Small empty patches are important

Metapopulation biology shows how

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In "An Island Away" (*Down To Earth*, April 30, 2006), I talked about the theory of island biogeography which played a major role in community ecology and conservation biology in the 1970s and the 1980s. In the 1990s, another theory came to the fore: metapopulation biology or dynamics. The term metapopulation was coined by Richard Levins in the early 1970s to describe a population of populations. Classical metapopulations comprise a series of patches where a particular species could potentially survive, with some patches being occupied and others lying empty at any point in time. In fact, island biogeography can be visualised within the framework of metapopulation theory, where one site is significantly larger than others (mainland and many islands) and colonisation largely takes place from the large site to the smaller ones.

There is also, however, a difference in perspective between the two theories, and that seems to have caused a paradigm shift. One factor that may have influenced this shift is that the island biogeography theory focuses on species equilibrium. Metapopulation theory, in contrast, focuses on population turnover (the extinction and re-establishment of each individual population on every patch). Further, much of the recent interest in conservation biology has centred on population genetics, especially the study of genetic drift and inbreeding in small populations. Small populations are also susceptible to extinction due to random demographic changes (such as reproduction, juvenile and adult mortality) or environmental events (fire, storms and other catastrophes). The role of population characteristics of different species and environmental factors in determining minimum viable populations for these species has also been an important part of conservation studies.

Most importantly, metapopulation theory may have rescued small patches from their devaluation in island biogeography models. The first rule of refuge design based on island biogeography said that larger areas would have more species than small ones, and suggested that small populations in small sites would be unviable because they are subject to more environmental and demographic factors and hence more susceptible to extinction. This could easily be interpreted by opponents of conservation processes to claim all small sites for development. Salvation came from metapopulation theory, which showed the importance of a larger number of sites, where extinction on some (some unoccupied sites always exixt) is a natural part of the process of metapopulation persistence: empty sites are necessary for a metapopulation.

ILLUSTRATIONS: SHYAMAL

Species survival is linked to the existence of a number of habitats even if some are empty

A metapopulation is a set of local populations within some larger area, where migration from one population to another is possible. A patch is a continuous area with all requisites for the persistence of a local population. It is separated from other patches by unsuitable habitat. The classical Levins metapopulation is a large network of similar small patches, with population processes within a patch occurring at a much faster rate than population processes across patches.

The simplest models of metapopulation dynamics, such as the classical model, only look at occupancy of sites by a species, ignoring population sizes. The more complex ones include the distribution of population sizes in various patches. At another level, the spatially explicit models include parameters such as distance between patches, which influence migration of animals between patches — an essential part of recolonisation. Spatially realistic models assign areas, spatial locations and other attributes to patches, based on real networks of patches in nature. Thus the most complex models attempt to reproduce natural conditions and study factors which influence the survival or persistence of the metapopulation.

The current literature would appear to suggest that metapopulation theory provides a more comprehensive framework to study fragmented populations than island theory. But metapopulation theory is a developing field: while some models have been developed in the context of single species population dynamics, much work is needed to develop models for communities and to integrate other fields such as genetics, evolution and epidemiology. Of course, the theory's development is inextricably linked with landscape ecology, especially with the wealth of new methods and information using a geographical information systems frameworks. ■

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