Partial differential equation techniques for analysing animal movement: a comparison of different methods

Yi-Shan Wang, Jonathan R. Potts

www.elsevier.com/locate/yjtbi

PII: S0022-5193(17)30002-4
DOI: http://dx.doi.org/10.1016/j.jtbi.2017.01.002
Reference: YJTBI8912

To appear in: *Journal of Theoretical Biology*

Received date: 25 May 2016
Revised date: 21 November 2016
Accepted date: 3 January 2017

Cite this article as: Yi-Shan Wang and Jonathan R. Potts, Partial differential equation techniques for analysing animal movement: a comparison of different methods, *Journal of Theoretical Biology* http://dx.doi.org/10.1016/j.jtbi.2017.01.002

Partial differential equation techniques for analysing animal movement: a comparison of different methods

Yi-Shan Wang* and Jonathan R. Potts†

*† School of Mathematics and Statistics, University of Sheffield, Hicks Building, Hounsfield Road, Sheffield S3 7RH, UK

* Corresponding author; e-mail: ywang244@sheffield.ac.uk

† E-mail: j.potts@sheffield.ac.uk

Abstract

Recent advances in animal tracking have allowed us to uncover the drivers of movement in unprecedented detail. This has enabled modellers to construct ever more realistic models of animal movement, which aid in uncovering detailed patterns of space use in animal populations. Partial differential equations (PDEs) provide a popular tool for mathematically analysing such models. However, their construction often relies on simplifying assumptions which may greatly affect the model outcomes. Here, we analyse the effect of various PDE approximations on the analysis of some simple movement models, including a biased random walk, central-place foraging processes and movement in heterogeneous landscapes. Perhaps the most commonly-used PDE method dates back to a seminal paper of Patlak from 1953. However, our results show that this can be a very poor approximation in even quite simple models. On the other hand, more recent methods, based on transport equation formalisms, can provide more accurate results, as long as the kernel describing the animal's movement is sufficiently smooth. When the movement kernel is not smooth, we show that both the older and newer methods can lead to quantitatively misleading results. Our detailed analysis will aid future researchers in the appropriate choice of PDE approximation for analysing models of animal movement.

Keywords: transport equation; theoretical ecology; movement ecology; central-place foraging; home range