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Estimating predation dynamics for wolves in Yellowstone National Park

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Matthew Metz, Paul Lukacs, Mark Hebblewhite, Daniel Stahler, Douglas Smith

Recent progress in carnivore conservation has sparked debates about trophic cascades and top-down effects on ecosystems. Fundamental to this debate is assessing predator impacts on prey population dynamics. However, in order to accurately assess the influence of predation, precise estimates of predation dynamics are required. For large carnivores preying on large ungulates, kill rate (kills per predator per unit time) is a common statistic used to evaluate the influence of predation on prey populations. An essential piece of knowledge for estimating kill rate is how many kills are made by predators during a monitoring period. However, in many cases, the probability of detecting a carcass is almost certainly less than one. As such, estimating the probability of detection may often be necessary to better estimate the number of carcasses. Here, we estimate the probability of detecting a carcass and, ultimately, the number of ungulate carcasses acquired by wolves (*Canis lupus*) in Yellowstone National Park via a closed population model. To do so, we use data collected during two 30-day monitoring periods during early (mid-November to mid-December) and late (March) winter from 1997–2014. Wolf packs were independently monitored by air and ground radio-tracking effort. During each 30-day monitoring period, three wolf packs were typically monitored by both air and ground crews. Through monitoring 15 packs over 101 30-day pack monitoring periods, we identified 1143 carcasses. However, only some of these 1143 carcasses were "available" to be detected by both air and ground crews because weather limited the number of days both crews simultaneously monitored wolves. Ultimately, we found that 97% of all carcasses were found by air or ground crews within the first two days after the wolves acquired the carcass. Therefore, to determine the probability that a crew detected a carcass, we used a subset of 868 carcasses that originated (i.e., died) during two-day periods when both crews were actively monitoring during at least one of the two days. For each of these 868 carcasses, we determined values for three covariates (distance of the carcass from the road, wolf pack size, biomass of the carcass) that may affect the probability of a crew detecting a carcass. Next, we developed time-varying models of carcass detection using a multi-step approach. We used AIC_c to assess model fit and identify the top models. Ultimately, our top model indicated that distance from the road influenced the probability of both air and ground crews detecting a carcass, although the effect of the covariate differed between crews. That is, the probability of detecting a carcass increased for air crews as distance from the road increased, whereas the probability decreased for ground crews as distance from the road increased. Biomass also had a significant influence on carcass detection, but only for air crews. Carcasses were significantly more likely to be detected on the first day for both crews. On average (i.e., for a carcass of average biomass [150 kg] and at an average distance from the road [2.4 km]), our top model predicted that ground crews found 67%, and air crews 55%, of carcasses. After accounting for detection probability, the top model produced an estimate of 1084 carcasses (95% CI: 1033-1153), which was ~1.25 times greater than the original estimate of 868 carcasses that were detected when both air and ground crews were active. As such, our work has shown that not accounting for detection probability would have severely underestimated the number of carcasses acquired by wolves. The importance of detection probability, however, is not limited to our study system. Rather, the importance of accounting for detection probability is a ubiquitous problem throughout ecology. We have highlighted through our work the importance of also accounting for imperfect detection in

understanding predation dynamics. Currently, we are further developing our model to account for variation in monthly monitoring effort so that we can use our estimates of the number of carcasses to also estimate kill rate for each 30-day monitoring period.