frontiers | Frontiers in Ecology and Evolution

TYPE Editorial
PUBLISHED 29 November 2022
DOI 10.3389/fevo.2022.1086408

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Orsolya Valkó,
Hungarian Academy of
Sciences, Hungary

*CORRESPONDENCE
Yixin Zhang
yixin.zhang2019@suda.edu.cn

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

RECEIVED 01 November 2022
ACCEPTED 07 November 2022
PUBLISHED 29 November 2022

CITATION
Zhang Y, Wang Z, Lu Y and Zuo L
(2022) Editorial: Biodiversity,
ecosystem functions and services:
Interrelationship with environmental
and human health.
Front. Ecol. Evol. 10:1086408.
doi: 10.3389/fevo.2022.1086408

Editorial: Biodiversity, ecosystem functions and services: Interrelationship with environmental and human health

Yixin Zhang[1,2]*, Zhenhong Wang[3], Yonglong Lu[4] and Li Zuo[5]

[1]Department of Landscape Architecture, Gold Mantis School of Architecture, Soochow University, Suzhou, China, [2]Research Center of Cultural Landscape Protection and Ecological Restoration, China-Portugal Belt and Road Cooperation Laboratory of Cultural Heritage Conservation Science, Suzhou, China, [3]School of Environmental Science and Engineering, Chang'an University, Xi'an, China, [4]State Key Lab of Marine Environmental Science, Key Lab of Coastal and Wetland Ecosystems, College of Environment and Ecology, Xiamen University, Xiamen, China, [5]School of Medicine, The University of Texas and UT Health Rio Grande Valley, Edinburg, TX, United States

KEYWORDS

ecosystem benefits, global environmental changes, ecosystem health, wellbeing, one health

Editorial on the Research Topic
Biodiversity, ecosystem functions and services: Interrelationship with environmental and human health

Biodiversity and ecosystem function are fundamental parts of life on the planet and are determinant components of ecosystem services, which largely affect human society (Costanza et al., 1997; Cardinale et al., 2012). Biodiversity (biological diversity) is a key factor to maintain primary and secondary productivity and ecosystem stability, to modulate the movements and fluxes of nutrients, material, and energy across ecosystems and habitats, which are all crucial parts of ecosystem functioning (Dudgeon et al., 2006). Integrating the relationship between biodiversity and ecosystem functioning can enhance our capability to anticipate changes in ecosystem services under the impacts of multiple stressors across ecoregions, including climate changes (Zhang et al., 2019; Weiskopf et al., 2022). Biodiversity, ecosystem functioning, and ecosystem services together maintain environmental health (Díaz et al., 2007), and provide indispensable benefits to humanity, as they are able to provide plant productivity, clean water, healthy food, and fresh air, and suppress disease-causing microorganisms (Grace et al., 2016; Leclère et al., 2020). Connections and mutual benefits among natural environment, biodiversity, ecosystem services, and human health and wellbeing have been thoroughly explored and assessed (Gascon et al., 2015; Frumkin et al., 2017; Bratman et al., 2019), with great potential for further investigation into the mechanisms that deliver such reciprocal benefits (Keniger et al., 2013) (Figure 1).

However, the challenges we are facing are the fact that multiple environmental stressors at both local and global scales reduce biodiversity and cause ecosystem degradation (Lu et al., 2020), and the information available to link biodiversity, ecosystem functioning, and services to human health is limited (Sandifer et al., 2015). Anthropogenic global disturbances, such as climate warming, land-use change and habitat loss, soil erosion, primary productivity reduction, infectious disease epidemic, and invasive species, have been impacting biodiversity and ecosystem functioning, as well as causing the reduction of ecosystem services (Leclère et al., 2020). It is urgent to enhance more in-depth interdisciplinary, collaborative research on relationships of biodiversity, ecosystem functioning and ecosystem services, and human health, and to gain a more robust understanding of interactive mechanisms of their effects on environmental and human health (Isbell et al., 2017). Promoting robustness of biodiversity and ecological complexity of ecosystem functioning represents ecosystem services' enhancement so that to increase the ability to benefit human health. Such ecosystem services' enhancing environmental and human health can be obtained through ecologic restoration to recover health capacities, environmental protection to reduce the negative effects of climate change, and sustainable ecosystem management (maintenance) to support environmental perception (Figure 1).

For this Research Topic of *Biodiversity, ecosystem functions and services: Interrelationship with environmental and human health* we published a wide array of papers at different angles from a local scale with microbiomes, plants, microarthropods, to reach scale with fish, to riparian landscapes for accessing aesthetic quality. The intention of this topic arrangement was aimed to acquire a deeper understanding of complex interactions among biodiversity, ecosystem functioning, and ecosystem services, with their relations to health in a variety of systems.

Robinson et al. assessed the effect of anthropogenic sound and artificial light pollution on microbiomes related to environmental and human health. Global changes, especially fast urbanization, have caused a significant increase in anthropogenic sound and artificial light pollution, which have increased to alarming levels and can potentially disrupt critical ecosystem processes and services essentially related to human health (Rook, 2013). This review indicates that anthropogenic sound and light pollution significantly influence microbiomes in urban ecosystems and human health *via* microbial interactions. Authors in this section have provided a critical appraisal of available scientific literature and discussed potential ecological and human health implications. Moreover, they proposed the "Photo-sonic Restoration Hypothesis", which asks the question of whether restoring natural levels of light and sound could help restore microbiomes and ecosystem stability. The assumption can be correlated to anthropogenic sound and light that disrupt microbiome assembly, potentially favoring certain adaptable species and reducing their functional diversity. Thus, such anthropogenic sound disruption and artificial light pollution can have important implications for ecosystem health and human health and should be restored through ecosystem management with new technology to recover their ecosystem functioning and services (Longcore and Rich, 2004; Pijanowski et al., 2011; Falchi et al., 2016).

Guo et al. reported a study of the response of soil microarthropod community to seasonal changes in the Urat Desert Steppe, in Inner Mongolia, China. They found that abiotic factors play an important role in the matter cycle and in the growth of soil microarthropods. The two environmental factors (moisture and temperature) in soil have a major influence on microarthropod distributions. More moisture or higher temperature or both conditions can induce a higher abundance of soil microarthropods. The total abundance and functional group richness of the animals were significantly greater in summer than in spring and autumn. Therefore, the soil microarthropods can be indicators to characterize soil conditions and environmental health, which potentially influence human health (Wall et al., 2015).

Wang et al. investigated the water usage efficiency of plants related to primary productivity supporting ecosystem functions and services to benefit environmental health. Relationships between plant species richness and primary productivity, and the process strengths determining the relationship are affected by environmental conditions (Wang, 2017; Wang et al., 2019), though plant diversity can enhance productivity and soil carbon storage (Chen et al., 2018). The authors assessed the response of water use efficiency of dominant species, coexisting species, and functional group-level plants to grazing intensity using the leaf carbon isotope composition in plants ($\delta^{13}C$) index in an alpine meadow, one of the most sensitive areas to global warming. They found that moderate grazing significantly increased the leaf carbon isotope composition in plants ($\delta^{13}C$), indicating that moderate grazing may improve the water use efficiency of species in alpine meadows for high productivity. However, increasing soil evapotranspiration with global warming reduces the efficiency of water usage (Jung et al., 2010). Therefore, moderate disturbance can be somewhat used to migrate global warming.

Dai et al. assessed environmental flow requirements for four major Chinese Carp in the lower reaches of the Jinsha River in Southwest China. Environmental flows science, practice, and policy are crucial parts of environmental water management (Arthington et al., 2006). Through a critical appraisal of reviewing available scientific literature, the authors discussed the potential ecological and environmental health implications in the field. The study along cascade reservoirs in the lower reaches of the Jinsha River indicated that the operation of cascade reservoirs has directly affected the spawning habitat of four fishes due to different outflows from the reservoir. The research results provide a scientific basis for the ecological operation of cascade reservoirs of lower sections for supporting healthy spawning habitats in an uncertain future (Tonkin et al., 2019).

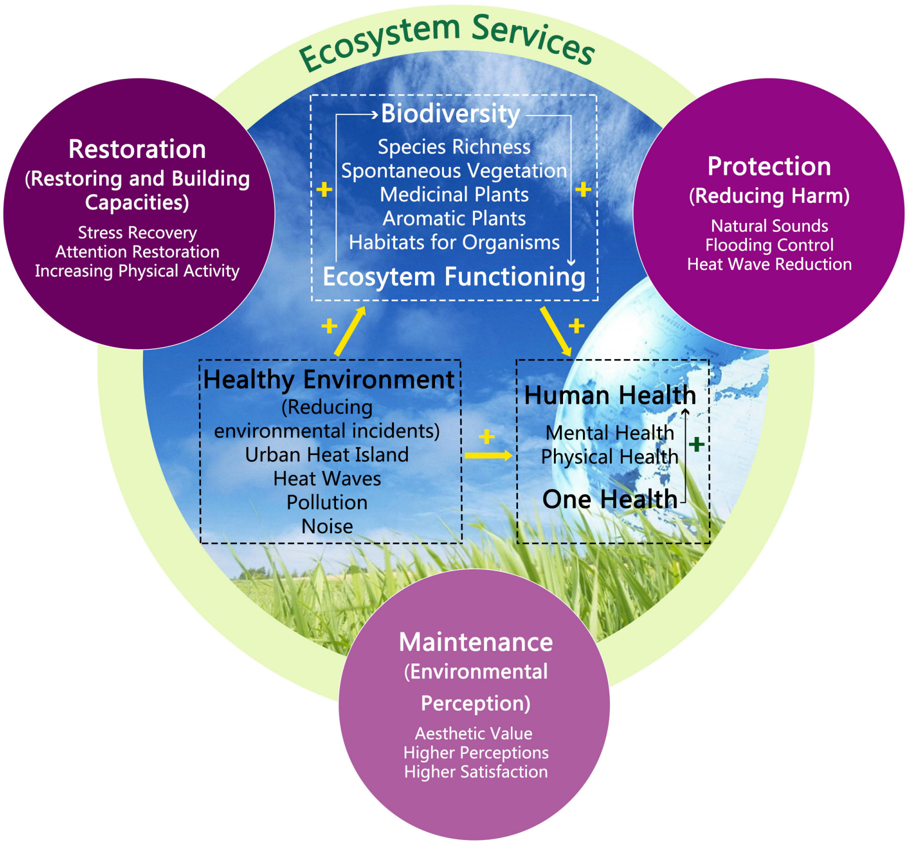

FIGURE 1
A conceptual framework for the interrelationship of biodiversity, ecosystem functioning, and ecosystem services with effects on human mental and physical health. The theoretical framework involves three processes: Protection, restoration, and maintenance. Arrows indicate directions of interactions and the plus sign (+) represents a positive influence.

Zhang et al. conducted an assessment of the aesthetic quality of urban landscapes by integrating objective and subjective factors through study sites at riparian landscapes. They focused on elevating aesthetic benefits by suggesting a set of indicator systems for landscape design, planning, and management for improving human wellbeing. They found that the overall aesthetic quality was determined by both vegetation and waterbody, and the higher the vegetation quality, the more vegetation patches and patch types, and the higher the waterbody quality. This system, with multi-level indicators consisting of landscape naturalness, landscape complexity, vegetation diversity, component qualities, water body diversity, and human subjective preferences, can address questions on the determination, integration, and validation of landscape aesthetic indicators. The approach offers a framework for landscape practices to enhance environmental perception through improving aesthetic value and cultural service, with an eco-healing contribution to human mental health (Bratman et al., 2019; Zhang et al., 2021).

Millennium Assessment Reports (2005) estimated that about 60% of the benefits provided by global ecosystems to support life on Earth have been degraded and explored unsustainably. Anthropogenic global changes, including climate change and pollution, have caused environmental degradation and habitat damaging world widely with significant loss of biodiversity, ecosystem function, and ecosystem service (Lu et al., 2015, 2019). Along with reduced environmental health, such declines in biodiversity, ecosystem functions, and services raise the serious potential for irreversible ecological changes to create catastrophic impacts on human health and wellbeing (Hartig et al., 2014) (Figure 1). The papers in our Research Topic collectively explore some of the environmental health issues in the relationship among biodiversity, ecosystem functions, and services, under influence of anthropogenic disturbance. One of our goals with this Research Topic was to highlight research from diverse research groups because multi-scale and multi-system studies can urge ecologists to collaborate for deepening our understanding of the interrelationship of biodiversity conservation and ecosystem functions and services from different perspectives (Zhang, 2022). Obviously, the superposition and cumulative effect of multi-processes in multi-systems on the linkage of biodiversity, ecosystem functions and services in natural ecosystems can be a great challenge (van der Plas, 2019), especially along with assessing their effects on human health and wellbeing. Toward a unified conceptual framework integrating biodiversity and ecosystem processes (Weiskopf et al., 2022), the positive and/or negative effects of each process should be clarified to integrate the respective effects of all individual processes into a total effect to biodiversity, ecosystem functions or ecosystem services, which link with people across landscapes (Kremen and Merenlender, 2018). Therefore, conclusions advancing our understanding of cumulative ecological effects for biodiversity conservation and ecosystem management with benefiting human health can be achieved.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

YZ is funded by a grant (2022010) of Suzhou Water Conservation Bureau Research Program.

Acknowledgments

We thank all contributing authors for submitting their manuscripts and for making our Research Topic on Biodiversity, Ecosystem Functions and Services—Interrelationship with Environmental and Human Health a success. We are grateful to the reviewers acknowledged on the first page of each paper, who gave lots of thoughtful comments and constructive suggestions for authors to revise their manuscripts. Thanks also go to the editorial team at Frontiers in Ecology and Evolution for their support at all stages of our Research Topic. Finally, we thank Xindi Zhang for her technical support for the figure.

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.

References

Arthington, A. H., Bunn, S. E., Poff, N. L., and Naiman, R. J. (2006). The challenge of providing environmental flow rules to sustain river ecosystems. *Ecol. Appl.* 16, 1311–1318. doi: 10.1890/1051-0761(2006)016(1311:tcopef)2.0.co;2

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., et al. (2019). Nature and mental health: An ecosystem service perspective. *Sci. Adv.* 5, eaax0903. doi: 10.1126/sciadv.aax0903

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

Chen, S., Wang, W., Xu, W., Wang, Y., Wan, H., Chen, D., et al. (2018). Plant diversity enhances productivity and soil carbon storage. *Proc. Natl. Acad. Sci. USA* 115, 4027–4032. doi: 10.1073/pnas.1700298114

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

Díaz, D., Lavorel, S., de Bello, D., Quétier, F., Grigulis, K., and Robson, T. M. (2007). Incorporating plant functional diversity effects in ecosystem service assessments. *Proc. Natl. Acad. Sci. USA* 104, 20684–20689.

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z., Knowler, D. J., Lévêque, C., et al. (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biol. Rev.* 81, 163–182. doi: 10.1017/S1464793105006950

Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C., Elvidge, C. D., Baugh, K., et al. (2016). The new world atlas of artificial night sky brightness. *Sci. Adv.* 2, e1600377. doi: 10.1126/sciadv.1600377

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H. Jr, Lawler, J. J., et al. (2017). Nature contact and human health: a research agenda. *Environ. Health. Perspect.* 125, 075001. doi: 10.1289/EHP1663

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència,. A., et al. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. *Int. J. Environ. Res. Public. Health.* 12, 4354–4379. doi: 10.3390/ijerph120404354

Grace, J. B., Anderson, T. M., Seabloom, E. W., Borer, E. T., Adler, P. B., Harpole, W. S., et al. (2016). Integrative modelling reveals mechanisms linking productivity and plant species richness. *Nature* 529, 390–393. doi: 10.1038/nature16524

Hartig, T., Mitchell, R., de Vries, S., and Howard Frumkin, H. (2014). Nature and Health. *Annu. Rev. Public Health* 235, 207–228. doi: 10.1146/annurev-publhealth-032013-182443

Isbell, F., Gonzalez, A., Loreau, M., Cowles, J., Díaz, S., Hector, A., et al. (2017). Linking the influence and dependence of people on biodiversity across scales. *Nature* 546, 65–72. doi: 10.1038/nature22899

Jung, M., Reichstein, M., Ciais, P., Seneviratne, S. I., Sheffield, J., Goulden, M. L., et al. (2010). Recent decline in the global land evapotranspiration trend due to limited moisture supply. *Nature* 467, 951–954. doi: 10.1038/nature09396

Keniger, L. E., Gaston, K. J., Irvine, K. N., and Fuller, R. A. (2013). What are the benefits of interacting with nature? *Int. J. Environ. Res. Public. Health* 10, 913–935. doi: 10.3390/ijerph10030913

Kremen, C., and Merenlender, A. M. (2018). Landscapes that work for biodiversity and people. *Science* 362, eaau6020. doi: 10.1126/science.aau6020

Leclère, D., Obersteiner, M., Barrett, M., Butchart, S. H. M., Chaudhary, A., De Palma, A., et al. (2020). Bending the curve of terrestrial biodiversity needs an integrated strategy. *Nature* 585, 551–556. doi: 10.10.38/s41586-020-2705-y

Longcore, T., and Rich, C. (2004). Ecological light pollution. *Front. Ecol. Environ.* 2, 191–198.doi: 10.1890/1540-9295(2004)002[0191:ELP]2.0.CO;2

Lu, Y. L., Song, S., Wang, R. S., Liu, Z., Meng, J., Sweetman, A. J., et al. (2015). Impacts of soil and water pollution on food safety and health risks in China. *Environ. Int.* 77, 5–15. doi: 10.1016/j.envint.2014.12.010

Lu, Y. L., Wang, R. S., Shi, Y. J., Su, C., Yuan, J. J., Johnson, A. C., et al. (2019). Interaction between pollution and climate change augments ecological risk to a coastal ecosystem. *Ecosyst. Health Sustain.* 4, 161–168. doi: 10.1080/20964129.2018.1500428

Lu, Y. L., Yang, Y. F., Sun, B., Yuan, J. J., Yu, M. Z., Steseth, N. Ch., et al. (2020). Spatial variation in biodiversity loss across China under multiple environmental stressors. *Sci. Adv*. 6, eabd0952. doi: 10.1126/sciadv.abd0952

Millennium Assessment Reports (2005). *Millennium Ecosystem Assessment*. *Ecosystems and Human Well-Being: Synthesis*. Island Press. Available online at: http://www.millenniumassessment.org/en/index.html

Pijanowski, B. C., Villanueva-Rivera, L. J., Dumyahn, S. L., Farina, A., Krause, B. L., Napoletano, B. M., et al. (2011). Soundscape ecology: the science of sound in the landscape. *BioScience* 61, 203–216. doi: 10.1525/bio.2011.61.3.6

Rook, G. A. (2013). Regulation of the immune system by biodiversity from the natural environment: an ecosystem service essential to health. *Proc. Nat. Acad. Sci. USA* 110, 18360–18367. doi: 10.1073/pnas.13137 31110

Sandifer, P. A., Sutton-Grier, A. E., and Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: opportunities to enhance health and biodiversity conservation. *Ecosyst. Serv.* 12, 1–15. doi: 10.1016/j.ecoser.2014.12.007

Tonkin, J. D., Poff, N. L., Bond, N. R., Horne, A., Merritt, D. M., Reynolds, L. V., et al. (2019). Prepare river ecosystems for an uncertain future. *Nature* 570, 301–303. doi: 10.1038/d41586-019-01877-1

van der Plas, F. (2019). Biodiversity and ecosystem functioning in naturally assembled communities. *Biol. Rev.* 94, 1220–1245. doi: 10.1111/brv.12499

Wall, D. H., Nielsen, U. N., and Six, J. (2015). Soil biodiversity and human health. *Nature* 528, 69–76. doi: 10.1038/nature15744

Wang, Z. H. (2017). Process strengths determine the forms of the relationship between plant species richness and primary productivity. *PLoS ONE* 12, e0185884. doi: 10.1371/journal.pone.0185884

Wang, Z. H., Chiarucci, A., and Arratia, F. J. (2019). Integrative models explain the relationships between species richness and productivity in plant communities. *Sci. Rep.* 9, 13730. doi: 10.1038/s41598-019-50016-3

Weiskopf, S. R., Myers, B. J. E., Arce-Plata, M. I., Blanchard, J. L., Ferrier, S., Fulton, E. A., et al. (2022). A conceptual framework to integrate biodiversity, ecosystem function, and ecosystem service models. *BioScience.* 2022, biac074, doi: 10.1093/biosci/biac074

Zhang, X. D., Zhang, Y. X., Zhai, J., Wu, Y. F., and Mao, A. Y. (2021). Waterscapes for promoting mental health in the general population. *Int. J. Environ. Res. Public. Health* 18, 11792. doi: 10.3390/ijerph182211792

Zhang, Y. X. (2022). Freshwater biodiversity conservation of China: progress in Yangtze River Basin. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 32, 1565–1570. doi: 10.1002/aqc.3861

Zhang, Y. X., Juvigny-Khenafou, N. P. D., Xiang, H. Y., Lin, Q. Y., and Wu, Z. J. (2019). "Multiple stressors in China's freshwater ecoregions," in *Multiple stress in river ecosystems. Status, impacts and prospects for the future*,eds S. Sabater, A. Elosegi, R Ludwig (New York, NY: Academic Press, Elsevier), 193–204.