

3.3.3 Work still to be done

3.3.3.1. Refine and update the geographic area to be excluded because of moth sites.—During the workshop, study team members provided an initial analysis that excluded marked F_{COY} resightings and sightings of unmarked F_{COY} within areas designated as moth feeding sites. A formal and objective procedure for defining areas inhabited by bears that use the moth sites during the period of observation flights is being developed. The downward bias resulting from excluding the moth sites entirely may be alleviated should it be possible to devise an additional estimate for moth sites only. To accomplish this, counts of F_{COY} during observation flights of confirmed moth sites will be conducted and evaluated for an annual moth-only addition to the mark-resight estimate. The accuracy of aerial observations of F_{COY} at moth sites will be evaluated based on simultaneous aerial and ground observations.

3.3.3.2. Work on an appropriate smoothing function.—The current protocol calls for fitting both linear and quadratic terms to series of F_{COY} estimates returned by the “Knight-Chao2” approach, with the single-best estimate in each year taken as the model-averaged mean using AIC_c weights. A similar approach could be applied to the series of estimates from the mark-resight approach. However, this approach may yet be improved by considering additional plausible models beyond the linear and quadratic. The quadratic model imposes a declining trend during later years of a series, thus not allowing for the possibility of population size becoming stable. Functions that include an asymptote would impose stability, thus not allowing for the possibility of a true decline. Because an a priori way to select among these possibilities does not exist, a larger array of candidate models of trend on time, weighted using AIC_c or similar information-theoretic methods, would offer the most objective assessment of recent population trends. We note that fitting smoothing functions will require several years as counts of F_{COY} based on moth-only observation flights could not be backcast but will only accumulate with additional years of data.

3.3.3.3. Power analysis.—Power analysis would estimate the ability of this monitoring protocol to correctly detect a specified change in state (e.g., increase to decline), given existing estimates of process and sampling variation and specified time frames. A similar analysis was already published for the “Knight-Chao2” approach (Harris et al 2007:174).

3.3.3.4. Improve the precision of mark-resight estimates by expanding it to all females with dependent offspring.—Protocols for aerial observation flights require pilots, upon finding a F_{COY} , to determine whether bears are radio-marked. However, unlike in the “Knight-Chao2” protocol, which depends on the unique nature of F_{COY} to discriminate one individual from another, it may be possible to expand the subset of the population estimated beyond F_{COY} . For the GYE, sample size of marked and unmarked animals would approximately double (assuming a roughly 3-year reproductive cycle) if all observations of adult females with any offspring were considered. This would require little or no additional investment of time on the part of pilots and observers, or reconsideration of the areas to exclude from moth sites (see 3.3.3.1, above). In extrapolating to the total number of females (and from there, to total population size),

transition probabilities would still be used, but the ratio to use would be all females except those in the “no offspring” state. However, this approach could fail if the detection probability of females with yearlings or 2-year-olds differs from that of females with cubs-of-the-year. Additionally, aerial observations of females with unrelated, young males could potentially be misclassified as females with offspring or vice versa.

3.4. Other alternative approaches to population estimation

Both the core study team members and larger group represented at the workshops were mindful of alternative approaches that exist to estimate the population size and trend of bears. Retrospective analyses using statistical population reconstruction (e.g., Gove et al. 2002) may be a potential avenue worth exploring and some simpler population reconstructions have already been completed. These would primarily be useful in either supporting or casting doubt on estimates obtained yearly because inference would lag behind management needs by a few years.

The group was also aware of, and had direct research experience, with mark-recapture estimators using either ingested marks (e.g., tetracycline, Garshelis and Visser 1997, Garshelis and Noyce 2006) or DNA from hairs (Woods et al. 1999, Kendall et al. 2009, Clark et al. 2010). These approaches had previously been considered by GYE managers and deemed currently impractical for budgetary reasons.

3.5. Discussion

The primary motivation for exploring alternative estimation techniques was the desire to obtain unbiased estimates of population size. The group clearly sees the mark-resight approach as the single best available alternative from which to estimate the number of adult females in the GYE (and thus total population size). As preliminary results have shown (Higgs et al., in review), there is an expectation that this technique will produce population estimates that are $\geq$ than those produced by the Knight-Chao2 approach. The mark-resight technique, unlike the Knight-Chao2 approach, is not increasingly biased low as population size increases (Higgs et al., in review). Although evaluations so far indicate precision of the mark-resight estimator is low, we note that uncertainty associated with the Knight-Chao2 estimates likely is understated (Higgs et al., in review). We take the view of Paulik (1963) and other population biologists that an approximately unbiased estimate with low precision is always better than a highly precise but biased estimate. We thus conclude the mark-resight technique meets the first workshop objective (see Section 1). However, the group also discussed that 3 issues be further evaluated: (1) low precision, (2) correction factor for F_{COY} observed at moth sites, and (3) trend estimation.

3.5.1 Low precision

Precision of mark-resight estimates of F_{COY} would increase if additional females could be radiomarked. Field sampling constraints limit opportunities to increase sample size of marked females so it is important to determine trade-offs between sample size and precision. Power analyses will be conducted to examine the effect of increased sample size on precision, with final evaluations expected by the end of 2012.

3.5.2 Correction for F_{COY} observed at moth sites

The current estimate of the zone of influence around army cutworm moth sites for F_{COY} (5,000 m from moth site boundary, based on telemetry data of independent females that used moth sites) is being evaluated by the study team. Evaluation of the effectiveness of this correction is based on comparison of F_{COY} from simultaneous ground and aerial observations (8 flights at 5 different sites) during 2012. Congruence of >95% between ground and aerial estimates would indicate a separate census of F_{COY} at moth sites is feasible, and would serve to adjust the mark-resight estimate. This issue should be addressed by the end of 2012.

3.5.3 Trend estimation

Power analyses are planned to determine the effectiveness to track changes in population trends under different scenarios of population size and change. Final evaluations are expected by the end of 2012. Application of this technique to develop and evaluate trend data, however, will take several years; whereas mark-resight estimates excluding moth feeding sites will be backcast to 1997, estimates that are corrected for F_{COY} using moth sites started in 2012. Therefore, trend data of F_{COY} estimates including moth sites require accumulation of additional years of data.

Because final evaluation of the mark-resight estimator is pending, there was consensus that data required for the “Knight-Chao2” estimator continue to be collected, and these estimates be updated and reported annually.