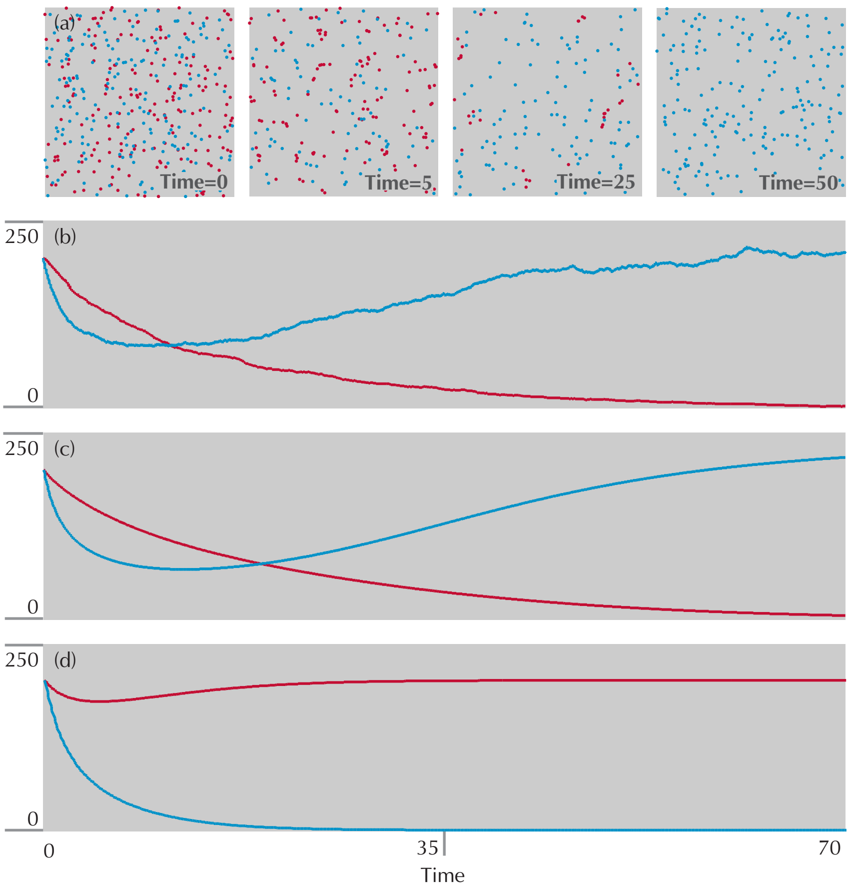
Simplifying Spatial Complexity

A sea change has come over theoretical ecology in the past 10 years. The heyday of the simple, general model that sought to capture the essence of an ecological community has passed. Today, ecological modeling relies on individual-based, spatially explicit computer simulations. Research has shown that spatial variations in population density within a given domain, both self-generated and exogenous, have major impacts on predictions of ecological and evolutionary change.

Individual-based simulations encompass the randomness of ecological dynamics that results from individual behavior and life-histories. Yet ecological researchers should not infer too much from single examples or simulations: it is not the location and behavior of each single individual that matters. Instead, to understand the relevance of pattern and process in spatial ecology, we must ask: What spatial and temporal patterns develop in the long run? How can they be characterized? Can we identify different kinds of patterns developing as the initial configuration of an ecological community changes? How many different kinds of patterns are expected to develop from different starting conditions? What happens when the environment in which the organisms live is altered, thus affecting the parameters of the ecological process? These are important questions, but ones that are very difficult to answer from examining instances of an individual-based process.

Along with a few other groups around the world (in Princeton, USA, and in Fukuoka, Japan), IIASA's ADN project is developing novel methods that provide answers to these questions. Mathematical techniques, including pair approximations and correlation dynamics, allow ADN to predict the changing spatial statistics of an individual-based process in terms of relatively simple deterministic models (see figure below). By analyzing these models, ADN can deal with many of the issues left unresolved by both the traditional nonspatial models of population ecology and by the modern generation of individual-based simulations.

For more information, see IIASA's ADN Web page www.iiasa.ac.at/Research/ADN/Space.html.



Correlation dynamics succeed in simplifying spatial complexity. (a) Changing patterns of two locally competing populations. One species (red) is the better competitor, the other (blue) the better disperser. (b) Over time, the better disperser wins, driving the better competitor to extinction. (c) The new correlation dynamics developed by IIASA's ADN project correctly capture this behavior of the complex spatial model. (d) In contrast, traditional nonspatial population models perform poorly on the same task: their forecasts predict the extinction of the better disperser, a qualitative error.