

When to be discrete: the importance of time formulation in understanding animal movement

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Abstract: Animal movement is essential to our understanding of population dynamics, animal behavior, and the impacts of global change. Coupled with high-resolution biotelemetry data, exciting new inferences about animal movement have been facilitated by various specifications of contemporary models that are appearing in the recent literature with great regularity. These models differ, but most share common themes. One key distinction between these approaches seems to be whether the underlying dynamic process is assumed to be discrete or continuous. In our experience, this is the greatest source of confusion among practitioners, both in terms of implementation and biological interpretation. In general, animal movement occurs in continuous time but we observe it at fixed discrete-time intervals. Thus, continuous time is conceptually and theoretically appealing, but in practice it is perhaps more intuitive to interpret movement in discrete intervals. This may in part explain why the methodological development and application of discrete-time formulations has thus far exceeded those in continuous time. We explore the differences and similarities between continuous and discrete versions of mechanistic movement models, establish some common terminology, and indicate under which circumstances one form may be preferred over another. Counter to the overly simplistic view that discrete- and continuous-time conceptualizations are merely different means to the same end, we present novel mathematical results revealing hitherto unappreciated consequences of time formulation on inferences about animal movement. We demonstrate these properties using northern fur seal (*Callorhinus ursinus*) biotelemetry data and conclude with a roadmap for future developments.