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Biodiversity dynamics under past, present and future global change – insights from macroecology and implications for biosphere stewardship

Earth's wonderful diversity of life is under strong, increasing pressures from human-induced global change, and it is a massive challenge how to avoid catastrophic biodiversity losses, while meeting the rising needs for sustainable development. Through large-scale and long-term perspectives, macroecology offer important insights on biodiversity dynamics under global change and what is required to achieve sustainable biosphere stewardship in the long-term on a human-dominated planet. The last few millions years have experienced extraordinary instability in climate and the rise of humans as a global ecological force. Hence, there is much to learn from biodiversity and ecosystem dynamics through this period for conservation, restoration and sustainable development in a future characterized by a rising human population and human-driven climate change. The strong climate shifts drove massive ecosystem reorganization, with dispersal and extinction playing major roles. Importantly, strong shifts to novel climates caused massive biodiversity losses, with enduring legacies. Further, there is a globally consistent pattern of strong biodiversity and ecosystem changes in the wake of the global spread of modern humans, *Homo sapiens*. Losses of large vertebrates are typical, and the associated trophic downgrading had profound ecological effects on a global scale. For the last 10,000 years increasing land transformation through agriculture have exacerbated these impacts. Looking ahead, we can forecast further intensifying impacts from direct human activities and human-driven climate change, with strong potential to lead to massive biodiversity losses with long-lasting consequences. Achieving a positive future for biodiversity requires intensified, integrative efforts to solve the climate and biodiversity crises alongside sustainable, democratic development. We need to strengthen conservation efforts, with major foci on safeguarding biodiversity hotspots and intact ecosystems with special attention to areas buffered against future climate stress – alongside the massive efforts needed to limit global warming as much as possible. Simultaneously, there is strong need, but also high potential for widespread ecosystem restoration through rewilding (restoration to restore self-managing complex ecosystems) to enhance the biodiversity capacity and resilience of natural areas. An emerging important point is that global change is increasingly forcing the rise of novel ecosystems, where alien species inevitably play increasing roles. While their effects can be negative, they also sometimes have positive contributions for biodiversity that need greater consideration. Proactive approaches such as species translocations will be needed to overcome negative effects and enhance adaptive responses to climate change. These efforts to secure biodiversity have major potential for sustainable development, contributing important co-benefits for climate mitigation and adaptation, livelihoods and livability.