METHODS

Data. *Waterbird count data.* Data used in this study consisted of site-specific annual counts from the International Waterbird Census (IWC) coordinated by Wetlands International[29] and the Christmas Bird Count (CBC) coordinated by the National Audubon Society[30].

Launched in 1967, the IWC is a scheme involving more than 15,000 observers that monitors waterbird numbers and covers more than 25,000 sites in over 100 countries. The IWC is divided into four regions, each of which corresponds to a major migratory flyway of the world: the African–Eurasian Waterbird Census (AEWC), Asian Waterbird Census (AWC), Caribbean Waterbird Census (CWC) and Neotropical Waterbird Census (NWC). We did not use data from the CWC, because it started only in 2010 and therefore provides only short-term data. The survey methodology is essentially the same across the four regional schemes. Population counts are typically carried out once every year in mid-January. Additional counts are conducted in other months, particularly in July in the Southern Hemisphere; for consistency, we used only counts from January and February. Our Northern Hemisphere data therefore relate to non-breeding populations, whereas those from the Southern Hemisphere also include some breeding populations. In each country that is covered by the survey, national coordinators manage an inventory of wetland sites (hereafter, survey sites) that include sites of international- or national-level recognition (for example, Ramsar sites, Important Bird Areas, national parks and so on). Each survey site is generally defined by boundaries so that observers know precisely which areas are to be covered in the surveys. The observers consist of a wide variety of volunteers, but national coordinators usually train them using materials produced by Wetlands International to ensure the quality of count data. Survey sites (normally up to a few km^2) are typically surveyed by about two observers for up to four hours, but larger sites can require a group of observers to work over several days. The time of survey on any given day depends on the type of survey sites: inland sites are normally surveyed during the morning or late afternoon, whereas coastal sites are surveyed during high tide periods (mangrove areas and nearby mudflats are, however, surveyed during low tides). Surveys cover waterbirds, which are defined as bird species that are ecologically dependent on wetlands[29]. Counts are usually made by scanning flocks of waterbirds with a telescope or binoculars and counting each species. Zero counts are not always recorded and are thus inferred using a set of criteria (see below). Count records and associated information are submitted to the national coordinators, who compile the submitted records, check their validity and submit them to Wetlands International. Further details of survey methodology have been previously published[29,31].

As the IWC does not cover North America, we also used data from the CBC, which has been conducted annually since 1900, involves more than 70,000 observers each year and now includes over 2,400 count circles (defined as survey sites in this study)[32]. Each CBC consists of a tally of all bird species detected within a survey site (a circle 24.1 km in diameter), on a single day that falls on a date between 14th December and 5th January. The majority of circles (and most historical data) are from the US and Canada. Observers join groups that survey subunits of the circle during the course of the day; they use a variety of transportation methods, mostly surveying on foot or in a car but also using boats, skis, or snowmobiles. The number of observers and the duration of counts vary among circles and through time. The total number of survey hours per count has been recorded as a covariate to account for the variable duration of and participation in the count. In this paper, we only used records describing waterbird species.

We compiled data from each scheme by species, except for data derived from the AEWC that had already been stored by flyway for each species[33]. Because data from the NWC are only available after 1990, we restricted the study to data that post-dated 1990 for all regions. The latest records were in 2013. Although the data included 487 waterbird species in total, we excluded from the analyses species with 20 or fewer records; this resulted in 461 species being analysed (see Supplementary Data 2 for the full list of species). For the IWC data, we generated zero counts using an established approach[33]. In this approach, we first established a list of all species observed in each country, and assumed a zero count for any species that was on the list but not recorded at a particular site on a particular day (if the site was surveyed on that day), as shown by the presence of any other species' record(s), and if no multi-species code related to the species (for example, Anatinae spp. for species of the genus *Anas*) was recorded for the site–date combination. We projected all survey sites onto a Behrmann equal-area cylindrical projection and assigned them to grid cells with a grain size of 96.49 km, or approximately 1° at 30° N or S.

When visualizing the estimated abundance changes (for example, see Figs 2b, 3b), the North and South American regions correspond to regions covered by the CBC and NWC, respectively. The regions covered by the AEWC and AWC were divided into a total of six regions on the basis of socio-economic and ecological differences. The AEWC was divided into three regions: Europe, Africa, and western and central Asia. The AWC was also divided into three regions: south and southeast Asia, east Asia and Russia, and Oceania.

Explanatory variables. To explain variations in waterbird abundance changes over space and species, we first set up multiple hypotheses on the basis of earlier studies and then identified explanatory variables that represented these hypotheses (Extended Data Table 1). We aggregated all the explanatory variables, except those relating to species characteristics, to the same 1° × 1° grid cells.

As measures of governance we used the Worldwide Governance Indicators, which summarize six dimensions of governance: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption[34]. A previous study[19] of six South American countries found that pro-environmental behaviours are associated with environmental aspects of governance rather than the conventional dimensions of governance represented by the Worldwide Governance Indicators. At the global scale, however, the mean of the Worldwide Governance Indicators was strongly correlated with the Environmental Performance Index (EPI)[35], one of the indicators of environmental governance used in the aforementioned study[19] ($r = 0.71$, $n = 180$). This indicates that the Worldwide Governance Indicators are also a good predictor of environmental aspects of governance at the global scale. Further, the EPI consists of multiple indicators, some of which are directly related to our measures of conservation efforts, such as terrestrial protected areas and species protection. We thus decided not to use the EPI in our analysis, as using it together with the coverage of protected areas in our analysis could result in redundancies.

In the World Database on Protected Areas (https://www.protectedplanet.net/), not every protected area has information on the year of designation. We therefore calculated the proportion of sites located within any protected area, assuming that this reflects the proportion of sites covered by protected areas designated at least before 2013 (the latest survey year of count data used in this study). To examine the sensitivity of our conclusions to this assumption, we also calculated as the most conservative approach only the proportion of sites covered by protected areas that are known to have been designated before 1990 (the oldest survey year), and conducted the same analyses using this variable (results in Extended Data Fig. 5 and Supplementary Discussion). When assessing the effectiveness of protected areas, confounding factors can mask or mimic the effects of protected areas. We controlled for effects of potential drivers of abundance changes (listed in Extended Data Table 1) by including them together with protected area coverage in the same multivariate models.

On the basis of information from the Birdlife Data Zone (http://datazone.birdlife.org/home), the migratory status of the 461 species analysed in this study falls into four categories: full migrant, altitudinal migrant, nomadic and not a migrant. In this study, we defined species that were categorised as full migrant or altitudinal migrant as migrants.

Other data. We derived information on generation length (in years) from the BirdLife Data Zone, and the Red List category assessed by the International Union for Conservation of Nature from the BirdLife Checklist of the Birds of the World[36], for each species. Generation length was not available for five species, for which we used the mean values across all species in the same genus. We used generation length as well as the bird species global distribution maps[37] for the visualization of results (see Supplementary Data 1 for more detail). Species groups used in Fig. 1 are based on the International Ornithological Congress World Bird List[38]: coursers, gulls, terns and auks (Alcidae, Glareolidae, Laridae and Stercorariidae), grebes and flamingos (Phoenicopteridae and Podicipedidae), loons and petrels (Gaviidae and Procellariidae), pelicans, boobies and cormorants (Anhingidae, Fregatidae, Pelecanidae, Phalacrocoracidae and Sulidae), rails and cranes (Aramidae, Gruidae and Rallidae), shorebirds (Burhinidae, Charadriidae, Dromadidae, Haematopodidae, Ibidorhynchidae, Jacanidae, Recurvirostridae, Rostratulidae and Scolopacidae), storks, ibises and herons (Ardeidae, Ciconiidae and Threskiornithidae), and waterfowl (Anatidae and Anhimidae).

Statistical analyses. *Model for quantifying abundance changes.* To account for missing values, large observation errors and spatial structure in the data, we used a hierarchical Bayesian spatial model and quantified population-level changes in the abundance of each species within each 1° × 1° grid cell. This model is an extension of a model developed and used to quantify waterbird abundance changes in previous studies[39,40]; it is based on the site effect for site i, overall year effect for year t and the cell-specific year effect for grid cell j and year t. The overall year effect β_t is assumed to be affected by the year effect in the previous two years:

$$\beta_t \sim \mathrm{normal}(\beta_{t-1} + r(\beta_{t-1} - \beta_{t-2}), \sigma_o^2)$$

Here σ_o^2 is the variance of the overall year effect, and r ranges from 0 to 1 and determines the smoothness of the estimated curve. With $r = 0$, the overall year effect is modelled as a simple random-walk process, whereas other values lead to a correlated random walk with different degrees of smoothness (a larger r causes