***CH 1***

*Movement ecology in wildlife – an overview*

Movement is ubiquitous throughout the life cycle of countless species. It is an essential characteristic of life that shapes numerous ecological processes (Nathan et al., 2008), including the search for food (Zuberogoitia et al. 2012), mates, breeding areas (Gregory et al. 2010), as well as the avoidance of detrimental factors such as predators (Fortin et al. 2005), disease, or competitors ([Hayward](https://journals.co.za/doi/epdf/10.10520/EJC117325) & Slotow 2009). Movement can thus be considered a fundamental component of many species’ ecology, and, consequently, of key interest in many scientific fields within ecology. The unifying framework under which this is studied is termed ‘*movement ecology*’.

A key driver of animal movement is often related to habitat quality (e.g., availability of resources Johnson 2007), and although this may be evident during the breeding period, this selection also drives animal movement throughout the whole annual cycle. Whilst resource availability drives movements over relatively large spatio-temporal scales with impacts on species’ biogeographic ranges and their population-level spatial structuring (e.g., migration), it can also occur at a smaller spatio-temporal scale (range-resident species), but show a similar pattern to migration behavior nevertheless (e.g. Benhamou 2014). Alongside resource abundance, population dynamics also play a role in animals’ movement, where density-dependent selection favors certain individuals whilst others are displaced to less optimal habitats (Fortin et al. 2005). Alternatively, predator-prey dynamics also influence movement, such as through prey species changing their behavior or spatiotemporal patterns of habitat use in the presence, or perceived presence, of predators. An example of this is the change in habitat selection by elk (*Cervus canadensis*) in high-use areas of wolves (*Canis lupus*) documented in Yellowstone National Park (Smith et al. 2023).



*Types of movements and resource acquisition*

Despite the prevalence of behavioral classification work in ecology, there is a lack of consensus and structure in the literature when classifying movement behavior. At the simplest level, animal movement can be classified differently depending on both the spatial and temporal scale used to assess them. On a broad scale (e.g., annually or interannually) movements can be classified as migratory, range-resident (Burt, 1943), or nomadic (Mueller and Fagan 2008). At smaller spatio-temporal scales (e.g., within seasons), movement can be also classified as one-way dispersive movements tied to reproduction, the navigation and search for conspecifics, and daily foraging movements.

For range-resident species, when individuals move in search of (a) resource(s) (e.g., food, mates, nesting sites, etc.) usually within their home-range, they can do so through ***navigation and*** ***search behavior*** (Mueller & Fagan 2008). Navigation (advective component) involves the movement directed to a known, predictable location – a commuting mode of movement between resource-rich patches (Benhamou 2014) usually aided by memory or landscape cues. Alternatively, search behavior refers to the intense search mode within a local patch (area-restricted search-ARS) or the exploration of new, unfamiliar sites (diffusive component) (Benhamou 2014).

Although classifying animal foraging behavior is not an easy task, even more relevant is whether we can tease apart these behaviors from tracking data. This, although challenging, is crucial to understand the underpinning drivers of movement and decision-making. Here, addressing the scale of movement is a relevant question. For example, when an animal periodically visits the same areas within a time frame (e.g., weeks or months), it performs confined movements (locational stationary phase) at this scale, whereas at a smaller spatial and temporal scales, the movement will resemble an advective-diffusive movement (Benhamou 2014). Hence, the quality of the tracking data available will also determine the scope of the research questions we can answer. For some species, addressing fine-scale movement types is possible, whereas for others, the data available might be only able to suggest commuting in general (navigation and search combined into one main category). For the purpose of my research, I will call this form commuting (navigation and search combined) **‘*search’.***

To understand how animals move between resource-rich patches when foraging, a group of models have been developed which are generally referred to as random walks. Random walks assume that movement of animals include a series of steps (usually modelled as discrete steps) and turning angles (Hengeveld, 2007) with some variations among models. However, regardless of the state and the movements they make when foraging, animals need to maximize returns (either in calories or nutrients). To do so, they optimize their overall efficiency in finding resources (Nonacs and Oikos 1993), either within high resource patches (ARS) or when commuting between these. Consensus has suggested that to do so, animals exhibit directed movement to maximize encounter rates (Shipley et al. 1996). This is especially true for non-revisitable food sources (e.g., non-destructive foragers, Nauta et al. 2020). This type of movement is termed **‘*ballistic motion’***. Whilst the idea that ballistic (straight-line) movement obeys a reasonable argument (as it is the shortest euclidean distance between two points), it still remains to be tested how this motion is exhibited by different groups of animals and whether there are variables (environmental and biological) that determine its length scale across individuals/species.

*Knowledge gaps and future directions*

It is unquestionable that since the first tracking devices were developed, science has made a significant amount of progress in the understanding of animal movement and behavior (Kays et al. 2015). Historically, studying movement in wildlife traditionally implied a large investment of time in the field or were limited to coarse sampling intervals from tracking devices which impacted home-range estimates. Nonetheless, in spite of having a vast amount of information on the foraging ecology for several species of birds, organizing and processing all this information together to draw conclusions on the determinant biological variables that shape foraging behavior, especially across taxa, remains an overlooked task. Hence, to the best of my knowledge, this thesis will pioneer in answering some of these overarching questions. Here, I will compile biological and ecological variables of bird species and test the relationship between these and communal roosting behavior, and complementary, test the relationship of this behavior with foraging efficiency using tracking data available, to then explore the energetics costs of it. Some of these biological variables have been discussed earlier in this opening chapter, but other biological and environmental variables can be added to the analysis and will be further discussed in chapters 2 and 3 respectively.