frontiers | Frontiers in Ecology and Evolution

PERSPECTIVE
published: 12 May 2022
doi: 10.3389/fevo.2022.891627

Promoting Biodiversity Conservation Requires a Better Understanding of the Relationships Between Ecosystem Services and Multiple Biodiversity Dimensions

Shuyao Wu[1,2], Yuqing Chen[3], Chaozhi Hao[4], Kaidi Liu[1,2], Wentao Zhang[1,2] and Linbo Zhang[1,2]*

[1] Qingdao Institute of Humanities and Social Sciences, Shandong University, Qingdao, China, [2] Center for Yellow River Ecosystem Products, Shandong University, Qingdao, China, [3] Fenner School of Environment and Society, Australian National University, Canberra, ACT, Australia, [4] School of Environmental Science and Engineering, Shandong University, Qingdao, China

OPEN ACCESS

Edited by:
Orsolya Valkó, Hungarian Academy of Sciences, Hungary

Reviewed by:
Jean-Olivier Goyette, Laval University, Canada

***Correspondence:**
Shuyao Wu
wushuyao@email.sdu.edu.cn

Specialty section:
This article was submitted to Conservation and Restoration Ecology, a section of the journal Frontiers in Ecology and Evolution

Received: *08 March 2022*
Accepted: *11 April 2022*
Published: *12 May 2022*

Citation:
Wu S, Chen Y, Hao C, Liu K, Zhang W and Zhang L (2022) Promoting Biodiversity Conservation Requires a Better Understanding of the Relationships Between Ecosystem Services and Multiple Biodiversity Dimensions. Front. Ecol. Evol. 10:891627. doi: 10.3389/fevo.2022.891627

In order to reverse the global trend of biodiversity loss, the concept of ecosystem services has been widely applied to make policymakers and the general public realize that conserving biodiversity possesses both intrinsic and utilitarian values. However, to achieve this goal, it is necessary to first have a clear understanding of the relationships between biodiversity and ecosystem services (BES). To advance our understanding of this issue, we first reviewed the major progress in current BES studies, with an emphasis on three biodiversity dimensions (i.e., taxonomic diversity, functional diversity, and ecosystem diversity). Based on the findings, we then propose three research topics as future directions: (1) More direct and explicit studies on the effects of different dimensions of biodiversity on various ecosystem service types; (2) developing a biodiversity-based understanding of the formation of ecosystem services; (3) creation of science-based ecosystem management plans and policies that can maximize synergies between biodiversity conservation and ecosystem service enhancement. By conducting such research, we will be able to not only further understand the complex relationships between biodiversity and ecosystem services but also better promote the concept of ecosystem services for more successful biodiversity conservation in the future.

Keywords: biodiversity conservation, ecosystem service, biodiversity dimension, review, future direction

INTRODUCTION

Natural ecosystems are the basis for human survival and the foundation for social stability and sustainable development. However, according to the 2019 report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the global biodiversity level and 23 essential ecosystem service indicators all showed declining trends in the past 50 years (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services., 2019). In order to decelerate and reverse the trends, many ideas, goals and approaches have been proposed and implemented, such as the "30 by 30" goal, "Half-Earth" target, nature-based solutions, etc.

(Pimm et al., 2018; Anderson et al., 2019; Dinerstein et al., 2019). Among the ideas, one particular school of thought is to incorporate the relatively more anthropocentric concept of ecosystem services, which can be defined as nature's contribution to human wellbeing, into biodiversity conservation (Mace et al., 2012; Pearson, 2016). One of the strong drivers behind such proposals is to make policymakers and the general public realize that conserving biodiversity also helps to preserve the essential benefits people obtain from nature (The Economics of Ecosystem and Biodiversity, 2012; Bai et al., 2018). To achieve this goal, it is paramount to first have a clear understanding of the relationships between biodiversity and ecosystem services.

According to the Convention on Biological Diversity, biodiversity should be viewed as "the variability among living organisms from all sources," which includes "diversity within species, between species and of ecosystems" (United Nations, 1992). Based on this definition, we can see that the meaning of biodiversity is multidimensional and has several aspects across scales. At the same time, the connotation of ecosystem services is also diverse (The Economics of Ecosystem and Biodiversity, 2012). In the seminal work by Costanza et al. (1997), they presented a total of 17 important ecosystem services and estimated their values around the world. Later on, the Millennium Ecosystem Assessment initiated by the United Nations classified these ecosystem services into four categories, namely provisioning, regulating, cultural, and supporting services (Millennium Ecosystem Assessment, 2005). This classification has also been adapted in the recently released System of Environmental Economic Accounting—Ecosystem Accounting, which depicts over 30 ecosystem service types (United Nations Committee of Experts on Environmental-Economic Accounting, 2021).

These various ecosystem services will not form without the support of biodiversity. According to the ecosystem service cascade framework proposed by Haines-Young and Potschin (2010), the effect pathways of ecosystem services can be summarized as from ecosystem "structure and process" to "functions," then to "services," then to socio-economic "benefits," and finally to the promotion of human "values." This framework establishes a link between natural ecosystems and socio-economic systems. There is mounting evidence showing that biodiversity, as one of the important characteristics of ecosystem structure, is the main driver and regulator of many crucial ecosystem functions (Isbell et al., 2011; Huang et al., 2018; Albrecht et al., 2021). Biodiversity can affect ecosystem functions like productivity, carbon storage and nutrient supply through mechanisms such as interspecific complementation, increased resource utilization and reduced disturbance (Tilman et al., 2014; Slade et al., 2019). Since ecosystem services are derived directly from these ecosystem functions, the supply of ecosystem services will also be significantly affected by the biodiversity (Wu and Li, 2019).

Recently, multiple major achievements have been made regarding the understanding of the relationships between biodiversity and ecosystem functions (Bongers et al., 2021; Hong et al., 2022; Scherer-Lorenzen et al., 2022). Compared with ecosystem functions, ecosystem services are more closely linked to human wellbeing (Manning et al., 2018). Nonetheless, how biodiversity affects ecosystem services still remains an open question (Maasri et al., 2022). Here, to advance our understanding of this important question, we first reviewed major progress in the studies on the relationships between biodiversity and ecosystem service (BES), with an emphasis on three important dimensions of biodiversity. They are taxonomic diversity, functional diversity and ecosystem diversity, which represent the biodiversity dimensions at both interspecies and ecosystem levels. Then, we summarized current challenges and proposed possible future directions of BES studies.

CURRENT ADVANCES IN BIODIVERSITY AND ECOSYSTEM SERVICE RESEARCH

Over the past two decades, the relationships between biodiversity and ecosystem services have become one of the research hotspots in the fields of both ecosystem services and biodiversity conservation. Based on the search results from the ISI Web of Knowledge database, more than 16,000 relevant studies have been published with an increasing trend during the period from 2001 to 2020 (**Figure 1**). However, if we break down these BES studies into different biodiversity dimensions and service types, we found that not all dimensions of biodiversity and types of services received the same amount of attention (**Figures 1A,B**).

Among the three biodiversity dimensions, taxonomic diversity (or species diversity), which is the representation of biodiversity at the species level, received the most research attention (**Figure 1A**). This is understandable since taxonomic diversity has also been the major focus of biodiversity conservation studies and policies for a very long time. Some major advances in the BES studies involving taxonomic species include Letourneau et al. (2011) systematic analysis of 552 experimental results in 45 related studies of agroecosystems. They found that 39% of the experiments suggested that high taxonomic diversity increased food production, but 61% of the results showed that production decreased with the increase of species diversity. On the other hand, Gamfeldt et al. (2013)'s extensive survey results of 4,335 forest plots in Sweden found that the supply level of multiple ecosystem services was generally higher in areas with higher taxonomic diversity. In 2016, Ricketts et al. (2016) presented their systematic review of over 500 studies on biodiversity and ecosystem services and summarized three general types of analysis methods for this issue. However, the conclusions of different analysis methods were found to be inconsistent and heavily affected by scale effects. More recently, Biber et al. (2020) also projected that only neutral or weak synergistic relationships exist between biodiversity and wood production as well as carbon sequestration by using simulation models under three combined climate and socio-economic scenarios across Europe. All of these mixed results suggest that we are still far from fully comprehending the relationship between taxonomic diversity and ecosystem service supply.

Another dimension of biodiversity that is receiving more and more attention from the research community is functional diversity and its effects on the supply of ecosystem services (**Figure 1A**). Functional diversity refers to the variation range of functional characteristics among species in a community or the

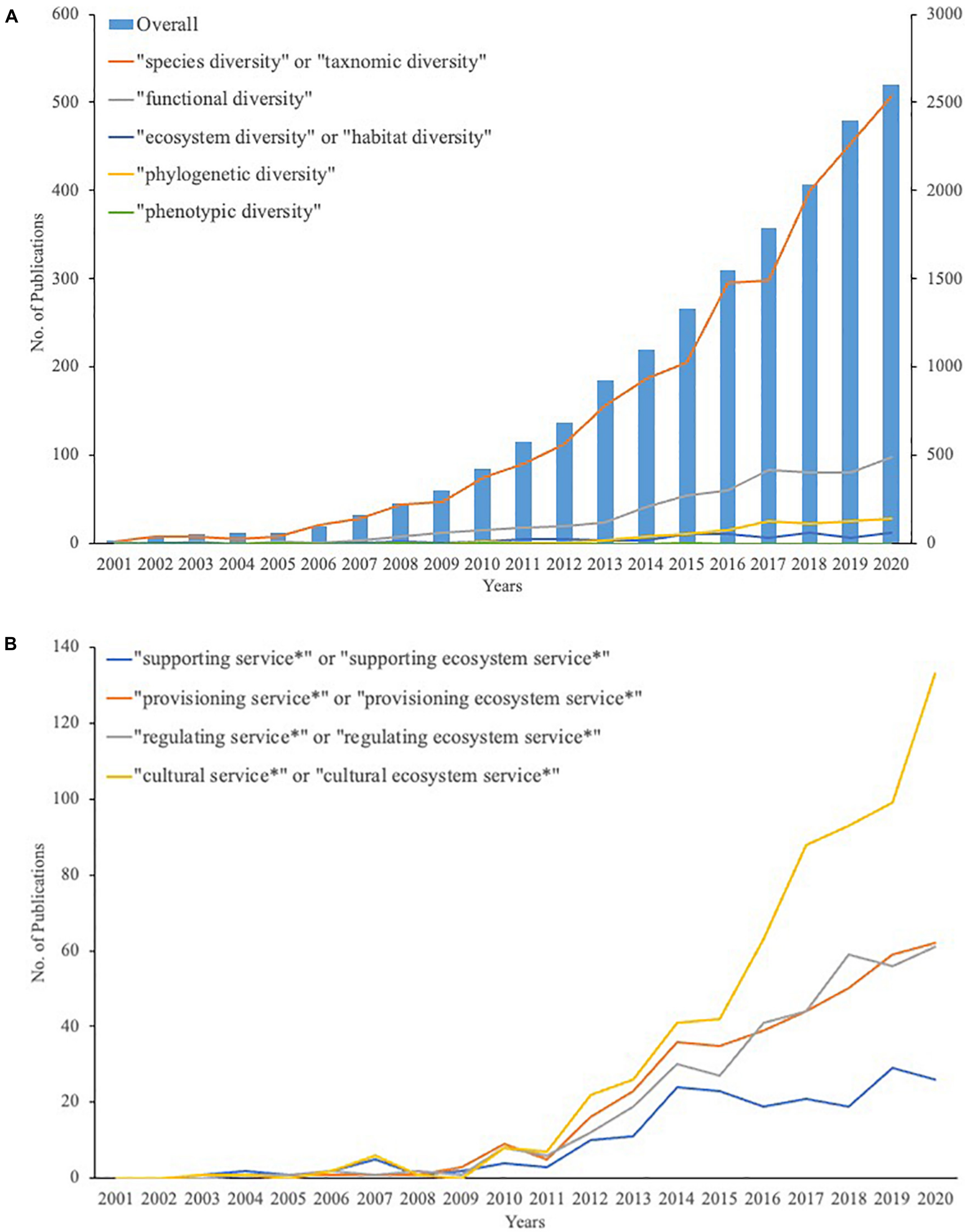

FIGURE 1 | Number of publications on biodiversity and ecosystem services from 2001 to 2020 in the ISI Web of Knowledge database. **(A)** The columns (right *y*-axis) represent the "Overall" search results using "biodiversity" and "ecosystem service*" as topic terms; the lines (left *y*-axis) represent refined search results using different dimensions of biodiversity as topic terms (only a total of four "phenotypic diversity" related publications found in 2005, 2008, 2010, and 2015). **(B)** The refined search results using different types of ecosystem services as topic terms.

value and range of functional characteristics of all species in a specific ecosystem (Petchey and Gaston, 2002). In recent years, functional traits of plants have gradually been seen as an effective tool to reveal the formation mechanism of ecosystem functions (Cadotte et al., 2011; Balzan et al., 2016). This is mainly due to the fact that the various functional traits of plants can reflect the differences in resource acquisition ability among plant species in the community and plants' adaptability to environmental changes (Díaz et al., 2007). At present, studies have tried to quantify the relationships between plant functional diversity and some important ecosystem functions by using observation quadrats, remote sensing data and controlled experiments. For example,

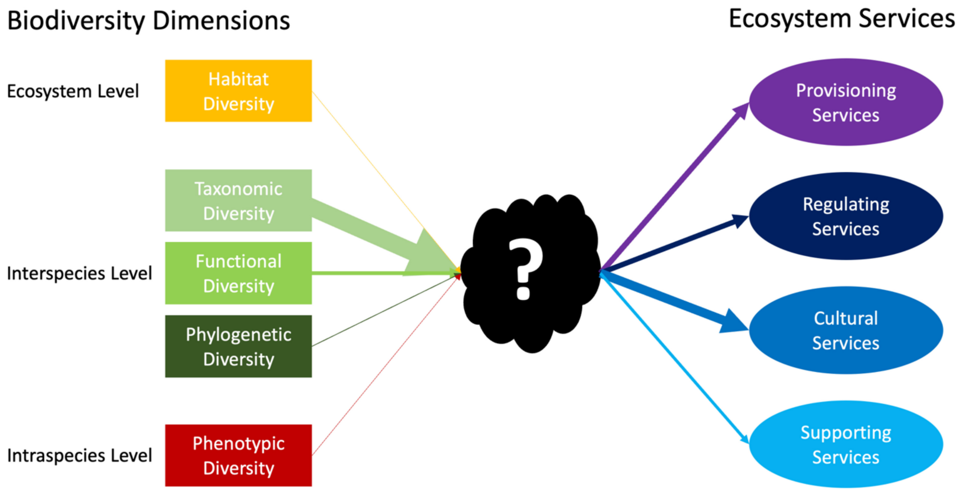

FIGURE 2 | Conceptual diagram of the future research needs on the relationships between multiple biodiversity dimensions and ecosystem service supply. Line widths correspond to the number of relevant publications found in our literature search from 2001 to 2020.

Bongers et al. (2021) analyzed the functional characteristics of 38 species of trees in 478 biodiversity control plots and found that functional diversity became the main predictor of tree productivity after 7 years of the experiment establishment. Furey and Tilman (2021) also found that higher functional diversity could effectively improve soil fertility by analyzing the long-term data of a grassland biodiversity control experiment for 23 years. It was shown that soil nitrogen, potassium, calcium, magnesium, cation exchange capacity, and carbon in high functional diversity areas increased by about 30–90% compared with areas with only one species. On the other hand, negative relationships between functional diversity and ecosystem functions have also been reported. Yi et al. (2022) explored the relationship between structural differences and vegetation productivity by using the long-term survey and LiDAR data of nine different succession stages of a one-hectare forest plot. The findings suggested that the asymmetric competition between upper and lower crowns for light resources might lead to a negative correlation between canopy structural diversity and productivity. Nevertheless, most studies involving functional traits focus on their effects on ecosystem functions rather than services. Direct research on the impacts of plant functional diversity on explicit ecosystem service supply (e.g., cultural services such as recreation, education, aesthetics, etc.) is still in its infancy and no unified conclusion has been drawn yet.

Compared to taxonomic and functional diversity, ecosystem diversity (or habitat diversity), which stands for the number, kinds and patterns of landscape ecosystems and their processes, has received much less attention in BES research (Lapin and Barnes, 1995; **Figure 1A**). Since there are differences in the main types of ecosystem services provided by different ecosystems (e.g., forests, grasslands, wetlands, etc.), greater ecosystem diversity can lead to more diverse supplies of ecosystem services (Alsterberg et al., 2017; Xie et al., 2017). Currently, empirical evidence on the effects of different habitat diversity levels on ecosystem service supply is still lacking. Some attempts include Shen et al. (2020) study, which identified seven ecosystem service clusters in the Beijing-Tianjin-Hebei region of China, and found that the service clusters provided by different land cover compositions vary largely. This result demonstrates that trade-offs among ecosystem services might be common in areas with different ecosystem compositions. Moreover, Oehri et al. (2020) also analyzed the abundance of land cover types and landscape productivity in 4,974 plots ranging from 6.25 to 25 hectares in the European Alps and concluded that there was a significant positive correlation between more diverse land cover types and landscape productivity as well as its temporal stability. Furthermore, Yang et al. (2021) used the villages and towns in Sichuan, China as research units and reported a strong correlation between landscape-scale diversity indices and three types of ecosystem services, namely soil conservation, water conservation, and carbon sequestration. Despite these efforts, a lot more studies are needed to answer how ecosystem diversity could affect the supply of ecosystem services at the landscape scale and what the potential effect pathways are.

In terms of the types of ecosystem service considered, our review agreed with Harrison et al. (2014) finding that most BES studies considered multiple ecosystem service types. In addition, we also found that cultural services are the most common topic followed by provisioning and regulating services such as biomass production, climate regulation and erosion control in BES research (**Figure 1B**). Multiple other reviews have also shown that different ecosystem services respond differently to the influence of biodiversity. For instance, after systematically analyzing 108 relevant studies on the relationship between 40 functional traits and 11 grassland ecosystem services, Hanisch et al. (2020) suggested that different ecosystem services could have distinct associations with various functional traits. Some associations (e.g., the one between biomass production and root tissue density) could be positive and strong; while others (e.g., the one between climate regulation and specific leaf area) could be negative and weak. Similarly, Zheng et al. (2021) conducted a meta-analysis on the association between 13 forest ecosystem services and 79 plant traits and discovered six groups of common "trait-service clusters" in forest ecosystems. They also found that many of the clusters among ecosystem services and various plant traits were not stable and could vary greatly in different environments. Nevertheless, there has been very little research into whether various ecosystem services have the same associations with different biodiversity dimensions.

DISCUSSION

After reviewing the current advances in BES research, we found that there are still great uncertainties in the current BES study results regarding how biodiversity affects the supply of ecosystem services (**Figure 2**). The academic community has not yet reached a consistent conclusion on the formulation of universal strategies for biodiversity conservation and ecosystem service enhancement. Studies have shown that great complexity is embedded in both ecosystem services and biodiversity (Meyer et al., 2018). On one hand, ecosystem services might be the result of multiple instead of one single ecosystem function (Cardinale et al., 2012; Hanisch et al., 2020). For instance, the temperature regulation service provided by urban greenery is the result of both evapotranspiration and shade provision (Wong et al., 2021). On the other hand, biodiversity includes many aspects across different dimensions. These biodiversity dimensions might not act equally in terms of influencing the supply of ecosystem services (Harrison et al., 2014; Ricketts et al., 2016). Some studies emphasized the importance of functional diversity; whereas others showed significant effects of species richness and ecosystem diversity. The lack of empirical evidence of the relationships between multiple biodiversity components and ecosystem services makes it difficult to reach more general conclusions on BES relationships.

To address these challenges, we propose three possible research directions for future BES studies. The first and foremost is the need for more direct and explicit studies that quantify the effects of different dimensions of biodiversity on various ecosystem service types, especially from the perspectives of currently overlooked dimensions. For example, measurements of all taxonomic, functional and ecosystem diversity in experimental or observation plots can be recorded along with the data of ecosystem services to explore the potential effects of each biodiversity dimension on service supply. These studies should also be conducted across different times, places and environmental change scenarios to obtain more universal patterns (Isbell et al., 2018). Secondly, we suggest developing a biodiversity-based understanding of the formation of ecosystem services. For instance, functional trait-based mechanisms can be hypothesized and tested to explain the formation of ecosystem service supply under different environmental conditions (van der Plas et al., 2020). The results from biodiversity-ecosystem functioning studies can be used to identify potential candidate traits, such as those related to the leaf economics spectrum, leaf structure, leaf chemicals, stomatal conductance, stem hydraulics, etc. (Bongers et al., 2021). Last but not least, how to create ecosystem management plans and policies that can maximize synergies between biodiversity conservation and ecosystem service enhancement should also be a research focus for broader BES results applications. Policies like the Ecological Redline Policy proposed by the Chinese government to promote sustainable land use planning can greatly benefit from such research (Bai et al., 2018). By conducting these studies, we will be able to not only further understand the complex relationships between biodiversity and ecosystem service supply but also better promote the concept of ecosystem services for more successful biodiversity conservation in the future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

SW contributed to the conception and design of the study and wrote the first draft of the manuscript. YC, CH, KL, WZ, and LZ contributed to the design of the study and wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

We thank the National Natural Science Foundation of China and the Natural Science Foundation of Shandong Province for funding this research.

REFERENCES

Albrecht, J., Peters, M. K., Becker, J. N., Behler, C., Classen, A., Ensslin, A., et al. (2021). Species richness is more important for ecosystem functioning than species turnover along an elevational gradient. *Nat. Ecol. Evol.* 5, 1582–1593. doi: 10.1038/s41559-021-01550-9

Alsterberg, C., Roger, F., Sundbäck, K., Juhanson, J., Hulth, S., Hallin, S., et al. (2017). Habitat diversity and ecosystem multifunctionality—The importance of direct and indirect effects. *Sci. Adv.* 3:e1601475. doi: 10.1126/sciadv.1601475

Anderson, C. M., DeFries, R. S., Litterman, R., Matson, P. A., Nepstad, D. C., Pacala, S., et al. (2019). Natural climate solutions are not enough. *Science* 363, 933–934. doi: 10.1126/science.aaw2741

Bai, Y., Wong, C. P., Jiang, B., Hughes, A. C., Wang, M., and Wang, Q. (2018). Developing China's Ecological Redline Policy using ecosystem services assessments for land use planning. *Nat. Commun.* 9:3034. doi: 10.1038/s41467-018-05306-1

Balzan, M. V., Bocci, G., and Moonen, A.-C. (2016). Utilisation of plant functional diversity in wildflower strips for the delivery of multiple agroecosystem services. *Entomol. Exp. Appl.* 158, 304–319. doi: 10.1111/eea.12403

Biber, P., Felton, A., Nieuwenhuis, M., Lindbladh, M., Black, K., Bahýl', J., et al. (2020). Forest Biodiversity, Carbon Sequestration, and Wood Production: modeling Synergies and Trade-Offs for Ten Forest Landscapes Across Europe. *Front. Ecol. Evol.* 8:547696. doi: 10.3389/fevo.2020.547696

Bongers, F. J., Schmid, B., Bruelheide, H., Bongers, F., Li, S., von Oheimb, G., et al. (2021). Functional diversity effects on productivity increase with age in a forest biodiversity experiment. *Nat. Ecol. Evol.* 5, 1594–1603. doi: 10.1038/s41559-021-01564-3

Cadotte, M. W., Carscadden, K., and Mirotchnick, N. (2011). Beyond species: functional diversity and the maintenance of ecological processes and services: functional diversity in ecology and conservation. *J. Appl. Ecol.* 48, 1079–1087. doi: 10.1111/j.1365-2664.2011.02048.x

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., et al. (2012). Biodiversity loss and its impact on humanity. *Nature* 486, 59–67. doi: 10.1038/nature11148

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., et al. (1997). The value of the world's ecosystem services and natural capital. *Nature* 387, 253–260. doi: 10.1038/387253a0

Díaz, S., Lavorel, S., de Bello, F., Quetier, F., Grigulis, K., and Robson, T. M. (2007). Incorporating plant functional diversity effects in ecosystem service assessments. *Proc. Natl. Acad. Sci. U.S.A.* 104, 20684–20689. doi: 10.1073/pnas.0704716104

Dinerstein, E., Vynne, C., Sala, E., Joshi, A. R., Fernando, S., Lovejoy, T. E., et al. (2019). A Global Deal For Nature: guiding principles, milestones, and targets. *Sci. Adv.* 5:eaaw2869. doi: 10.1126/sciadv.aaw2869

Furey, G. N., and Tilman, D. (2021). Plant biodiversity and the regeneration of soil fertility. *Proc. Natl. Acad. Sci. U.S.A.* 118:e2111321118. doi: 10.1073/pnas.2111321118

Gamfeldt, L., Snäll, T., Bagchi, R., Jonsson, M., Gustafsson, L., Kjellander, P., et al. (2013). Higher levels of multiple ecosystem services are found in forests with more tree species. *Nat. Commun.* 4:1340. doi: 10.1038/ncomms2328

Haines-Young, R., and Potschin, M. (2010). ""The links between biodiversity, ecosystem services and human well-being,"," in *Ecosystem Ecology*, eds D. G. Raffaelli and C. L. J. Frid (Cambridge: Cambridge University Press), 110–139. doi: 10.1017/CBO9780511750458.007

Hanisch, M., Schweiger, O., Cord, A. F., Volk, M., and Knapp, S. (2020). Plant functional traits shape multiple ecosystem services, their trade-offs and synergies in grasslands. *J. Appl. Ecol.* 57, 1535–1550. doi: 10.1111/1365-2664.13644

Harrison, P. A., Berry, P. M., Simpson, G., Haslett, J. R., Blicharska, M., Bucur, M., et al. (2014). Linkages between biodiversity attributes and ecosystem services: a systematic review. *Ecosyst. Serv.* 9, 191–203. doi: 10.1016/j.ecoser.2014.05.006

Hong, P., Schmid, B., De Laender, F., Eisenhauer, N., Zhang, X., Chen, H., et al. (2022). Biodiversity promotes ecosystem functioning despite environmental change. *Ecol. Lett.* 25, 555–569. doi: 10.1111/ele.13936

Huang, Y., Chen, Y., Castro-Izaguirre, N., Baruffol, M., Brezzi, M., Lang, A., et al. (2018). Impacts of species richness on productivity in a large-scale subtropical forest experiment. *Science* 362, 80–83. doi: 10.1126/science.aat6405

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES secretariat.

Isbell, F., Calcagno, V., Hector, A., Connolly, J., Harpole, W. S., Reich, P. B., et al. (2011). High plant diversity is needed to maintain ecosystem services. *Nature* 477, 199–202. doi: 10.1038/nature10282

Isbell, F., Cowles, J., Dee, L. E., Loreau, M., Reich, P. B., Gonzalez, A., et al. (2018). Quantifying effects of biodiversity on ecosystem functioning across times and places. *Ecol. Lett.* 21, 763–778. doi: 10.1111/ele.12928

Lapin, M., and Barnes, B. V. (1995). Using the Landscape Ecosystem Approach to Assess Species and Ecosystem Diversity. *Conserv. Biol.* 9, 1148–1158. doi: 10.1046/j.1523-1739.1995.9051134.x-i1

Letourneau, D. K., Armbrecht, I., Rivera, B. S., Lerma, J. M., Rrez, C. G., Rangel, J. H., et al. (2011). Does plant diversity benefit agroecosystems? *Synthet. Rev. Ecol. Appl.* 21:13.

Maasri, A., Jähnig, S. C., Adamescu, M. C., Adrian, R., Baigun, C., Baird, D. J., et al. (2022). A global agenda for advancing freshwater biodiversity research. *Ecol. Lett.* 25, 255–263. doi: 10.1111/ele.13931

Mace, G. M., Norris, K., and Fitter, A. H. (2012). Biodiversity and ecosystem services: a multilayered relationship. *Trends. Ecol. Evol.* 27, 19–26. doi: 10.1016/j.tree.2011.08.006

Manning, P., van der Plas, F., Soliveres, S., Allan, E., Maestre, F. T., Mace, G., et al. (2018). Redefining ecosystem multifunctionality. *Nat. Ecol. Evol.* 2, 427–436. doi: 10.1038/s41559-017-0461-7

Meyer, S. T., Ptacnik, R., Hillebrand, H., Bessler, H., Buchmann, N., Ebeling, A., et al. (2018). Biodiversity–multifunctionality relationships depend on identity and number of measured functions. *Nat. Ecol. Evol.* 2, 44–49. doi: 10.1038/s41559-017-0391-4

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press.

Oehri, J., Schmid, B., Schaepman-Strub, G., and Niklaus, P. A. (2020). Terrestrial land-cover type richness is positively linked to landscape-level functioning. *Nat. Commun.* 11:154. doi: 10.1038/s41467-019-14002-7

Pearson, R. G. (2016). Reasons to Conserve Nature. *Trends Ecol. Evol.* 31, 366–371. doi: 10.1016/j.tree.2016.02.005

Petchey, O. L., and Gaston, K. J. (2002). Functional diversity (FD), species richness and community composition. *Ecol. Lett.* 5, 402–411. doi: 10.1046/j.1461-0248.2002.00339.x

Pimm, S. L., Jenkins, C. N., and Li, B. V. (2018). How to protect half of Earth to ensure it protects sufficient biodiversity. *Sci. Adv.* 4:eaat2616. doi: 10.1126/sciadv.aat2616

Ricketts, T. H., Watson, K. B., Koh, I., Ellis, A. M., Nicholson, C. C., Posner, S., et al. (2016). Disaggregating the evidence linking biodiversity and ecosystem services. *Nat. Commun.* 7:13106. doi: 10.1038/ncomms13106

Scherer-Lorenzen, M., Gessner, M. O., Beisner, B. E., Messier, C., Paquette, A., Petermann, J. S., et al. (2022). Pathways for cross-boundary effects of biodiversity on ecosystem functioning. *Trends. Ecol. Evol.* S0169534721003566. [Epub online ahead of print]. doi: 10.1016/j.tree.2021.12.009

Shen, J., Li, S., Liang, Z., Liu, L., Li, D., and Wu, S. (2020). Exploring the heterogeneity and nonlinearity of trade-offs and synergies among ecosystem services bundles in the Beijing-Tianjin-Hebei urban agglomeration. *Ecosyst. Serv.* 43:101103. doi: 10.1016/j.ecoser.2020.101103

Slade, E. M., Bagchi, R., Keller, N., and Philipson, C. D. (2019). When Do More Species Maximize More Ecosystem Services? *Trends Plant Sci.* 24, 790–793. doi: 10.1016/j.tplants.2019.06.014

The Economics of Ecosystem and Biodiversity. (2012). *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. Routledge: Abingdon and New York.

Tilman, D., Isbell, F., and Cowles, J. M. (2014). Biodiversity and Ecosystem Functioning. *Annu. Rev. Ecol. Evol. Syst.* 45, 471–493. doi: 10.1146/annurev-ecolsys-120213-091917

United Nations (1992). *Convention on Biological Diversity*. Available online at https://www.cbd.int/convention/text/ (accessed on 28 Feb 2022)

United Nations Committee of Experts on Environmental-Economic Accounting (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting: Final Draft*. Available online at https://seea.un.org/ecosystem-accounting (accessed on 2 Mar 2022).

van der Plas, F., Schröder-Georgi, T., Weigelt, A., Barry, K., Meyer, S., Alzate, A., et al. (2020). Plant traits alone are poor predictors of ecosystem properties and long-term ecosystem functioning. *Nat. Ecol. Evol.* 4, 1602–1611. doi: 10.1038/s41559-020-01316-9

Wong, N. H., Tan, C. L., Kolokotsa, D. D., and Takebayashi, H. (2021). Greenery as a mitigation and adaptation strategy to urban heat. *Nat. Rev. Earth Environ.* 2, 166–181. doi: 10.1038/s43017-020-00129-5

Wu, S., and Li, S. (2019). Ecosystem service relationships: formation and recommended approaches from a systematic review. *Ecol. Indic.* 99, 1–11. doi: 10.1016/j.ecolind.2018.11.068

Xie, G., Zhang, C., Zhen, L., and Zhang, L. (2017). Dynamic changes in the value of China's ecosystem services. *Ecosyst. Serv.* 26, 146–154. doi: 10.1016/j.ecoser.2017.06.010

Yang, M., Xiao, Y., Ouyang, Z. Y., Jiang, L. H., and Hou, P. (2021). Relation of biodiversity and ecosystem multifunctionality in Sichuan Province (in Chinese). *Acta Ecol. Sin.* 41, 9738–9748.

Yi, X., Wang, N., Ren, H., Yu, J., Hu, T., Su, Y., et al. (2022). From canopy complementarity to asymmetric competition: the negative relationship between structural diversity and productivity during succession. *J. Ecol.* 110, 457–465. doi: 10.1111/1365-2745.13813

Zheng, H., Pan, Q., Wen, Z., and Yang, Y. Z. (2021). Relationships between plant functional traits and ecosystem services in forests: a review (in Chinese). *Acta Ecol. Sin.* 41, 7901–7912.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.