Effects of trapping with bait on bait-station indices to black bear abundance

Lara L. Brongo, Michael S. Mitchell, and James B. Grand

Abstract Indices of relative abundance allow managers and researchers to examine changes in population size over time or compare relative population sizes in different areas. In the Pisgah Bear Sanctuary, bait station surveys were conducted in most years from 1983 to 2000 to follow trends over time in the black bear (*Ursus americanus*) population. Baited bear trapping also took place in the sanctuary during those years, and some trap lines coincided with bait-station lines. Because the same baits were used for both trapping and bait station lines, we hypothesized that visitation rates of bears to bait stations established in proximity to baited trap lines would differ from rates at bait stations that were not associated with baited trap lines. We modeled probability of bait stations being visited by bears on trapped and untrapped lines to estimate the effect baited trapping had on visitation rates. We found that population trends inferred from bait-station visits in areas that also were trapped with bait were biased high and that bias increased over time. Bears may have become habituated to the bait on trap lines and incorporated it as a regular food source. Bait-station indices should not be conducted near research sites that employ similar bait when both produce a tangible reward for the animals.

Key words bait-station index, black bears, mark–recapture, North Carolina, relative abundance, southern Appalachians, *Ursus americanus*

Indices of relative abundance are a common tool used to analyze animal populations. Although not actual population estimates, unbiased indices of relative abundance allow managers or researchers to track relative changes in populations among different areas and over time. The validity of an index depends on the strength of the linear relationship assumed to exist between observations collected and the phenomena of interest (i.e., track counts are proportional to animal density; Williams et al. 2002). Indices usually are less costly than other research methods such as mark-recapture, radiotelemetry, and DNA analysis. Therefore, they often are used by management agencies.

Bait-station indices measure relative abundance and commonly are used to assess trends in black bear (*Ursus americanus*) populations (Rice et al. 2001). A bait station typically consists of sardine cans or other baits nailed to a tree or suspended above the ground within reach of a bear. Bait stations are placed at regular intervals along roads or trails, and all the stations on a particular road or trail are considered a bait-station line. Visitation rates at bait stations over a fixed sampling period (generally 5–7 days) are used to determine population trends over time or to compare relative abundance between populations. Relative abundance indices are most effective as a supplement to other methods of population estimation, such as mark–recapture, rather than as a substitute (Sargeant et al.

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1998). Bait-station indices can provide insights into population trends, but they do not provide estimates of population size, survival, or fertility.

Our research project included both trap lines and bait-station lines in most years from 1983-2000. The purpose of the trap lines was to capture bears for mark-recapture analysis and radiotelemetry, while the purpose of bait stations was to gain a relative index of bear densities in different areas and over time. Traps were usually baited with open sardine cans to lure bears in so that we could catch the bear, collect data, and in some cases radiocollar the bear. Stations were baited with sardine cans nailed to a tree so that we could judge the presence of a bear when the can was chewed or clawed open without actually catching the bear.

Our original research objective was to estimate population growth from the change in visitation rates from year to year. Since black bears readily become habituated to outside food sources (Ternet and Garshelis 1999), we began to question whether having bait stations on the same trails as baited traps would affect visitation rates of bait stations and would, in turn, bias estimates of population growth. The presence of baited trap stations in areas with bait stations could potentially attract proportionally more bears to the bait stations than would normally register, thus inflating index data recorded in that area. To address that question, we shifted our research focus and hypothesized that visitation rates would differ between trapped and untrapped bait-station lines.

Study area

The Pisgah Black Bear Sanctuary was located in the southern Appalachians (35°17'N latitude, 82°47'W longitude). The 235-km² sanctuary was contained within the Pisgah National Forest, and the major road through the sanctuary was the Blue Ridge Parkway. Elevation in the sanctuary ranged from 650-1,800 m. Oak (*Quercus* spp.), pine (*Pinus* spp.), and pine-hardwood were the major forest types. The forest understory was often dense with rhododendrons and laurels (*Rhododendron* spp. and *Kalmia* spp.), other ericaceous shrubs, and berry bushes (*Vaccinium* spp., *Gaylussacia* spp., and *Rubus* spp.). The area was considered a temperate rainforest, with high (up to 250 cm/yr) annual rainfall. Human use of the area included hiking, biking, camping, hunting for species other than bears, and other recreation (Powell et al. 1997).

Methods

Bait-station indices

We collected bait-station index data beginning in either mid-May or late June until early July in 1983-1990, 1993-1996, and 1999-2000. Project personnel set an average of 60 bait stations (60.29 ± 21.84 [SD]) each year in Pisgah Bear Sanctuary. We constructed bait stations by nailing 2 partially opened sardine cans to a tree approximately 2 m above ground. We set stations along trails and unpaved roads and spaced them at ca. 0.8-km (0.5-mile) intervals. A member of the research crew checked each station after 5-7 days and recorded whether the station had been visited (hit) by a bear. When a sardine can had been removed and had bite marks that were clearly from a bear, we considered the station visited. We recorded the date, station location, and whether or not the station had been visited for each bait station.

Approximately 30% of the bait stations were on trails also used for trapping. Along trapping lines, we live-trapped bears May-July from 1981-2002 using Aldrich foot snares modified for bear safety (Johnson and Pelton 1980) or culvert traps. We baited traps daily with 1-3 cans of sardines. Trap and bait-station trails ranged from 2-6 miles in length and usually had 5-10 trap locations or bait stations on each. Bait stations never coincided with trap sites.

Analysis

We used logistic regression mixed models to analyze bait-station visitations among years to estimate the probability of bears visiting a station in a 5-7-day sampling period. We examined 3 models for correlated data that incorporated random effects to control for expected correlation among bait stations along each line (PROC NLMIXED, SAS Institute, Cary, N.C.; Hosmer and Lemeshow 2000). Our first model evaluated probability of a bait station being visited over time (YEAR). The second model evaluated the additive effects of time and trapping on probability of a station being visited (YEAR + TRAP). This model evaluated the difference in probabilities between bait stations that were trapped and not trapped. The third model evaluated the interactive effect of time and whether the bait-station line also was trapped on the probability of a station being visited (YEAR *

TRAP). This model evaluated the variation over years in the difference in probability of visitation between bait-station lines that were trapped and not trapped. We ranked models using Akaike's Information Criterion adjusted for small sample size (AIC_c, Akaike 1973) to determine which model best fit the data. We used estimates from the highest-ranking model to graph trends in probability of a visit over time.

We examined discriminatory ability of our best model based on AIC_c by calculating the area under the receiver operating characteristic (ROC) curve, which measures the model's ability to correctly predict whether a station is visited or not visited (Hosmer and Lemeshow 2000). Using a decision criterion of 0.5 for discriminating among stations that were expected to be visited ($\hat{P} \geq 0.5$) and those not expected to be visited ($\hat{P} < 0.5$), we measured the probability (area under the curve) that the outcome predicted by the model was correct. We calculated the percent to which the model improved discrimination among visited and unvisited sites over random chance (i.e., ROC=0.5; Hosmer and Lemeshow 2000) as (ROC−0.50)/0.50.

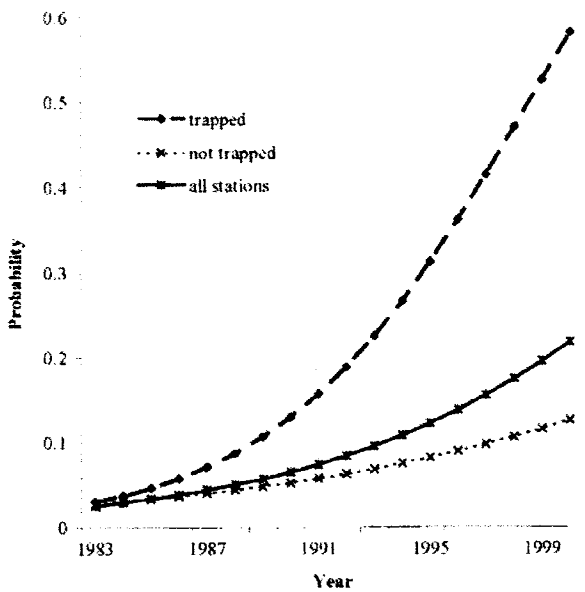

Figure 1. Probability of a black bear bait station being visited in a 5–7-day period for stations that were trapped (interaction model, YEAR*TRAP; Table 1), not trapped (interaction model, YEAR*TRAP), and for all stations together (year-only model, YEAR) in the Pisgah Bear Sanctuary of North Carolina from 1983–2000.

Results

The highest-ranking model was YEAR * TRAP (Table 1). Evidence for the YEAR * TRAP model (model weight, w=0.875) was 7 times greater than the YEAR+TRAP (w=0.125), and there was virtually no evidence (w=0) supporting the model that only included differences among years (YEAR, Table 1). The ROC curve indicated the highest-ranking model assigned a higher probability of visitation to sites actually visited by bears in 86.1% (area under the curve) of all pairwise comparisons, suggesting the model was 72% better than random discrimination of visited and unvisited stations.

According to the YEAR * TRAP model, in 1983 the probability of a station being visited was nearly equal for bait stations located on trapped and untrapped lines (P=0.030 and 0.027, respectively; Figure 1). By 2000 the probability of a trapped station being visited (P=0.581) was nearly 5 times that of a visit on a station not trapped (P=0.125; Figure 1). In 2001 the probability of a bait station being visited on any line (YEAR model; Figure 1) was 74% higher than a station being visited on an untrapped line (YEAR * TRAP model; Figure 1), suggesting the effect of baited trapping on visitation of bait stations increased over time.

Table 1. Selection criteria for models estimating probability of black bear bait station visits incorporating variation over time (YEAR), combined effect of trapping or not trapping and variation over time (YEAR + TRAP), and the interaction of trapping or not trapping with variation over time (YEAR * TRAP) in the Pisgah Bear Sanctuary of North Carolina from 1983–2000.

Model	AIC	AIC_c	ΔAIC_c	w	Parameters
YEAR * TRAP	340.9	341.2	0.0	0.875	4
YEAR + TRAP	344.9	345.1	3.89	0.125	3
YEAR	361.7	361.8	20.61	0.0	2

Discussion

The random-effects analysis we used allowed us to control for any correlations within our data structure (e.g., between bait stations or traps within the same lines, between spatial or temporal heterogeneity of bear population dynamics or behavior, etc.), permitting an unbiased assessment of the effects of baited trapping on bait-station estimates of relative abundance (Hosmer and Lemeshow 2000). Our hypothesis that visitation rates differed between lines of bait stations that were trapped with bait and those that were untrapped was supported. Both models incorporating trapping effects ranked higher than the model that did not incorporate effects of trapping. Model weights (w) indicated a much higher probability that YEAR*TRAP was the best approximating model given the suite of models we evaluated. Since the YEAR*TRAP model ranked higher than the YEAR + TRAP model, not only did a difference in probability of a visit on trapped and untrapped bait station lines exist, but also that difference changed over time. According to Hosmer and Lemeshow (2000), an ROC likelihood between 0.8 and 0.9 is considered excellent discrimination between events (i.e., visited bait stations) and nonevents (unvisited stations). Thus, our model strongly suggested that the bears we studied became habituated to bait stations and baited trapping sites.

The YEAR model, which did not incorporate the effect of baited trapping, represented the typical approach used to infer population trends over time through analysis of bait-station visits. Our analysis suggested that our observations were not independent within years or trap lines: unless we used a YEAR*TRAP model that could account for this correlation, any inferences about population trends we would develop from our bait-station data would be biased. Thus, we concluded that inferring population trends from both trapped and untrapped lines of bait stations over time without considering the effect of the trapping on visitation rates could be misleading. Trends estimated using the typical bait-station approach (i.e., our YEAR model) may be biased in an area where baited trapping was taking place because of habituation by bears. In a mark-recapture analysis of the bear population in Pisgah conducted over the same time period as the bait-station data surveys were performed, Brongo et al. (2005) estimated that the population was decreasing in the early-mid 1980s, increasing in the late 1980s to mid 1990s, and decreasing again from the late 1990s to 2002. This trend was not reflected in our analysis of bait-station indices.

The interaction in our best model suggested it may take a number of years for bears to become habituated to bait. One plausible explanation for this could be that when bears are at low densities and food resources are not limiting, as in the beginning of this study (Brongo et al. 2005), bait is not recognized as a regular food source. As densities increase and food becomes more limiting, as may have been the case over the middle portion of this study (Brongo et al. 2005), bears may be increasingly likely to use bait stations as a regular food source. If this explanation is correct, bias to bait-station estimates introduced by habituation will increase with bear density, violating the assumption of a linear relationship between bear density and the index (Williams et al. 2002). In this case little can be done to minimize bias from habituation other than conducting bait-station sampling in areas where no baited trapping occurs. Another explanation for an increasing trapping effect over time may be that females in the area learn to recognize bait as a food source and pass this behavior along to their cubs. Because female bears usually do not disperse (Powell et al. 1997), over time this could result in an accrual of bears habituated to bait. If this explanation is correct, periodically moving trap lines (e.g., once every 2 years) may reduce bias to bait-station estimates caused by habituation.

Management implications

Bait stations sometimes are used to compare bear population trends in different areas. If one area also is trapped using similar bait, differences in the rate of bait-station hits between areas may be misleading. The area with baited trapping likely will have higher visitation rates on bait stations over time than the area without baited trapping.

Although bait stations are useful as a supplement to other forms of information such as bear trapping, bait stations should not be placed in proximity to trap lines. Where bait-station indices have been used in the same areas as baited trapping and some stations on lines that were also trapping lines, analyses incorporating trapping effects should be used or trapping lines should be excluded from analyses. Managers and researchers also should consider alternatives to bait stations that do not include tangible rewards for bears. Scent stations (Johnson and Pelton 1981) may be an alternative index to abundance because bait is not rewarding. Future research should examine indexing methods that use nonrewarding lures, such as scent on DNA hair-snaring corrals, to assess whether baited trapping can bias a population index that does not use a tangible reward as bait.

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