

INTRODUCTION TO ANIMAL SPATIAL ECOLOGY



Josh Cullen

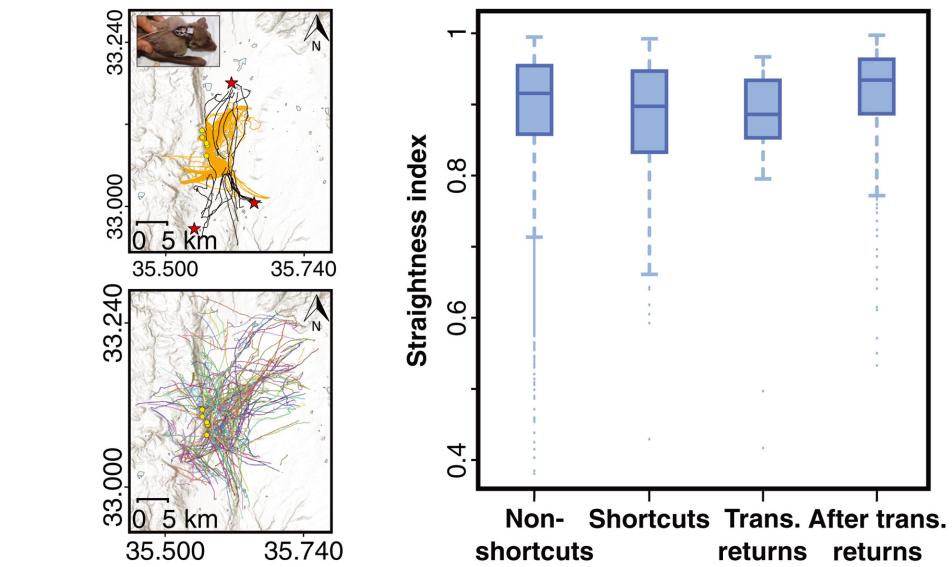
September 9, 2022

Background

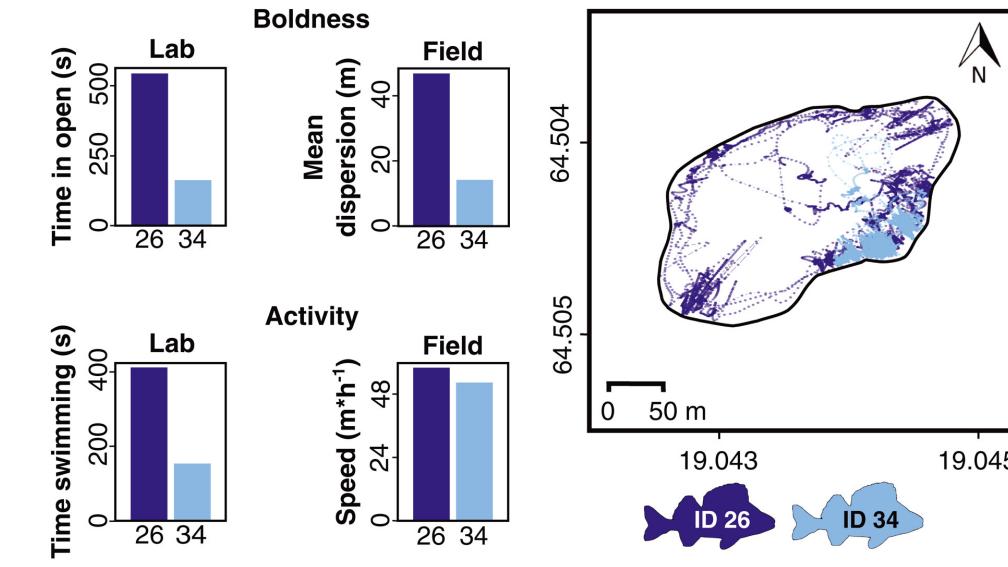
- Movement is fundamental to the life history and fitness of organisms
- The study of animal movement via telemetry devices (e.g. GPS, Argos, VHF) has enabled a variety of detailed analyses
- Often, researchers want to estimate space-use and latent behavioral states from animal tracks

Study Design

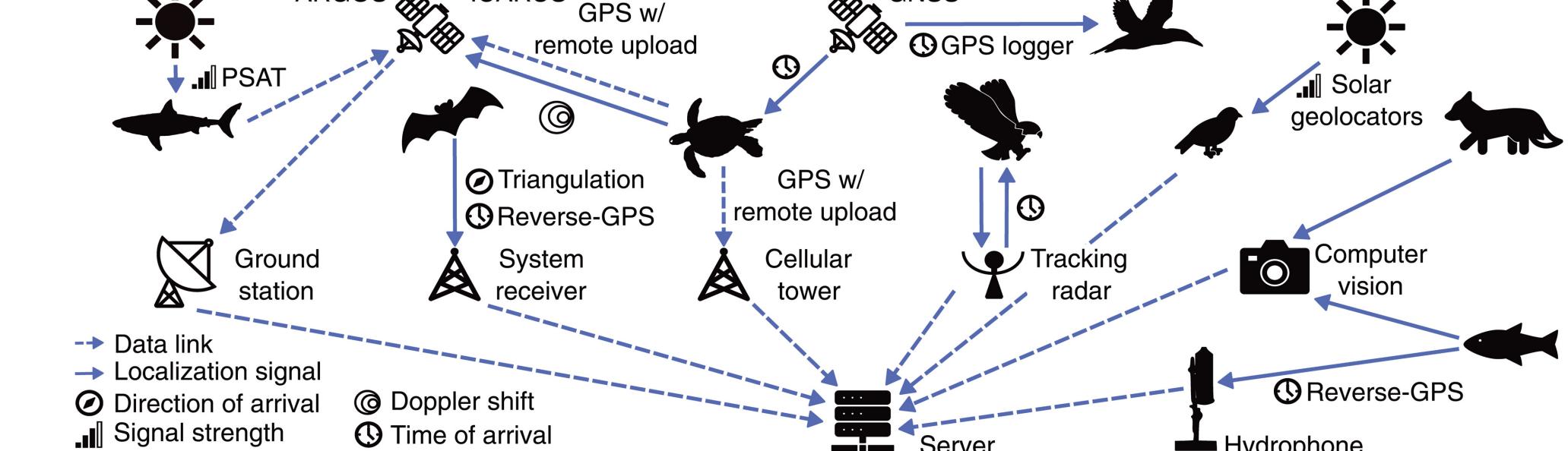
A Animal cognition experiments



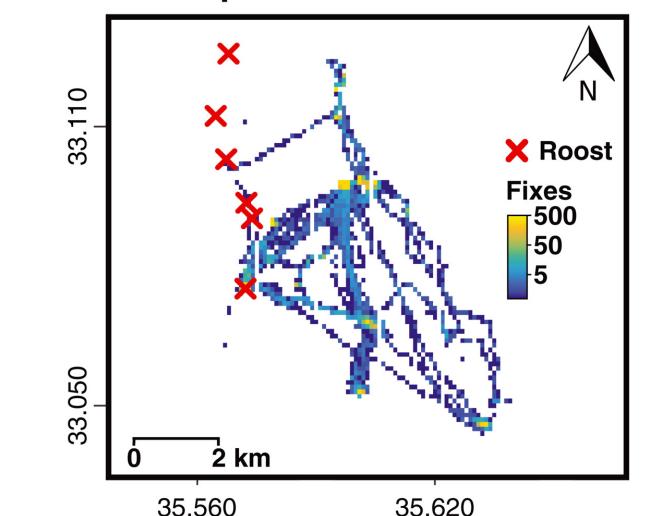
B Animal personality experiments



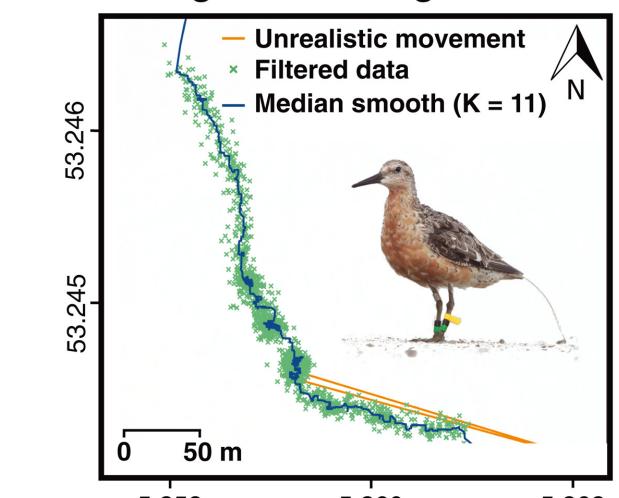
C Data Collection



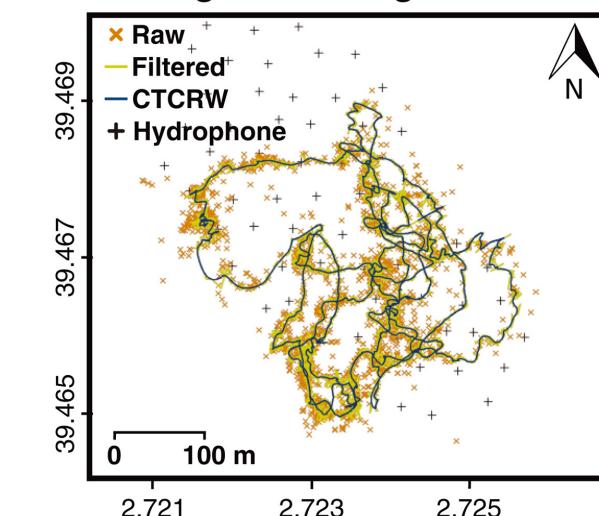
D Data exploration



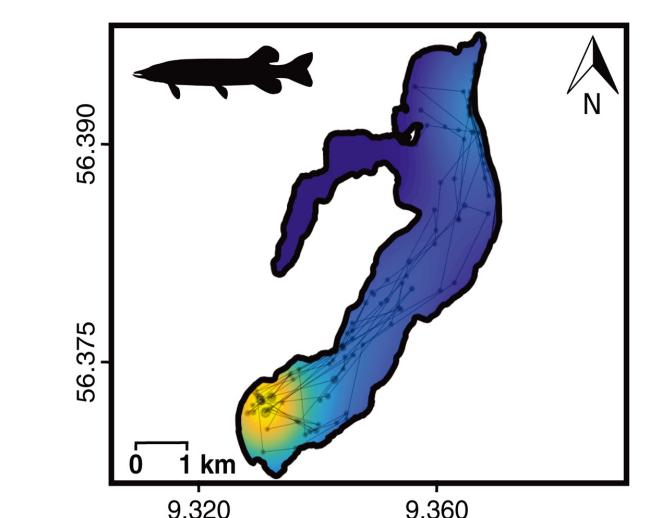
E Filtering & smoothing



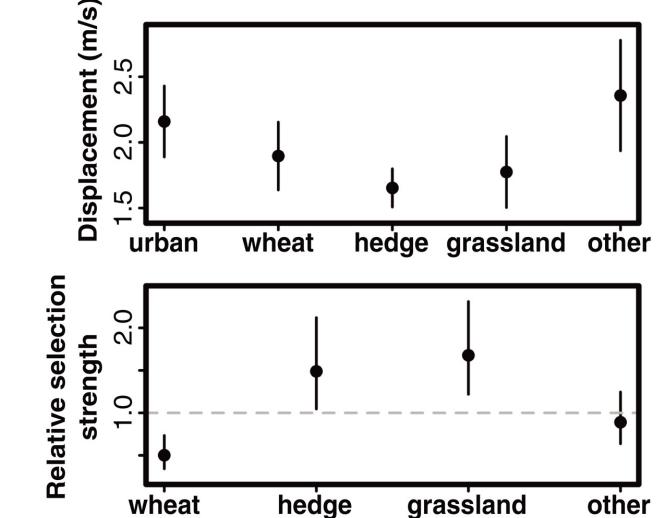
F Filtering & modeling



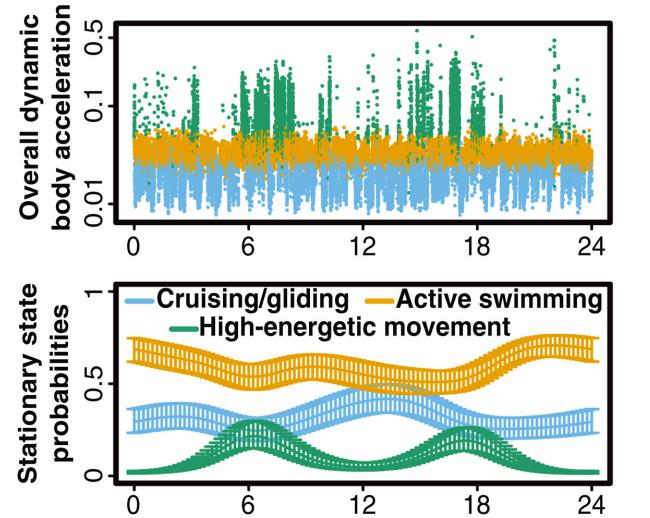
G Kernel density estimation



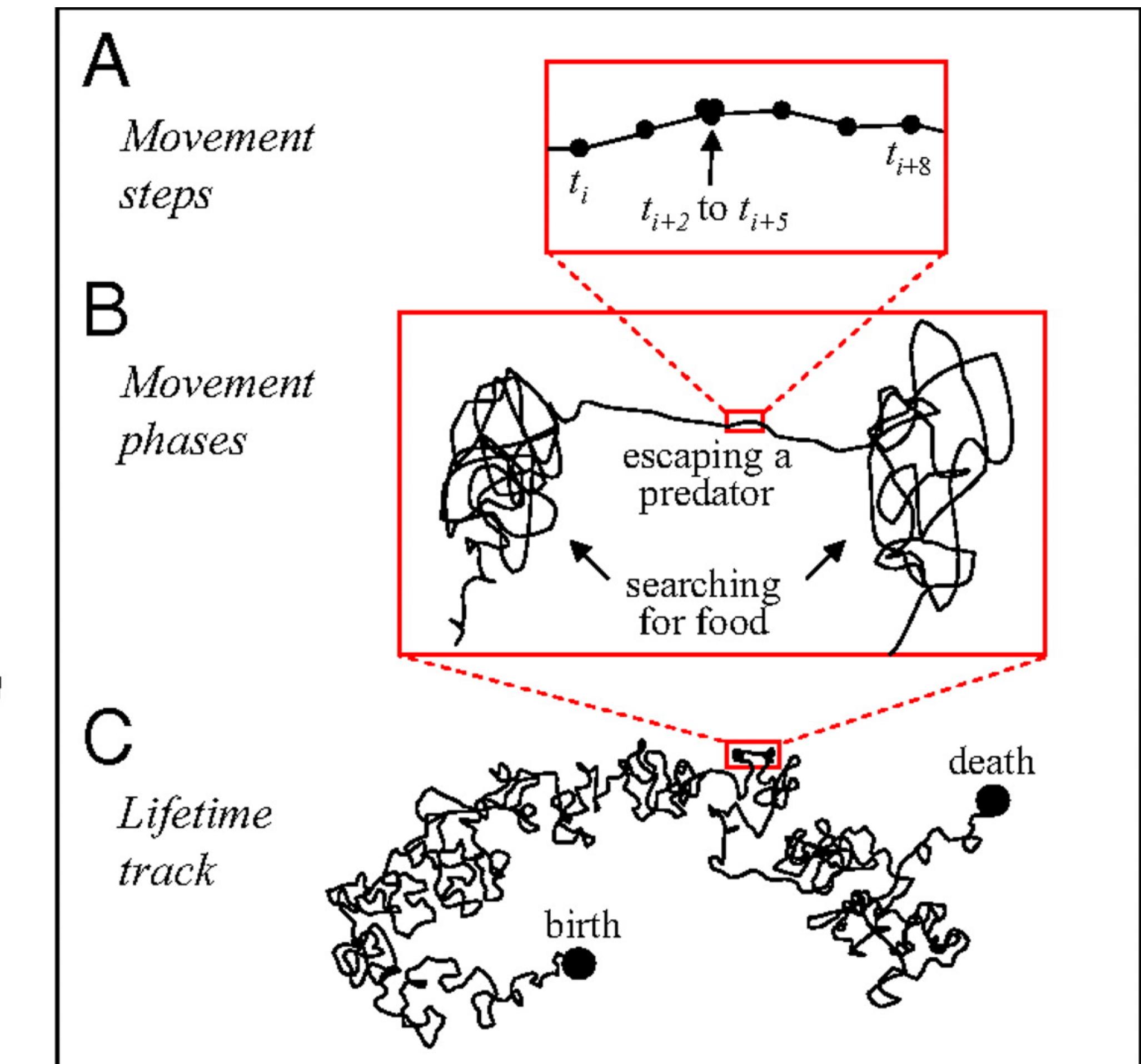
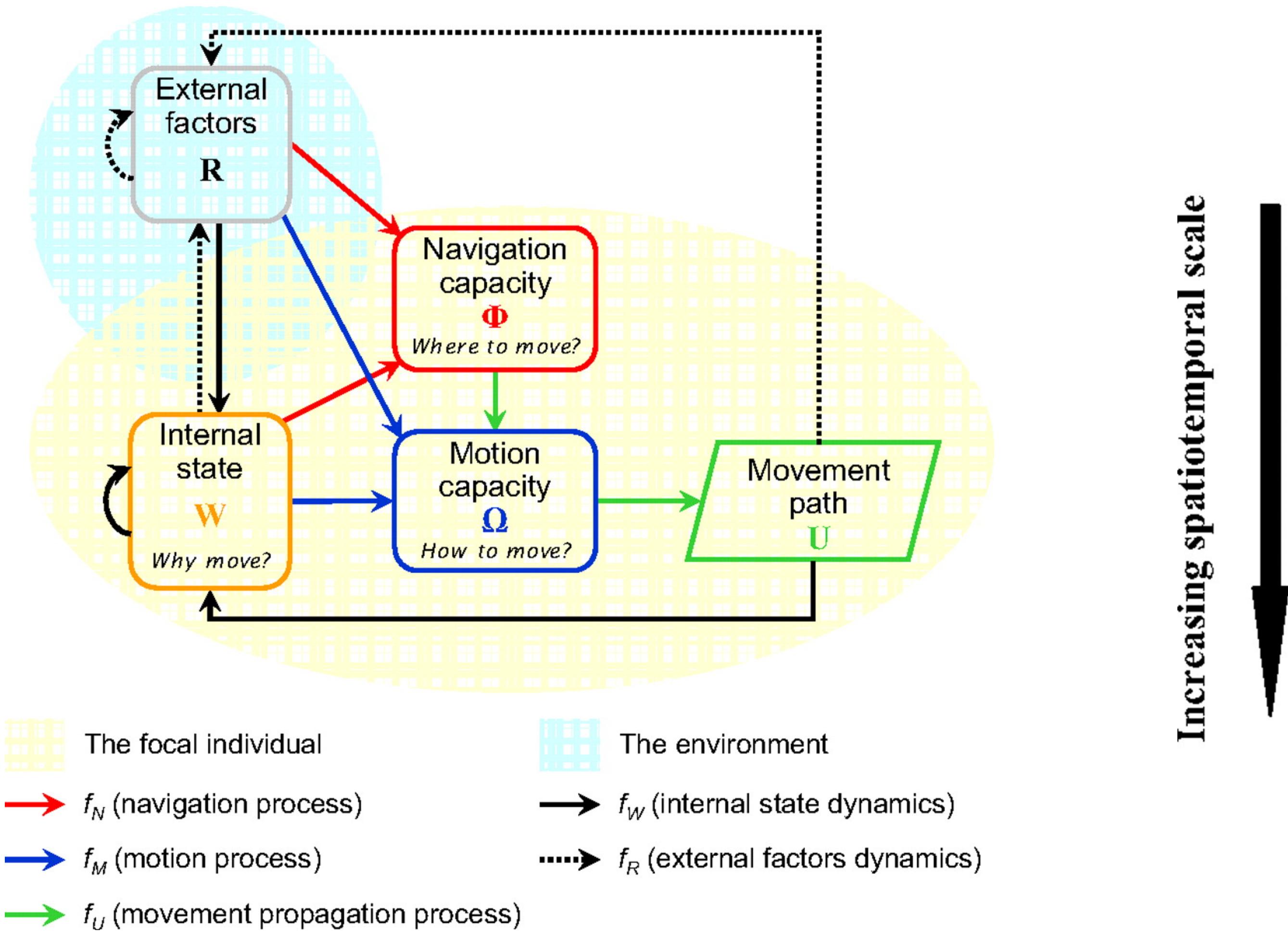
H Step selection function



I Hidden Markov modeling



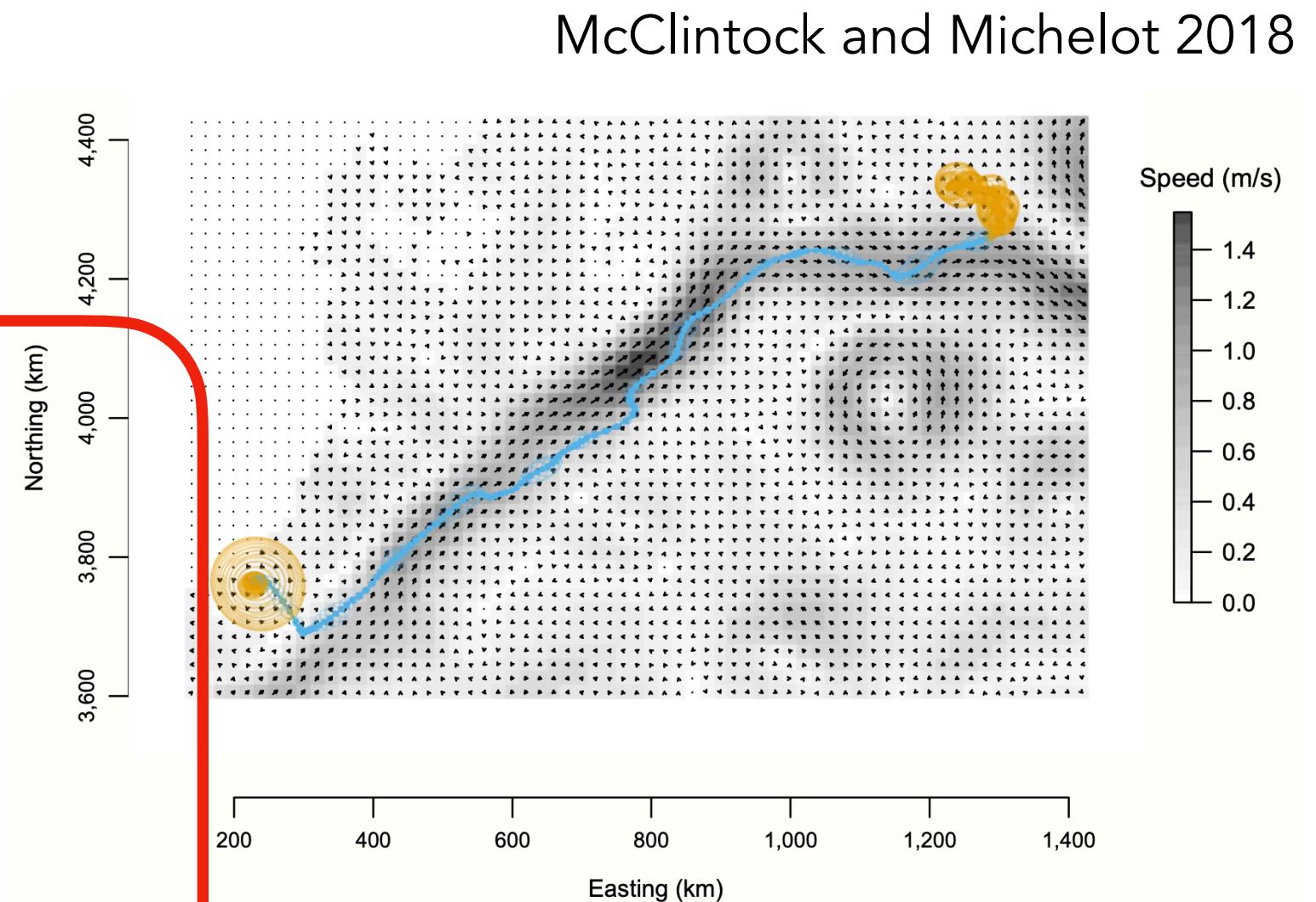
Movement ecology paradigm



Big picture applications

Space use

- By an individual
- By a population
- Temporal patterns
- Relationship w/ MPAs
- Comparisons among life stages
- Determine centers of activity

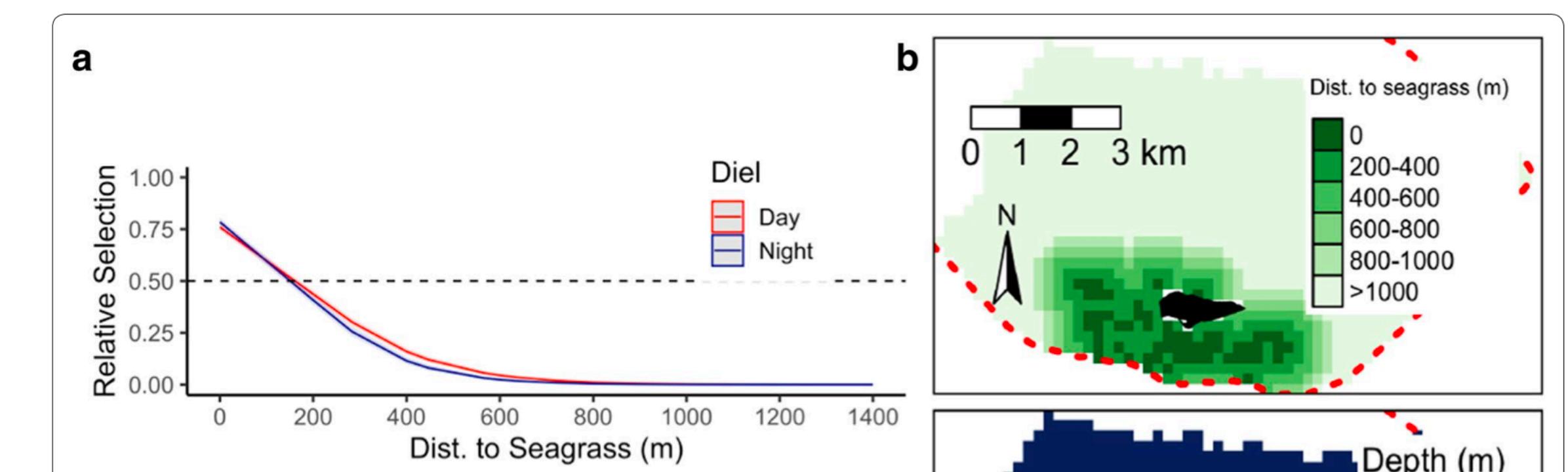


Behavioral states

- What is the animal doing?
- Activity budgets
- Identification of possible corridors or foraging grounds

Habitat selection and suitability

- What type of habitat does the animal prefer?
- Does this differ by season/age/sex?
- Does this differ by behavioral state?
- How is this expected to be impacted by climate change?
- Can we use habitat preferences of some species of a community to inform habitat preferences of other species?



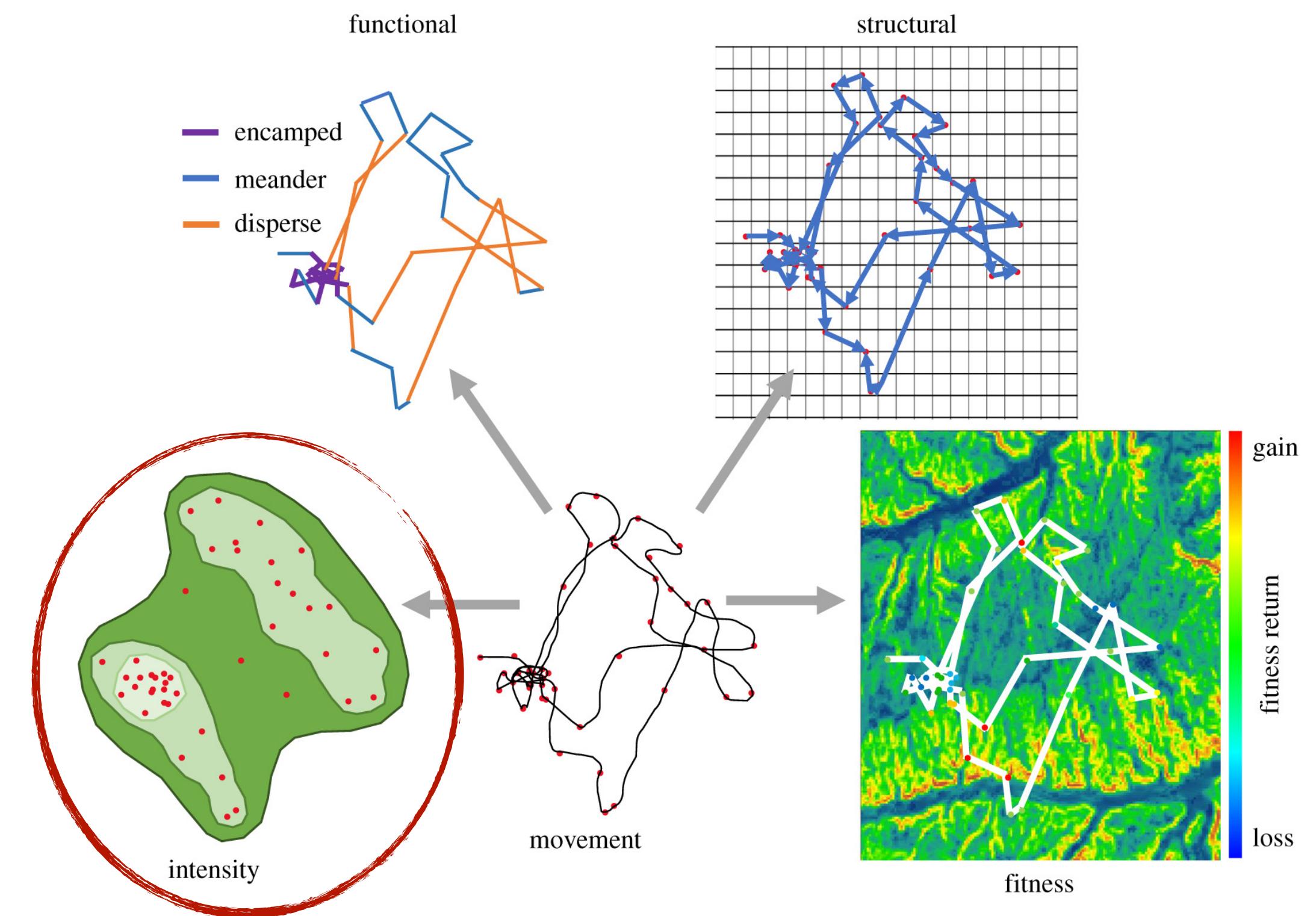
Drymon et al. 2020

Griffin et al. 2020

What is spatial ecology?

According to Fletcher and Fortin (2018):

- “Spatial ecology focuses on the study and modeling of the role(s) of space on ecological processes that in turn affects ecological patterns.”



Wittemyer et al. 2019

**How to study space-use (or
spatial intensity)?**

Concept of home ranges

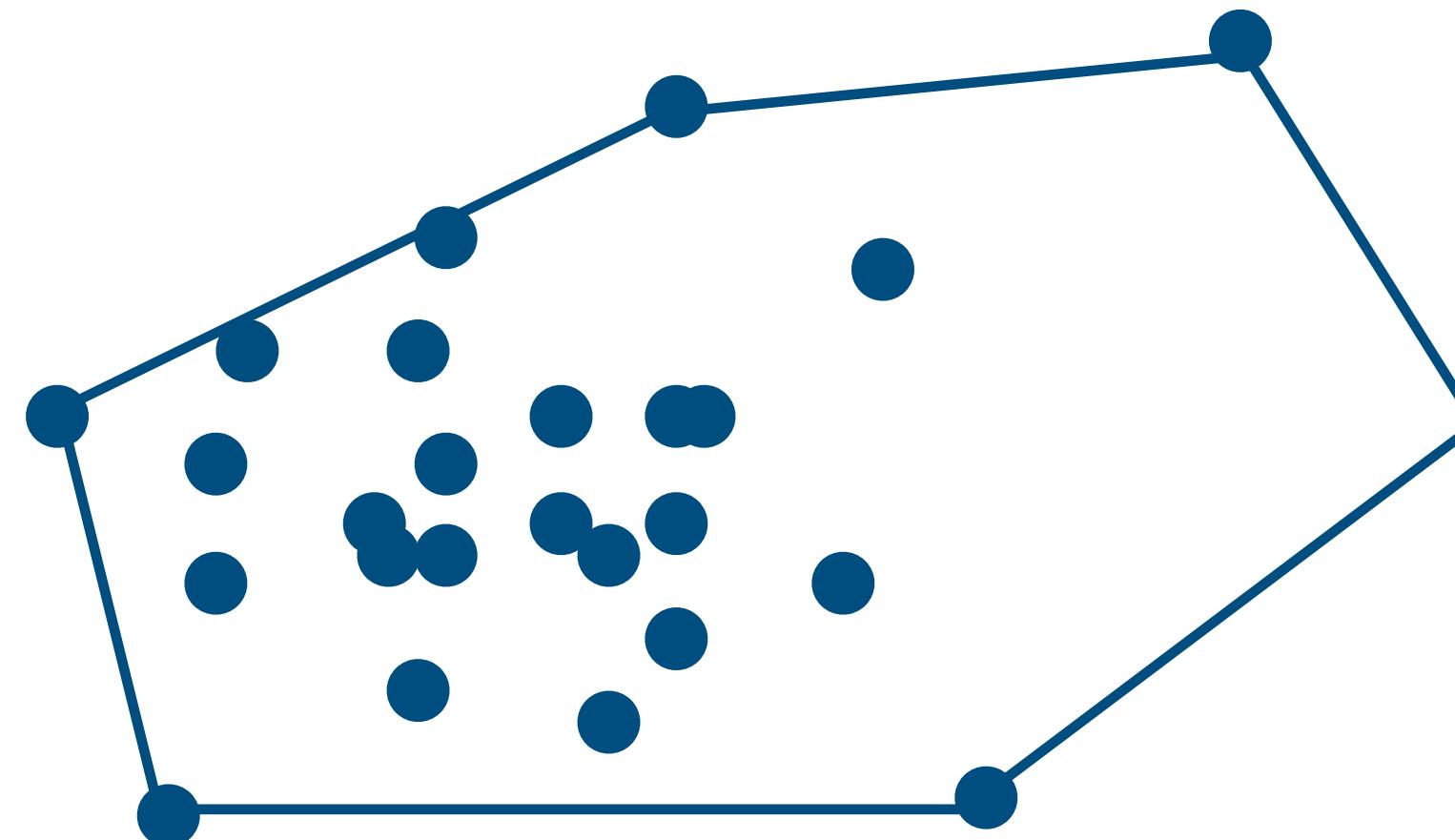
Definition from Horne et al. (2020) per Burt (1943):

- “Home ranges are the consequence of behavioral and environmental process...that result in predictable patterns of restricted space use on the landscape”
- “Animals might occasionally make exploratory forays, but home ranges should be those areas that are normally used”
- “Temporal stability in the area used is expected such that an animal will make repeated visits to places within the home range.”

But how to estimate space-use?

Minimum convex polygons (MCPs)

- Arguably the simplest method
- Create a convex hull that connects the outermost points
 - Extremely sensitive to outliers and sample size
- Doesn't account for spatial intensity of points



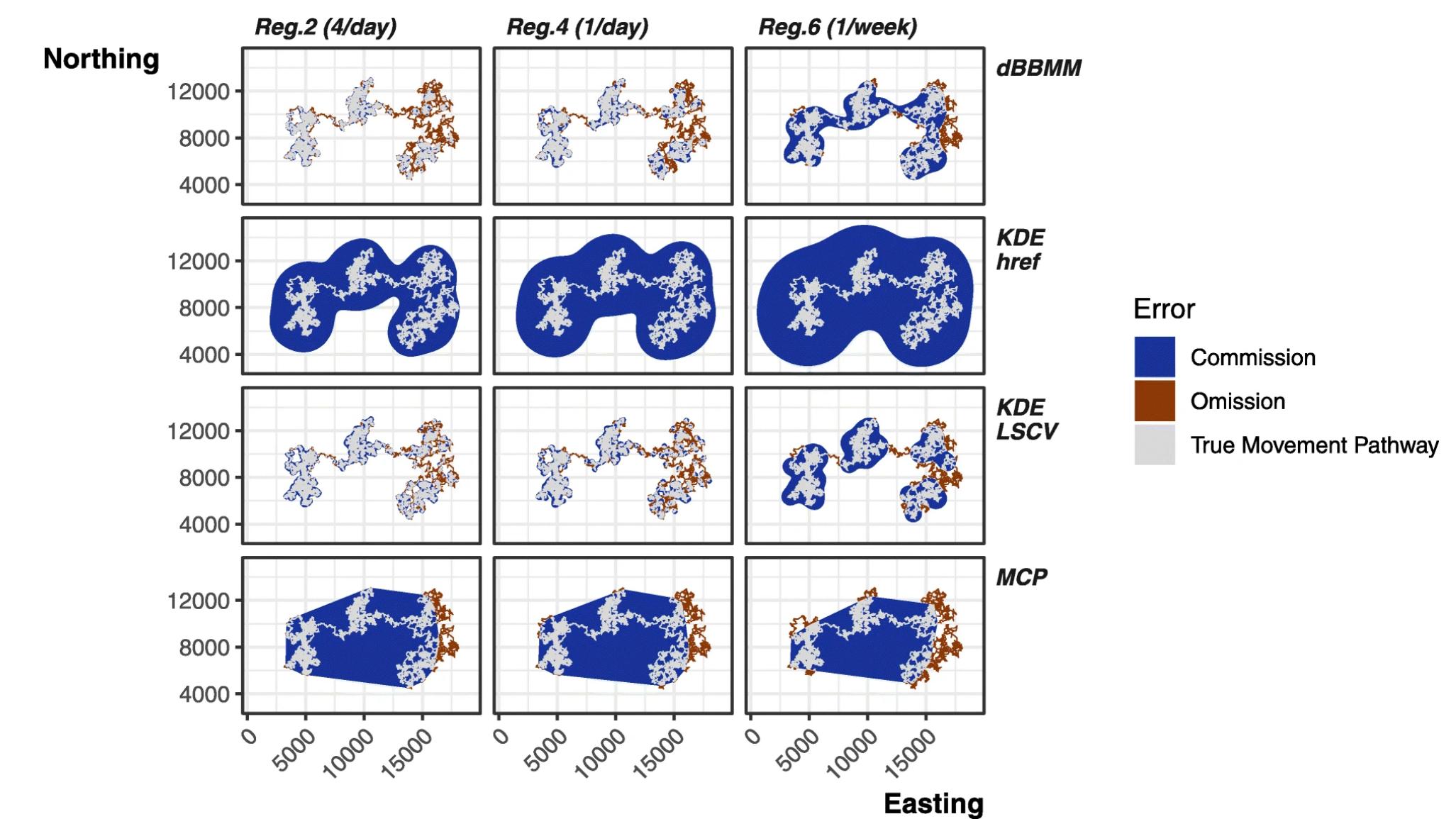
Utilization distributions (UDs)

- Characterizes space-use as a density function
 - Accounts for intensity of use
- Frequently used methods include:
 1. Kernel density estimation (KDE)
 2. Brownian bridge movement models (BBMM)

$$Pr(S) = \int_S UD(x, y) dx dy$$

↑
2D probability
density function

↑
Spatial region



Silva et al. 2020

Utilization distributions (UDs)

What does your space-use estimate mean?

Concept: Occurrence distributions

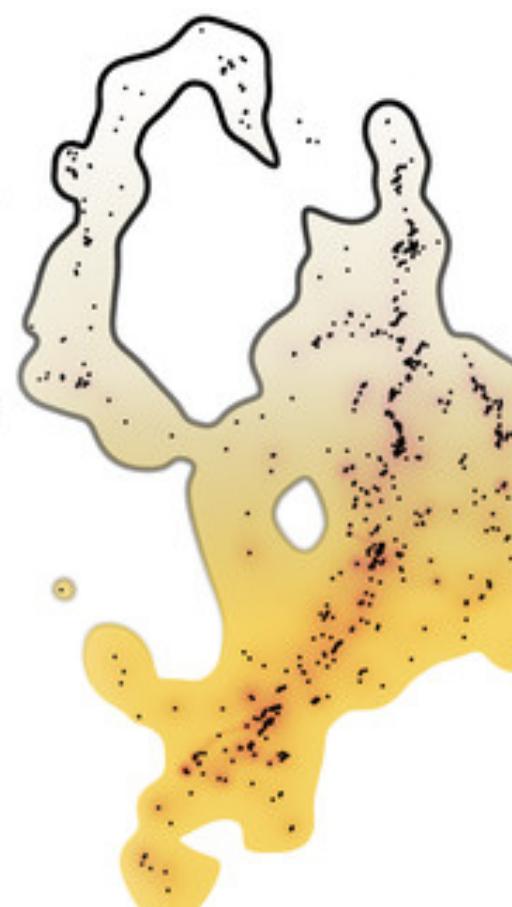
Estimating the space potentially used by animals during the sampling period, essentially estimates of uncertainty between known locations.

Distribution: Occurrence distribution

Contour: Confidence area

Predictive scope: Within sample interpolation

Example question: What potential movement corridors does species A use?



e.g., dynamic Brownian Bridge Movement Models

Range distributions

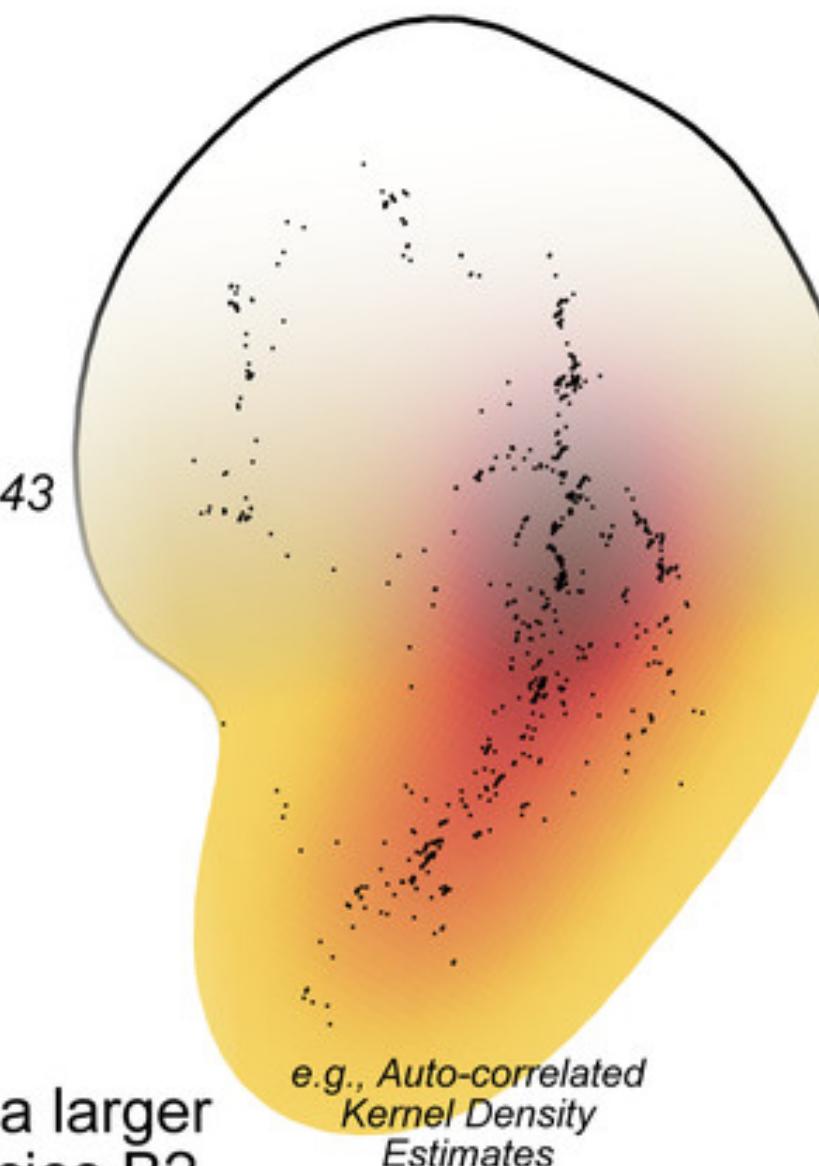
Estimating the space requirements of animals, corresponding to Burt's 1943 concept of home range.

Utilisation distribution

Home range

Beyond sample extrapolation

Does species A have a larger home range than species B?



Crane et al. 2021

Potential issues to consider

- Why estimate space-use for your study?
- What is sample size? (# of individuals and # observations/individual)
- What is tracking duration?
- What is the time interval of tag transmissions?

Let's estimate space-use!



So much room for activities!

References

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