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Successful conservation of global waterbird populations depends on effective governance

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Understanding global patterns of biodiversity change is crucial for conservation research, policies and practices. However, for most ecosystems, the lack of systematically collected data at a global level limits our understanding of biodiversity changes and their local-scale drivers. Here we address this challenge by focusing on wetlands, which are among the most biodiverse and productive of any environments[1,2] and which provide essential ecosystem services[3,4], but are also amongst the most seriously threatened ecosystems[3,5]. Using birds as an indicator taxon of wetland biodiversity, we model time-series abundance data for 461 waterbird species at 25,769 survey sites across the globe. We show that the strongest predictor of changes in waterbird abundance, and of conservation efforts having beneficial effects, is the effective governance of a country. In areas in which governance is on average less effective, such as western and central Asia, sub-Saharan Africa and South America, waterbird declines are particularly pronounced; a higher protected area coverage of wetland environments facilitates waterbird increases, but only in countries with more effective governance. Our findings highlight that sociopolitical instability can lead to biodiversity loss and undermine the benefit of existing conservation efforts, such as the expansion of protected area coverage. Furthermore, data deficiencies in areas with less effective governance could lead to underestimations of the extent of the current biodiversity crisis.

Quantifying global patterns of biodiversity change is essential for assessing anthropogenic impacts on biodiversity, conservation priorities and the effectiveness of conservation efforts[6,7]. It has therefore been identified as a research priority by major international bodies[8,9]. However, most taxa have serious gaps in the spatial extent and resolution covered by available biodiversity data[10], and our current view of global biodiversity change is therefore limited to coarse-resolution patterns[11], data-rich countries[12] or protected areas[13]. This has impeded the identification of hotspots of abundance loss, and the analysis of the effects of local-scale drivers on biodiversity change at the global scale (see Supplementary Discussion; also see Supplementary Information for the Abstract in different languages).

Globally, wetlands cover more than 1,280 million hectares of coastal, inland and human-made habitats[3,14]. Despite their high levels of biological diversity and productivity[1,2] and the crucial ecosystem functions and services they provide[1,3,4], wetlands have been degraded and lost at higher rates than any other ecosystem[3]. However, the lack of appropriate data has hampered assessments of changes in wetland biodiversity at a global scale.

Here we address this by examining waterbirds as an indicator taxon for assessing the status of biodiversity in wetland ecosystems. Waterbirds have a long history of systematic monitoring, and therefore present a global dataset of abundance changes with unusually high spatial extent and resolution[15]. Modelling the global data for waterbirds enabled us to test two fundamental questions that are rarely explored in tandem; we asked where global changes in species abundance have been concentrated and what might explain changes in abundance at community, species and population levels. For the second question, we tested hypothesized predictors that were categorized into three groups: (i) anthropogenic effects (surface water change, economic and human population growth, agricultural expansion and climate change), (ii) conservation efforts and effectiveness (protected area coverage and governance), and (iii) biological characteristics of species (range size, migratory status and body size) (Extended Data Table 1). Our dataset comprised 2,463,403 count records, covering the months of January–February for the past three decades and recording 461 waterbird species at 25,769 survey sites throughout the globe (Extended Data Fig. 1). Using a hierarchical Bayesian model, we estimated the global distribution of changes in the abundance of each species between 1990 and 2013 at $1° \times 1°$ spatial resolution (Supplementary Data 1). We then summarized the changes at three levels: mean changes in abundance across all waterbird species present in each grid cell (community-level changes), mean changes across all grid cells for each species (species-level changes) and changes in each grid cell for each species (population-level changes).

In most species, population-level changes in abundance varied markedly across geographical ranges. Some species that have increased in abundance in Europe showed severe declines in other regions (Fig. 1a–c) and vice versa (see Supplementary Data 1). Declines were especially pronounced in Africa for grebes, flamingos, pelicans, cormorants and shorebirds, in South America for shorebirds, storks, ibises, herons, waterfowl, cranes and rails, and in western and central Asia for waterfowl, cranes and rails (Fig. 1d–k).

We found major community-level abundance losses in areas in which biodiversity assessments have been limited, namely western and central Asia, sub-Saharan Africa and South America (Fig. 2a). On average, community-level declines were most severe in South America, which has experienced a 0.95% annual decline that equates to a 21% total decline over 25 years (Fig. 2b). The declines were also severe in western and central Asia, but predominantly occurred inland rather than in coastal regions. By contrast, Europe has experienced community-level increases in waterbird abundance, though even in regions that experienced these increases some species showed severe abundance declines (Supplementary Data 1). These geographic patterns predominantly reflected patterns in migrant species (Extended Data Fig. 2a), as non-migrants were observed only in some regions; non-migrants showed community-level declines in South America and parts of east Asia, south Asia and southeast Asia (Extended Data Fig. 2b).

Of the eight explanatory variables representing anthropogenic impacts and conservation efforts and effectiveness (see Methods),

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