An Approach to Simulating Localised Diffusion Processes on Large-scale Landscapes

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Abstract

The simulation of spatial diffusion processes using both individual- (or agent-) based and cellular approaches has become commonplace in a range of disciplines. In the context of plant dispersal dynamics, models have focussed on one of two scales: local or regional. In particle systems models plants are modelled individually, with plant locations at continuous coordinates on grids at a resolution approximating the size of individual plants (< ~10m), seed dispersion processes represented stochastically and sometimes in considerable mechanistic detail, and study areas ranging up to around only 2x2km (i.e. 4km^2). Alternatively, regional-scale models represent only 'presence' or 'absence' of species on grids with cell sizes typically ~1km or greater and highly abstracted diffusion processes. In this paper, we present a preliminary model for regional-scale modelling of plant dispersal dynamics that can accommodate more detailed cell-by-cell variation in plant density, but which accounts for local scales of spread using the classical probability result of 'Buffon's Needle' as recently advocated by Birch (*Ecol. Mod.* **192**: 637-644). The model represents local sub-populations explicitly but uses statistical approximations to model adequately local dispersal processes at scales typically less than 10m, on a grid with a resolution of 100m (or greater). Rare long distance dispersal events, which are known to be an important component of seed dispersal, are conveniently modelled in this context via a simple stochastic process. This approach offers the prospect of computationally efficient simulations of spread across large heterogeneous landscapes, which remain faithful to empirical data on the spread of particular species, and that are useful in management applications. The model in its current form will be described, including facilities for generation of suitability landscapes that enable exploration of spread dynamics on the complex fragmented landscapes seen in contemporary peri-urban settings. Prospects for experimental exploration of invasive spread dynamics and control strategies will be discussed.

Keywords and phrases: individual-based models, plant ecology, invasion biology, seed dispersal, Buffon's needle