Introduction Movement Metrics and Analysis

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Movement is fundamental for animals to obtain resources, escape threats, disperse, and find mates

It plays a major role in determining the fate of individuals, the structure and dynamics of population, communities and ecosystem

Individuals within a species may exhibit different movement patterns depending on their sex, age or life-history stage, and reproductive status

Extrinsic factors such as habitat quality, resource availability and access, as well as anthropogenic features on the landscape, also influence animal movement

TYPES OF MOVEMENT

Migration

Migration consists of seasonal, round-trip movements between spatially disjunct areas

Resident

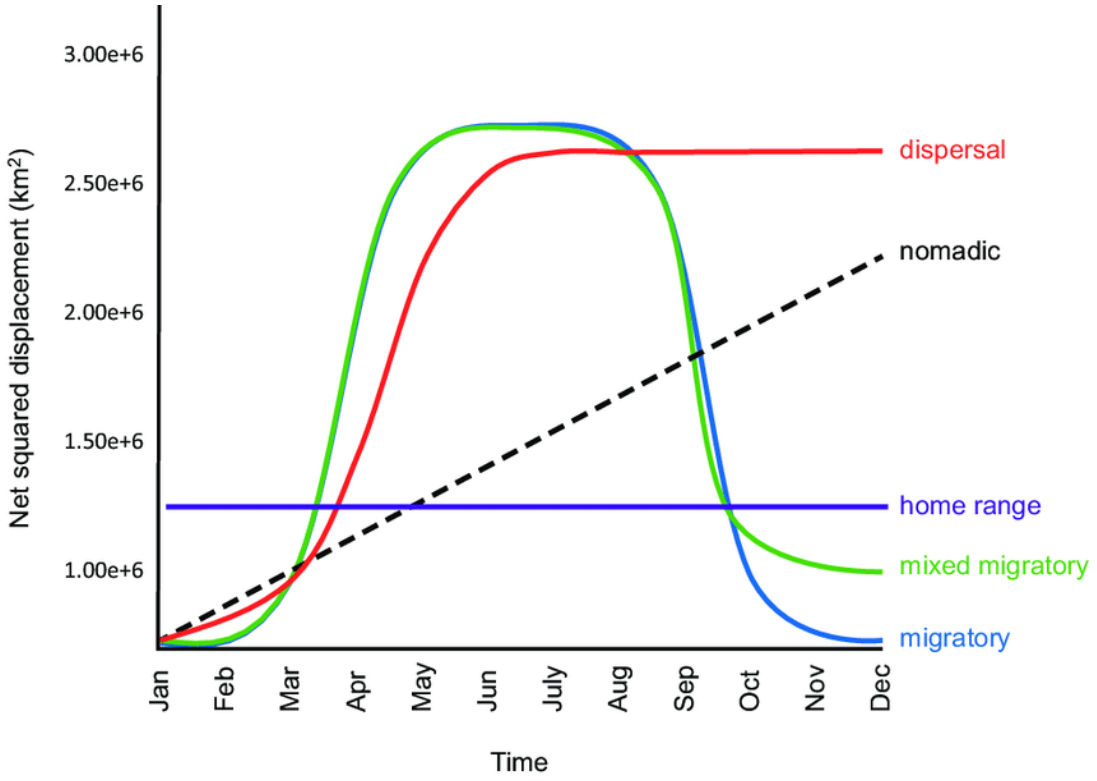
Stable home ranges or territories where an individual occupies a relatively small area compared to the population distribution (Mueller and Fagan, 2008)

Dispersal

Movement from the site of birth (natal dispersal) to a new area in search of resources and mate

Nomadic

Movement in a landscape using routes that do not repeat across the years



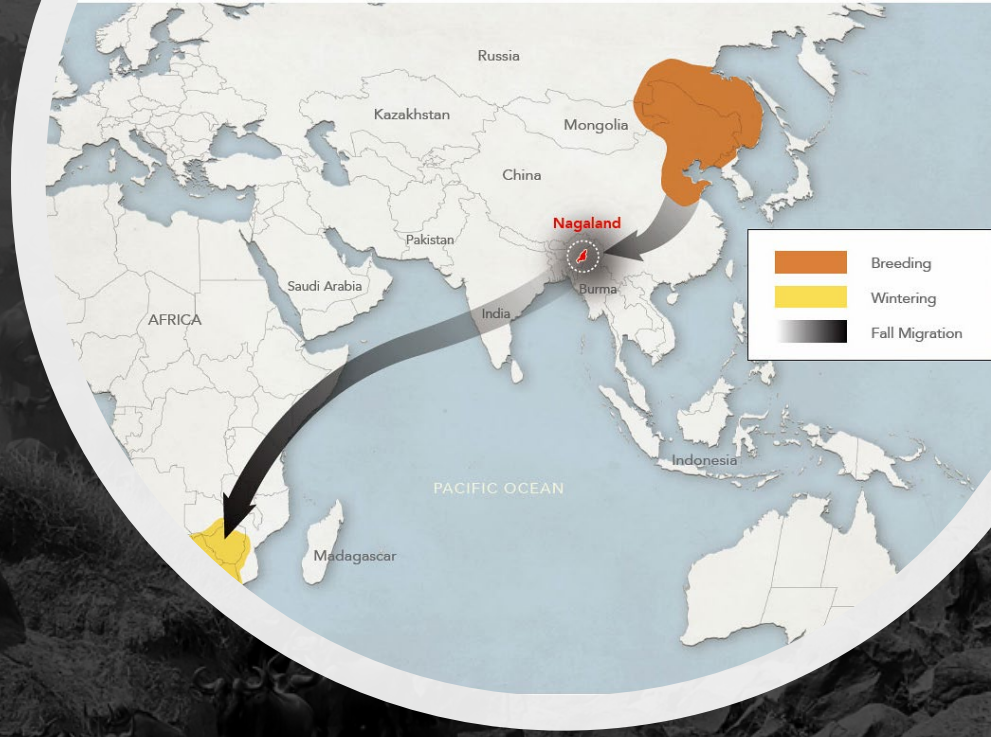
MIGRATION

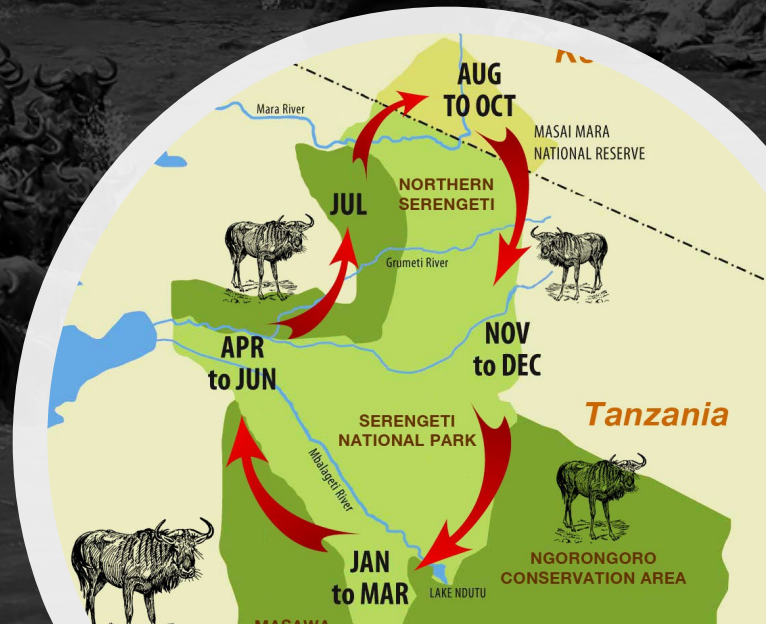
Round trips amongst two spatially disjunct habitats/areas.

This phenomenon is observed from the tiniest insects to the gargantuan blue whale.

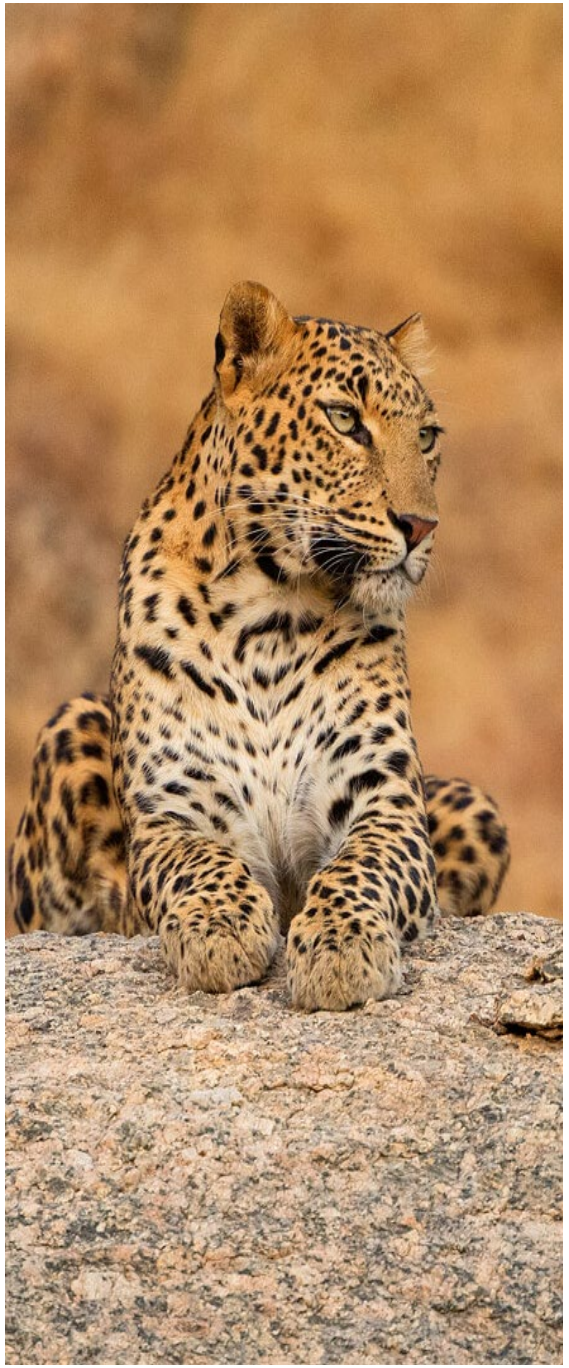
The Great Migration

Wildebeest during the dry season, moves from the Serengeti-Mara ecosystem of Tanzania and Kenya in search of fresh grass and water. A round-trip that spans hundreds of miles and two countries

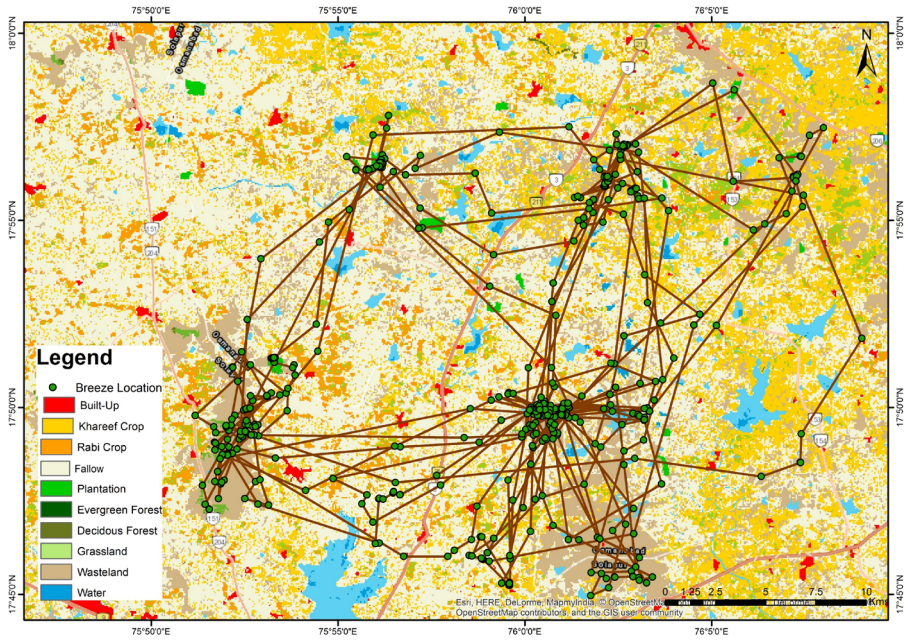


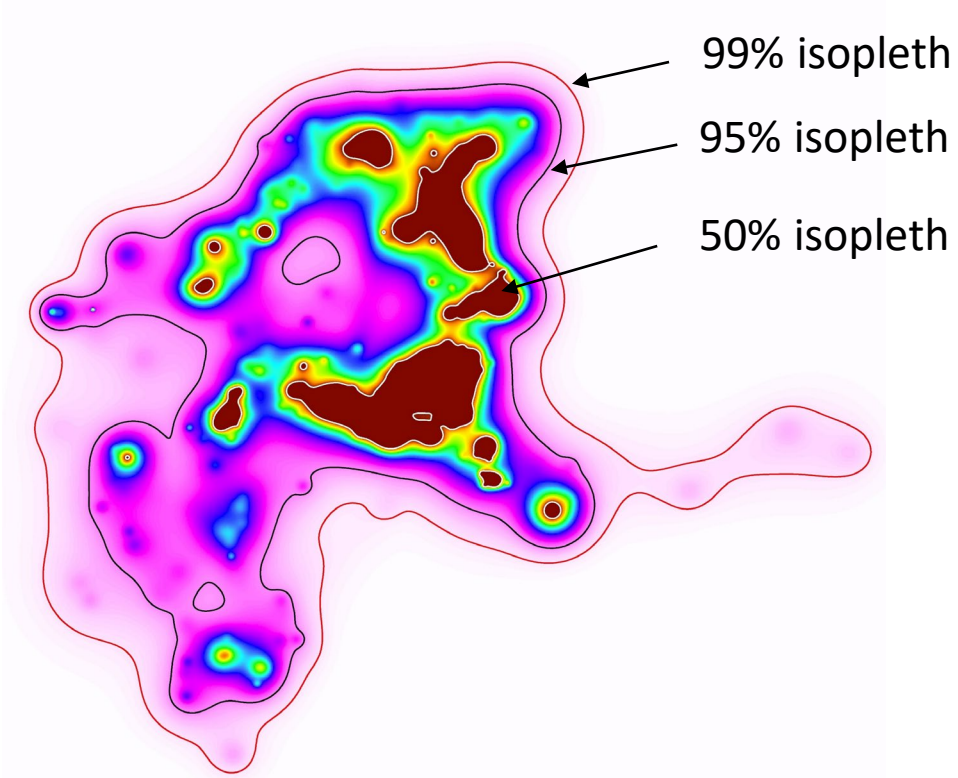


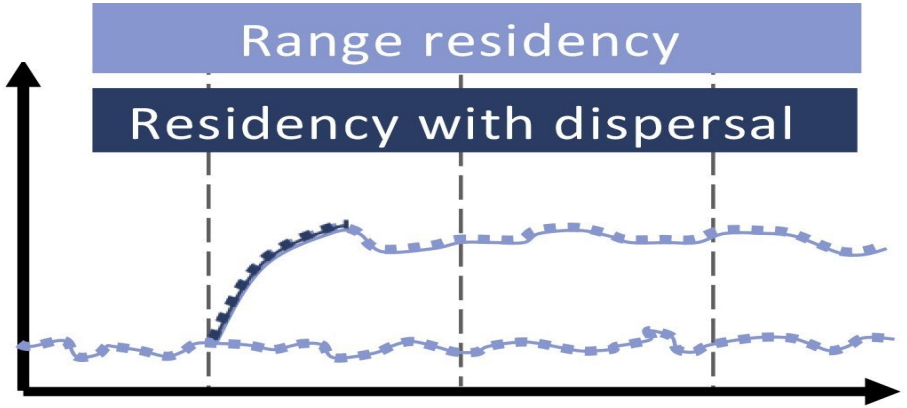
Territoriality
and
Resident Movement



Territoriality and Resident Movement



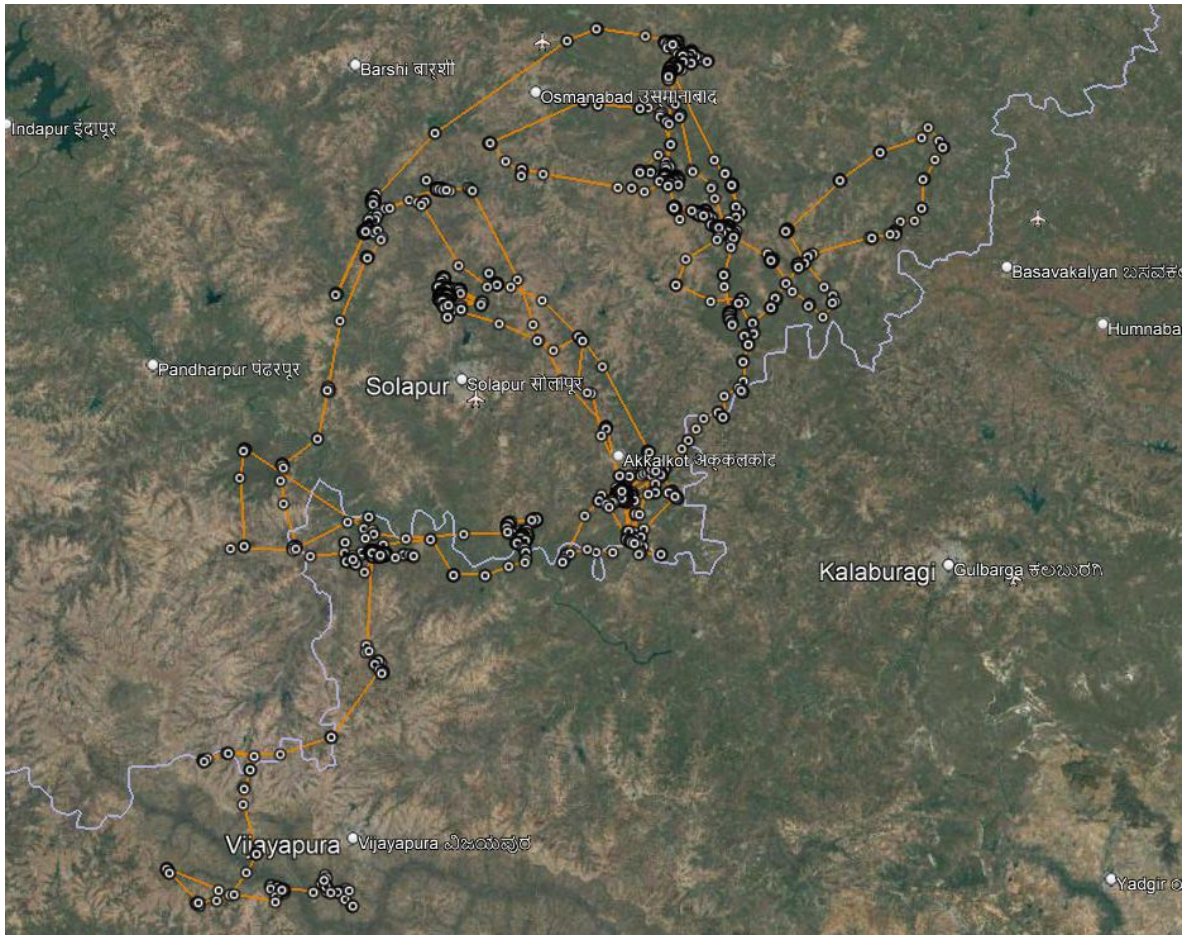


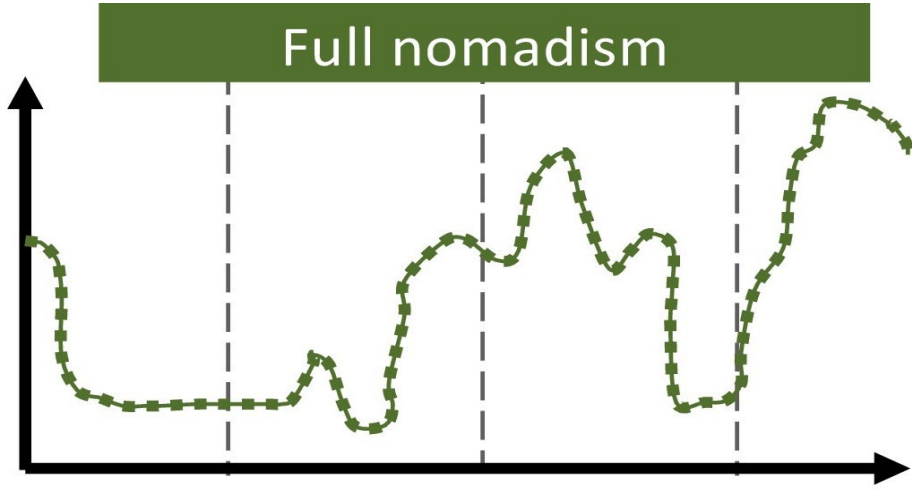


Territoriality refers to the behavioral strategy in which an animal or a group of animals defends a specific area against conspecifics or other species.

Resident refers to daily or seasonal movements within a defined home range

Nomadic Movement





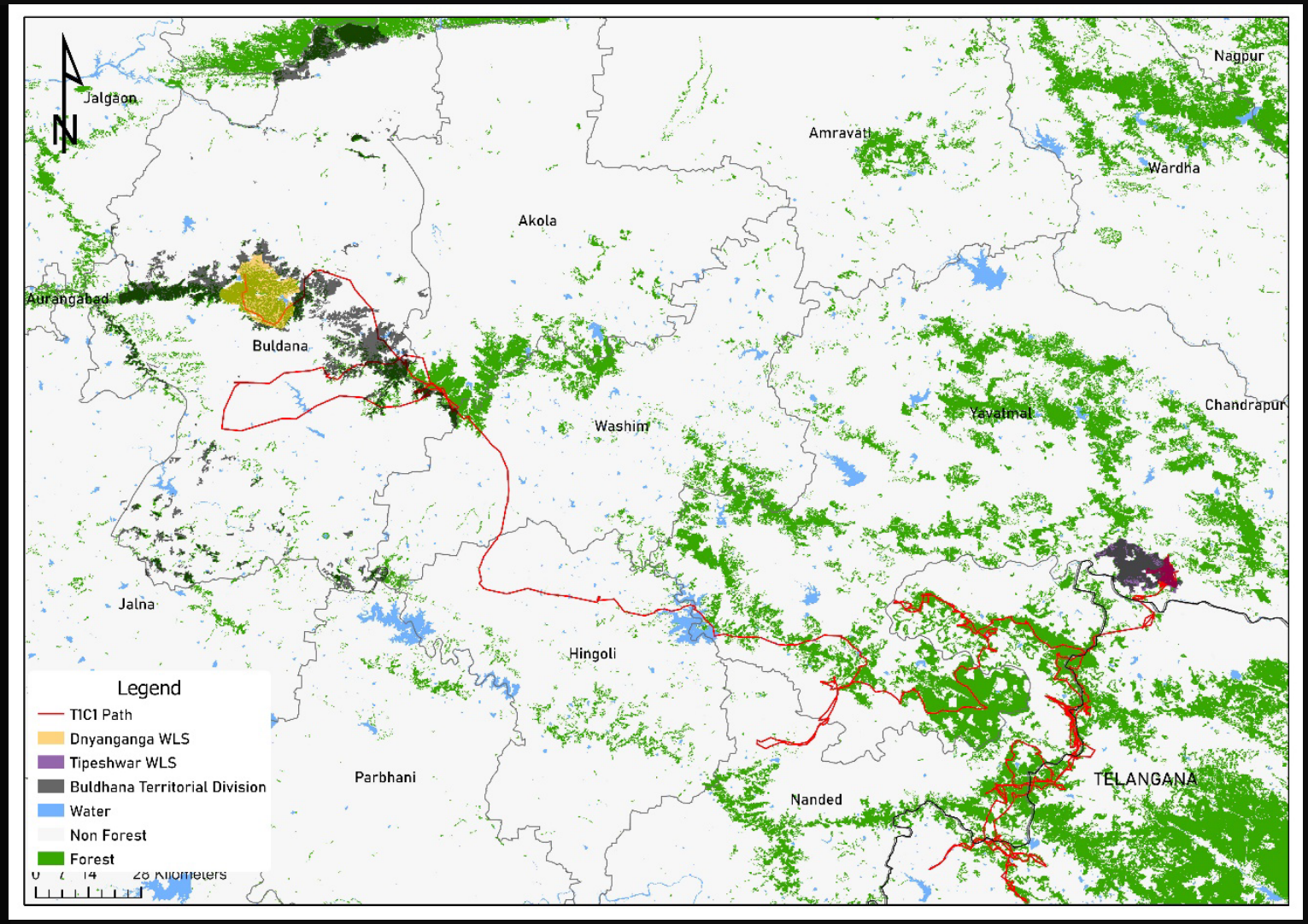
- Move across a large area in irregular and non-seasonal pattern without a static home range
- Infrequent revisitations occurring irregularly and often at a lower frequency
- Nomadism usually occurs in highly variable and resource-limited environments
- Species such as Mongolian gazelle use areas that are much larger than expected based on energetics alone, e.g., 45 000 sq km

Dispersal

Movement between successive reproductive sites/habitat and away from the birthplace

Dispersal allows animals to avoid competition, avoid inbreeding and to colonize new habitats

Animals disperse by leaving their natal area and finding new territories or home ranges.



Questions

Large-scale movement patterns:

- Are the individuals long ranging or solitary?
- Whether they have long-distance dispersal movements?
- Do individuals migrate between seasonal home ranges? All animals or just some?

Fine-scale movement patterns:

- Do animals move more/less during the middle part of the day?
- Do animals slow down/spend more time foraging in edge habitat?
- Variation in temporal movement (day/night)?

Movement Data

Two fundamental types of movement data

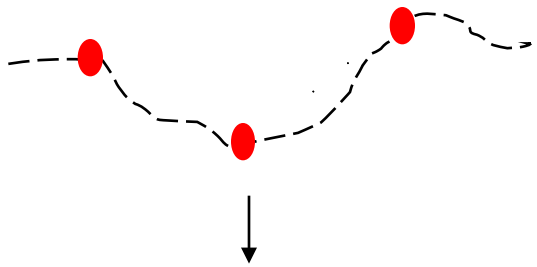
Eulerian methods

- Camera traps
- Rings and bands
- RFID tags

Lagragian methods

- Radio tracking
- Satellite tracking
- GPS
- Geo-locators

Coordinates



Non-spatial attributes

Event ID	Animal ID	Species
1	Leo	Turkey vulture
2	Leo	Turkey vulture

Time

TIMESTAMP
2024-06-17 09:00:00
2024-06-17 09:10:00

Movement Metrics

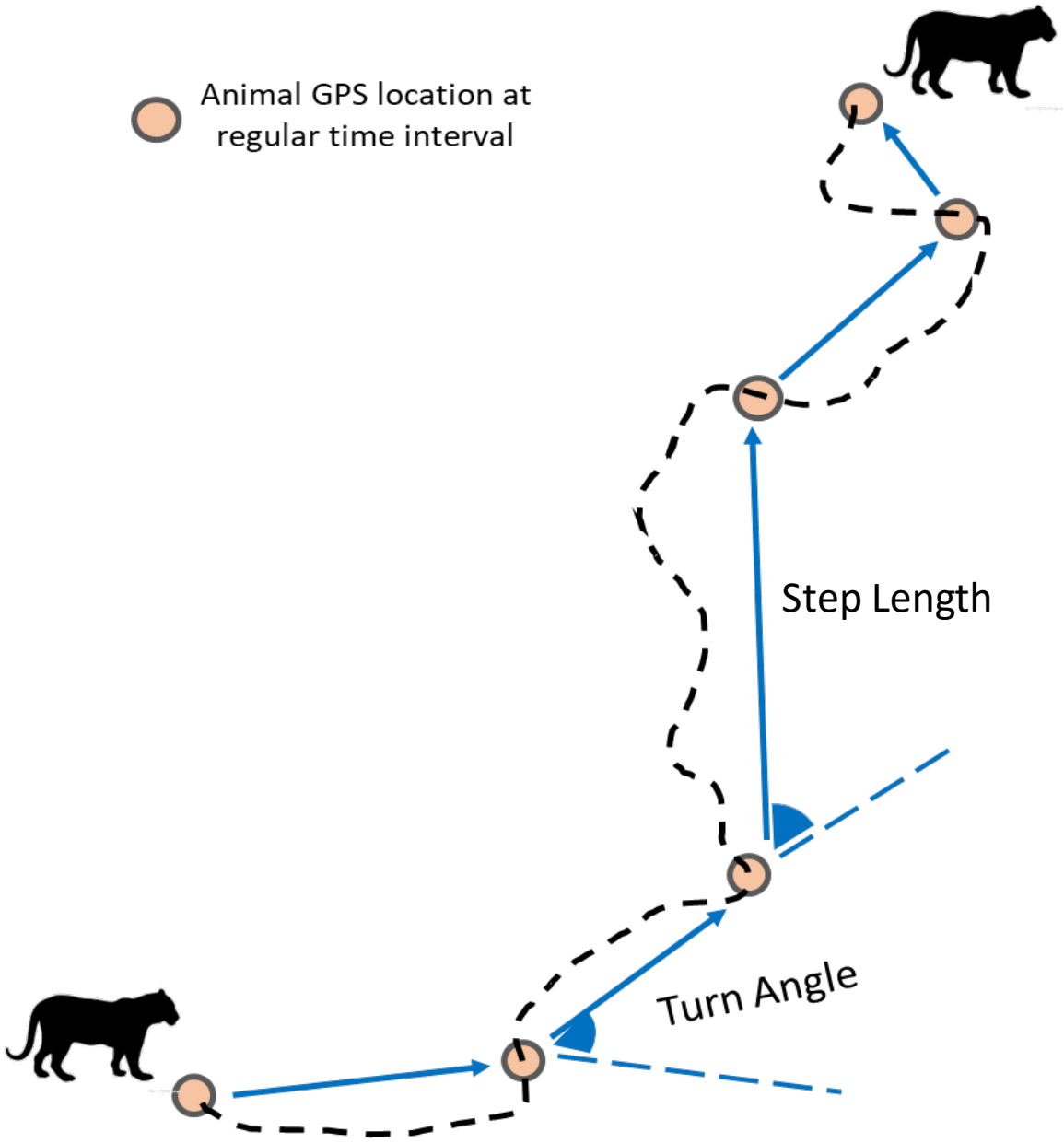
Movement metrics are quantitative measures used to describe and analyze the patterns and behaviors of animals as they move through their environment.

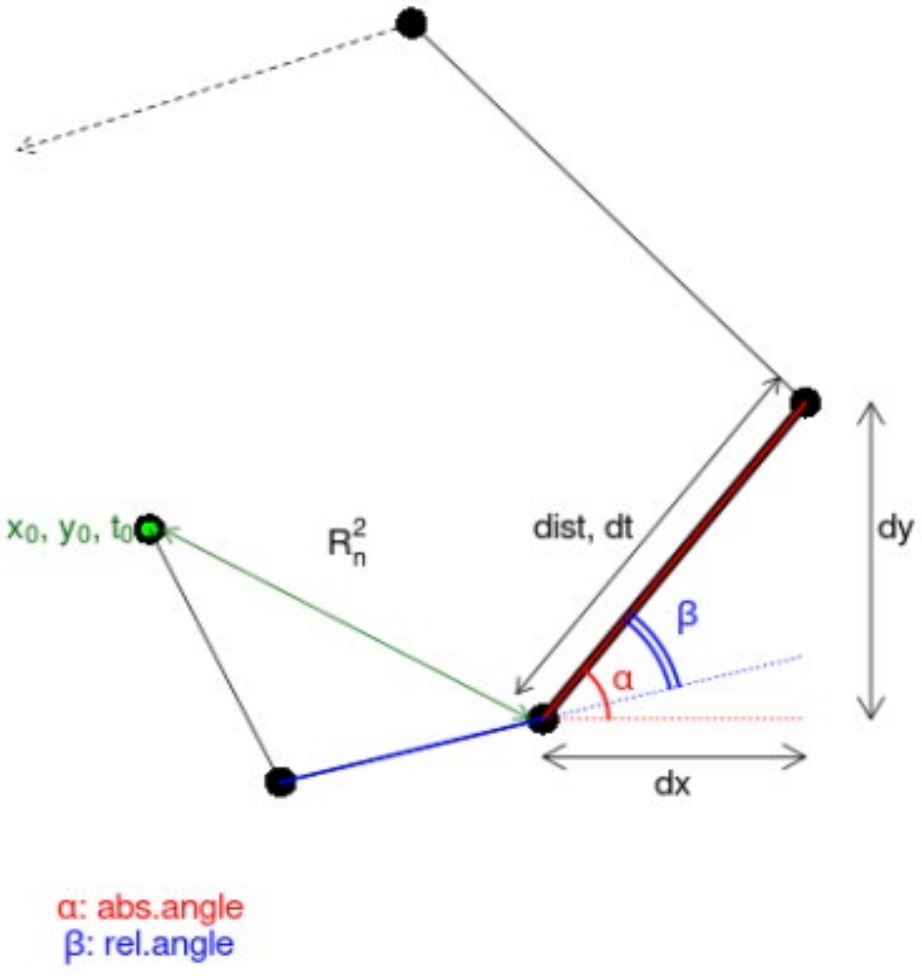
Step Length — Distance between GPS locations.

Turn Angle — Angle between movement steps.

Velocity (Speed) — Step length divided by time interval.

Net Squared Displacement — Displacement from starting point over time.





Descriptive Parameters of the Trajectory

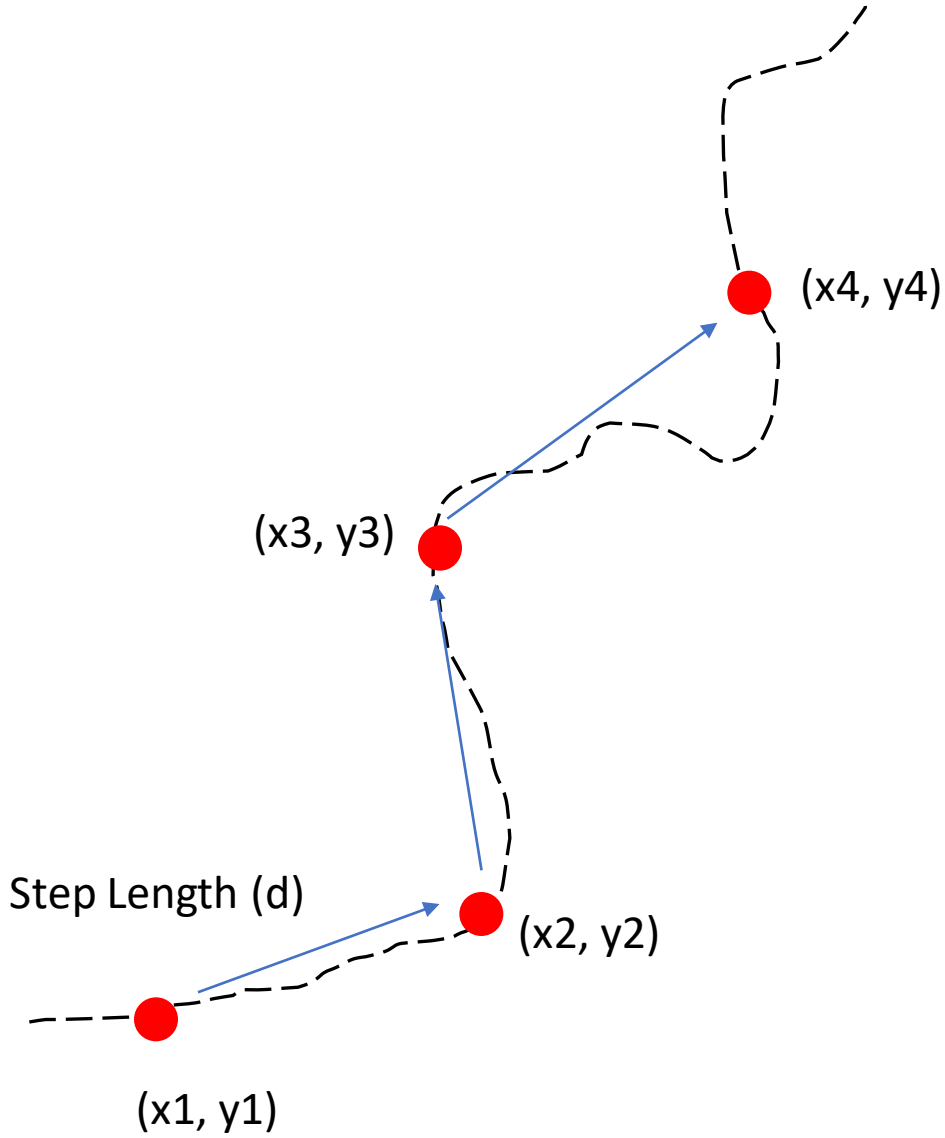
- dx, dy, dt: measured at relocation i describe the increments of the x and y directions and time between the relocations i and i + 1.
- dist: the distance between successive relocations
- rel.angle: measures the change of direction between the step built by relocations i − 1 and i and the step built by relocations i and i + 1 (often called “turning angle”).
- abs.angle: the absolute angle between the x direction and the step built by relocations i and i + 1 is sometimes used together with the parameter dist to fit movement models (e.g. Marsh and Jones 1988)

(Based on a literature review of Calenge et al. 2009)

Step length

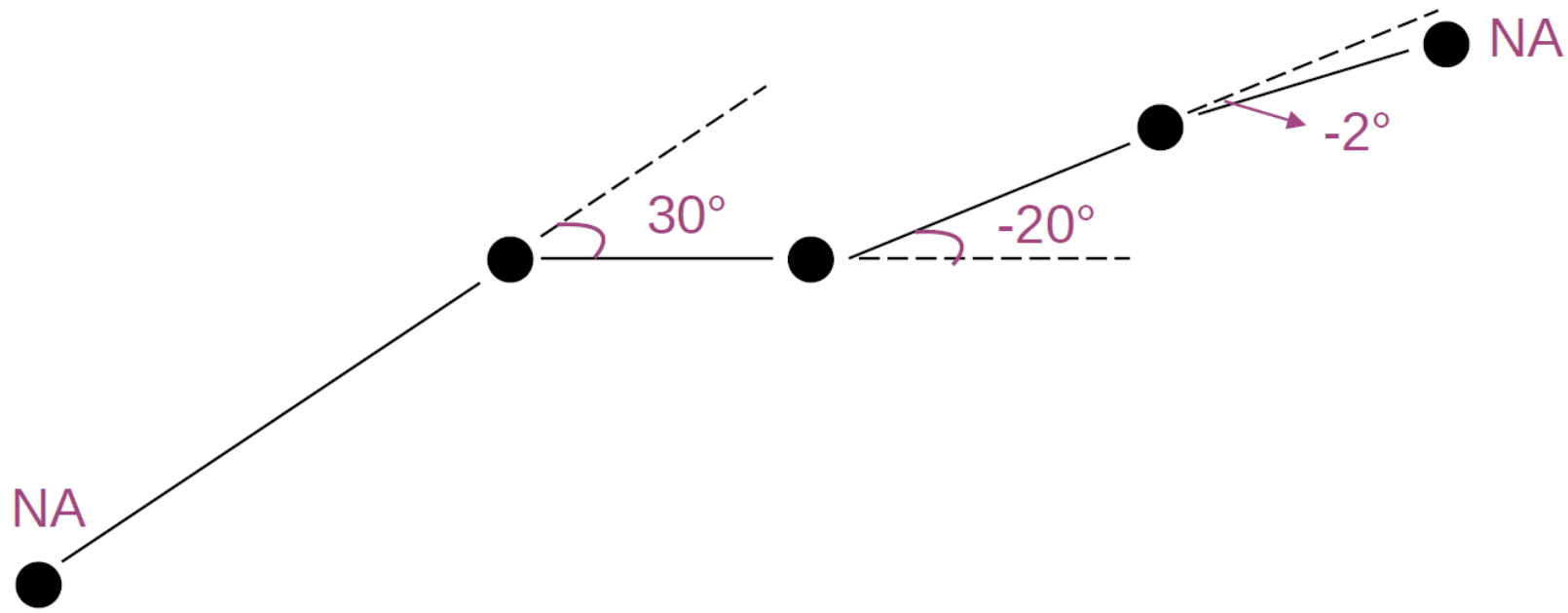
- The straight-line distance between two consecutive GPS.
- The step length (d) between two consecutive points ($x1$,$y1$) and ($x2$,$y2$) can be calculated using the formula:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$



Turn Angle

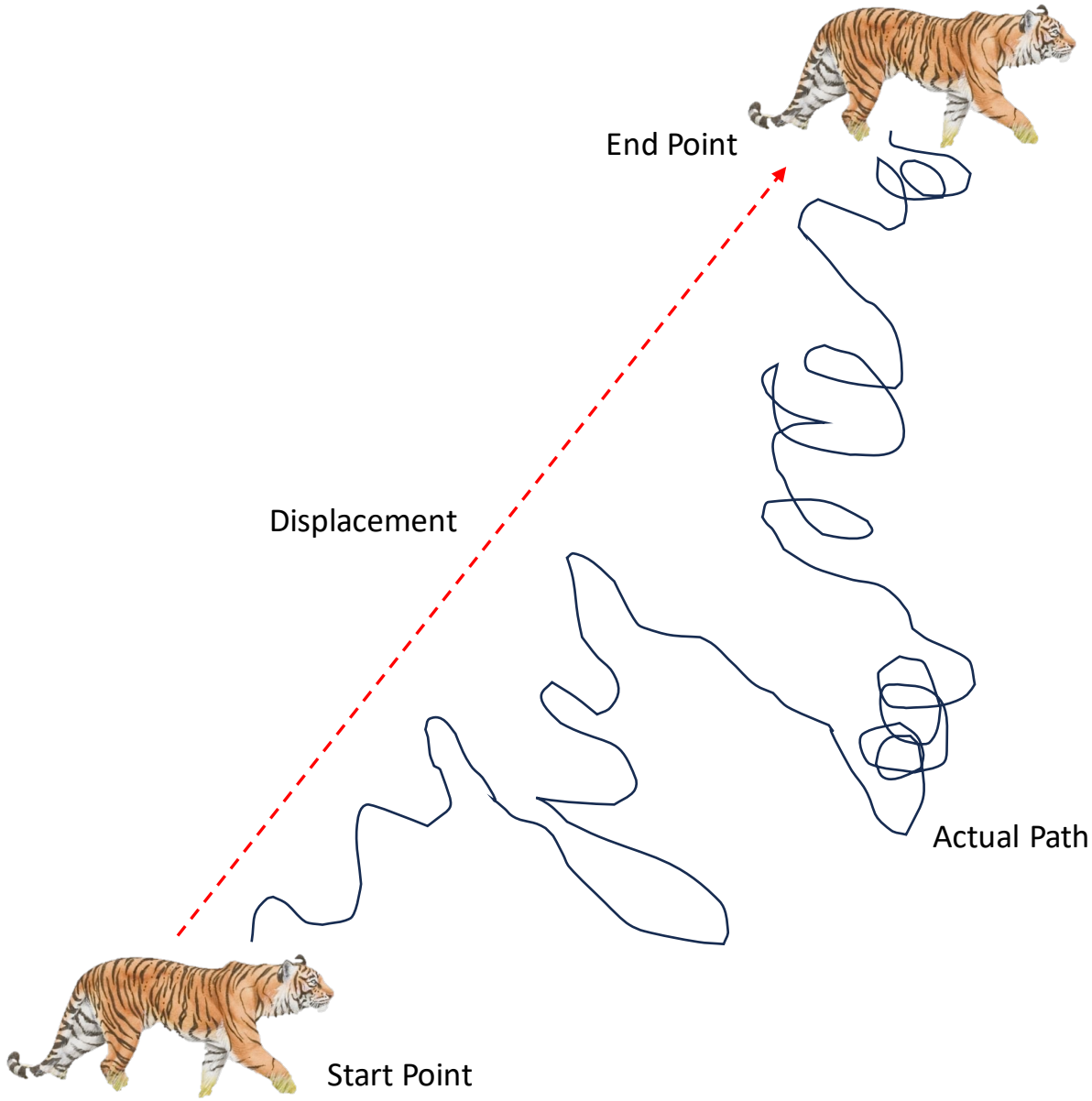
- It is the measure of directional change between two consecutive movement steps of an animal.
- It quantifies how much an animal deviates from its previous direction and is used to analyze movement behavior, such as foraging pattern and territorial behavior.
- Positive Angle (+): Indicates a right turn.
- Negative Angle (−): Indicates a left turn.
- Zero Angle (0°): Indicates no change in direction (i.e., a straight line).



Displacement

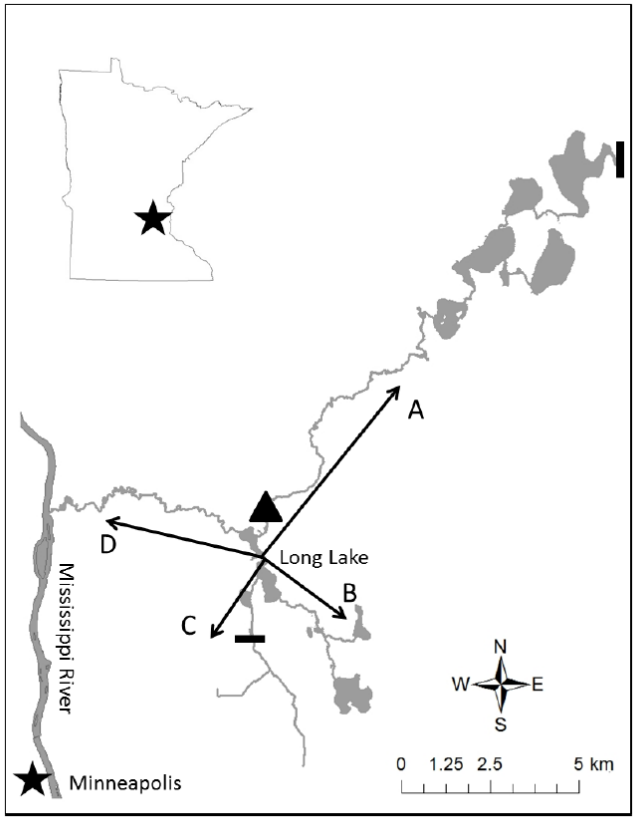
- Displacement is typically defined as the straight-line distance between two points, representing how far an animal moves over a given time interval

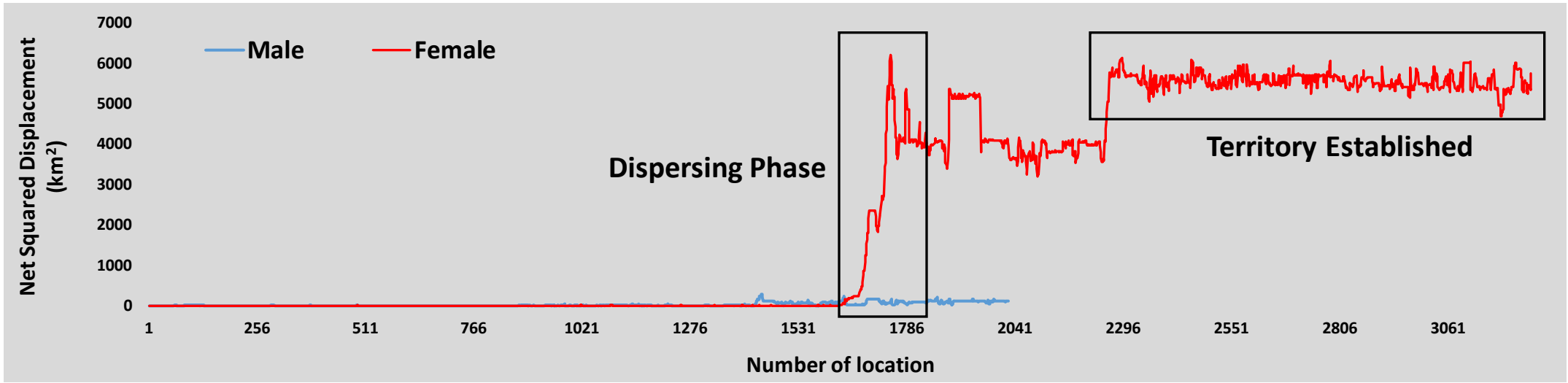
- *How far do males disperse in a week/month?*
- *How far individuals go for resources for their nesting site?*



Net-Squared Displacement

- NSD is calculated as the squared Euclidean distance from the starting point to the last location.
- It provides insights into movement patterns such as dispersal, migration, or area-restricted searches.
- NSD values typically increase over time for animals in dispersal or migration phases but may fluctuate for animals exhibiting area-restricted search behavior





What can we ask?

- Can movement metrics define the ecology of a species? If yes, what are the parameters?
- Is there more movement metrics we can calculate?
- Explore how movement metrics (step length, turn angles) vary with time of day/season, sex, age, weight
- Does movement metrics change with week, month, and year?

Let's try some examples !!