Using dispersal data to model invasive spread and management effectiveness

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Abstract

Fundamentally, plant invasions are about the movement of individuals through an ecosystem. In contrast, management is often focused on killing plants and generally gives little or no consideration to the implications of plant movement for the management strategy adopted or its likely success. This is potentially a mistake, as understanding how invaders are moving through the landscape may offer insights into how management can be improved. The catch, however, is that our understanding of movement tends to be limited to the outcomes of movement, i.e. final patterns of spread, rather than the process of movement. We describe a project which is using a basic understanding of the ecology of plant movement in ecosystems to develop models of invasive spread that allow prediction of the effects of management on the rate and pattern of spread within real landscapes. These models are being used to assess the efficacy of management and to identify opportunities for its improvement.

Our models are based around a detailed understanding of the process and outcomes of seed dispersal in rainforest ecosystems (Dennis and Westcott 2008, Westcott *et al*. 2008). Because we are focused on rainforest ecosystems, we are concerned primarily with seed dispersal by vertebrates. We combine the frequency distribution of seed passage times through the guts of dispersers and models of disperser displacement rate (estimated from captive feeding trials and radio-telemetry in the wild, respectively) to estimate dispersal kernels, i.e. the frequency distribution of dispersal distances (e.g. Westcott *et al*. 2005, Westcott *et al*. 2008, Dennis and Westcott 2008). This dispersal kernel is then used to parameterize the dispersal behaviour of plants in an individually based simulation model of weed spread. Verification of the model results, using spatial data from a 25 year old infestation of *Miconia calvescens* at El Arish, Far North Queensland, indicate that the model is able to predict spread adequately (Murphy *et al*. 2008). The discovery during more recent surveys of additional plants at larger distances from the original infestation than previously recorded, indicate that these original assessments of the model's performance were conservative. Furthermore, incorporation of the effects of habitat suitability and of management activities on the pattern and scale of spread further improve the fit of the model to the field data.

The success of the model in predicting spread provides us with a platform for evaluating likely patterns of spread under different landscape scenarios, as well as the likely efficacy of different approaches to the management of invasive spread. For example, it is possible to determine the effect of differing detection probabilities on abundance and the rate and pattern of spread, the effect of different search areas on limiting spread, and the consequences of failing to detect parts of an infestation. While these are relatively simple examples, as the model is refined more complex scenarios are being examined.

Though it is tempting to interpret the results of the simulation model as reflections of reality, this is very risky. The simulation model is based on stochastic processes with effects that are manifested on both spatial and temporal scales. As a consequence the models predict, not the expected distribution of individual plants but rather probability distributions reflecting the likelihood of recruitment in an area. Though the distinction is subtle, it is important in terms of how the models are interpreted and utilized: the utility of these models is not in predicting what will happen and what the appropriate response should be, but rather in identifying general situations and rules of thumb, based on a good ecological understanding of the system, for responding to those situations.

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References

Dennis, A.J. and Westcott, D.A. (2007). Estimating dispersal kernels produced by a diverse community of vertebrates. *In* 'Frugivory and seed dispersal: theory and its application in a changing world', eds A.J. Dennis, R. Green, E. Schupp and D.A. Westcott, pp. 201-28. (CAB International Publishing, Wallingford).

Murphy, H.T., Hardesty, B.D., Fletcher, C.S., Metcalfe, D.J., Westcott, D.A. and Brooks, S.J. (2008). Predicting dispersal and recruitment of *Miconia calvescens* (Melastomaceae) in Australian tropical rainforests. *Biological Invasions* 10, 925-36.

Westcott, D.A., Bentrupperbaumer, J., Bradford, M.G. and McKeown, A. (2005). Incorporating disperser movement and behaviour patterns into models of seed dispersal. *Oecologia* 146, 57-67.

Westcott, D.A., Setter, M., Bradford, M.G., Setter, S. and McKeown, A. (2008). Dispersal of pond apple seeds by the southern cassowary: ecological interactions between a threatened and a threatening species. *Diversity and Distributions* 14, 432-9.

Westcott, D.A., Dennis, A.J., Bradford, M.G., McKeown, A. and Harrington, G.N. (2008). Seed dispersal processes in Australia's Wet Tropics rainforests. *In* 'Living in a dynamic tropical forest landscape', eds N. Stork and S. Turton, pp. 210-23. (Blackwell Publishing, Malden).