SPECIAL FEATURE

# Long-Distance Dispersal[1]

The past 5–10 years have witnessed a dramatic upsurge of interest in long-distance dispersal, or LDD. In one sense, the recent interest in LDD is nothing new: Ecologists, biogeographers, and evolutionary biologists long have recognized the fundamental role of LDD in natural populations (e.g., classic works by Charles Darwin or H. N. Ridley). However, the study of LDD was neglected for much of the past 40 years, due to factors such as the rise of vicariance biogeography (which explains biogeographical patterns in terms of events like continental drift that create barriers to dispersal) and the focus of many ecologists on quantifying short-distance movements (which can be measured relatively easily and have important consequences for local population dynamics).

Naturally and by Anthropogenic causes - why study natural dispersal when human dispersal can "jump" even LDD?

Interest in LDD may have waned, but it certainly never disappeared. For example, highly innovative studies by J. G. Skellam, R. H. MacArthur and E. O. Wilson, R. Levins, and D. Mollison stressed the importance of long-distance movements and provided a firm conceptual foundation for later studies on LDD. In addition, our growing ability to monitor the human impact on the biosphere stimulated an explosion of research on topics such as metapopulation dynamics, habitat fragmentation, biological invasions, and global climate change. As researchers turned their attention to these and other ecological processes that operate at intermediate to large spatial scales, they often faced such questions as: How far can organisms move? How often do they disperse long distances?

But therein, of course, lies the problem: While of great importance, LDD is notoriously difficult to document. As a result, few data sets provide quantitative information about long-distance movements. In addition, theorists have been slow to incorporate realistic dispersal functions into ecological models, in part due to a lack of data to guide model selection. Fortunately, exciting new methods for collecting data are under active development, as are models that examine consequences of LDD in a wide range of settings. This Special Feature highlights some of these new developments and includes papers that address such topics as (1) new methodologies for the collection and analysis of long-distance dispersal data, (2) ecological and evolutionary models of LDD, (3) implications of LDD for conservation biology and the spread of populations, and (4) LDD data from a wide range of habitats, including marine, agricultural, and tropical forest ecosystems.

Turning first to the issue of data, the study of LDD has been, and still remains, severely data limited. In the opening paper of the Special Feature, Higgins et al. survey mechanisms of LDD and argue that long-distance movements often result from nonstandard means of dispersal. Higgins et al. go on to suggest ways in which a better appreciation of mechanisms that promote LDD can improve both the collection and analysis of LDD data.

The study of LDD is also hindered by the fact that we know little about fitness trade-offs involving long- and short-distance dispersal, fecundity, and establishment. To address such issues, Muller-Landau et al. explore evolutionary benefits of LDD that derive from the ability of distantly dispersed offspring to escape the region in which local population dynamics are spatially autocorrelated, and thereby to colonize patches in which rapid population growth can subsequently occur. Muller-Landau et al. also show how natural enemies may facilitate the evolution of LDD, thereby providing an evolutionary framework for articles in the Special Feature that address the spread or impact of natural enemies (e.g., Aylor; Fragoso et al.).

With the opening two papers providing general context for the study of LDD, the next three papers examine the role that LDD plays in the spread of organisms. In the first of these papers,

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Caswell et al. explore parallels in conservation biology between analyses of population growth rate (sensitivity, elasticity, life table response experiments [LTRE]) and the corresponding calculations for wave speed, an index of the performance of populations that combines demographic and dispersal data. Clark et al. complement Caswell et al. by extending classical approaches, which estimate spread from integrodifference or related dispersal models, to include a nonparametric estimate of the dispersal curve. Their approach allows estimation of the asymptotic wave speed from raw dispersal data, and avoids the anomaly of asymptotically infinite wave speeds. Finally, Aylor discusses the spread of agricultural pests over large spatial scales (hundreds of kilometers), incorporating effects of atmospheric turbulence, pathogen survival during flight, carrying capacity of the recipient habitat, and pathogen reproductive rate. Aylor applies a model that incorporates those factors to the spread of two classic plant diseases (wheat stem rust and tobacco blue mold), illustrating the critical impact of survival during flight.

The last two papers of the Special Feature examine community, landscape, and ecosystem level implications of LDD. In the first of these papers, Fragoso et al. show that LDD of tropical palm seeds by tapirs increases the probability of establishment by taking seeds out of beetle-predation impact zones that are concentrated near conspecific palm aggregations. Consequently, Fragoso et al. propose that LDD generates the observed mesoscale patchiness of palms, and possibly of other tropical trees. In the closing paper of the Special Feature, Kinlan and Gaines estimate dispersal in marine organisms from genetic isolation-by-distance slopes, showing that the range of variation is huge, depending on taxon. Marine organisms also are shown to have much wider scales of dispersal than their terrestrial counterparts. These and other observations in Kinlan and Gaines have profound implications for the ecological and evolutionary dynamics of ecosystems across multiple scales, and for the design of reserves.

The papers of this Special Feature synthesize current knowledge of LDD and suggest many avenues for future work. For example, as we continue to develop better tools for the study of LDD, the data and analyses that result will shed light on fundamental questions, such as the relative role of LDD vs. establishment in spatial spread, the likely response of species to habitat fragmentation, and the costs, benefits, and evolution of LDD. Although studying LDD will always be challenging, we hope this Special Feature stimulates new technological developments, groundbreaking empirical studies, and innovative modeling and analytical approaches. Together such advancements will further deepen our understanding of the patterns, mechanisms, and consequences of long-distance dispersal.

—Michael L. Cain
*Coordinating Editor*
*Rose-Hulman Institute of Technology*
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*Ben-Gurion University*
—Simon A. Levin
*Guest Editor*
*Princeton University*

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