

BLACK BEAR MANAGEMENT IN YOSEMITE NATIONAL PARK

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Abstract: Conflicts between park visitors and the American black bear (*Ursus americanus*) in Yosemite National Park pose serious management problems for the National Park Service and often result in extreme inconvenience and monetary losses to park visitors. Food-reward associations with humans have resulted in the loss of the black bear's instinctive fear of people and in the development of highly sophisticated patterns of depredation. A management program consisting of 5 basic elements was implemented in the spring of 1975 to meet bear management objectives of the National Park Service. The effects of management on bears and park visitors were evaluated by monitoring the patterns of damage that bears displayed before and during the program. Analyses of data accrued from property damage, personal injuries, and control of problem bears were also made. The results of these analyses are discussed and their implications applied to management practices and research needs. Comparisons of data accrued before and through the first 2 years of the program appear to support the hypothesis that the program is achieving its stated objectives.

The natural behavior, foraging habits, distribution, and numbers of black bears in Yosemite National Park have been significantly altered by habituation to human-supplied food sources. During the past 6 decades of food-reward associations with people, bears have evolved deeply ingrained, sophisticated patterns of depredation.

The Yosemite Human-Bear Management Program was implemented in 1975 to meet bear management objectives of the National Park Service with minimum adverse impact on the black bear population and environment. This paper summarizes the management problem and management activities, describes evaluation procedures, presents preliminary results, and brings together data that may be used for future program analysis.

The conflict between bears and people and the effects of people upon bears are seen nowhere more dramatically than in Yosemite National Park. Extensive development, high levels of visitor use, and patterns of visitor use are key factors contributing to the conflict. Visitation has exceeded 2.25 million people since 1968 and 2.7 million in 1976 (Table 1). Levels of backcountry use tripled in less than 10 years. Recorded visitor-nights of use increased from 77,654 in 1967 to 169,924 in 1976. In 1976, 64,606 people spent nights in the backcountry.

Extensive development including campgrounds, hotels, restaurants, stores, swimming pools, tennis courts, golf courses, a ski area, and 5 backcountry High Sierra Camps concentrates human use in available bear habitat, increasing the potential for encounters with bears. Stokes (1970) found that repeated visits of bears to developed areas and garbage disposal sites to obtain food represent reward-reinforced behavior.

Through food-reward association, bears have learned the relationship between vehicles and food stored in them. In the last 3 years, 1,493 vehicles were damaged or broken into by bears seeking food — 65 percent of the 2,293 recorded bear incidents. Bears have also learned the association between backpacks or foodsacks suspended from trees and the ropes holding them up. Today, the average backpacker finds it increasingly more difficult to suspend food supplies in a manner that prohibits bears from reaching them. In the past 2 years, it is estimated that 3,840 bear incidents occurred in the backcountry. The level of sophistication shown by bears in their patterns of depredation appears to be increasing as their instinctive fear of people decreases.

After review of available information, the Superintendent of Yosemite National Park directed that a program be implemented to (1) restore and maintain the natural distribution, abundance, and behavior of the endemic black bear population; (2) provide for the safety of park visitors and their property; and (3) provide opportunities for visitors to observe, understand, and appreciate the black bear in its natural habitat.

METHODS

Methods employed included (1) public information and education, (2) removal of all artificial food sources, (3) enforcement of regulations regarding proper food storage and the feeding of wild animals, (4) control of problem animals, and (5) research and monitoring.

Public information systems and steps taken to increase the public's awareness of the program and compliance with its provisions included (1) distribution of bear brochures to both frontcountry and backcountry users; (2) permanent warning signs at park entrances, campground entrances, parking lots, and park restrooms; (3) articles regarding bears and people in each

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Table 1. Property damages and personal injuries attributable to black bears, Yosemite National Park, 1966-76.

Year	Park visitation	Damage incidents ^a		Decrease/increase of incidents from previous year (%)	Number of personal injuries	Number of visitors per injury	Control actions ^b
		Number	Estimated value (\$)				
1966	1,817,000	49	1,888	-	29	63,000	47 (24)
1967	2,201,500	72	2,843	47	11	200,000	48 (17)
1968	2,281,100	49	2,670	-47	6	380,000	16 (4)
1969	2,291,300	86	6,360	76	12	191,000	38 (4)
1970	2,277,200	27	4,730	-69	3	759,000	40 (6)
1971	2,416,400	103	11,835	282	10	242,000	61 (13)
1972	2,266,600	262	28,588	154	3	746,000	81 (17)
1973	2,339,400	246	24,367	-6	16	146,000	43 (9)
1974	2,343,100	613	80,248	149	28	84,000	26 (1)
1975	2,619,000	975	113,197	59	15	175,000	135 (10)
1976	2,753,100	688	66,294	-29	12	229,000	147 (16)

^a Not including personal injuries.

^b Numbers of bears killed given in parentheses.

summer issue of the park newspaper; (4) increases in the numbers of ranger patrols and interpretive programs about bears; and (5) an AM taped radio broadcast receivable on all roads entering Yosemite Valley informing the public about bears.

Open garbage pit dumps were sources of artificial food until 1969 and 1970 when land dumps were closed and a solid waste collection system was adopted. Despite the conversion, bears continued to feed on garbage provided by the non-bearproof dumpsters. In the spring of 1975, all dumpsters in use in the park were bearproofed. Cables from which park visitors could suspend their food supplies out of reach of bears were installed in selected backcountry areas and frontcountry walk-in campgrounds.

Efforts to insure denial of human food sources and to have visitors store food so as not to lure bears into campgrounds were aided by the adoption of Special Regulation S7.16e (3) CFR 36 requiring proper food storage methods. The level of enforcement varied from verbal warnings to arrest and/or impoundment of property.

One control action was recorded each time a bear was either captured and transplanted, shipped to a zoo, or destroyed. Efforts to remove bears promptly from park developments when property damage or injuries were occurring were intensified. Bears were captured, while free-ranging, with Sernylan (phencyclidine hydrochloride) administered by projectile-syringe, with baited culvert traps, and with Aldrich snares. Measurements, weight, sex, and age were recorded, and a blood sample was collected. Bears were tagged with metal cattle ear tags with vinyl streamers attached.

Bears were relocated 13-48 airline km from their capture sites and released at predesignated release sites.

To control bear densities in each release area, a minimum interval of 7 days was allowed between successive releases in each area: this 7-day release interval was violated only when all other release sites were full.

Bears were intentionally destroyed using pentobarbital sodium and processed as scientific specimens if they had been relocated twice, captured a third time, and their individual trapping records showed conclusively that they were confirmed rogue animals or were responsible for personal injuries. Bears twice relocated and captured a third time that were not serious problem animals were relocated a third time.

The Division of Resources Management maintained a central monitoring system that recorded human injuries, property damage incidents, and all bear control actions on a daily basis. Thus, current information for guiding the overall program and data for evaluation studies were available.

A 2-year research study on the population ecology of the black bear in Yosemite National Park was contracted to the University of California, Berkeley, in 1974 and has since been extended to cover a 4-year period ending September 1978.

The success of the program depends on the validity of the hypothesis that removal of unnatural foods will restore a natural population of bears, thereby reducing the need to control (capture and transplant or destroy) bears to protect humans and their property. Data accrued from problem bear control, property damage, personal injuries, and research on population dynamics will be used to test the following hypothesis:

Bear control procedures, law enforcement, public information systems, and management actions to

eliminate unnatural food sources, applied under the 1975 Human-Bear Management Program, will (1) restore a more natural black bear population than exists at present, as evidenced by fewer bears using developed areas and by progressive reduction in the numbers of bears controlled or destroyed; (2) reduce the number of property damage and human injury incidents from previous levels; and (3) not prevent the park bear population from stabilizing at the natural carrying capacity of the park.

RESULTS

Property Damage Incidents

Removal of artificial food sources in the spring of 1975 marked the beginning of a transition period in which bears are expected to resort primarily to natural foraging for energy requirements. In the first year after artificial foods were eliminated, incidents increased to a high of 975 but decreased to 688 in the second year (Table 1). Plotting property damage incidents (PDs) on a graph showed that the number of PDs increased exponentially from 1961 through 1975. The number of PDs fitted to a regression line with a square-root transformation as the dependent variable and with time as the independent variable (Fig. 1) shows that PDs increased significantly with time ($t = 5.73, df = 9, \alpha$

$= 0.01, r = 0.89$). A 95 percent confidence interval is constructed around the regression line as graphically portrayed by the dashed lines in Fig. 1. The 975 and 688 incidents recorded in 1975 and 1976, respectively (after removal of unnatural foods), fall within these boundaries, indicating that they do not differ significantly from the exponential growth trend. However, incidents in 1976 decreased 29 percent from those of the previous year. We expect further decreases in incidents as young bears without human-altered behavior progressively replace incorrigible animals and the population readjusts to natural carrying capacity levels.

Patterns of damage and changes in patterns that bears display may be useful in determining the effects on both bears and people of removing unnatural foods. Patterns monitored included (1) time of incidents, (2) location, (3) type of property damage, and (4) the relation of food and food storage to incidents.

The time that incidents occurred in 1974 through 1976 (month; weekend vs. weekday; hour) remained relatively unchanged; 70 percent of the damage occurred in June, July, and August; and 18 percent occurred in September, October, and November. The percentage of incidents that occurred in the daytime (15 percent) and at night (74 percent) also remained the same, suggesting that the bearproofing program has not altered the bears' crepuscular activities (times of occurrence for 11 percent of the incidents were unknown).

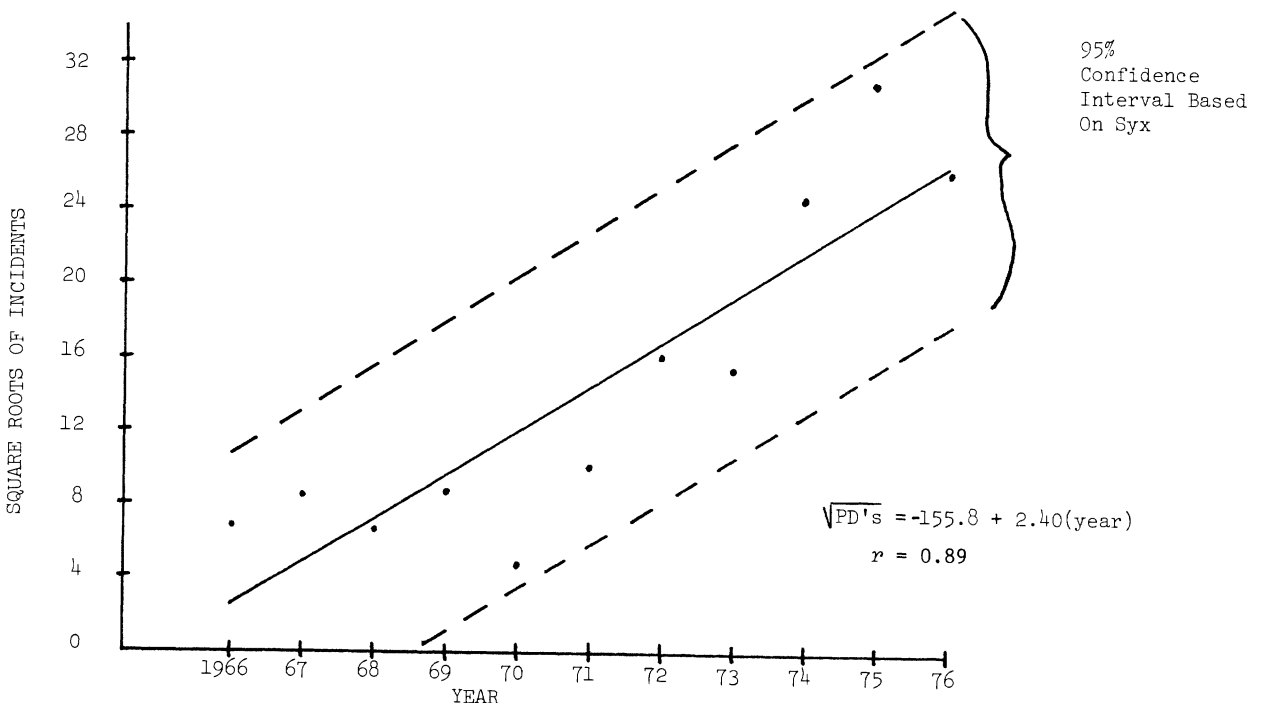


Fig. 1. Property damage incidents fitted to a regression line using a square-root transformation as the dependent variable and time as the independent variable.

The percentage of incidents that occurred in campgrounds decreased from 71 percent in 1974 to 46 percent in 1976 but the percentage of incidents in parking lots increased 15 percent. This shift suggests to some degree the effectiveness of the new program. The percentage of incidents in all other locations except backcountry areas remained the same.

Food rewards associated with people or with objects that contain food have resulted in deeply ingrained patterns of depredation. Some forms of bear behavior appear to be conditioned responses from past experiences that resulted in positive food rewards; examples are smashed windows of vehicles that contained no food, tree limbs or ropes chewed into to retrieve suspended food, and false charges at people. Behavior that resulted in bear incidents due to conditioned responses and in which no human error precipitated the incident is referred to in this paper as *conditioned bear behavior*.

Smashing vehicle windows and pulling out window and door frames to gain entry into vehicles for food represent a behavior pattern that characterizes the Yosemite population. Methods of food storage in a vehicle are critical factors in determining the likelihood

of bear damage to the vehicle (Table 2). Vehicles that had food in the passenger sections either because they lacked trunks or because people neglected to store food properly sustained 68 percent of the total vehicular damage incidents in 1976. Vehicles with properly stored food represented only 18 percent of the incidents. Fourteen percent of the damaged vehicles had no food in them. Over \$54,000 damage to vehicles occurred in 1976, a decrease of 43 percent from a high of \$96,594 recorded in 1975. An indication of a favorable trend is that the percentage of incidents involving vehicles declined from 70 percent in 1974 to 57 percent in 1976.

To determine the cause of incidents, causative factors were assigned to each incident investigated (Table 3). Unstored food and improperly stored food were major causative factors for 48 percent of frontcountry incidents in 1976. Forty-six percent of the incidents were attributed to conditioned bear behavior.

Backcountry Incidents

Surveys by backcountry rangers checking compliance with wilderness permits showed the number of

Table 2. Analysis of bear incidents relating food and food storage to property damage, Yosemite National Park, 1974-76.

	Food in trunk of vehicle	Food in passenger section; vehicle with trunk	Food in passenger section; vehicle without trunk	No food present	Food storage unknown	Food present	Food left in open	Food hung from tree/cable	Total ^a
Vehicles									
1974	64(15) ^b	163(37)	93(21)	33 (8)	86(20)	-	-	-	439(70%)
1975	132(20)	205(31)	237(36)	87(13)	-	-	-	-	661(68%)
1976	70(18)	124(32)	143(36)	56(14)	-	-	-	-	393(57%)
Towed units									
1974	-	-	-	-	-	-	-	-	-
1975	-	-	-	1 (6)	-	15(94)	-	-	16 (2%)
1976	-	-	-	1(10)	-	9(90)	-	-	10 (2%)
Tents									
1974	-	-	-	26(46)	11(20)	19(34)	-	-	56 (9%)
1975	-	-	-	19(46)	-	22(54)	-	-	41 (4%)
1976	-	-	-	11(39)	-	17(61)	-	-	28 (4%)
Backpacks									
1974	-	-	-	-	4 (6)	-	20(27)	49(67)	73(12%)
1975	-	-	-	-	8 (6)	-	38(26)	100(68)	146(15%)
1976	-	-	-	-	18 (9)	-	28(13)	165(78)	211(31%)
Ice chests									
1974	-	-	-	-	-	-	26(100)	-	26 (4%)
1975	-	-	-	-	7(10)	-	58(88)	1 (2)	66 (7%)
1976	-	-	-	-	16(27)	-	41(69)	2 (3)	59 (9%)
Other									
1974	-	-	-	-	-	-	-	-	36 (6%)
1975	-	-	-	-	-	-	-	-	71 (7%)
1976	-	-	-	-	-	-	-	-	94(14%)

^a Percent given as percent of total incidents.

^b Percent of damaged items given in parentheses.

Table 3. Causative factors for property damage incidents in Yosemite National Park, 1975-76. Table gives the percentage of incidents assigned to each factor.

	Feeding/ baiting (intentional)	Food left in open	Improper food storage	Improper disposal of garbage	Accidental encounter	Conditioned bear behavior	Unknown
Frontcountry							
1975	1	9	35	0	0	54	1
1976	0	12	36	1	0	46	5
Backcountry							
1975	0	8	16	0	1	75	0
1976	0	10	8	0	0	74	8

reported incidents to be low and unrepresentative of actual backcountry bear encounters. The number of backcountry incidents can be estimated from the percentage of parties contacted that suffered incidents and from data on wilderness permit compliance. The level of incidents expressed as incidents per thousand visitor-nights decreased from 13.5 in 1975 to 7.0 in 1976 (Table 4).

The reduction in backcountry incidents is attributed largely to information systems, enforcement of food storage regulations, and the installation of food suspension cables in selected high-problem areas. However, it is clear from the number of incidents and from personal observation that the large majority of backcountry users underestimate the cleverness and ability of bears to retrieve food suspended from or between trees. Aversive conditioning of bears may be required to reestablish an avoidance of people and minimize backcountry conflicts.

Injuries

A reduction in injuries occurred each year after the program was implemented (Table 1). The 12 injuries recorded in 1976 represent decreases of 57 and 20 percent from the 28 and 15 injuries recorded in 1974 and 1975, respectively. Two of the injuries in 1975 and 9 of the injuries in 1976 occurred in backcountry areas. Four of the backcountry injuries in 1976 occurred in 1 night and were attributed to a single yearling bear

seeking food in an area of high visitor use. The bear was destroyed the next day.

Problem Bear Control

Cooperative efforts between contract researchers from the University of California, Berkeley, and park rangers and biologists have served to accentuate both research and management programs. Since 1974, 202 individual bears have been captured and marked. Intensified efforts to keep bears out of developed areas increased the number of control actions sharply in 1975 and 1976 and yielded many data useful in evaluating currently accepted management practices regarding control of problem bears. Under the criteria outlined in the management plan, 26 bears were killed in management actions in 1975 and 1976. The effects of management-induced mortality on the population will be analyzed when results of current research on population dynamics become available.

Relocation of problem bears resolved immediate problems only temporarily. During 1976, 98 different bears were relocated within park boundaries a total of 131 times. Observation of bears returned and/or recaptured at the same or another developed area indicated a 38 percent return rate (31 percent returned to their original capture sites). In 1975, the rate of return to developed areas for 100 bears relocated 125 times was 26 percent (21 percent returned to their original capture sites); in 1974 the rate was 8 percent for 23

Table 4. Levels of visitor use, bear incidents, personal injuries, and control actions in Yosemite's backcountry, 1973-76.

Year	Recorded visitor- nights	Estimated number of bear incidents	Incidents per thousand visitor- nights	Recorded incidents	Recorded damage (\$)	Personal injuries	Control actions
1973	141,464	-	-	-	-	-	-
1974	192,180	-	-	61	2,145	2	0
1975	196,565	2,654	13.5	96	5,762	2	2
1976	269,924	1,186	7.0	160	4,471	9	3

Table 5. Summary of black bear captures/relocations and return rates to developed areas for 1-, 2-, and 3-year intervals, 1974-76.

Year	Total number of captures	Total number of new animals	Sex ratio M:F	Cumulative new animals	Number of times captured					Total number of individuals
					1	2	3	4	5	
1974	55	42	21:19	42	32(76%)	7(17%)	3 (7%)	0 (0%)	0 (0%)	42
1975	160	93	50:61	135	78(69%)	25(22%)	8 (7%)	2 (2%)	0 (0%)	113
1976	172	67	55:58	202	75(66%)	23(20%)	10 (9%)	4 (4%)	1 (1%)	113

Year	Total relocations	Number of times each individual relocated				Total number individuals relocated	Recaptures			Return rates ^a		
		1	2	3	4		First year	Second year	Third year	1-year interval	2-year interval	3-year interval
1974 ^b	25	21	2	0	0	23	2	8	3	8% (0%)	40%	52%
1975 ^b	125	76	23	1	0	100	33	31	-	26% (21%)	51%	-
1976 ^b	131	71	23	3	1	98	44	-	-	34%	-	-
1976 ^c	-	-	-	-	-	-	49 ^d	-	-	38% (31%)	-	-

^aNumbers in parentheses indicate return rates to original capture sites.

^bReturn rates based on recapture data only.

^cReturn rates based on recaptures and observations.

^dIncludes observations of 5 bears returned but not captured.

bears relocated 25 times. Table 5 shows the successive increases in the return rate as the time interval after relocation increased. The tendency for bears to return to their original capture sites, the geographical distribution of developed areas in Yosemite, and insufficient land area for relocation all served to negate the effectiveness of transplants.

Transplant success in 1975 was shown to be related to the distance transferred from the capture site (Harms 1976). The transplant success (85 percent) for bears transferred 37-48 km was significantly greater ($P < 0.05$) that the success (65 percent) for bears transferred 13-20 km. However, in 1976, no significant difference could be shown between success rates and transfer distances (Table 6). This lack of significance may be explained in part by the fact that many bears relocated in 1976 had also been relocated one or more times in

1974 and/or 1975 and may have improved their homing abilities.

When return rates to developed areas were analyzed by age-class (Table 6), yearlings and subadults showed successes of 29 percent and 11 percent, respectively, as compared with 42 percent for adults. Optimistic interpretation of these data suggests that successful rehabilitation of these age-classes may be occurring. It is recognized, however, that the stress of the relocation in terms of placing a subdominant animal in an area in which the natural carrying capacity is already exceeded may increase the mortality rates for these age-classes. Jonkel and Cowan (1971), studying a black bear population in Montana, found that young bears over 1.5 years of age rapidly disappeared from the population. No difference was observed in return rates between females and males relocated in Yosemite.

Table 6. Black bear return rates, by age-class, in relation to relocation distances, Yosemite National Park, 1976.

Relocation distance (km)	Number released					Number returned to developed areas					Return rate
	Cub	Year-ling	Sub-adult	Adult	Total	Cub	Year-ling	Sub-adult	Adult	Total	
1.0-17.9	2	7	0	7	16	0	2	0	4	6	38%
18.0-33.9	10	9	3	24	46	3	4	1	10	18	39%
34.0-49.9	23	5	6	35	69	11	0	0	14	25	36%
Total	35	21	9	66	131	14	6	1	28	49	38%
Return rate by age-class						40%	29%	11%	42%	38%	

Females with cubs showed the strongest homing instincts. All females with cubs that were relocated and recovered in 1976 returned to their original capture sites at an average rate of 2.75 km/day (Table 7) with an average recovery time of 21 days. The rate of return for adult males averaged 1.61 km/day with an average recovery time of 38 days.

Table 7. Transplant/recovery distances (airline km) and rates of return to original capture sites for 41 black bears by sex and age-class, 1976.

Age-class	Transplant/recovery distance (km)		Rate of return (km/day)		Elapsed time (days), release to return	
	Male	Female	Male	Female	Male	Female
Adult						
X	29.45	33.69	1.61	2.44	38.18	21.77
N	11	13	11	13	11	13
SD	10.59	10.56	1.26	2.02	40.99	16.88
Subadult						
X	-	-	-	-	-	-
N	0	0	0	0	0	0
SD	-	-	-	-	-	-
Yearling						
X	10.33	-	1.24	-	17.00	-
N	3	0	3	0	3	0
SD	5.13	-	0.21	-	6.92	-
Cub						
X	35.86	38.29	2.75	2.75	20.43	21.57
N	7	7	7	7	7	7
SD	7.84	6.45	1.27	1.40	21.31	20.90

Emigration and dispersion of bears as a result of the relocation program and/or removal of artificial food sources have been observed. Some bears made substantial treks beyond park boundaries after being transplanted. The greatest distance traversed from the release site was approximately 100 km. One adult male traversed 97 km in 14 days. A female with a cub was observed near Kings Canyon National Park, a distance of 77 km, 13 days after being released. All bears that made long treks in short periods of time continued to travel in the same approximate direction as their transplantation, e.g., bears relocated southward continued moving south (Graber and White 1976). These movements are contrary to the typical response in which 31 percent of the bears relocated in 1976 returned to the exact locations of their capture. Perhaps these bears were completely confused in their "compass orientation" and moved long distances in an attempt to find their home territories or familiar landmarks.

Population Levels

Present population levels greatly exceed past reported natural levels. Grinnell and Storer (1924) esti-

mated 125 bears in 1920. Until current research shows otherwise, this figure represents our best estimate of the natural carrying capacity of the park. The present population is estimated to be between 220 and 350 animals; this estimate is based upon density levels of 0.13-0.19 bear/km² of available bear habitat. The number of bears tagged (202) since 1974 indicates the minimum estimate of 220 to be low.

As artificial food sources are removed and natural carrying capacities restored, the population is expected to decrease. Through scat analysis, Graber and White (1976) showed that the use of human foods by bears in Yosemite Valley during the spring of 1976 (17 percent by volume, 17 percent by frequency) was substantially reduced from the summer of 1974 (48 percent by volume, 63 percent by frequency). Continued research on food habits and population dynamics should detect responses of the population to the restoration of natural carrying capacities.

CONCLUSIONS

The basic premises of Yosemite's black bear program follow those for grizzly bears in Yellowstone National Park (Cole 1976). These premises include: (1) The "right" number of bears is the number that occurs naturally (i.e., without human influences on bear behavior, habits, or population dynamics). (2) Removals of unnatural food and incorrigible animals will allow young bears without human-altered behavior or habits to progressively replace incorrigible animals in the population. Once replacement is accomplished, (3) the control of human influences alone will prevent corruption of new bears and will thereby supersede control of bears. Since the program has been in effect only 2 years, statistical analysis of the effects of the program is confined to the limitations set by the sample size. Personal injuries decreased in both years of the program but it is difficult to show that the reductions were significant. However, the hypothesis that the program will reduce injuries need not be rejected. The alternative hypothesis that the program will increase injuries, or the null form that it had no effect on injuries, is not supported by the preliminary data.

Regression analysis correlating incidents with time showed a significant positive relationship before the program's implementation. The equation of the lines allows forecasts of the number of incidents in future years. The difference between actual values and predicted values can be tested to determine whether the observed values differ significantly from the trend line. Neither the increase in incidents after program implementation nor the decrease that occurred in the sec-

ond year differed significantly from the trend line. Four hundred or fewer incidents in 1977 would represent a significant reduction.

Experience in several national parks demonstrates that relocation programs have limited success unless the homing abilities of the bears can be overcome through transplant distances of 80 km or more. Relocation at great distances is physically impossible at Yosemite if bears are to be released inside park boundaries. Information on recovery times and on rates of return for relocated bears in Yosemite suggests that preventive programs of sanitation, information, law enforcement, visitor control, and perhaps aversive conditioning should preclude bear control in the priorities of responsive management tools.

Levels and patterns of visitor use continuously expose artificial food sources to bears and provide food-

reward associations with people. Human-altered behavior has become deeply ingrained in the majority of the bear population as evidenced by the high number of incidents despite intense control efforts. Visitor use levels and patterns in Yosemite may preclude the possibility of achieving a wholly natural black bear population. That goal however, should not be reduced. Instead, managers should seek to apply new techniques and methods in addition to following currently accepted management practices. Aversive conditioning, area closures, restricted visitor use, and use of individual food lockers in both backcountry and frontcountry areas are possible methods yet to be tried. In the final analysis, however, the priority that Park Service administrators place upon achieving *naturalness* in the black bear population will determine the level and nature of future management programs.

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