Standard Operating Procedure (SOP) 10: Data Analysis

Protocol for Monitoring Small Mammals

Central Alaska (CAKN) Inventory and Monitoring Network

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The main Narrative for the Protocol for Small Mammals Monitoring in Central Alaska (CAKN) Inventory and Monitoring Network is available from the NPS Inventory and Monitoring Central Alaska Network website (https://science.nature.nps.gov/IM/units/cakn/index.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/

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SOP 10.0 – Introduction

This SOP describes the assumptions and methods required for data analyses of Small Mammals monitoring data collected on four plots at the Rock Creek watershed in Denali National Park and Preserve from 1992-2017. The mark-recapture data generated from live-trapping of the three target species (*Myodes rutilus, Microtus eoconomus, Microtus miurus*) was used to estimate vole abundance and density and examine vole population cycles from mid-August annually (see Schmidt *et al.* 2017).

SOP 10.1 – Methodological assumptions

The capture-recapture approach assumes the population of interest is closed to births, deaths, immigration and emigrating during the sampling period. This assumption is approximately met by conducting trapping efforts over a very short time period (i.e., 4 days). Substantial violations of the closure assumption would result in biased estimates, although we expect the sampled population to remain relatively closed over the short sampling window. We also assume that marked individuals are identified without error and that the location of capture (i.e., trap ID) is correctly recorded. Violation of these assumptions would also result in estimator bias. Ample training provided to observers and strict protocols minimize the potential for such errors.

SOP 10.2 – Analysis of small mammal mark-recapture data

Spatially-explicit capture-recapture models are considered to be the standard approach for analyzing datasets such as ours, and the basic underlying theory are well developed (Royle and Young 2008; Gardner *et al*. 2009; Efford and Fewster 2013; Royle *et al*. 2014). Spatially-explicit capture-recapture approaches utilize the locations of recaptures to estimate the activity center of each individual, while also addressing the decline in detection probability with distance of the activity center from each trap (Royle and Young 2008; Gardner et al. 2009; Efford and Fewster 2013). This straightforward combination of the process and detection models allows the direct estimation of abundance or density within the sampling area without requiring the concept of the somewhat ambiguous effective trapping area (Efford and Fewster 2013). Data augmentation (Royle *et al*. 2007) is employed to address the problem of an unknown number of activity centers within the sample area (Gardner *et al.* 2010).

Specifically, we used the spatial mark-recapture model presented by Gardner et al. (2009) to estimate the number of individuals, *N*, with activity centers within the sampling area, *S*. Density is defined as *N*/*S*. We can include covariates by formulating a model for the inclusion probability, *psi*. The inclusion probability is the probability that an individual from the augmented data list is a member of the population (Gardner *et al*. 2009). This allows us to assess the influence of covariates on population size. We will allow capture probability to vary by year, and include an individual random effect to account for heterogeneity in capture probability among individuals in addition to variation due to the locations of each activity center. This mitigates the effects of heterogeneity in capture probability on estimation. We can also include a plot by year random effect in the model for *psi* to account for differences between plots and years that are not explained by the covariates. See Gardner *et al*. (2009) and Schmidt *et al.*

(2018) for further model details and example code. All models will be fit using program R (v. 2.14.2, R Development Core Team 2012) and OpenBUGS (Thomas *et al.* 2006).

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