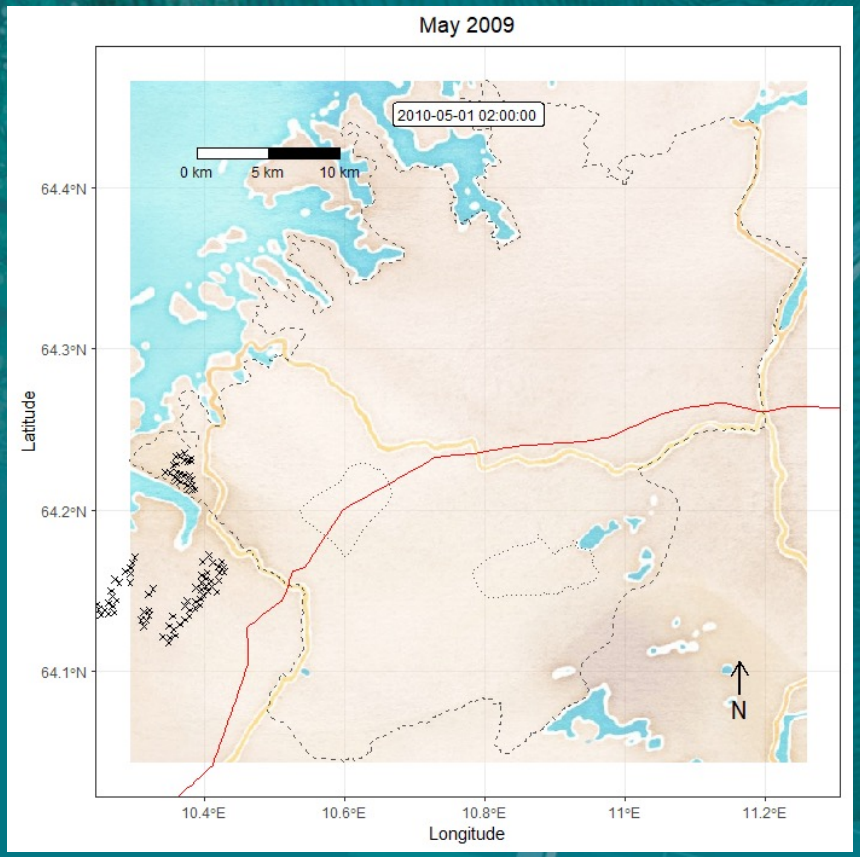
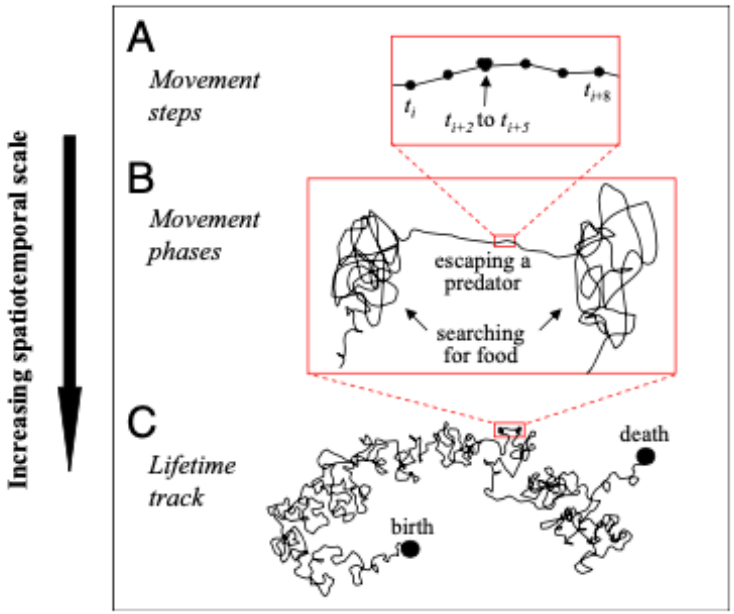
Introduction to animal movement analysis

PhD-course 4-8 September 2023



Movement ecology paradigm – Nathan et al. 2008

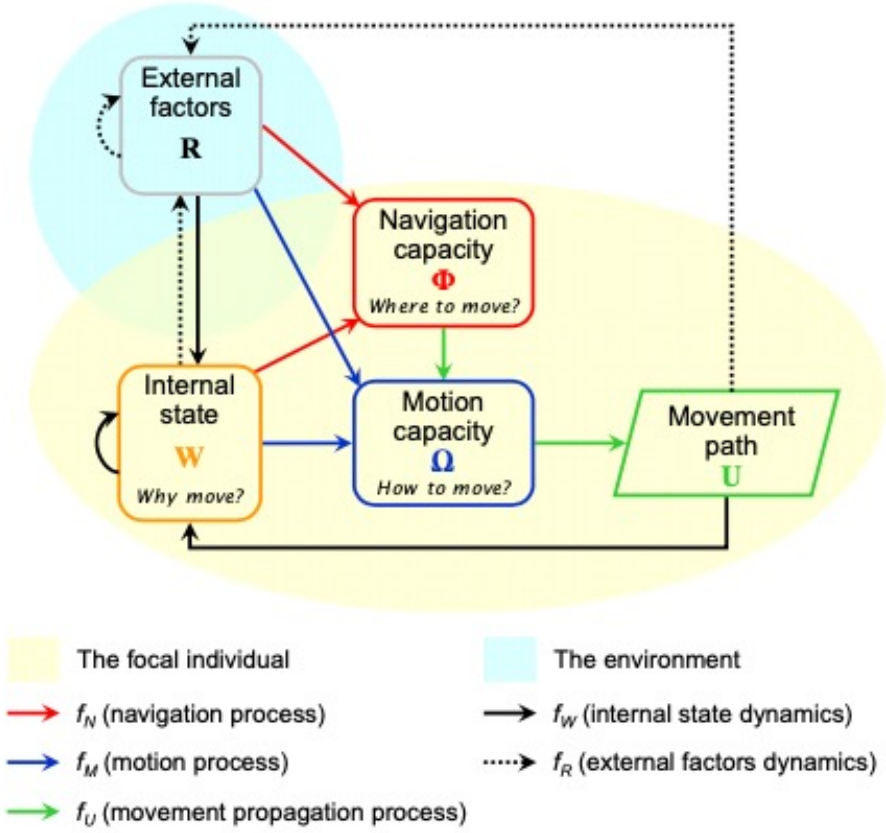


Nathan et al. 2008

- Change of an organism's spatial location in time
- Spreading of species
  - For ex movement of seeds
- Animal movement
  - Migratory birds
  - Vertical movement of in the sea
  - Terrestrial animal movement

Movement ecology paradigm

- Framework around movement
  - Internal state - Why move?
  - Motion capacity - How to move?
  - Navigation capacities of the individual - When and where to move?
  - External factors affecting movement



Nathan et al. 2008

Animal movement part of the behavioural ecology and population dynamics

- Movement behaviour can explain evolutionary aspects and fitness of the species (Nathan et al. 2008)

- First radio collar on grizzly bears in 1960s by the Craighed brothers (Craighed & Craighed 1972)
- Documentation of denning activities - digged their own dens.

FRONTISPIECE. Female grizzly bear equipped with radio collar. This bear, No. 40, was radiotracked for portions of 8 consecutive years. Note placement of numbered ear tags and individualized color markers.

Research question

- What is your research question?

- Breeding, reproduction
- Life history patterns

- Foraging behaviour
- Dispersal
- Predator-prey interactions

Study system and species

- Solitary animals
- Territorial animals
- Predator

Photo: Martin Mecnarowski

- Herd-living animals
- Migratory animals
- Herbivore

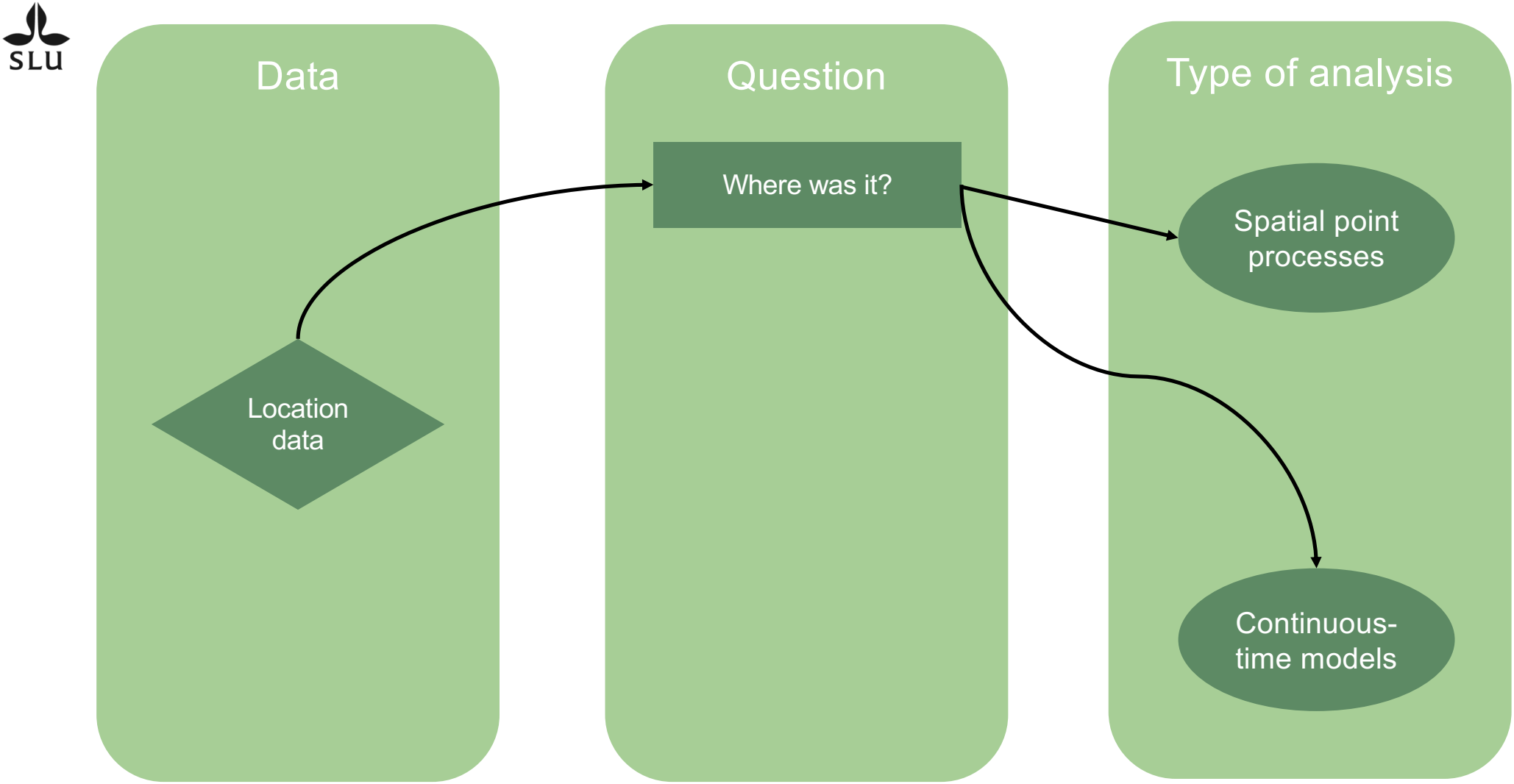
Photo: Jeff Kerby

Data

Question

Type of analysis

From Hooten et al. 2021 (Figure 1.1)



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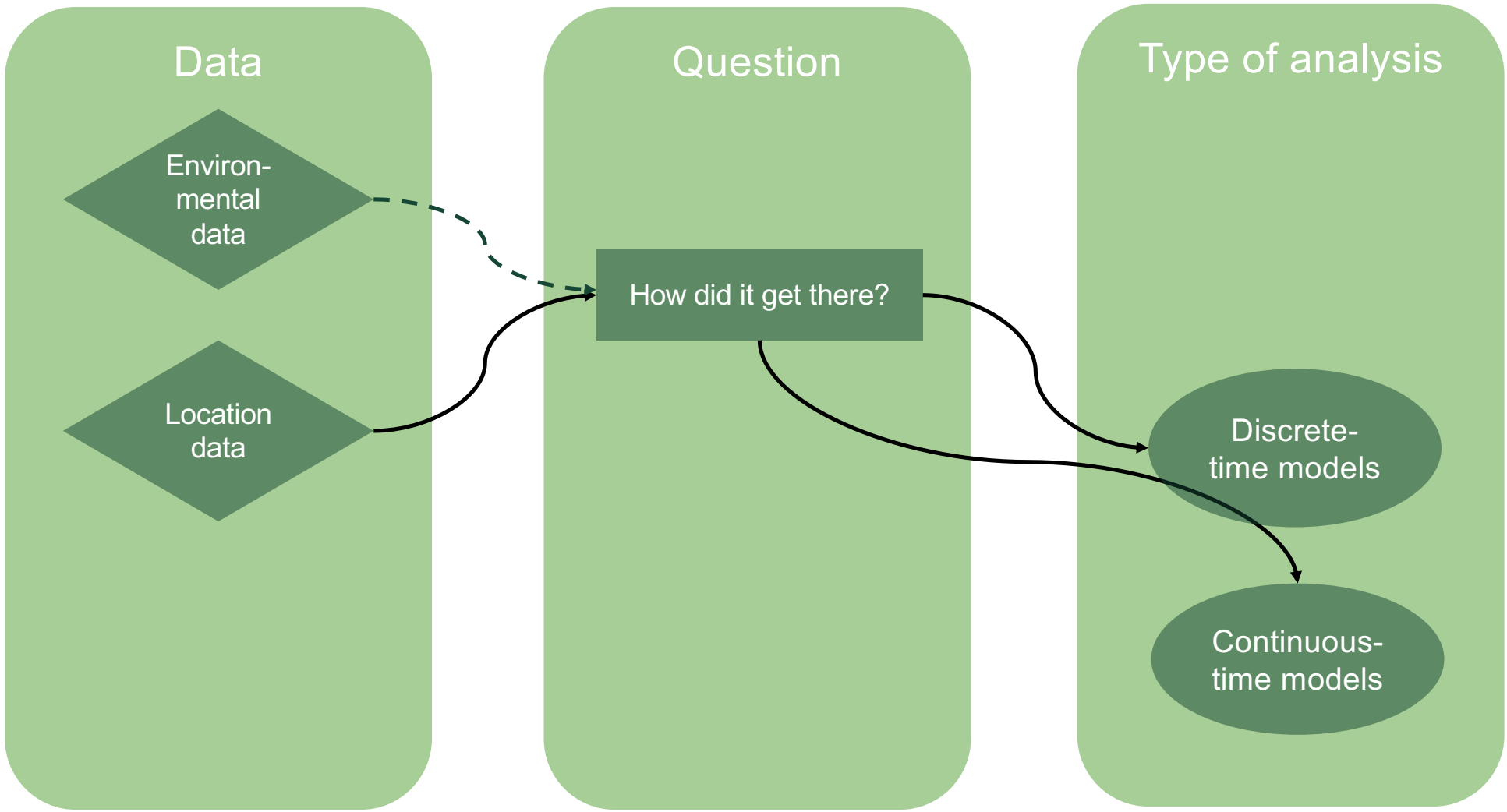

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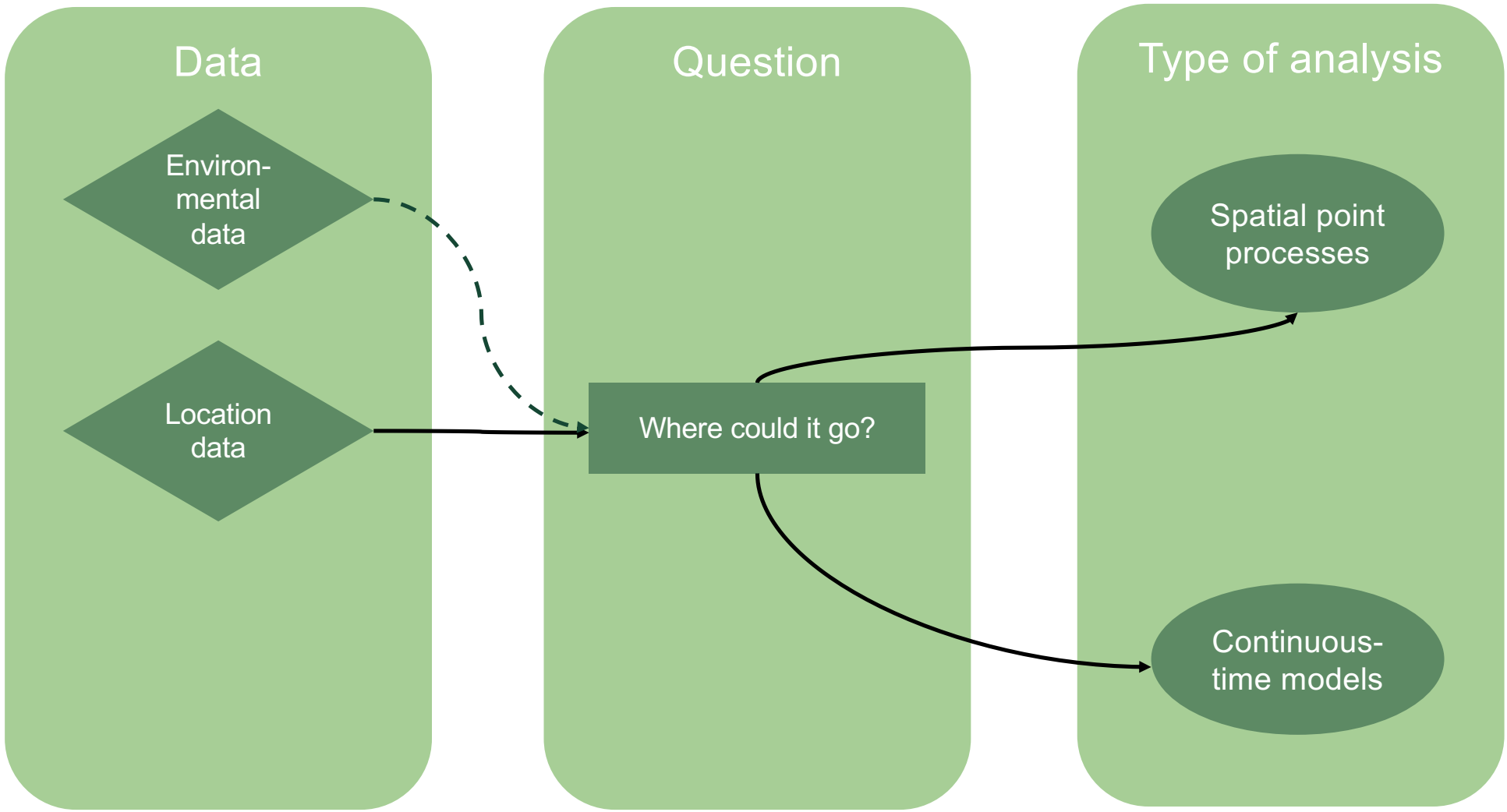

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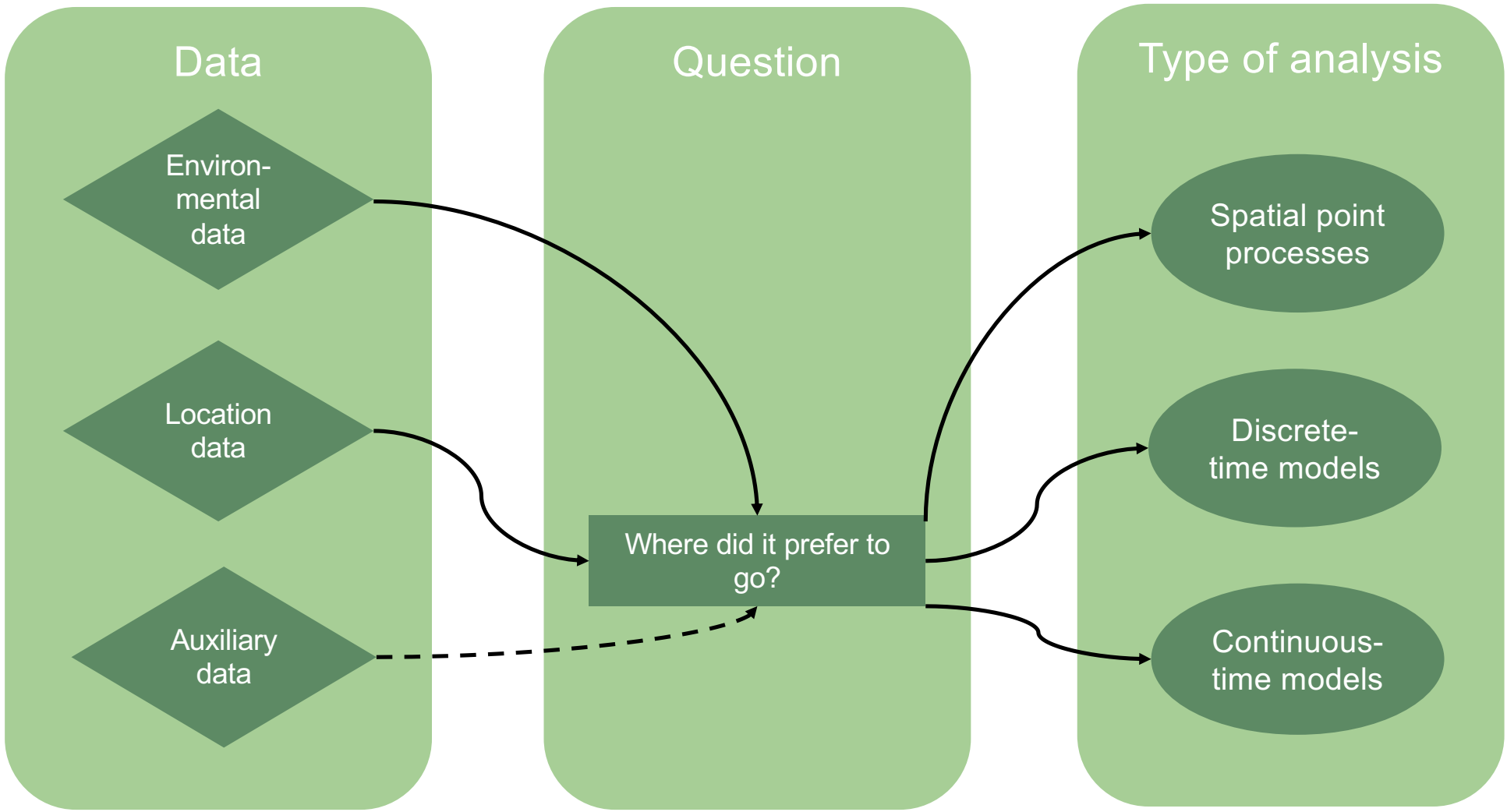

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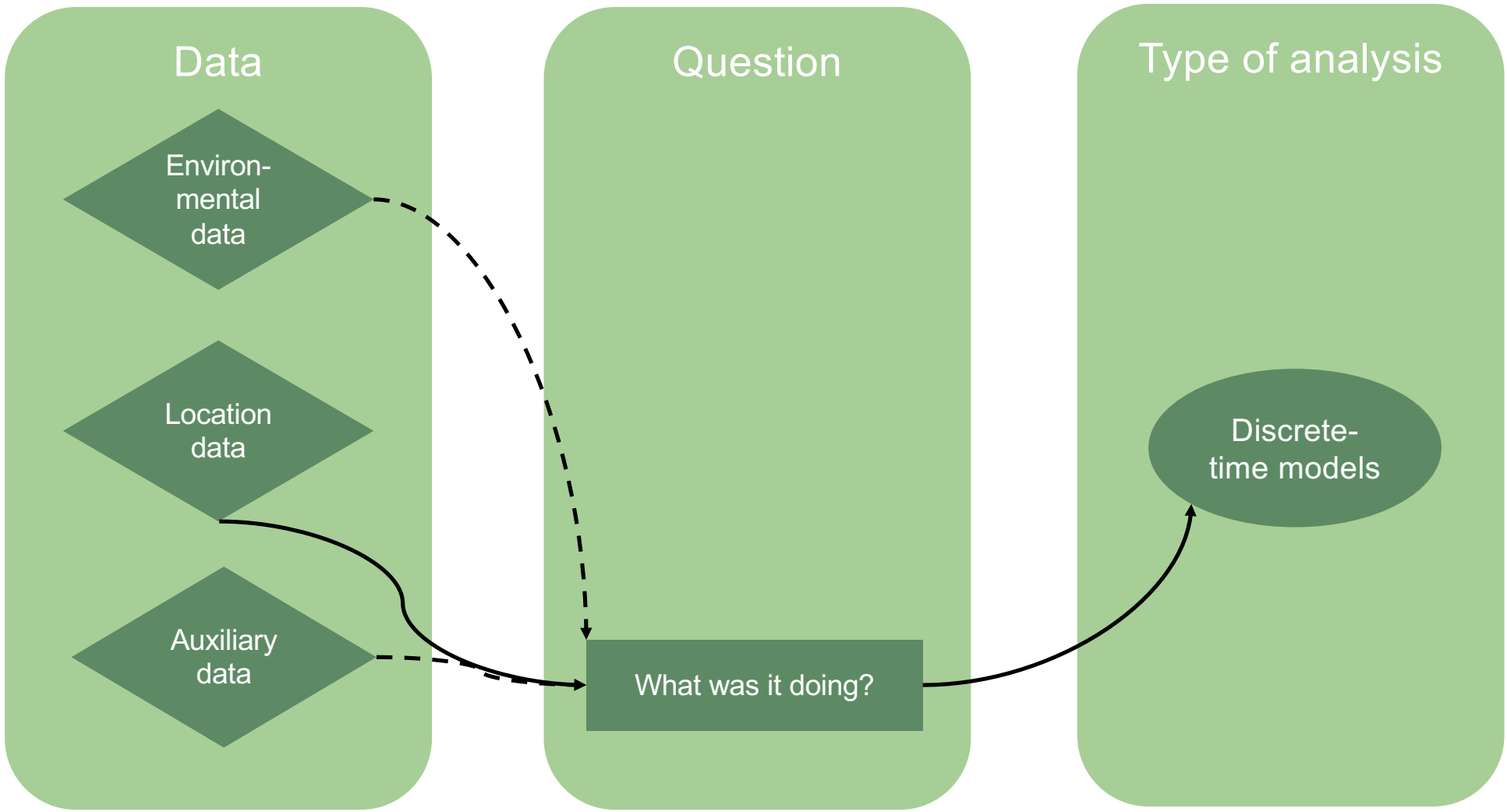

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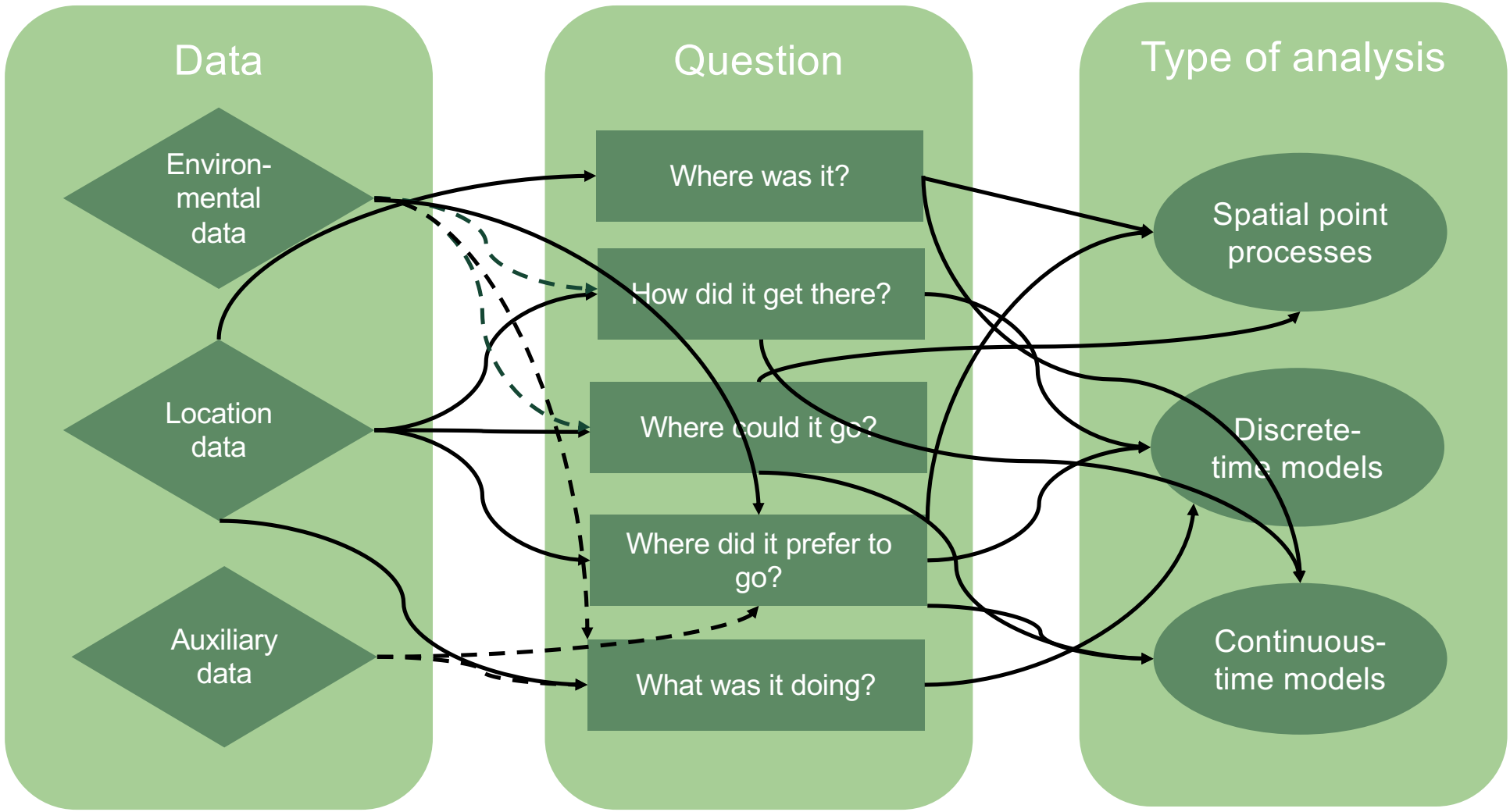

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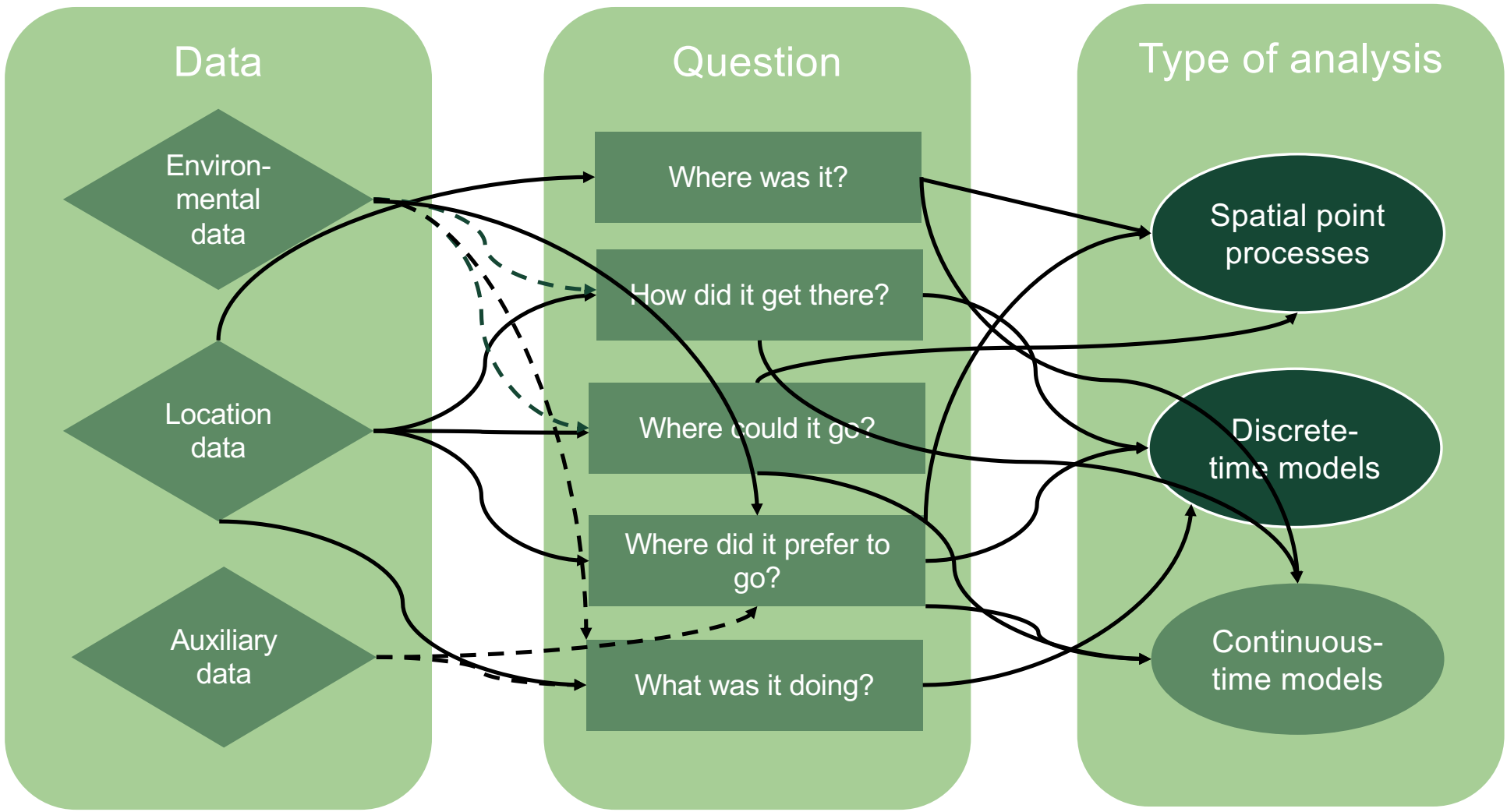
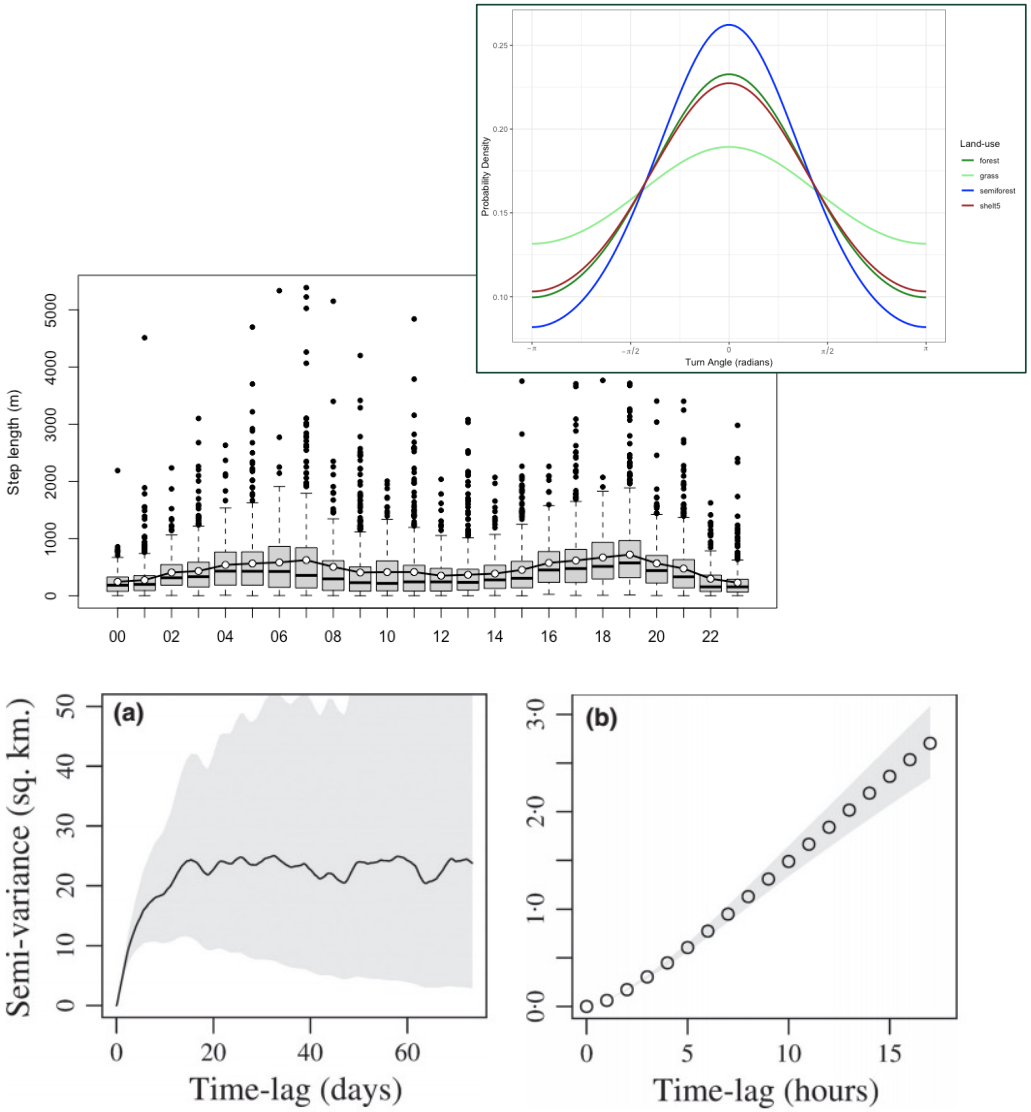


From Hooten et al. 2021 (Figure 1.1)

Descriptive statistics

- Time series data
- Step length
- Speed
- Turn angle between positions
- Autocorrelation – many analysis assume independence between positions
- Night and day differences



Habitat

- How do you define a habitat?

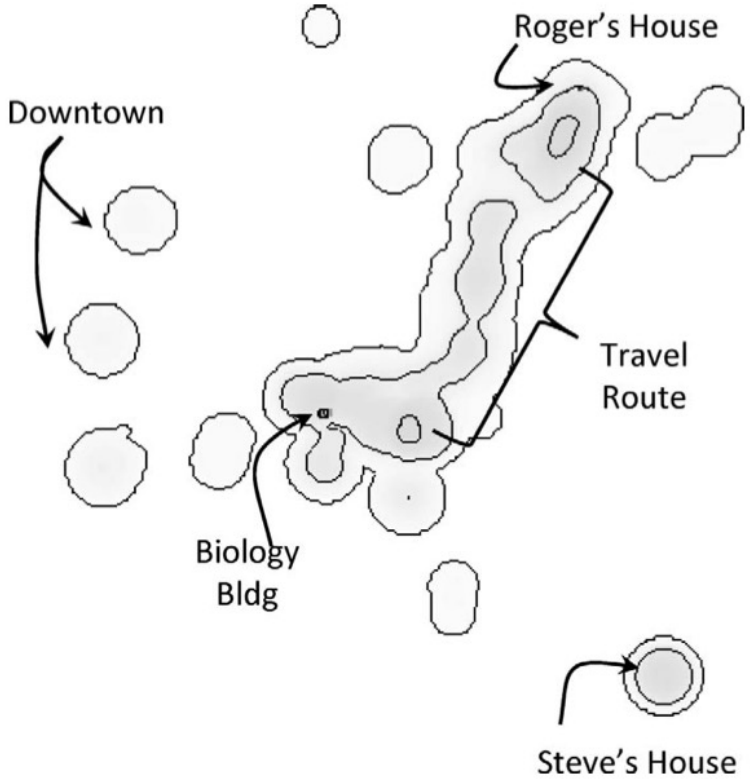


FIG. 1.—The 95% kernel estimate of Roger's home range in Laramie, Wyoming, where he spent sabbatical at the University of Wyoming in 1990–1991. Roger's house, the Biology Building on the university campus, Steve Buskirk's (a friend) house, and areas in downtown Laramie frequented by Roger are noted.

Powell & Mitchell 2012

Home range

Territory or home range? - Thoughts on home range definition emerged from the reasoning about territoriality.

William H. Burt 1943:

Home range then is the area, usually around a home site, over which the animal normally travels in search of food. Territory is the protected part of the home range, be it the entire home range or only the nest. Every kind of mammal may be said to have a home range, stationary or shifting.

Only those that protect some part of the home range, by fighting or agressive gestures, from others of their kind, during some phase of their lives, may be said to have territories.

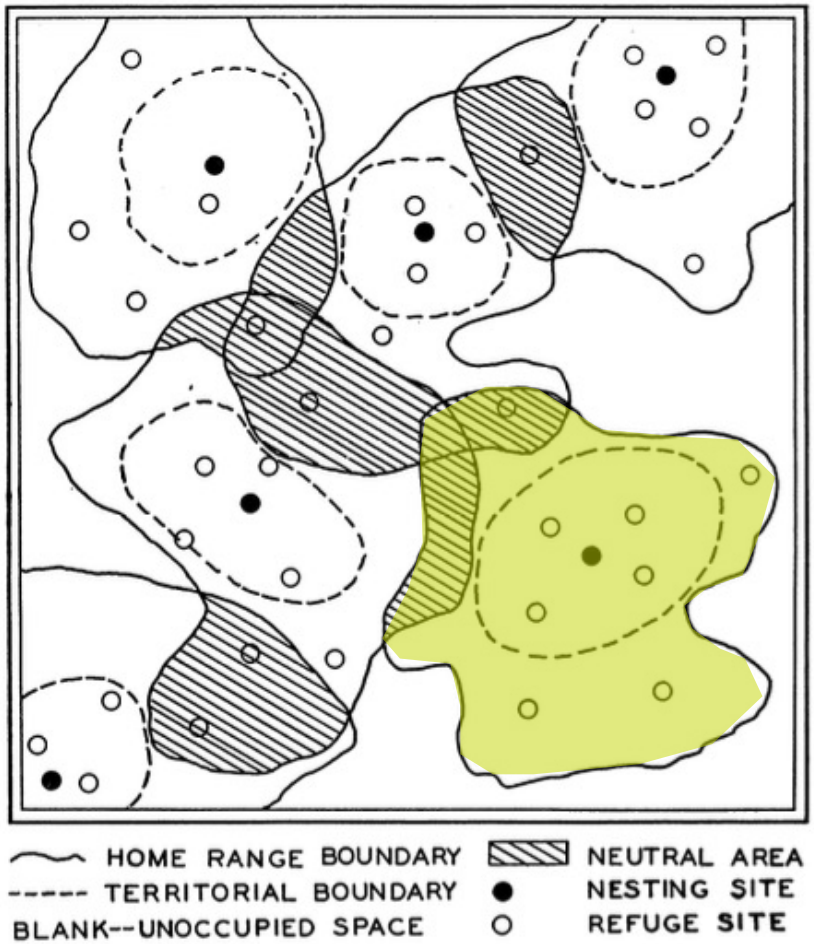
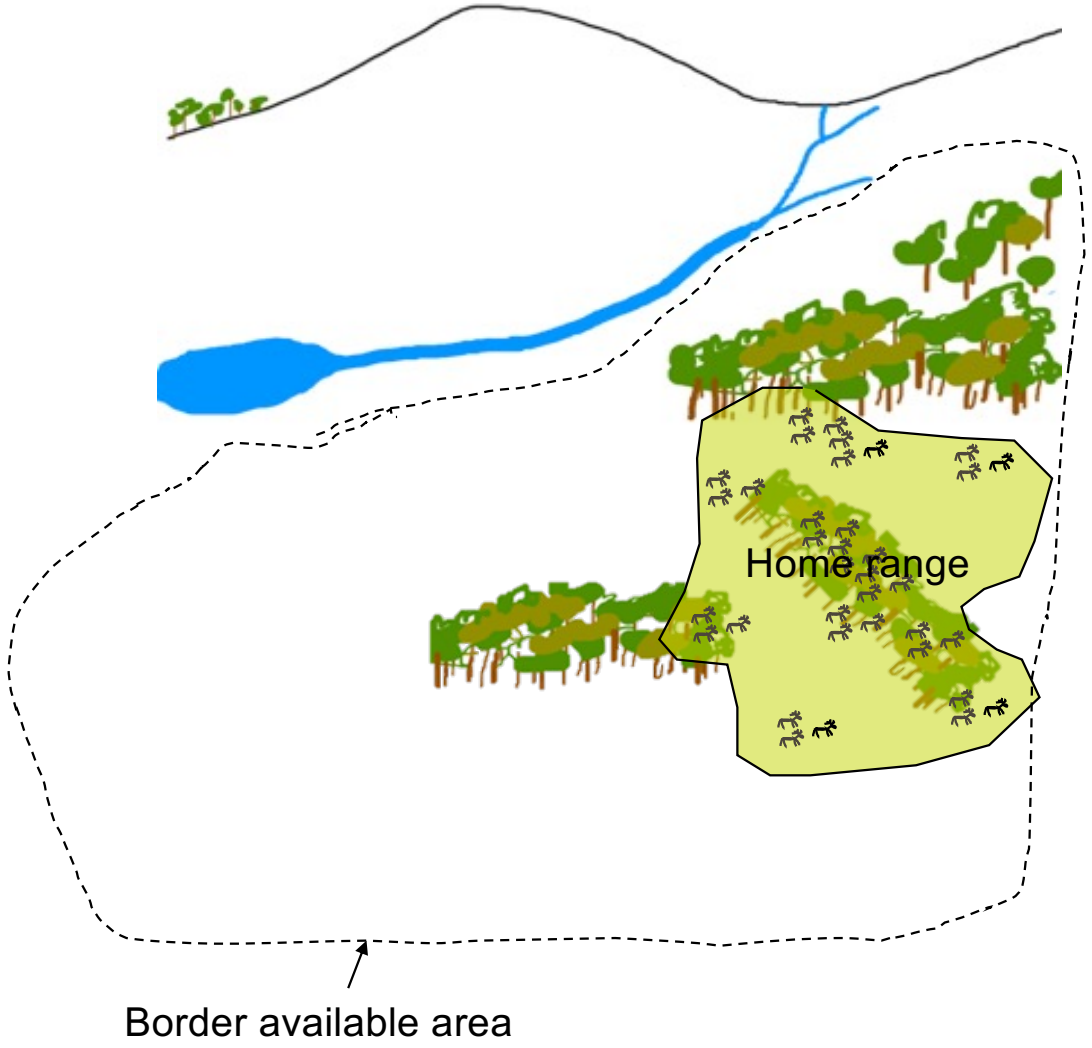


FIG. 1. Theoretical quadrat with six occupants of the same species and sex, showing territory and home range concepts as presented in text.

Habitat selection

- Where did it prefer to go?
- What is available?
- What resources are selected – resource selection
- “selective if components are used disproportionately to their availability”
- Different scales of selection - Johnson 1980
  - First ➔ fourth order of selection



Step selection

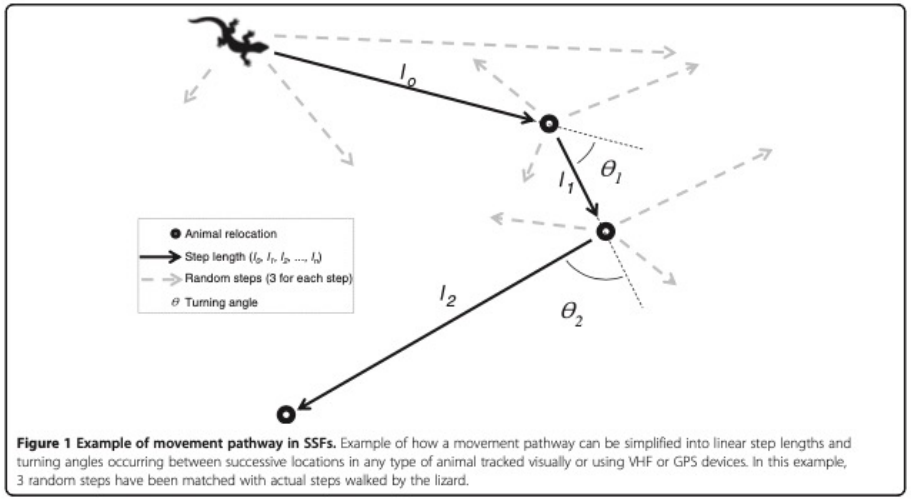


Figure 1 Example of movement pathway in SSFs. Example of how a movement pathway can be simplified into linear step lengths and turning angles occurring between successive locations in any type of animal tracked visually or using VHF or GPS devices. In this example, 3 random steps have been matched with actual steps walked by the lizard.

- Compare between steps
- Selection of end or start points in relation to a number of random available points
- Good when high resolution can take into account some of the serial autocorrelation

Thurfjell et al. 2014

Behavioural states

- Definition of different behaviours – what are they doing?
- How to separate foraging from resting? As the trajectories can look very similar.
- Increased possibility to detect fine-scale behaviour with accelerometer sensors

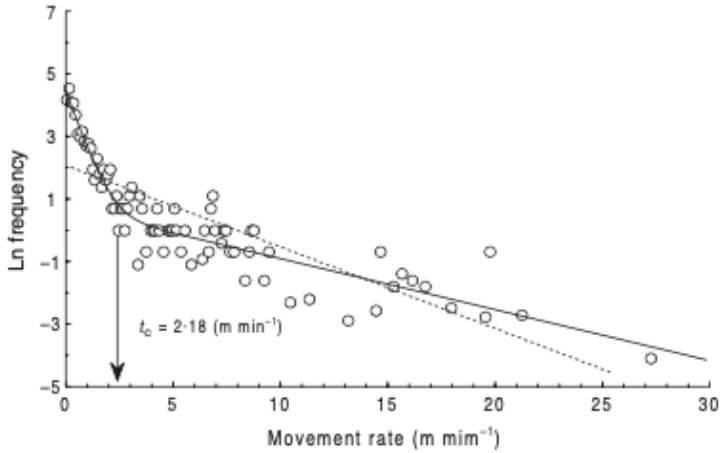


Fig. 1. Example of log, frequency distribution of movement rates by caribou 042B during winter (December 1997–April 1998). A non-linear two-process model was fit (equation 2) and the scale criterion (equation 3; r_c) was calculated using the parameters of the fitted equation. For comparison, a linear regression (dashed line) serves as the null model of a nonscalar response.

Johnson et al. 2002

Spatial redistribution

- Landscape connectivity – how organism (can) move in the landscape. are there barriers etc?
- How species spread and use the landscape
- Depend on phenotype – preconditions
- For example - net square displacement (NSD) can be used to illustrate the possibility to move in the landscape.

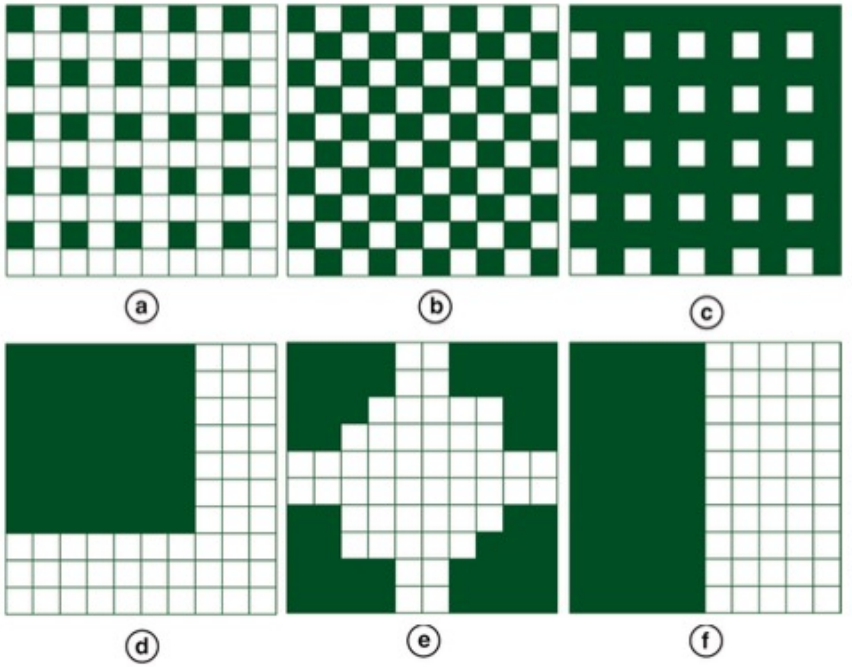
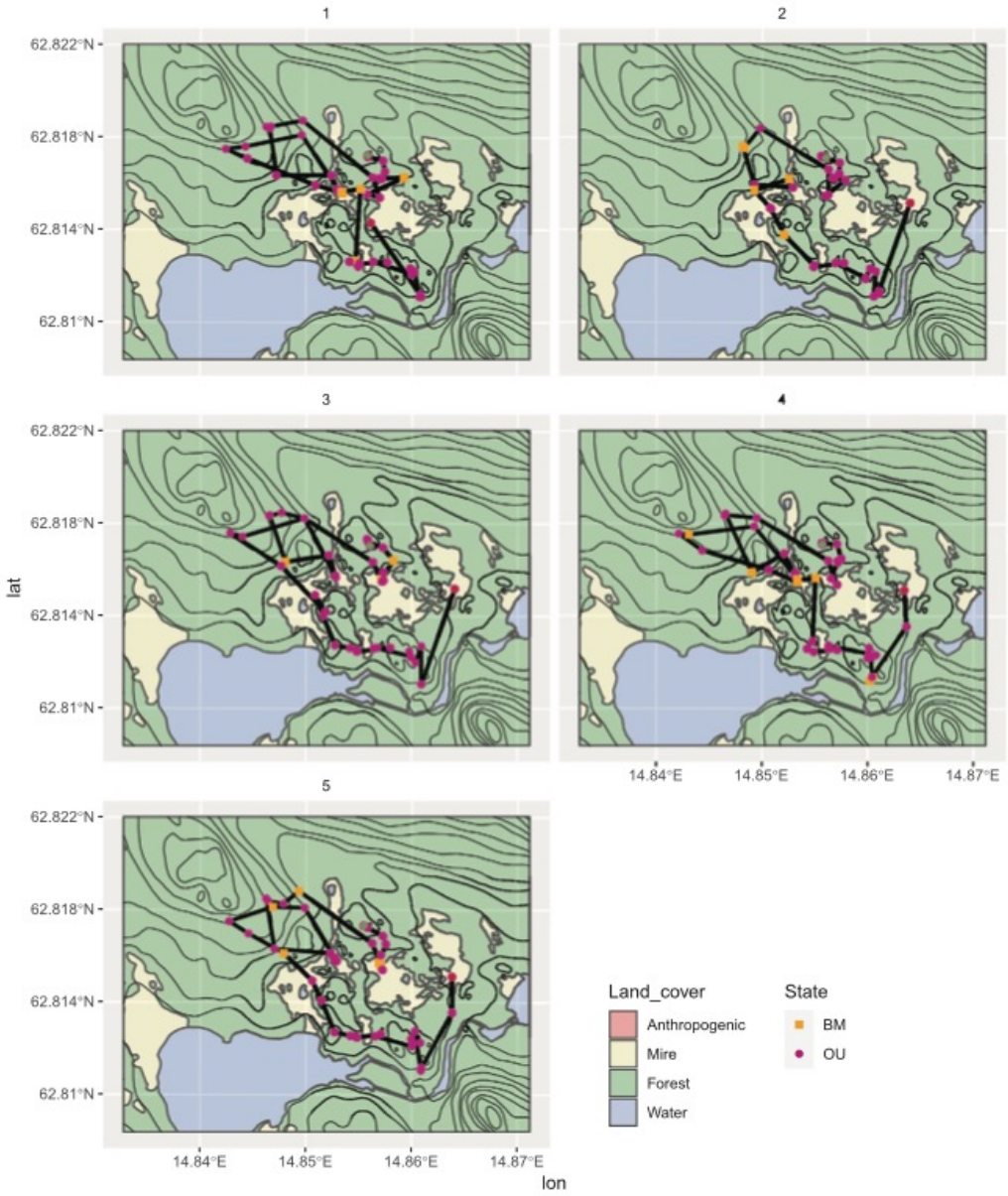


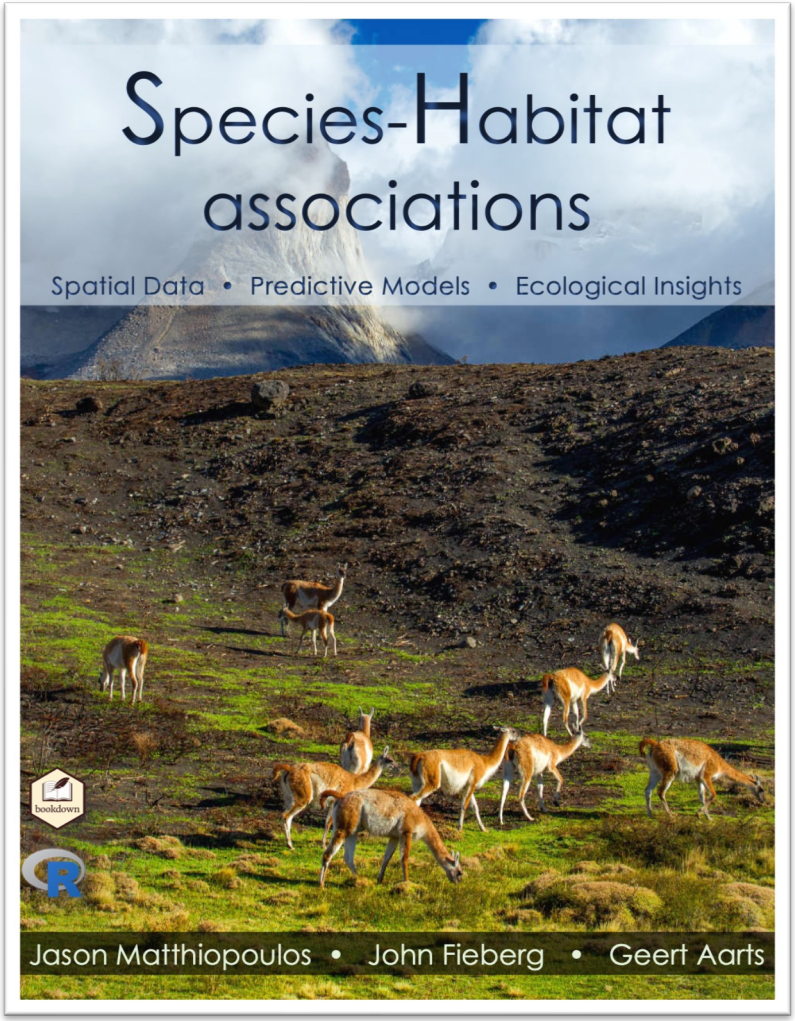
FIGURE 6.7.
Patterns of clearcutting developed under various models by Franklin and Forman (1987). In (**a–c**), a dispersed cut pattern is used in which the amount of cutover area (*black*) varies but there is a regular distribution across the landscape. In (**d–f**), the cutover area is 50 % but it is arranged as a single nucleus, four-nucleus, or progressive parallel cutting system.
ADAPTED FROM FRANKLIN AND FORMAN (1987)

Group movement

- Possibilities to estimate when animals are grouping and when the movement are independent
- Ornstein-Uhlenbeck (OU) process - group movement
- Brownian motion (BM) - independent movement
  - In forests with lichen

Niu et al. 2020 Biometrics



Population dynamics

- Link between behaviour, habitat selection and population dynamics
- Which habitats is best and give high survival and fitness?