Research Summary 2018-2021
Estimating Cougar Density and Population Size in New Mexico using Spatial Mark-Resight Models

Background

In 2017, the Department implemented a study using a novel approach for estimating cougar population densities using GPS tracking collars, trail cameras, and advanced, Spatial Mark-Resight models. These models incorporated data from the capture process, recaptures via trail camera photos, and weekly GPS locations. The findings from that 2017 study were published by Murphy et al. (2019), and were incorporated into a harvest limit adjustment for Cougar Management Zone (CMZ) F, where the study was conducted.

We used that methodology for an expanded study in CMZs B and F in 2018, to estimate population size across both zones where localized population dynamics were expected to be occurring. Harvest limits were again adjusted in 2019 based on the findings of that 2018 study, and CMZs B and F were combined into one zone (CMZ B). In 2019, the Department began another study using the same methods in CMZ Q, which was concluded by August 2021. The results from this study were used to inform the proposed changes for the 2023 Bear and Cougar Rule development process. Recognizing the novelty of these field and analytical methods for a cryptic species like cougar, and their use across a large area, the Department worked with independent statisticians to review these models.

We present in this report a brief summary of the findings of those efforts. An in-depth description of the field methodology and analytical techniques can be found in the Murphy et al. (2017) publication, and will be described further in publications by the Department as we continue to implement, adjust and assess this approach across multiple years and study areas throughout the state.

Results and Analysis of the Study in CMZs B and F, 2018

The study in CMZs B and F occurred from May through November, 2018. We deployed 109 camera sites across 15 grids in GMUs 4, 5A/B, 6A/B/C, and 51A/B. During that time, there were 14 cougars fitted with GPS collars, 146 photo captures of cougars, and no mortalities.

We used a model that incorporated GPS data, flexibility for activity centers to shift, and sex-specific differences in detection parameters to estimate for the study area a population size of 124 (79 – 169) independent-aged cougars and population density of 0.70 (0.45 – 0.96) independent-aged cougars per 100 km^2.

In 2022, we then assessed the models from Murphy et al. (2017) under a simulation-based framework to understand how sampling effort affects model precision, and validate model accuracy and precision. This approach used a simulated population and simulated data generated with information from the models of our observed data for CMZs B and F to examine how the model performed estimating for a known population size with a dataset similar to ours. These results aligned well with the models from our observed dataset in generating estimates with similar accuracy and precision (Figure 1).

We then tested simulated capture data sets with low, normal, or high number of marked animals, or a low, normal or high number of recaptures. This allowed us to assess how the model performed under different scenarios with fewer or more marked animals on the landscape, or fewer or more detections of marked animals on cameras. In general, there was relatively little bias to abundance estimates with changes to marking and resighting, and increases in accuracy and precision that levelled off within range of mark and resight probabilities of our observed data (Figure 2). These simulations provided insight on general impacts that would occur over the entire estimation area if these conditions were homogenous across all individuals and cameras.

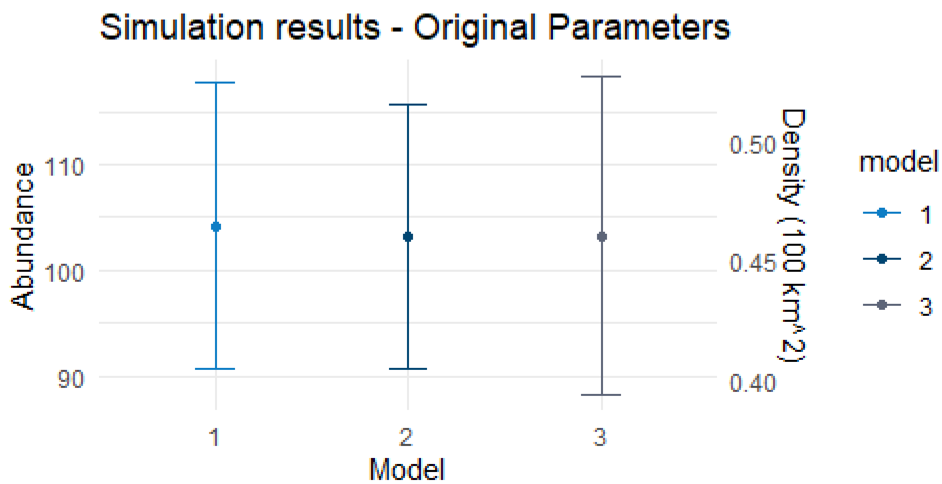

Figure 1. Abundance stimates for a simulated data set for a simulated population (N=100), from Spatial Mark Resight models using GPS collar data (Models 1 and 2), and without GPS collar data (Model 3).

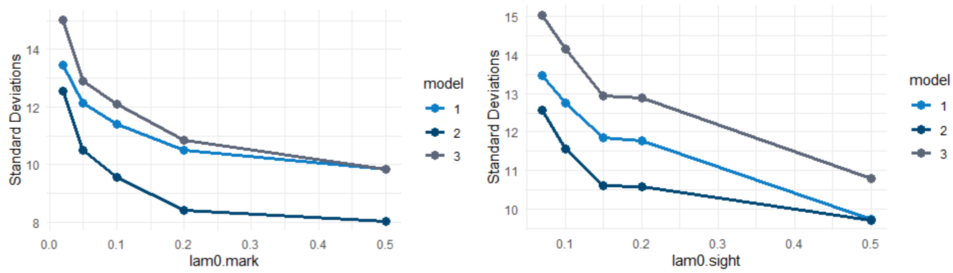

Figure 2. Changes in model precision with increasing probabilities of marking an individual (lam0.mark) and increasing probabilities for recapturing (lam0.sight) via trail cameras individuals for Spatial Mark Resight models using GPS collar data (Models 1 and 2) and without GPS collar data (Model 3).

We also took a closer look at the spatial distribution of the data, which suggested it could be impacting estimates. Generally for spatial capture recapture models, when there are no detections at a detector or an entire grid the model assumes a lower density than what may be observed at detectors where individuals are regularly detected, or assumes no individuals occur there, and assumes an averaged density as you move away from detectors in general (Royle et al. 2014). The implications of this are that site selection and camera placement may impact density estimates. If the reason for a lack of detections is poor site selection or camera placement, and as a result there are no detections of cougars where it is known that they occur, then the models will estimate lower densities in that area. We can see in our data there are grids that had few to no photo detections, but where we know cougars were present from GPS data for collared individuals (Figures 3 and 4).

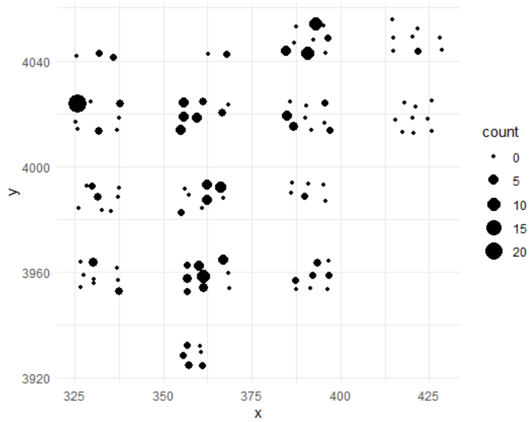

Figure 3. Distribution of trail camera photo 'recaptures of cougars in Cougar Management Zones B and F, New Mexico, 2018.

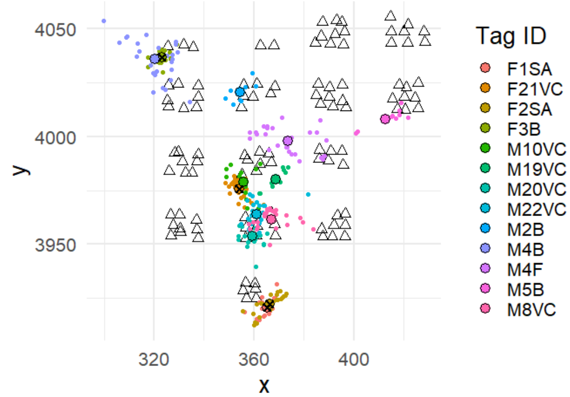

Figure 4. Distribution of GPS locations from cougars used in density estimation for Cougar Management Zones B and F, New Mexico, 2018.

Additionally, we have made some initial investigation into the impact of the spatial arrangement of GPS collared individuals through data augmentation of this data set. We removed GPS and marking data for individuals that had home ranges overlapping with another collared individual, and found that with no data showing home range overlap the model estimates of density were lower than when your data did include individual's whose home ranges overlap (Figure 5). Home range overlap is expected with our sampling because we captured both males and females which tend to have overlapping home ranges between the sexes. Home range overlap between individuals of the same sex is less common.

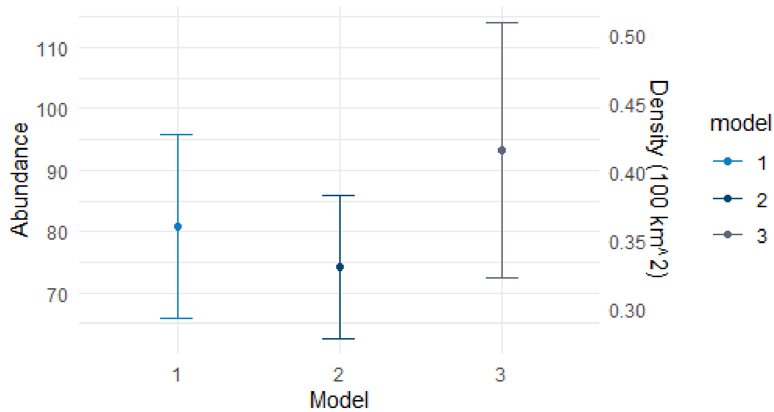

Figure 5. Abundance estimates for the data from Cougar Management Zones B and F, 2018, when the data is augmented to remove individual's whose spatial distribution overlapped another individual's.

Results of the Study in CMZ Q, 2019-2021

In 2019 we used the same methodology to estimate cougar population density in CMZ Q, across GMUs 28, 29, 30, and 34. Captures and camera deployment began in 2019, and we analyzed the data collected at 119 camera sites from April 2020 to December 2020 (weeks 67-101 of the study). During that time, there were 18 cougars that were GPS collared, 368 photo captures, and three mortalities which were accounted for by censoring those individuals.

We estimated density and population size for the study area using a model that incorporated GPS locations and sex differences in the detection parameters, but did not include flexibility for activity centers to shift because we did not include data on the capture process. We estimated a density of 0.56 (0.47-0.64) independent-age cougars per 100 km^2, and a population size for the study area of 116 (98-134) independent-age cougars.

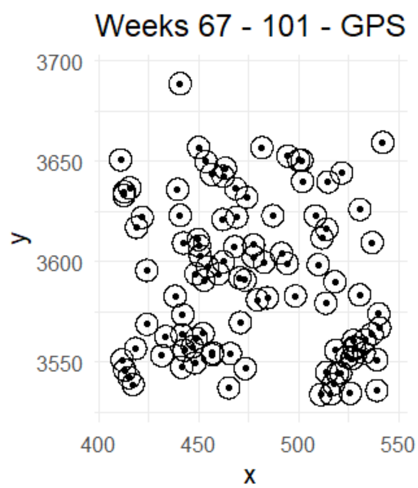

Figure 5. Distribution of estimated activity centers across the state space from Spatial Mark-Resight model estimation of cougar density in Cougar Management Zone Q, New Mexico, 2020.

Literature Cited

Murphy, S.M., D.T. Wilckens, B.C. Augustine, M.A. Peyton, and G.C. Harper. 2019. Improving estimation of puma (Puma concolor) population density: clustered camera-trapping, telemetry data, and generalized spatial mark-resight models. Scientific Reports 9:4590. https://doi.org/10.1038/s41598-019-40926-7

Royle, J.A., R.B. Chandler, R. Sollmann, and B. Gardner. 2014. Spatial capture-recapture. Academic Press, Waltham, Massachusetts, USA.