Leveraging Hunters as Citizen Scientists for Monitoring Statewide Moose Populations

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Hunter populations can provide a tremendous workforce of citizen scientists afield when queried for data. Soliciting incidental observations of non-target species from hunters may be a relatively important but untapped population monitoring resource in systems where hunter effort is common and widespread. During 2012-2016, we queried hunters of deer and elk for observations of a non-target species, moose, across their statewide distribution in Montana. We analyzed data in an abundance-detection framework with n-mixture models and evaluated the effects of covariates such as hunter effort, survey response totals, weekly session, and forest cover on detection probability before using models to predict moose abundance. We collected an average of 3,409 moose observations per year and our best n-mixture model included effects of week, year (number of responses), site (proportionate forest cover), and site-year (hunter effort) on detection probability, as well as an effect of site (area of forest and shrub habitat) on abundance. Density estimates averaged 0.099 (range 0.002-0.439) moose/km2 across sites or 0.200 (range 0.017-0.799) moose/km2 when limited to density within shrub and forest cover specifically. Statewide abundance totals across the five-year study period averaged 10,755 (range 9,925-11,620). Goodness-of-fit tests showed that models were identifiable and overdispersion of the data was low, yet some caution is still warranted when extrapolating these data to abundance estimates. Synthesis and applications. Querying a sample of deer-elk hunters for observations of a non-target species yielded thousands of spatially georeferenced detections per year and analysis in a temporally structured framework yielded estimates of both detection probability and abundance. Abundance estimates at this scale are unprecedented for moose in Montana and are encouraging for long-term monitoring over space and time.