

IRSAE Summer School 2018



From locations to steps:
the movement model

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University of Florida

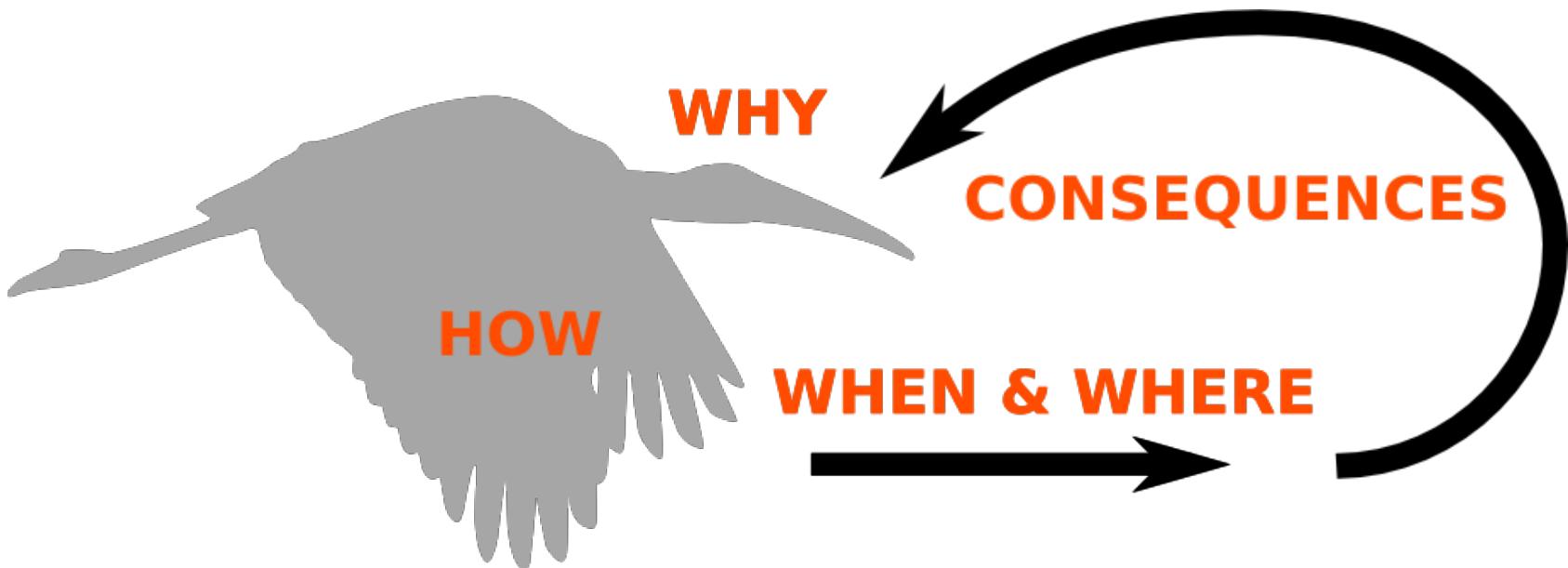
June 20 2018

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SECONDS

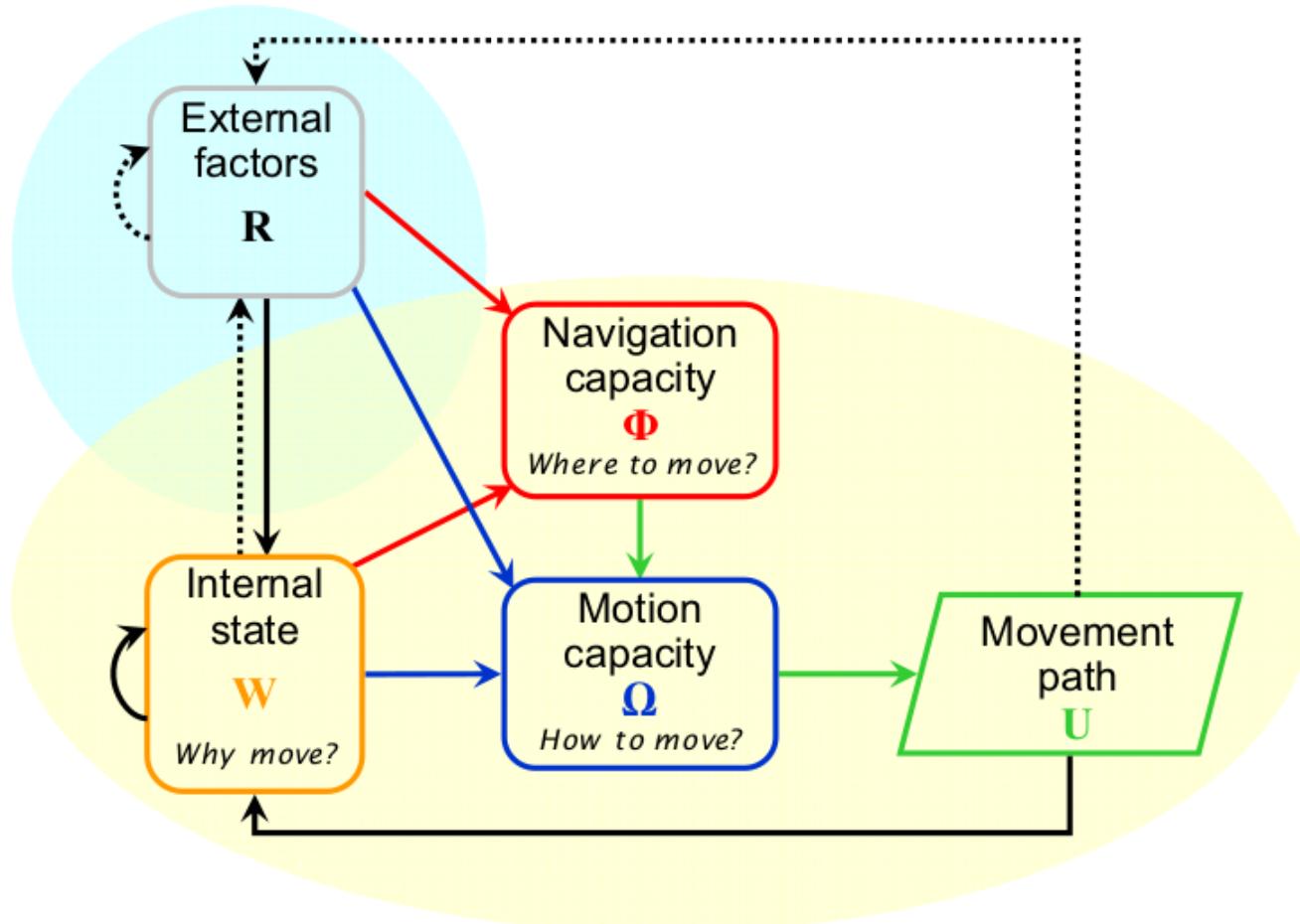


Movement ecology framework

Why studying movement ecology?



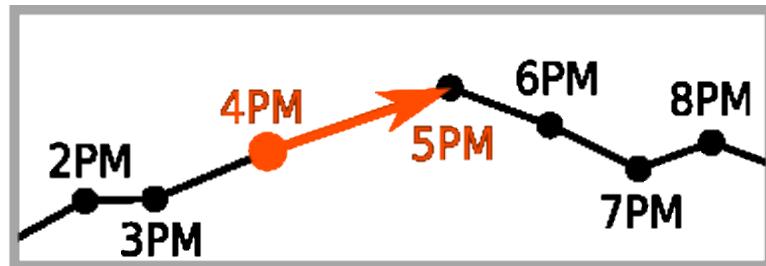
The movement ecology framework



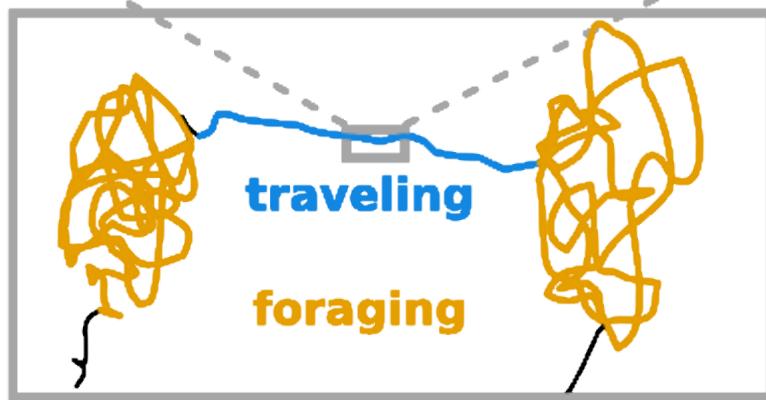
"Movement processes,
*i.e. behavioural decision rules about navigation and space use,
 have to be inferred from the **patterns** they generate,
 with the possible help of various sensors and detailed maps."*

From points to steps: trajectories

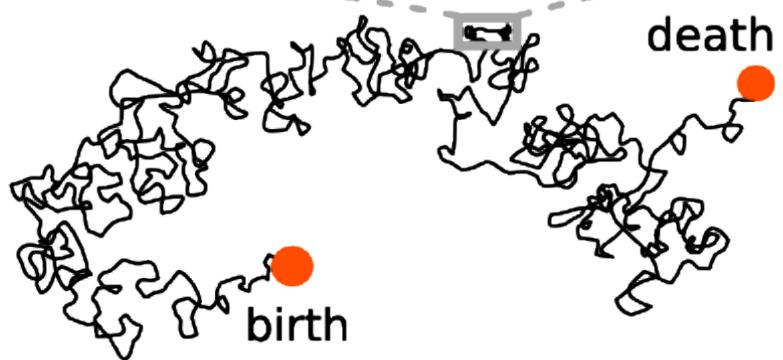
Movement step



Movement modes

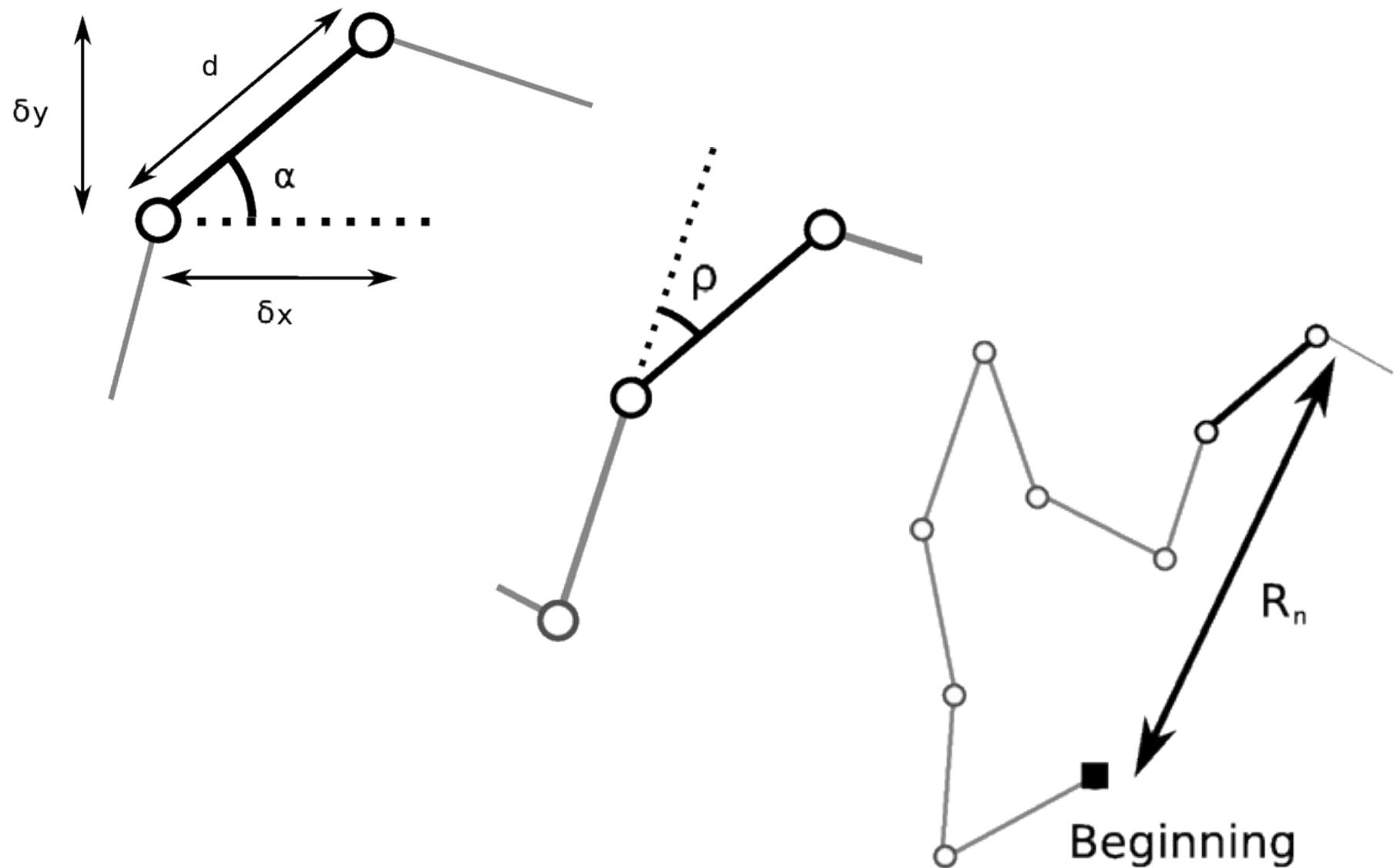


Lifetime track



Mechanisms of geographical distribution

Conceptual model of a trajectory



Temporal autocorrelation as information

80s: Autocorrelation as a nuisance! Time To Independence (TTI)

Ecology, 66(4), 1985, pp. 1176–1184
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TESTING FOR INDEPENDENCE OF OBSERVATIONS IN ANIMAL MOVEMENTS¹

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Abstract. Many analyses of animal movements assume that an animal's position at time $t + 1$ is independent of its position at time t , but no statistical procedure exists to test this assumption with bivariate data. Using empirically derived critical values for the ratio of mean squared distance between successive observations to mean squared distance from the center of activity, we demonstrate a bivariate test of the independence assumption first proposed by Schoener. For cases in which the null hypothesis of independence is rejected, we present a procedure for determining the time interval at which autocorrelation becomes negligible. To illustrate implementation of the test, locational data obtained from a radio-tagged adult female cotton rat (*Sigmodon hispidus*) were used. The test can be used to design an efficient sampling schedule for movement studies, and it is also useful in revealing behavioral phenomena such as home range shifting and any tendency of animals to follow prescribed routes in their daily activities. Further, the test may provide a means of examining how an animal's use of space is affected by its internal clock.

Key words: cotton rat; home range; independence; Markov process; movements; radiotelemetry; *Sigmodon hispidus*; spatial analysis.

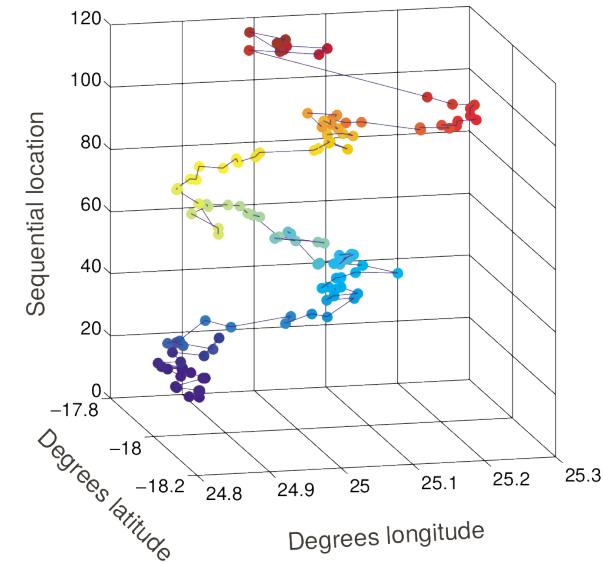
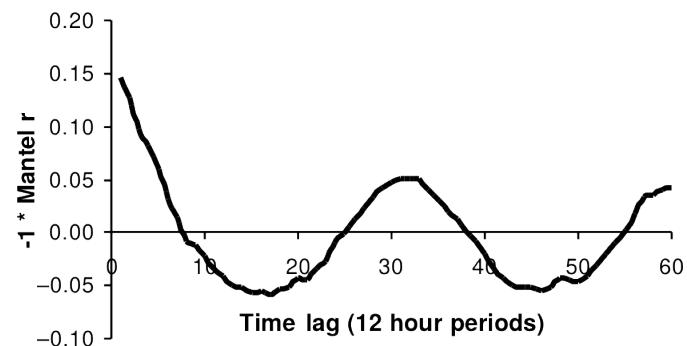
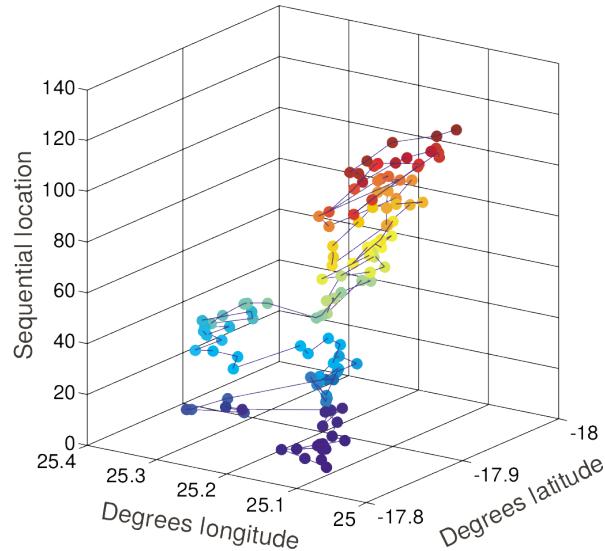
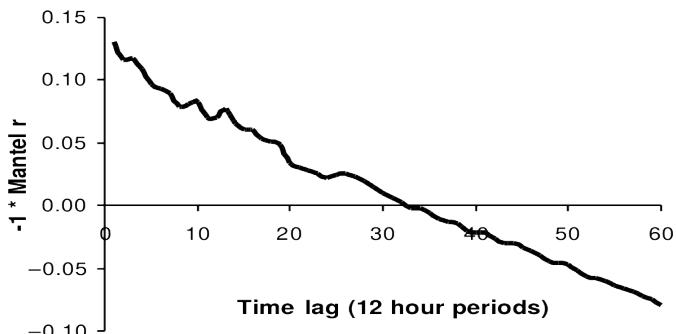
INTRODUCTION

Independence between successive observations is an implicit assumption in most statistical analyses of an-

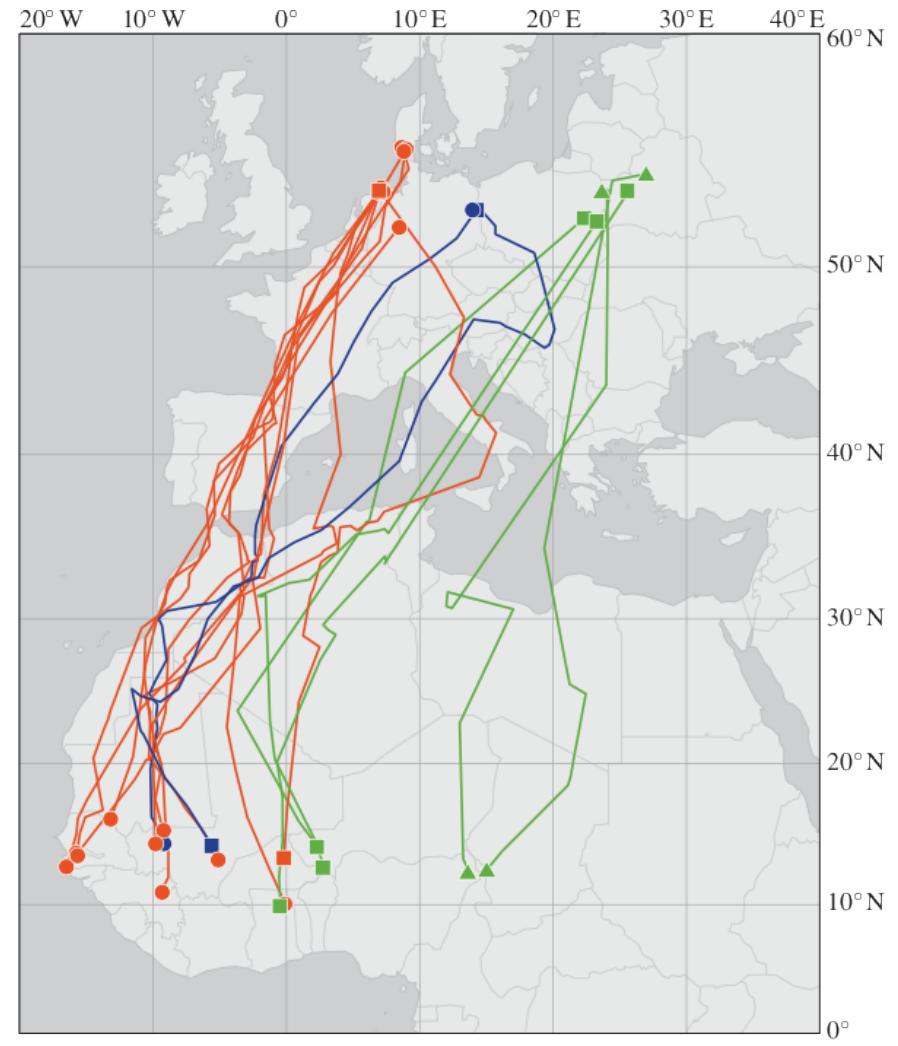
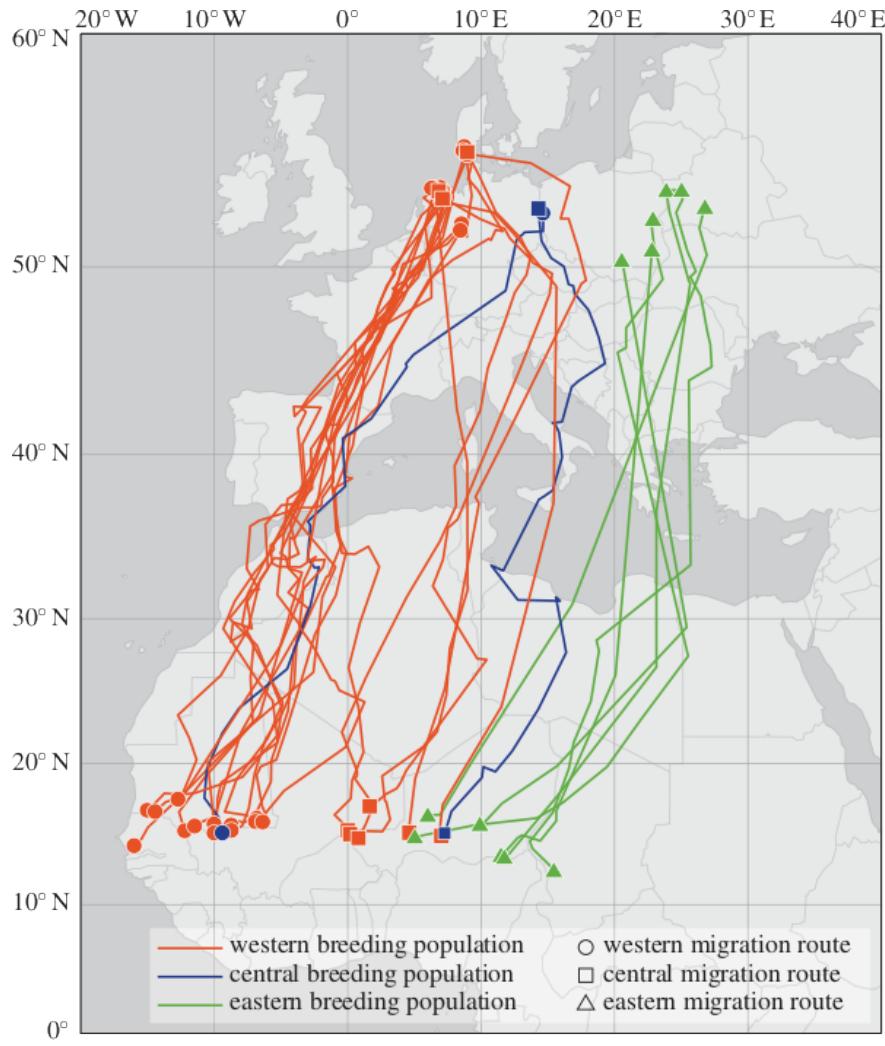
tribution with fixed mean (center of activity) and variance-covariance matrix; that is, the animals occupied stable home ranges during the observation period. Us-

Temporal autocorrelation as information

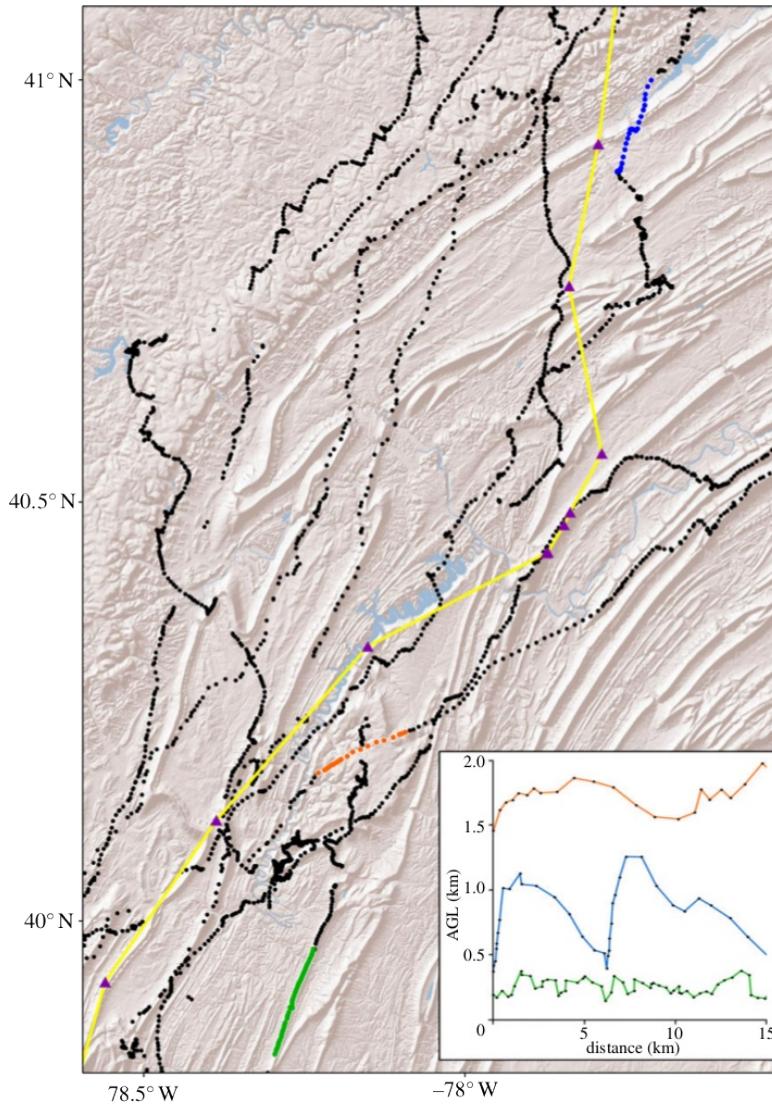
XXIst century: Autocorrelation as information!



Technical progress

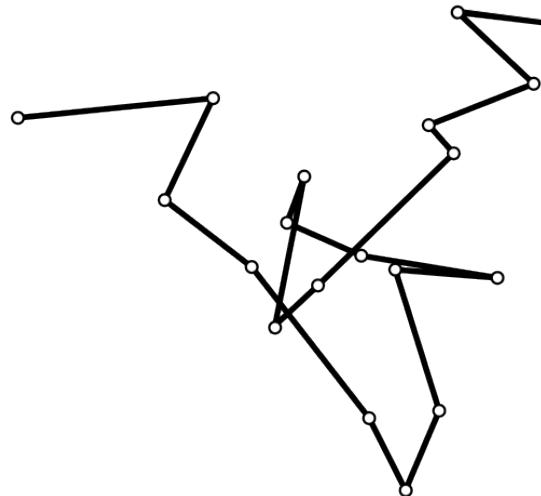
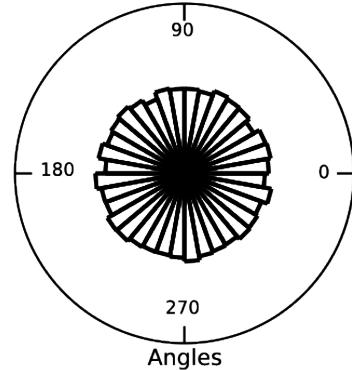
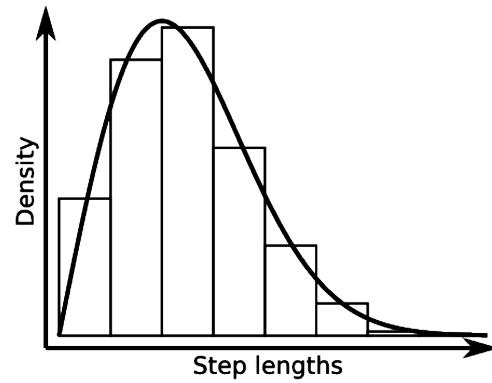


Technical progress

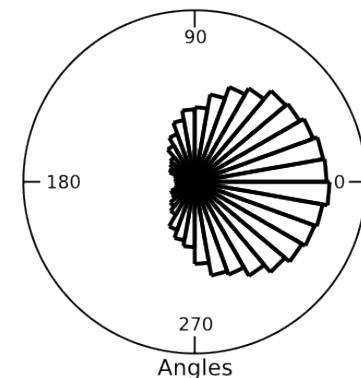
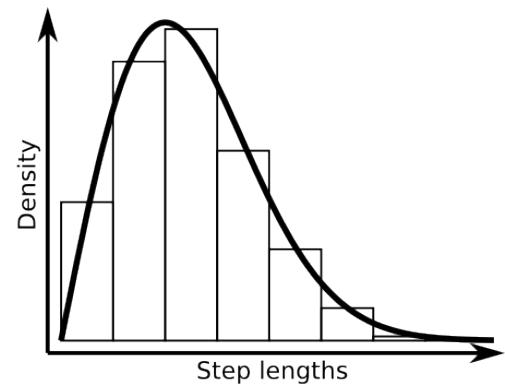
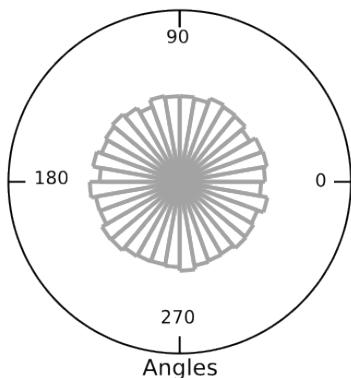
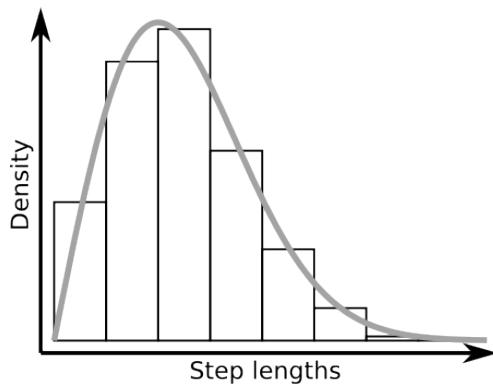


Random walks (and other mechanistic movement models)

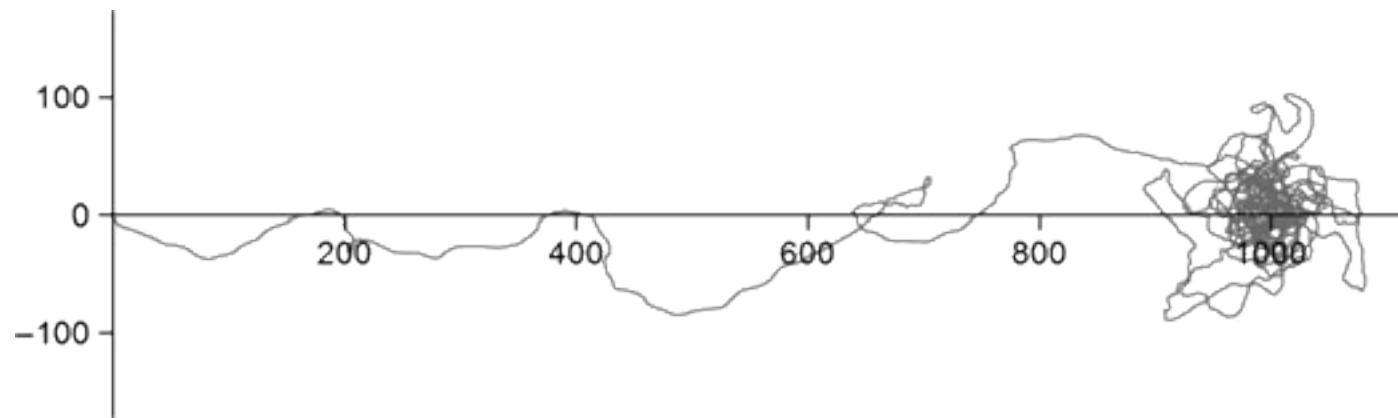
Random walk: diffusion process



Correlated RW: persistence process



Biased RW: advection process



More thoughts on random walks

Parametric distributions:

- Step lengths
 - gamma distribution
 - Weibull distribution
- Turn angles
 - wrapped Cauchy distribution
 - von Mises distribution

Brownian motion:

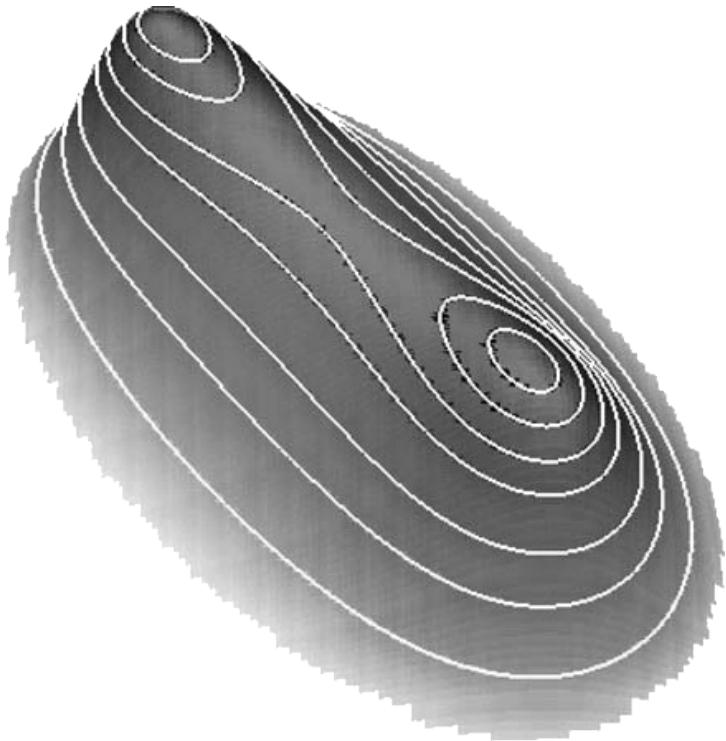
- continuous time
- limit of RW

Levy walk:

- infinite variance in step lengths
- scale free

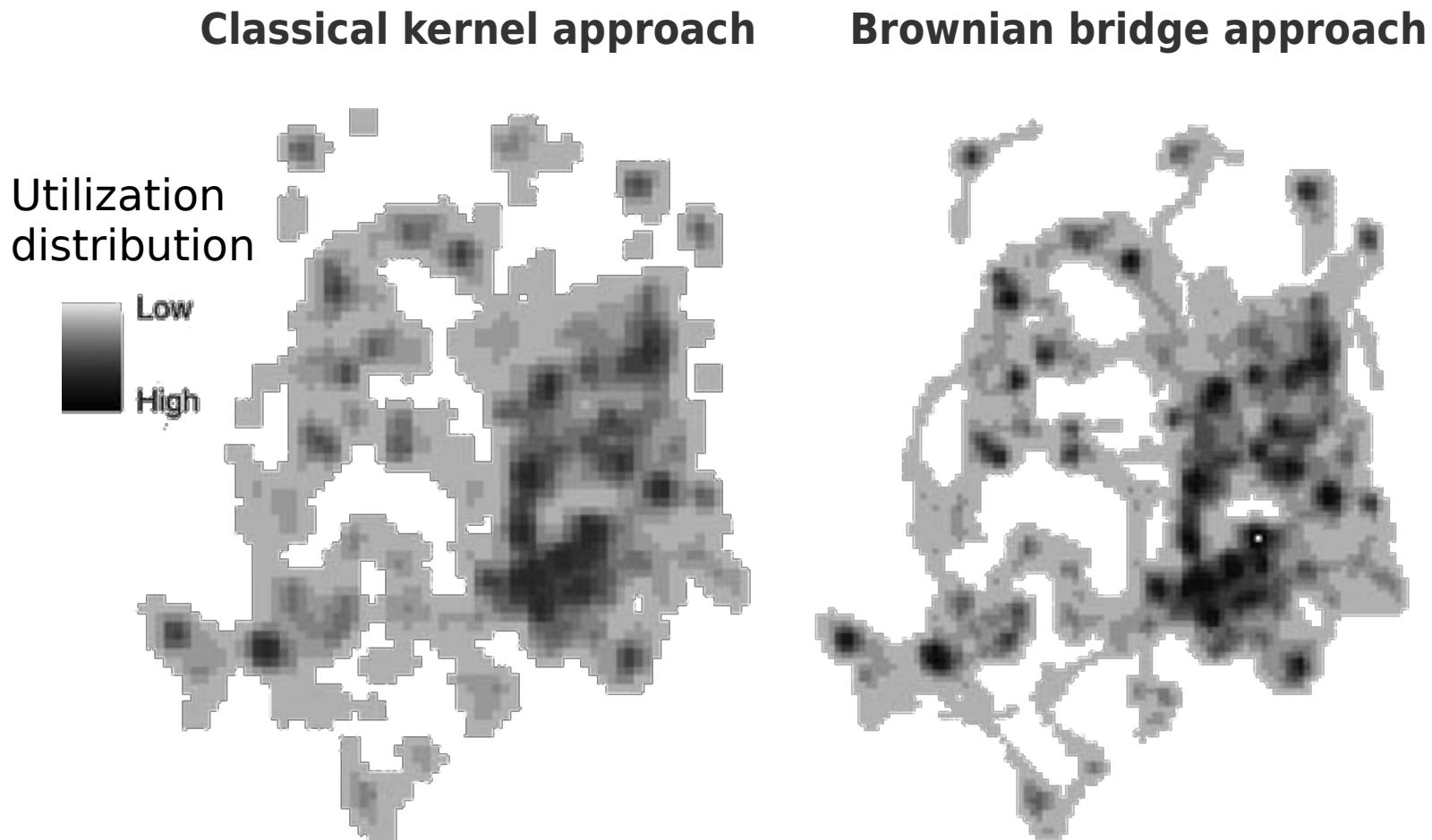
Mechanistic home ranges

Using line density: Brownian bridges



Conditional
random walk!

Brownian bridge movement model

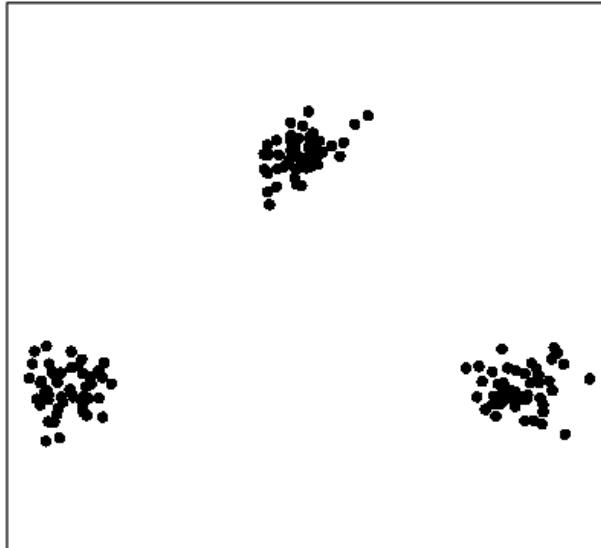


Brownian bridge movement model

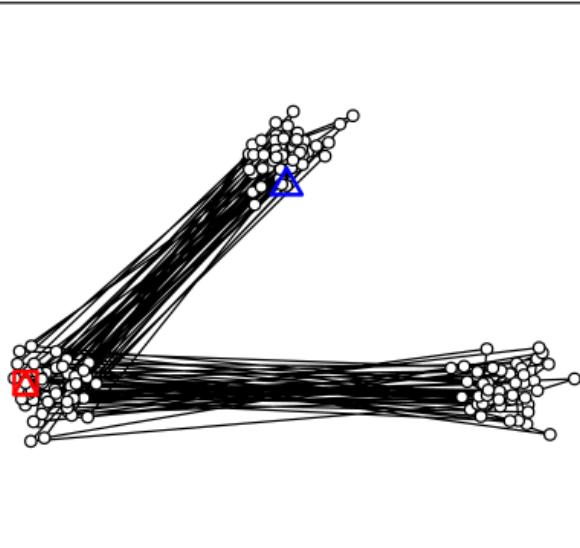


An extreme example...

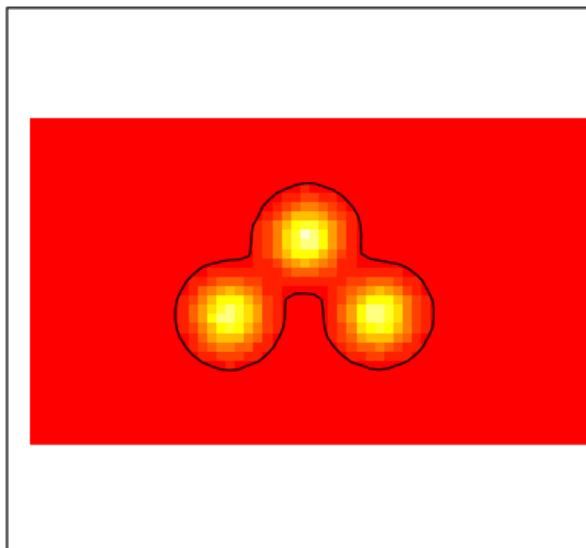
The relocation pattern



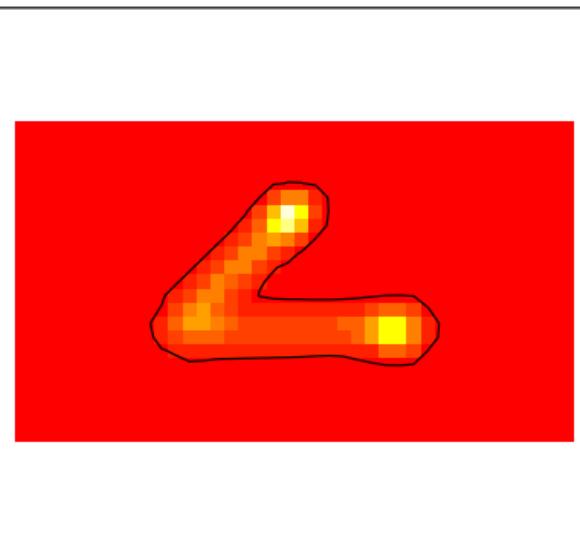
The trajectory



Classical kernel home range

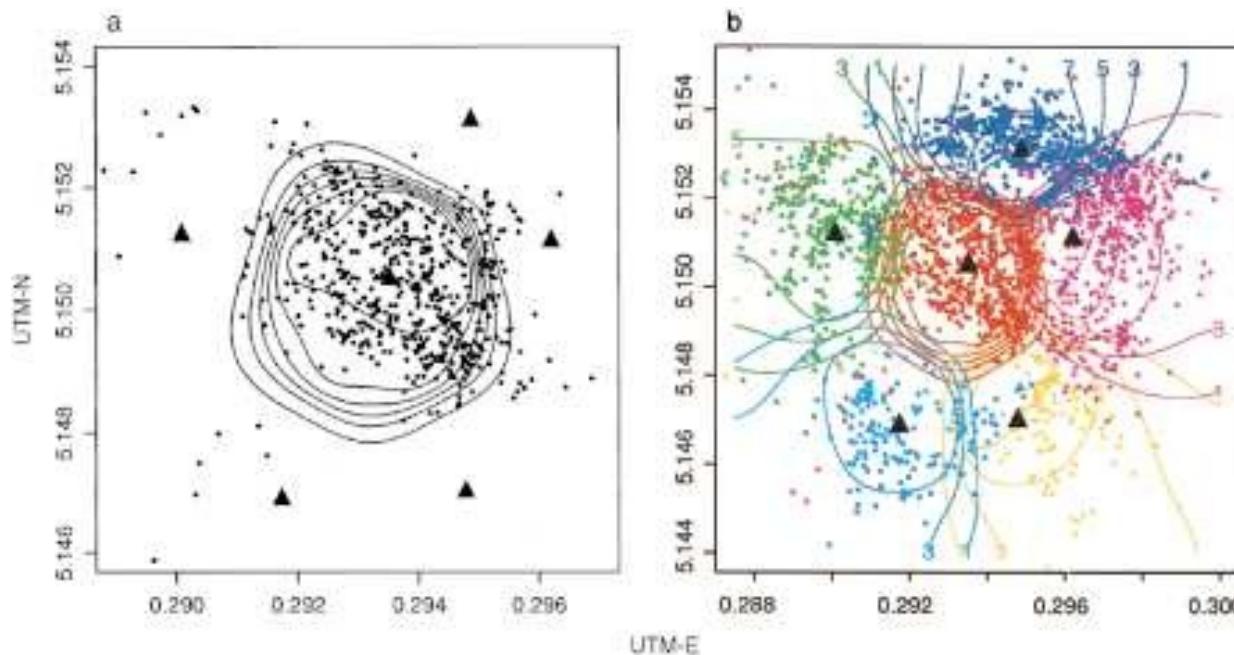


Brownian bridge kernel home range



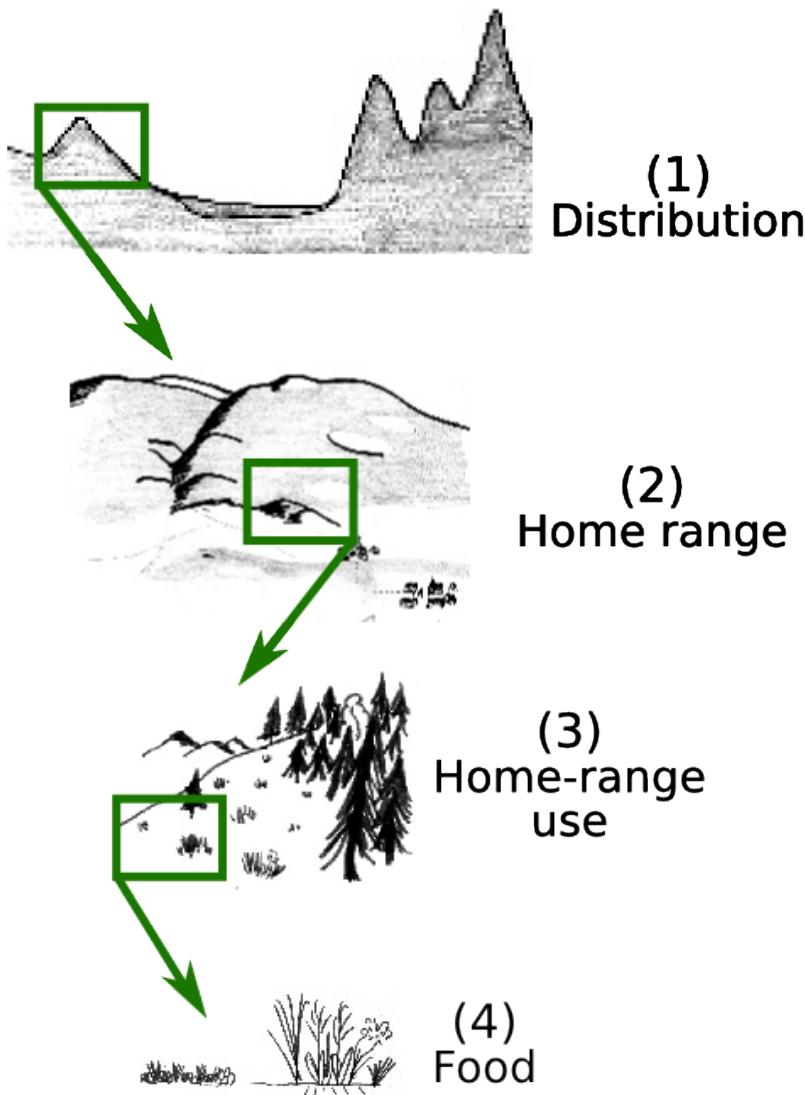
Mechanistic HR models

Differential equations of space use in time:
advection-diffusion models

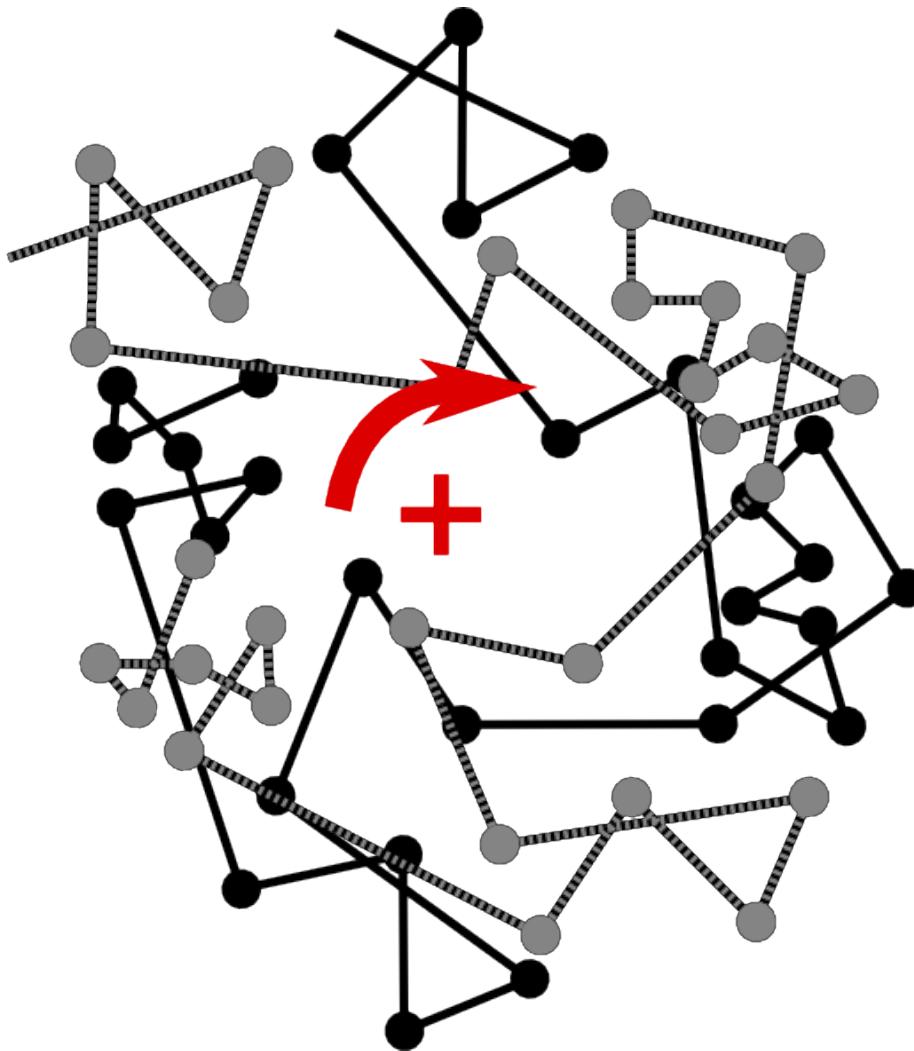


Habitat selection

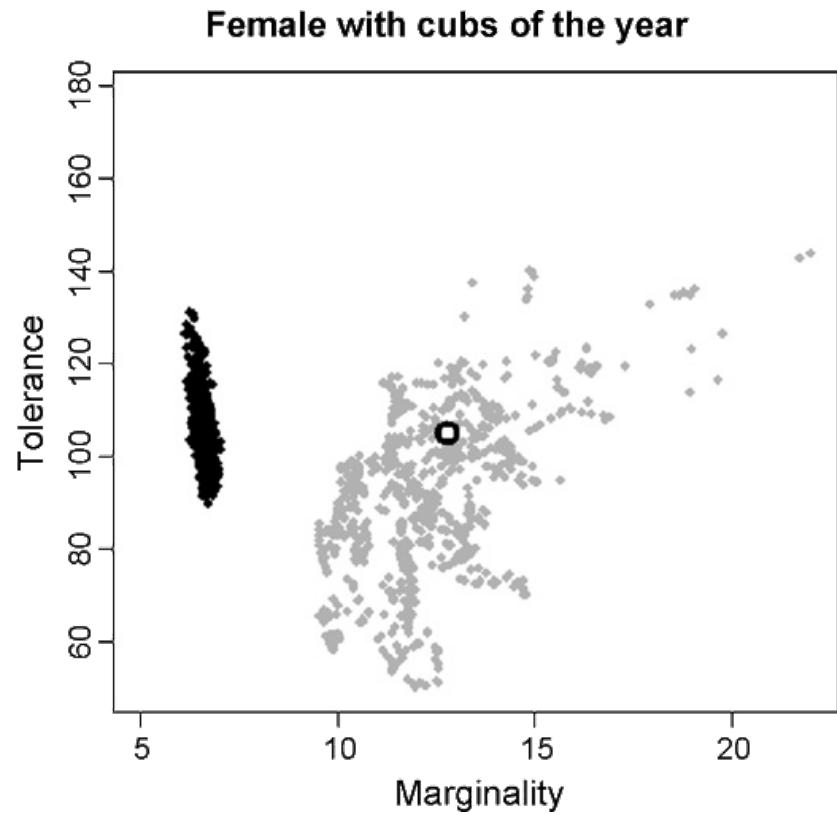
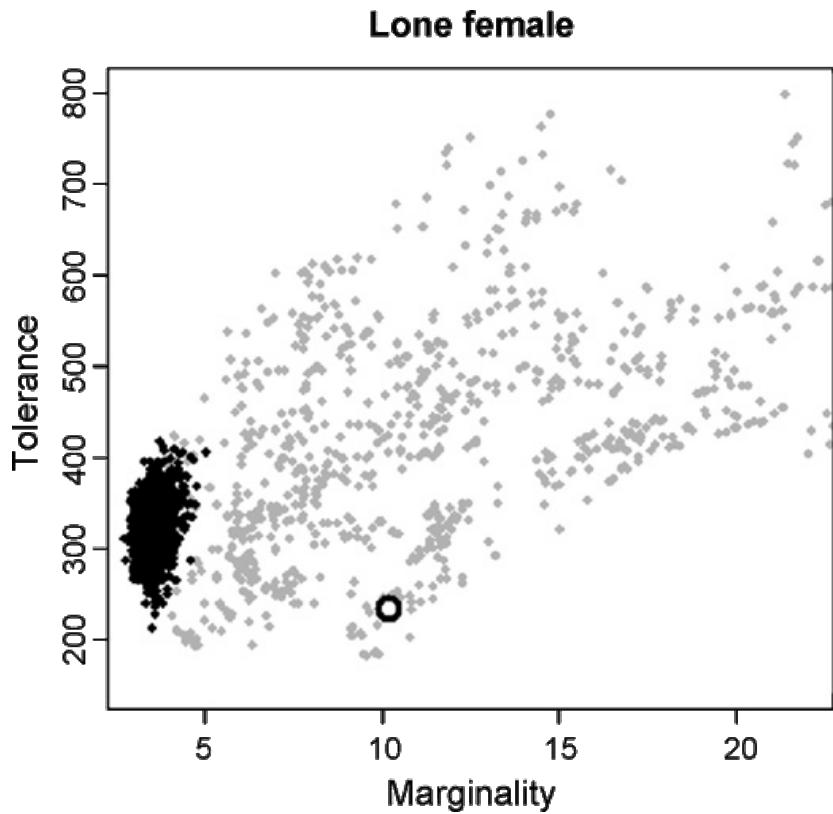
A hierarchical approach



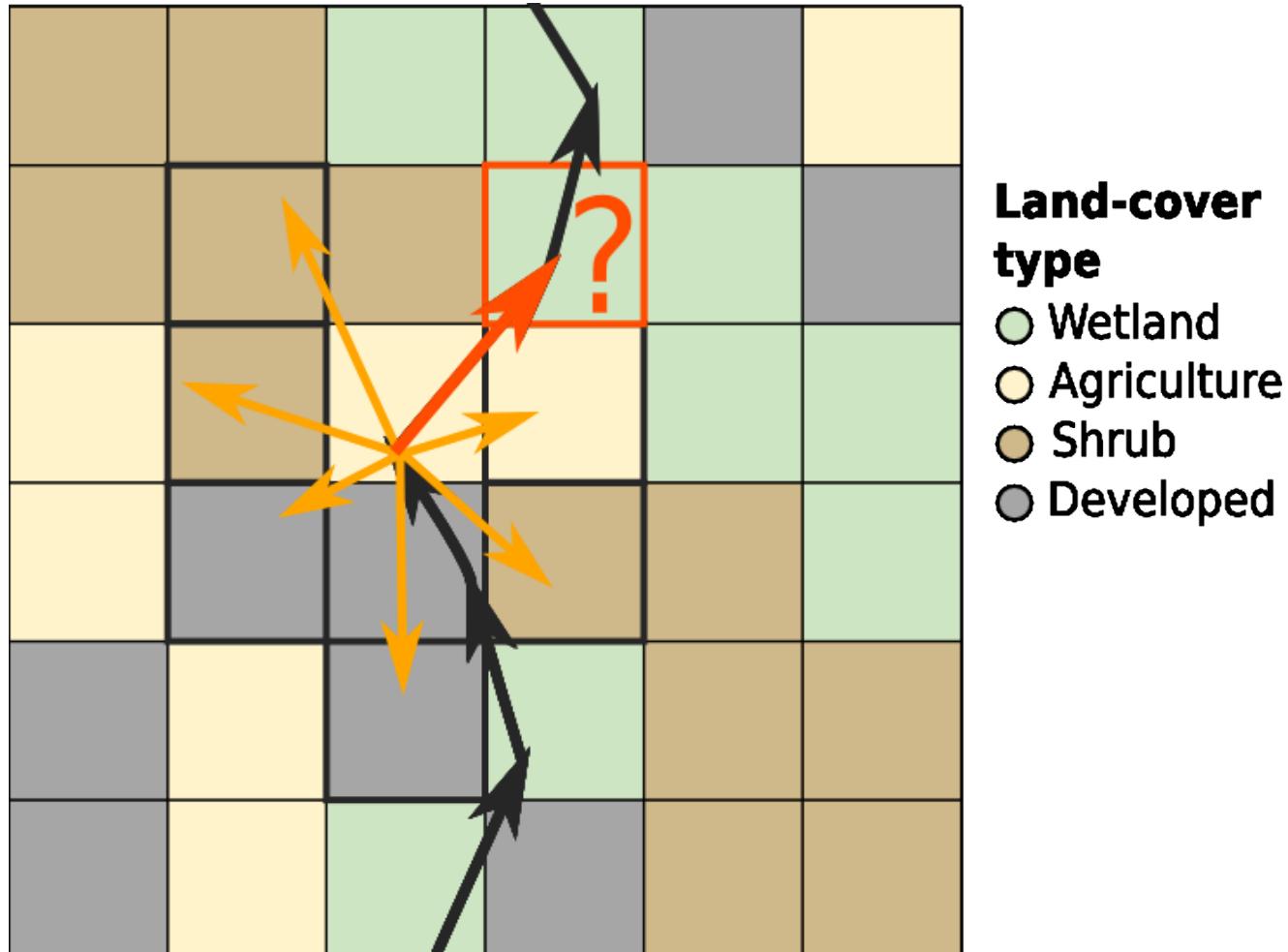
Setting the scene: movement constraints



Setting the scene: movement constraints



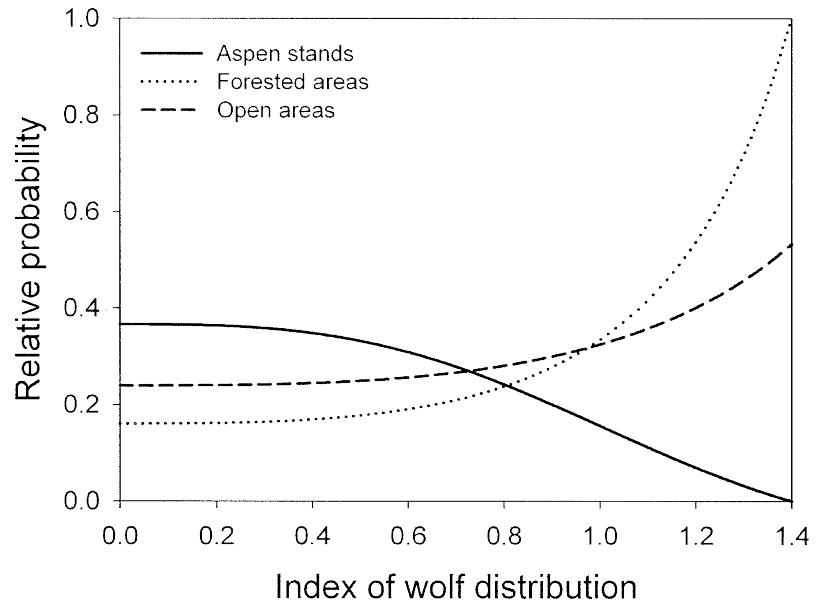
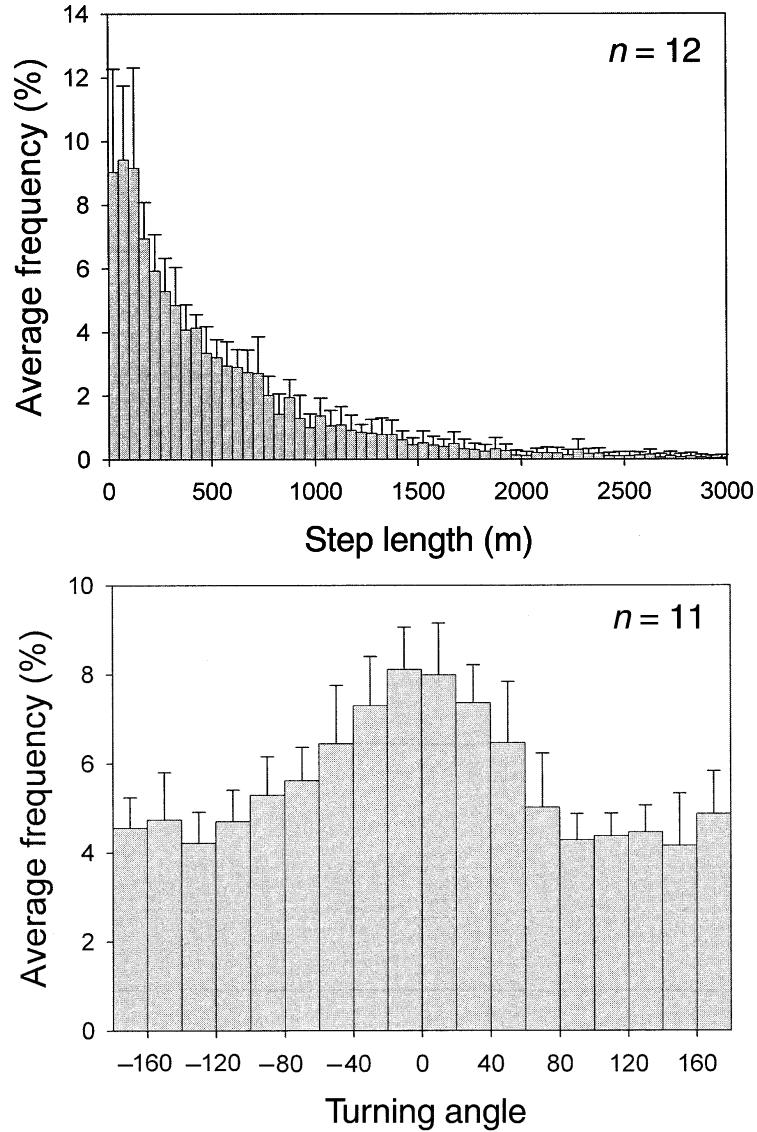
Step Selection Functions (SSF)



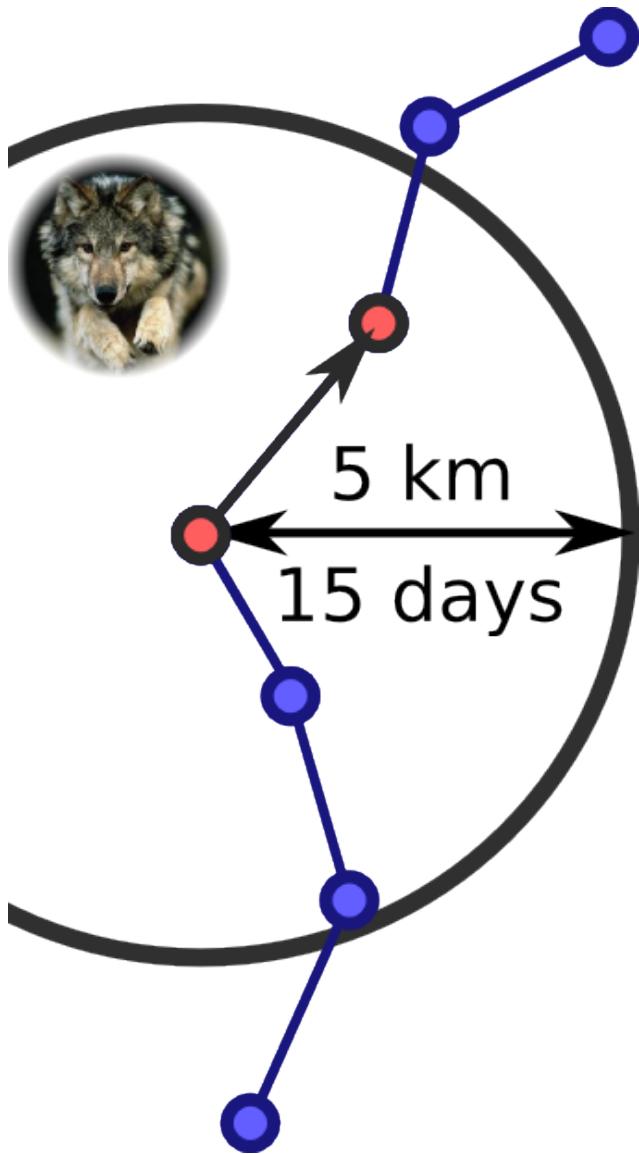
Step Selection Functions (SSF)



Step Selection Functions (SSF)

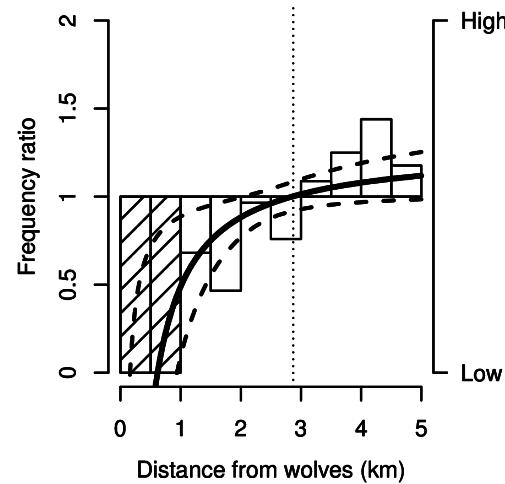


Decomposition of predation risk

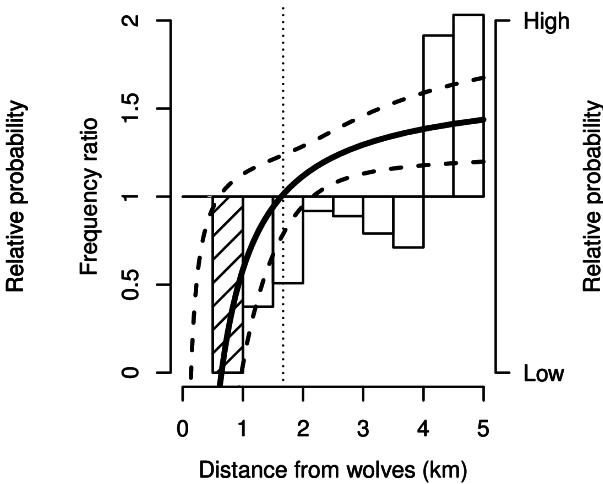


Decomposition of predation risk

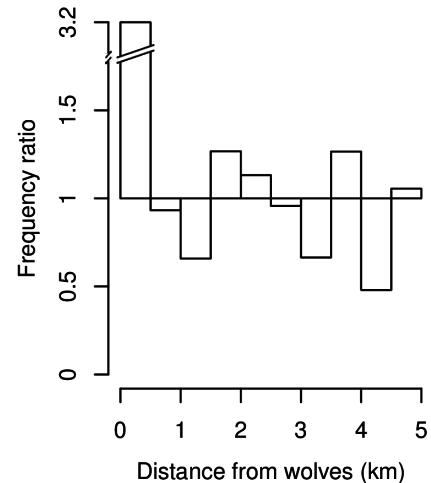
a) Deciduous forests



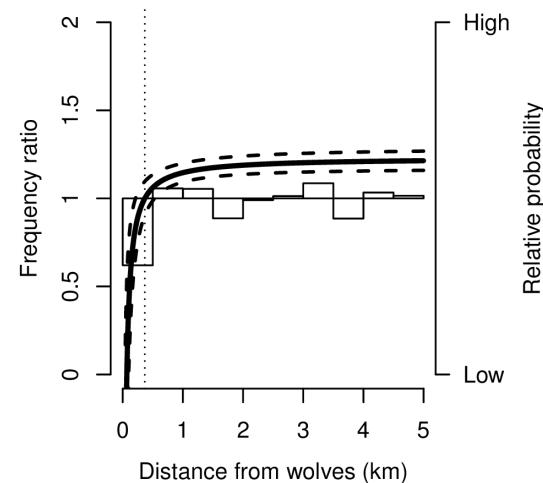
b) Open areas



c) Dense conifer forests



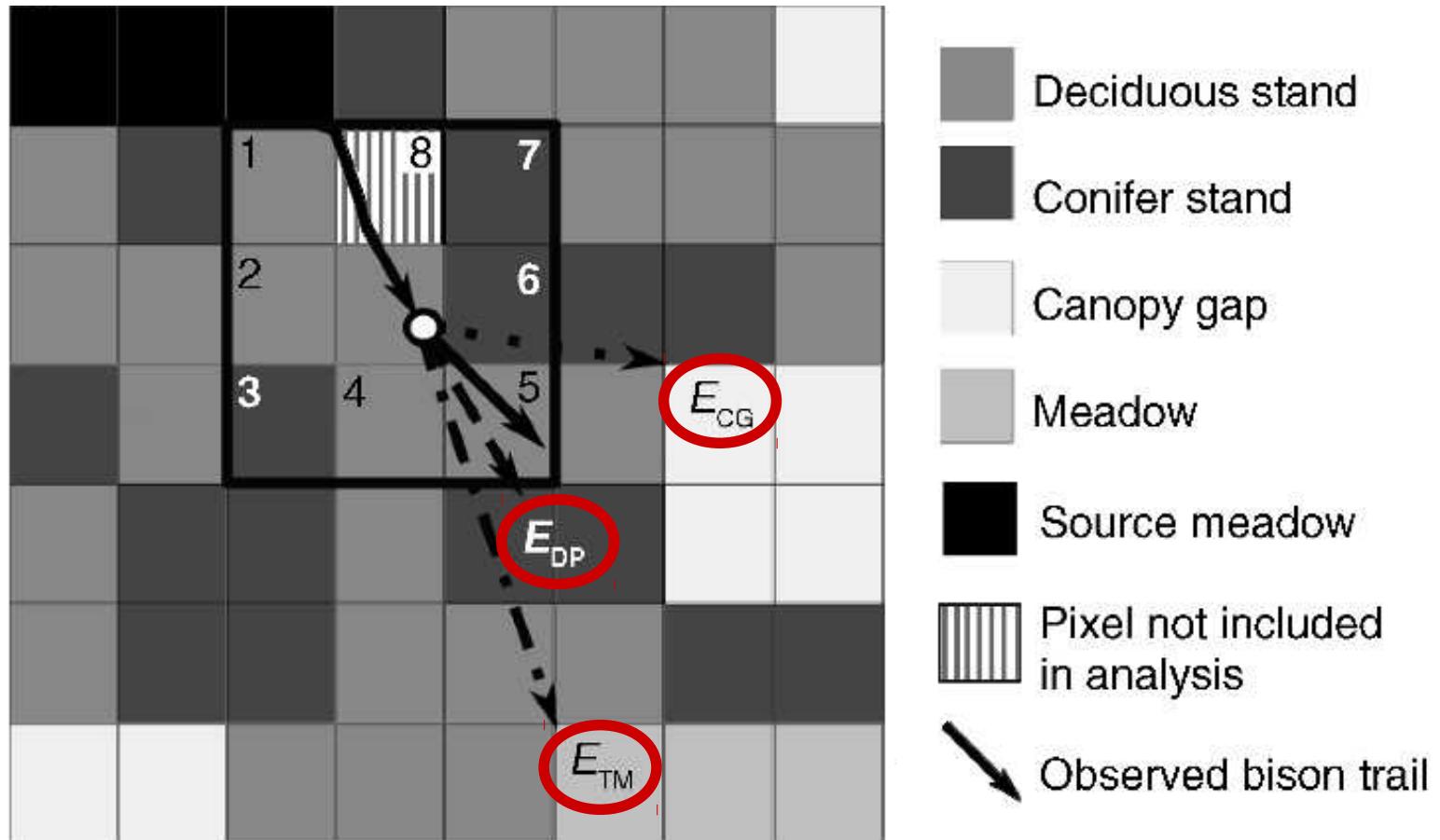
d) Conifer forests with lichen



SSF: Directional biases



SSF: Directional biases

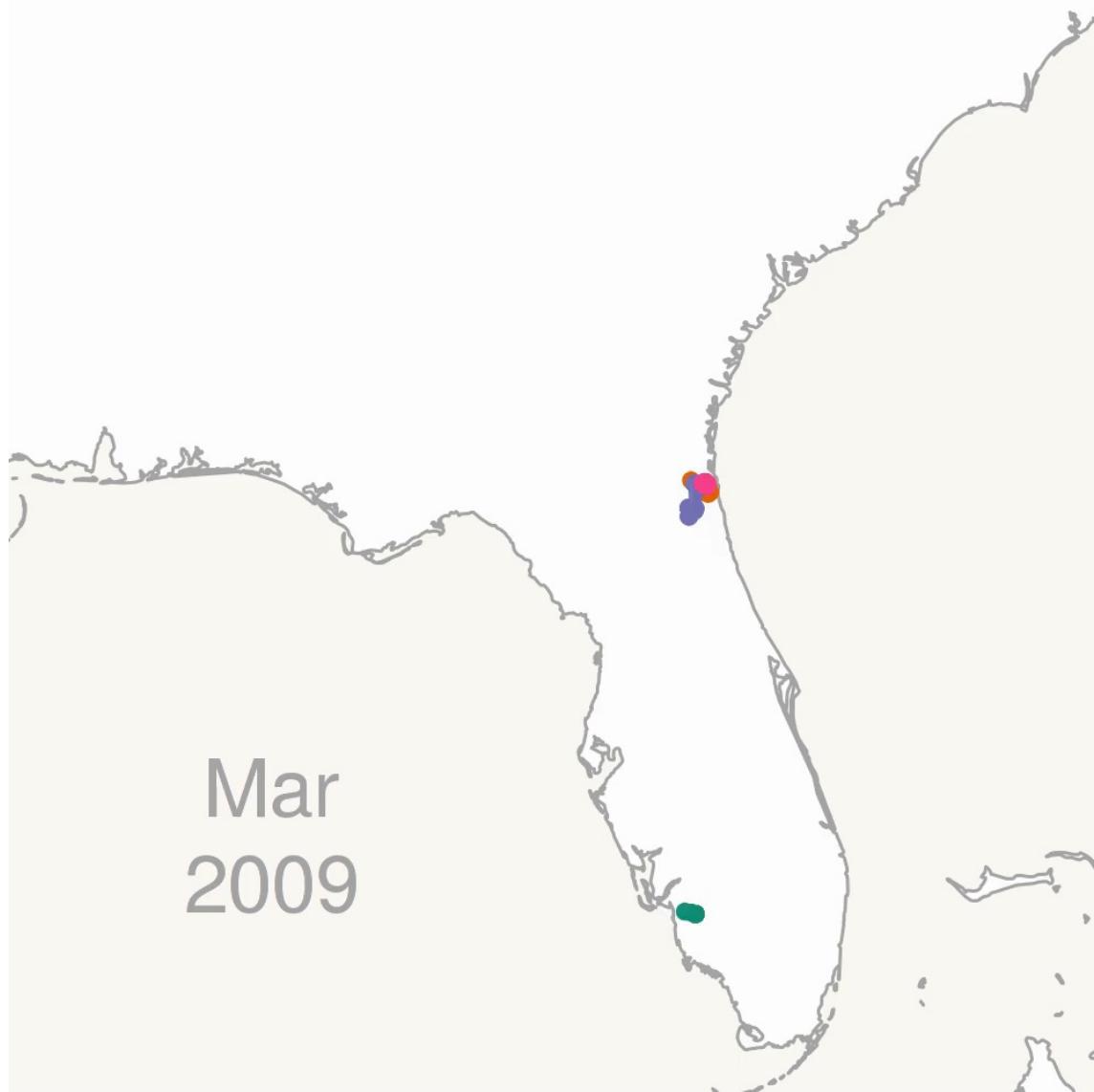


Integration

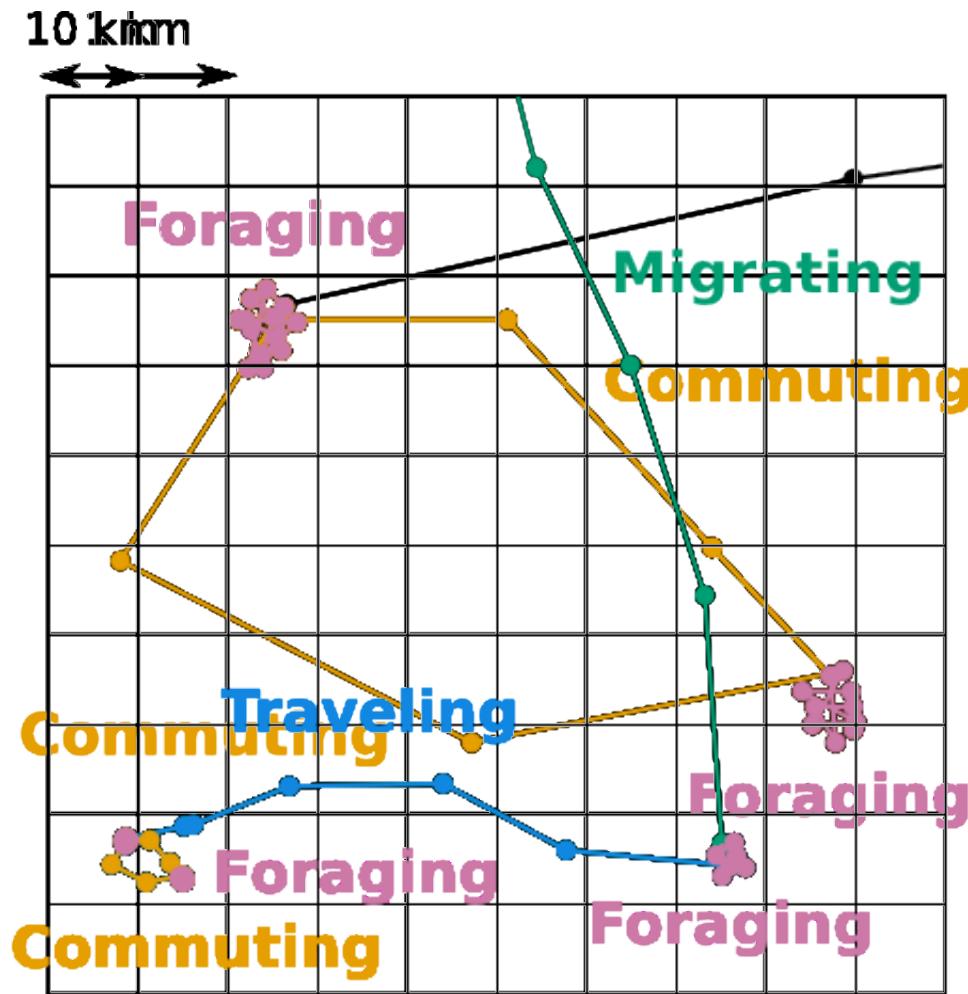
Interlude: wood stork movements



Interlude: wood stork movements

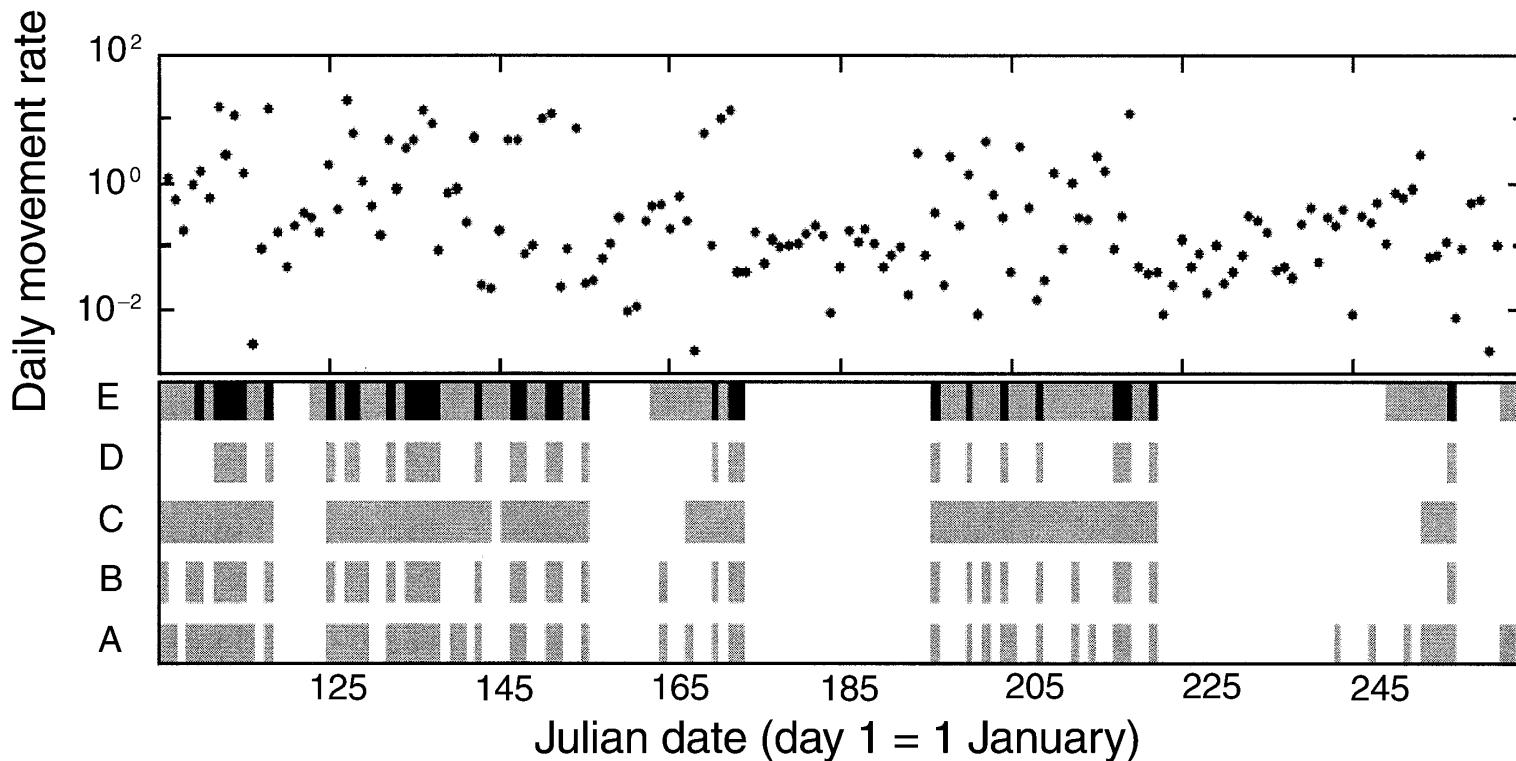


Movement modes: introduction



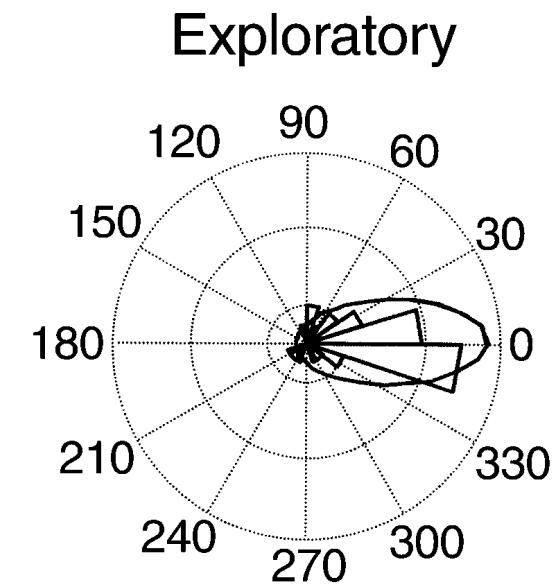
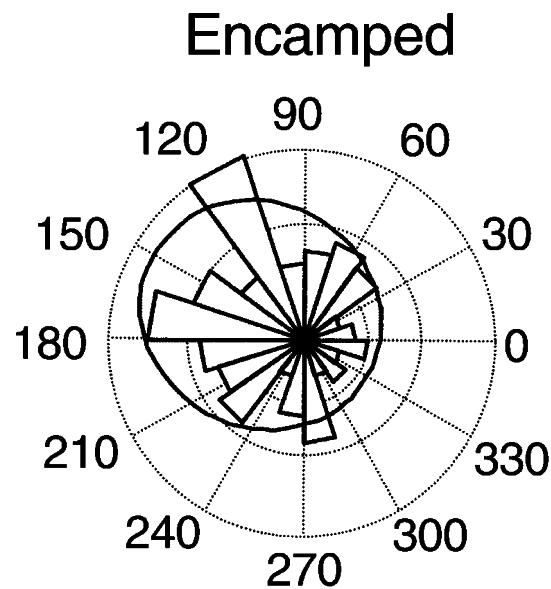
Movement modes: first approach

- Fitting multiple random walks
- Use flexible step length and turning angles distributions
- Let the data speak

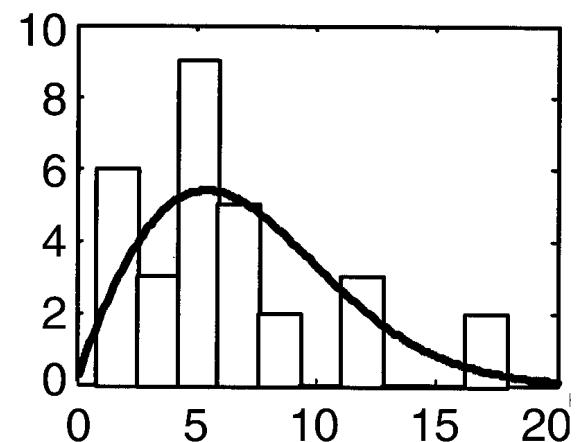
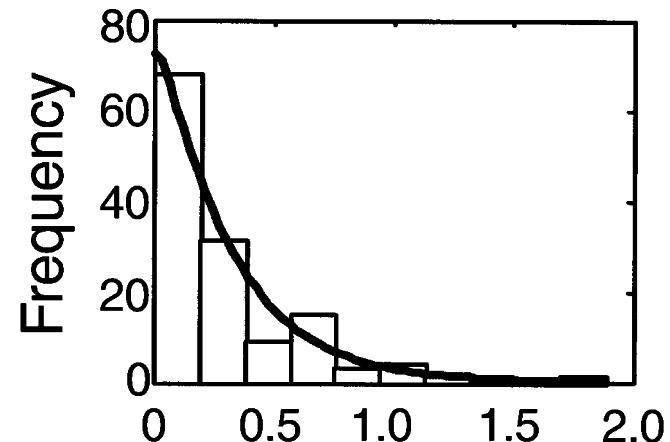


Movement modes: first approach

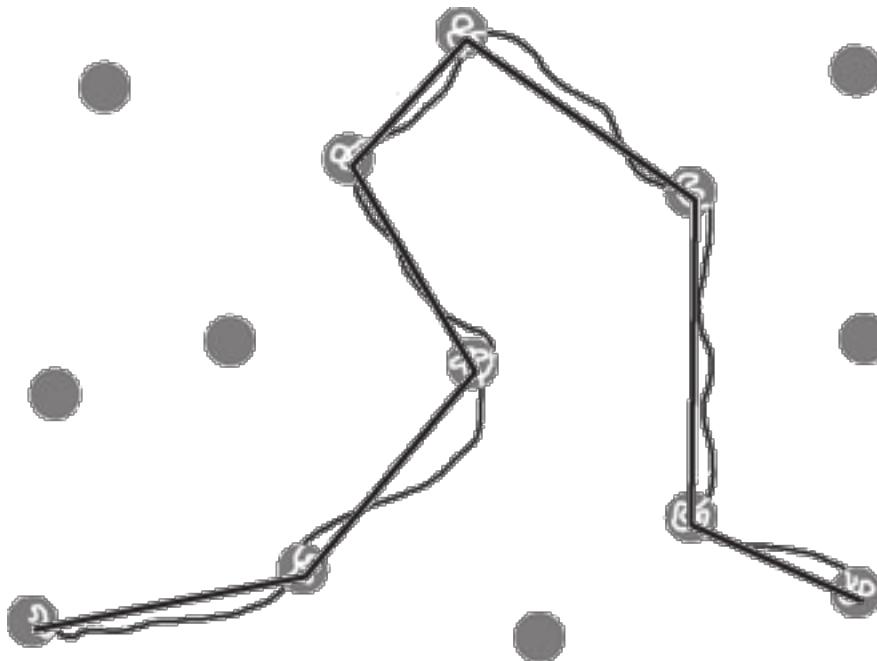
Turning angles



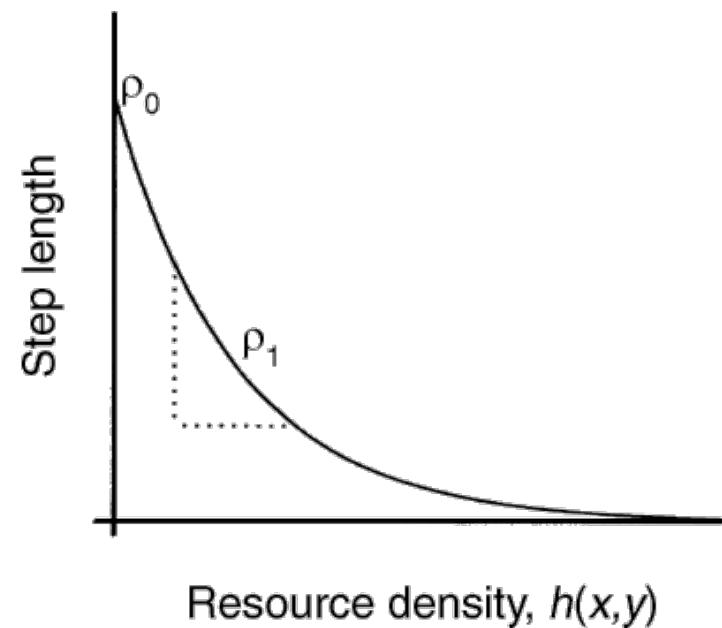
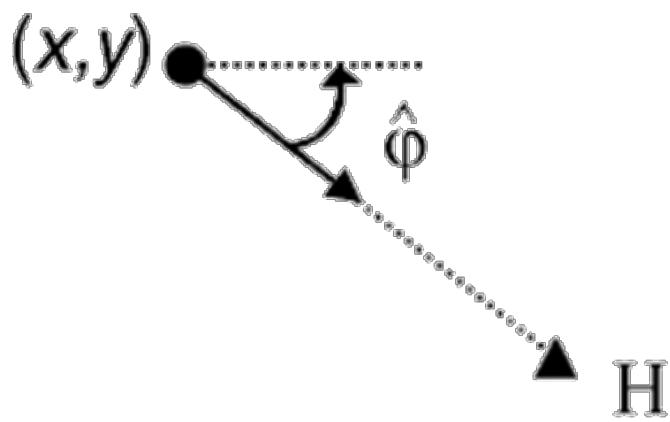
Daily movement
rate (km)



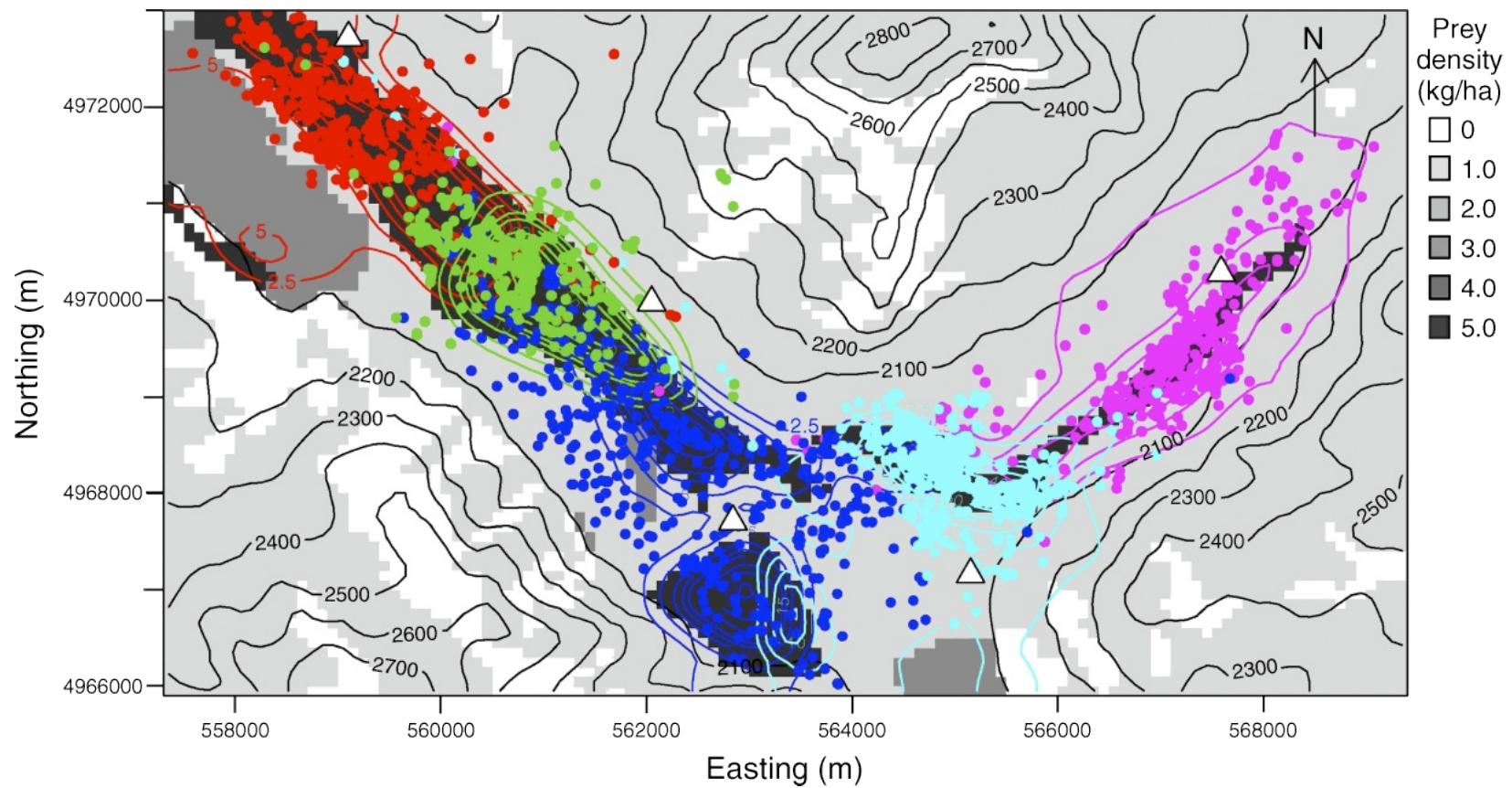
Scales and stationarity



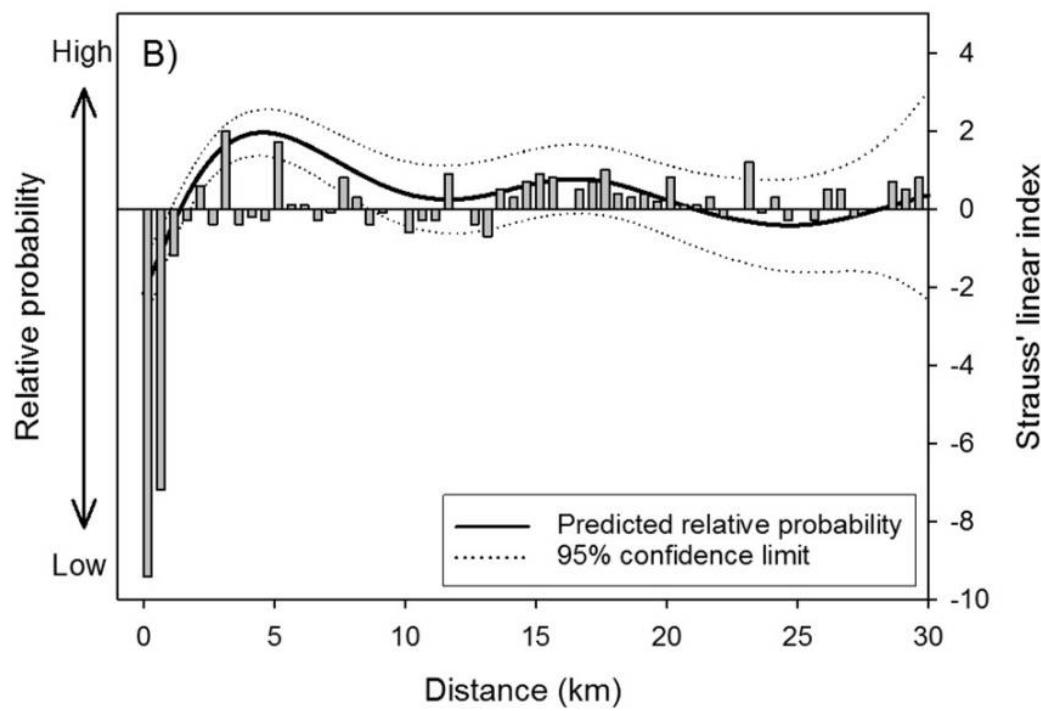
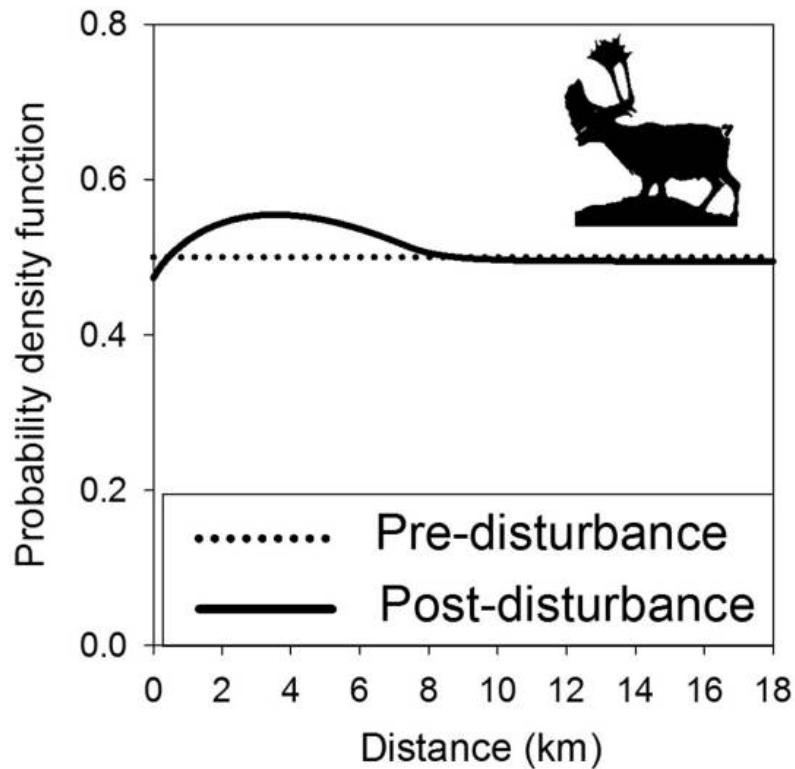
Convergence... [1]



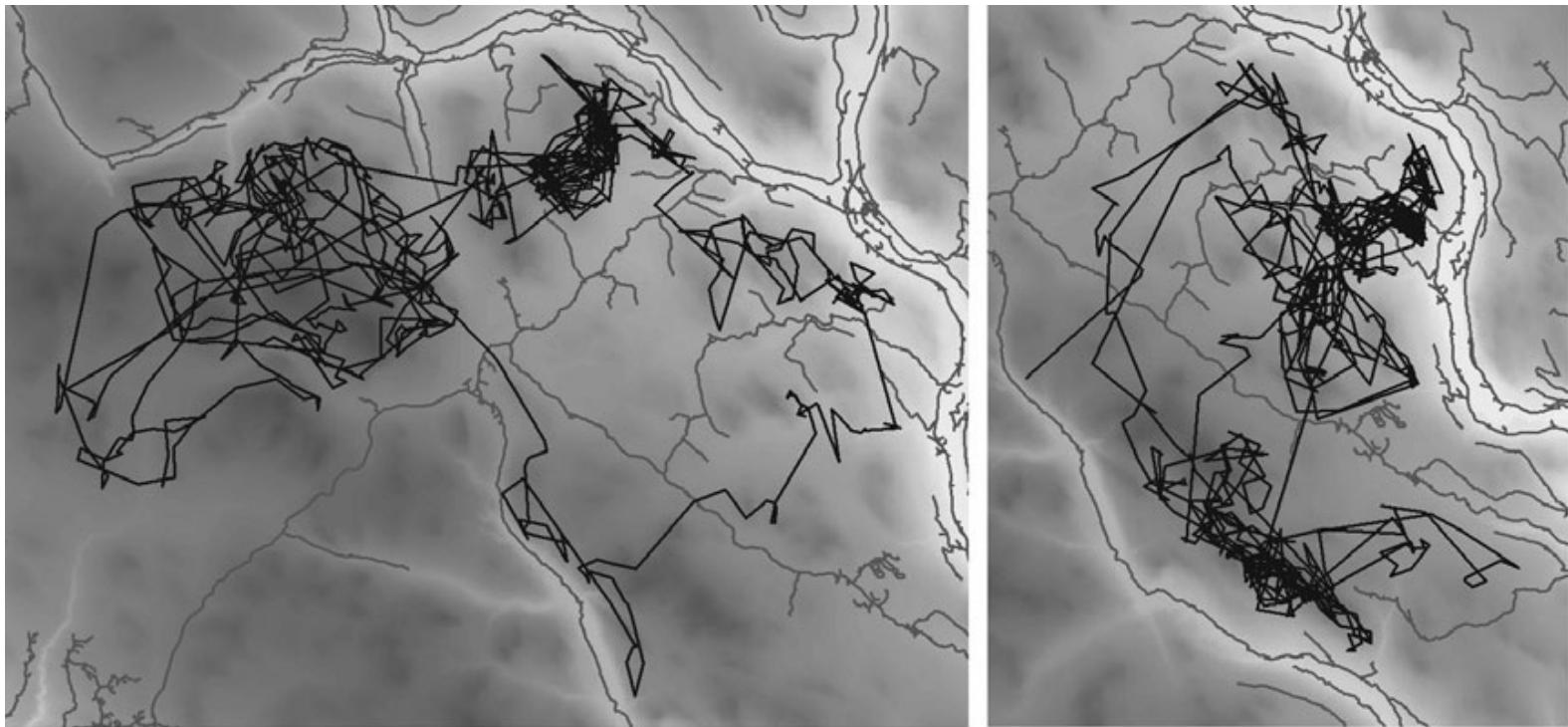
Convergence... [1]



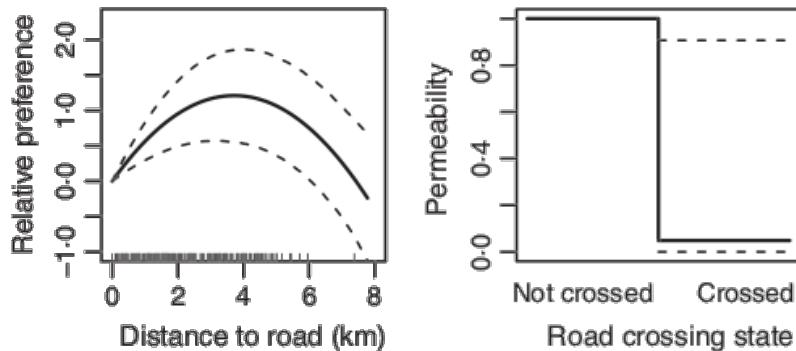
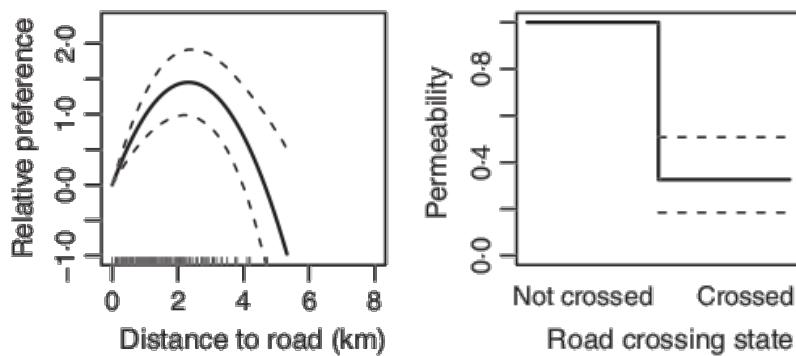
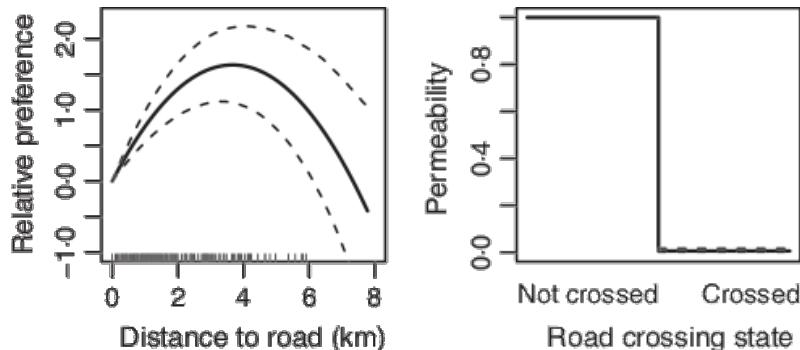
Convergence... [2]



Convergence... [3]



Convergence... [3]



Ecology
on the move...

Some perspectives

- **Memory**
BCRW with two-part memory system (18)
- **Individual behaviors**
Random effects to reveal different foraging strategies (19)
- **Sociability**
Attraction/avoidance of conspecifics, group dynamics (fusion-fission) (20,21)

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