

Contribution to the development of a multifaceted diversity framework in the context of the Biology–Ecology–Environmental Sciences–Environmental Engineering–and–(Human) Society (BEES) System.

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Structural and functional loss of biodiversity and habitat heterogeneity are among the main plagues of the age and pose an increasing threat to the future of our planet. Despite all efforts, mostly declaratory and less effective, the edge of the diversity crisis, embodied by the next, also called the sixth mass extinction, was allegedly already passed. Among the many cases of failure of decelerating extinction rates and environmental damage are the conceptual and methodological limitations. Biodiversity and its ecological counterpart have been defined and measured mostly unidimensionally or at least in a very narrow approach, including taxonomic, functional, phylogenetic, and other constitutive details, ranging from genes to human society, without any holistic attempt to combine and express the multidimensional features of life and environmental heterogeneity in a unified hyperspace. First, we stress that all ecological and societal issues must be placed in a broad context, defined as the holistic paradigm termed Biology–Ecology–Environmental Sciences–Environmental Engineering–and–(Human) Society (BEES) System. Then, within this system, the traditional metrics of diversity, namely the Taxonomic, Functional, Niche-based, and Phylogenetic Diversity as well as their constituents, have to be combined and unified into a multifaceted conceptual and methodological framework. We introduced several new indices and approaches: the Overall Diversity (OD) which combines taxonomic, functional, niche, and phylogenetic diversities into a single measure, visualized geometrically as multidimensional volumes, Lambda diversity (λ) captures the dynamic changes in community composition along gradients —reflecting species turnover, persistence, and replacement, Xi diversity (ξ) links biodiversity with environmental and spatial heterogeneity, integrating “life, environment, and space” into a common measure of ecological diversity, and the SADDI (Standardized Average Diversity Distinctness Index) synthesizes all these dimensions into one standardized value, providing a holistic picture of biodiversity complexity. SADDI is calculated as an n-th root of the determinant of a distance or dissimilarity matrix between several diversity measures. Relying on real and simulated data sets, we formally described the measures and their assessment using scripts and projects in software such as R, Mathcad, and Canoco. Our introduced measures reveal geometric structure, multidimensional relationships, and hidden dependencies that univariate indices cannot capture. They also facilitate communication between experts and the public, providing accessible means to express diversity dynamics, paralleled by an increasing reliance on biodiversity data by managers and policymakers. Rather than replacing established methods, our synthetic measures aim to complement them. Together, they can enhance monitoring, modelling, conservation, management, and cross-disciplinary dialogue, while supporting trans- and interdisciplinary research and education, strengthening communication, and may ultimately help establish more effective strategies to mitigate loss and protect the ecological and cultural values of diversity.

References

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