Estimation of Black Bear Population Dynamics

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I estimated size of the black bear population in the Carson Range, Lake Tahoe and the Reno-Carson City areas, and rate of change of the population using data from individual bears marked by Carl Lackey of the Nevada Department of Wildlife. I conducted analyses using a software program, Program MARK, designed by Dr. Gary White, Colorado State University. Dr. White is an acknowledged expert in estimation of demographic parameters from wildlife populations. I explain these estimates below.

I estimated size of the population using the Jolly-Seber method. This approach uses the following logic. A sample of animals is captured, marked and released. A second sample is then captured. If the first sample mixed with the entire population the ratio of marked animals to the size of the total sample in the second sample is the same as the ratio of total marked animals (from the first sample) to the size of the entire population. If the size of the entire population is N (which we don't know but are trying to estimate), the number of marked animals released in the first sample is M, the size of the second sample is n and the number of marked animals in the second sample is m, we can write a formula for our estimate of population size as:

$$\frac{M}{N} = \frac{m}{n}$$

$$\xrightarrow{yields} N = \frac{Mn}{m}$$

The Jolly Seber approach is a little more complex because it allows for mortality between the first and second samples (which it adjusts for), and combines the results from multiple samples. The basic logic of the calculation remains the same. It is important to note that these approaches generally produce underestimates of population size. If the first marked sample did not randomly mix, or if some individuals have a greater chance of being caught than others, population size will be underestimated. To see this, think about what happens if some individuals are more catchable. This will cause m, the number of marked animals in the second sample to be too large, because animals caught the first time are more likely to be caught the second time than expected if all animals are equally catchable. This will cause the ratio m/n to be too large, or n/m to be too small. If n/m is too small our estimate of N will be too small.

I estimated the rate of change in the size of the population, λ, using analyses of data from marked animals developed by Roger Pradel. Pradel analyses rely on the pattern of encounters of marked bears. NDOW marks each unmarked bear when it is

captured and records all subsequent captures of each marked bear. The data are then structured so a marked bear receives a 1 each time it is caught and a 0 when it is not caught. We defined capture occasions as the 3 month seasons, defined by the solstices and equinoxes. If a bear was caught in a particular season it received a 1 for that season, if not, it received a 0. The analyses produced four kinds of parameters: survival, recruitment, capture probability and λ, the rate of population increase. Capture probabilities are estimated based on the proportion of bears that are missed on a particular occasion but captured later. Survival is estimated from the bears that are never caught again after a particular occasion, after accounting for the probability that some bears were never caught again even though they were alive (accounting for the fact that the capture probability was not 1 for any given season). Estimates of recruitment are based on when individuals first appear in the data (the season when they receive their first 1), accounting for the fact that some bears were present for some period before they were first detected (those capture probabilities again). Rate of population increase just represents the sum of per capita recruitment and survival, and can also be thought of as the ratio of the number in the population in one year divided by the number in the previous year. That is, λ is the proportional increase in the population from one year to the next. A λ greater than 1 indicates the population is increasing, while a λ less than 1 indicates the population is declining.