# EFFECTS OF HUMAN ACTIVITY ON BROWN BEAR USE OF THE KULIK RIVER, ALASKA

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***Abstract:*** I systematically observed brown bear (*Ursus arctos*) and human activity on a sockeye salmon (*Oncorhynchus nerka*) stream in Katmai National Park during fall 1993 and 1995. More than 700 hours of observations were used to determine the temporal and spatial use patterns by people and bears as well as the frequency, nature, and outcome of bear–human interactions. Bears altered their temporal and spatial use of the river to accommodate human activity, seeking times and places where human use was lowest. Bear–human interactions were primarily the result of people venturing into areas of concentrated bear activity, rather than bears entering areas heavily used by people. Approximately one-fourth of bears involved in bear–human interactions left the river, not to return for several hours. Bears acted differently in river zones dominated by people than in zones dominated by bears in that they spent less time on the river, less time resting, and more time moving about in human-dominated zones. The data suggest that as long as there are areas where bears can avoid human activity, they will seek them to gain access to salmon. If, however, human use of the river continues to increase as it has the past decade, the day may come when there will be no more room for bears.

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***Key words:*** bear–human interactions, brown bear, human activity, Katmai National Park, *Ursus arctos*

Knowledge of brown bear activity patterns permits scientists to: (1) establish a baseline activity pattern against which future observations can be compared, (2) delineate diel activity patterns which can be used to minimize undesirable bear–human interactions, and (3) schedule census and research efforts for optimal times (Interagency Grizzly Bear Committee 1987). Factors that may influence bear activity patterns include: (1) weather, (2) time of day and year, (3) lunar phase (as related to light levels and tidal cycle), (4) size, quantity, and distribution of food resources, (5) individual social status and presence of conspecifics, (6) individual physiological state (e.g., pregnant versus barren), (7) timing, distribution, and intensity of human activity levels, and (8) variation of individual bears. Bear activity patterns are primarily crepuscular (Stokes et al. 1981, Schleyer 1983, Harting 1985, Phillips 1986), although exceptions have been observed (Olson et al. 1998). The purpose of this study was to characterize bear and human activity patterns at the Kulik River to assist National Park Service (NPS) management of the area.

In 1988, Olson et al. (1990) began documenting human and bear activity at Kulik River. They sampled systematically dawn to dusk from 16 August through 14 September, the same period I sampled in 1993 and 1995. They observed that most human activity was focused in downstream areas bordered by willow–alder scrub (*Salix* spp.–*Alnus* spp.) (zones 1–3; Fig. 1), whereas bear activity was greatest upstream (river zones 6–7, Fig. 1). They also found that bear activity was crepuscular and human activity peaked around mid-day. Consequently, Olson et al. (1990) concluded that the daily pattern of bear use showed a clear inverse relationship to human use in the river zones with the highest human activity. Human use patterns shifted significantly between 1988 and 1993 when I began my study (T.S. Smith, 1995, Brown bear and humans at Kulik River, Katmai National Park and Preserve: patterns of activity, behavior and interaction; U.S. Geological Survey [USGS], Anchorage, Alaska, USA). Anglers no longer concentrated in zones 1–3, but dominated zones 6–7. This shift in fishing activity, which likely was due to guides discovering better places to fish in late summer–early fall (B. Bennett, Kulik Lodge, Katmai National Park, Alaska, USA, personal communication, 1997), provided an opportunity to analyze bear response to a shift in human use patterns.

Park managers, responsible for maintaining the natural setting and providing recreational opportunities for visitors, have been concerned that concurrent human activity may disrupt bear use of the river. Frequent disruptions may lessen foraging efficiency, displace bears from the salmon resource, alter natural behaviors, reduce reproductive rates, and cause bears to be inadequately prepared for hibernation (Bunnell and Tait 1981). Hence, documenting the levels of bear and human activity, as well as the frequency and nature of bear–human interactions, was the focus of this research. To accomplish this, I studied temporal and spatial use patterns of people and bears on the river from late August through mid-September, a time when bears were known to congregate at the river to feed on spawning salmon. I also documented the frequency and nature of bear–human interactions during the study period.

Experienced guides who know which areas provide the best sportfishing accompany most anglers on the Kulik. Anglers consistently fish the same areas in mid-August, when no bears are present, and late September, when many bears use the river. If bears are negatively influenced by human activity, one might expect to see (1) patterns of use and timing consistent with human avoidance, (2) behaviors reflective of wariness and unrest, (3) adverse bear–human interactions, (4) more use of the river by bears low in the social hierarchy in areas with high levels of

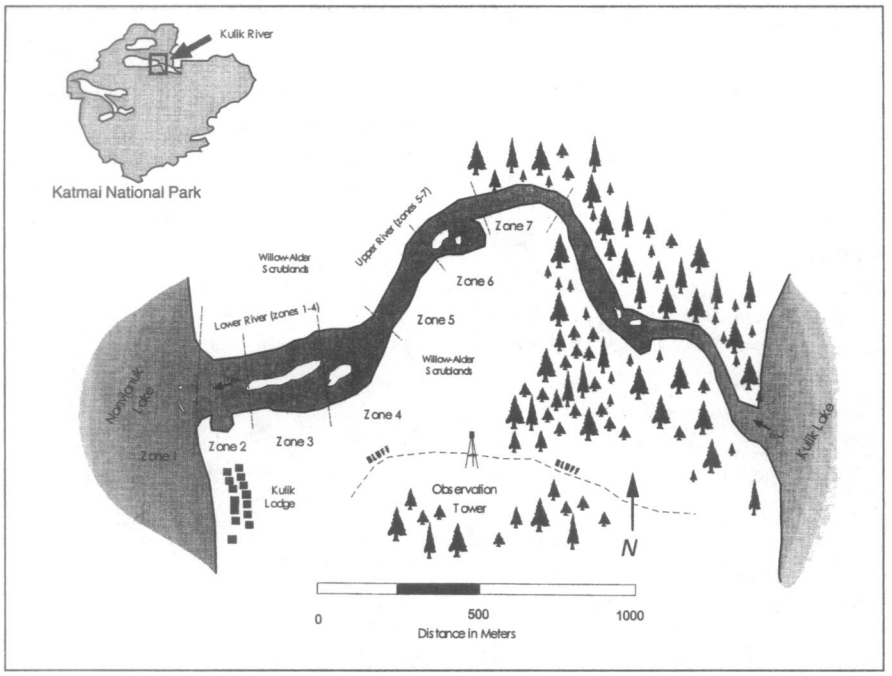


**Fig. 1. Location of the Kulik River study area, observation tower, and river zones 1–7, Katmai National Park, Alaska, USA.**

human use, (5) or any combination of these symptoms. To establish a cause and effect relationship between people and bears would have required manipulation of the timing and levels of human use, which was not allowed by the NPS or area lodges. Hence, this study was limited to an assessment of existing patterns for correlative evidence, which may suggest cause and effect but not establish it. Nonetheless, multiple correlations can strengthen the assumption of cause and effect (Romesburg 1981). The following null hypotheses were addressed by this work:

$H_{01}$: Brown bear temporal use of the Kulik River is independent of human activity.

$H_{02}$: Brown bear spatial use of the Kulik River is independent of human activity.

$H_{03}$: Brown bear behavior budgets along the river are independent of human presence.

$H_{04}$: Brown bear tolerance of humans does not vary by bears' sex, age, or reproductive status.

$H_{05}$: Brown bear-human interactions are a random, infrequent process without adverse effects to bears.

## STUDY AREA

Kulik River is a short (<3 km), shallow (mostly <2 m) waterway draining Kulik Lake into Nonvianuk Lake in the northern region of Katmai National Park (Fig. 1). Dense thickets of willow–alder scrub dominate the lower river while sparse stands of white spruce (*Picea glauca*) border the upper stretches. Small sedge meadows (*Carex* spp. and *Arctagrostis* spp.) are interspersed throughout. Alpine tundra south of the river supports many species of berries (*Rubus* spp., *Empetrum* spp., *Viburnum* spp., *Vaccinium* spp., and *Sorbus* spp.), providing bears extensive foraging in fall. Stands of birch (*Betula* spp.) and poplar (*Populus* spp.) lie just beyond the river's north shores. There are no significant ungulate (*Rangifer tarandus* and *Alces alces*) or ground squirrel (*Spermophilus variegatus*) populations at Kulik River. However, brown bears congregate along the river in late summer and fall to feed on dead and dying sockeye salmon, with occasional forays to nearby berry patches.

Lacking natural barriers and having a swift current, the Kulik River provides few opportunities for bears to capture live salmon. Hence, bears are rarely seen until late August when the first spawning salmon begin dying, even though salmon arrive in July. Bears obtain fish by searching shorelines for beached, dead salmon as well as by swimming with heads submerged in search of carcasses on the bottom.

Kulik Lodge is situated near the river's outflow into Nonvianuk Lake, hosts 16 guests daily from 15 June to 1 October, and is supported by a staff of 20. During summer and fall, 20–30 anglers and guides arrive daily by floatplane to fish for Kulik's trophy steelhead trout (*Oncorhynchus mykiss*). Serving as runway, taxiway, and travel corridor, the Kulik River experiences frequent aircraft arrivals, departures, over flights, and watercraft traverses daily. Consequently, this otherwise isolated wilderness stream experiences a surprising level of human activity, with as many as 12 aircraft and >30 anglers

scattered along the river on most days.

## METHODS

I observed human and bear use of the river corridor from a 7-m tower located on a bluff overlooking the river from 350 to 1,200 m away from the river zones I observed (Fig. 1). Although observations at this distance required high power optics, it minimized the influence of observer presence on bear and human activities. In 1995 the tower was moved 100 m east and 10 m higher than its 1988–93 location, improving the view of the river. An enclosed observation blind on top of the tower protected observers from wind and weather, enabling long-term observation while minimizing observer fatigue.

I subdivided the lower half of the river into 7 zones (Fig. 1). Zone lengths (mean = 100 m) were such that people and bears sharing the same zone were likely aware of, and capable of interacting with, one another. I did not record bear and human activity for the upper half of the river due to heavy tree and shrub cover.

We sampled from 0800 to 2000 Alaska Standard Time (AST), which enabled the field crew to safely travel through dense scrub and forest with acceptable light levels (dawn was just prior to 0800 AST and dusk near 2000 AST). Night observations were not attempted because night vision gear would not have been effective at the distances from which we observed the river.

We used instantaneous scan sampling (Altmann 1974) to record bear and human activities at 10-minute intervals for 72 scans/day. Only bears that were directly observed were recorded as present in a given zone, even when it was highly likely that they were present but were obscured by vegetation. Bears roamed freely throughout the river corridor, and I could never be certain where they were once they entered shrubbery bordering the river. However, when people were known to be in a zone but were not directly observed, they were counted as present and their activity recorded as unknown. I chose this sampling design because people came to the river either by plane or boat, had to leave that way, and were there to fish. They did not stray into the brush, but stayed on the river. All bear and human data were recorded on standardized data sheets.

We made no effort to identify individual people using the river. However, I did record individual bears and family groups and attempted to note when they were present during scan sampling. Although observation distances were great, many family groups were easily identifiable by number and color of dependent young. Similarly, some adult bears had unique pelage characteristics or other distinguishing traits that enabled us to note their presence. We classified bears into 1 of 4 categories: large males (as inferred by size), females with cubs born that year, females with dependent young (i.e., yearling and subadults), and single bears. On many occasions the sex of known single bears was determined by watching them urinate. Bear and human activities were placed in 1 of 12 categories unique to each group. Bear activities were fishing, consuming fish, consuming other, walking or wading, running, resting, showing aggression (with other bears), staring or scanning (toward other bears), social behaviors (e.g., playing), actively interacting (with people), scanning or staring toward people, and unknown. Human activities were fishing from shore, fishing in river (waders), fishing from boat, passing through on boat or plane, walking or wading, running, resting, photography, sightseeing, showing aggression to bears, avoiding or deferring to bears, and unknown. Weather information was recorded hourly and included temperature, wind speed and direction, cloud cover, and precipitation.

We used the all-occurrences sampling method (Altmann 1974) to document bear–human interactions. An interaction was defined as any event wherein the activity or presence of 1 species was close enough (<50 m) to influence the other. For example, when a bear was feeding midstream and a jet boat passed through the zone, a bear–human interaction incident was recorded regardless of the bear's response. Aircraft take-offs and landings were recorded as bear–human interactions whenever bears were <50 m of the moving aircraft. When an interaction occurred, I recorded the following: initiator (bear or person), river zone, distance between person and bear, sex–age class of bear, bear activity and human activity at time of interaction, result of interaction, and intensity of interaction.

I recorded all occurrences of watercraft and aircraft activity on the river. To be counted as an occurrence, boats and planes had to be in motion on the river (including floating, drifting, full speed traverses, take-offs, landings) and not moored on its banks. Each incidence of craft activity was recorded on standardized data forms and included the following information: date, time, river zone, craft type, number of people, speed, direction, and duration of activity.

Scan samples included only bears and people, not crafts moored along the banks of the river. However, the number of people in crafts in motion observed during a scan sample was counted. For analysis of bear and human use, crafts and people were treated separately.

Olson et al. (1990) studied bear and human activity on the Kulik River from 16 August to 14 September 1988. They divided the lower half (my zones 1–7) of the river into only 2 zones: zone 1, which includes my zones 1–4, and zone 2, which corresponds to my zones 5–7. For consistency and clarity, I will refer to their zone 1 as zones

1–4 or the lower river and their zone 2 as zones 5–7 or the upper river when making comparisons. They observed bear and human activity from a tower on the same ridge as the tower in this study, and their scan data were recorded in a similar fashion. Olson et al. (1990) calculated bear and human activity rates as follows:

rate of bear activity = total bear minutes/total observation minutes

rate of human activity = total number of people/total number of scan samples

Given that bear and human use patterns were highly similar between 1993 and 1995 (T.S. Smith, 1997, Brown bear and humans at Kulik River—fall 1995, Katmai National Park and Preserve, USGS, Anchorage, Alaska, USA), I used only the 1995 data for comparison with their 1988 use patterns. Their raw data were not available for analysis, so I equilibrated my work to theirs as follows: (1) 1995 data from zones 1–4 were pooled and used as raw data for comparison with 1988 lower river activity rates, (2) 1995 data from zones 5–7 were combined and used as raw data for comparison with 1988 upper river activity rates, (3) rate of human activity was calculated for the 1995 study using Olson's method of dividing the total number of people observed in the zone by the total number of scan samples that provided those numbers, and (4) rate of bear activity was calculated by counting each bear occurrence as a 10-minute event (reflecting scan length), summing them, and dividing by number of scans (each a 10-minute event). For example, if 234 people were observed in 100 scans of the lower river (zones 1–4) during the 0800 to 1000 time slot, the rate of human activity value would be 2.34 people/scans. Similarly, if 35 bears were observed during the same 100 scans the rate of bear activity would be 0.35 bears/minute.

The average length of stay by bears in each zone was of interest because bears at nearby Brooks River have been reported to spend less time on the river when people are present (Braaten and Gilbert 1987, Olson et al. 1998). However, since scan sampling was used to collect count data in this research, an index to length of stay by zone was calculated by using the number of consecutive scans observed multiplied by 10 minutes, the length of time between scans. Significance for length of stay between zones was determined with the Kruskal-Wallis test statistic.

I used standard non-parametric data analysis procedures (Zar 1974). The Student's *t*-test was used to compare levels of human, aircraft, and watercraft activity between years. Pearson correlation coefficient was used to measure the degree of association between bear and human activity patterns. Spearman's rank correlation test was used to test differential zone use by people and bears for significance. The Mann-Whitney *U*-test was used to test for differences between the lengths of time that bears spent in zones of the river. The $\chi^2$ test was used to identify significant differences in bear activity budgets by zone. Statistical significance was set at $\alpha = 0.05$.

## RESULTS

The 1993 study began at 0800 AST on 28 August and ran continuously for 20 days through 1200 AST 16 September 1993. We recorded 1,380 scan samples during 230 hours of tower observation. The 1995 study was initiated at 0800 AST on 26 August and ran continuously for 23 days through 1200 AST, 17 September 1995. During this period we recorded 1,656 scan samples in 276 hours of tower-based observations. Weather did not interfere with data collection in either year because the enclosed blind provided relief from rain, wind, and snow.

### Levels of Activity

Daily levels of human activity in 1995 were less than in 1993 (Student's *t*-test, 38 df, $t = 2.28$, $P = 0.014$), whereas daily levels of bear activity in 1995 were greater than in 1993 (Student's *t*-test, 38 df, $t = -3.54$, $P = 0.000$). In 1995, aircraft use was 18% less, watercraft activity 35% less, and bear–human interaction levels approximately the same as in 1993 (Table 1). The number of people using the river simultaneously, not including those being transported in aircraft and watercraft, varied from 1–32 in 1993 and 1–25 in 1995, with a mean group size of 4 people/group for both years. The number of bears observed in a single scan ranged from 1–12, with 11 bears observed only once during the 1993 study and 12 bears once in 1995. Seasonal patterns of human and bear activity were similar both years studied. Rates of human activity were relatively constant throughout the study period each year, whereas bear activity increased as fall progressed (Fig. 2).

In 1993, we observed 482 watercraft and 476 aircraft occurrences on the river ($\bar{x} = 50$ craft/day). On the busi-

**Table 1. Sampling intensity, human and bear activity, and bear–human interactions on the Kulik River, Alaska, USA, for 28 Aug–16 Sep 1993 and 1995[a].**

| Category | 1993 total | 1995[b] total | Difference (%) |
|---|---|---|---|
| Scan samples collected | 1,380 | 1,411 | +2 |
| People observed[c] | 12,263 | 6,224 | -49 |
| Bears observed[c] | 1,136 | 2,529 | +123 |
| Aircraft observed[c] | 1,527 | 1,246 | -18 |
| Watercraft observed[c] | 2,363 | 1,540 | -35 |
| Bear–human interactions | 131 | 124 | -5 |

[a] Sampling began at 0800 AST 28 Aug and terminated at 1200 AST 16 Sep.

[b] Only 1995 data for the same 20 days sampled in 1993 are presented.

[c] Number reported for people, bears, aircraft, and watercraft is the sum of the number observed in all scans combined, not an actual number of different individuals using the river throughout the study.

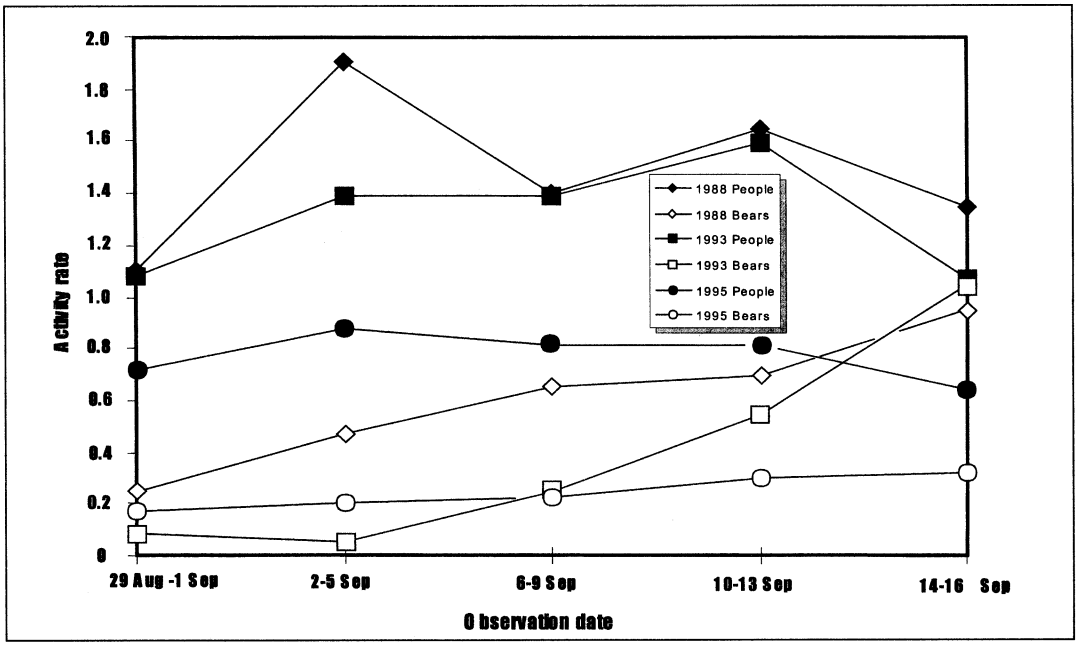


**Fig. 2. Bear and human activity rates observed from 29 Aug–16 Sep 1988, 1993, and 1995 at the Kulik River, Katmai National Park, Alaska, USA.**

est day in 1993, we observed 45 watercraft traverses of the river, and 37 aircraft arrivals or departures were observed. In 1995, we observed 390 watercraft and 361 aircraft ($\bar{x}$ = 33 craft/day). Watercraft and aircraft were almost always solitary (>80% of the time in both years), although occasionally 2 were seen (13 and 17% of the time in 1993 and 1995, respectively), and very rarely 3 or more. Although watercraft activity was evenly distributed across all zones, aircraft use was highest in zones 1–2 due to Kulik Lodge traffic (Fig. 3). When transporting guests to outlying areas of the Alaska Peninsula, Kulik Lodge pilots routinely used these lower river zones (1–2) for take-offs and landings.

## Bear Composition and Use

We observed 14 individual bears and bear groups (i.e., sows with dependent young) on the Kulik River in 1995 (Table 1). This was 39% fewer bears than in 1993 ($n$ = 23) and 56% fewer bears than observed in 1988 ($n$ = 32) by Olson et al. (1990). In 1993 and 1995, adult females with and without dependent offspring (57% and 79%, respectively) dominated use of the river. Family groups comprised 48% and 36% of all bears in 1993 and 1995, respectively. Adult male bears were relatively rare as only 6 different males used the river in 1988 and 1993 and only 1 in 1995.

## Spatial and Temporal Use Patterns

In 1993 and 1995, bear and human activity were spatially segregated; bear activity was highest in the lower stream areas (zones 1–4: 85.1% in 1993 and 85.3% in 1995 and human activity highest in the upper stream (zones 5–7: 85.3% in 1993, 86.6% in 1995, Fig. 4). In both 1993 and 1995 bear activity was highest at dawn and dusk (Fig. 5). Conversely, human activity peaked during mid-afternoon and was lowest at dawn and dusk. A small decrease in human activity occurred daily at noon when lodge patrons left the river for lunch.

I jointly analyzed bear and human activity data by day, year, and zone in search of relationships. However, computation of Pearson's correlation coefficients ($r$) failed to reveal a significant ($P < 0.05$) relationship between any of the paired bear–human activity patterns observed in each zone for 1993 or 1995. Overlay plots of bear and human activity by zone were prepared for 1993 and 1995. In all cases, the few bears present and the segregation of activities along the river confounded attempts to identify patterns. Nonetheless, bear and human activity in zone 7 in 1995 suggested that bears might have been avoiding people (Fig. 6). In zone 7, bears were most active during early morning, mid-day, and evening when people were absent (zone 7, Fig. 6). On the 6th day of the 1995 study, no people were on the river and bear use levels were the highest observed in that zone for the duration of the study (Fig. 6). Motorized activity on the river (Fig. 3) was not correlated with bear activity (Student's $t$-test, 5 df, $P >$ 0.05 for bears and planes and for bears and boats in either 1993 or 1995), although planes and bears concentrated their activities in lower river zones (Fig. 3 and 4).

In 1993 and 1995, bears used the lower river zones (1–

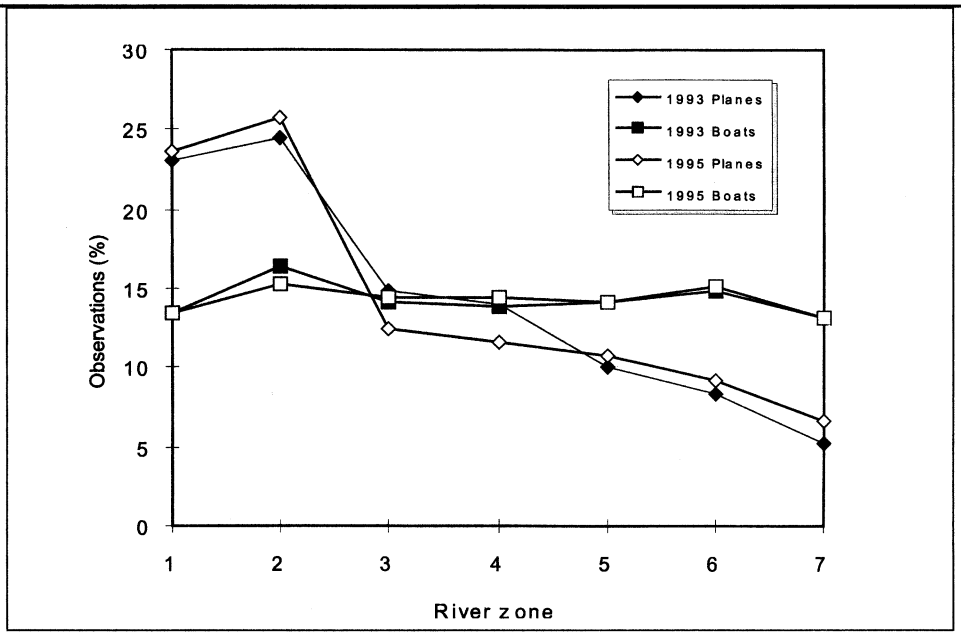


**Fig. 3. Water and aircraft activity from 28 Aug–16 Sep 1993 and 1995, by river zone on the Kulik River, Katmai National Park, Alaska, USA.**

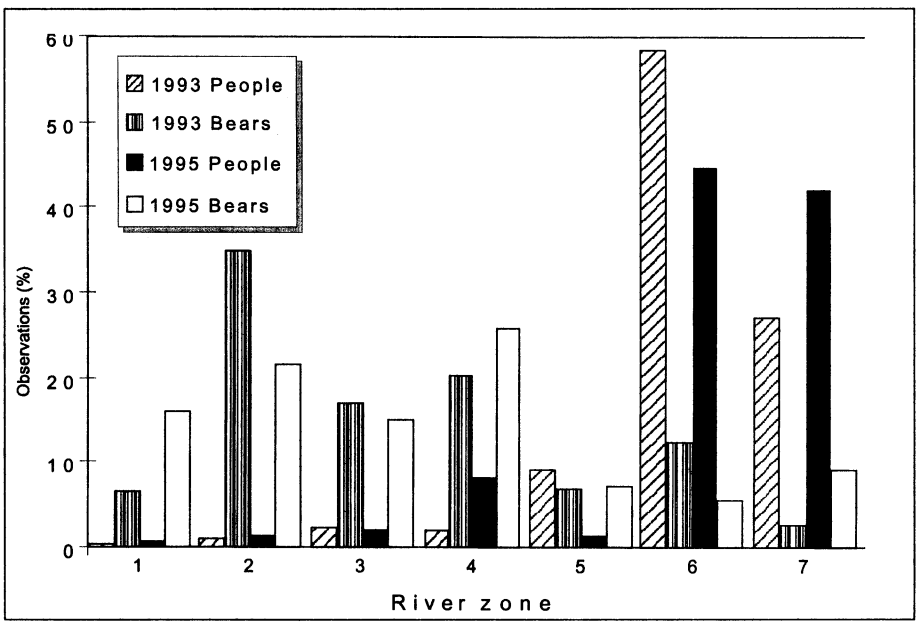


**Fig. 4. Frequency of use by bears and people by Kulik River zone, 28 Aug–16 Sep 1993 and 1995, Katmai National Park, Alaska, USA.**

4) most, while human activity was concentrated in the upper portions of the river (zones 6–7, Fig. 4). However, Olson et al. (1990) observed the opposite pattern in 1988, with human use concentrated near the river mouth (zones 1–4) and bear activity heaviest in the upper areas (zones 5–7; Fig. 7). Olson et al. (1990) reported a significant negative correlation between bear and human temporal use of zones 1–4, the stretch of river dominated by people (Spearman's rank correlation $R_s$ = -0.821, $P$ = 0.012) but no significant correlation between patterns of use in zones 5–7, where human activity was low (Spearman's rank correlation $R_s$ = -0.179, $P$ = 0.351). Likewise, in 1995 bear and human temporal use were negatively correlated in the zone where human activity was most intense (zones 5–7, Spearman's rank correlation $R_s$ = -0.928, $P$ = 0.033) but not correlated where human activity was slight (zones 1–4, Spearman's correlation sum $R_s$ = -0.812, $P$ = 0.060). Bear and human activity were negatively correlated in 3

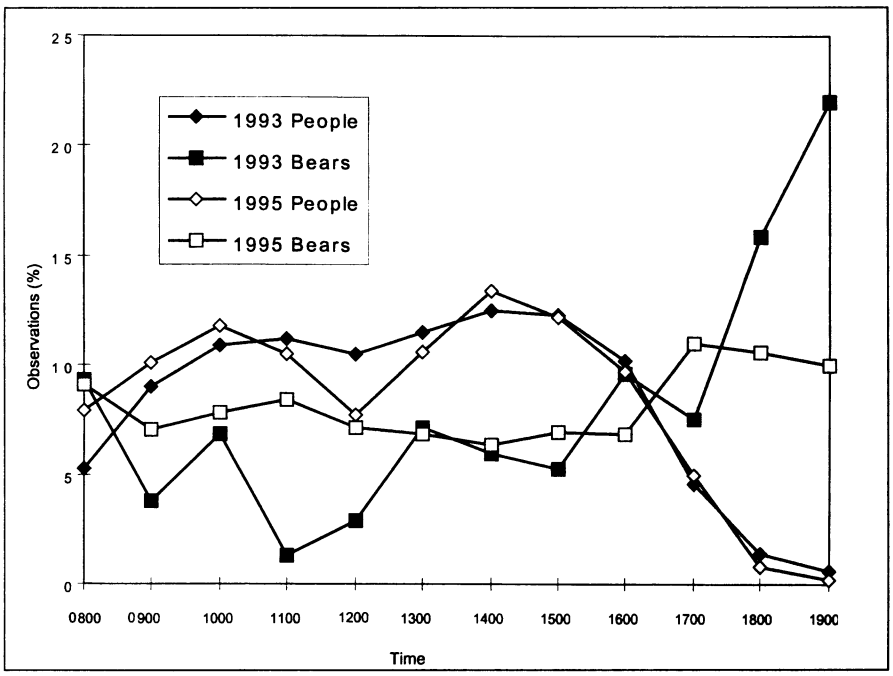


**Fig. 5. Frequency of use by bears and people of the Kulik River, 28 Aug–16 Sep 1993 and 1995, Katmai National Park, Alaska, USA.**

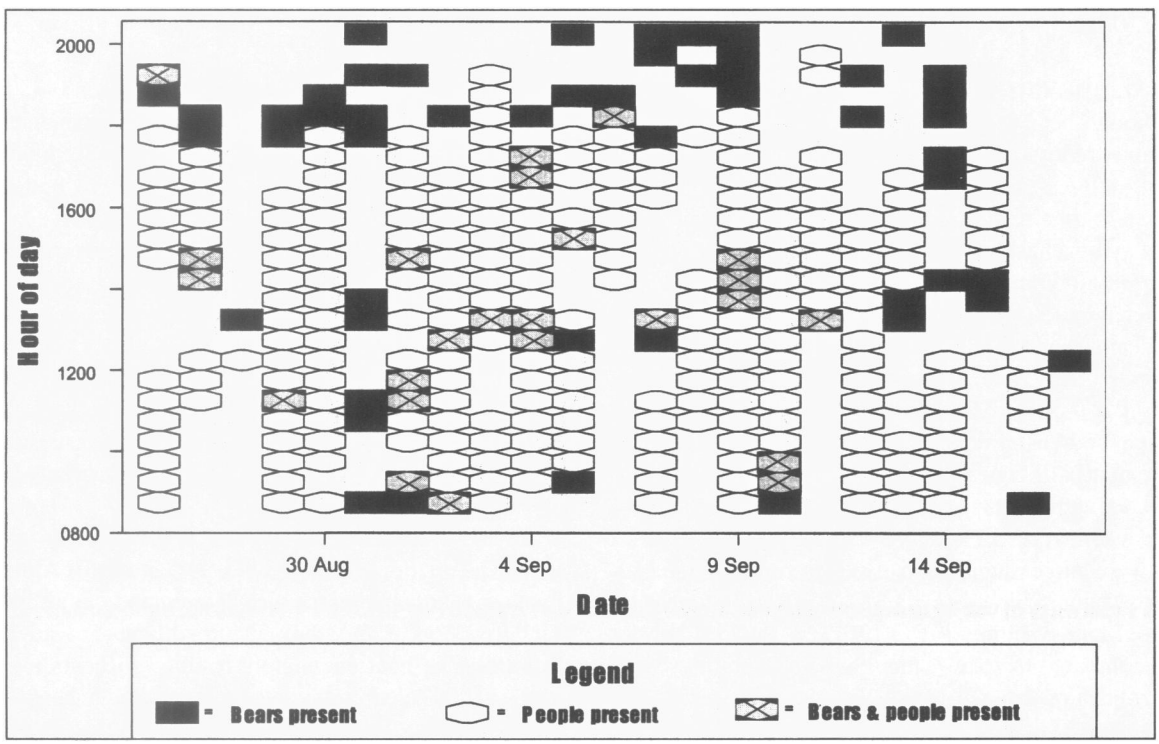


**Fig. 6. Temporal use of zone 7 of the Kulik River by bears and people, 28 Aug–16 Sep 1995, Katmai National Park, Alaska, USA.**

of 4 comparisons, suggesting an inverse relationship exists between the 2 species' activity patterns.

I calculated activity rates for people and bears using the lower (zones 1–4) and upper (zones 5–7) river in 1993 and 1995. Bear activity was heaviest along the lower river, whereas human activity was concentrated in the upper river (Student's $t$-test, 5 df, $P = 0.000$ and $P = 0.007$ for bears and humans, respectively). However, in 1988 human activity rates were highest in the lower river and bear activity rates highest in the upper river, strengthening the notion that bears actively avoided areas of concentrated human activity in all 3 years of study.

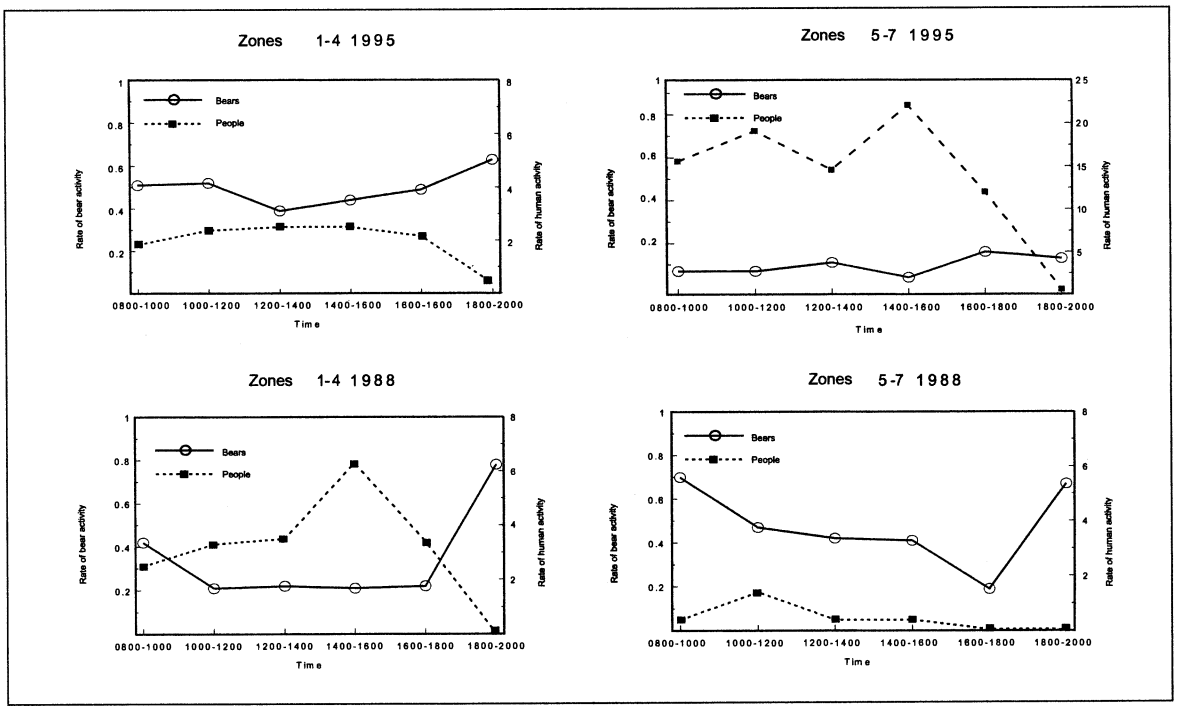


**Fig. 7. Rate of bear and human activity on the Kulik River by 2-hour blocks, 28 Aug–16 Sep 1988 and 1995, Katmai National Park, Alaska, USA.**

## Bear Behavior Patterns by Zone

Although bear use of the river was unevenly distributed, the predominant behavior in all zones was feeding (Fig. 8). Bears in zones 5–7 spent more time moving about, less time resting, and less time in other activities (i.e., playing, chasing one another) than bears in zones 1–4. A $\chi^2$ test of homogeneity applied to counts of observed bear behavior (5 categories) by zone (7 zones) was highly significant, thus I rejected the null hypothesis that bears partitioned their time similarly in all zones ($\chi^2$ = 194.4, 24 df, $P < 0.005$). Moving, resting, and other were the principal sources of deviation from expected cell values for the matrix of zones versus behavior.

Mean length of stay by bears was inversely related to human use levels. Lengths of stay for bears in zones 1 and 2 were longer than length of stay in zone 6 (zone 1 vs. zone 6, Mann-Whitney $U$ = 3,313, $P$ = 0.015; zone 2 vs. zone 6, Mann-Whitney $U$ = 3,130, $P$ = 0.025 ), but not when compared to zone 7, though the probabilities were low (zone 1 vs. zone 7, Mann-Whitney $U$ = 4,359, $P$ = 0.059; zone 2 vs. zone 7, Mann-Whitney $U$ = 4,106, $P$ = 0.10) and suggest significant differences do exist.

## Bear–Human Interactions

I observed 131 bear–human interactions in 1993 and 153 in 1995. People initiated the majority of bear–human interactions by approaching bears (85% in 1993 and 97% in 1995). The majority of bear–human interactions took place in zones used most by bears (zones 1–4: 81% in 1993, 78% in 1995). Female bears with dependent offspring were the age–sex class most commonly involved in bear–human interactions (63% in 1993 and 58% in1995). People in boats and planes were involved more often in bear–human interactions than other forms of activity both years of the study (82% in 1993 and 94% in 1995). Although most bears were only temporarily disturbed (64% in 1993 and 58% in1995), nearly one-fourth ceased all activities and left the river immediately following an interaction with people (24% in 1993 and 23% 1995). Similarly, most people involved in bear–human interactions quickly resumed their previous activity (50% in 1993 and 84% in 1995).

Air and watercraft were involved in the majority of bear-human interactions (80% in 1993, 94% in 1995). Although boats encountered bears twice as frequently as aircraft in 1995 (62% vs. 32%), they disturbed bears considerably less (29% of boat encounters resulted in bears leaving whereas 40% of aircraft encounters resulted in bears leaving the river). Bear–human interactions that displaced bears from the river occurred nearly always in bear-dominated areas (zones 1–2) both years of study. Boats and aircraft involved in bear–human interactions were nearly always traversing the river at high speed (i.e., planing speeds for boats, full power take-offs or landings for aircraft) and accounted for 64% and 68% of interactions observed.

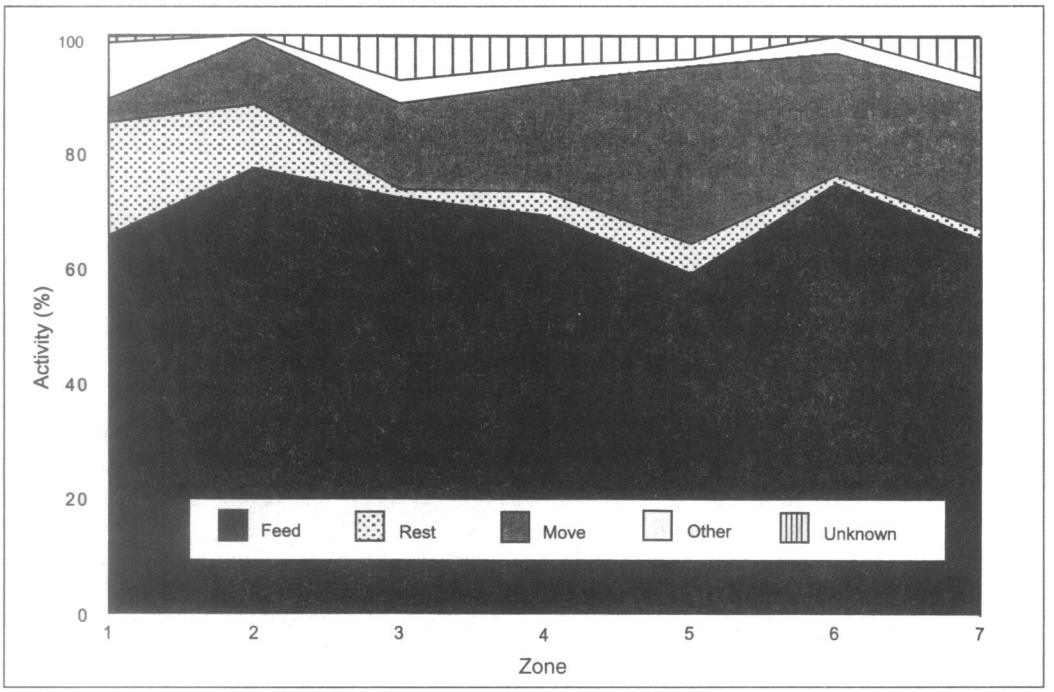


**Fig. 8. Predominant bear behavior observed by zone of the Kulik River, 28 Aug–16 Sep 1993 and 1995, Katmai National Park, Alaska, USA.**

## DISCUSSION

### Levels of Activity

In 1988, 1993, and 1995 the number of bears observed using the river increased as fall progressed. Kulik hosts one of the latest salmon runs on the Alaska Peninsula, and as other streams' salmon resources dwindle, bears migrate to Kulik prior to denning. Although the number of individual bears using the river in 1995 was 40% lower than 1993 levels and 56% lower than 1988 levels (Table 1), bears present in 1995 used the river more frequently (Table 2). While 23 individual bears present in 1993 were observed 1,136 times on the river (49 sightings/known bear in 1993), the 14 individual bears present in 1995 were observed 2,262 times, resulting in >3-fold increase in individual bear activity (162 sightings/known bear). Although salmon run strength can vary greatly year to year, the number of spawning salmon at Kulik was essentially the same both years of this study (34,100 sockeye counted in 1993 and 35,100 in 1995; C. Anderson, Alaska Department of Fish and Game, Anchorage, Alaska, USA, personal communication, 1998) and seems an unlikely explanation for the observed difference in use levels. It is possible that bears less tolerant of people avoided Kulik in 1995, leaving more room and less competition for the bears that were there. However, further investigation would be needed to determine why fewer bears used the river more.

### Bear Composition and Use

While the number of individual bears on the Kulik River in late August to mid-September decreased 56% from 1988 to 1995, human use levels increased four-fold. Although the increase in human activity may have caused the decrease in bear numbers, several other possible explanations exist: changes in the greater Katmai bear population level, fluctuations in the salmon resource, availability of other area food resources (e.g., berries, ground squirrels, ungulates), and variations in the timing of bears arriving at the river. It seems likely that the differences have more to do with inter-year variation in the timing of bear migrations to the area rather than a real decrease in the number of bears. However, this underscores the need for the NPS to continue to monitor bear numbers so that trend data will be available.

Female bears with dependent young dominated the river in 1993 and 1995. Females with young can be intolerant of other bears (Egbert and Stokes 1976) and tend to avoid bear concentration sites since they represent a potential hazard to their young. But in places where human activity has displaced adult male bears, females with cubs may be the predominant cohort. Mattson (1990) suggested that where excessive human activity has displaced large males, females with cubs might tolerate people to gain access to food resources. Supporting this, Warner (1987) found a significant difference in the composition of bears observed using 2 areas in southeast Alaska. The bear population at

**Table 2. Number of individual bears identified in each age–sex class during the 1988, 1993, and 1995 field seasons, Kulik River, Katmai National Park, Alaska.**

| | Kulik River Aug–Sep 1988[a] | | Kulik River Aug–Sep 1993 | | Kulik River Aug–Sep 1995 | |
|---|---|---|---|---|---|---|
| Age–sex class | *n* | % | *n* | % | *n* | % |
| Adult male | 6 | 19 | 6 | 26 | 1 | 7 |
| Adult female | nd[b] | nd | 2 | 9 | 6 | 43 |
| Females with cubs of the year | 9 | 3 | 13 | 17 | 1 | 7 |
| Females with dependent young[c] | 3 | 9 | 8 | 35 | 4 | 29 |
| Other single bears[d] | 20 | 63 | 4 | 17 | 2 | 14 |
| Total | 32 | 100 | 23 | 100 | 14 | 100 |

[a] Data from Olson et al. 1990.

[b] nd = no data

[c] Dependent young includes all unweaned young older than a cub.

[d] Includes adult males, adult females, and subadult bears that could not be differentiated as to their sex.

Pack Creek, an area subjected to intensive human use, consisted of >80% females (including females with young), whereas family groups comprised only 1.6% of the sample at a nearby control study area, a creek with negligible human use. Egbert and Stokes (1976) reported that family groups comprised only 12% of the bear population using the falls at McNeil River where human activity is tightly controlled and large male bears are common. Similarly, family groups comprised 12–21% of the bear population at Brooks Camp, where human activity is somewhat controlled and predictable (Olson et al. 1990). The representation of females with offspring at Kulik River (48% in 1993, 36% in 1995) supports the displacement theory. Alternatively, the salmon in Kulik River, which is deep and swift, may not be as abundant and easy to catch as in other area streams. These latter streams would attract large dominant male bears, leaving Kulik available for subordinates. Without additional research it is not possible to determine why female bears and family groups dominate Kulik.

## Spatial and Temporal Use Patterns

In 1993 and 1995, bear activity was highest in zones 1–4 and human activity highest in zones 5–7, suggesting that bear activity patterns were influenced by human use. Other possible explanations may account for the highly segregated patterns of use I observed, including the possibility that bears may prefer to feed in the downstream portions where fish carcasses accumulate. However, bear activity patterns in zone 7 suggest that bears avoided people because their use was highest when people were absent (Fig. 6). Additionally, the only day of the study that people did not use zone 7, the bear activity rate was nearly double that observed on any other day. By using night vision equipment I found that bear activity continued well into the night, although I did not collect data consistently. It is possible that some bears, including large males, used the river at night to avoid diurnal human activity.

Bear and human use along the Kulik River was highly segregated in 1988, prompting Olson et al. (1990) to conclude that bears actively avoided areas of concentrated human use. In 1993 and 1995, I observed the same temporal-spatial segregation, but with the important difference that bears and people had exchanged the activity centers reported by Olson et al. (1990): in 1988 human activity dominated zones 1–4, while bear activity was focused in zones 5–7; in 1993 and 1995, the heaviest human activity had shifted to zones 5–7 whereas bear activity had shifted to zones 1–4. This consistent and inverse relationship between bear and human activity strongly supports the conclusion that concentrated human activity on the Kulik River reduces available habitat for bears and, to a large extent, controls where bear activity will be focused.

## Bear Behavior Patterns by Zone

Bear behavior patterns varied across zones (Fig. 8). Bears spent similar amounts of time feeding in all zones, but the percent time spent in each varied greatly (Fig. 4). Bears in zones 5–7 spent more time moving about and less resting than those in downstream areas, suggesting that bears were more wary in upper river zones dominated by people.

## Bear–Human Interactions

People, primarily in air and watercraft, initiated the majority of bear–human interactions as they traveled through areas heavily used by bears. Hence, interactions occurred most frequently when people entered bears' chosen areas, not vice versa, suggesting that areas selected by bears may have been chosen because of a lack of human activity.

In both years of this study, moving air and watercraft accounted for most bear–human interactions; nearly 25% of bears involved left the river, not to return for hours.

## Bear Habituation to Human Activity

Although levels of bear habituation to humans have been estimated in other studies (Olson et al. 1990), it was not addressed in this work. Habituation is an adaptive behavior allowing an animal to ignore disturbances that have proven benign. At the Kulik River, many bears appear

habituated to human activity and are seemingly unaffected by it. However, this research shows that habituated or not, bears avoided areas frequented by people on the Kulik River.

## CONCLUSIONS

Bears altered their temporal and spatial use of the Kulik River to accommodate human activity, seeking times and places where human use was lowest. Bear–human interactions were primarily the result of people venturing into areas of concentrated bear activity, rather than bears entering areas heavily used by people. Approximately one-fourth of bears involved in bear–human interactions left the river, not to return for several hours. Bears acted differently in river zones dominated by people than in zones dominated by bears in that they spent less time on the river, less time resting, and more time moving about in human-dominated zones. The population of bears using the river was predominantly female, suggesting that large males may have avoided the area due to the high levels of human activity. These observations are consistent with the understanding that brown bears' normal response is to avoid people (Herrero 1985:13). Thus, I conclude that as long as there are areas where bears can avoid human activity along the Kulik River, bears will seek them to gain access to salmon. If, however, human use of the river continues to increase as it has the past decade, the day may come when there will be no more room for bears.

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