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Glacier National Park (GNP) is charged with preserving its natural resources while providing for visitor safety. Trends in GNP's grizzly bear (*Ursus arctos*) population are an important consideration in balancing these objectives. Some relatively recent trends have been studied (Martinka 1974, Kendall In press, Jope 1985), but poorly documented methodologies and changing observer efforts have deterred interpretation of historical records.

I developed a standardized sighting index to estimate grizzly bear sighting rates from historical records. Sighting rates were compared with grizzly population estimates and park visitation in exploring relationships between bear numbers, distribution, and behavior over time.

METHODS

Grizzly bear sighting rates were derived from April–October entries in GNP ranger station logs, 1928–1976. Kilometers of back-country travel (KBT) and number of grizzly bears sighted were determined for each day. Only direct sightings, made during back-country travel and unambiguously recorded as grizzlies, were included. Sighting rates were calculated as the number of grizzlies sighted/10,000 KBT. Mean group size was also calculated. I assumed that distance traveled was a reasonable index of observer effort and that the proportion of unreported sightings was constant over time.

Sighting rates were compared with grizzly population estimates, 1924–1976. Population estimates were based on Baggley (1936), Martinka (1974), and unpublished files. For 1921–1930, Baggley's estimate of 60 bears was used in preference to park estimates of 104, 100, and 105 for 1924, 1928, and 1930, respectively. This was done because (1) it appeared to more accurately reflect the 1924–1934 trend, as perceived by park officials (Baggley 1936), (2) the 1924 park census, which served as a baseline for subsequent estimates, was later criticized for overestimates of other species, and (3) Baggley's estimate was more consistent with qualitative accounts (Bailey and Bailey 1918) describing the grizzly population during GNP's early history. By 1936, GNP estimates agreed closely with Baggley.

Sighting rates were also examined for evidence of changing bear behavior. It was hypothesized that increased sighting rates may reflect greater habituation (Jope 1980, 1985; McCullough 1982) rather than population trend. Trends in sighting rates and park visitation were therefore compared. Visitation was used to indicate the potential for habituation. Frequency and predictability of human activity were assumed to increase with increasing visitation. Visitation figures (1910–1980) were obtained from unpublished park files.

Data were collated in park-wide, 5-year periods to reduce potential biases and better elucidate long-term trends. Logarithmic transformation of independent variables was used in all regression analyses. Statistical methods were based on Snedecor and Cochran (1980).

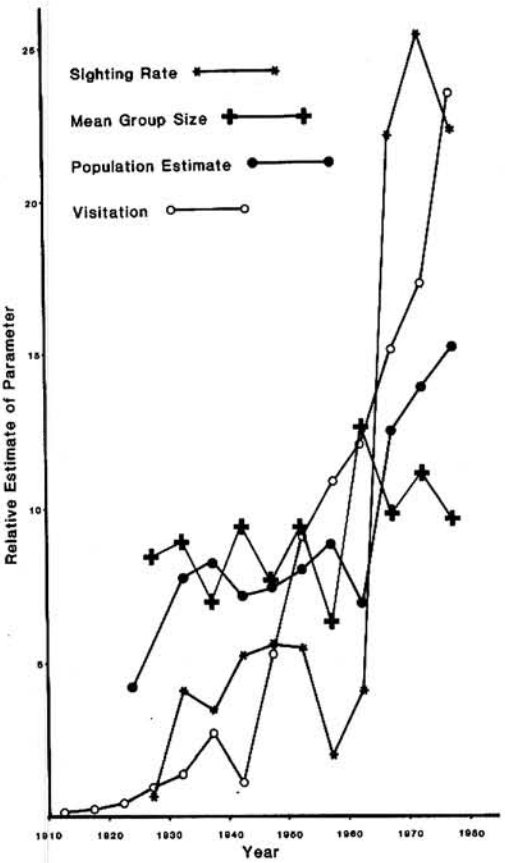

Fig. 1. Relative trends in sighting rates, mean grizzly group size, grizzly population estimates, and human visitation in Glacier National Park. Estimates are expressed as a percent of the sum of estimates over time for each parameter.

RESULTS

Regression analysis indicated sighting rates increased ($r^2 = 0.62$, $P < 0.005$) with time at a mean annual rate of 5.2% (Fig. 1). This relationship did not appear constant over time, however. Sighting rates increased precipitously about 1930 and 1965, but otherwise appeared relatively stable. Low sighting rates for 1956–1960 may have reflected a relatively small (5,380 km) sampling effort.

A qualitative change in sightings was also indicated. Periods of apparent low and high mean group size (1926–1960 and 1961–1980, respectively; Fig. 1) were grouped and tested for equality. Mean group size for 1961–1980 was greater than for earlier periods ($t = 3.19$, $P < 0.01$).

The regression of mean grizzly population estimate on time was significant ($r^2 = 0.73$, $P < 0.001$), as was the regression of visitation on time ($r^2 = 0.94$, $P < 0.001$, Fig. 1). Population estimates and visitation were highly intercorrelated ($r^2 = 0.76$, $P < 0.001$).

Because of the intercorrelation of population estimates and visitation, partial correlations were calculated to better distinguish relationships to sighting rates. Sighting rates were positively correlated with population estimate when visitation was held constant ($r^2 = 0.62$, $P < 0.01$), suggesting that population estimates were reasonably independent of increasing visitation. Sighting rates were not correlated with visitation when the population estimate was held constant ($r^2 = 0.02 \times 10^{-3}$, $P > 0.50$), suggesting that habituation of bears to people did not affect the propensity to see grizzly bears.

DISCUSSION

Sighting rates reflected the propensity of rangers to see grizzly bears during any given period in GNP's history. Theoretically, rates could have been influenced by (1) vegetation change, (2) human numbers, distribution, and/or behavior, and/or (3) grizzly bear numbers, distribution, and/or behavior.

Fire was the only factor capable of effecting vegetation change which would increase bear visibility over wide areas. Fire patterns could not account for the ubiquity or timing of sighting rate increases.

Human factors were not believed to significantly affect sighting rates. By basing indices on distances traveled by rangers, averaged over 5-year periods and covering the same general areas each year, biases from changing num-

bers and distribution of observers were obviated. Changing human behavior was also dismissed as a significant factor because human behavioral changes were counter to sighting rate trends. Rangers of the 1920s and 1930s spent more time on horseback (which should have increased the likelihood of seeing grizzly bears [Jope 1982]), were more likely to be on the trail during crepuscular hours (when grizzlies are more often sighted [Kendall In press]), and kept more detailed wildlife records.

Three lines of reasoning intimated an increased grizzly population. First, sighting rates correlated significantly with population estimates over time, even when corrected for increased visitation, suggesting that estimates were relatively objective. Second, trends in sighting rates and population estimates (showing increases about 1930 and 1965) corresponded to changing human activities during those periods. Predator control was curtailed within the park in 1931, sheep ranching along the park's eastern boundary declined during the late 1950s to 1960s, and predator control along the park's western boundary declined after the mid-1950s. Third, increased mean group size suggested that family groups, as a proportion of the population, increased about 1960. This may have reflected increased survival of females to breeding age as a result of reduced mortality along the park's periphery.

Though sighting rates suggested an increased grizzly population, other changes were also indicated. Sighting rates increased 33.2-fold from 1928 to 1976. During the same period, population estimates increased only 3.6-fold. Changes in the distribution and/or behavior of park grizzlies were implied in accounting for remaining sighting rate increases. Three lines of reasoning suggested habituation was not responsible.

First, sighting rates did not follow the pattern which would be predicted if the increase were due to habituation. Jope (1982) noted that rate and persistence of habituation were influenced by frequency and predictability of the stimulus. Thus, if increased sighting rates resulted from habituation, sighting rates should increase with visitation. Analysis showed sighting rates were not significantly correlated with visitation when the relationship was corrected for increases in the bear population. Visitation increased homogeneously over time (with the exception of the World War II period) while sighting rates were characterized by long periods of relative stability punctuated by periods of rapid growth (Fig. 1).

Second, data from about 1930 indicated disproportionate increases in sighting rates in the absence of habituation. Population estimates showing an 85% increase about 1930 (from 60 in 1924 to an equilibrium of 111 during 1930–1965) were associated with a 6-fold increase in mean sighting rate. Habituation was an inadequate explanation for the disproportionate increase in sighting rates because (1) habituation among GNP's grizzlies has apparently arisen only recently (Jope 1980, Kendall In press), (2) visitation levels during the 1930s were probably too low to effect habituation, and (3) harassment along the park's boundary during that period probably precluded habituation.

Third, habituation could not explain increased sighting rates in remote areas. Sighting rate increases were observed in all 9 subdistricts in GNP. However, heavy human use is and has been confined to only 4 subdistricts, making habituation an inadequate explanation for similar or greater increases in remote areas.

Distributional changes in the grizzly population were implied, by default, in accounting for disproportionate increases in sighting rates. I hypothesize that population expansion increased sighting rates by increasing the number of bears and promoting a distributional expansion which served to increase average visibility per bear. According to the hypoth-

esis, grizzlies tended to be surreptitious during the park's early history. Under low density conditions they selected for secluded habitats and were rarely observed. As the population expanded, grizzlies occupied habitats where they were more visible. Because habitat and distribution have both spatial and temporal components, distributional change may have involved movement into unoccupied areas and/or a change in the timing of use in previously occupied areas.

Though not viewed as a primary force driving sighting rates upward, habituation was nonetheless postulated to be a necessary component of this process—being viewed as a phenomenon which allowed distributional shifts into high human use areas. Jope (1980) similarly postulated that habituation may allow bears to use resources which might otherwise be unavailable.

MANAGEMENT IMPLICATIONS

Recent discussions of grizzly-human conflicts have emphasized the role of increasing visitation (Martinka 1982) and the presumably related phenomenon of habituation of bears to people (Jope 1980, 1985; McCullough 1982). Grizzly population trends have previously been considered stable (Martinka 1974) and the potential role of grizzly population dynamics in bear-human relations has therefore been ignored.

Results of this study indicate conflicts may have been tied to coincident increases in both grizzly and human populations, and suggest the interrelatedness of numerical, distributional, and behavioral grizzly population responses. A prediction of the postulated model is that aversive conditioning should result in distributional contraction and reduced carrying capacity for grizzlies. Assuming that GNP's grizzly population is currently at carrying capacity (Martinka 1974), a reduction in the population would presumably follow. This suggests that aversive conditioning should be evaluated not merely as a public relations problem (McCullough 1982), but as a tradeoff between the park's responsibilities to preservation and visitor safety.

SUMMARY

Trends in sighting rates and population estimates indicated GNP's grizzly population increased significantly about 1930 and 1965. Habituation was an inadequate explanation for disproportionate increases in sighting rates, suggesting that population expansion also prompted a distributional change. Habituation was postulated to be necessary in allowing distributional expansion, but not a primary cause of it. Findings suggested that aversive conditioning of bears may occur at the expense of the park's responsibility to preservation.

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