BROWN BEAR SUMMER USE OF ALPINE HABITAT ON THE KODIAK NATIONAL WILDLIFE REFUGE

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Abstract: Brown bear (*Ursus arctos middendorffi*) alpine summer habitat use patterns were studied at the Kodiak National Wildlife Refuge in 1973, 1974, and 1975. Seven plant communities were described and mapped within the alpine and subalpine zones of the 56.5-km^2 study area. Single bears and family groups showed an almost exclusive preference for *Carex macrochaeta* as the primary food. Alpine activity areas, determined for 29 individually identified bears, were small; those of lone adults were twice the size of those females with young, 1.70 and 0.85 km^2, respectively. The average density was 0.85 bear/km^2 but rose to 2.60 bears/km^2 in an area where animals concentrated to feed. Bears spent 5-6 weeks in the high mountains, abruptly departing when young *Carex macrochaeta* plants were no longer being produced.

In Alaska, little effort has been directed towards studying brown bear use of alpine habitat. Alpine investigations have been confined to denning studies on the Alaska Peninsula and Kodiak Island (Lentfer et al. 1972). Annual alpine composition counts on the Kodiak National Wildlife Refuge have revealed many bears (*U. a. middendorffi*) in summer months. A study was conducted during 1973, 1974, and 1975 to determine the reasons for their presence.

Brown bears (*U. a. arctos*) in Europe, and Russia (*U. a. beringianus*) also commonly use high mountains in summer. Curry-Lindahl (1972), referring to European bears, states that these animals visit alpine areas in late summer to feed on berries. He comments on Scandinavian populations by adding (p. 78) that some "subalpine birch forests . . . are characterized by a luxurious vegetation, which offers the bear optimal habitats." Novikov (1956) reported that brown bears in interior Russia make regular seasonal vertical migrations into the mountains, frequenting the alpine zone to an altitude of 2,800 m or higher. In eastern Siberia, where the habitat resembled that of southwestern Alaska, Kistchinski (1972:70) says that brown bears "often" move up to the alpine zone at 1,500-1,800 m by July. Brown bears in the Austrian Alps (Krott 1962) and in Italy's Abruzzo National Park (Zunino and Herrero 1972) move into the alpine zone in late spring to graze on the freshly sprouted greenery of the high mountain meadows.

Grizzly bears (*U. a. horribilis*) also utilize alpine vegetation. In Canada, Mundy and Flook (1973) report that grizzlies move from avalanche slopes and lower forests in the spring and early summer to alpine meadows in midsummer and back to lower elevations in autumn. These authors further state that the movements seem related to the availability of natural foods and that the greater density of these bears in Glacier National Park can be attributed to the highly productive alpine and subalpine vegetation.

Brown bear habitat in Alaska is under disruptive pressures from several sources. The Alaska Native Claims Settlement Act is causing millions of hectares of wildlands to be transferred from public to private ownership, with potential exploitation of natural resources likely in many areas. On the Kodiak National Wildlife Refuge, 140,000-224,000 ha of bear habitat will be patented to Native villages. The search for oil on the Alaska Peninsula and in the Gulf of Alaska, with attendant construction of onshore staging facilities, and increased timber harvests in coastal southcentral and southeastern Alaska, all pose threats to bear habitat. As man continues to infringe on these wildlands, effective management schemes will have to be based on a sound knowledge of the bears' habitat use patterns if more than remnant populations are to be perpetuated.

The study objectives were (1) to define the major plant communities in the study area, (2) to measure bear use of each community and determine the most important plant species sought, and (3) to determine summer alpine activity areas (a unit of alpine habitat used to fulfill normal living demands) used by family groups and single bears.

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STUDY AREA

The Kodiak Island group (Fig. 1) is positioned in the Gulf of Alaska southeast of the Alaska Peninsula. Kodiak, the largest of the 3 main islands, is approximately 96 km by 160 km. It is typified by fjord-like bays penetrating as far inland as 50 km. These bays and associated cirques and U-shaped intermountain valleys were created by the scouring action of Pleistocene glaciers. The result is a succession of mountain spurs flanked by fjords and valley extensions (Karlstrom and Ball 1969). Rugged mountains rising to a maximum of 1,360 m dominate the island's interior. Sharp crested alpine peaks protrude from the main northeast-trending axis of the range, and broad ridges extend to the northwest.

The island's climate is influenced by the Japanese Current; therefore, temperatures are mild, with extremes at sea level seldom fluctuating below -18C or above 27 C. Frost occurs every month of the year at altitudes higher than 700 m. Annual precipitation is 157 cm, with drizzle and fog common. Cyclonic lows move in from the Aleutian Islands and cause frequent precipitation and windstorms throughout the year.

The most characteristic vegetation of Kodiak Island, from sea level to the brush line at about 580 m, is an alder (*Alnus* sp.) - willow (*Salix* spp.) complex that is interspersed with lush grass-forb meadows. Cottonwood (*Populus trichocarpa*) grows along river valleys and stunted birch (*Betula papyrifera* var. *kenaica*) occurs on gentle slopes below 250 m. The 1 conifer present, Sitka spruce (*Picea sitchensis*), is confined to the northeast section of the island.

About 80 percent (7,200 km^2) of Kodiak Island's southwest portion constitutes the Kodiak National Wildlife Refuge. On one of the remote mountain spurs within the refuge, a 56-5 km^2 alpine study area was selected because of heavy summer use by bears (Fig. 1). The study area, which dips into the subalpine zone, is about 9.7 by 5.8 km, and is comprised of mountainous terrain ranging in elevation from 305 to 1,316 m. It is located on the west side of Kodiak Island between Uganik Lake and the head of the South Arm of Uganik Bay, 64 km west-southwest of municipal Kodiak.

METHODS

The study area was monitored each year with a fixed-wing aircraft, commencing in late April, to determine when bears first moved to the high country. Flights were conducted at approximately 10-day intervals until the field crew was on site. Personnel stayed in the mountain study area as long as bears remained. To minimize disturbance, party size was limited to 2. Plant identifications were based on Hultén's (1968) *Flora of Alaska and Neighboring Territories* and were corroborated by D. Murray, curator of the University of Alaska herbarium. Plant communities were identified by using Hjeljord's (1971) Kodiak alpine vegetation analysis as a reference and were then mapped for the entire study area at a scale of 1:15,840. In determining the communities, Hanson and Churchill's (1961:66) generalized definition was followed, i.e., "a group of stands that are similar in species composition and structure and occupy similar habitats." The term *alpine* as used in this paper refers to the entire study area, and unless stated otherwise, includes the subalpine zone comprised of the Willow Field - Subalpine Meadow and protruding tongues of the Alder Community's upper limits.

Bear observations were made daily, using variable-power (20-45X, 15-60X) spotting scopes at distances of 50 m to 2 km. With little vegetation to hide them, bears were easily observed in the high mountains. The entire study area was searched once a week, but locations where these animals concentrated, as determined from aerial and ground surveys, were monitored every 1 or 2 days. Thus, the same bears were usually seen several times a week and frequently for several consecutive days during each week. Bears were observed continuously for as long as conditions allowed. Their activities were noted and coded in sequence so that an observation usually consisted of a series of activities.

Repeated observations of the same bears in open country allowed the field team to identify many animals individually. Size, conformation, deformities, pelage shedding patterns, pelage color, and scars were distinguishing characteristics. Sex, age, family groupings, and behavior traits were also distinguishing factors, leading to high confidence in the identification of individuals. Other investigators have used similar physical and behavioral peculiarities to identify individual animals (Burkholder 1959, Meehan 1961, Woodgerd 1964, Craighead et al. 1974, Martinka 1974).

Boundaries of activity areas were established by connecting the outermost position locations, as determined from ground observations, with straight lines.

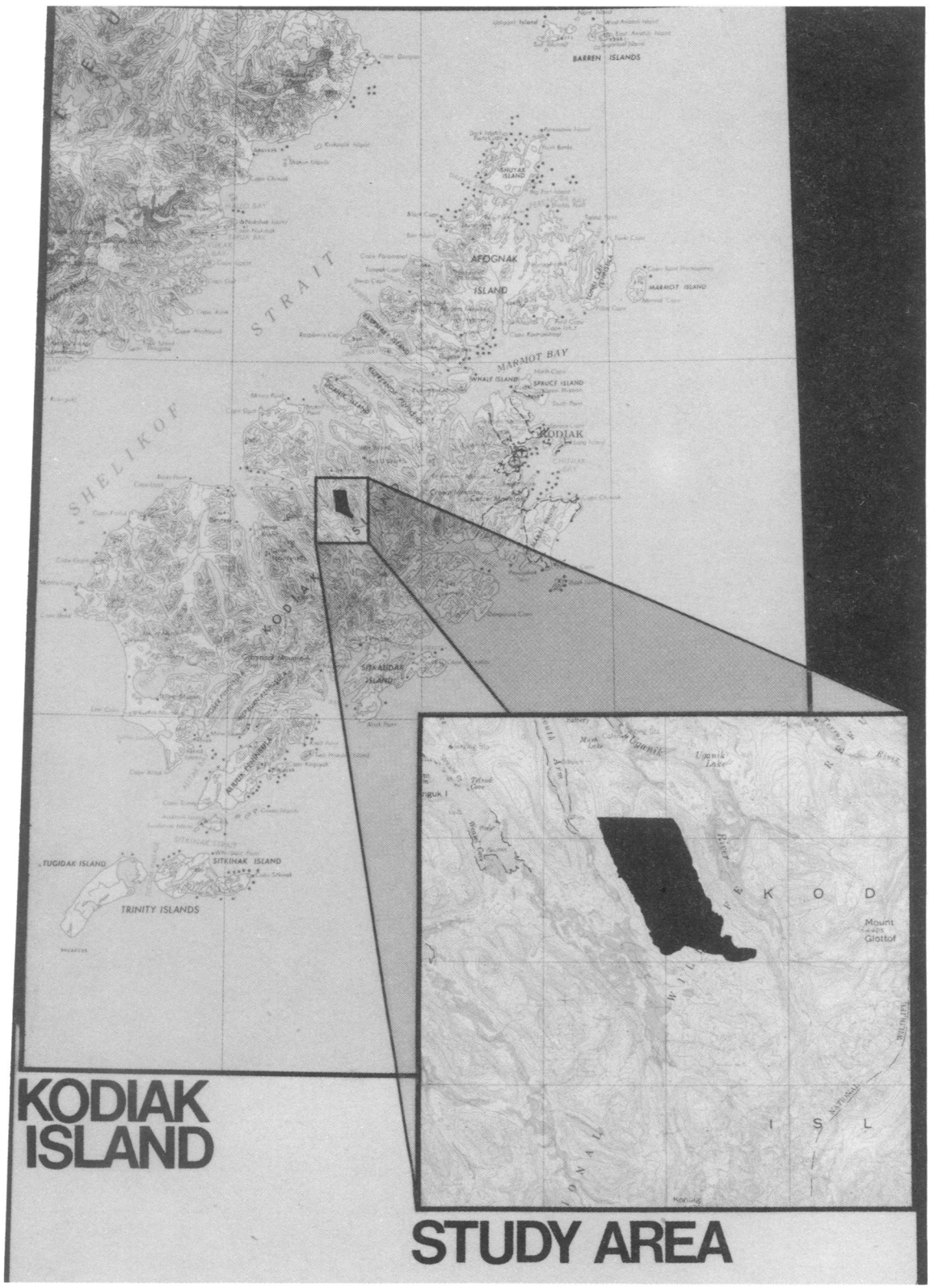

Fig. 1. Kodiak Island and the alpine study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

The alpine zone was never completely without snow, the amount varying at any given time from year to year. In both 1973 and 1975, the study area remained completely snow-covered through the first 3 weeks of May. New growths of grasses, sedges, and forbs did not appear on snow-free areas until the first week of July. Snow in gullies, hollows, and chutes receded gradually through mid-August, continuously releasing shoots of fresh vegetation.

By contrast, the spring of 1974 was unusually warm and sunny; a few ridges and knolls were exposed the first week of May. By the second week of June, snowslides had cleared some south- and southwest-facing slopes and plant growth occurred. Snowmelt, and consequent plant development, were 2 weeks earlier in 1974 than in 1973 and 1975.

RESULTS

Plant Communities

The identity of 99 different plant species was established and 7 communities were recognized (Table 1).

Table 1. Plant community criteria for the alpine and subalpine zones of the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

Plant community	Characteristics	Most common species	Altitude range	Aspect	Slope
Carex-Forb Meadow	A thick, nearly continuous growth of *Carex macrochaeta* mixed with numerous broad-leaved species. Ericaceous plants are absent. Soil fertility is high and the sites, frequently located below snowbanks and rocky outcroppings, are well supplied with moisture.	*Carex macrochaeta, Calamagrostis canadensis, Anemone narcissiflora, Lupinus nootkatensis, Geranium erianthum, Veratrum eschscholtzii, Angelica lucida, Arnica latifolia.*	670-945 m	South and southwest	30-50°
Ericaceous Knolls and Hummocks	Differs from Carex-Forb Meadows in having overall gentler topography, lower average fertility, and the presence of interrupted mats of Ericaceae species. Both xeric and mesic conditions exist and, together with a wide variety of soils and microenvironments, contribute to species diversity.	Rocky, exposed knolls are dominated mainly by *Empetrum nigrum, Cassiope stelleriana, Oxytropis nigrescens, Sedum rosea, Loiseleuria procumbens, Salix arctica,* and *Arnica lessingii.* Rolling hummocks and mixed meadow slopes between the rocky knolls are densely vegetated with *Carex macrochaeta, Festuca altaica* tussocks, *Poa arctica, Calamagrostis canadensis, Empetrum nigrum, Anemone narcissiflora, Lupinus nootkatensis, Salix reticulata,* and *Salix barclayi.*	670-790 m	No specific aspects.	0-40°
Rocky Carex-Forb Meadow	Moderately vegetated, very precipitous, and interrupted by extensive rocky outcroppings. Ordinarily situated immediately above Carex-Forb Meadows.	Most of the same species found in Carex-Forb Meadow, but also some hardier plants found on higher-stress sites such as Ericaceous knolls; these include *Cassiope stelleriana, Empetrum nigrum, Rhododendron camtschaticum,* and *Geum rossii.*	790-1,130 m	South and southwest	50-80°

Table 1, Continued

Plant community	Characteristics	Most common species	Altitude range	Aspect	Slope
Talus Slope and Bare Rock	This community is characterized by rocks, volcanic ash, and little vegetation. It is a xeric community, even though it becomes snowfree late in the year.	Scattered clumps of *Luzula wahlenbergii.*	Usually above 915 m but occasionally as low as 760 m in areas covered by snowbanks most of the summer.	Most frequently on steep north-facing slopes but may be found on almost any aspect.	Mainly 40-90° but sometimes 30-40°
Luzula-Congeliturbation Slope	These slopes are sparsely vegetated, xeric, and of low fertility. They are located where environmental conditions are severe. Loose volcanic ash is interspersed with rock slides and barren late snow-free areas. Frost action is manifest in soil lobes with obvious downslope creep; frost scars and miniature stone rings may be present.	*Luzula wahlenbergii, Sedum rosea,* prostrate *Salix* sp., *Saxifraga bronchialis, Papaver alaskanum, Potentilla villosa, Oxytropis nigrescens, Carex* sp., *Geum rossii, Silene acaulis, Minuartia* sp., and *Luetkea pectinata.*	760-1,220 m	North	15-50°
Willow Field-Subalpine Meadow	This type encompasses the transition zone between the true alpine and lower Alder Community. Fertile soil and an abundant moisture supply make it high in plant productivity.	*Carex macrochaeta, Calamagrostis canadensis, Salix barclayi, Salix glauca, Salix* sp., *Geranium erianthum, Arnica latifolia, Heracleum lanatum, Rubus spectabilis,* and *Alnus crispa.*	490-730 m	Any aspect	0-35°
Alder	This community is characterized by a discontinuous belt of *Alnus crispa* interspersed with dense meadows of grasses, sedges, ferns, and forbs, the result of deep, fertile soil and a good moisture supply.	*Calamagrostis canadensis, Carex macrochaeta, Athyrium filix-femina, Rubus spectabilis, Sambucus racemosa, Salix* spp., *Heracleum lanatum, Geranium erianthum,* and *Alnus crispa.*	580 m and below	Any aspect	0-65°

There was considerable variation in community size (Table 2). As the largest, Ericaceous Knolls and Hummocks covered 40 percent of the study area. The Alder and Willow Field-Subalpine Meadow communities were second at 19 percent each, with the remaining 4 plant aggregations accounting for a total of 22 percent of the land area.

Bear Use of Alpine Habitat

Bear tracks first appeared on the study area in early May each year but were not common until late May. Bear occurrence was not continuous until the last week of June or the first week of July when new vegetation was available in quantity on the snow-free south- and southwest-facing slopes. Ground team observations began after continuous occupation by bears. Bear numbers generally increased through the second and third weeks of July, then slowly declined. In the first half of August, the animals abruptly left the study area.

A total of 804 hours were spent, during the 3 years, observing 305 individual bears and family groups (Table 3). Activity sequences for this period numbered 2,077. An average of 29 different bears was individually identified yearly. An average of another 42 was seen too infrequently to establish sufficient criteria for field recognition. These latter individuals were mainly transient animals, but undoubtedly some bears with established identities were occasionally included in this category when seen for only brief periods.

Fifty percent of the time that bears were under observation, they were feeding; plants consumed were identified in about half the instances. These plants in-

Table 2. Comparison of plant community sizes within the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75. Water surface areas are excluded.

Plant community	Area (ha)	Percent of study area
Ericaceous Knolls and Hummocks	2,247	40
Alder	1,071	19
Willow Field-Subalpine Meadow	1,072	19
Carex-Forb Meadow	492	9
Talus Slope and Bare Rock	339	6
Luzula-Congeliturbation Slope	287	5
Rocky Carex-Forb Meadow	100	2
Total	5,608	100

Table 3. Total brown bear observations by year on the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

	1973	1974	1975	Total
Number of observations (may include more than one observation of same animal)	84	120	101	305
Number of activity sequences (a series of all activities documented while an animal was under observation)	448	884	745	2,077
Number of different individually identified bears (does not include young in company of an adult)	15	44	29	86[a]
Total observations of individually identified bears	46	47	86	179
Bears not individually identified	38	73	15	126
Time bears were observed (hours)	164	366	274	804

[a] Only 1 animal with known identity was observed each of the 3 years.

cluded *Angelica lucida, Carex macrochaeta, Carex* sp., *Equisetum arvense, Heracleum lanatum, Lupinus nootkatensis,* and *Salix* sp. When bears fed on known plant species, they were almost exclusive in their choices and concentrated on *Carex macrochaeta* 97 percent of the time. Bears frequented the steep Carex-Forb Meadow Community on south- and southwest-facing slopes in the 670- to 945-m altitude range where *Carex macrochaeta* grew in lush and almost pure stands (Table 1). The Carex-Forb Meadow prevailed in areas having a good moisture supply. In these locations, bears fed along the hillsides in a manner similar to that of grazing ruminants, and, as has been noted for other grazers, they probably select the highest-quality forage available (Klein 1970). *Carex macrochaeta* was pulled, rather than bitten off, and separated from the roots to expose whitish basal stems. Several mouthfuls were taken before the material was chewed and swallowed.

As snow receded in depressions, new growths of *Carex macrochaeta* were continuously released through July. By the second or third week of August (first week in 1974), the perimeters of the snowbanks had melted, exposing ash and scree. These areas ordinarily are snow-covered for so much of the year that they are devoid of vegetation.

The early development, extreme abundance, apparent palatability, and high utilization of *Carex macrochaeta* made it the most important component in the bears' alpine diet. Second to sedges, bears preferred feeding on flowers of *Angelica lucida, Heracleum lanatum,* and *Lupinus nootkatensis.*

Eighty-two percent of the bears' time was spent in 2 plant communities in which 88 percent of their feeding occurred (Table 4). By far the most important community was the Carex-Forb Meadow, where the bears spent 65 percent of their time and which accounted for 73 percent of their feeding. Apparently, bears concentrate in these areas because of the key alpine food *Carex macrochaeta*. Although this sedge is available in several communities, it is only abundant in Carex-Forb Meadow and Willow Field-Subalpine Meadow complexes (Table 5). Because of steeper slopes, which trigger snowslides earlier in the higher Carex-Forb Meadows, spring shoots emerge about 2 weeks earlier there than in the Willow Field-Subalpine Meadows. In addition, *Carex macrochaeta* concentrations in the former community are more nearly pure.

Table 4. Percentage of time brown bears were observed in each of 7 plant communities within the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

Plant community	All activities combined (percent)	Feeding only (percent)
Carex-Forb Meadow	65	73
Willow Field-Subalpine Meadow	17	15
Ericaceous Knolls and Hummocks	8	8
Rocky Carex-Forb Meadow	6	2
Luzula-Congeliturbation Slope	2	1
Alder	1	1
Talus Slope and Bare Rock	1	0
	Observations total 801 hours	Observations total 393 hours

Activity Areas

In a sample of 17 individually identified family

Table 5. ***Carex macrochaeta*** **occurrence by plant community within the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.**

Community	*Carex macrochaeta*
Carex-Forb Meadow	Abundant in nearly pure stands
Willow Field-Subalpine Meadow	Extensive and predominant, but in mixed stands
Alder	Moderate, but mainly in mixed stands
Ericaceous Knolls and Hummocks	Light, with occasional almost pure pockets
Rocky Carex-Forb Meadow	Light and scattered
Luzula-Congeliturbation Slope	None
Talus Slope and Bare Rock	None

groups composed of females with cubs or yearlings, the average activity area was 85 ha (Table 6). When 1 aberrantly large activity area of 834 ha is included, the average becomes 127 ha. For 12 solitary adults assumed to be mostly males, the average activity area was 170 ha, twice the average for females with young. In a paired t-test this difference was significant ($P < 0.025$). Apparently, the dense stands of *Carex macrochaeta* made it unnecessary for bears to move long distances for food, as demonstrated by the size of alpine activity areas.

Table 6. Sizes of activity areas of single adult brown bears and family groups within the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

	Sample size	Number of position locations	Activity area average size (ha)
Females with cubs-of-the-year	10	135	94
Females with yearlings	7	57	72
Females with young (above 2 categories combined)	17	192	85
Single adults	12	195	170
	29	387	120

Activity areas for succeeding years were determined for only 1 animal — No. 06-73 (Fig. 2). One hundred and seven position locations for this bear were recorded during the 3 years. Locations were concentrated in the Carex-Forb Meadow Community adjacent to 2 cirque lakes. No. 06-73 returned to the same alpine area each year but made occasional feeding forays, of less than 3 days each, up to 1.6 km east over a low pass. The straight-line distance of these trips increased in 1974 and 1975. As a result, the activity areas became larger: 1973 — 166 ha, 1974 — 209 ha, and 1975 — 472 ha.

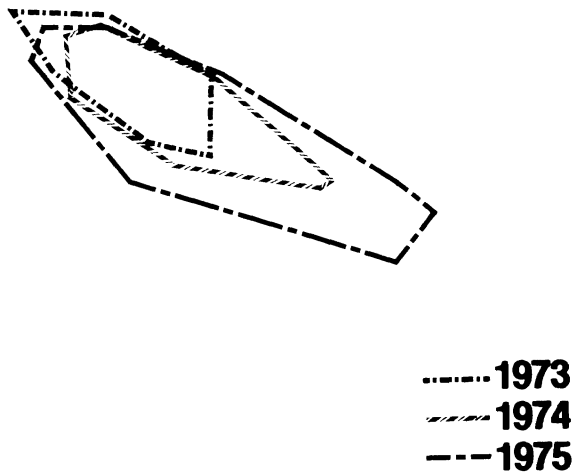

Fig. 2. Alpine activity areas of brown bear No. 06-73 for 3 consecutive years (1973-75), Kodiak National Wildlife Refuge, Alaska.

Bears tended to congregate, as reflected in the overlapping activity areas shown in Fig. 3. On 2 August 1975, 32 bears were under observation simultaneously in an area roughly 2.5 by 5.0 km, for a density of 2.6 bears/km^2. Even with these high concentrations, intraspecific strife was not common. Occasionally a female with cubs chased a solitary adult that wandered too close, or 1 lone adult ran at another, but no encounters that we witnessed ever ended in physical contact.

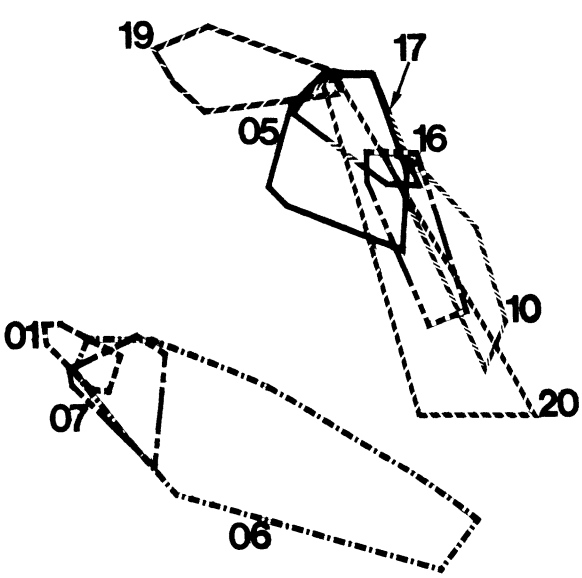

Fig. 3. Alpine activity areas of individually identified brown bears on the study area, Kodiak National Wildlife Refuge, Alaska, 1973-75.

Age Composition of Bears

Age composition for the 581 bears seen during the study is compared with aerial count data in Table 7. The most obvious differences occur in the cub and subadult categories. Particularly lush growths of the preferred *Carex macrochaeta* may attract and concentrate family groups, which would account for the higher percentage of cubs. Females with cubs, while on the study area, were apparently able to obtain their food in relatively small units of alpine habitat.

Table 7. Composition of brown bear age classifications as determined by aerial and ground counts, Kodiak National Wildlife Refuge, Alaska, 1973-75. Aerial counts were conducted annually on predesignated alpine units of which the study area represents 17 percent.

Age classification	Aerial counts		Study area ground counts	
	Number	Percent	Number	Percent
Adults	196	48	261	45
Subadults (2.5-3.5 years old)	55	13	32	5
Yearlings	68	17	90	15
Cubs	89	22	198	35
Total	408		581	

Migration From Study Area

Bears typically left the study area rather abruptly each year. This migration coincided with a marked decrease in availability of sedge shoots. In 1973, bear observations were numerous through 17 August but only 2 sightings were recorded afterwards. The bears departed earlier in 1974 than in either of the other 2 years but not as abruptly. During the 1975 field season, bears were consistently located in moderate numbers through 10 August; only 1 animal was found after that date.

Salmon (*Oncorhynchus* spp.) began arriving in Kodiak Island's spawning systems adjacent to the study area in early June but were most numerous during the second half of August. In the nearest stream, the Uganik River, peak counts during the study by biologists of the Alaska Department of Fish and Game averaged 77,000 salmon per year. These fish became available and were heavily utilized by bears when new sedge shoots were no longer being produced in the alpine zone.

DISCUSSION

Bears appeared to have been attracted to the study area each summer primarily by *Carex macrochaeta* — a localized but abundant, fast-growing, and probably highly nutritious food (Mealey 1975). This sedge is one of the earliest plants to emerge after snowmelt. Initial growth is rapid because of the large amounts of carbohydrates stored in the roots and rhizomes (Johnson and Tieszen 1973). Klein (1970) has stated that the highest nutritive quality of most forage plants coincides with the early stages of growth, which is probably true of *Carex macrochaeta*.

Cubs only 6-7 weeks out of the den have rapid growth rates, placing heavy dietary requirements on their lactating dams, who in turn must not only feed their young but must also recover from the vicissitudes of denning. The lush stands of *Carex macrochaeta* may satisfy these needs.

The bear density was high on the study area, 0.85 bear/km^2, determined from individually identified animals seen on 2 or more occasions. This density approximates the 0.65 bear/km^2 found by Troyer and Hensel (1964) in a 249 km^2 study area at Karluk Lake on Kodiak Island, where brown bears had concentrated to feed on salmon, another easily available and probably nutritious food (Mealey 1975). Kistchinski (1972:69), citing Lavov et al. (1963), quoted figures of 1.2-2.0 bears/km^2 for parts of Paramushir Island (Kurile Islands, USSR) rich in fish, but did not include the size of the land mass involved.

Activity areas were small and frequently overlapped. Troyer and Hensel (1964) found brown bear movements to be similarly limited in the vicinity of dense spawning areas. Most animals remained there for several weeks within 1.6 km of their food supply.

Brown/grizzly bears are known to congregate seasonally at sources of preferred foods and in this study the Carex-Forb Meadow Community was especially important. There, and to a lesser degree in the Willow Field-Subalpine Meadow, activity areas frequently overlapped. Animals so localized would be those whose home ranges encompassed the feeding area, as reported for black bears (*Ursus americanus*) by Jonkel and Cowan (1971). One individually identified bear returned each year to the same part of the study area, which indicates that others may have done the same.

After 5-6 weeks of grazing in the high mountains, the bears abruptly left. Their departure coincided with the return of spawning salmon, similar to what Kistchinski (1972) reported for eastern Siberia. Whether the presence of salmon at Kodiak Island attracts the bears from the alpine areas is not known; however, the bears' departure occurs at the time salmon become readily available. Most likely, as alpine plants become less palatable with age, the bears merely leave to seek substitute foods and the salmon fulfill this need.

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