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Biodiversity in a changing world: Global issues and projections of diversity changes at large scales

Summary

Changes in biodiversity have been measured in the last decades at different scales and in various ways. Good examples of measurable changes at the species level are changes in phenology (annual patterns) and changes in geographical distribution. Models are now able to predict changes in phenology. For many species there are good records of colonization and invasion, and recent reported changes are for 80% as predicted.
Projections of changes in species distributions can be assessed in different ways like with the help of expert opinion, with conceptual models (e.g. plant functional trait), statistical models or dynamic models.

Tools for predicting changes in biodiversity

The species area relationship (often presented as $S = cA^2$ on a log/log scale)
When the natural area is reduced, the number of species decreases. The Millennium Ecosystem Assessment predicts a loss of 15% of species. In the tundra ecosystem, climate change is the main driver, whereas in warm mixed forests the agricultural expansion the main driver is. In the boreal forest there are hardly changes expected in species richness. It should be noted that these are relative changes in species richness. When loss is expected to be low, but not many species are left, loss of species is still risky. This method has several disadvantages. The 'highest point' in the curve is assumed to be the species diversity at equilibrium for an certain area, but mostly it is not known whether species got lost before measuring. Another assumption is that habitat loss results in species loss not accounting for possible adaptation of species.

Niche-based modeling of species distributions
This method tries to determine a species' ecological space from its geographical distribution and various environmental variables. With this information one can model from the current geographical distribution the future geographical distribution under different scenarios. This is an at the moment a widely used method. A disadvantage of this method is that one models the geographical range of suitable habitat under different scenarios, but that it is not known whether a species will colonize these new areas.

Niche-based species change
This method aggregates individual species' responses in order to assess the percentage change in species diversity per region. This approach showed that for plants the mountain and Mediterranean areas of Europe, with the greatest changes expected for the intermediate altitudes.

Model uncertainties
Different models with a similar application will mostly yield different predictions. To overcome this problem, one can apply a consensus analysis. From a bench of models a range of projections per species is created. Trough so called 'averaging boosting' the models are combined to one map for species range shifts. This has the advantage of a single visualization for different models, and can be used as input for models that combine different species. This method can be used to combine different model types, but also to combine different scenarios. It should be noted that this method looks at uncertainty between models and not within each model. The internal variation of the models can sometimes be larger than the variation between models.
Other important uncertainties can be found in the biological simplifications. Most climate models ignore other drivers for ecological distribution, and ignore interactions between species like competition.

Model validation
Validation of bioclimatic models remains tricky because it is hard to get independent data sets and good time series. It is possible to apply tricks like data splitting or historical model projections, but these are still non-independent. Really independent are for example data series from 20 year species surveys.

Hybrid models
The future of predictive modeling of biodiversity changes lies in combining two different types of models. The first type consists of the niche based models without biological interactions that predict a potential future distribution. The second type consists of spatially explicit models that implement spatial and temporal changes and test for realized species distributions.

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