Community Ecology
https://doi.org/10.1007/s42974-024-00184-8

FORUM

Increased focus on measuring diversity may lead to a crisis in community ecology

Christian Damgaard[1]

Received: 19 December 2023 / Accepted: 3 April 2024

Traditionally, the focus in community ecology has been to measure species abundance and investigate how the community composition changed over time as functions of biotic interactions and the environment, $\frac{dx_i}{dt} = f(\boldsymbol{x}, \boldsymbol{z})$, where $\boldsymbol{x}$ is a vector with the abundance of the interacting species and $\boldsymbol{z}$ is the environment. Such general equations have been the backbone of community ecology since the pioneering work of Lotka, Volterra, Gause, and May (Gause, 1934; Lotka, 1920; May, 1971; Volterra, 1926) and have been the conceptual foundation underlying many of the central hypotheses on species interaction in community ecology, e.g. species competition, food webs, etc. Furthermore, species abundance measurements are critical for using trait-based methods in community ecology (Garnier et al., 2016; Grime, 1998).

However, lately the central object of investigation in community ecology seems to be shifting away from species abundance towards diversity. Biodiversity has become the most important catch phrase in ecology, and the objective of most current ecological investigations is to understand and predict the current decline in biodiversity. Unfortunately, biodiversity is a complicated concept, and there is no uniformly agreed upon definition or way to measure it (Magurran, 2004). Typically, biodiversity is used synonymous with species richness (the number of species), but it is also common to weight species richness with abundance (e.g. Shannon or Simpson diversity). However, more importantly, we do not have a general mechanistic model of how biodiversity changes with time (Storch et al., 2018). The absence of a model of biodiversity change means that the only theoretically sound way we can predict a change in biodiversity is by studying the expected changes in species abundance and then predict the probabilities of extinction and migration of different species. However, such an indirect methodology is often not the preferred way to study biodiversity. Instead, it is increasingly common to collect biodiversity measures directly, e.g. species richness or functional diversity (Carmona et al., 2016). While such direct measurements of biodiversity and variation provide a good status of the biodiversity measure of interest, the studies do not lead to predictions on future biodiversity, except for non-mechanistic statistical relationships, such as the observed change in biodiversity along environmental gradients (Storch et al., 2018). Then again, observed relationships among biodiversity patterns and environmental gradients may generate interesting hypotheses and initiate research leading to deeper understanding of the underlying ecological processes.

In a literature search of articles with the term "community ecology", where the terms "abundance" and "diversity" are used (Fig. 1), it was found that the use of the term "diversity" is increasing with time relative to the use of the term "abundance". This indicates that that the primary focus of community ecologists is shifting away from abundance towards diversity.

In my opinion, a reduced focus on empirical measurements of species abundance may lead to a scientific crisis in community ecology, where the development of theoretical ecological models will be more and more separated from the empirical ecological work and data collection.

In Denmark, an ambitious ecological monitoring program (Nielsen et al., 2012), where plant species cover was measured by the pin-point method, has been discontinued, and in most habitat types only presence-absence plant species data are now recorded. This change in the monitoring protocol was partly motivated by taking working conditions into account but was also due to the fact that species diversity data were considered sufficient for monitoring and predicting the plant ecological component of habitat quality. Consequently, it is now impossible to maintain the monitoring of, e.g. the cover of sensitive species in calcareous grasslands (Damgaard, 2023).

✉ Christian Damgaard
cfd@ecos.au.dk

[1] Department of Ecoscience, Aarhus University, C.F. Møllers Allé 4, 8000 Aarhus C, Denmark

Published online: 17 April 2024

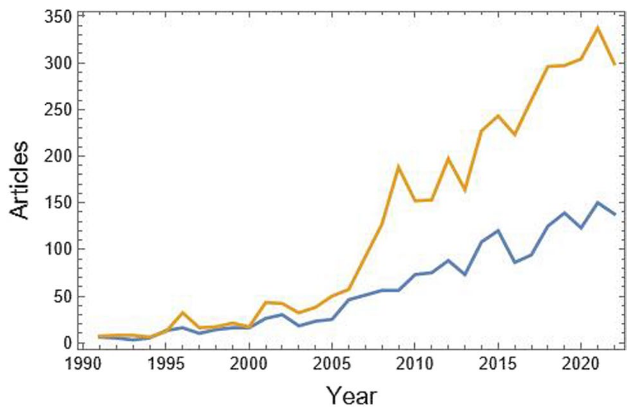

Fig. 1 Trends in the use of the terms "abundance" (blue) and ("diversity" OR "biodiversity") (yellow) in articles with the term "community ecology" (extracted from the Web of Science database). Please note that using the search term "abundance" does not capture all studies where abundance was measured, but it is assumed that the proportion is not changed over the years

The increasing focus in community ecology on measuring species diversity rather than abundance has been accelerated by the exceptional developments in E-DNA methodology. It is now becoming a standard technique in most ecological laboratories to extract DNA from soil and water samples and make inferences on species diversity, and the reporting of species diversity using E-DNA methods is increasing exponentially (Rodríguez-Ezpeleta et al., 2021). It is often discussed that it is possible to measure species abundance in E-DNA samples using quantitative PCR methods (Shelton et al., 2023; Tsuji et al., 2022), but there are several fundamental problems, e.g. i) the variable and species-specific number of DNA copies per individual, ii) the redistribution and degradation processes of E-DNA during space and time, iii) the partly random sampling process during the PCR cycles, and iv) generally non-reproducible results (Klymus et al., 2020). So, even though it may be theoretically possible to measure species abundance in E-DNA samples, the typical outcome of an investigation using E-DNA methods is still a measure of species diversity.

To better align theoretical and empirical ecological work, it is important that the development of new sampling techniques in ecology refocus on the importance of measuring species abundance of the dominant species. In this respect, it is promising that the use of drones and neural networks in the near future will enable us to obtain low-cost high-resolution maps of plant species abundance at a relatively large spatial scale (Damgaard, 2021; Detka et al., 2023). This important development may spur a renewed interest in developing plant ecological models that may be fitted to the new data types and allow us to make credible ecological predictions with a variable degree of uncertainty. Such ecological predictions that are rooted in theoretical models and empirical species abundance data may provide important input for dealing with the biodiversity crisis in the Anthropocene.

Funding Open access funding provided by Aarhus Universitet.

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