

## Opinion

## Detecting the Multiple Facets of Biodiversity

Marta A. Jarzyna<sup>1,\*</sup> and Walter Jetz<sup>1,2</sup>

Interest in, and opportunities to include functional and phylogenetic attributes of species in community ecology and biogeography are rapidly growing and seen as vital for the assessment of status and trends in biodiversity. However, the fundamental underlying evidence remains the (co-)occurrence of the biological units, such as species, in time and space and our ability to appropriately detect and quantify them. Here, we examine the implications of imperfect detection of species for functional and phylogenetic diversity (FD and PD) estimates. We explore how FD and PD might have different detectabilities than taxonomic diversity (TD) and how all three might vary differently along spatial and environmental gradients. We also extend occupancy modeling and dendrogram-based methods to address the imperfect detection of different biodiversity facets.

## The Multifaceted Nature of Biodiversity

Ongoing and projected global biodiversity loss has triggered a surge in studies documenting spatial variation and temporal changes in biodiversity [1–4]. Most usually, these focus on **taxonomic diversity** (TD; [Glossary](#)), often measured as species richness [3,5,6]. TD measures ignore the fact that communities comprise species with different phylogenetic positions and a range of ecological functions, and, thus, often miss information regarding ecosystem functioning and community evolutionary history [6,7]. Acknowledging the trait-based and phylogenetic attributes of species, in both a global and a local context, is not only increasingly seen as vital for conservation prioritization [8–11], but has also become a promising avenue to better address the processes responsible for spatial and temporal dynamics of species co-occurrence [12–14]. This has led to the increasing popularity of alternative biodiversity metrics, such as **phylogenetic diversity** (PD; reflecting the assemblage evolutionary history and measured as the sum of the branch lengths of a phylogenetic tree connecting all species; [15]) and **functional diversity** (FD; reflecting the diversity of ecological functions and often captured as the sum of branch lengths in a dendrogram representing differences among species in terms of forms or functions [16,17]). The rapid growth in phylogenetic trees and trait compilations paired with dendrogram-based approaches has resulted in several applications, including mapping ecosystem services [18–20], elucidating trait–environment relations [21,22], evaluating conservation targets [23], and impacts of global change [24,25].

These significant advances for bringing new facets of biodiversity into the analysis of assemblage structure and change stand in contrast to ongoing limitations in the spatiotemporal evidence base. The fundamental unit of all TD, FD, and PD metrics usually remains the presence or abundance of a single species over a defined area and time [26,27]. However, beyond small plots, even systematic surveys rarely detect all species or individuals in a community or population, resulting in either false species absences or the underestimation of population sizes [28]. Factors affecting the detection of both animal and plant species or individuals include, but are not restricted to, characteristics of the organism being surveyed (e.g., species distinctness; abundance; behavior, such as vocalization rate or movement frequency; species size; life stage; morphology; etc. [29–33]), the environment and accessibility of a given site (e.g., habitat

## Trends

Trait-based and phylogenetic attributes of species are increasingly seen as vital components to better address the processes underlying spatial and temporal biodiversity dynamics and the potential consequences of biodiversity change.

A rapid growth in phylogenetic trees and trait compilations has led to an increase in phylogenetic and functional diversity studies and resulted in numerous applications, including evaluating impacts of global change, setting conservation targets, and mapping ecosystem services.

All diversity metrics remain limited by our ability to measure them in the field. The fundamental unit (the presence or abundance of a single species) is rarely perfectly captured and measurement quality varies by species, environments, and traits.

The potential consequences of this imperfect detection for functional or phylogenetic diversity have to date remained unexamined.

<sup>1</sup>Department of Ecology and Evolutionary Biology, Yale University, 165 Prospect Street, New Haven 06520, CT, USA

<sup>2</sup>Department of Life Sciences, Imperial College London, Silwood Park Campus, Buckhurst Road, SL5 7PY Ascot, Berks, UK

\*Correspondence: [marta.jarzyna@yale.edu](mailto:marta.jarzyna@yale.edu) (M.A. Jarzyna).

structure; topographical gradient; etc. [34,35], site species richness [36], and factors related to an individual survey or sampling event (e.g., weather conditions; noise level; observers' experience and ability to detect species; size of the survey plot; etc. [32,37–39]).

The consequences of ignoring the imperfect detection of species have been recognized in wildlife sciences and population biology for over a decade [28,40], and biodiversity studies have recently begun to appreciate the full impact of imperfect detection [26,41]. Initial inquiries examined the consequences of ignoring the imperfect detection of species on species richness [40–43]; since then, multispecies frameworks have emerged to account for imperfect detection in the estimates of taxonomic diversity [26]. However, the **site-level probability of species detection** is intimately connected to their behavior and ecology [44] which in turn often have strong phylogenetic determinism and co-variation with multiple sets of traits [45,46]. It follows that metrics related to species functional or phylogenetic attributes will be closely linked to the site-level probability of species detection in an assemblage. Despite this obvious connection and the broad interest in multiple biodiversity measures, the potential consequences of imperfect species detection for FD or PD have to date remained unexamined. Here, we address this by examining the potential magnitude and consequences of this issue for inference and application in biodiversity science and change assessments and illustrate how different biodiversity facets can be corrected for imperfect detection.

### Detectabilities of Taxonomic, Functional, and Phylogenetic Diversities

We first assess the different scenarios for how imperfect detection of species might misrepresent the true variation in TD, FD, and PD along spatial or environmental gradients. We recognize that biodiversity studies are also vulnerable to false positive detection errors, which can lead to the overestimation of biodiversity and bias estimates of temporal biodiversity change [47], but a detailed discussion of the consequences of false positives for the different biodiversity attributes is beyond the scope of this paper. We further focus on incidence-based measures of assemblage diversity, such as those based on count of species (TD) or sums of branch lengths in phylogenetic or functional dendrograms [16,48]. We acknowledge that FD and PD can rarely be considered interchangeable [49,50]; however, the influence of imperfect detection of species on FD and PD will often be based on the same underlying principles, and might be similarly measured in dendrograms. For the sake of exploring the basic principles related to detection, we treat the two measures as interchangeable. To illustrate the general principle of detecting the multiple facets of biodiversity, we define the ability to detect biodiversity at a given site as the **'detectability of biodiversity'** ( $q$ ) and quantify it as a ratio of observed naïve biodiversity to true or detection-corrected biodiversity at that site.

We identify six general scenarios (Figure 1) of how detectability can vary along gradients for estimates of TD, FD, and PD. In a first scenario, species are observed perfectly along the entire spatial or environmental gradient (Figure 1A) and, accordingly, the measurements accurately represent the variation in biodiversity. We expect this case to be rare or even unrealistic for most spatiotemporal biodiversity data, with the exception of small (e.g., vegetation) plots, surveys with large sampling effort, or taxonomically narrowly restricted situations. In other instances (Figure 1B), the ability to detect the true state of biodiversity might be imperfect (i.e., detectability of biodiversity is  $<1$ ) but constant across gradients. Here, the relative variation in biodiversity will likely be captured, but biodiversity itself is underestimated. If detectability of biodiversity varies along spatial, environmental, or temporal gradients (Figure 1C; e.g., when the ability to observe a true state of biodiversity decreases with elevation), then biodiversity will not be consistently represented in all locations and environments, obfuscating the relative variation in biodiversity.

More critically, the ability to detect biodiversity might also vary among the different facets of biodiversity. For example, the ability to detect TD (i.e., detectability of TD;  $q_{TD}$ ) might surpass that

### Glossary

**Dendrogram-based functional diversity (FD):** a diversity of forms and functions found within an assemblage, captured as the sum of branch lengths in dendrogram representing species differences in forms or functions (*sensu* Petchey and Gaston [16]).

**Dendrogram-based phylogenetic diversity (PD):** the sum of the branch lengths of a phylogenetic dendrogram connecting all species (*sensu* Faith [11]).

**Detectability of biodiversity:** the ratio between TD, FD, or PD that is observed during a sampling event at a given location and the true (or detection-corrected) TD, FD, and PD present at that location.

**Local functional distinctness of species:** the uniqueness of a species in terms of its functional characteristics among all species found in the local community; given by the fair proportion branch length of the branches in a functional dendrogram leading to a species tip. The local functional distinctness of a species depends not only on the characteristics of the species itself, but also on the distribution of different forms and functions within the local community.

**Local phylogenetic distinctness of species:** the uniqueness of a species in terms of its evolutionary history among other species in the community; given by the fair proportion branch length of the branches in a phylogenetic dendrogram leading to a species tip. The local phylogenetic distinctness of a species depends on the distribution of phylogenetic relations within the local community.

**Site-level probability of species detection:** probability that a species will be detected at a site, given that it is present at that site. The probability of species detection depends on the factors related to an individual survey or a sampling event (e.g., observer, effort, time of day or year, etc.), environmental characteristics of the site (e.g., elevation, habitat conditions, etc.), and characteristics of species and individuals being surveyed (e.g., behavior, life history, abundance, age, etc.).

**Taxonomic diversity (TD):** the number of different species present in the community (i.e., species richness).

Download English Version:

<https://daneshyari.com/en/article/142293>

Download Persian Version:

<https://daneshyari.com/article/142293>

[Daneshyari.com](https://daneshyari.com)