens Cr.	M	15+	284[d] (270)[d] (270)	6-14-83 (7-6-84) (6-11-86)	h	transmitting
55	Greens Cr.	F	7	124	6-21-83	h	transmitting
35	Wheeler Cr.	F	8	135[d]	6-17-83	h	mortality
18	Greens Cr.	M	6	214[d]	6-17-83	h	? last located 8-85
16	Greens Cr.	F	4	90[d]	6-17-83	h	? last located 9-84
66	Greens Cr.	M	4	180[d]	6-22-83	h	? last located 8-85
64	Eagle Peak	F	14	190[d]	6-24-83	h	transmitting
57	Greens Cr.	F	11	203[d]	9-28-83	h	? last located 7-85
68	Greens Cr.	F	5	146[d]	9-28-83	h	radio lost -86
4	Greens Cr.	F	6	214[d]	9-29-83	h	? last located 10-84
19	King Salmon	F	13	191	9-29-83	h	mortality
41	Mansfield Pen.	M	2	135	6-21-84	h	transmitting
49	Mansfield Pen.	M	3	100	6-16-84	h	no radio ?
81	Mansfield Pen.	F	14	200	6-21-84	h	? last located 9-85
29	Wheeler Cr.	F	12	158	7-5-84	h	? last located 11-84
69	Greens Cr.	M	(2)	59	7-9-85	h	radio lost 5-86
79	Greens Cr.	F	(4)	124	6-11-86	s	transmitting
27	Greens Cr.	M	(3)	77	6-11-86	s	transmitting
28	Greens Cr.	M	adult	260	6-11-86	s	transmitting
61	Hawk Inlet	M	adult	215	6-12-86	s	transmitting

Table 1. Continued.

Bear No.	Location	Sex	Capture (recapture)			Capture techniques[c]	Current status (30 June 1986)
			Age[a]	Weight (kg)[b]	Date		
77	Greens Cr.	M	(3)	115	6-26-86	h	transmitting
46	Greens Cr.	M	adult	248[d]	6-26-86	h	transmitting
52	Greens Cr.	M	adult	190	6-26-86	h	transmitting
98	Greens Cr.	M	adult	315[d]	6-26-86	h	transmitting

[a] Age determined by tooth sectioning or (estimated).

[b] Weight estimated.

[c] h = helicopter
s = snare
t = trap
d = darted, free ranging.

[d] Actual weight.

Table 2. Summary and status of brown bears captured on Chichagof Island, summer 1983 through 30 June 1986.

Bear No.	Location	Sex	Capture (recapture) Age[a]	Weight kg[b]	Date	Capture techniques[c]	Current status (30 June 1986)
23	Kadashan	M	5	158[d]	6-23-83	h	last located 10-83
21	Corner Bay	F	Adult	169[d]	6-23-83	h	radio lost 6-85
88	Kadashan	M	5	167[d](190)	6-23-83(7-18-85)	h	DLP mortality[e]
24	Corner Bay	F	16	225[d]	6-23-83	h	radio lost 9-84
12	Kook Lake	F	3	100	6-24-83	h	radio lost 8-84
30	Kadashan	M	3	126[d](136)	6-24-83(9-16-83)	h/s	transmitting
2	Crab Bay	M	6	216[d]	6-24-83	h	last located 7-84
73	Kadashan	F	11	158(181)[d]	8-8-83(7-12-84)	s	transmitting
18	Kadashan	M	19	215	9-16-83	s	hunter kill 5-84
44	Kadashan	F	Adult	272	9-17-83	s	found dead 9-84
90	Corner Bay	M	4	135	9-22-83	d	radio lost, sighted 5-84 Portage
32	Kadashan	F	5	136	7-10-84	s	transmitting
11	Kadashan	F	2(3)	118(100)[d]	7-10-84(6-20-85)	s/h	transmitting
82	Kadashan	F	4	145[d](158)[d]	7-11-84(7-15-85)	s	transmitting
53	Kadashan	F	16	215	7-12-84	s	transmitting
65	Corner Bay	F	2	79	7-19-84	s	lost radio, last sighted 6-85 Corner Bay
33	Corner Bay	F	(3)	79	7-19-84	s	not transmitting, sighted 7-85 Kadashan trap
26	Kadashan	F	Adult	200[d](180)	7-21-84(8-1-85)	s	lost radio 5-86
9	Kadashan	F	Adult	154[d]	7-21-84	s	radio lost 8-84, sighted 7-85 Kadashan
3	Kook Lake	M	3	136[d](167)[d]	10-2-84(7-18-85)	s	trasnmitting
22	Kook Lake	F	3	91	10-8-84	s	transmitting
17	Crab Bay	M	4	200[d]	6-18-85	h	transmitting
5	Crab Bay	F	4	118[d]	6-18-85	h	transmitting
70	Kadashan	M	4	163[d]	6-18-85	h	transmitting
15	Corner Bay	F	5	113[d]	6-18-85	h	transmitting
25	Crab Bay	F	15	159[d]	6-20-85	h	transmitting
7	Kadashan	F	17	160	7-19-85	s	transmitting

Table 2. Continued.

[a] Age determined by tooth sectioning or (estimated).

[b] Weight estimated.

[c] h = helicopter
s = snare
t = trap
d = darted, free ranging

[d] Actual weight.

[e] DLP = defense of life or property.

Table 3. Percent seasonal distribution of radio-collared brown bears, relative to elevation, on Admiralty and Chichagof Islands, Alaska, 1985.

Elevation (M)	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<300	45	29	44	72	67	89	39	75
300-600	41	57	26	18	9	5	29	21
600-900	14	14	27	10	17	5	29	4
>900	0	0	9	0	7	1	3	0
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 4. Percent seasonal distribution of radio-collared brown bears, relative to slope, on Admiralty and Chichagof Islands, Alaska, 1985.

Slope (degrees)	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<11	35	0	30	52	69	83	37	61
11-25	41	86	38	33	22	8	24	25
26-45	24	14	31	15	9	9	39	14
>45	0	0	1	0	0	0	0	0
n[c]	17	7	152	61	134	127	59	51

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 5. Percent seasonal distribution of radio-collared brown bears, relative to aspect, on Admiralty and Chichagof Islands, Alaska, 1985.

Aspect	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
N	9	14	11	18	12	37	15	13
NE	5	29	14	19	9	19	8	27
E	9	0	19	8	9	8	13	4
SE	14	14	14	15	7	3	21	13
S	5	14	13	10	15	5	10	6
SW	23	0	10	7	24	5	5	11
W	23	29	11	5	9	6	10	16
NW	14	0	9	18	16	17	19	13
n[c]	22	7	170	67	147	132	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 6. Percent seasonal distribution of radio-collared brown bears, relative to aspect, on Admiralty and Chichagof Islands, Alaska, 1985.

Terrain	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Smooth	73	57	76	84	90	97	63	82
Broken	27	43	24	16	10	3	37	18
n[c]	22	7	170	67	147	132	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 7. Percent seasonal distribution of radio-collared brown bears, relative to habitat, on Admiralty and Chichagof Islands, Alaska, 1985.

Habitat type	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Beach/tidal flat	0	0	8	21	1	7	0	7
Old-growth forest	90	72	45	50	18	16	36	54
Riparian old-growth	5	0	5	8	47	51	22	25
Avalanche slope	0	14	14	10	6	5	22	5
Subalpine	5	14	7	3	10	3	10	2
Alpine	0	0	14	2	12	3	2	2
Rock	0	0	6	1	0	0	8	0
Clearcut	0	0	0	2	0	2	0	2
Stream	0	0	0	0	4	13	0	3
Other	0	0	9	3	2	0	0	0
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 8. Percent seasonal distribution of radio-collared brown bears, relative to spruce composition, on Admiralty and Chichagof Islands, Alaska, 1985.

Spruce (%)	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<26	67	69	58	60	20	16	38	36
26-50	33	25	29	13	22	26	37	44
>50	0	6	13	27	58	58	25	20
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 9. Percent seasonal distribution of radio-collared brown bears, relative to timber volume, on Admiralty and Chichagof Islands, Alaska, 1985.

Timber volume (mbf)	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<8	5	33	17	22	17	7	15	13
8-20	27	33	25	27	17	20	27	14
20-30	59	17	43	43	32	43	40	62
>30	9	17	15	8	34	30	18	11
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 10. Percent seasonal distribution of radio-collared brown bears, relative to forest canopy, on Admiralty and Chichagof Islands, Alaska, 1985.

Canopy (%)	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<26	0	43	48	40	30	31	32	20
26-50	73	14	9	15	11	8	15	9
51-75	27	43	42	45	58	61	51	71
>75	0	0	0	0	1	0	2	0
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 11. Percent seasonal distribution of radio-collared brown bears, relative to soil drainage, on Admiralty and Chichagof Islands, Alaska, 1985.

Drainage	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Poor	6	20	23	36	17	22	22	26
Good	94	80	77	64	83	78	78	74
n[c]	22	5	116	42	110	98	41	47

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 12. Percent seasonal distribution of radio-collared brown bears, relative to nearest distance to alpine, on Admiralty and Chichagof Islands, Alaska, 1985.

Distance to alpine (km)	Spring A[a]	Spring C[b]	Early summer A	Early summer C	Late summer A	Late summer C	Fall A	Fall C
<0.2	27	57	48	15	28	10	60	14
0.2-0.8	32	14	14	6	10	13	6	16
0.8-1.6	23	0	14	24	24	40	11	34
1.6-3.2	18	29	23	45	38	27	23	29
>3.2	0	0	1	10	0	10	0	7
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 13. Percent seasonal distribution of radio-collared brown bears, relative to nearest distance to coast, on Admiralty and Chichagof Islands, Alaska, 1985.

Distance to coast (km)	Spring A[a]	Spring C[b]	Early summer A	Early summer C	Late summer A	Late summer C	Fall A	Fall C
<0.2	18	0	27	40	38	44	16	38
0.2-0.8	5	29	8	7	16	19	11	5
0.8-1.6	18	28	17	24	16	12	19	27
1.6-3.2	50	43	24	29	11	25	28	30
>3.2	9	0	24	0	19	0	26	0
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 14. Percent seasonal distribution of radio-collared brown bears, relative to nearest distance to anadromous salmon stream, on Admiralty and Chichagof Islands, Alaska, 1985.

Distance to stream (km)	Spring A[a]	Spring C[b]	Early summer A	Early summer C	Late summer A	Late summer C	Fall A	Fall C
<0.2	0	0	14	23	50	68	24	32
0.2-0.8	14	0	14	26	14	14	8	27
0.8-1.6	18	14	8	14	4	9	11	18
1.6-3.2	36	72	19	35	5	7	13	18
3.2-4.8	9	14	18	2	5	1	18	5
>4.8	23	0	27	0	22	1	26	0
n[c]	22	7	170	62	147	133	62	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 15. Percent seasonal distribution of radio-collared brown bears relative to distance to cover, on Admiralty and Chichagof Islands, Alaska, 1985.

Distance to cover (km)	Spring A[a]	Spring C[b]	Early summer A	Early summer C	Late summer A	Late summer C	Fall A	Fall C
0	100	100	58	59	76	77	90	82
10-20	0	0	25	23	3	14	2	9
30-50	0	0	10	4	4	6	6	9
60-100	0	0	4	8	3	2	0	0
100-200	0	0	1	2	5	0	2	0
200-500	0	0	2	4	8	1	0	0
>500	0	0	0	0	1	0	0	0
n[c]	6	5	129	48	145	131	61	56

[a] Admiralty site.

[b] Chichagof site.

[c] No. of relocations.

Table 16. Percent seasonal distribution of radio-collared brown bears, relative to distance to roads, on Chichagof Island, Alaska, 1985.

Distance to roads (km)	Spring	Early summer	Late summer	Fall
<0.8	29	29	11	7
0.8-1.6	0	13	12	13
1.6-8	14	37	53	55
>8	57	21	24	25
n[c]	7	62	133	56

[a] No. of relocations.

Table 17. Percent seasonal distribution of radio-collared brown bears, relative to distance to clearcuts, on Chichagof Island, Alaska, 1985.

Distance to clearcuts (km)	Spring	Early summer	Late summer	Fall
<0.3	29	36	18	21
0.3-1.6	0	13	12	13
1.6-4.8	14	37	53	55
4.8-8.0	57	21	24	25
>8.0				
n[a]	7	62	133	56

[a] No. of relocations.

Table 18. Summary of alpine bear surveys conducted on Admiralty Island, Alaska, from 1983 through 1985.

	North Admiralty			
	6/29/83	6/25/84	7/4/84	7/15/85
Survey time (hrs)	1.8	0.9	1.1	1.5
Bears observed:				
adults	28	18	18	30
cubs of year	7	2	3	5
total cubs	14	8	13	6
cubs:100 adults	50	30.4	41.9	20
Total	42	26	31	36
Bears:hour	23.3	29.0	28.2	24
Total marked bears observed	4	6	5	4
Total marked bears in area	25	24	24	20
Approximate size of area	390 km^2 (150 mi^2)			
Sightability of marked bears	16%	25%	21%	20%
Mark/recapture estimate:				
adults	175	72	86	150
correction for cubs	88	22	36	30
Total	263	94	122	180
Estimated density of bears per km^2 (mi^2)	0.67 (1.8)	0.24 (0.6)	0.31 (0.8)	0.46 (1.2)

Table 19. Reproductive history of radio-collared female brown bears on Admiralty Island, Alaska 1981-86.

Bear No.	Age at capture (yrs)	Offspring[a] by year					
		1981	1982	1983	1984	1985	1986
60	20	1 2-yr	0	2 Coy[b]	1 Coy	1 1-yr	1 2-yr
36	14	2 Coy	--	--	--	--	--
14	7	0	0	0	2 Coy	0[c]	0
43	15	0	2 Coy	2 1-yr	--	--	--
6	8	0	0	1 Coy[d]	0	0	--
62	14		0	0	0	2 Coy	0
38	23		0	0	0	0	0
99	17		2 3-yr	2 Coy	2 1-yr	1 2-yr[d]	--
63	17		2 cubs	0	0	2 Coy	--
95	8		2 1-yr	2 2yr	0	2 Coy	2 1-yr
34	2		0	0			
56	13		2 2-yr	2 3-yr	2 Coy	2 1-yr	2 2-yr[e]
67	2		0	--	--	--	--
37	10		0	1 Coy			
39	9		0	0	2 Coy	0[d]	1 Coy
7	11		1 Coy	1 1-yr	1 2-yr		
8	10		0	0	2 Coy	2 1-yr	2 2-yr
9	Coy		0	0	0	0	0
35	8			0			
16				0	0	--	--
91	19			0			
92	16			0	2 Coy		
55	7			0			
64	14			1-yr	1 2-yr	2 Coy	2 1-yr
94	10			0	2 Coy	2 1-yr	2 2-yr
57	11			2 2-yr	2 3-yr	2 Coy	
68	5			0	0	0	0
4	6			0	2 Coy	2 1-yr	--
19	13			1 2-yr	--	--	--
81	14				0	0	--
29	12				3 1-yr[f]	--	--
79	4						0

[a] Coy = cub of year
1-yr = yearling
2-yr = 2-year-old
cub = cub older than COY
0 = no cubs observed

[b] Male killed cubs in June.

[c] Female ate cubs in den.

[d] Cubs disappeared over winter.

[e] Cubs left over summer.

[f] One cub disappeared over summer.

Table 20. Reproductive history of radio-collared female brown bears on Chichagof Island, Alaska, 1983-86.

No.	(yrs)	1983	1984	1985	1986
21	Adult	0	3 Coy	3 1-yr	--
24	16	0	2 Coy	--	--
12	3	0	0	--	--
73	11	0	2 2-yr	0	3 Coy
44	Adult	0	3 Coy[b]	--	--
32	5		0	0	0
11	2	0	0[c]	0	0
82	4	0	0	0	0
53	16		0	2 Coy	2 1-yr
65	2		0	0	--
33	2		0	0	0
26	Adult		2 cubs[d]	1 2-yr[e]	--
9	5		0	0	--
22	3		0	0	0
5	4			0	0
15	4			0	2 yr
25	11			0 2 1-yr	2 yr
7	17			2 1-yr	2 2-yr

[a] Coy = cub of year
1-yr = yearling
2-yr = 2-year-old
cub = cub older than Coy
0 = no cubs observed

[b] Female found dead by midsummer.

[c] Offspring of No. 73.

[d] Cubs different sizes.

[e] Cub gone by 7-85.

APPENDIX A.

DENNING ECOLOGY OF BROWN BEARS ON ADMIRALTY AND CHICHAGOF ISLANDS

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Abstract: From fall 1981 through fall 1985, 58 radio-collared brown bears (*Ursus arctos*) were followed to winter dens on Admiralty and Chichagof Islands in southeast Alaska. One hundred twenty-one dens were located and their site characteristics described. Mean dates of den entry and emergence, 30 October and 2 May, varied between sexes and among years. Mean elevation and slope of 121 dens were 640 m and 35 degrees, respectively. Dens were at higher elevations and on steeper slopes on Admiralty Island than on Chichagof Island. Females denned on higher and steeper slopes than males. Admiralty Island bears preferred subalpine and alpine/rock habitats and Chichagof Island bears preferred old-growth forest for denning. On Admiralty, rock caves were the most frequent den type; on Chichagof, bears excavated dens, most frequently under large-diameter Sitka spruce (*Picea sitchensis*) or in the bases of large snags. Mine development on Admiralty Island may have caused bears to avoid certain denning areas. Industrial scale logging may reduce brown bear denning habitat in this region. Management recommendations for reducing the impact of human activity and resource development on denning brown bears are provided.

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Key Words: Admiralty Island, Brown bear, Chichagof Island, denning ecology, habitat management, mining, radiotelemetry, southeast Alaska, timber harvest, *Ursus arctos*.

BACKGROUND

A significant feature of brown bear and grizzly bear ecology is winter dormancy (see Folk et al. 1980, Nelson et al. 1983), which allows bears to spend 5-6 months of the year hibernating in a winter den. Predenning accumulation of energy stores and den site suitability are critical for successful denning.

Brown bear or grizzly bear dens and den site characteristics in Europe (Couturier 1954, Curry-Lindahl 1972), the Rocky Mountains (Craighead and Craighead 1972; Vroom et al. 1980; Servheen and Klaver 1983; Judd et al., in press), northern Canada (Pearson 1975, Harding 1976), and Alaska (Lentfer et al. 1972, Reynolds et al. 1976, Smith and Van Daele 1984, Miller 1985) have been described. There are, however, no published reports on the denning ecology of brown bears of the coastal rain forests of southeast Alaska or British Columbia. Human activity and resource development, particularly logging and mining, are increasing in this coastal region, which supports significant brown bear populations.

As part of a major investigation of brown bear ecology in southeast Alaska (Schoen and Beier 1986), we studied denning ecology from fall 1981 through fall 1985. Our objectives were to document denning chronology, delineate denning habitat, identify landscape variables important in den site selection, assess the availability of suitable den sites, and consider the potential influence of resource development on the denning ecology of brown bears in southeast Alaska. This paper summarizes our findings.

This study was supported by the Alaska Department of Fish and Game through Federal Aid in Wildlife Restoration Projects W-22-1,-2, -3, and -4 and by Noranda Mining Company. The U.S. Department of Agriculture, Forest Service, Sitka Ranger District, provided habitat typing for the Chichagof study site. Numerous individuals provided assistance throughout this study. We acknowledge D. Barril, S. Buchanan, B. Englebrecht, R. Flynn, K. Hart, M. Kirchhoff, J. Matthews, T. McCarthy, D. McKnight, S. Peterson, H. Reynolds, M. Thomas, and B. Townsend. S. Miller and C. Servheen refereed the manuscript and offered numerous suggestions for improvements.

STUDY AREA

Southeast Alaska lies in a narrow band between the coastal mountains of British Columbia on the east and the Pacific Ocean to the west. It extends from Dixon Entrance at the Canadian border to Icy Bay 840 km to the north. Islands of the Alexander Archipelago compose much of the land area. Chichagof and Admiralty islands are the 2nd and 3rd largest islands in the archipelago, measuring 5,340 km^2 and 4,430 km^2, respectively. The 2 study sites are located on northern Admiralty and southeastern Chichagof Islands at 57-58 degrees north latitude and 134-136 degrees west longitude.

The topography of the area is rugged with mountains rising from sea level to over 1,400 m. Vegetation is primarily of 2 major types: temperate rain forest and alpine tundra. Scattered throughout this area are steep avalanche slopes, poorly drained muskeg bogs, and tidal wetlands. A cool, maritime climate is characteristic of this region. Snow often accumulates at sea level during the winter, and elevations above 600 m are covered by snow for 6-9 months of the year. Annual precipitation averages about 140 cm, and January and July temperatures average -6 and 13 C, respectively (National Oceanic and Atmospheric Administration weather records).

Within southeast Alaska, brown bears occur only on the mainland and on islands north of Frederick Sound, including Admiralty, Baranof, and Chichagof. Although wolves (Canis lupus) and black bears (Ursus americanus) occur on the southern islands and mainland, they are absent on these northern islands.

The Admiralty site is steeper and has more high-elevation alpine habitat than the Chichagof site. Logging activity has been minimal on the Admiralty site, although Chichagof has been extensively logged within the past 25 years. The Noranda Mining Company is now developing a major mine at Greens Creek in the center of the Admiralty site.

METHODS

We captured and instrumented bears with radio collars (all with mortality modes and many with motion sensors) in alpine areas, along fish streams, and on tidal grass flats (Schoen and Beier 1986). We then tracked radio-collared bears from fixed-wing aircraft, using a directional Yagi antenna mounted under each wing. We flew 1 telemetry survey per week, weather permitting, from 1 April through mid- November. During the winter, we made surveys by air approximately once every 6 weeks. Habitat variables recorded from the air included habitat type, elevation, slope, aspect, terrain, percent canopy cover, percent spruce composition, and timber stand volume. Denning habitat preference was determined by comparing percentage use of these habitat variables with their availability within the study area. All locations were plotted on U.S. Geological Survey 1:63,000 scale topographic maps.

Den entry and emergence dates were usually approximations. Based on observations made from consecutive flights, we defined date of den entry as the mean date between when a bear was last located out of the den and when its location became stationary. Similarly, the mean date of den emergence was the mean date between when a bear was clearly in a den and first located out of a den. Once a bear was out of the den during the spring emergence period, it was considered emerged even if it remained in the den vicinity.

During late winter, we marked some of the dens by dropping weighted flagging or a radio transmitter from an aircraft. After the bears had left their dens, we returned to measure pertinent variables.

We recorded snow measurements at the den sites of 13 radio-collared bears in January and April 1983. Where open and forested areas were adjacent, we measured snow depths in both habitat types. For dens that could not be reached, we based estimates of snow depths on snow depths at nearby locations, tree canopy cover, topographic features, and snow drift patterns. We based our subjective descriptions of snow characteristics on surface appearance and probing. Maximum-minimum thermometers were placed in the vicinity of 5 representative dens. In April, we examined snow profiles from the snow surface to the ground and measured moisture content and density by weighing core samples at 5 dens. We used snowfall data for 8 years (1977-1985) from a 425-m elevation site at the Eaglecrest ski area on Douglas Island (12-20 km east of most dens) to predict the amount of snow cover at den sites during years of minimum and maximum snowfall.

Mann-Whitney U tests of significance were used for 2-sample comparisons and Kruskal-Wallis tests were used for multisample comparisons. Contingency tables were analyzed with Chi-square analysis.

RESULTS AND DISCUSSION

From fall 1981 through fall 1985, we followed 58 brown bears (18 males, 40 females) to their winter den sites on Admiralty and Chichagof Islands. One hundred twenty-one den sites (86 on Admiralty, 35 on Chichagof) were described from the air, and 38 of those dens (29 on Admiralty, 9 on Chichagof) were located on the ground and described.

Denning Chronology

Mean dates of den entry and emergence for radio-collared brown bears were 30 October and 2 May, respectively. Sex and reproductive status influenced both entry and emergence dates ($\underline{P} < 0.001$, Table 1). Females and females with young entered dens earlier than single females or males (Fig. 1).

In general, females began denning by the 2nd week of October; by the end of October more than 70% were in dens. Males began denning the 3rd week of October, but by the end of October fewer than 50% were denned. By mid-November about 80% of males and 95% of females had denned. Several radio-collared males remained active until about mid- December. These bears, as well as other unmarked bears of undetermined sex, were observed feeding on late salmon runs from November through much of December.

In spring, males were the 1st to emerge from dens. Next were single females and finally females with young (Table 1). Males began emerging in late March, and by the end of April, 67% had left their dens (Fig. 2). Females began emerging from dens in early April, and by the end of April 56% of single females had emerged compared with 13% of females with young. By the 3rd week of May, all males had emerged in contrast with about 80% of the females. Most females had emerged by the end of May; however, in 1985, following a late spring, several females remained in their dens through the 1st half of June.

Males spent an average of 165 days in winter dens compared with 194 days for females. Parturient females averaged 211 days, 46 days longer than males. Other investigators have described similar patterns of den emergence (Craighead and Craighead 1972; Pearson 1975; O'Pezio et al. 1983; Smith and Van Daele 1984; Judd et al., in press). Following den emergence, many bears (particularly females with cubs) remained near the den site. The length of time varied from several days to several weeks for females with cubs.

Mean dates of den entry and emergence varied among years ($P < 0.05$ and 0.0001, respectively, Table 2). Winter snowpack and timing of spring snowmelt appear to be correlated with mean date of den emergence. The spring hunter harvest of brown bears on Admiralty Island, in turn, appears negatively correlated with den emergence (Fig. 3).

The winter of 1983-1984 was relatively mild and the snowpack above 425 m at Eaglecrest on Douglas Island (about 15 km east of most Admiralty dens) was about 90 cm below the 8-year average. That spring, the mean day of den emergence for all radio-collared bears was 26 April. This was 9 days earlier than the mean (6 May) for the 4 years of study. This same spring was a near-record high spring bear harvest (39 bears, 17 more than the 25-year mean) for Admiralty Island.

The following winter of 1984-1985 was one of near-record snowpack at higher elevations. The snowfall at Eaglecrest was about 240 cm above the 8-year mean, and the mean date of den emergence for all radio-collared bears was 14 May. This was 8 days later than the 4-year mean and 17 days later than the mean emergence date the previous year. The 1985 spring bear harvest on Admiralty was 15 animals (7 fewer than the 25-year mean).

Late den emergence of brown bears from the Susitna Basin of south-central Alaska has also been associated with late spring conditions (S. Miller, pers. commun., 1985), as has late emergence of black bears from the Susitna Basin and Kenai Peninsula in Alaska (Schwartz et al., these Proceedings).

The denning chronology of brown bears in southeast Alaska differs from that of grizzly bears in the Rocky Mountains (Craighead and Craighead 1972; Servheen and Klaver 1983; Judd et al., in press) and brown bears in south-central Alaska (Miller 1985); some southeast Alaska brown bears den later (primarily males) and emerge later (mostly females) than grizzly or brown bears from the Rocky Mountains and interior Alaska.

Several possibilities may account for these differences. The bears we observed denning late (December) had access to late-fall salmon runs that provided abundant nutrient-rich food. December denning of male brown bears has also been described on Kodiak Island, where late salmon runs occur (Smith and Van Daele 1984; V. Barnes, pers. commun., 1986). Bears in the Rocky Mountains or interior Alaska do not have a late seasonal abundance of food resources comparable to those found in southeast Alaska. The earliest denning of brown bears or grizzly bears has been reported from the eastern Brooks Range of Alaska (Reynolds et al. 1976), where winter comes early and late-fall food resources are scarce.

What triggers bears to enter their winter dens is not clear. Craighead and Craighead (1972) postulated that environmental conditions such as the 1st winter snowfall trigger grizzly bears to move simultaneously into their dens in Yellowstone Park. In our study, denning did not occur with the first snowfall. We speculate that the disappearance of abundant high-quality food determines time of den entrance. Food availability can vary substantially among geographical localities. It is interesting to note that zoo bears, when fed throughout the winter, do not den.

Den Site Characteristics

The mean elevation of 121 brown bear dens located in this study was 640 m; the mean slope was 35 degrees (Table 3). Dens on Admiralty were at higher elevations and on steeper slopes than those on Chichagof ($P < 0.001$), reflecting differences in habitat availability. All dens of females (and those of 2 subadult males) were at higher elevations and on steeper slopes ($P < 0.05$) than dens of adult males. The security provided by high, steep terrain may be more important to females with cubs than to other bears.

On Admiralty Island, most females spend part of the year in coastal areas feeding on spawning salmon, although some females spend the entire year in interior regions of the island without access to spawning salmon (Schoen et al., in press). Interior females den at higher elevations and on steeper slopes than do coastal females ($P < 0.01$, Table 3). This probably reflects the higher elevational distribution of interior bears throughout the year.

On both Admiralty and Chichagof islands, bears preferred den sites above 300 m elevation (Fig. 4). This is comparable to den site selection by brown bears on Kodiak Island (Lentfer et al. 1972, Smith and Van Daele 1984) and the Alaska Peninsula (Lentfer et al. 1972).

Radio-collared brown bears on Admiralty and Chichagof islands preferred den sites on moderate-to-steep slopes (Fig. 5). The preference for steep, high-elevation denning habitats observed in southeast Alaska is similar to elsewhere in Alaska (Lentfer et al. 1972, Reynolds et al. 1976, Miller 1985), the Yukon (Pearson 1975), and the Rocky Mountains (Craighead and Craighead 1972; Servheen and Klaver 1983; Judd et al., in press). Several of these authors have speculated that bears seek out remote, isolated areas and sites that will accumulate enough snow to insulate them from cold winter temperatures. Snow is probably less important for insulation in south-coastal Alaska, where winter temperatures rarely fall below -20 C. Instead, we suggest that bears need dry cold sites where temperatures generally remain below 0 and free-flowing surface water is rare. In southeast Alaska, torrential winter rain storms frequently occur below 300 m. This may explain why bears avoid den sites below that elevation.

More bears in this region chose southerly exposures than any other. Forty-four percent of the dens had southerly exposures, 29% had northerly exposures, and 27% had east or west exposures. Southern exposures are the last to accumulate deep snow in the fall and the first to be snow-free in the spring. In other regions, bears appear to prefer slope exposures accumulating the greatest snowpack, which insulates the den chamber (Craighead and Craighead 1972, Vroom et al. 1980). As described previously, we consider the insulating value of snow to be less important in southeast Alaska than in areas with colder winter temperatures.

Sixty-five percent of all dens were in areas of highly dissected terrain. Although greater use of rugged terrain occurred on Admiralty, we suggest that steep, rugged country is generally preferred by bears in both areas.

Of the 5 habitats used for denning, bears chose old-growth forest most frequently (Table 4). Bears on Chichagof denned twice as frequently in old growth as bears on Admiralty (Fig. 6). On Admiralty, 39% of the dens occurred in higher-elevation subalpine and alpine/rock habitat. The differences in habitat types selected for denning between study areas are probably due to differences in habitat availability. Half of the coastal females on Admiralty denned in old-growth habitat types; none of the interior females did so.

Although we suspect that high-elevation alpine/rock habitat may be preferred if it is available (Fig. 6), 52% of all dens we located occurred in old-growth forest habitat. An important caveat when determining habitat preference from use and availability data is that the importance of abundant habitat categories may be underestimated. If we assume that a brown bear is intimately familiar with its home range, then the actual use of habitat may, in itself, be an important indicator of habitat preference (McLellan 1986). Thus, in both sites, old-growth forest, followed by alpine/rock and subalpine forest, provide important denning habitat for brown bears in southeast Alaska. Craighead and Craighead (1972), Vroom et al. (1980), and Judd et al. (in press) also identified forested habitat as an important component in grizzly bear den site selection.

For 63 den sites in old-growth forest habitat, spruce composition was 29%. This is higher than the average composition of less than 20% and may reflect a preference for denning under spruce compared to hemlock. Eighty-eight percent of old-growth forest dens occurred in commercial timber stands: 33% in low-volume (8,000-20,000 board feet/acre), 48% in midvolume (20,000-30,000 board feet/acre), and 8% in high-volume (>30,000 board feet/acre) stands. Noncommercial sites were used less and mid-volume sites more than their availability within the study area. Noncommercial forest sites were probably avoided because they occur on poorly drained sites with standing water.

Den Types

We visited and classified 38 dens as to type. Twenty-four (63%) occurred in natural rock cavities, 8 (21%) were excavated in or under live trees or snags, 3 (8%) were excavated in earth, and 3 were surface beds.

On Admiralty Island, rock cavities were the most common den (79%), whereas on Chichagof Island only 1 of 9 dens (11%) was in a rock cavity. Rock cavities varied from large caves 7.5 m deep to small crevices under boulders. Several had more than 1 entrance. Some rock cavities had been sightly modified by digging. We suspect most rock dens had been used in prior years; some had probably been used for centuries. There appeared to be an abundance of acceptable rock cavities on the Admiralty study site but not on the Chichagof site.

Cave denning by brown or grizzly bears is generally atypical in North America (Craighead and Craighead 1972, Lentfer et al. 1972, Pearson 1975, Vroom et al. 1980, Servheen and Klaver 1983, Miller 1985). Although Couturier (1954) and Curry-Lindahl (1972) described cave denning by European brown bears, only Reynolds et al. (1976) and Judd et al. (in press) have described more than occasional cave denning by brown/grizzly bears in North America. We believe that many brown bears, on Admiralty Island, prefer rock caves or crevices for denning.

We have no reason to believe that cave dens are inferior to earth-excavated dens as postulated by Judd et al. (in press); however, we recognize that winter temperatures in southeast Alaska are not as cold as in the Rocky Mountains.

Three dens were excavated in the earth and 8 were excavated under or in trees and snags. Six of the 7 excavated dens on Chichagof were associated with large-diameter spruce trees or snags. On Admiralty, 2 of 4 excavated dens were under live trees. The mean diameter at breast height of these trees and snags was 99 cm (SE = 9.9, range = 61-152 cm). Tree ages were estimated at well over 200 years. Grizzly bear dens excavated under the bases of trees have been described as typical by Craighead and Craighead (1972) and Judd et al. (in press).

Our sample of visited dens was biased toward high-elevation, nonforested sites that were relatively easy to reach, but we did examine 14 dens within old-growth forest. Of those, 8 (57%) were excavated under the roots of old, large-diameter Sitka spruce trees or were excavated within the bases of snags with well-developed heart rot. We strongly suspect these are typical den sites within old-growth habitat. In areas where bears den predominately in old growth, extensive timber harvesting, particularly on steep slopes (>20 degrees) and at elevations above 300 m, could reduce the availability of suitable denning habitat. In this region where soil depth is shallow and torrential rainfall common, trees and snags may be important elements of excavated dens. It is unlikely that the second-growth stands replacing old growth would provide the large diameter trees and large snags with heart rot which brown bears prefer for forest den sites. Judd et al. (in press) also found that grizzly bears in Yellowstone Park denned under large trees and also suggested that logging could destroy some den sites.

Three bears in this study, excluding animals that moved to new dens in midwinter, apparently denned on the surface of the ground or in snow dens. One was a young male that spent the winter on the ground at the base of a large tree in the beach fringe forest 6 m above sea level. This was atypical and the lowest denning elevation recorded. We found surface den sites of 2 other bears, both females, in old-growth forest at about 400 m elevation. We suspect that these bears dug snow dens as described by Lentfer et al. (1972) in southwest Alaska. One of these females denned with 2 cubs-of-the-year, which she apparently lost over winter.

The mean dimensions of dens measured in this study were entrance height x width = 72 x 79 cm (N = 31), chamber height x width = 107 x (N = 28), and total length = 272 cm (N = 28). These measurements are similar to those described by Craighead and Craighead (1972), Lentfer et al. (1972), Vroom et al. 1980, and Servheen and Klaver (1983).

We found nest material, including conifer branches, alder (Alnus sp.) branches, a variety of deciduous shrubs, heather (Cassiope sp.), and rotten wood, in most dens. The type of material used reflected what was available within the immediate vicinity.

Spatial Distribution and Reuse of Dens

Most dens were located on the periphery of bears' annual home ranges. On Admiralty Island, little overlap in male and female denning areas was found. In several instances, however, both males and females denned within 0.4 to 1.0 km from one another on Chichagof Island.

The mean distance individual bears denned from a previous year's den site was greater ($P < 0.001$) for males (8.8 km) than females (3.5 km); however, these data suggest some degree of fidelity to a general denning area for both sexes. The difference between males and females reflects the larger size of male home ranges. Annual home range sizes for males and females were approximately 100 km^2 and 25 km^2, respectively.

It was uncommon for individual bears to reuse the same den in subsequent years. Although we do not have proof of den reuse by the same individual, we suspect that 2 females used their dens (rock caves in both cases) for 2 and perhaps 3 consecutive years. All other bears used different dens in consecutive years. Our summer visits to the den sites may have inhibited reuse; we did not visit the dens of the 2 bears that may have reused their dens until the last year of the study. However, numerous dens we did not visit on the ground were not reused by instrumented bears in subsequent years.

Den Mortality and Den Abandonment

Overwinter den mortality was documented in 1 case and was strongly suspected in 2 additional cases. In the 1st instance we found the remains of 2 yearlings in a rock den following the long winter of 1984-1985.

That same year another radio-collared bear, which denned with her 2 cubs, was observed the next spring without young. This bear spent the winter in a surface nest or perhaps in a snow den.

In winter 1983-1984, a radio-collared female entered her den (a rock cave) in the fall with 1 cub. In March, she abandoned her den and moved to a site 2.9 km away. She was alone when first observed after emergence. We presume her cub either died in the den and she abandoned it or was lost as she traveled to the new den site. We were unable to examine either den. An additional case of winter den abandonment was by an old female without young who moved in midwinter to a new site 0.4 km away.

During the winter of 1986, December and January had near-record mild temperatures and heavy rainfall. By early February 1986, 30% of 33 radio-collared bears abandoned the dens they entered in October and November and moved into new dens. This is a minimum estimate of the number emerging, because some bears may have come out during the mild weather and returned to their original dens. Nevertheless, these data indicate that a substantial number of bears may abandon their dens during mild weather conditions. We suspect that some of these bears may have left their dens because of wet conditions caused by thawing and rain. During the same time period, R. Smith (pers. commun., 1986) reported about the same percentage of radio-collared bears abandoning dens on Kodiak Island during wet, mild conditions.

Increased energy expenditure and difficulty in finding a new den site are problems bears that abandon dens in midwinter may encounter. Den abandonment could also pose problems to newborn cubs. Blix and Lentfer (1979) reported that polar bear cubs have no internal thermo-regulatory mechanism, depending instead on the mother's body heat, the shelter of the den, and the high energy content of the mother's milk to maintain body heat throughout the first several months of life. If brown bears are similar, den abandonment and relocation could be particularly stressful or perhaps fatal to cubs-of-the-year. Excavating a den or finding a suitable rock cavity would be difficult in midwinter. Thus, some bears might be forced to dig snow dens (Lentfer et al. 1972) of perhaps inferior quality.

Snow Characteristics at Winter Den Sites

Snow measurements were recorded at or near the winter den sites of 13 radio-collared bears during January and April 1983. Snow depths at dens ranged from 0.1 to 2.7 m ($\bar{x}$ = 1.3 m, SE = 0.17) in January and from 0 to 2.2 m ($\bar{x}$ = 1.4 m, SE = 0.23) in April.

In January, surface snow ranged from light and dry to heavy and moist to hard-packed and dry, depending on air temperature and wind conditions at the site. Probing to obtain depth measurements indicated an occasional hard layer. Snow was consistently more dense and contained more moisture in April than in January. Mean snow density in April based on measurements from 5 den sites was 0.42 (SE = 0.04, Table 5).

One or 2 layers of consolidated ice occurred in 3 of 5 locations where snow profiles were examined (Table 5). Whether such conditions could restrict gas exchange to the extent that respired carbon dioxide would concentrate within the den and make oxygen levels inadequate is unknown. Hock (1960) reported hibernating black bears consume from 0.5 to 0.1 as much oxygen as active bears. If brown bears are similar, this would reduce the problem of oxygen consumption in dens affected by ice layering. Following a long winter such as 1984-1985, however, bears in small dens overlain by layers of ice could conceivably encounter respiratory difficulties.

Ten sets of snow depth measurements were obtained in open areas and in adjacent areas with forest cover in the vicinity of 7 dens which occurred in both open and forested areas. Mean snow depths based on all measurements were 1.5 m (SE = 0.08, N = 55) in open sites and 0.9 m (SE = 0.07, N = 55) in forested sites ($P < 0.05$). Winter 1982-1983 had below average snowfall. Using an 8-year average from the 425-m elevation Douglas Island site as a standard, the 1982-1983 snowfall was 79% that of the 8-year average. As an additional comparison, the minimum snowfall in 1980-1981 was 60% that of 1982-1983 while the maximum snowfall in 1984-1985 was 200% of the 1982-1983 snowfall. These figures suggest that snow depths at the den sites measured could possibly range from 0 to 5.4 m. It should be recognized, however, that this is an 8-year average and not representative of the extreme snowfalls that might occur.

In this study, bears denned over a wide range of snow depths (0.1-2.2 m). The shallow snow accumulation at some dens contrasts to studies in other areas where deep snow conditions were considered important (Craighead and Craighead 1972, Lentfer et al. 1972, Vroom et al. 1980). Snow cover as insulation for the den chamber is likely more important in colder interior areas such as the Rocky Mountains than in southeast Alaska, where the maritime climate moderates winter temperatures.

Effects of Resource Development and Disturbance

Craighead and Craighead (1972) suggested that grizzly bears seek isolated den sites far from developed areas and human activity. Our observations suggest this may also be the case for brown bears in southeast Alaska. Resource development and human activity can affect denning environment through disturbance and habitat loss. Frequently, bears instrumented with motion sensor transmitters became active as we flew over their dens at an altitude of about 150 m. These flights were in small, fixed-wing aircraft, which are much quieter than helicopters. Thus, in an area that receives intensive aircraft traffic, especially helicopter traffic, bears could be negatively affected by disturbance. The Noranda Mining Company has a major development at Greens Creek in the middle of the Admiralty study area. The project is inactive during midwinter, but helicopter traffic occurs during fall and spring when bears are in dens or entering or emerging from dens.

To assess the effect of helicopter traffic on denning, we selected 6 female bears that had denned within 4 km of the mine site in the upper Greens Creek drainage. Because of their proximity to the development area, we assumed these bears were most influenced by mine site activities, including intensive helicopter traffic. The mean distance these bears denned from the mine site during the 1st year of observation was 3.4 km. They denned significantly farther from the mine site the next year (mean = 11.7 km, $P < 0.05$). We further assessed this relationship by comparing the mean distance from the mine site, among subsequent years' den sites for the 6 radio-collared females mentioned previously, with that of 11 radio-collared females that denned outside the area of mine influence. The mean distance among den sites in subsequent years was significantly greater ($P < 0.05$) for the 6 bears that initially denned closest to the mine (10.4 km) than for the 11 bears outside the mine's influence (1.9 km). None of the males radio-collared in this study denned near the mine site or within the Greens Creek drainage. These findings suggest that intensive development, including aircraft traffic, may reduce an area's suitability as brown bear denning habitat. Reynolds et al. (1976) described 5 cases of den site abandonment after bears were tracked to dens with a helicopter shortly after den construction. Reynolds et al. (in press) found increased heart rate and movements of instrumented grizzly bears in dens in northern Alaska in response to disturbances related to seismic surveys. During that study, aircraft overflights shortly before den emergence also disturbed denned bears.

Three types of development, hydroelectric, mining, and logging, have the potential to reduce denning habitat in southeast Alaska. Mining and hydroelectric development are relatively site-specific and will probably not be widespread in the near future. Site specific impacts of hydroelectric development on brown bears are being assessed elsewhere in Alaska (Smith and Van Daele 1984, Miller 1985). Industrial-scale logging, however, is a major industry in southeast Alaska and with passage of the Alaska National Interest Lands Conservation Act in 1980, 450 million board feet or approximately 7,000 ha of old-growth forest are scheduled for harvest annually on the Tongass National Forest.

MANAGEMENT IMPLICATIONS

Since 1933, the known sport harvest of brown bears on Admiralty, Baranof, and Chichagof islands has averaged 55 bears annually (Alaska Dept. Fish and Game harvest records, Johnson 1980). Seventy percent of the harvest, of which males compose 70%, occurs in the spring (Johnson 1980). During spring, hunting has generally been most productive beginning about

20 May, whereas the 1st 2 weeks of September have been the most productive period of the fall season. Since 1967, skull size and age of bears has remained constant, suggesting that an annual harvest rate of about 60 bears has had little impact on the overall population. This harvest level was incorporated into a brown bear management plan for Admiralty, Baranof, and Chichagof islands in 1981.

In 1975 and 1976 and again in 1985, the harvest increased to over 100 bears. To prevent the high harvest that occurred during the mid-1970's, the season was altered to eliminate the most productive hunting periods in late spring and early fall. These restrictions successfully reduced the harvest and remain in effect today; however, the early spring of 1985 still resulted in a higher harvest than desired.

Denning chronology of brown bears in southeast Alaska varies annually and among sex and reproductive classes. The spring bear harvest may vary substantially among years in relation to the amount of spring snowpack, which influences the timing of emergence from dens. Following a late spring with higher than average snowpack above 400 m, fewer bears, particularly females, are likely to be harvested.

The data obtained from this study offer managers additional flexibility for maintaining harvest levels within prescribed limits. Based on a knowledge of spring snow depth at or above 400 m, managers could adjust spring bear seasons corresponding to a predictable pattern of den emergence. The season could be extended if snow depths were above average and reduced if snow depths were below average.

Brown bears generally den at high elevations and on steep slopes. In southeast Alaska, where high mountains are common, brown bears prefer den sites in subalpine and alpine/rock habitat above 600 m elevation on rugged slopes of greater than 25 degrees. In these sites, natural rock caves, if available, are preferred for denning. In more forested and less mountainous areas, preferred den sites are midvolume, old- growth forest habitat above 300 m elevation on slopes greater than 20 degrees. In these areas, large-diameter (>75 cm dbh) Sitka spruce trees and large snags with heart rot are preferred for denning. Under natural conditions, availability of denning habitat does not appear to be a limiting factor for brown bear populations in southeast Alaska. Mining and logging are the 2 major land use activities in southeast Alaska today. Although mining is relatively localized, industrial-scale forestry affects thousands of hectares annually in southeast Alaska and, in some areas, has the potential to reduce suitable denning habitat for brown bears. To minimize loss of brown bear denning habitat as a consequence of logging, we recommend avoiding logging of midvolume, hemlock-spruce stands on slopes of greater than 20 degrees at elevations above 300 m in or adjacent to areas of brown bear concentrations. Brown bears and grizzly bears prefer remote denning areas isolated from human activity and development (Craighead and Craighead 1972). Human activity near den sites, including noise from machinery, blasting, or aircraft (particularly helicopters), appears to disturb denning bears and may force some to avoid the area for future denning. Where development or major activity is unavoidable in denning areas, use of heavy machinery, blasting, and aircraft traffic should be minimized during the denning period, particularly during den entry (October through mid-November) and den emergence (April through May). Helicopter traffic in particular should be routed away from denning areas during periods of den entry and emergence.

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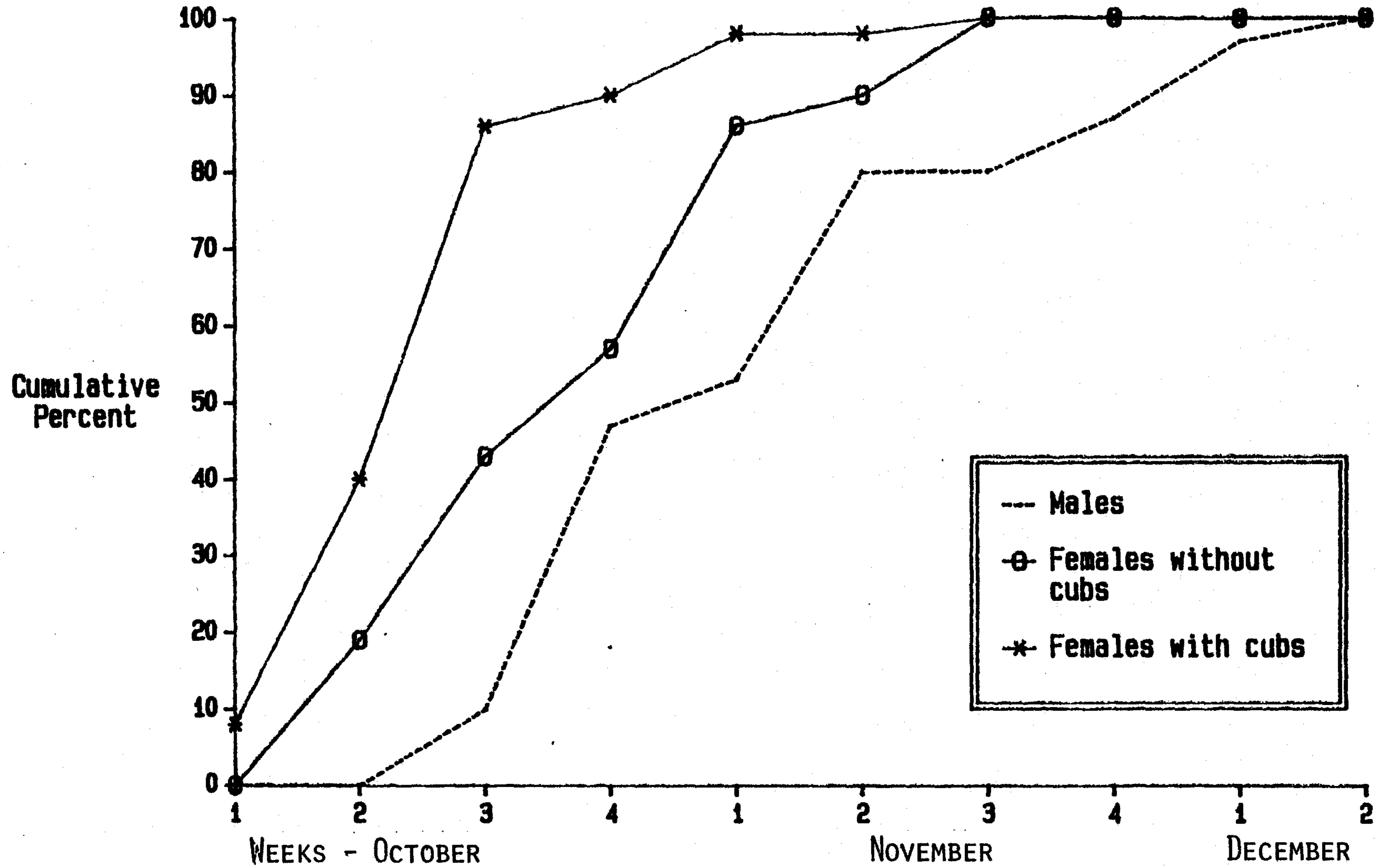

Fig. 1. Cumulative percent of radio-collared brown bears which have entered dens on Admiralty and Chichagof Islands, southeast Alaska, fall 1981-85.

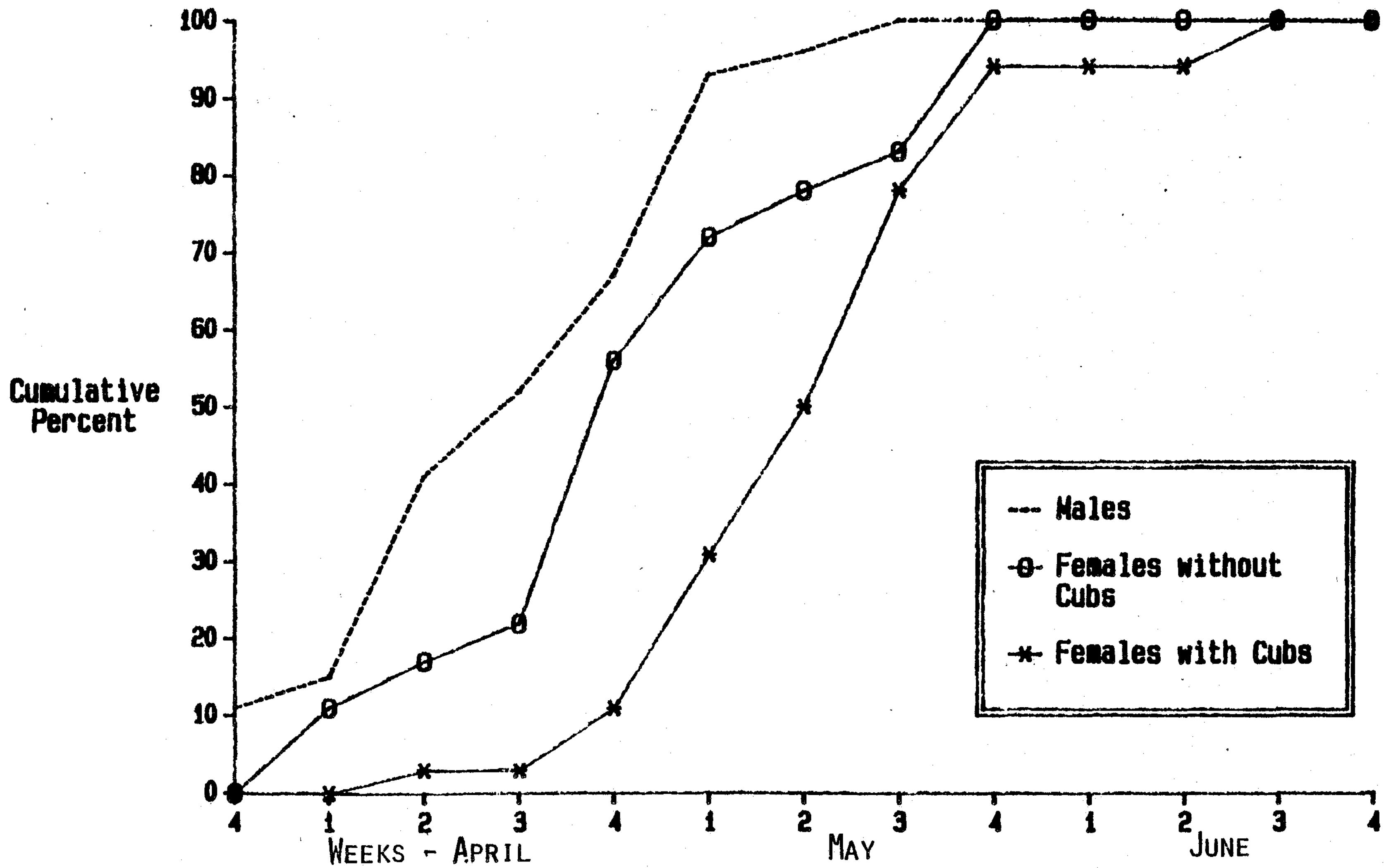

Fig. 2. Cumulative percent of radio-collared brown bears which have emerged from dens on Admiralty and Chichagof Islands, southeast Alaska, spring 1985-86.

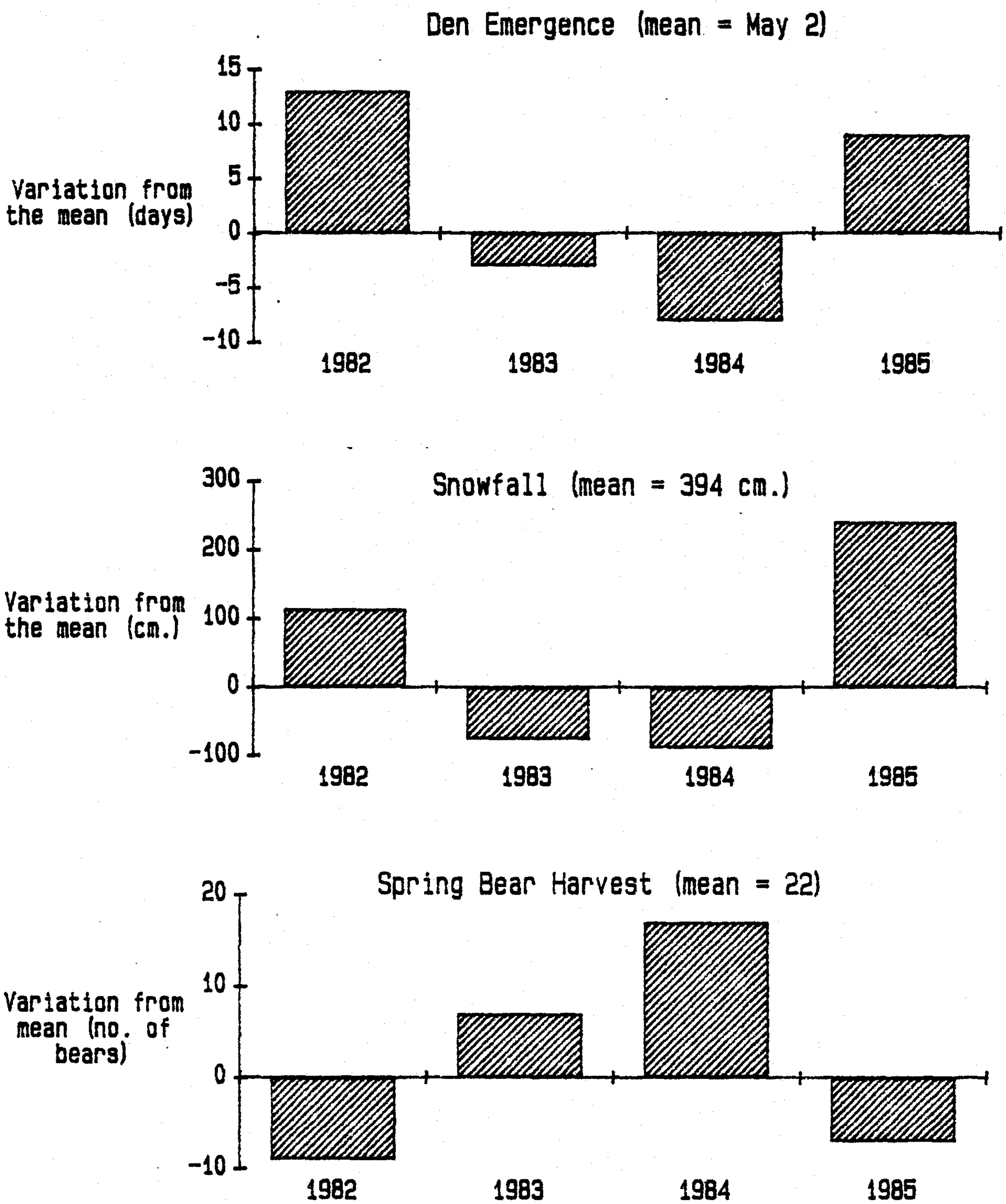

Fig. 3. Relationship between spring den emergence of radio-collared brown bears, winter snowfall at 425 m, and spring bear harvest on Admiralty Island, 1982-85.

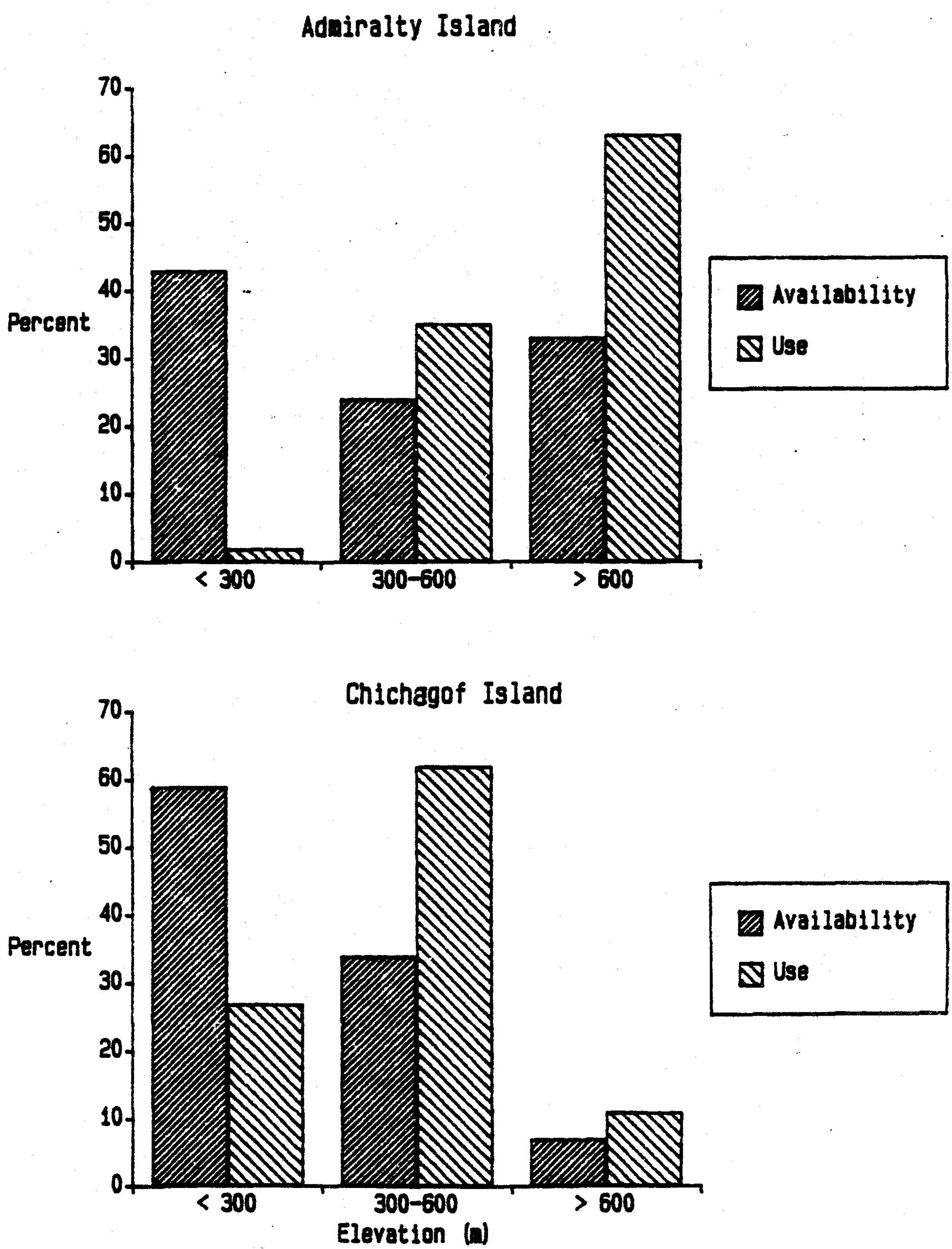

Fig. 4. Frequency of occurrence of brown bear den sites relative to availability of elevation intervals on Admiralty and Chichagof Islands.

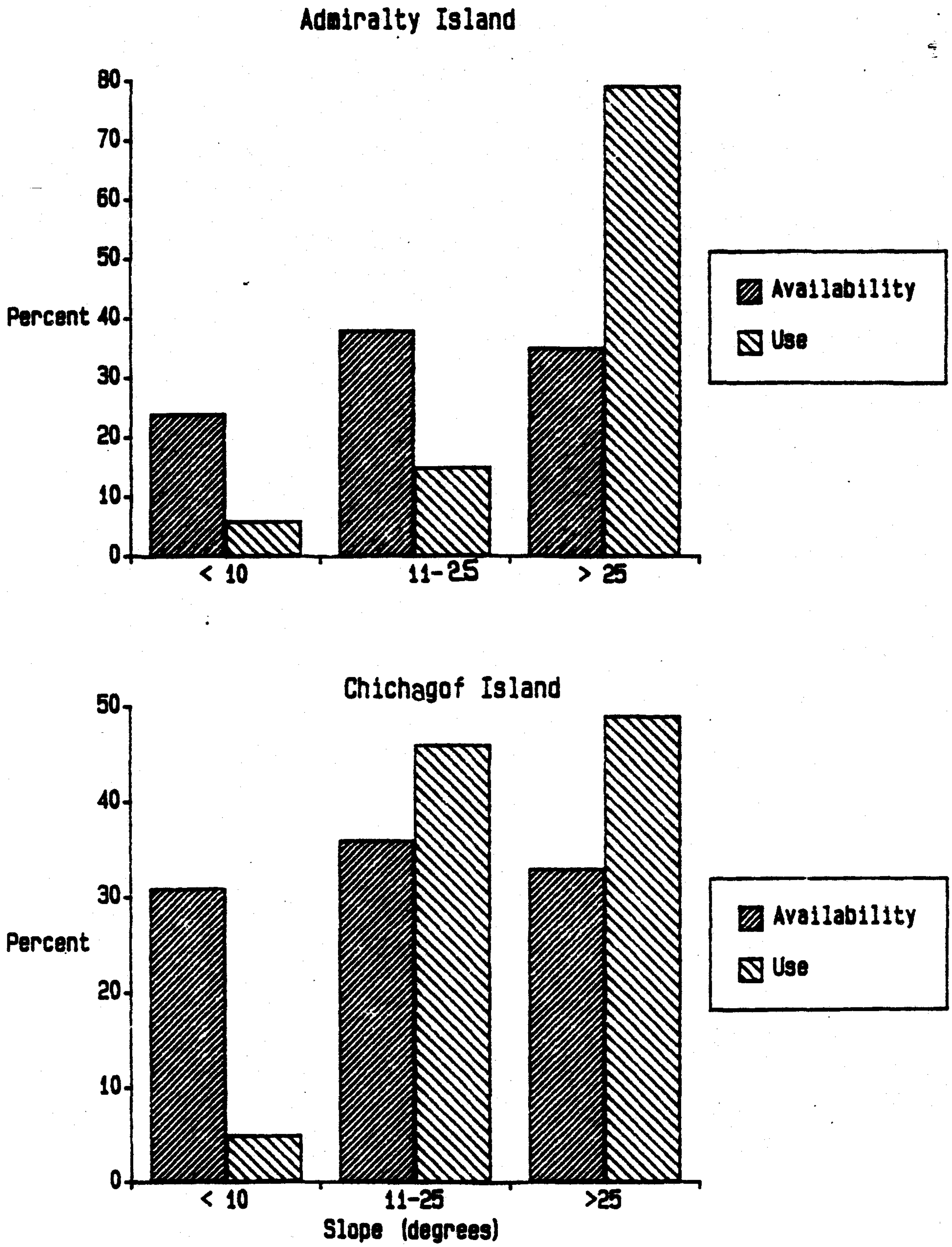

Fig. 5. Frequency of occurrence of brown bear den sites relative to availability of slope categories on Admiralty and Chichagof Islands.

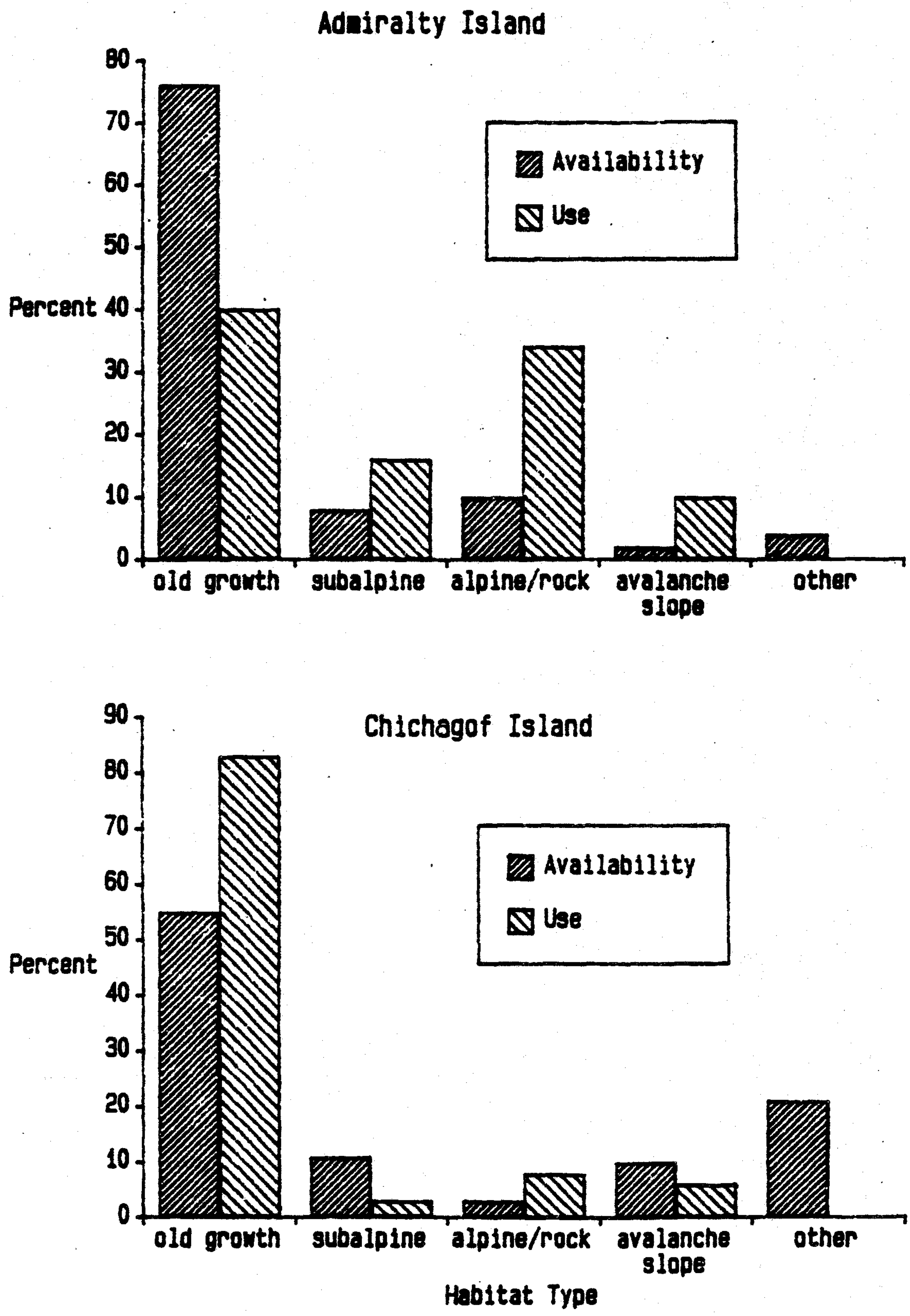

Fig. 6. Frequency of occurrence of brown bear den sites relative to availability of habitat types on Admiralty and Chichagof Islands.

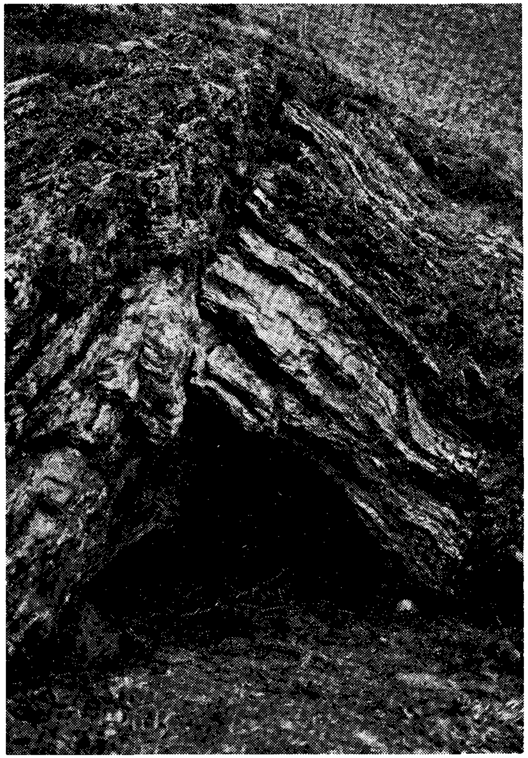

Fig. 7. Brown bear den in a rock cave in the high alpine of Admiralty Island, southeast Alaska.

Fig. 8. Brown bear den excavated under a Sitka spruce tree in old-growth forest on Chichagof Island, southeast Alaska.

Fig. 9. Brown bear den excavated into a large-diameter snag with well-developed heart rot in old-growth forest on Chichagof Island, southeast Alaska.

Table 1. Mean dates of den entrance and emergence of radio-collared brown bears by sex and reproductive status on Admiralty and Chichagof Islands, fall 1981 through fall 1985.

Sex/reproductive status	Mean date of den entrance	Range (days)	N	Mean date of den emergence	Range (days)	N
Parturient females	Oct. 22	25	17	May 11	72	18
Females w/young	Oct. 27	44	23	May 16	61	18
Single females	Nov. 5	40	22	April 29	52	16
Males	Nov. 5	58	30	April 19	57	28

Table 2. Mean annual dates of den entrance and emergence of radio-collared brown bears on Admiralty and Chichagof Islands.

Year	Mean date of den entrance	Range (days)	N	Mean date of den emergence	Range (days)	N
1981-82	Oct. 20	15	4	May 15	22	5
1982-83	Nov. 3	33	15	April 29	43	17
1983-84	Oct. 28	66	29	April 24	64	28
1984-85	Oct. 30	38	31	May 11	74	34
1985-86	Nov. 2	31	27			
Total mean	Oct. 30	68	107	May 2	95	84

Table 3. Elevation and slope of brown bear dens by area, sex, and distribution on Admiralty and Chichagof islands, southeast Alaska, 1981-85.

Category	Elevation (m) $\bar{x}$	SE	Min	Max	N	Slope (degrees) $\bar{x}$	SE	Min	Max	N
All dens	640	21	6	1190	121	35	1.0	5	75	121
Admiralty dens	713	23	6	1190	86	36	1.2	5	60	86
Chichagof dens	460	25	210	760	35	31	1.8	20	75	35
Male dens	535	47	6	915	29	30	2.0	5	45	29
Female dens	658	23	240	1190	85	36	1.2	10	75	85
Coastal[a] dens	674	28	370	1100	42	34	1.6	10	60	42
Interior[a] dens	848	41	460	1190	18	42	2.0	20	55	18

[a] Distribution status of Admiralty females.

Table 4. Frequency of habitat types for brown bear dens by area and distribution on Admiralty and Chichagof islands, southeast Alaska, 1981-85.

Den category	N	Habitat type (%)				
		Old-growth forest	Avalanche slope	Subalpine forest	Alpine	Rock
All dens	121	52	9	13	13	13
Admiralty	86	40	10	16	15	19
Chichagof	35	83	6	3	8	0
Coastal[a]	42	0	17	11	33	39
Interior[a]	18	52	7	17	10	14

[a] Distribution status of Admiralty females.