BIODIVERSITY–ECOSYSTEM FUNCTION

Humans pressure wetland multifunctionality

A large dataset of aquatic biodiversity across multiple trophic levels from several wetlands in Brazil reveals that biodiversity–multifunctionality relationships break down with human pressures.

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As human activities continue to cause biodiversity loss worldwide[1], there is growing evidence that species declines are linked to reduced ecosystem functioning, which in turn can limit the capacity of natural ecosystems to provide the numerous services essential for human well-being[2]. However, much of this evidence is based on experiments in which biodiversity loss is simulated by randomly assembling communities of varying species diversity, often at single trophic levels[2,3]. The relevance of such experiments for real-world ecosystems has been questioned[4–6], given that community assembly or disassembly in natural ecosystems may be non-random[7,8]. Moreover, ecosystem functioning is typically influenced by multiple organismal groups at varying trophic levels, as well as environmental and anthropogenic factors such as climate and land use[7,8]. Writing in *Nature Ecology & Evolution*, Moi et al[9]. fill a gap in biodiversity–ecosystem function research with an impressive real-world dataset spanning a broad geographic extent across major wetlands in Brazil. The authors examine whether freshwater biodiversity across multiple trophic levels is associated with enhanced wetland ecosystem functioning. Importantly, they also investigate how anthropogenic pressure alters the observed biodiversity–ecosystem function relationships in Neotropical wetlands.

To address these questions, Moi et al. present a robust dataset on species richness and functional diversity of 1,465 plant, animal and microbial species from seven groups of aquatic organisms. These data were obtained from 72 lakes spread over four major wetlands in Brazil (Amazon, Araguaia, Pantanal and Paraná). The authors measure functional diversity via a key set of species traits (body size, resource use and mobility) that mediate species responses to a cumulative index of eight anthropogenic pressures (the human footprint[10]). Further, they quantify wetland ecosystem functioning with a set of 11 variables that together represent environmental characteristics directly associated with ecosystem functions.

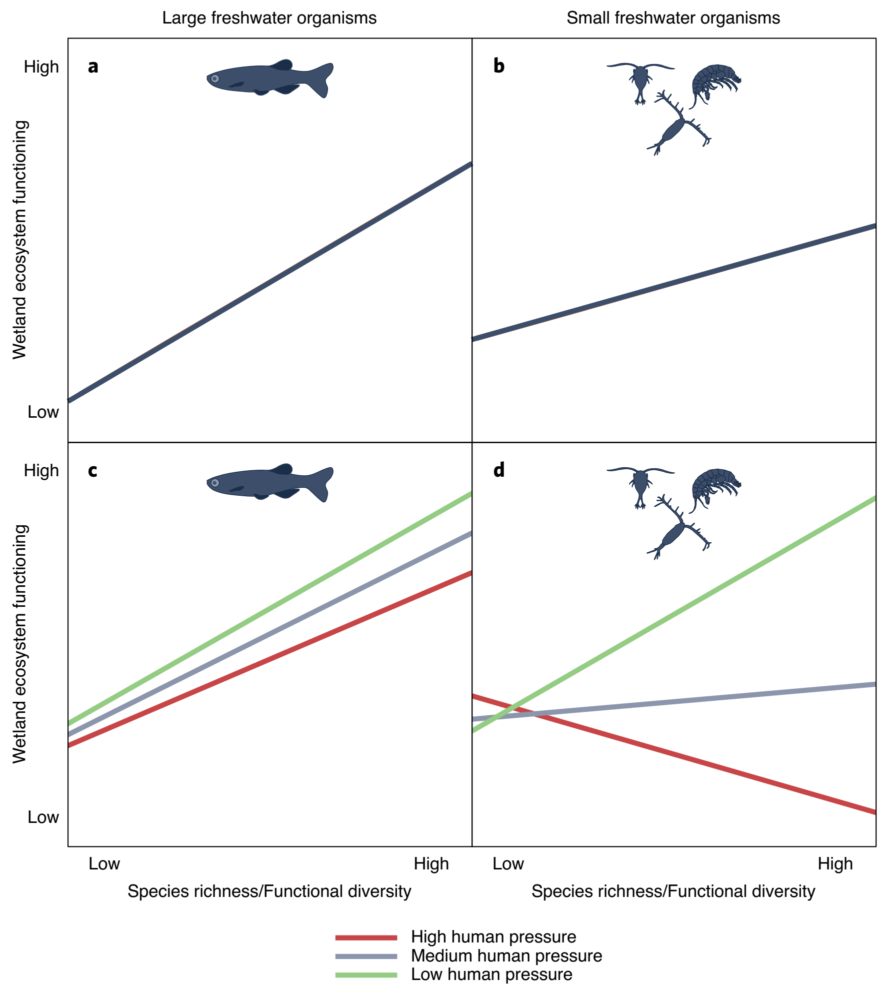

Fig. 1 | High human pressures are associated with lower wetland multifunctionality, mediated via direct effects of pressures as well as indirectly via shifts in biodiversity. a,**b**, Moi et al[9]. provide evidence from Neotropical wetlands that high species richness and functional diversity of multiple freshwater organisms, both large (**a**) and small (**b**), are linked to enhanced wetland ecosystem multifunctionality. **c**, **d**, However, high levels of human pressure were associated not only with lower species richness and functional diversity, but also shifts in biodiversity–ecosystem functioning relationships from positive to negative. The ability of large freshwater organisms (**c**) to enhance ecosystem functioning appeared less sensitive to human pressures than that of small organisms (**d**). These findings support the prediction that biodiversity loss can impair the ability of real-world ecosystems to sustain multiple ecosystem functions, and highlight the potentially elevated role of fish and aquatic plants for maintaining wetland ecosystem functioning in an era of rapid environmental change.

Moi et al.'s dataset thus has the statistical power needed to investigate broad-scale biodiversity–ecosystem function relationships across wetlands and to unravel the effects of human pressure on these relationships.

Moi et al. exploit their dataset by building statistical models that reveal that high species richness and functional diversity of seven organismal groups, as well as high multidiversity (the joint diversity of all organismal groups[11]), are associated with greater ability of wetlands to sustain multiple ecosystem functions (that is, multifunctionality as defined in their study[12]). Their models indicate that biodiversity variables are the best predictors of wetland multifunctionality, even after accounting for the influence of other well-known drivers of multifunctionality such as distance from the Equator, climate (precipitation and temperature) and water properties (conductivity, pH and water level). Notably, Moi et al. show that larger organisms (fish and aquatic plants) are more strongly associated with wetland multifunctionality than smaller organisms (microcrustaceans, rotifers, phytoplankton, ciliates and testate amoebae), although positive biodiversity–multifunctionality relationships were observed for all organismal groups (Fig. 1a,b).

A major finding is that a high level of anthropogenic pressure is not only associated with lower species richness and functional diversity across organismal groups, but also with shifts in biodiversity–multifunctionality relationships from positive to negative (Fig. 1). Thus, deleterious human activities appear to erode the positive effects of biodiversity on wetland ecosystem functioning. Further, Moi et al. demonstrate both direct and indirect (mediated via shifts in biodiversity) pathways through which human pressures negatively affect wetland multifunctionality. Crucially, the ability of smaller organisms to enhance multifunctionality seems to be more sensitive to human pressure than that of larger organisms, underscoring the potentially elevated role of fish and aquatic plants for maintaining wetland ecosystem functioning in an era of human-induced global environmental change (Fig. 1c,d).

Recent studies have demonstrated evidence for positive biodiversity–multifunctionality relationships with real-world data from forest ecosystems[13,14]. Moreover, a comparison of data from real-world grassland plant communities with data from grassland plant diversity experiments suggests that the conclusions of biodiversity–multifunctionality experiments are largely robust[15]. Moi et al. make a key addition to the existing literature by establishing how human pressure can reverse the nature of biodiversity–multifunctionality relationships from positive to negative. The authors thus provide further evidence to support the prediction that biodiversity loss can impair the ability of real-world ecosystems to sustain multiple ecosystem functions[2]. Their work is particularly noteworthy, given the use of a unique field dataset on largely understudied organisms across multiple trophic groups in wetlands — freshwater ecosystems that rank not only among the most biodiverse and productive environments on Earth, but also among the most threatened[16].

Moi et al.'s study has two limitations worth noting. First, their data is static in time and the corresponding set of analyses represents a space-for-time substitution, a widely used approach in ecological studies given the dearth of long-term datasets. Space-for-time substitution can often be reliable for ecological inference[17], but may potentially underestimate effect sizes[18]. Therefore, longitudinal analyses of real-world datasets to test whether change in human pressure over time leads to change in biodiversity–multifunctionality relationships represents a major research gap. Second, it remains to be tested whether the adverse effects of human pressure on biodiversity–ecosystem function relationships in Neotropical wetlands alter their capacity to provide critical ecosystem services[8,12]. This is an important avenue for future research, given that larger aquatic organisms — which currently appear to be relatively resilient to human pressure — may provide functional redundancy to alleviate potential downstream impacts on ecosystem services[19]. However, functional redundancy may fade over time[20], further emphasizing the value of longitudinal analyses with real-world datasets as a frontier in biodiversity–multifunctionality research.

Despite these limitations, Moi et al.'s findings add to the evidence that biodiversity plays a vital role in regulating multiple ecological functions[3,7]. Most notably, their work highlights the importance of limiting human pressures on aquatic biodiversity to maintain multiple ecosystem functions in wetlands. Preserving wetland ecosystem functioning is likely to be a major challenge as human pressures on natural ecosystems exacerbate worldwide. Thus, management efforts aimed at conserving freshwater biodiversity at multiple trophic levels are urgently needed alongside efforts to limit anthropogenic pressures on highly diverse and imperilled wetland ecosystems. ❐

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Competing interests

The author declares no competing interests.