Workshop on R and movement ecology:

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Lecture 2

Introduction to Movement Ecology

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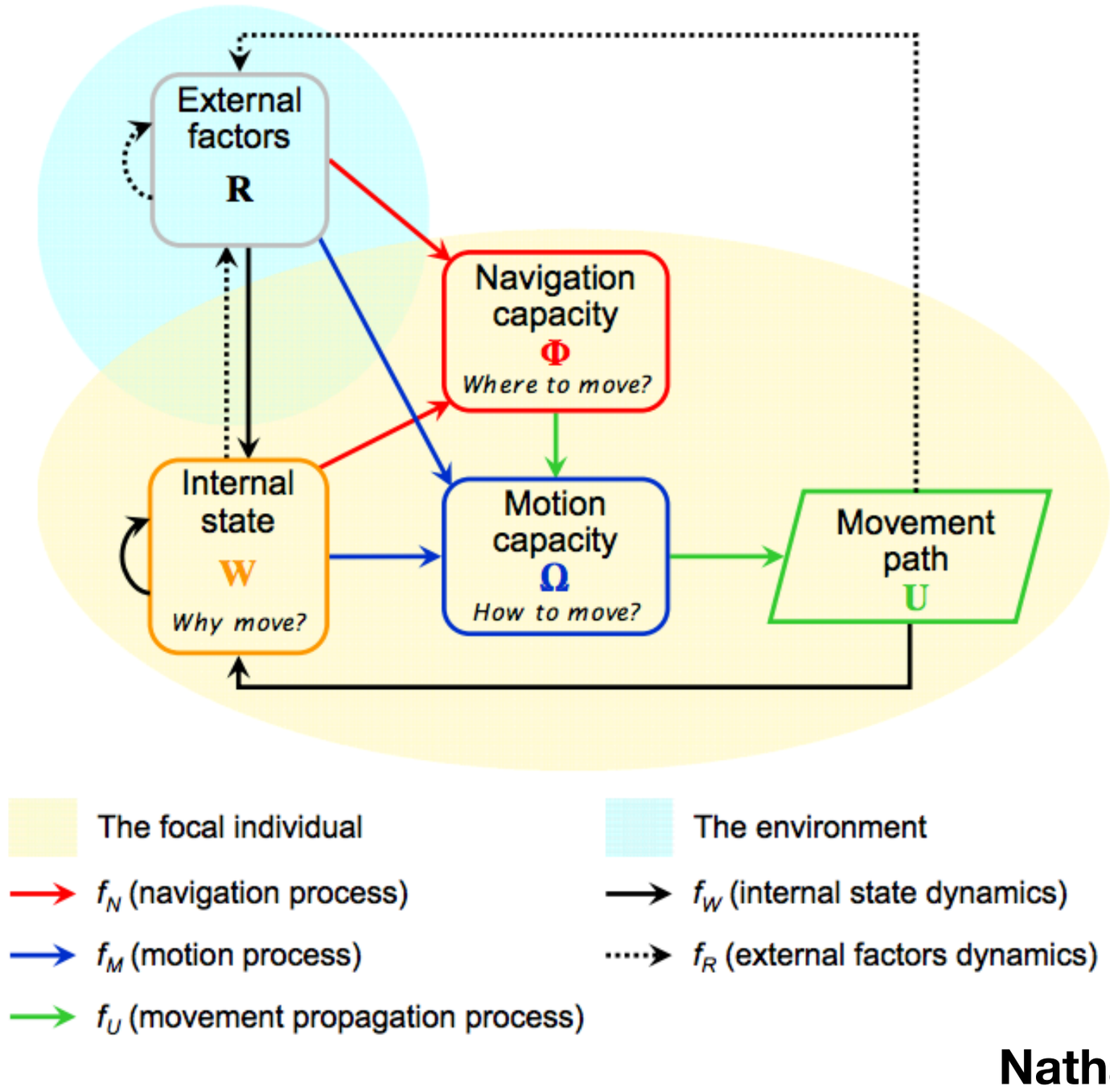
On the Movements of Animals

“The movement of animals that belong to each genus, and how these are differentiated, and what the reasons are for the accidental characteristics of each—all this we have considered elsewhere. But now we must consider in general the common reason for moving with any movement whatever (for some animals move by flying, some by swimming, some by stepping, some in other comparable ways)”

-Aristole, *De Motu Animalium (~300 B.C.)*

Movement Ecology Paradigm



Nathan et al. 2008; PNAS

Four Fundamental Components

- Internal State – the question of whether or not to move is dictated in large part by the internal needs and motivations of an animal

- Motion Capacity – The biomechanical elements that enable or preclude an animal from making particular movements

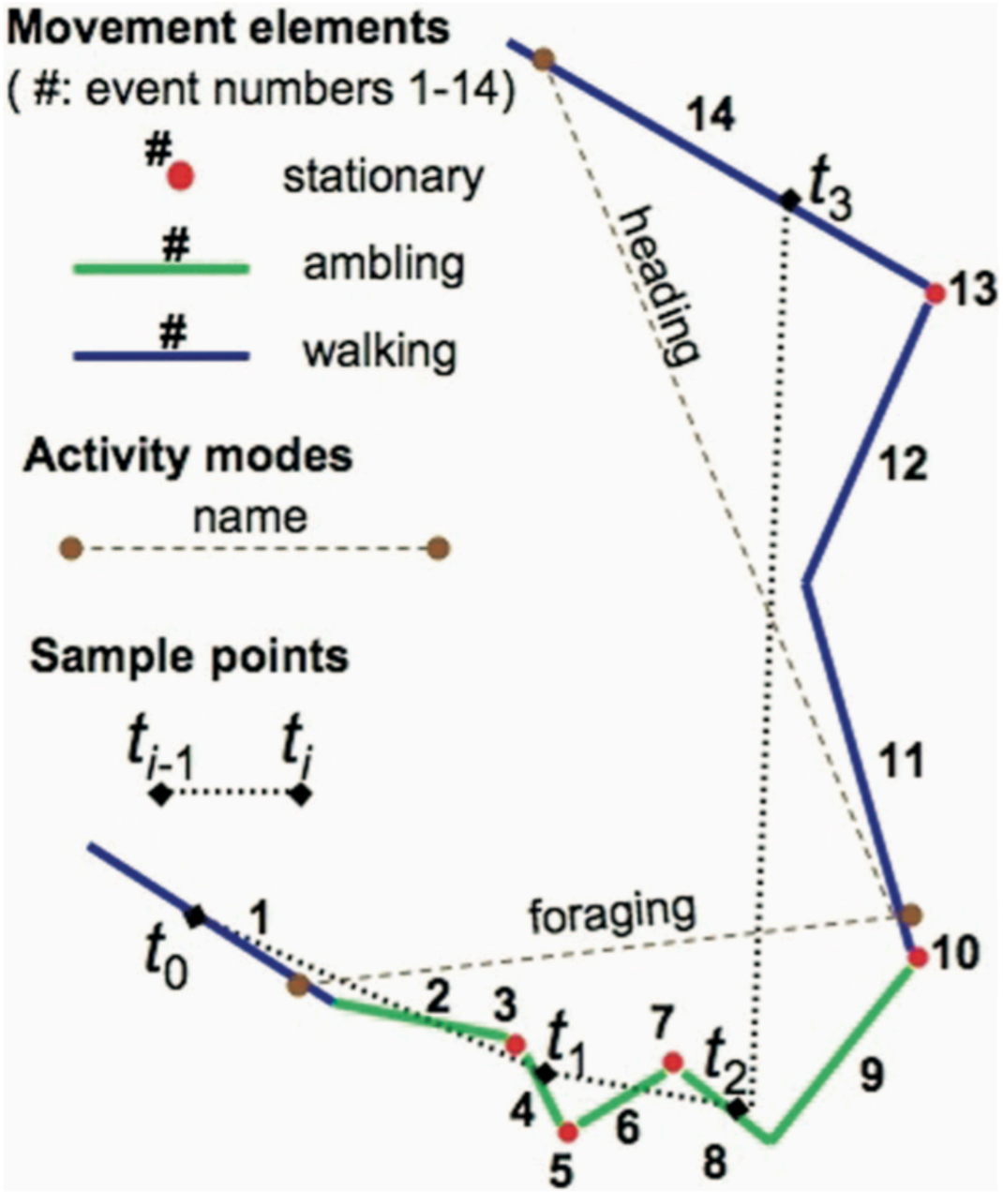
- Navigational Capacity – the ability to determine a direction and speed of movement will emerge largely from memory and perception

- External Factors – the environment (resources, predators, competition, etc.) will expand or reduce possible movements

Measuring Movement

- Fundamental Movement Elements (FMEs) – extremely fine-scale motor movements that comprise all movements, such as a lunge versus a step taken at normal speed

- Canonical Activity Modes (CAMs) – distributions that emerge from the mix of FMEs that characterize the activity in question, such as foraging

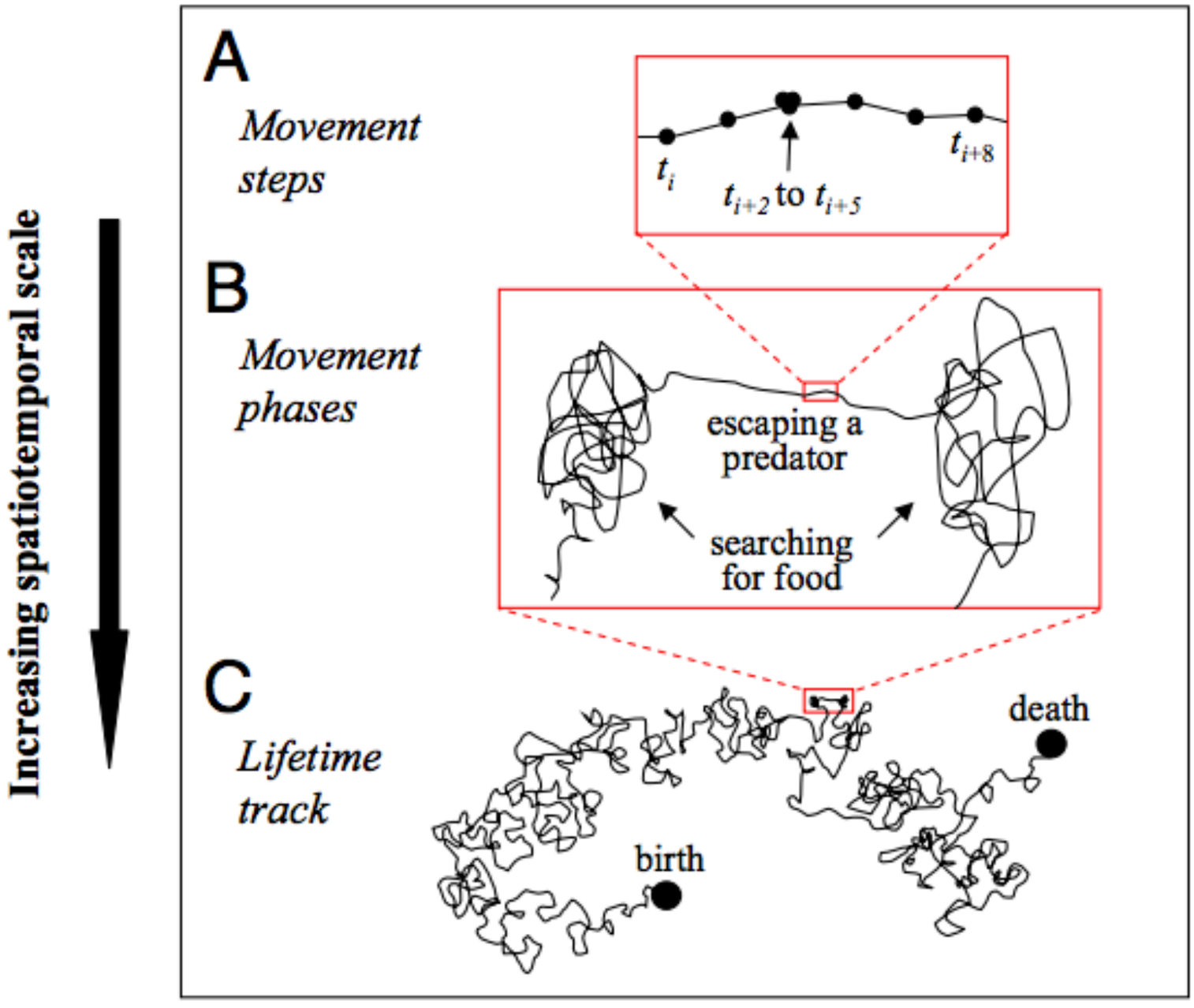


Getz & Saltz 2008; PNAS

Types of Movement Data

- Irregular interval data
  - Direct observation; Very High Frequency (VHF) telemetry; Autonomous arrays; Genetic profiles.
- Regular interval data
  - GPS monitoring; new tags may even include video, photo, or proximity capabilities
- Complementary data sources
  - Accelerometers, altimeters, physiological metric monitors

Scales of Movement Analysis



Questions we ask in ME

Broadly, you can consider the fundamental questions of movement ecology to fall into 2 classes:

1. Questions of movement behavior
2. Questions of landscape structure and function

These broad categories contain research across scales.

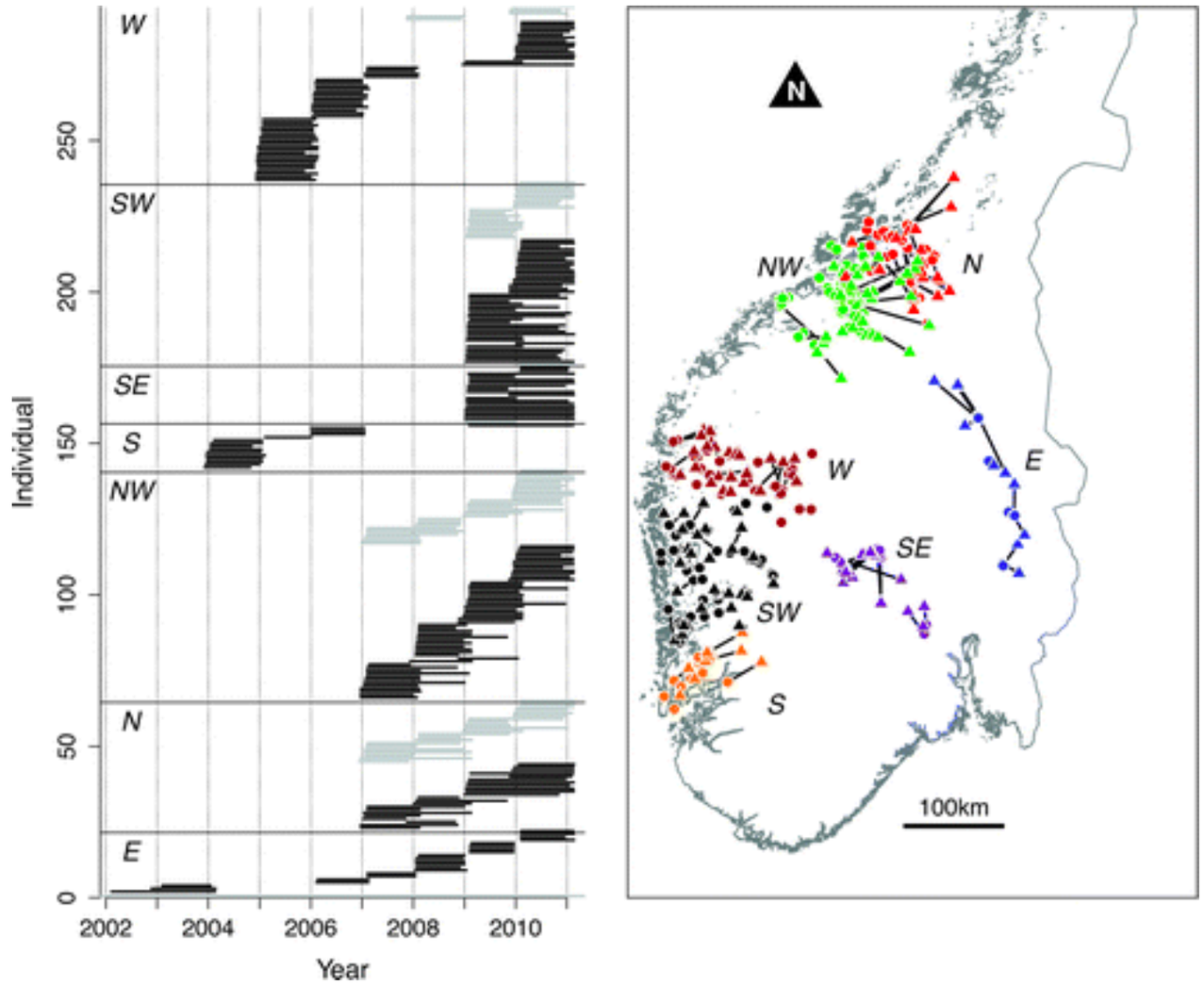
Coarse Scale

e.g.

- When do animals migrate? What drives the decision to migrate?
- When do landscapes act as barriers for animal movement? How does animal movement change in human altered landscapes?

Bischof et al. 2012

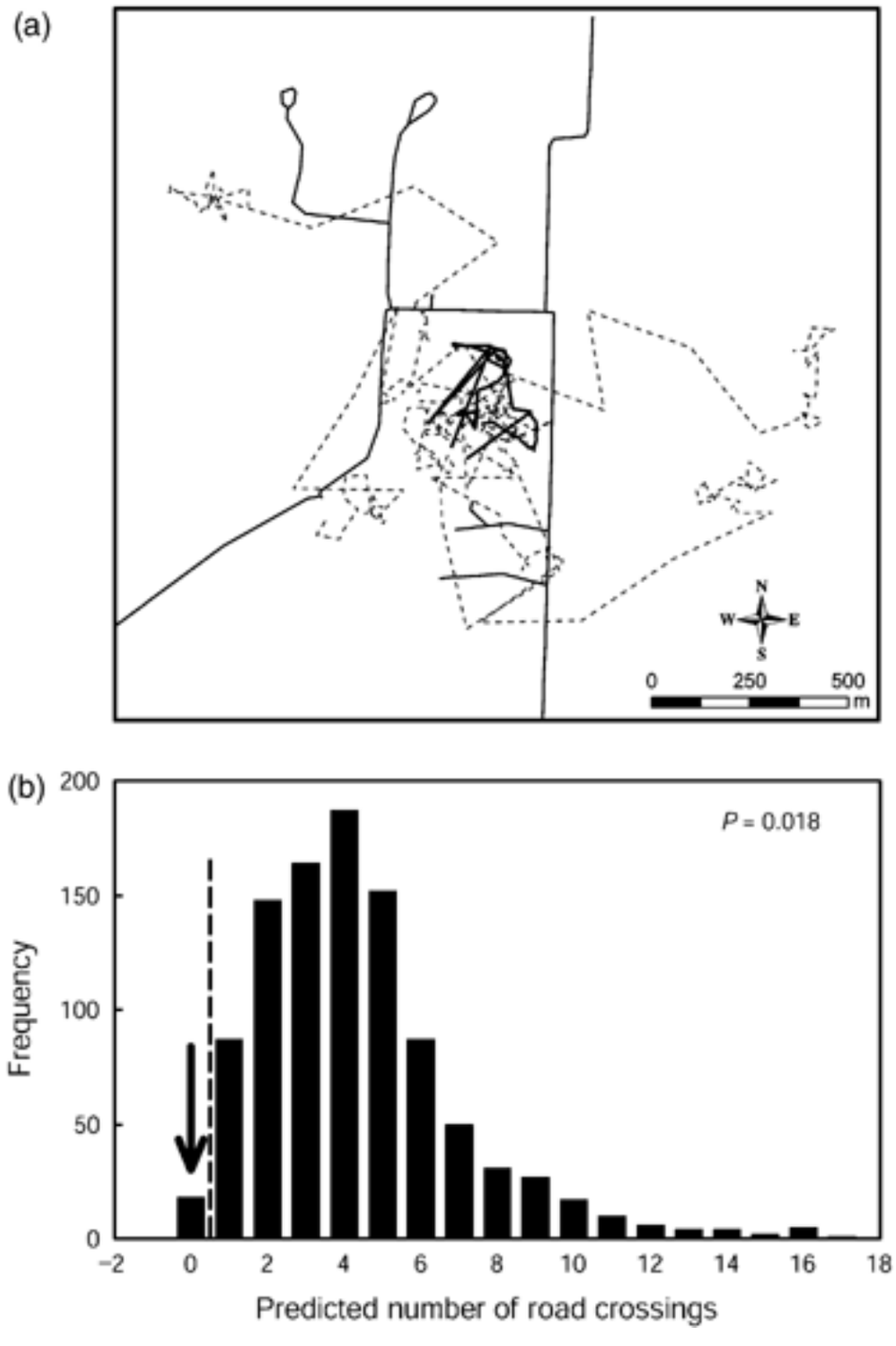
- Using GPS collared red deer to evaluate the seasonal migration behaviors of migratory versus resident deer as it relates to seasonal greenup



Shepard et al. 2008

- Looked at road crossing in three species of terrestrial vertebrates. All demonstrated road avoidance.

- Given individual variation in propensity to move, if road avoidance behavior is heritable, it is proposed this movement response could lead to genetically partitioned subpopulations likely experiencing inbreeding depression and each at risk of extinction.



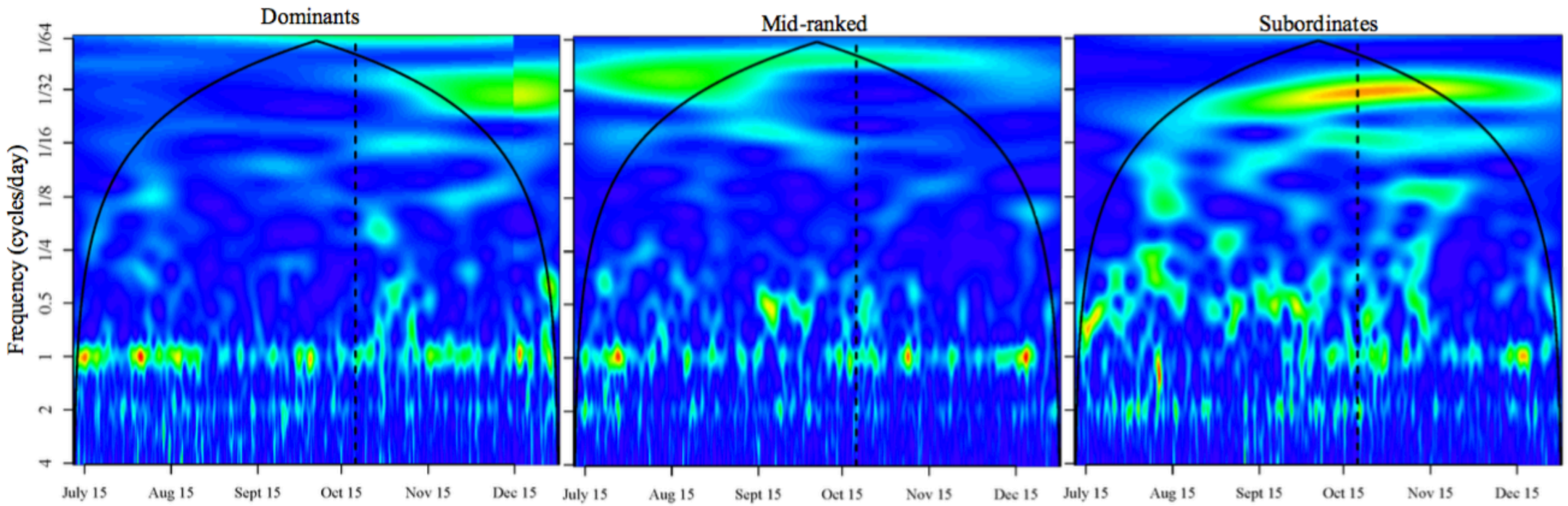
Fine Scale

e.g. Do animals follow daily movement patterns?
What habitats do animals prefer?

Wittemeyer et al. 2008

- A fascinating and inventive use of movement analysis applied wavelet methods to identify dominant frequencies in autocorrelation of elephant steps

- They recognized that they could separate dominant individuals from mid-ranked and subordinate individuals based on the frequency of forays to watering holes.



Brager et al. 2003

- Analysis of off shore habitat selection by Hector's dolphins

- Habitat selection by dolphins differed between study areas, particularly between east and west coasts, in summer (December–February) and winter (June–August). Dolphin abundance appeared to change seasonally in some study areas, possibly due to a more offshore distribution of their prey in the winter, with its lower SSTs. This was so especially in summer (the main reproductive season), when dolphins (frequently with calves) occupied shallow and turbid waters, whereas in winter less use was made of this habitat.

Even Finer Scale

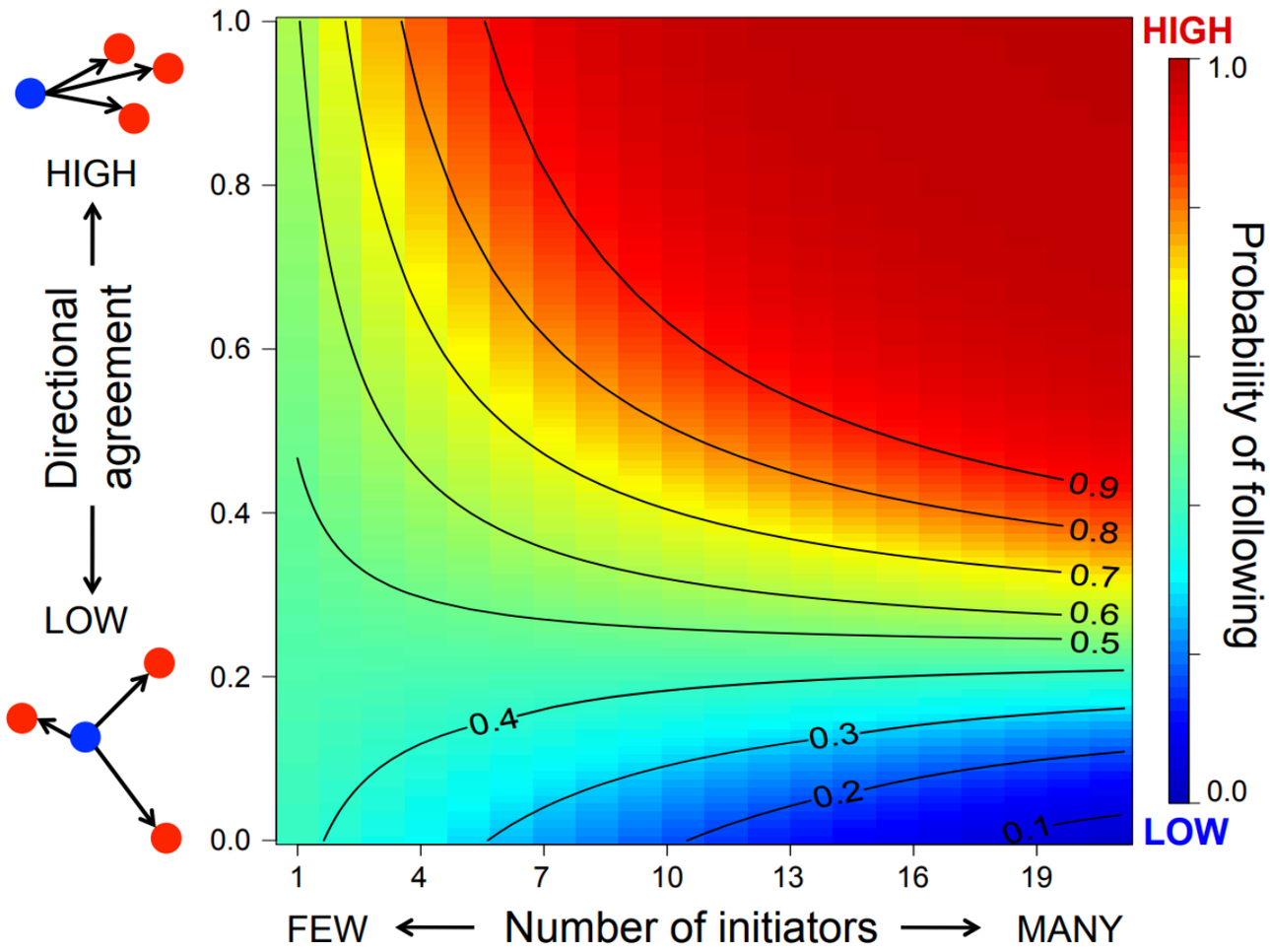
e.g. How do animals move?

How are movement decisions made?

Strandburg-Peshkin et al. 2015

- Extremely high resolution movement data was collected from every adult individual in a troop of baboons

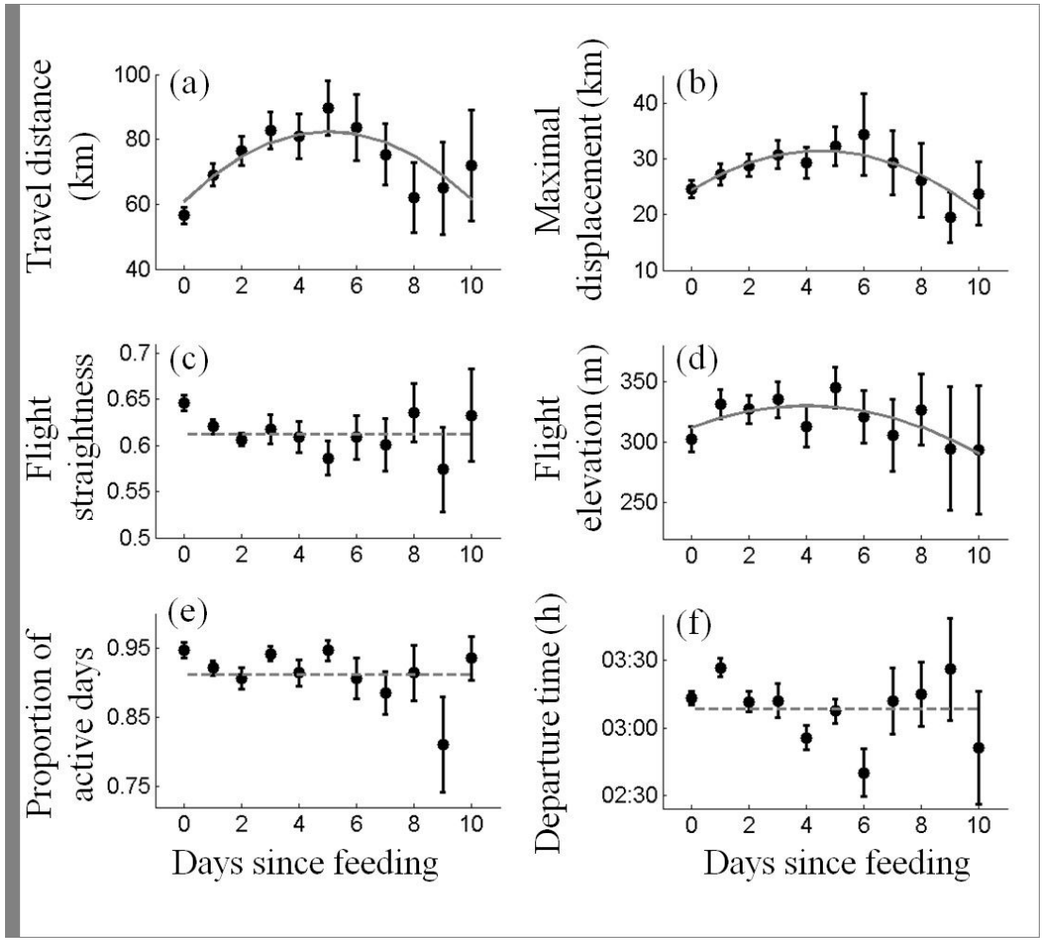
- Found that decisions regarding group movement were more likely to be democratic (i.e., movements were frequently induced by multiple individual at once) rather than autocratic (i.e., following a single dominant individual)



Nathan et al. 2013

- Used high-resolution GPS/ACC tracking to quantify how the change in the internal state of vultures (hunger level) shapes its movement patterns.

- Vultures increased their daily flight distances during early food deprivation periods (FDP) and even more so in short FDP sequences, while decreasing them at later stages of FDP. This implies that vultures combine different strategies in the face of increasing hunger and that these strategies affect ensuing FDP lengths.



Applications

Movement ecology research gives us the tools to better understand:

- animal space use decisions
- Group social structure
- Life history strategies: migration, nomadism, territoriality

Applications, cont.

With better understanding of the processes driving animal movement, researches and policy makers can better:

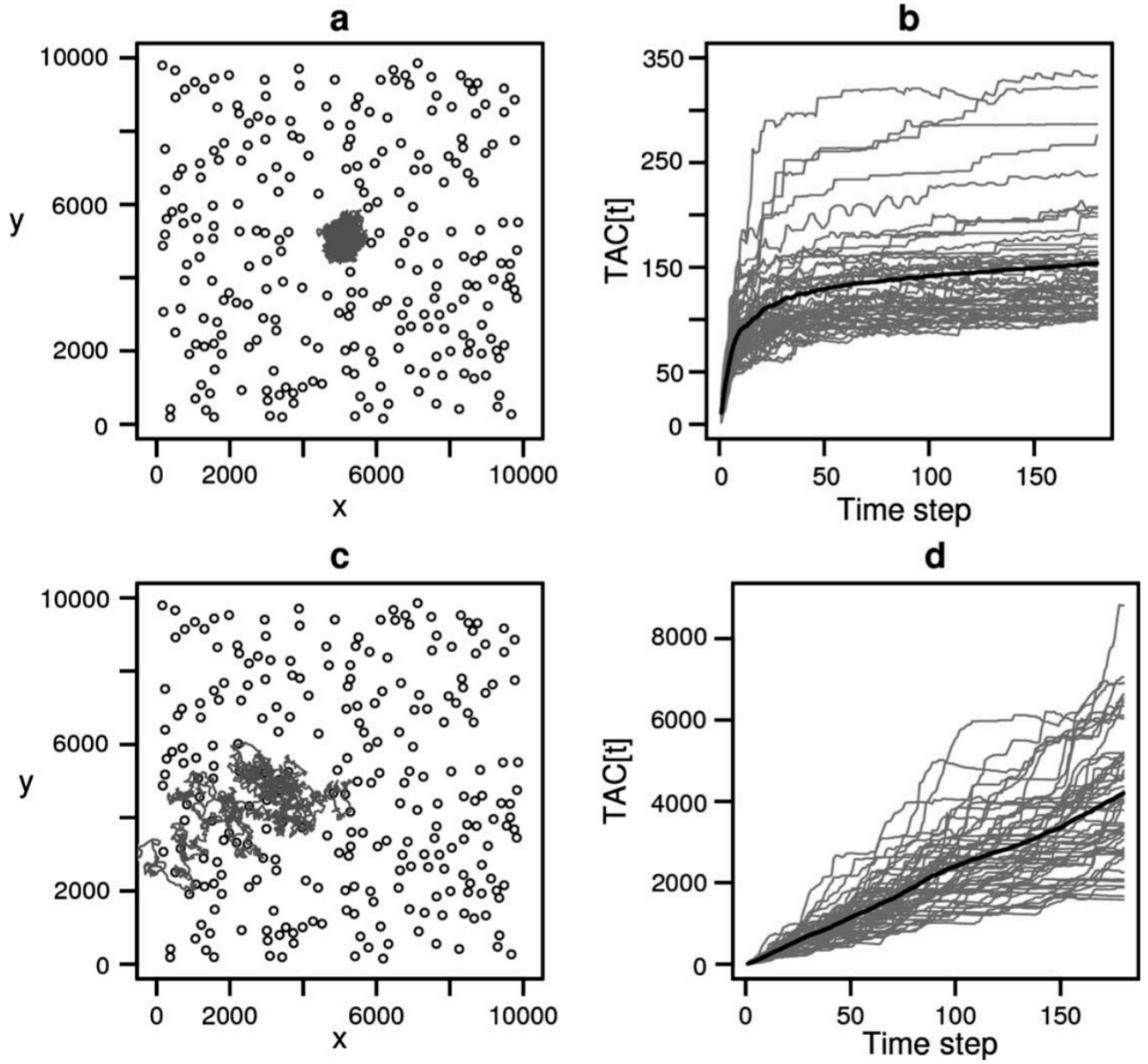
- Evaluate the impact of global climate and land use change on animal populations
- Understand functional landscape connectivity and it’s impact on range shifts, gene flow, disease spread.
- Predict and prevent human-wildlife conflict

Other cool cross diciplinary ME research…

Van Moorter et al. 2009

- A stochastic movement simulation model was used to explore the potential mechanisms underlying home range formation in natural systems

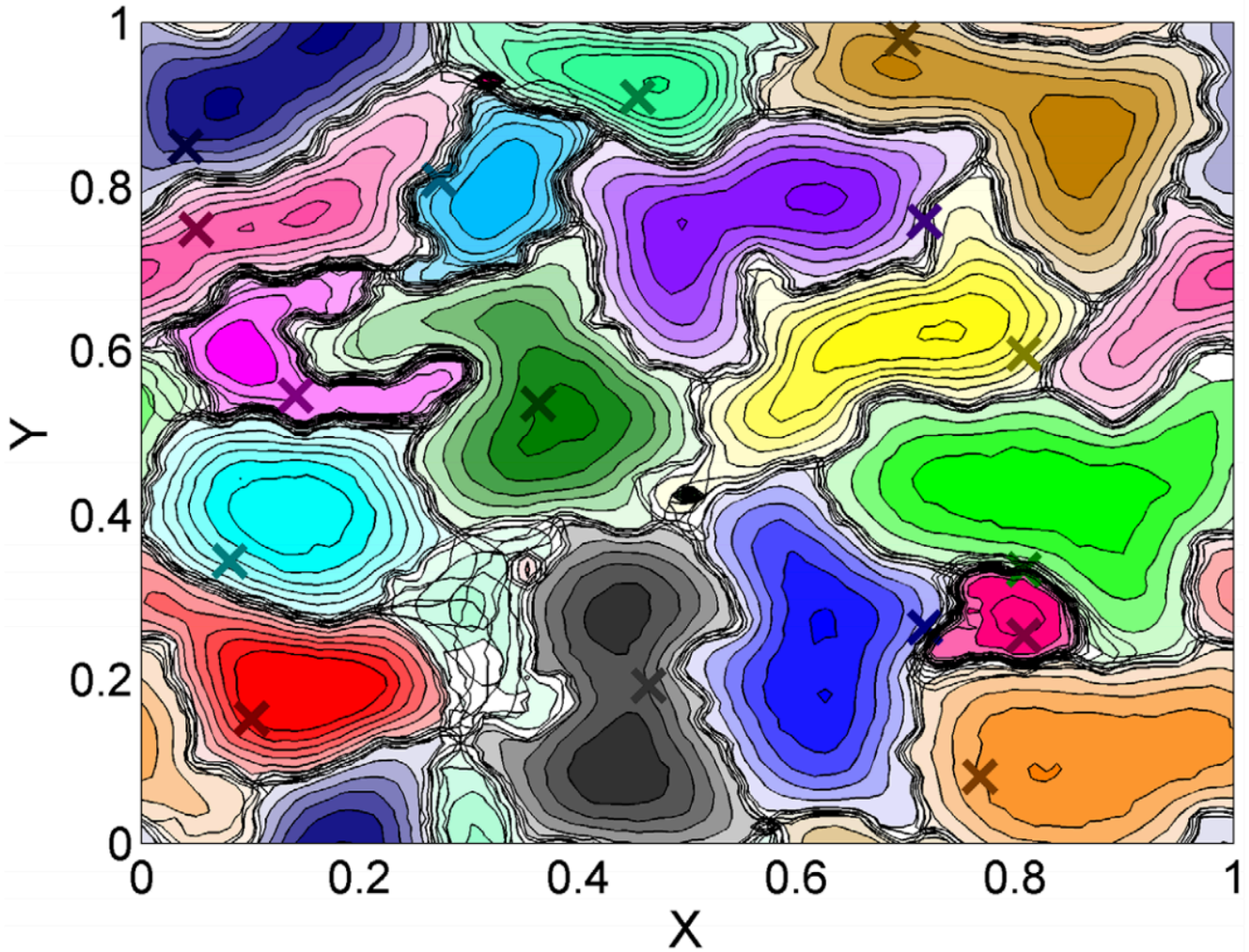
- Using two forms of memory (reference and working), home ranges were induced in a set of random walkers



Giuggioli et al. 2011

- In another example of a mechanistic simulation model, the authors explored the emergence of territoriality in wild populations like the red fox

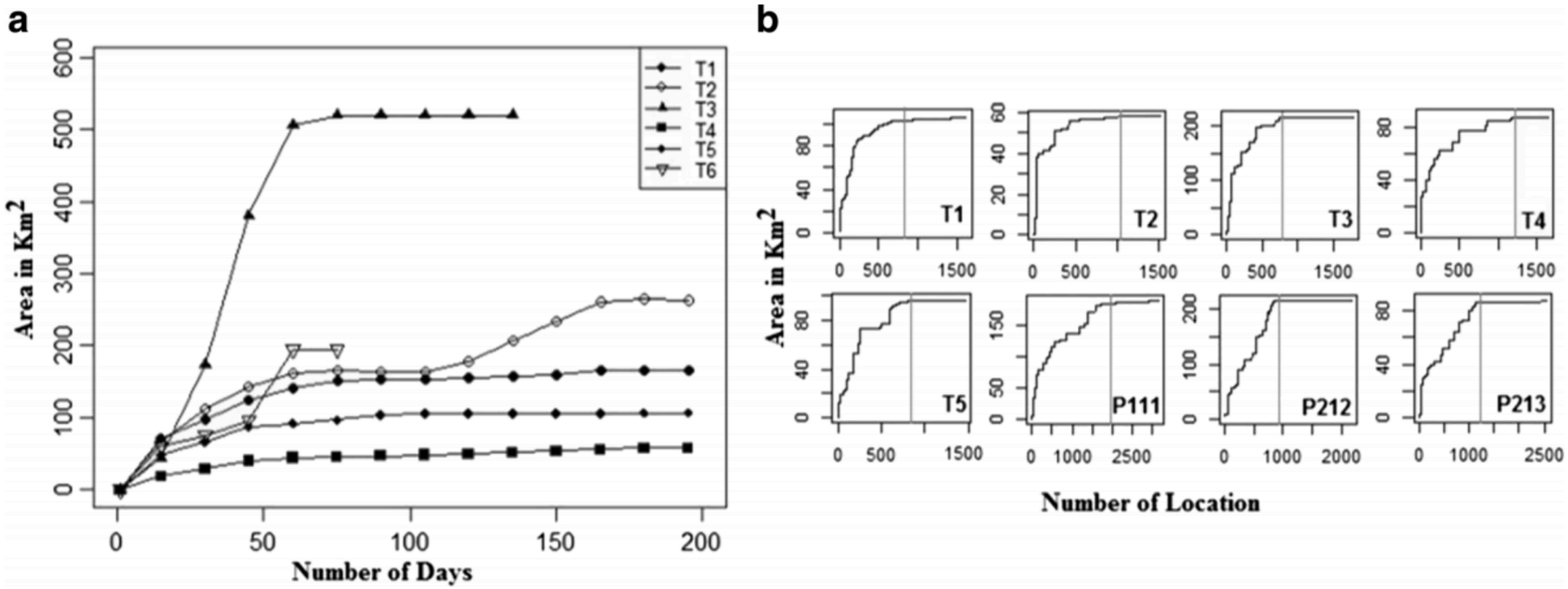
- Using simple rules to represent scent-marking dynamics, territory boundaries were established and maintained between individuals



Sarkar et al. 2016

- The reintroduction of tigers to a protected area in India offered an ideal opportunity to examine the manner by which individuals establish home ranges

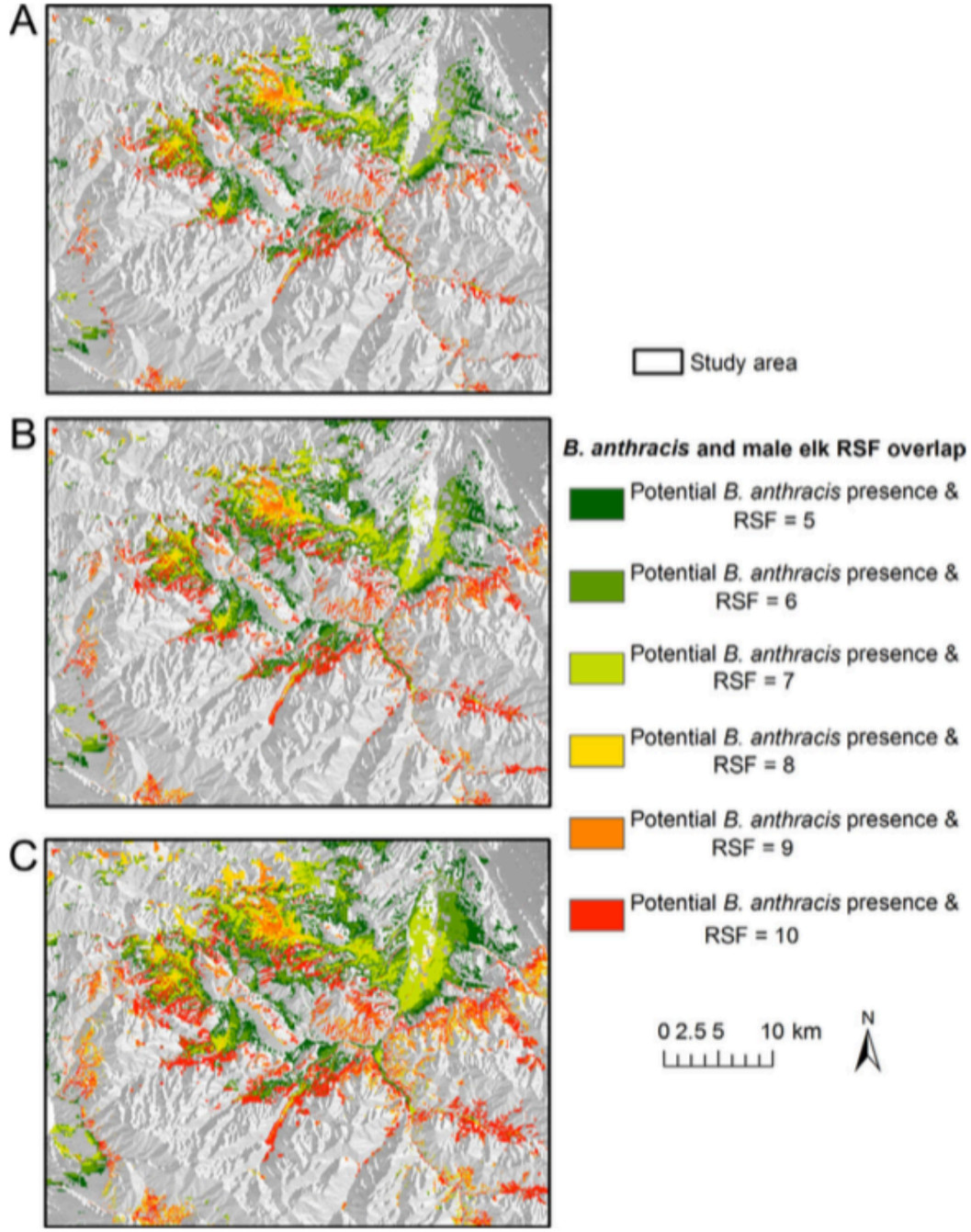
- Found that all of the tigers established home ranges following a short exploratory phase, and they all demonstrated a high level of site fidelity once established



Morris et al. 2016

- Developed a model to predict the location of elk throughout the anthrax season on a ranch in Montana and assessed the risk of exposure they faced

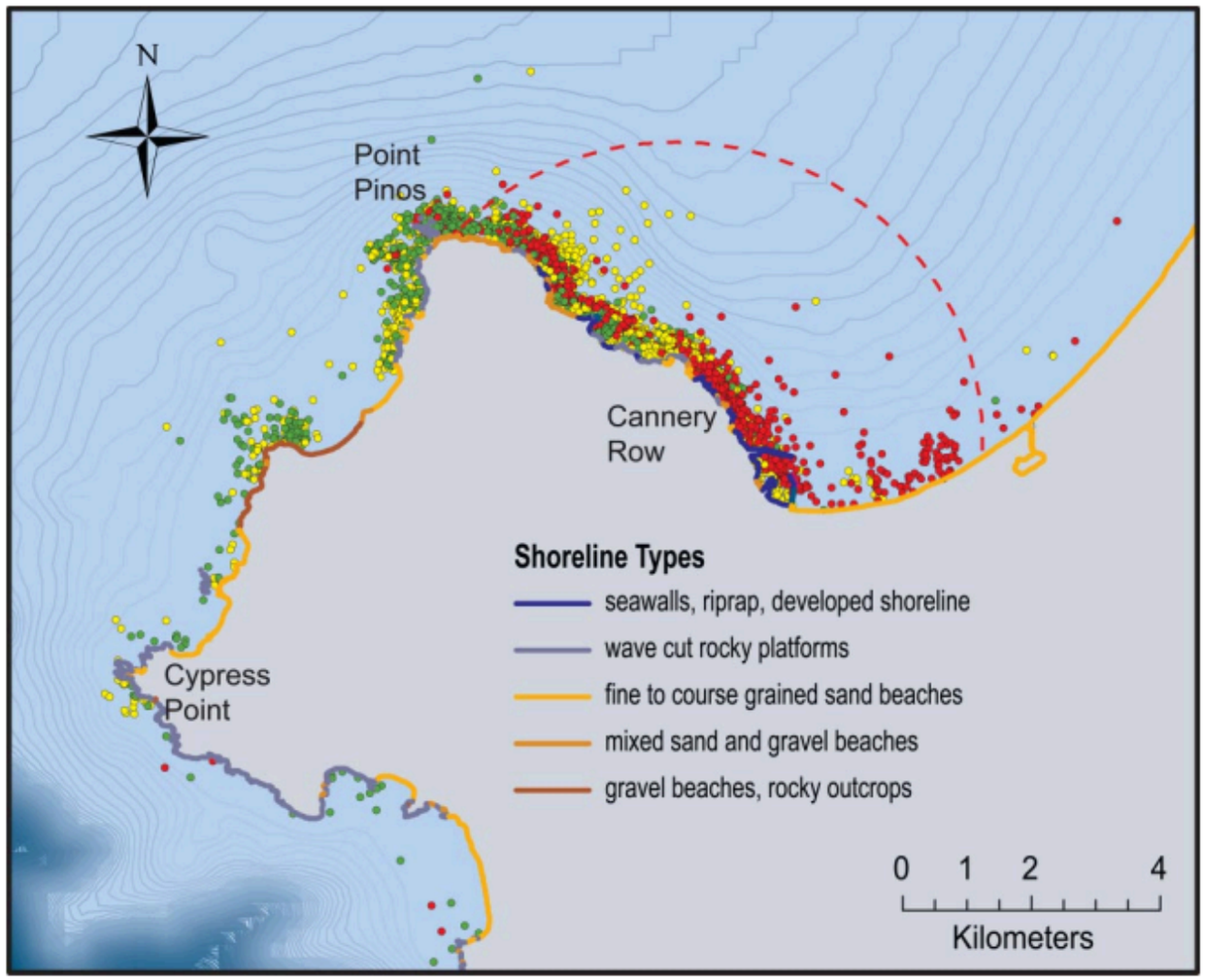
- Found that there were extensive regions of overlap between habitat selected by elk and areas with environmental features conducive to maintaining anthrax



Johnson et al. 2009

- Used radiocollars on sea otters to explore the connection between disparate resource exploitation strategies and infection dynamics

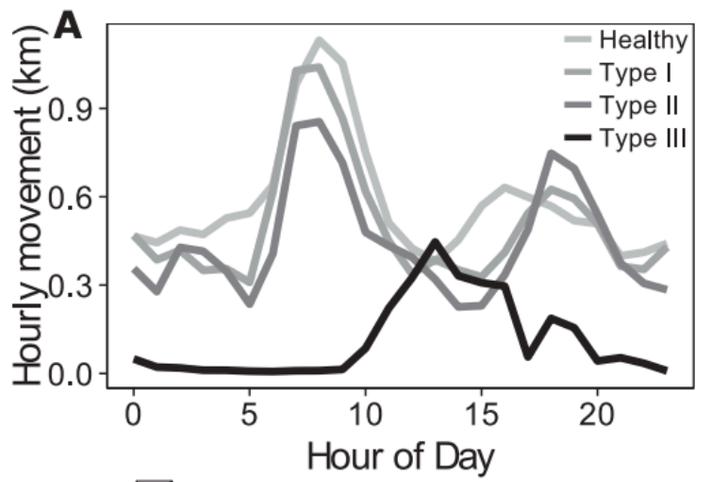
- Found that otters in resource-rich areas fed on abalone and had much lower infection prevalence than those in resource-poor regions feeding on marine snails

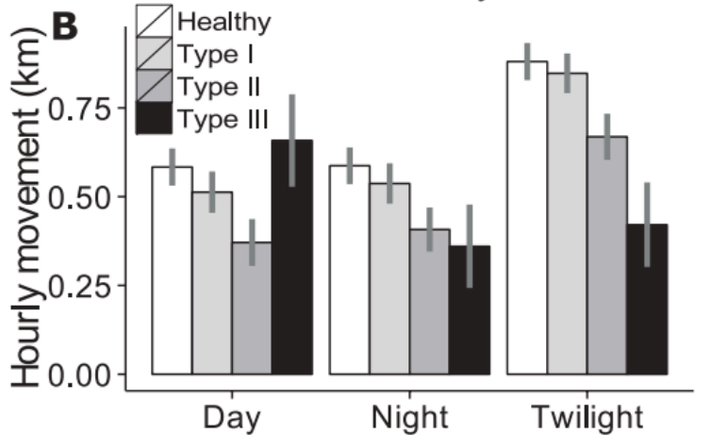


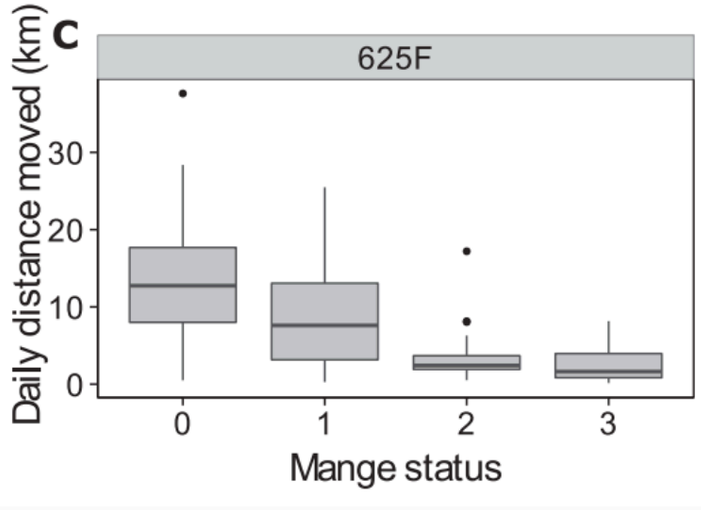
Cross et al. 2016

- Deployed GPS collars on a population of wolves containing individuals infected with sarcoptic mange

- Found that mange had notable impacts on the daily movements of individuals, with later stages of infection reducing total distance more than earlier stages. In addition, infected wolves spent significantly less time in an active behavioral mode than healthy wolves







Kittle et al. 2016

- Used movement data to analyze the role of landscape features, prey availability, and competition in determining the distribution of large carnivores

- Found that lions were uninhibited by their competitors (hyenas), but that prey availability and habitat both influenced the distribution of lions across the Serengeti