Assessing the effectiveness of the Ramsar Convention in preserving wintering waterbirds in the Mediterranean

Article *in* Biological Conservation · February 2020

DOI: 10.1016/j.biocon.2020.108485

21 authors, including:

Elie Gaget
Tour du Valat, Research Institute for the Conservation of Mediterranean Wetlands

Isabelle Le Viol
Muséum National d'Histoire Naturelle

Diego Pavón-Jordán
Norwegian Institute for Nature Research

Christian Kerbiriou
Sorbonne Université

Assessing the effectiveness of the Ramsar Convention in preserving wintering waterbirds in the Mediterranean

Gaget E.[1,2], Le Viol I.[2], Pavón-Jordán D.[3], Cazalis V.[4], Kerbiriou. C[2], Jiguet F.[6], Popoff N.[1], Dami L.[1], Mondain-Monval J.Y.[5], Defos du Rau P.[5], Abdou W.A.I.[7], Bozic L.[8], Dakki M.[9], Encarnação V.M.F.[10], Erciyas-Yavuz K.[11], Etayeb K.S.[12], Molina B.[13], Petkov N.[14], Uzunova D.[15], Zenatello M.[16] & Galewski T.[1]

[1] Institut de recherche pour la conservation des zones humides méditerranéennes, Tour du Valat, le Sambuc, 13200 Arles, France

[2] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, station marine, 1 place de la croix, 29900 Concarneau

[3] Norwegian Institute for Nature Research (NINA), Dept. of Terrestrial Ecology, P.O. Box 5685, Trondheim, Norway

[4] Centre d'Ecologie Fonctionnelle et Evolutive, CEFE UMR 5175 – Univ. Montpellier – CNRS – Univ. Paul Valéry Montpellier – EPHE, 1919 route de Mende, 34293 Montpellier Cedex, France

[5] Office National de la Chasse et de la Faune Sauvage, Unité Avifaune Migratrice, Le Sambuc, 13200 Arles, France

[6] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, CP 135, 57 rue Cuvier 75005 Paris, France

[7] Egyptian Environment Affairs Agency, Nature Conservation Sector, 30 Misr Helwan ElZyrae, Rd, Maadi, Cairo, Egypt.

[8] DOPPS - BirdLife Slovenia Kamenskova ulica 18 SI-2000 Maribor, Slovenia.

[9] Scientific Institute, Mohammed V University of Rabat, Av. Ibn Battota, 10106 Rabat-Agdal, Morocco.

[10] Instituto da Conservação da Natureza e das Florestas, IP (ICNF), Centro de Estudos de Migrações e Proteção de Aves (CEMPA), Lisboa, Portugal.

[11] Ornithological Research Center, Ondokuz Mayis University, 55139 Atakum, Samsun, Turkey.

[12] The University of Tripoli, Faculty of Science, Zoology Department. P.o. Box: 13227, Alfornag, Tripoli, Libya.

[13] Bird Monitorin Unit. SEO/BirdLife. C/Melquiades Biencinto, 34. 28053. Madrid, Spain.

[14] Bulgarian Society for the Protection of Birds, PO Box 50, BG-1111 Sofia, Bulgaria.

[15] Macedonian Ecological Society, Arhimedova 5, 1000 Skopje, R. North Macedonia.

[16] Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), via Ca' Fornacetta 9, I-40064 Ozzano Emilia BO, Italy.

Article impact statement: Identification of the regional disparities in the Ramsar Convention effectiveness to enhance waterbird populations across the Mediterranean Basin

Keywords: Conservation measures; International conventions; Protected areas; Protection status; Monitoring; Wetlands

Number of words in the paper: 7992

Correspondence: Elie Gaget, Tour du Valat, Arles, 13200, France. Tel: +33-(0)4-9097-2978; Fax: +33-(0)4-9097-2019. E-mail: gaget@tourduvalat.org

Abstract

Although biological conservation is based on international agreements, its effectiveness depends on how countries implement such recommendations as effective conservation tools. The Ramsar Convention is the oldest international treaty for wetland and waterbird conservation, establishing the world's largest network of protected areas. However, since it does not constitute any binding measure, its effectiveness in protecting wintering waterbird populations at an international scale has been questioned. Here, we use long-term (1991–2012) count data to assess the effectiveness of the Ramsar Convention in the Mediterranean Basin. We compared abundance and temporal trends of 114 waterbird species between 251 Ramsar wetlands and 3,486 non-Ramsar wetlands. We found that the Ramsar network is critical for wintering waterbirds, concentrating nearly half of all waterbirds counted in the Mediterranean Basin in only 7% of monitored wetlands. Waterbird trends followed a northwest-southeast gradient, with a population decrease in the East. A significant and positive Ramsar effect on population trends was only found for the species of higher conservation concern in the Maghreb, particularly when a management plan was implemented. The Ramsar Convention was previously used on very important wetlands for waterbirds in Southern Europe, but is now an underused conservation tool. Our study suggests weaknesses in the use of Ramsar as an effective conservation tool in most of the Mediterranean Basin. However, the Ramsar Convention effectiveness to enhance waterbird populations in the Maghreb should encourage strengthening the Ramsar Convention. It should be done particularly in countries with limited environmental agreements and by systematic implementation of management plans.

1. Introduction

Protected areas are the cornerstone of biodiversity conservation aiming to preserve nature from anthropogenic threats (Margules & Pressey 2000, Godet & Devictor 2018). In 2018, the coverage of the overall network of protected areas reached 14.9% of world's land surface (UNEP *et al*. 2018), close to the 17% established in the Aichi Targets to reduce biodiversity loss before 2020 (CBD 2010). However, the increase in terrestrial protected areas did not halt overall biodiversity declines over the last decades, potentially, among other factors, because of the insufficient proportion of protected surface (Rodrigues *et al.* 2004, Pouzols *et al.* 2014), the poor coherence of the global network (Virkkala & Rajasärkkä 2007, Gardner *et al.* 2015), and the lack of targeted and adaptive management (Leverington *et al.* 2010, Alagador *et al.* 2014). In this context, measuring the direct effect of protected areas on animal populations is of main importance (Devictor *et al.* 2007, Cazalis *et al.* 2019).

The Ramsar Convention (1971) established the world's largest network of protected areas focusing on wetland biodiversity conservation. Wetlands are recognized as internationally important for waterbirds if they regularly support at least 1% of the flyway population of at least one waterbird species and/or at least 20,000 waterbirds. Historically, these criteria were mainly used to quickly identify the most important sites that needed protection, due to the worrying conservation status of waterbirds (Gardner & Davidson 2011). The strategy was to maximize the protection of a small amount of very important sites against local and global threats (Finlayson *et al.* 2018), expecting that these islets of protection will be sufficient even for migratory species, such as waterbirds. Because of the great biological importance of these sites, several protection statuses may overlap them, strengthening their protection. Locally, waterbirds have been shown to increase more rapidly in Ramsar designated wetlands than in unprotected wetlands (e.g., Kleijn *et al.* 2014). Currently, like other environmental conventions (Gamero *et al.* 2017), the Ramsar Convention is expected to deliver greater benefits for species of higher conservation concern, which are specifically targeted by conservation efforts (Koleček *et al.* 2014). However, as stressed by Finlayson et al. (2018) in the Second Warning to Humanity for Wetland Management and Policy, international assessments of the Ramsar Convention effectiveness are still scarce.

The Ramsar Convention's main conservation tool is the implementation of management plans in Ramsar sites (Hettiarachchi *et al.* 2015). Such management plans provide guidelines to the stakeholders (Billgren & Holmén 2008) based on assessments of the ecological characteristics of each Ramsar site and the socio-economical features of the region, for maintaining the ecological functions of wetlands and protect them against loss and degradation (Davidson 2016). However, the Ramsar Convention is not necessarily supported by legal regulations nor accompanied by binding measures, meaning that conservation effectiveness may depend on the country's governance (Leverington *et al.* 2010, Amano *et al.* 2018).

The Mediterranean Basin is the place of origin of the Ramsar Convention, where wetland biodiversity face heavy pressures in a heterogeneous panel of country's governance (MWO 2018). Despite the general awareness of the importance of wetland conservation and the Ramsar Convention, environmental care strongly differs between Mediterranean countries by a North-Western/South-Eastern gradient (Kark *et al.* 2009, Fosse 2016, UNEP *et al.* 2018, Saura *et al.* 2017), notably through the ratification of international environmental agreements (Table S1). These contrasted geo-political governances constitute four categories (MWO 2018), which contribute to differences in the application of wetland conservation agreements within the region (see Amano *et al.* 2018). Southern European (Western) countries are old European Union (EU) Member States with long-standing environmental governance. During the expansion of the EU towards Eastern Europe, the Balkan countries - most of which are to date not included in the EU - have also reinforced and implemented new environmental laws (Koschová *et al.* 2018). In recent decades, the environmental concern in the Maghreb has increased, notably for wetland ecosystems with the establishment of National Wetland Strategies (CEPF 2017). In the Middle-East, the environmental legislation differs between countries, but in general, environmental concern remains relatively low (e.g., low achievement of Sustainable Development Goals, particularly on the environmental issues, Sachs *et al*. 2017) for economic reasons and sometimes political instabilities.

This article presents the first international assessment of the effectiveness of the Ramsar Convention in conserving wintering waterbirds in the Mediterranean Basin, using data from the International Waterbird Census (IWC). We compared the impact of Ramsar wetland protection on waterbird populations of species of higher and least conservation concern, listed in the Appendix II and III of the Bern Convention respectively, for each of the four Mediterranean geo-political sub-regions (Fig. 1). The Bern Convention is one of the main international conservation policies operating in the Mediterranean Basin, establishing species protection status and conservation priorities which are expected efficient for the targeted species like the higher conservation concern species (Gaget *et al.* 2018). For those species, such conservation measures likely enhance their population trend in the climate warming context, particularly in the Southern Europe and in the Balkan (Gaget *et al*. 2018). First, we investigate the importance of the Ramsar site designation for waterbirds by comparing waterbird abundance (i.e., population state), and the Ramsar effectiveness to conserve waterbird populations by comparing trends in abundance (i.e., population dynamics) between Ramsar and non-Ramsar sites. Because of the predominance of the bird criteria in their designation process, we expect higher waterbird abundance and if the designation translates in enhanced conservation, more positive (or less negative) trends in Ramsar than in non-Ramsar sites. Moreover, we expect more favourable trends in the Southern Europe sub-region due to generally greater environmental concern, particularly for species of higher conservation concern. Second, we investigate the importance of the implementation of Ramsar management plans by assessing differences of waterbird abundance and trends as a function of such implementations within Ramsar sites, controlling for the time since designation. We hypothesize that when the Ramsar effectiveness is observed, the management plan implementation will provide even more positive population trends, especially for species of higher conservation concern.

2. Material and methods

2.1 Study region

The study region covers 24 countries in the Mediterranean Basin, all of which are members of the Ramsar regional initiative for Mediterranean wetlands (Medwet; Fig. 1). We divided the region into four sub-regions based on geo-political context (Table S1, MWO 2018): Southern Europe (i.e., joined EU before 1990; France, Greece, Italy, Portugal and Spain), Maghreb (Algeria, Libya, Morocco and Tunisia), Balkans (Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Macedonia, Montenegro, Serbia and Slovenia) and Middle East (Cyprus, Egypt, Israel, Jordan, Lebanon, Turkey and Syria).

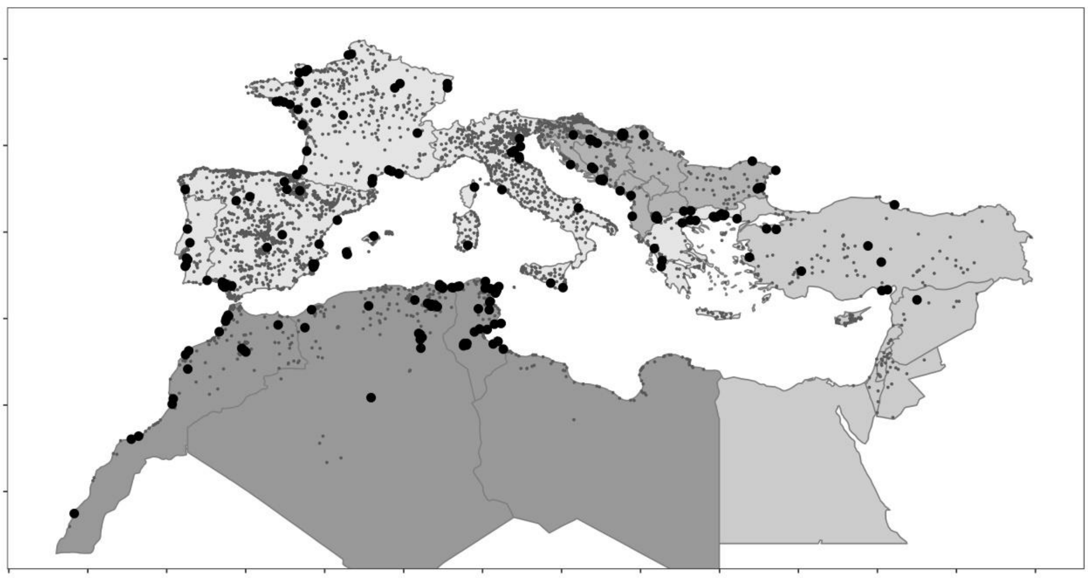

Figure 1: Study region divided in four geo-political sub-regions, Southern Europe (light grey), Maghreb (dark grey), Balkans (medium dark grey) and Middle East (medium light grey). Sites monitored for their waterbirds are represented by small grey (Non-Ramsar sites) and large black (Ramsar sites) dots. Ramsar sites are only those with waterbird criteria (see Methods).

2.2 Waterbird monitoring

We used data from one of the oldest international monitoring programs, the International Waterbird Census (IWC), which proved to be useful to measure the effectiveness of international conservation strategies (Johnston *et al.* 2013, Pavón-Jordán *et al.* 2015, Amano *et al.* 2018, Gaget *et al.* 2018). Data on wintering waterbirds are site-specific annual counts performed by skilled volunteer or professional ornithologists, coordinated by Wetlands International (Delany 2010). The IWC aims to evaluate the size and trends of waterbird populations (e.g., Conservation Status Reports for the African-Eurasian Waterbird Agreement, wpe.wetlands.org/). One counting session per year per wetland is conducted in mid-January, i.e., during the non-breeding season. Because of lack of human, financial or logistical support, not all wetlands are surveyed every year (Fig. S1). We only selected sites surveyed at least twice during the 1991-2012 and for which geographical coordinates were reported in the IWC database. Sites hold on average 12.7 ± 10.6 (sd) waterbird species (Fig. S2, listed in Table S3) and had nine sampled years (median, Fig. S1). As many waterbird species are not distributed throughout the study region and to avoid the subsequent inflation of absence data, we only considered species abundance data inside their wintering distribution range (based on Birdlife maps, BirdLife International and HBW 2017). We considered as wintering distribution range the union of 'Native resident' and 'Native non-breeding' distributions where the species is known or thought very likely to occur in the area (BirdLife International and HBW 2017). Thus, 82% of the species/site/count absences and 13% of the total number of counted birds (i.e., outside of their wintering area defined in the BirdLife International maps) were removed. Despite removing this data, the proportion of zero abundance per species/site/count represented 73.5% of the data. Our final dataset consists of 37,614 count events of 114 species in 21 years at 3,737 sites in the 24 countries (Fig. 1, see Table S3 for sub-regional information).

2.3 Ramsar sites

The meticulous cross-checking between Ramsar sites (designated up to 2012) and IWC sites first used the geographical coordinates and site names, and secondly the verification of these correspondences by the IWC national coordinators. The error of the first cross-checking was <3%. Note that the Ramsar sites did not overlap necessarily 100% of the corresponding IWC sites (e.g., 65% in average based on expert assessment in Italy). Ramsar site data (downloaded from https://rsis.ramsar.org/, updated 26/02/2016) included geographical coordinates of each site, site names, criteria used for designation, time since designation, presence of an implemented management plan and presence of other protection statuses. We only used Ramsar sites designated under at least one of the two "waterbird" criteria: criterion 5 (wetlands regularly supporting 20,000 or more waterbirds) and criterion 6 (wetlands regularly supporting 1% of the individuals in a flyway population of one waterbird species). Among the 3,737 IWC sites included in this study, 251 were located within 138 Ramsar wetlands as it is common that a Ramsar site corresponds to a complex including several IWC sites. Fifty-nine Ramsar sites had a management plan implemented, representing 43% of the Ramsar sites (see Table S2 for sub-regional information).

2.4 Species conservation concern

Waterbird classification distinguished species in two categories following their international conservation concern, "least" (LCC) or "higher" (HCC), reflected by their protection status in the Bern Convention (19.IX.1979, Appendix III and II, respectively). The Council of Europe established the Bern Convention in 1979 to ensure nature conservation through a binding international legal instrument. Indeed, species of HCC (48 species) are strictly protected while species of LCC (65 species) could be hunted. The Bern Convention was ratified before the study period by all countries included in the Southern Europe, and during the study period by all countries in the Balkans, plus Morocco and Tunisia in the Maghreb. In the Middle East, only Turkey and Cyprus ratified the Bern Convention, before the study period.

2.5 Data analysis

1) Ramsar effectiveness

We evaluated the Ramsar effectiveness by analysing independently the HCC and LCC species, in the four Mediterranean sub-regions. We used Hurdle models (A1) because of the large zero-inflation still present in the abundance data (i.e., 73%, package 'glmmTMB', Magnusson *et al.* 2017). We used a negative binomial error distribution (type 2: variance increases quadratically with the mean) to deal with the over-dispersion, with a log-link and a random zero-inflation to describe the probability of observing an excess of zeros not generated by the explanatory variables (Zuur & Ieno 2016). The fixed covariates included in the models are Ramsar status (categorical; Yes or No Ramsar designation "Ramsar"), year (continuous variable standardized to account for the linear trend) and their interaction ("Year : Ramsar"). Species and site identity were added as random effects. Explanatory variables and random effects were applied for both Hurdle model components. We accounted for the spatial auto-correlation by using an exponential structure on site coordinates, which is adapted for wintering waterbirds (see Gaget *et al*. 2018), and checked the absence of autocorrelation in the residuals (Magnusson *et al.* 2017). The number of sites, species and observations per model are given in Table S4. Structure of the model (glmmTMB form):

(A1) Abundance ~ Ramsar + Year + Year : Ramsar

+ (1|Site) + (1|Species) + exp (Coordinates) + ZeroInflation = ~ 1

2) Management plan implementation

We investigated whether the implementation of a management plan and the time since designation had a positive effect on waterbird abundance and on population trends in Ramsar sites, in a Hurdle model (A2) with the similar structure as before. Waterbird abundance (in Ramsar sites only) was the response variable. The explanatory terms included the fixed effects and interactions between year and the presence of an implemented management plan ("M.Plan"). To assess if higher time since designation was related to more positive population trends, we included the time since designation ("T.Des") as a co-variable and added the interaction with the year (see model specification below). The numeric explanatory variables were standardized. Structure of the model (glmmTMB form):

(A2) Abundance ~ M.Plan + Year + Year : M.Plan + T.Des + Year : T.Des +

+ (1|Site) + (1|Species) + exp (Coordinates) + ZeroInflation = ~ 1

3. Results

3.1 Ramsar effectiveness

Of the 131.4 million waterbirds counted in the Mediterranean Basin from 1991 to 2012, 43% were recorded in total within Ramsar sites. The abundance of both HCC and LCC waterbird species was consistently higher in Ramsar sites compared to other sites throughout the entire Mediterranean Basin ($p < 0.003$, Fig. 2) at the exception of the Balkans (Table S4 for details). Indeed, HCC species were approximately 5 times and 3 times more abundant in Ramsar sites than in non-Ramsar sites in Southern Europe and the Maghreb, respectively (Fig. 2). During the study period, the abundance of HCC species increased by +27% in Southern Europe ($\beta = 0.07$, $p < 0.001$). Populations of LCC species declined in the Balkans and the Middle East by 44% and 25%, respectively, over the study period (Fig. 2). However, the other overall trends were not significant in the other Mediterranean sub-regions ($p > 0.05$, Fig. 2, Table S4). A significant positive effect of the Ramsar status on HCC trend was observed in the Maghreb ($\beta = 0.11$, $p = 0.03$), where species increased by +19% over the 21 years (Fig. 2). A significant negative Ramsar effect was assessed in Southern Europe and in the

Maghreb for LCC species (β = -0.03, p = 0.01; β = -0.06, p = 0.046; respectively), but the Ramsar effect on temporal trends was not significant elsewhere (p > 0.05, Fig. 2, Table S4).

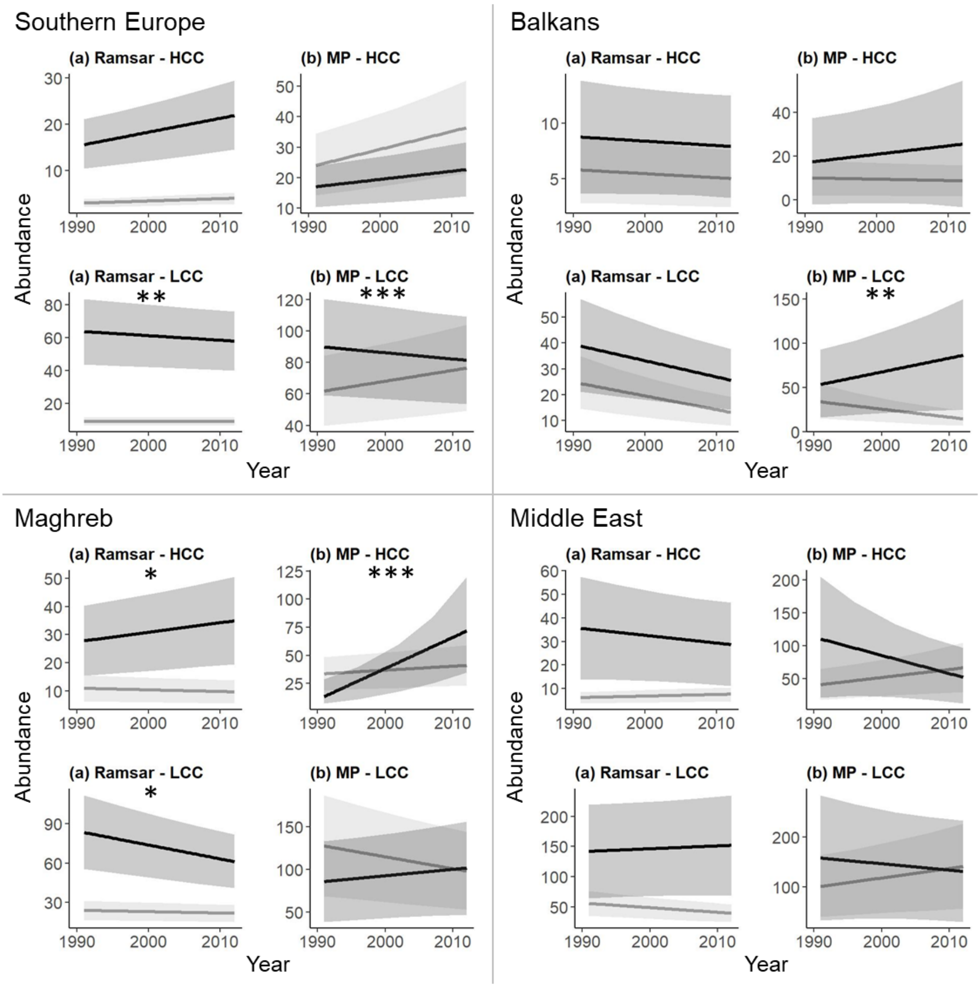

Figure 2: Estimated waterbird abundance and population trends over years (±se) for species of higher (HCC) and least (LCC) conservation concern in (a) Ramsar (black) and non-Ramsar (grey) sites, and (b) in Ramsar sites with a management plan (MP) implemented (black) or not (grey), in the four Mediterranean sub-regions. Significant interactions between population trends and Ramsar status or population trends and management plan implementation were denoted by "***" (p < 0.05), "**" (p < 0.01), "*" (p < 0.001) (See Results and Table S4-S5 for statistical details).

3.2 Management plan implementation

Overall, the abundance of waterbirds did not differ between Ramsar sites with and without a management plan except in the Balkans, where LCC species were more abundant in Ramsar sites with a management plan implemented (Fig. 2, Table S5 for details). In the Ramsar sites, both HCC and LCC species significantly increased in Southern Europe during the study period ($\beta = 0.12$, $p < 0.001$; $\beta = 0.06$, $p < 0.001$; respectively). However, overall trends were significantly negative for LCC species in the Maghreb and Balkans ($\beta = -0.07$, $p = 0.001$; $\beta = -0.24$, $p < 0.001$; respectively), and not significant elsewhere ($p > 0.05$, Fig. 2). The implementation of a management plan had a positive effect on waterbird trends in the Balkans for the LCC species (+39% with, -57% without) and in the Maghreb for the HCC species (+14% with, -21% without) (Fig. 2, Table S5). In Southern Europe, management plan implementation had a negative effect on LCC species trends (-9% with, +18% without) and no significant effect in the Middle East (Fig. 2). We only found a significant positive effect of the time of designation in Southern Europe (the older the date of designation, the greater the abundance of HCC species; $\beta = 0.36$, $p = 0.03$). We also found a negative effect of date of designation on LCC in the Balkans (the older the date of designation, the lower the abundance; $\beta = -0.36$, $p = 0.05$). Regarding the trends, we found that in Southern Europe, the older the date of Ramsar designation, the more negative the trends in abundance of HCC and LCC species ($\beta = -0.10$, $p < 0.001$; $\beta = -0.02$, $p = 0.03$; respectively). The opposite was true in the Middle East for HCC and LCC species ($\beta = 0.18$, $p = 0.05$; $\beta = 0.30$, $p < 0.001$; respectively; Table S5).

4. Discussion

Assessing the effectiveness of conservation agreements is critical for achieving global biodiversity conservation goals (Sutherland et al. 2004, Finlayson et al. 2018). In order to assess the effectiveness of the Ramsar Convention halting the decline in wintering waterbirds around the Mediterranean Basin, we compared long-term trends in their abundance within and outside Ramsar sites. We found that the Ramsar sites support nearly half of all wintering waterbirds recorded in total in the Mediterranean Basin. However, based on long-term abundance trends, the Ramsar site network only proved to provide more benefits than non-Ramsar sites in the Maghreb sub-region. In addition, we only found an effect of the implementation of a management plan derived from the Ramsar Convention in the Maghreb sub-region, further highlighting regional disparities in the waterbird conservation effectiveness under the Ramsar Convention in the Mediterranean Basin. Considering the designation time, it seems that in Southern Europe the Ramsar Convention was rapidly used to designate the wetlands supporting the highest number of waterbirds.

4.1 Mediterranean waterbird trends

Waterbird trends over the study period were almost all not significant or negative, in contrast to the conservation objectives initiated to reverse the worrying species conservation status in the past (Gardner & Davidson 2011). The trend was positive only for Higher Conservation Concern (HCC) species in the Southern Europe, suggesting that all efforts made by the EU, notably through enforcement of the Bern Convention by the Bird Convention (2009/147/EC), were fruitful (Musilová *et al.* 2018, Pavón-Jordán *et al.* 2015). However, wintering waterbird abundance and distribution are also influenced by large scale factors such as temperature and precipitation changes (Johnston *et al*. 2013). Indeed, conservation policies are also effective to facilitate abundance increase of several species at their northern range in response to climate warming (Gaget *et al*. 2018), without promoting species extirpation at their southern range (Pavón-Jordán *et al.* 2015). This means that the current positive population trends likely result from a general population increase (Amano et al. 2018) and a spatial reallocation of the populations in the Southern Europe (e.g. Pavón-Jordán *et al.* 2015). Lower conservation policy effectiveness in the other regions may limit species population increases and distribution changes, despite the overall Mediterranean climate warming (Mariotti *et al.* 2015) and its importance for trans-Saharan species (Sayoud *et al.* 2017). However, despite that the methodological approach allows to reveal abundance changes, we acknowledge that the use of static species distribution maps (see methods) may have limited the assessment of a northward extension. Nevertheless, the negative trend of Lower Conservation Concern (LCC) species in the Balkans and Middle East, and the absence of significant trends in the Maghreb are coherent with the Mediterranean North-Western/South-Eastern spatial contrast of wetland biodiversity trends (Galewski *et al.* 2011), with the geo-political governances and with their conservation successes (Guillemain & Hearn 2017, Amano *et al.* 2018).

4.2 The effectiveness of the Ramsar network

Our results provide evidence of the importance of Ramsar network for waterbird populations wintering in the Mediterranean region. Ramsar-designated sites (i.e., only 6.8% of the IWC sites included here) support 43% of the waterbirds counted in the past two decades. This is not surprising, as all these sites were designated for their high importance for waterbirds - they regularly support more than 20,000 birds or 1% of a population, and were more frequently monitored (Table S1). The data collected under the IWC are used to validate the international (ecological) importance of wetlands after their designation as Ramsar protected areas. Even if this may seem trivial, it is a basic step to achieve conservation targets. The extremely valuable information on wintering waterbird abundance and distribution worldwide provided by monitoring schemes, such as the IWC, is critical for the classification of wetlands as Ramsar sites and the evaluation of its effectiveness. Indeed, our study suggests regional disparities in the effectiveness of the network of Ramsar sites enhancing waterbird populations across the Mediterranean Basin.

In the Maghreb, we show that the Ramsar designation is effective to result in an increase of HCC waterbird populations. This result is consistent with previous assessments done in Morocco (Dakki *et al*. 2002, Cherkaoui *et al.* 2018, Kleijn *et al.* 2014). In the Maghreb, the Ramsar Convention is one of the main conservation tools and, thus, its importance is higher than other national conservation measures (Kleijn *et al*. 2014). However, in Morocco at least, the Ramsar network was enlarged in 2005 from 4 to 24 sites (Dakki *et al*. 2011), based on wetlands previously included in a national network of protected areas, defined in 1996 (AEFCS 1996) and designated later as permanent hunting reserves (Dakki *et al.* 2016). Ramsar sites in the Maghreb have proved to be very important for species of international conservation concern, like the Marbled Teal (*Marmaronetta angustirostris*) and the Ferruginous duck (*Aythya nyroca*), which favour high water levels and habitat quality (Cherkaoui et al. 2016, Ouassou *et al.* 2018). Contrary to the situation with HCC species, LCC species decreased in Ramsar sites, suggesting that Ramsar designation and site management effects may depend on the species requirements (e.g. water cover or bare soil, Kleijn *et al*. 2014). Land use change and climate variabilities could also interact with the protection, because recurrent droughts have decreased water availability for wintering birds during the 1980-2000 decades while the exponential increase of artificial reservoirs during this period may have induced specific changes in species distribution (Green *et al*. 2002). The regional Ramsar effectiveness for HCC species conservation is also correlated with efforts undertaken by countries in the Maghreb in recent decades to conserve wetlands, i.e. through the establishment of water strategies and environmental impact assessments (MWO 2018).

In the Middle East, the Ramsar Convention has failed to improve waterbird population trends. In this region like in the Maghreb, there are severe pressures on naturally restricted water resources (e.g., agriculture, pollution, dam construction) threatening wetlands (Karadeniz *et al.* 2009) but there are generally few strategies for wetland conservation and sustainable water use (Geijzendorffer *et al.* 2019). Consequently, Ramsar wetlands are not always effectively protected (Gürlük & Rehber 2006). For example, despite the importance of Ramsar sites for the endangered White-headed Duck (*Oxyura leucocephala*) in Turkey, some have been severely damaged by pollution or decreased water levels, and eventually have seen the collapse of their waterbird populations (Adaman *et al.* 2009, Green *et al.* 2017). Political instabilities and military conflicts have also not helped to make environmental protection a priority (Machlis & Hanson 2008), water resources being sometimes at the root of conflicts (Medzini & Wolf 2004). Thus, the lack of general governmental effort and the difficult geopolitical context in the Middle East humpers the achievement of international conservation targets (Green *et al.* 2017).

Contrary to the expected population increase inside protected areas in countries with more effective governances (Amano *et al.* 2018), the Ramsar Convention showed low effectiveness at enhancing waterbirds populations in Southern Europe and the Balkans. The absence of a significant effect is unlikely due to a lack of statistical power as for the two regions several tens of sites were used (Table S4). However, the surface overlapped between Ramsar and IWC sites in some countries is not systematically complete (e.g., 65% in Italy), which may reduce our capacity to detect differences in population trends between Ramsar and non-Ramsar sites. For the two northern Mediterranean regions, most of the countries are included in the EU or are in the process of completing the entry procedures. In the Balkans however, the limited political and financial support for biodiversity conservation weakens the enforcement of the environmental legislation (UNDP 2007). The EU Member States benefit from strong environmental laws for species and habitat conservation, e.g., the Birds, the Habitats (92/43/EEC), and the Water Framework (2000/60/EC) Directives. Such legislation might have not been sufficient to halt pressures on Ramsar wetlands, as in France for example where Ramsar sites lost 6% of their natural wetlands between 1975 and 2005 (Perennou *et al.* 2016). However, in the EU countries the detection of the Ramsar effectiveness is challenging. In fact, the Natura 2000 network targets also the protection of the wetlands important for biodiversity, overlapping 81% of the Ramsar network (Table S2) and probably some non-Ramsar designated wetlands. Because the Ramsar Convention is not accompanied by binding measures, unlike the European (Natura 2000) or national (nature reserve or park) legislation, Ramsar designation could be less used by the stakeholders in the European countries. For instance, 82% of the Ramsar sites information lack of update in Spain (SEO Birdlife 2018). In France, the “Baie de l’Aiguillon” is one of the most important sites for wintering waterbirds on the Atlantic coast (70,000 waterbirds counted annually) and is protected by a national nature reserve but it is not included in the Ramsar site network. Interestingly, the older designated Ramsar wetlands in the Southern European countries held more HCC species, suggesting that before the establishment of the European Directives, the Ramsar designation was used primarily on the wetlands hosting the largest waterbird abundance. Therefore, if the use of Ramsar as a conservation tool is still desired in the European countries, then its use should be strengthened (Geijzendorffer *et al*. 2019).

4.3 Management plan implementation

The implementation of a management plan, which determines the guidelines to ensure "wetland wise use", was effective in enhancing HCC population trends only in the Maghreb. The interpretation of these results is limited by the lack of available information on the targets of the management plans and the legal means involved to implement them. However, the positive effect of the management plan in Maghreb on HCC species is coherent with the high recognition of the Ramsar Convention in this sub-region (see also Kleijn *et al*. 2014). In the Middle East, because only one Ramsar site without management plan implemented was compared to eleven other sites, the analysis should be considered cautiously. In Southern Europe, the implementation of a management plan had a negative effect on LCC species. We suspect that such protected areas do not necessarily benefit these species, because conservation measures do not target them (Musilová *et al.* 2015), or because these species find increasingly favourable conditions on artificially managed sites, such as marshes specifically managed to attract waterfowl or rice fields (Rendón *et al.* 2008). Indeed, Musilová *et al.* (2018) found that wintering waterbird distribution is only partially explained by protected areas, particularly for LCC species, so that protection and successful management alone cannot be sufficient to guarantee the protection of waterbird populations. In the Balkans, however, our results show that the abundance of LCC species increased inside the managed Ramsar sites compared to unmanaged. Legal and illegal hunting pressures are strong in this region (Hirschfeld &

Heyd 2005, Brochet *et al.* 2016) and, thus, it is possible that well-managed Ramsar sites act as refuges for waterbirds sought by hunters. Additionally, the overall decrease in LCC species in the Balkans may also suggest changes in wintering strategies in response to climate warming (Gaget *et al.* 2018). Considering the climate warming context, protected areas may increase population trend at the leading distribution edge and reduce extirpation at the trailing edge, thanks to a likely buffering effect against the climate warming which increased species persistence (Pavón-Jordán *et al.* 2015). However, inappropriate conservation measures can limit species persistence at their trailing edge (Wessely *et al.* 2017). Consequently, in the Southern Europe a negative effect on LLC population trends could notably result by an extirpation in response to climate warming.

4.4 Implication for conservation

The lack of effectiveness of the Ramsar Convention in the worrying wetland conservation context (Finlayson *et al.* 2018) urges signatory countries to strengthen their commitments, especially in Eastern Europe and the Middle East. However, the impact of this pioneer environmental convention (1971) goes beyond the findings showed here, as it was used as a basis for other international conservation policies and national wetland legislations (Gardner & Davidson 2011). Indeed, some EU countries have used the designation of Ramsar sites as reasoning for Natura 2000 designation and therefore protection of the sites for waterbirds and other species. The Birds, Habitats, and Water Directives in the EU are also shaped following the recommendations of the Ramsar Convention. Consequently, the success of the Ramsar Convention for waterbird conservation should not be only reduced to the direct impact of the Ramsar designated sites but enlarged to the overall international and national waterbird conservation.

The contrasted effectiveness of the Ramsar Convention increasing waterbird abundance across the Mediterranean sub-regions stress the need for a more effective waterbird and wetland conservation

(Geijzendorffer *et al.* 2019). A first step should be to widen the designation of the wetlands of international importance, to increase the coherence between the Ramsar network and the core distribution of wintering waterbirds periodically assessed. Indeed, even in the EU countries the protected area network for waterbirds, including Natura 2000 sites, is still not enough to cover all the important sites (e.g. Pavón-Jordán *et al.* 2015). This could be done by using gap analyses and knowledge on the waterbird distribution provided by the IWC (Delany 2010). For example, a recent North Africa IWC synthesis revealed 42 wetlands of international importance for waterbirds that are not Ramsar designated (Sayoud *et al.* 2017). Such "Shadow Ramsar Lists", i.e., sites that meet the criteria for designation, should be regularly updated and disseminated by conservation organizations to encourage Ramsar new designations. Because the Ramsar designation has to be done by a national administrative authority, each contracting party has to take its own responsibilities to provide an updated list to the Ramsar secretariat, to fulfil their commitments. Then, information about the conservation state of the Ramsar designated wetlands should be updated regularly to avoid obsolete data (Yeniyurt & Hemmami 2011, González & Atienza 2018), notably in the EU countries (e.g., SEO Birdlife 2018). Thus, conservation objectives should be clearly documented and defined through a management plan in order to provide the guidelines to maintain a wise use of the resources considering the ecological characteristics and the socio-economical features (Hettiarachchi *et al.* 2015). The improvement of both wetland conservation concern and waterbird population trends through massive Ramsar designations and management plan implementations in the Maghreb provide a good example of the Ramsar Convention relevance.

Since the Ramsar Convention aims to build an international co-operative network (Finlayson 2014), especially relevant for migratory waterbirds, the application of the Ramsar Convention should be exemplary. This is required not only to ensure the integrity of the Ramsar Convention, but also to improve its appraisal (Finlayson *et al.* 2018). This study depicts a worrying underuse of the Ramsar Convention as a conservation tool in some countries, weakening the establishment of a cohesive conservation network. What is encouraging is the successful performance in the Maghreb, where the use of the Ramsar Convention for the conservation of wetlands boosted waterbird protection.

Finally, international conventions, such as the Ramsar Convention, may provide crucial tools for countries strengthening their conservation efforts. Numerous international agreements for biological conservation lie on non-binding measures. Their objectives may be threatened by the weakness of country governance (Amano *et al.* 2018) or the lack of achievements (Leverington *et al.* 2010). However, this study suggests the potential for international convention effectiveness translated into concrete conservation tools.

Acknowledgements

We acknowledge the thousands of volunteers and professionals involved in waterbird counts, the International Waterbird Census (IWC) coordination units (Wetlands International, Tour du Valat, the National Office for Hunting and Wildlife (ONCFS), and the National IWC North African network) for providing help to national coordinators, centralizing and managing data and making this research possible. We thank the two anonymous reviewers whose comments greatly improved the manuscript.

References

Adaman F., Hakyemez S., Özkaynak B. 2009. The Political Ecology of a Ramsar Site Conservation Failure: The Case of Burdur Lake, Turkey. *Environment and Planning C: Government and Policy*, **27**(5):783–800.

AEFCS 1996. Plan Directeur des Aires Protégées du Maroc, Volumes 2 and 3: les sites d'intérêt biologique et écologique (domaine continental et littoral). Rapport, Administration des Eaux et Forêts et de la Conservation des Sols/BCEOM/SECA/ISR/EPHE.

Alagador D., Cerdeira J.O., Araújo M.B. 2014. Shifting protected areas: scheduling spatial priorities under climate change. *Journal of Applied Ecology*, **51**:703–713.

Amano T., Székely T., Sandel B., Nagy S., Mundkur T., Langendoen T., Blanco D., Soykan C.U., Sutherland W.J. 2018. Successful Conservation of Global Waterbird Populations Depends on Effective Governance. *Nature*, **553**(7687):199.

Billgren C., Holmén H. 2008. Approaching Reality: Comparing Stakeholder Analysis and Cultural Theory in the Context of Natural Resource Management. *Land Use Policy*, **25**(4):550–62. Brochet A-L., *et al.* 2016. Preliminary Assessment of the Scope and Scale of Illegal Killing and Taking of Birds in the Mediterranean. *Bird Conservation International*, **26**(1):1–28.

BirdLife International and HBW (2017). Bird species distribution maps of the world. Version 7.0. Available at <http://datazone.birdlife.org/species/requestdis>.

Cazalis V., Belghali S., Rodrigues A.S.L. 2019. Using a large-scale biodiversity monitoring dataset to test the effectiveness of protected areas in conserving North-American breeding birds. bioRxiv, 433037, ver.4 peer-reviewed and recommended by PCI-Ecology.

CEPF 2017. Ecosystem Profile, Mediterranean Basin Biodiversity Hotspot, Extended Technical Summary. https://www.cepf.net/sites/default/files/mediterranean-basin-2017-ecosystem-profile-summary-english.pdf

Cherkaoui S.I., Magri N., Hanane S. 2016. Factors predicting Ramsar site occupancy by threatened waterfowl: the case of the Marbled Teal *Marmaronetta angustirostris* and Ferruginous Duck *Aythya nyroca* in Morocco. *Ardeola*, **63**(2): 295-310.

Cherkaoui S.I., Selmi S., Amhaouch Z., Hanane S. 2018. Assessment of the effectiveness of wetland protection in improving waterbird diversity in a Moroccan wetland system. *Environmental monitoring and assessment*, **190**(12):699.

Dakki M., El Agbani M.A., Qninba A. 2011 (Eds). Zones humides du Maroc inscrites jusqu'en 2005 sur la Liste de la Convention de Ramsar. Trav. Inst. Sci., Rabat, Sér. Générale, 7, 238 pp.

Dakki M., Qninba A., El Agbani M.A., Benhoussa A. 2002. Recensement hivernal d'oiseaux d'eau au Maroc : 1996-2000. Trav. Inst. Sci., Rabat, Sér. Zool., pp. 1-28.

Dakki M., Menioui M., Amhaouch Z. 2016. Stratégie Nationale et plan d’action 2015-2024 pour les Zones Humides du Maroc. HCEFLCD/DLG/GIZ, 54 pp. Davidson N.C. Ramsar Convention on Wetlands: Scope and Implementation. In The Wetland Book, edited by Finlayson C.M., Everard M., Irvine K., McInnes R.J., Middleton B.A., van Dam A.A., Davidson N.C, 1–9. Dordrecht:Springer Netherlands.

Delany S. 2010. Guidance on Waterbird Monitoring Methodology: Field Protocol for Waterbird Counting (Wetlands International).

Devictor V., Godet L., Julliard R., Couvet D., Jiguet F. 2007. Can common species benefit from protected areas? *Biological Conservation*, **139:**29–36.

Finlayson C.M. 2014. Linking Science to International Wetland Policy–the Ramsar Convention on Wetlands. *Marine and Freshwater Research*, **65**(7):573-574.

Finlayson C. M., Davies G.T., Moomaw W.R., Chmura G. L., Natali S.M., Perry J. E., Roulet N., Sutton-Grier A.E. 2018. The Second Warning to Humanity – Providing a Context for Wetland Management and Policy. Wetlands, 1-5.

Fosse J., et al. 2016. Towards a Green Economy in the Mediterranean - Assessment of National Green Economy and Sustainable Development Strategies in Mediterranean Countries. eco-union, MIO-ECSDE, GEC. Athens.

Gaget E., Galewski T., Jiguet F., Le Viol I. 2018. Waterbird Communities Adjust to Climate Warming According to Conservation Policy and Species Protection Status. *Biological Conservation*, **227**:205–12.

Galewski T., Collen B., McRae L., Loh J., Grillas P., Gauthier-Clerc M., Devictor V. 2011. Long-Term Trends in the Abundance of Mediterranean Wetland Vertebrates: From Global Recovery to Localized Declines. *Biological Conservation*, **144**(5):1392–99.

Gamero A., et al. 2017. Tracking progress toward EU biodiversity strategy targets: EU policy effects in preserving its common farmland birds. *Conservation Letters*, **10**(4):395-402.

Gardner R.C., et al. 2015. State of the world's wetlands and their services to people: a compilation of recent analyses. Ramsar Briefing Note 7, www.ramsar.org/library

Gardner R.C., Davidson N.C. 2011. The Ramsar Convention. In:LePage B. (eds) Wetlands. Springer, Dordrecht.

Geijzendorffer I.R., et al. 2019. Increasing the impact of the Ramsar convention on the conservation of Mediterranean wetlands. *Frontiers in Ecology and Evolution*, **7:**21.

Godet L., Devictor V. 2018. What conservation does. *Trends in ecology & evolution*, **33**(10):720-730.

González G.R., Atienza J.C. 2018. Humedales Ramsar en España de Interés para las aves acuáticas: Estado de Conservación y recomendaciones. SEO/BirdLife, Madrid.

Guillemain M., Hearn R. 2017. Ready for climate change? Geographic trends in the protection status of critical sites for Western Palearctic ducks. *Biodiversity and Conservation*, **26**(10):2347-2360.

Green A.J., El Hamzaoui, M., El Agbani, M.A., Franchimont, J. 2002. The conservation status of Moroccan wetlands with particular reference to waterbirds and to changes since 1978. *Biological conservation*, **104**(1):71-82.

Green A.J., *et al.* 2017. Creating a Safe Operating Space for Wetlands in a Changing Climate. *Frontiers in Ecology and the Environment*, **15**(2):99–107.

Gürlük S., Rehber E. 2006. Evaluation of an Integrated Wetland Management Plan: Case of Uluabat (Apollonia) Lake, Turkey. *Wetlands*, **26**(1):258–64.

Hettiarachchi M., Morrison T.H., McAlpine C. 2015. Forty-Three Years of Ramsar and Urban Wetlands. *Global Environmental Change*, **32**:57–66.

Hirschfeld A., Heyd A. 2005. Mortality of migratory birds caused by hunting in Europe: bag statistics and proposals for the conservation of birds and animal welfare. Berichte zum Vogelschutz, **42**:47-74.

Johnston A., et al. 2013. Observed and Predicted Effects of Climate Change on Species Abundance in Protected Areas. *Nature Climate Change*, **3**(12), 1055–61.

Karadeniz N., Tiril A., Baylan E. 2009. Wetland management in Turkey: Problems, achievements and perspectives. *African Journal of Agricultural Research*, **4**(11):1106-1119.

Kark S., Levin N., Grantham H.S., Possingham H.P. 2009. Between-Country Collaboration and Consideration of Costs Increase Conservation Planning Efficiency in the Mediterranean Basin. *Proceedings of the National Academy of Sciences*, **106**(36):15368–73.

Kleijn D., Cherkaoui I., Goedhart P.W., van der Hout J., Lammertsma D. 2014. Waterbirds Increase More Rapidly in Ramsar-Designated Wetlands than in Unprotected Wetlands. *Journal of Applied Ecology*, **51**(2):289–98.

Koleček J., *et al*. 2014. Birds protected by national legislation show improved population trends in Eastern Europe. *Biological Conservation*, **172**:109-116.

Koschová M., Rivas-Salvador J., Reif J. 2018. Continent-Wide Test of the Efficiency of the European Union's Conservation Legislation in Delivering Population Benefits for Bird Species. *Ecological Indicators*, **85**:563–69.

Leverington F., Lemos Costa K., Pavese H., Lisle A., Hockings M. 2010. A Global Analysis of Protected Area Management Effectiveness. *Environmental Management*, **46**(5):685–98.

Machlis G.E., Hanson T. 2008. Warfare ecology. *BioScience*, **58**(8):33-40.

Magnusson A., Skaug H., Nielsen A., Berg C., Kristensen K., Maechler M., van Bentham K., Bolker B., Brooks M. M. 2017. Package 'glmmTMB'.

Margules C.R., Pressey R.L. 2000. Systematic Conservation Planning. *Nature*, **405**(6783):243–53.

Mariotti A, Pan Y, Zeng N, Alessandri A. 2015. Long-term climate change in the Mediterranean region in the midst of decadal variability. *Climate Dynamics* 44:1437–1456.

Medzini A., Wolf, AT. 2004. Towards a Middle East at peace: hidden issues in Arab–Israeli hydropolitics. *International Journal of Water Resources Development*, **20**(2):193-204.

Musilová Z., Musil P., Zouhar J., Romportl D. 2015. Long-term trends, total numbers and species richness of increasing waterbird populations at sites on the edge of their winter range: cold-weather refuge sites are more important than protected sites. *Journal of ornithology*, **156**(4):923-932.

Musilová Z., Musil P., Zouhar J., Adam M., Bejček V. 2018. Importance of Natura 2000 Sites for Wintering Waterbirds: Low Preference, Species' Distribution Changes and Carrying Capacity of Natura 2000 Could Fail to Protect the Species. *Biological Conservation*, **228:**79–88.

MWO. 2018. *Mediterranean Wetland Outlook 2: Solutions for sustainable Mediterranean Wetlands*. Tour du Valat: Geijzendorffer I.R, Chazée L., Gaget E., Galewski T., Guelmami A., Perennou C. Available at: https://tourduvalat.org/en/actualites-en/press-release-extreme-climatic-events-biodiversity-394loss-what-if-wetlands-were-part-of-the-solution/.

Ouassou A., Dakki M., Lahrouz S., El Agbani M.A., Qninba A. 2018. Status and trend of the Ferruginous duck's (Aythya nyroca) wintering population in Morocco: Analysis of 37 years of winter census data (1983-2019). Intern. J. Zoology, Article ID5767194, 9 p.

Pavón-Jordán D., et al. 2015. Climate-Driven Changes in Winter Abundance of a Migratory Waterbird in Relation to EU Protected Areas. *Diversity and Distributions*, **21**(5) :571–82. Perennou, C., Guelmami, A., Gaget, E. 2016. Les milieux humides remarquables, des espaces naturels menaces. Quelle occupation du sol au sein des sites Ramsar de France métropolitaine? Rétrospective 1975-2005. Tour du Valat, OZHM.

Pouzols F.M., et al. 2014. Global protected area expansion is compromised by projected land-use and parochialism. *Nature*, **516**(7531):383.

Rendón M.A., Green A.J., Aguilera E., Almaraz P. 2008. Status, distribution and long-term changes in the waterbird community wintering in Doñana, south–west Spain. *Biological Conservation*, **141**(5):1371-1388.

Rodrigues, A.S.L., et al. 2004. Effectiveness of the Global Protected Area Network in Representing Species Diversity. *Nature*, **428**(6983):640–43.

Sachs J., Schmidt-Traub G., Kroll C., Durand-Delacre D., Teksoz K. 2017. SDG Index and Dashboards Report 2017. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN)

Saura S., Bastin L., Battistella L., Mandrici A., Dubois G. 2017. Protected Areas in the World's Ecoregions: How Well Connected Are They? *Ecological Indicators*, **76**:144–58.

Sayoud M.S., et al. 2017. The First Coordinated Trans-North African Mid-Winter Waterbird Census: The Contribution of the International Waterbird Census to the Conservation of Waterbirds and Wetlands at a Biogeographical Level. *Biological Conservation*, **206:**11–20.

SEO Birdlife. 2018. Estado de los humedales ramsar en españa de interés para las aves acuáticas. Madrid.

Seto K.C., Fragkias M. 2007. Mangrove conversion and aquaculture development in Vietnam: A remote sensing-based approach for evaluating the Ramsar Convention on Wetlands. *Global Environmental Change*, **17**(3-4):486-500.

Sutherland W.J., Pullin A.S., Dolman P.M., Knight, T.M. 2004. The need for evidence-based conservation. *Trends in ecology & evolution*, **19**(6):305-308.

UNDP. 2007. Sixth ministerial conference "Environment for Europe". Environmental policy in south-eastern Europe. United Nation. Belgrade, Serbia. p.207.

UNEP-WCMC, IUCN and NGS. 2018. Protected Planet Report 2018. UNEP-WCMC, IUCN and NGS: Cambridge UK; Gland, Switzerland; Washington, D.C., USA.

Virkkala R., Rajasärkkä A. 2007. Uneven regional distribution of protected areas in Finland: Consequences for boreal forest bird populations. *Biological Conservation*, **134**:361-371.

Wessely J., et al. 2017. Habitat-based conservation strategies cannot compensate for climate-change-induced range loss. *Nature Climate Change*, **7**(11):823.

Yeniyurt C., Hemmami M. 2011. Ramsar Sites of Turkey. Doğa Derneği, Ankara, Türkiye.

Zuur A. F., Ieno E. N. 2016. A protocol for conducting and presenting results of regression-type analyses. *Methods in Ecology and Evolution*, **7**(6):636-645.

Supporting information

Table S1: International Environmental Agreement ratification by country

Table S2. Sub-regional Ramsar characteristics

Table S3: Species status in the Bern Convention and proportion of zero count

Table S4: Ramsar effect on waterbirds

Table S5: Management plan effect on waterbirds

Figure S1: Sampled years per site

Figure S2: Species richness per site