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The Dynamics and Regulation of Black Bear *Ursus Americanus* Populations in Northern Alberta

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INTRODUCTION

This paper describes the dynamics of an unexploited black bear population on a 207 sq. kilometer study area in mixed forest type near Cold Lake in northeastern Alberta. It also reports on a population manipulation designed to examine the regulatory effects that adult males have on the population.

Numbers of black bears on the study area varied little from 1968 through 1971. The removal of 26 large adult males in 1971 and 1972 was followed by an apparent increase in the bear population in 1972 and 1973, primarily in the subadult component. Alternate years of high cub production in 1968, 1970 and 1972 probably were solely a function of the number of adult females breeding. Evidence from other studies indicates no significant change in annual litter size. The greater proportion of males in the captured subadult sample was due to their greater mobility during dispersal as evidenced by the fact that seventy percent of the within-year recaptures of males were in excess of 4, 570 meters from the initial point of capture, while 92 percent of female recaptures were less than 4, 570 meters from initial point of capture.

The removal of 26 adult male bears in 1971 and 1972, and subsequent decline in egress of subadult, largely male bears plus possible increased subadult survival, accounted for the estimated population increase to 117 in 1972 and 175 in 1973 from the pre-manipulation mean estimate of 80 animals from 1968 to 1971. This supports the widely held view that bear populations are largely self-regulated. Year to year population changes are largely a function of alternate year synchrony in female reproduction while long term population regulation is a function of adult-male-induced mortality in the subadult cohort.

STUDY AREA AND METHODS

The 207 sq. kilometer study area, located on the northwest edge of Cold Lake, lies in the southern fringe of the Boreal Forest. Approximately 40 percent of the study area is aspen-dominated while 5 percent is spruce-dominated. The remainder is equally dominated by jackpine, brushland, treed muskeg, water and old burn areas. Except for the Martineau and Medley River valleys, bordering the east and west sides of the study area and Primrose Mountain on the north edge of the study area, the topography is generally flat. A few summer residents on the shore of Cold Lake are the only human inhabitants on the study area.

PROCEDURES

A more detailed account of capture and marking procedures than given here is presented by Kemp (1970). All animals were captured in foot snares, per-

manently and individually color-marked and a tooth, usually P_1 or P_3, extracted for subsequent sectioning and ageing.

During each of the first four years of this project, an incident of mortality of a snared subadult induced by an adult male was recorded. After reviewing the relatively high rates of subadult mortality it was hypothesized that directly and indirectly adult males may be effecting a regulatory influence on the bear population. To test this hypothesis, 14 and 12 adult male bears in excess of 90.8 kilograms were removed from the population in 1971 and 1972. It was concluded that any documented changes in subadult survival or population numbers would, in part, suffice as a test of the hypothesis.

CENSUS TECHNIQUES

Several methods were used to estimate the bear population on the study area. The results of each year's trapping were divided into four equal groups forming the necessary trapping and resampling periods. Tests for homogeneity of trap response indicated that the distribution of total captures did not differ significantly from a Poisson, i.e. they tended to occur at random. We thus feel justified in using retrapping to obtain marked-unmarked ratios for Lincoln index calculations (Table 1). Completion of the O-capture category of each truncated distribution and their subsequent summation yielded additional estimates of population size. The employment of the capture efficiency method (Table 1) followed the technique as described by Meslow *et al.* (1968).

POPULATION ESTIMATES

Population estimates by several independent methods indicated no significant change in the population during the first four years of study from 1968-1971 (Table 1). The mean estimate for 1968-1971 of 80 results in an overall density of one per 2.6 sq. kilometer. In 1972, the second year of the population manipulation, the population increased to 117 and continued to increase in 1973 to 175 animals (Table 1).

REPRODUCTION

The reproductive performance of the black bear population was principally affected by the proportion of the adult female cohort successfully breeding each year (Table 2). Sows with cubs were rarely seen on the study area, hence no average annual litter sizes could be calculated. Data reported by Jonkel *et al.* (1971), however, indicate that average litter size is remarkably constant from year to year and thus would not importantly affect changes in the size of the cub cohort. Litter sizes as reported by Jonkel for other areas of North America range from 2.0 to 2.5.

The effect of the changing proportion of adult females breeding is reflected in the age composition of the population (Table 3). Unless the litter is lost prior to the breeding season adult females generally breed only every second year. The data (Table 3), however, suggest an element of synchrony when it would normally be expected that about 50 percent of the adult females would breed in any one year. Loss of a litter, age at sexual maturity, age composition and failure to breed every two years would result in asynchronous breeding. This

would indicate that some agent(s) in the environment induce this synchrony by either uniformly stimulating reproduction or impeding it. Our hypothesis at this time is that reproduction is uniformly impaired.

TABLE 1. BLACK BEAR POPULATION ESTIMATES FOR COLD LAKE STUDY AREA, 1968-1973.

Mean Date	Numbers Estimated		Basis[1]
July 31 1968	108		A
	38[2]		B
	76		C
	x 84	(50-118)[3]	
July 29 1969	72		A
	59		B
	108		C
	x 71	(65-86)	
July 20 1970	99		A
	82		B
	94		C
	x 92	(77-107)	
July 4 1971	72		A
	77		B
	90		C
	x 75	(47-103)	
July 6 1972	120		A
	88		B
	87		C
	x 117	(85-150)	
July 16 1973	188		A
	64		B
	158		C
	x 175	(106-244)	

[1] Numbers estimated based on:
- A. Lincoln index; retrapping of marked individuals.
- B. Modified capture efficiency.
- C. Completion of O-capture category using a 'maximum likelihood' technique.

[2] Each Lincoln index and modified capture efficiency estimate is mean of one or more individual estimates.

[3] Confidence limits are at 95 percent level.

TABLE 2. THE ANNUAL NUMBER OF FEMALE BLACK BEAR WITH CUBS CAPTURED ON THE COLD LAKE STUDY AREA, 1968-1973.

Number of female bear with Cubs					
1968	1969	1970	1971	1972	1973
13(16)[1]	2(13)	5(11)	1(6)	6(11)	3(4)

[1] Total number of adult females present on the study are in parenthesis.

TABLE 3. AGE DISTRIBUTION OF INDIVIDUAL CAPTURES OF BLACK BEAR ON COLD LAKE STUDY AREA, 1968-1973.

Age (in years)	1968	1969	1970	1971	1972	1973	Total
cubs	10	3	5	3	8	3	32
1	0	12	3	10	6	6	37
2	2	0	12	1	23	12	50
3	1	4	4	9	10	19	47
4	0	1	3	6	5	2	17
5	29	22	22	15	21	13	122
Total	42	42	49	44	73	55	305

AGE COMPOSITION

The summer age composition of the black bear population was determined from the capture of known-age animals (Table 3). A pre-molar was extracted from animals one year and older and later sectioned to determine the exact age.

The lack of subadults in the 1968 age distribution is probably the result of several years of successive reproduction failure. The strong cub crop of 1968 can be seen in the strong succeeding age cohorts of 1969-1971. The subadult (including cubs)/adult age ratio changes progressively from 0.45 in 1968 to 0.83, 0.96, 1.14, 1.80 and 2.4 in 1969 to 1973, respectively.

As will be shown later, the dramatic increase in the subadult/adult age ratio in 1972 and 1973 is, at least in part, a function of the removal of adult males from the study area and the subsequent increase in subadult male ingress on to the study area.

MORTALITY

Calculation of mortality rates from life table analysis was precluded because the population was neither stationary (Table 1) nor age stable (Table 3).

Average annual subadult ($\leq$2 yr. old) survival as calculated from a survival series (Ricker 1958) was 0.42, 0.43, 0.30 and 0.55 in 1968 to 1971, respective-

TABLE 4. SEX RATIOS OF BLACK BEAR NEAR COLD LAKE, ALBERTA. SAMPLE SIZE IN PARENTHESIS.

Percent Males						
1968	1969	1970	1971	1972	1973	Total
52 (46)	61 (28)	71 (35)	58 (24)	76 (38)	81 (31)	66 (202)

TABLE 5. DISTANCES MOVED BY BLACK BEAR IN THE SAME YEAR AS INITIAL CAPTURE ON THE COLD LAKE STUDY AREA, 1968-1973.

		Percentage of Recaptures at Various Distances from Point of Initial Capture			
Sex	Total Recaptures	914 m	914-4, 570 m	4, 770-18, 280 m	>18, 280 m
Female	24	33.3	58.3	8.3	0
Male	43	11.6	18.6	39.5	30.2

ly. The removal of adult males in 1971 and 1972 precluded the calculation of adult survival rates in this manner.

The low survival in 1970 probably reflects the presence of a large dispersing cohort of 2-year-olds born in 1968, with a normal number of adult males present on the study area. It is felt that the relatively high survival of 1971 is a result of the removal of 14 adult males from the study area.

SEX RATIOS

The overall sex ratio of the black bear population (133 : 69) differed significantly from the theoretical 50 : 50 (Table 4). The sex ratio of 25 : 10 in 1970, 29 : 11 in 1972 and 25 : 6 in 1973 were significant departures from the expecte ratio ($P < .05$). Yearling, 2-yr old and 3-yr old cohorts show a substantial departure from the 50 : 50 sex ratio (Table 5). Since the cub and adult age cohorts are close to the expected sex ratio and since we have no evidence of sex specific mortality, the resultant high proportion of males reflects the increased mobility of dispersing subadult males and in the post 1971 period, the ingress of subadult males onto the study area.

MOVEMENTS

Bear movements are examined in this paper for two reasons: (1) seasonal and/or annual changes in movements may bias the estimation of numbers of bears on the study area; and (2) movements and dispersal are population phenomenon which may importantly affect survival.

Tests for homogeneity of trap response have indicated that the frequency of capture does not differ significantly from the expected random. Captures per trap-night remain constant until the latter part of September at which time the

TABLE 6. DISAPPEARANCE OF MARKED INDIVIDUALS FROM THE COLD LAKE STUDY AREA, 1968-1973.

Number Marked and Recovered in the Succeeding Years						
Year	1968	1969	1970	1971	1972	1973
1968	46	14	7	5	5	1
1969		28	10	5	6	3
1970			35	12	10	4
1971				25	13	6
1972					38	10
1973						31

TABLE 7. DISAPPEARANCE OF MARKED ADULTS (≥3 YRS) FROM THE COLD LAKE STUDY AREA, 1968-1973.

Number Marked and Recovered in the Succeeding Years						
Year	1968	1969	1970	1971	1972	1973
1968	33	11	5	5	5	1
1969		12	9	5	5	3
1970			14	7	6	2
1971				8	2	2
1972					7	2
1973						4

TABLE 8. DISAPPEARANCE OF MARKED SUBADULTS (≤3 YRS) FROM THE COLD LAKE STUDY AREA, 1968-1973

Number Marked and Recovered in the Succeeding Years						
Year	1968	1969	1970	1971	1972	1973
1968	13	3	2	1	0	0
1969		16	1	0	1	0
1970			21	5	4	2
1971				17	11	4
1972					31	8
1973						27

onset of hibernation results in reduced mobility. This evidence strongly suggests that seasonal movements do not bias the estimation of numbers.

Ninety-two percent of the captured female population moved less than 4,570 meters from point of initial capture to subsequent capture in the same year (Table 6). Likewise, 70 percent of the male population moved more than 4,570 meters. Preliminary analysis indicates that the bulk of the males moving more than 18,280 meters are dispersing subadults.

Relative disappearance rates may also be indicative of mobility and/or mortality combined. For the period 1968-1973, 34 percent ($n = 172$) of the animals marked in one year were recovered the following year (Table 6). The overall recovery rate for adults was 42 percent ($n = 74$) (Table 7) while that for subadults was 29 percent ($n = 98$) (Table 8). A further examination of the subadult recovery rates indicates that 18 percent ($n = 50$) of the subadults were recovered in the pre-manipulation period prior to 1971 while 40 percent ($n = 48$) were recovered in the post manipulation period of 1972 and 1973. Although the data is admittedly crude, it is felt that the increased recovery rates in the post-manipulation period reflects the lack of adult males and the increased desirability of these vacant areas to subadults.

DISCUSSION

Population regulation is here defined simply as the dampening of numerical fluctuations by density-dependent processes. Evidence presented in support of the hypothesized regulatory effect of adult males on the bear population is:

(1) the population increase from 80 in the pre-manipulation period to 175 in the post-manipulation period; and

(2) the increased recovery rate and hence possibly survival of subadults in the post-manipulation period.

The fact that snared subadults were killed by adult males indicates that adult males are capable, if given the opportunity, of inflicting outright mortality. It is not suggested that this occurs in significant instances in free-ranging animals. Whether or not directly induced mortality by adult males is significant, or whether mortality is from other causes resulting from aggressive behavior and subsequent increased dispersal of subadults, remains to be tested in 1974 and 1975.

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