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IMPACT OF INCREASED BEAR HUNTING ON SURVIVORSHIP OF YOUNG BEARS

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Managers of exploited bear populations sometimes suggest that greater mortality of adult bears will be offset by increased survival of young bears. The most commonly offered theory behind this suggestion is that because male bears tend to be more vulnerable to hunters than females (Bunnell and Tait 1980), a reduction in the number of males will result in decreased intraspecific predation on cubs (bears <1 year old). Advocates of this theory suggest that reduced numbers of males will cause corresponding increases in cub survivorship and recruitment to adult age classes. This supposed relationship has been used as 1 component of a justification for hunting small populations of grizzly bears (*Ursus arctos*) (Dood et al. 1986). This relationship is also frequently advanced by persons justifying increased harvest rates for grizzly or black bear (*Ursus americanus*).

This theory has a seductive appeal as it suggests that bear populations have a built-in resiliency that will tend to correct for harvests in excess of sustainable levels calculated based on observed reproductive rates. If this theory is correct, managers do not need to set harvest quotas as conservatively as they must if overharvests are not automatically compensated by increased recruitment. Reliance on such mechanisms, unless they are well-proven, to justify nonconservative population management of bears is dangerous because bears have low reproductive rates and depleted populations will be slow to recover (Leopold 1933, McCullough 1981, Miller 1990a). Also, bear population assessment techniques are poorly developed and expensive, which makes it difficult for managers to detect any but extreme changes in bear numbers (Harris 1986, Miller 1990a).

Here, I briefly review the literature most frequently cited as supporting a direct relationship between increased hunting (or decreased number of males) and increased survivorship of subadults (reproductively immature bears). This review demonstrates that the authors of these studies usually have not concluded the existence of a relationship between hunting and increased subadult survival although some have suggested the possibility of such a relationship. I also briefly discuss other studies dealing with this topic and present evidence from 1 area in Alaska which suggests the absence of a relationship between heavy grizzly bear hunting and cub survivorship. It is not my intention to deny that density dependent relationships in bear populations may exist in some circumstances such as when populations are near carrying capacity or are at very depleted densities. Instead, my intention is to point out that such relationships have not been demonstrated in exploited bear populations. Correspondingly, managers of such populations should avoid using such density dependent functions in their management schemes.

Observations of killing by adult bears of cub and subadult bears led to early speculation that there might be a density dependent relationship between survivorship of young bears and bear density (Jonkel and Cowan 1971, Egbert and Luque 1975, Glenn et al. 1976). A review paper on this speculation concluded there was a possibility such a relationship existed, but available data were inadequate to demonstrate it (Stringham 1980).

In Yellowstone National Park, reproductive rates of grizzly bears were thought to be approximately constant from 1959 through 1967

but to have declined subsequently as a result of decreased nutrition caused by closure of garbage dumps (Craighead et al. 1974). Reexaminations of these data found a negative relationship between recruitment of subadults and number of adult bears (McCullough 1981, 1986; Stringham 1983). These studies concluded that killing of subadults by adult males could have caused or contributed to suppressed recruitment. However, they did not state that this was demonstrated. These studies mentioned alternative hypotheses including direct killing, food competition, exile, and socially induced physiological stress (McCullough 1981, 1986; Stringham 1980, 1983, 1986). It is also possible that number of males and recruitment rates shown in these Yellowstone data were correlated dependent variables influenced by a third, independent, variable. Such possibilities can be difficult to isolate in independent analyses of data collected by others. Regardless of whether the Craigheads' original or subsequent interpretations of the Yellowstone data are correct, none of the Yellowstone analyses provided evidence supporting the theory that increased hunting will result in increased subadult survivorship. Indeed, Stringham (1983: 150) specifically cautioned, "Until impacts of adult male abundance can be distinguished from those of nutritive balance, effects of harvesting adult males cannot be reliably predicted."

An Alberta black bear study is also frequently cited to support the theory of a compensatory relationship between adult male abundance and cub survivorship; however, it also does not demonstrate such a relationship. This study involved experimental removal of males from an unhunted population at Cold Lake, Alberta (Kemp 1972, 1976; Young and Ruff 1982). Here the population was estimated to double following removal of adult males constituting approximately 30% of the population but declined to preremoval densities in 5–6 years (Young and Ruff 1982). The increase was attributed to increased subadult immigration

and possibly increased survivorship (Young and Ruff 1982). In apparent recognition that their results were being misinterpreted by some managers of bear populations, Ruff (1982:91) wrote:

"Before managers seize upon the Cold Lake experiment as a means of increasing bear numbers through adult male removal (e.g., trophy hunting, late fall or early spring hunts, etc.), we hasten to emphasize that little or no conclusive evidence is available to suggest [enhanced] survival of resident cubs or subadults. . . . Nearly 80% of the population increase could be attributed to subadult ingress from a large (5,600 km²) and unhunted reservoir area surrounding the Cold Lake study area."

It is clear that the Cold Lake study should not be used to support the theory that increased hunting will lead to increased recruitment in bears.

In an Idaho population, a removal of a large proportion of adult males by hunters resulted in no real increase in population size like that reported at Cold Lake, although there was a temporary increase in the number of transient subadults moving through the area (Beecham 1983). Beecham concluded that reduced density could be anticipated in heavily exploited bear populations unless lightly hunted reservoir areas existed nearby from which subadults could immigrate. On the Kenai Peninsula in Alaska, black bear cub survivorship was higher (0.91) in a heavily hunted than in a less heavily hunted area (0.74) (Schwartz and Franzmann 1991). These differences were attributed to habitat quality differences (based on moose calf consumption) rather than to intraspecific predation (Schwartz and Franzmann 1991). In Arizona, cannibalism as well as nutrition and subadult survival were thought to contribute to black bear population regulation (LeCount 1982). However, elsewhere LeCount (1987:80) has cautioned that "increased cub survival may not result from increased [hunter] harvest."

Similarly, Rogers (1987:55) noted, "A question remains as to whether [black bear] cannibalism rates are sufficiently density dependent to significantly regulate population growth. The scant evidence available suggests they are not." In Ontario, removal of resident adult females by hunters was thought to result in increased mortality of cubs and decreased productivity of a black bear population (Kolenosky 1990). This was attributed to better condition of resident females, which were born in years when natural foods were abundant, compared to transient females born when food was scarce (Kolenosky 1990). High rates of cub mortality occurred in the absence of killing by unrelated conspecifics in a Massachusetts study of a hunted black bear population (Elowe and Dodge 1989).

Larger litters were observed in 2 hunted grizzly bear populations adjacent to Glacier National Park than in an unhunted population within the Park (McLellan 1989). These observations led McLellan to infer a possible density dependent relationship between reproductive rates of grizzly bears and hunting. The smaller litters within the Park may also have resulted from exclusion of females by males from the most productive foraging habitats (McLellan and Shackleton 1988, McLellan 1989) as has been observed for black bears (Garshelis and Pelton 1981). Potential differences in nutritional carrying capacity between different areas clearly make it difficult to conclude that hunting caused the differences observed by McLellan (1989). More convincing evidence requires observations within an area where density and male abundance were changing over time. Such a study is currently ongoing in Alaska (Reynolds 1989).

Evidence implicating males as the cause of intraspecific mortality is frequently inconclusive (Stringham 1980). Usually the sex of the bear causing the mortality is unknown, but there are cases of cub killing by unrelated female as well as male bears (Lindzey and Meslow 1977, LeCount 1982, Rogers 1983). At

McNeil River, Alaska where high concentrations of grizzly bears gather to fish for salmon, 4 cases of unrelated females killing cub or yearling offspring have been observed (P. Hessing and L. Aumiller, pers. commun.). Although there have been no observations of males killing offspring at McNeil, cases of males chasing offspring and of females protecting offspring from males have been observed (L. Aumiller, pers. commun.). Theoretically, female fitness would increase by killing of unrelated offspring if this resulted in more resources available for her own offspring (LeCount 1987).

My own studies do not support the theory that increased hunting will result in increased cub survival. In Game Management Unit 13 in south-central Alaska, I investigated the cause of neonatal grizzly bear mortality following emergence from dens by attaching transmitters with expandable collars (Strathearn et al. 1984) to 6 cubs in 3 litters in 1983 and to 7 cubs in 4 litters in 1984. Six of these cubs died before they reached 1 year of age. Cause of death for 4 cubs was determined to be predation by grizzly bears of unknown sex or identity. Cause was not determined for 2 radio-marked cubs when their bodies were not found (circumstantial evidence suggested they may have drowned and been swept away by swift currents) (Miller 1987).

I calculated annual mortality rates of grizzly bear newborns accompanying radio-marked females during 1978–1989 using the technique of Pollock et al. (1989). Annual mortality was based on the period from emergence from natal dens to emergence from dens the following year. Based on the result of the cub collaring study, mortality was assumed when cubs disappeared from litters. For 111 cubs observed throughout the period, annual mortality rate was 0.31 (95% CI = 0.22–0.40). Most mortality occurred during May and June (Miller 1988). These mortality rates are near the middle of the reported range for grizzly bear cubs (Bunnell and Tait 1985). The technique suggested by Heisey and Fuller (1985) yielded higher

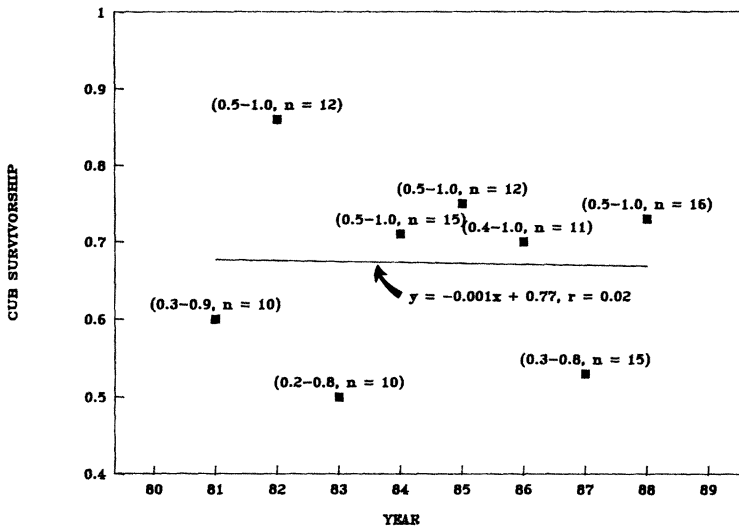


Fig. 1. Regression illustrating absence of trend in survivorship of grizzly bear cubs accompanying radio-marked females in south-central Alaska during a period when bear density and proportion of males in the population was declining (95% CI for mortality each year is given in parentheses; survival rates were calculated following Pollock et al. [1989]).

mortality rate estimates for these same data (Miller 1988).

In this area of Alaska, grizzly bear density was declining dramatically as a result of intentional hunting in excess of sustainable levels during the period 1980–1987 (Miller 1988, 1990b). The measured reduction in density in the northern part of Game Management Unit 13 was within the range of 33–65%; unmeasured but significant reductions were thought to have occurred throughout most of the Unit (Miller 1988). As a result of heavy hunting, the proportion of the adult (≥ 5 yr) population composed of males declined about 60% to less than 40 males per 100 females (Miller 1988, 1990b). Regardless of this heavy hunting and decline in males, survivorship of cubs did not change during the period of heavy bear hunting and bear reduction (Fig. 1). Although conspecific killing was a major cause of cub mortality, these results do not support the theory that heavy hunting will result in compensatory increases in cub survivorship.

It is well established that bear reproduction is influenced by nutrition and fluctuates from

year to year in a density independent fashion (Rogers 1976, 1983, 1987; Bunnell and Tait 1981; Beecham 1983; Elowe and Dodge 1989; Schwartz and Franzmann 1991). I suspect that in most circumstances, such fluctuations are sufficient to overwhelm any slight density dependent effect on survivorship that may result from increased bear harvests. My review of the literature on this topic suggests there is little support for a relationship between hunting pressure and cub survivorship beyond often repeated speculations, misinterpretations of published reports, and observations leading to inferences that have feasible alternative explanations. A reverse effect has also been postulated: increased hunting may increase cub mortality if it results in increased immigration of subadult males that may be more prone to cannibalize cubs than are resident adult males that are more likely to have genetic investments in local cubs (Stringham 1980, LeCount 1987). Like the opposite theory discussed here, this possible relationship has not been adequately demonstrated.

Bear density certainly influences productiv-

ity and probably influences survivorship in high density bear populations existing at or near habitat carrying capacity. Additional research is required to clarify the social and physiological regulatory mechanisms that operate to prevent populations from exceeding available food resources. This question is distinct from the one addressed here. Bear population managers should be careful not to apply answers to this second question to their management of exploited populations which exist at densities below carrying capacity.

I conclude that, unless managers or modelers have specific information demonstrating such relationships, it is unwise to include density dependent functions between hunting, or number of males, and cub survivorship in exercises designed to estimate sustainable harvest rates for bears or to estimate the effects of increasing exploitation rates. Inclusion of such relationships increases the risk of management errors that result in overexploitation. For bears, especially grizzly bears that reproduce very slowly (Miller 1990a), this type of error is more serious than underestimating the number of bears that can be harvested at sustainable levels. While this paper was in review, Ginzburg et al. (1990) recommended that conservative assessments of population extinction probabilities, for any species, be made by omitting density dependent functions when data are insufficient to reliably describe these functions. This cautious approach towards use of density dependent functions should also be followed by managers of exploited bear populations.

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