SPECIAL FEATURE

Determinants of Biodiversity Change: Ecological Tools for Building Scenarios[1]

As defined in the recent Millenium Ecosystem Assessment (MA), biodiversity scenarios are "plausible alternative futures." They do not attempt to predict the precise future state of biodiversity, but rather they identify the consequences of the different paths that human society may follow for biodiversity. Scenarios are designed to assist decision makers by identifying costs and benefits, in terms of biodiversity, of alternative actions. Within the framework of the MA, the first stage in developing biodiversity scenarios was to identify the major drivers of biodiversity change in the next 50–100 years. Land-use change, climate change, and nutrient enrichment were identified as the major drivers of biodiversity change in terrestrial and freshwater ecosystems. The next steps in constructing successful biodiversity scenarios are (1) assessing changes in drivers of different socioeconomic scenarios and (2) developing the algorithms that relate changes in drivers with changes in biodiversity. This Special Feature focuses on a key component of the second of these two steps: evaluating the current tools used by ecologists to develop scenarios based on changes in drivers of biodiversity change.

Land-use change has been recognized as the most important driver of biodiversity change in the current century. Models that simulate the interaction between economic and ecological systems estimate rates of deforestation and land-use change for different socioeconomic scenarios. However, not all species disappear as a result of land-use change. In this Special Feature, Pereira and Daily explore the question of how many species and which species can persist in modified landscapes. They used two different approaches, the classic species–area relationship and demographic models, focusing on the terrestrial mammal fauna of Central America.

The approaches reported in the article by Pereira and Daily require information on species density in addition to data on land-use change. Biodiversity scenarios also need to start with a solid understanding of the current biodiversity patterns before human disturbance, but information on global patterns of current biodiversity is scarce. These data are generally available only for a few taxa, such as vascular plants, which have been a primary focus of taxonomic efforts. Volkmar Wolters et al. report on a study of the relationship among patterns of species density for different taxa and address the question of how valid it is to extrapolate from data based on the diversity of vascular plants to other taxa.

Biodiversity scenarios should also explore the consequences for species richness of changes in drivers, such as land-use or climate change. Ibáñez et al. explore new approaches to assess the impacts of climate change and land-use change on biodiversity that go beyond the use of climate envelopes and species–area relationships. The authors suggest that extinctions are difficult to predict and to assess in the field. Their proposed alternative is to use variables that are related to biodiversity and that are diagnostic of extinction but that are more predictable than extinctions. Expected anthropogenic climate change will redistribute the locations where specific climatic conditions favorable to the survival of a species will occur. The effect of climate change on biodiversity loss is determined not only by the occurrence of climate conditions for survival, but also by the ability of individual species to migrate to the new location. Ibáñez et al. address the question of migration constraints and how these constraints may modulate the effect of climate change on biodiversity loss.

[1] Reprints of this 50-page Special Feature are available for $7.50 each, either as PDF files or as hard copy. Prepayment is required. Order reprints from the Ecological Society of America, Attention: Reprint Department, 1707 H Street, N.W., Suite 400, Washington, D.C. 20006.

Freshwater biodiversity is the most threatened of all the components of global biodiversity, but some of the tools developed for terrestrial ecosystems do not work well for freshwater ecosystems. For example, changes in the area of lakes and rivers are not comparable with the effect on habitat loss resulting from deforestation. Xenopoulos and Lodge develop algorithms that predict changes in fish species diversity based on changes in river discharge. They present a statistical model relating fish species richness to river discharge that is an index of habitat availability. Their article applies the diversity–discharge model to scenarios of reduced discharge resulting from changes in climate and water consumption by humans.

This Special Feature ends with an article relating changes in biodiversity to their consequences for the provisioning of ecosystem goods and services. Dobson et al.'s approach is based on the concept that different ecosystem services are provided by species in different trophic levels. The authors present a model describing how changes in habitat result in a sequential loss in trophic diversity. Model results indicate that, as habitat availability declines, ecosystem services provided by species in the upper trophic levels will decrease before those goods and services provided by species in lower trophic levels do. Moreover, this exercise suggests that the losses of ecosystem services may occur faster than the loss of species diversity. For example, a loss of 50% of habitat area may result in the loss of a small number of species based on the species–area relationship, but most likely all those species may belong to a same upper trophic level. Entire ecosystem services may disappear quickly with the loss of a trophic level.

Taken together, the articles in this Special Feature present the most recent conceptual progress in our understanding of the relationships between changes in the environment and changes in biodiversity in terrestrial and freshwater ecosystems. Such progress is important in our understanding of the ability of ecosystems to continue to provide essential goods and services for humans. These relationships and algorithms are the tools needed to develop scenarios of biodiversity change for the coming decades.

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