Individual Variation in Animal Movement

This should be the abstract

# Introduction

Modeling animal telemetry data is is often necessary to understand animal behavior, space use patterns, movement patterns, and responses to the environment. This type of data is usually analyzed with discrete time movement models, defining regular time steps between animal relocations. However, certain telemetry data such as that for marine animals, or data collected in environmental conditions that interfere with satellite signals, such as dense forest or cloud cover, can lack regular time intervals in data collection, causing these telemetry data to be observed irregularly. Although technological advances have allowed for new and more precise data collection methods, smaller tags, and data storage, some of the same problems remain and data with irregular time steps and high levels of uncertainty pose complex statistical problems (**???**). The flexible framework of state-space models has been used as a valuable tool to model this irregularity and uncertainty, as state-space models allow for separation of the movement process from the sampling mechanism. State-space models are used to analyze time series of location observations, also referred to as movement pathways or trajectories (**???**). In movement data, a state-space process allows us to couple a statistical model for the observation method, accounting for errors in sampling or detection, with a separate model for the movement dynamics which are determined by the effects of behavior or responses to the environment (Patterson *et al.* 2008), thus modeling true animal locations directly with a stochastic process, and model observed locations as the conditional distribution given the true locations. Although the flexibility of a state-space framework allows for both continuous and discrete time, the applications of these approaches are still limited by number of observations, as they require good time series data and long enough animal trajectories with multiple consecutive relocations.

## How does this relate to mutualisms and long-distance movements?

Individuals will vary in their distances traveled while foraging or searching, directly influencing seed dispersal for the plant. Individuals with a tendency to travel larger distances or with higher probabilities of long-distance movements, will have a larger impact on plant population dynamics by increasing the plant’s long-distance dispersal. These long-distance movements for seed-dispersing animals, or long-distance dispersal events for plants, can lead to spatial sorting of populations and range expansions [These are sources I haven’t finished reading yet: Shine2011PNAS, Philips2008AmNat, Riotte-Lambert2019Trends.] This is also the case for pollination, where pollinator variability in movement patterns and long-distance movements has direct implications for pollination success and plant population persistence, specially in fragmented landscapes [need to find sources for this]. Shaw makes references to how interspecific interactions can contribute to individual movement variation in parasite/pathogen systems. In my case, I would consider how presence of other competitive frugivores could influence this variation (Competition between toucans for the virola fruits and space. Larger aracari kick out the little ones (Holbrook 2011)). Shaw brings up how worse conditions can cause increased movement for searching better habitats and escape from these areas.

## What will this paper actually do to address the main question?

In this paper we would like to present a statistical framework that incorporates variability among individuals into population level movement patterns. Providing theoretical frameworks that incorporate individual variation in animal movement can help us link that variation to seed dispersal patterns, and in particular to range expansion dynamics, having consequences at the landscape and regional scales. We will also explore how the variation in long-distance movements translates to population level estimates and how these long-distance movements or deviations from typical movement patterns can be incorporated into this framework.Although it increases the complexity and requires more fine scale data, the framework recognizes how variation at the level of individuals can have consequences at larger ecological scales. In this regard, state-space models (SSMs) have been suggested as flexible options to describe the general framework that incorporates observation error and noisy data, as it is common in the case of radiotelemetry data, and even the use of hierarchical structures or mixed-effects SSMs that can explicitly model variability across individuals (Patterson *et al.* 2008). With our work, we seek to expand on the use of state-space models that incorporate variability in movement and can later be used to simulate movement patterns that affect seed dispersal or pollination patterns at the landscape scale.

# Methods

The moveHMM package allows for fitting hmm models to different time series, which can come from different individuals, assuming that all individuals share the same movement models, meaning the same distributions and parameters for step length and angle. This is referred to as ‘complete pooling’ (Langrock *et al.* 2012), but there is no current implementation for fitting HMMs to highly irregular and noisy tracking data, that explicitly incorporates variability among individuals. In this paper, we would like to show the effects of incorporating individual variability under a HMM framework that allows for variation not only in parameter values associated to udnerlying model distributions of step length and angle, but also on overall distribution function.

# Notes on March 17, 2021

So, one of the main questions I have is that I am trying to decipher animal paths yet it seems like most animal movement ecologists are trying to figure out behavioral states out of movement data, which is not my focus. Reading the (Langrock *et al.* 2012) paper.

# References

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