Project Completion Report
Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU)

Project Title: Developing Methods to Understand Elk Movements and Abundance on Winter Range in Rocky Mountain National

Project Code (such as UMT-72 and/or the "P" number): H1200090004 P13AC00671
Type of Project (Research, Technical Assistance or Education): Research

Funding Agency: National Park Service

Partner University: Colorado State University

NPS Agreement Technical Representative (with complete contact information):
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Principal Investigators (with complete contact information):

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Start Date of Project: 7/15/13

End Date of Project: 1/31/16

Funding Amount: $133,085

Project Summary, including descriptions of products, work accomplished and/or major results. If the information is restricted (e.g. location of endangered species or cultural resources), indicate the title and location of the final report. Also add web sites where project-related information may be found.

We developed a hierarchical Bayesian state space model of movements and abundance of elk in Rocky Mountain National Park. Input data for the model included weekly telemetry observations of elk movements and monthly ground counts and sex-age classifications during winter.

Simulations were run to test and verify the state space model and the model fitting demonstrated acceptable performance. Multiple methods for approximating the joint posterior distribution of the model were also tested. Initially the simulation was fit using JAGS, however I also developed my own Gibbs sampler. The process of writing my own Markov-Chain Monte Carlo sampler revealed several problems with model misspecification. The model was modified to account for these problems. Then I switched methods back to JAGS because the computation time for my own Gibbs sampler was unrealistically long (with an order of magnitude longer model fitting times).

Telemetry data from both the National Park Service and Colorado Parks and Wildlife were obtained and loaded into the geographic information system program ESRI ArcGIS. A study area

was drawn to establish the elk locations that were in the “town” of Estes Park. This study area was later modified according to feedback from Therese Johnson. The data were extracted from ArcGIS into the categorical form necessary for model fitting, a category for each location observation. The extracted data was then cleaned and streamlined, because the two agencies used different codes to reference the same collared individuals.

Ground counts of elk herds during three days of the first week of each winter month (November-March) were obtained from the National Park Service. We wrote a program to extract the count data from the excel spreadsheet database using Bash.

Combining both of these data sources, we fit the model to the first two years of the study: 2011-2012, and 2012-2013. The data for last year was recently obtained and a similar procedure for combining and cleaning the data was followed. The model was then fit for 2013-2014. Telemetry data from 2013-2014 only consisted of NPS data because CPW has not yet finished data entry. Results indicate that the across winter average in RMNP was 233.37(sd = 20.46), 393.20(38.99) and 385.17(40.12) for 2011-2012, 2012-2013, and 2013-2014, respectively. The across winter average in the town of Estes Park was 142.16(sd = 12.31), 569.72(54.03), and 284.90(25.11) for each year of study.

A problem with the ground counters missing marks was identified and a simulation was used to inflate the number of marks identified. Collecting data on the collar detection process by the ground counters themselves was proposed and implemented in early 2015 because this simulation was a rather ad hoc method for inflating the collar resight counts. The preliminary results of the analysis suggest that the model may be over-estimating abundance in the park and in the town. This is currently being address by shifting the data used within the model from overall valley counts to using park/town counts separately.

A continued problem with this estimator is that we are using collars deployed for a different study entirely, so the population we are doing inference about is not fully represented: there are only collars on females but we are extrapolating population estimates to the entire elk population. To account for this, we are trying to use classification data to adjust the overall abundance estimates. However, a problem with inconsistent classification and unreliable counts was identified from the volunteer ground count data. A literature search has revealed several methods in the statistical (but not ecological) literature for accounting for missing or unknown classification data. A model for handling classification data for ungulates specifically is currently being developed.

A preliminary analysis for examining the density of elk in the Estes Valley was implemented using the ground count data in ArcGIS. Line transect maps and elk exclosure maps were obtained from the ArcGIS expert at RMNP. Data describing land development was obtained from the National Land Cover Database from the USGS National Map website for the years 2001, 2006, and 2011. The elk ex-closures were added to the NLCD developed land maps because they were considered to be a human impact on the elk ecosystem. The percent of developed land was calculated and then used as a predictor in a generalized linear mixed model.

The model results showed that development had a statistically significant negative impact on the number of elk in the Estes Valley. A website was created to describe the project background:

http://warnercnr.colostate.edu/~alisonck/ArcGIS_project/projecthome.html

Future work includes using data from aerial helicopter survey flights which have location data for herds in a continuous space, rather than on a discrete space because road transect data was used in this preliminary analysis. Additionally, an analysis on the space use and home range is proposed with GPS data on ~20 elk and could be linked to developed land along the front range.

A new hierarchical population model was developed to examine demographic parameters such as the growth and survival rates, using the annual ground and helicopter survey data from the last 45 years. The model was fit to data in a Bayesian framework, although several problems with model fitting remain to be improved. The survival probabilities of four age/sex categories (Bulls, Spikes, Cows, and Calves) were estimated as well as an overall population growth rate. The relative contribution of hunting and Chronic Wasting Disease need to be considered for their separate influence on the growth rate. This model will be coupled with the state space model described above.

An undergraduate field tech was hired to supplement the field tech for the Chronic Wasting Disease study by the NPS because CPW stopped collecting weekly telemetry data. The field tech collected weekly telemetry data under the supervision of the NPS tech and graduate student on the project. The graduate student also participated in the collection of some ground telemetry and participated in the aerial helicopter surveys.

Number of students participating in this project: undergraduates, graduate students, degrees conferred.

Alison Cartwright Ketz, graduate student
Matthew Danielson, undergraduate student field tech

Lessons Learned from this project:

We learned that ground counts adjusted for detection using a Lincoln-Peterson estimator appear to be a feasible approach for estimating the true, unobserved overwinter population size of elk in Rocky Mountain National Park. A state-space model of animal movement is needed to avoid the assumption of a closed population required by the Lincoln-Peterson approach.

Other RM-CESU agencies or research partners who participated in this project:

Colorado Parks and Wildlife
National Park Service Biological Resource Management Division