Pinpointing which protected area characteristics help community response to climate warming: waterbirds in the European Union's Natura 2000 network

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Abstract

Protected area (PA) networks facilitate community changes in response to climate warming. However, the contribution of the site characteristics are not well understood. Here, we investigate how composition of non-breeding waterbird communities within the Natura 2000 (N2K) network changes in response to increases in temperature. We measured the community reshuffling of 97 waterbird species in 3,018 N2K sites over 25 years in 26 European countries. We find that N2K sites explicitly designated for protection of waterbirds and with a management plan had faster climate-driven community changes. In contrast, the designation period of the PA was not associated with community adjustment, and PAs funded under EU-LIFE had lower climate-driven community changes. Our findings imply that efficient conservation policy that may help a target community adjust to climate warming is to manage sites that are specifically designated for that target community.

Introduction

Conservation policies have historically aimed to stop or mitigate species extinction, habitat degradation and natural resource depletion. A major new conservation objective arising in the 21st century is to facilitate species responses to climate warming (Rannow et al. 2014, van Teeffelen et al. 2015). That includes, enabling species movement through a landscape so that species can track their climatic niche and prevent the population being static at places that no longer have suitable climate. The need for this conservation objective has become pressing as species' distribution changes lag behind the velocity of climate warming (Devictor et al. 2012, Lenoir et al. 2020), increasing the risk of mismatch between species' niches and abiotic conditions (Essl et al. 2015). Time lags in organismal responses are exacerbated by anthropogenic pressures, mainly due to habitat degradation (Schinegger et al. 2016, Auffret and Thomas 2019, Gaget et al. 2020a) and population over-exploitation (Engelhard et al. 2014, Lenoir et al. 2020).

Protected area (PA) networks can facilitate community changes in response to climate warming (Thomas et al. 2012, Gaüzère et al. 2016, Lehikoinen et al. 2019). Species extending their distribution more often colonize PAs (Thomas et al. 2012), resulting in changes to the overall community composition within PAs according to species' thermic affinities (Gaget et al. 2020b). However, it is unclear which protective actions contribute to a PA being effective in facilitating such responses to climate warming (van Kerkhoff et al. 2019, but see Lawson et al. 2014, Wessely et al. 2017). Individual PAs differ in when and why they were established, management planning, and funding base, amongst other factors. These protectives actions might have effects on conservation effectiveness (Rodrigues

& Cazalis 2020) and perhaps on how they facilitate species response to temperature increase. Conversely, while PAs may facilitate species distribution shifts (Gaget et al. 2020b), species-specific management may also increase species persistence by maintaining the pre-existing habitat conditions despite climate warming or mitigating the negative impacts of the temperature changes (Greenwood et al. 2016). Pinpointing which conservation policies help species to respond to climate warming in both ways, can help refine climate resilient PA networks.

Here, we investigate inside the Natura 2000 (N2K) network whether climate-driven community changes, i.e. the whole community response to temperature increase, were positively influenced by early designation, having a management plan, targeting particular species or having funding supports. The N2K network is the backbone of the European Union's (EU) strategic aim to maintain and restore European biodiversity according to the Nature Directives (the Birds and Habitats Directives, 2009/147/EC and 92/43/EEC respectively). The effectiveness of the N2K network for mitigating the negative effects of climate warming is thought to be limited by insufficient and misallocated funding from the EU's LIFE programme (Lung et al. 2014, Hermoso et al. 2017), as well as a lack of site management (Hochkirch et al. 2013). Therefore, it is important to evaluate how a management plan and funds impact the ability of PAs to facilitate climate-driven community changes.

We assess spatial and temporal changes in avian communities on the basis of a major long-term monitoring programme, the International Waterbird Census (IWC) of non-breeding waterbirds. These species are all targeted by the Birds Directive to establish a N2K protected area, meaning that site conservation might explicitly provide benefits to these species. Conversely, waterbirds are not explicitly under the Habitats Directive, allowing us to test whether having waterbird conservation targets improve their response to climate warming. Distribution changes of non-breeding waterbirds are highly dynamic (Maclean et al. 2008, Lehikoinen et al. 2013, Pavón-Jordán et al. 2019) and PAs are known to be important for both waterbird conservation (Amano et al. 2018) and response to climate warming (Pavón-Jordán et al. 2015, Gaget et al. 2020b).

We use the Community Temperature Index (CTI) framework (Devictor et al. 2008) and its standard deviation (CTI_{SD}) (Gaget et al. 2020b) to evaluate the community reshuffling of 97 waterbird species at 3,018 sites inside the N2K network over 25 years. The CTI is based on combining the relative abundance and the thermal affinity of each species into an overall index of community 'temperature'. We quantify the effectiveness of EU conservation policies by examining the degree to which this thermal index of waterbird communities changed in relation to warming across Europe, with a focus on climatic debt (the difference between temperature increase and CTI increase, Devictor et al. 2012). The changes in CTI and CTI_{SD} are used to evaluate the changes to the species community, for example an increase in both CTI and CTI_{SD} suggests a community response to climate warming, driven by more warm-dwelling species (Gaget et al. 2020b). The CTI and CTI_{SD} changes are then used to evaluate the consequences of four N2K characteristics that are thought to positively affect climate-driven community adjustment, whether: (1) PAs are targeted toward the focal community (i.e. waterbirds in this study), (2) PAs have received LIFE funding, and (3) PAs have been established for longer periods of time (here, prior to year 2000), (4) PAs have management plans. We hypothesise that each of these actions will facilitate more positive changes in CTI in response to temperature changes and will result in a positive CTI_{SD} trend. However, we also hypothesise that having a management plan may increase the persistence local of cold-dwelling species, and thereby slow down the CTI change but also increase the CTI_{SD} because cold-dwelling species stay and warmer-dwelling species join them.

Methods

We used abundance data for 97 non-breeding waterbird species gathered at 3,018 N2K sites from 1993-2017 from the International Waterbird Census (IWC) conducted in 26 EU Member States (Fig. 1a) (including the UK, Appendix 1). The IWC, coordinated by Wetlands International (www.wetlands.org), takes place once a year in January, where skilled ornithologists follow a standardized survey protocol (Delany 2010). An IWC site was considered to represent an N2K site if the central IWC coordinates fell within the polygon of a N2K site (www.eea.europa.eu). This approach resulted in a reasonable overlap, with on average (±SD) 80.8 ± 23.3 % of the IWC surface included in the corresponding N2K site (based on 1,307 IWC sites with available polygons). Not all IWC sites are surveyed every year and because our aim was to quantify temporal community changes, we considered only sites with ≥ 5 surveys and ≥ 2 species per survey. All species included in the analysis overwinter in the Western-Palearctic and are listed as targeted by N2K designation, referred to in the Article 4 of the Birds Directive (Appendix 2). The above-mentioned criteria resulted in a dataset of 38,559 surveys of 3,018 sites, with a cumulative record of 199 million birds from 97 species over 25 years.

The N2K site characteristics were collated from the N2K and the LIFE programme databases (Appendix 2). These document whether waterbird(s) were targeted ([Yes/No]), a management plan has been prepared ([Yes/No]), LIFE funding had been obtained ([Yes/No]) and the period during which protection was first designated ([Early/Late], where early is <2000, the mid-year according to PA designation period [1982-2017]) (Figure 1, Appendix 2). The existence of a management plan prepared (the only information about management in the N2K database) is necessary to its implementation, but does not confirm implementation. We thereby assumed that any association we found between a management plan and our response would be an underestimated effect of the actual site management. We treated all of these characteristics only as binary (e.g. Yes/No) to capture broad patterns of community changes. We focus on the LIFE programme because it is the most dedicated to N2K conservation, but the N2K network is supported by other agencies including the European Agricultural Fund for Rural Development and Structural and Cohesion Funds. For each site, annual winter temperatures were computed over the non-breeding period, as the average of the mean monthly temperatures of November, December and January from the HadCRUT4 dataset (Morice et al. 2014, spatial resolution of 0.5°, www.cru.uea.ac.uk).

We measured the community response to climate warming by calculating the CTI and the CTI_{SD} based on species abundance, using non-breeding waterbird species temperature indices (STI) from Gaget et al. (2020b). The STI of a given species corresponds to the long-term average temperature in January (1950-2000, www.worldclim.org, spatial resolution of 0.25°) calculated across its non-breeding distribution (BirdLife International and HBW 2017). The CTI of one site in a given survey corresponds to the mean STI of all species present in that site in that survey, weighted by their $\log_{(e)}$(abundance+1) to buffer the influence of the highly abundant waterbird species (Godet et al. 2011). A CTI increase can be caused by an increasing abundance of species with high STIs or a by a decreasing abundance of species with low STIs. The CTI_{SD} represents the standard deviation around the CTI, assessed from the species STI present in the community and weighted by the $\log_{(e)}$(abundance+1). When the CTI trend is positive, a positive CTI_{SD} trend suggests that the warm-dwelling species increases exceed the relative decreases of cold-dwelling species. A positive CTI trend with a negative CTI_{SD} trend suggests that the cold-dwelling species decreases exceed the relative increases of warm-dwelling species (Gaget et al. 2020b).

Statistical analyses

To evaluate the temporal trends of CTI, CTI_{SD} and temperature in relation to the N2K characteristics, we used linear mixed-effects models with CTI, CTI_{SD} or temperature as the response, and with fixed effects being the N2K site characteristics (waterbirds target, management plan, LIFE funding and designation period) and two-way interactions between year and each of the N2K characteristics. The site and the country were added as random effects while the spatial autocorrelation was taken into account by including an exponential spatial correlation structure in the model (Gaget et al. 2018). Then, the temporal trends of CTI, CTI_{SD} and temperature were estimated separately for each of the 16 possible combinations of characteristics and compared to each other in a post-hoc analysis using a Bonferroni correction.

We measured the climatic debt (Devictor et al. 2008) for each N2K protective action. First, we assessed both temperature and CTI spatial gradients by measuring their latitudinal gradient with a linear model and converted them into kilometre gradients (divided by 111.128, i.e., the average kilometres per 1 decimal degree latitude over the study area). Then, we assessed the velocity of both temperature and CTI changes (km yr^{-1}) from their temporal trends (°C yr^{-1}) and their spatial gradients (°C km^{-1}). The spatial climatic debt is the difference between CTI velocity and temperature velocity (both km yr^{-1}).

We conducted four additional sensitivity analyses (Appendix 3), to evaluate the robustness of our results to a number of analytical decisions. We checked: (1) whether CTI and CTI_{SD} trends were overly influenced by a few abundant species, by using species occurrence instead of abundance. (2) Whether the CTI and CTI_{SD} trends were affected by the geographical West-East EU accession gradient, by fitting models only with the subset of 11 countries in the EU before 1992 (n = 2,186 sites); (3) whether the community changes resulted from a decrease or an increase of species richness; and (4) whether the CTI trends associated with each N2K site protective action were correlated with the amount of protected wetland surface.

All statistical analyses were performed with R.3.6.2 (R.C. Team 2019), using the 'glmmTMB' package (Magnusson et al. 2017), and the package 'emmeans' to assess the CTI temporal trend for N2K characteristics and the post-hoc assessments (Lenth et al. 2018).

Results

There was considerable variation in the characteristics across the N2K sites (Fig. 1); almost 82% of sites were designated specifically for waterbirds (Fig 1b), 43% had a management plan (Fig 1c), 50% received LIFE funding (Fig 1d) and 46% were designated after the year 2000 (Fig 1f).

Temperatures rapidly increased across all of the IWC sites within the N2K network, and all of these increases were statistically significant (Fig. 2). There was a markedly slower increase in temperature at N2K sites established before 2000 compared with those established after 2000 (t = 7.1, $p < 0.001$), but the temperature increase was similar across the other characteristics (Fig. 2a). Nevertheless, the community adjustment as quantified by the CTI temporal trend differed substantially across N2K characteristics (Table 1). The trend for increasing CTI through time was only significant in N2K sites targeted to protect waterbirds (Fig. 2a, black dot), but not in PAs with only a management plan, an early designation, EU LIFE funding, nor the absence of all of these characteristics (Fig. 2a, grey dots). Looking at the combinations of characteristics (Fig 2b, Table 1, Appendix 4), we found that if a protective action was not combined with another, PAs designated for waterbirds showed the strongest community adjustment (significant in sites with early and late designation, Fig. 2b), followed by PAs with a management plan (significant in sites with early but not late designation, Fig. 2b). In contrast, LIFE funding alone was not associated with climate-driven community adjustment in PAs (Fig. 2b). Furthermore, in PAs designated for waterbirds, also having a management plan was associated with greater community adjustment (Fig. 2b). Surprisingly, for combinations of protection actions, including LIFE funding was not associated with community adjustment to climate warming (Fig. 2b). The CTI_{SD} trends were only strictly positive at sites designated early, whatever the combinations of other characteristics (Table 1). Consequently, when the CTI increased in early designated PAs, the increase in warm-dwelling species abundance exceeded the decrease of cold-dwelling species (Fig. 2b left, black dot). In late designated PAs the CTI increase was likely related to both increase in warm-dwelling species and decrease in cold-dwelling species (Fig. 2b right, black dot).

The temperature latitudinal gradient was about -0.36°C per 100 km (-0.40°C per latitudinal degree; SE = 0.01, t = -51.89, p < 0.001) and the latitudinal gradient for CTI was about -0.26°C per 100 km (-0.28°C per latitudinal degree; SE = 0.01, t = -31.41, p < 0.001). Thus, on average a northward shift in 100 km is equivalent to a reduction in average temperature of -0.36°C and in average CTI of -0.26°C. Converting the temporal trends to spatial velocity (km yr^{-1}) revealed an overall climatic debt of over 257 km in 25 years across all sites. So, in order to keep pace with the climate warming, waterbird communities would have had to move an additional 257 km northwards over the 25 year period. Not surprisingly, the climatic debt was twice as high in late- compared to early-established sites (Table 1). The climatic debt varied from 86 km in early designated sites targeted to protect waterbirds with a management plan, to 415 km in late designated sites with only a LIFE funding (Table 1).

Our sensitivity analyses (Appendix 3), showed that (1) the CTI and CTI_{SD} trends were fairly consistent if based on occurrence instead of abundance, (2) the CTI and CTI_{SD} trends remained mostly unchanged considering all the EU countries or just the subset of countries that joined the EU before 1992, (3) the species richness increase was significantly more positive for each combination of N2K protective action and trends of species richness were correlated to CTI trends, and (4) CTI increases were correlated with protected wetland surface area, but including the surface as a covariate did not qualitatively change the results described above.

Discussion

We find that N2K network sites designated for waterbirds were characterized by faster responses of the waterbird communities to increasing winter temperature. The response was particularly strong in N2K sites targeting waterbirds for which additionally a management plan had been created. However, despite the clear climate-driven community adjustment, the temperature increase was two to four times faster than the community waterbird response, resulting in a large climatic debt. Such lags are common for terrestrial taxa (Lenoir et al. 2020) and are typically viewed as an insufficient distribution change in response to climate warming (Devictor et al. 2012). Our findings hence imply that the most efficient, although perhaps not sufficient, conservation policy to aid a target community to adjust to climate warming can be to protect sites that are specifically suitable for such a community and develop a plan for managing the protected sites.

Protection of sites under the N2K scheme is typically based on recognising that certain sites are of ecological importance for conservation of particular species or habitats. Our findings demonstrate that sites targeted to wetland species indicate capacity of sites to maintain – and enhance – the species richness (Appendix 3), but also to accommodate a more dynamic climate-driven community change. Indeed, sites in which the CTI increased rapidly were also sites where the number of species increased rapidly, demonstrating a directionality wherein community changes were driven by colonisation of warm-dwelling species and likely not by extinction of cold-dwelling species. A colonisation-driven community change in protected landscapes appears to be common in birds (Lehikoinen et al. 2019, Gaget et al. 2020b) and invertebrates (Thomas et al. 2012).

Our findings highlight that the main tool to enforce conservation measures, the management plan, was associated with faster community adjustment to climate warming in early designated sites. The presence and implementation of a management plan indicates active involvement of the site managers to identify the environmental and socio-economic issues with the stakeholders and elaborate successful conservation measures to maintain the targeted species to a favourable conservation status. A clear, and also intuitive, finding is that the community adjustment was faster in sites with a management plan and targeting the focal community. The management may improve the ecological processes of climate-driven distribution change (Lawson et al. 2014), by limiting the negative impact of land-use change (Wessely et al. 2017) or disturbance (Väänänen 2001). Apart from this “facilitation” process, species-specific management may improve species persistence (Greenwood et al. 2016). In our case, for example, a management plan could facilitate the persistence of some cold-dwelling species, which then translates to an increase in the mean climatic debt of the community.

Importantly, however, we lack information on whether and the extent to which a management plan has actually been implemented as the publicly available records merely denote whether a management plan has been prepared. It therefore remains possible that N2K sites for which a management plan exists (42% in this study) present a subset that – for whatever reason – show faster community responses to climate warming. To ascertain whether it is indeed the (costly) management on the ground that benefits community adjustment to climate warming (Lawson et al. 2014), future work should directly contrast sites in which planned management has been implemented with those where merely a plan exists. To allow critical evaluation of this conservation policy, further development of N2K reporting should include information on implementation of management plans (e.g., Pearce-Higgins et al. 2011).

Interestingly we found no evidence of an association between the designation period and the CTI change. The result suggests that PA designation itself is not associated with more positive community response to climate warming. Indeed, depending on political and stakeholder supports, N2K designation itself can be not sufficient to achieve conservation goals (Kati et al. 2015). However, looking at the CTI_{SD} trends, early PA designation is positively associated with cold-dwelling species persistence. Species-specific models would be more adapted to clarify this pattern. Overall, despite the absence of immediate effects of the designation period on the CTI trend, early designation might still benefit species vulnerable to climate warming.

We found an unexpected, but consistent pattern, of negative relationship between LIFE funding and community response to climate warming. We expected the opposite as we assumed that the LIFE funding would strengthen site conservation and indicate a good ecological status of a PA, favourable to warm-dwelling species colonisation. However, sites receiving LIFE funding might be those sites that have major threats presenting a critical conservation issue (Lung et al. 2014), like the reed-beds for instance (Giakoumi et al. 2019). Hence, it may suggest that substantial conservation funding is allocated to PAs that are degraded or threatened (but see Hermoso et al. 2017). Alternatively, hypotheses could be that the granted conservation measures might design to support the persistence of a targeted population in species-specific interventions, without any benefits for warm-dwelling species extending their distribution. We did not filter the LIFE funding according to wetland or waterbird targets, meaning that the fundings might not be targeted at wetland ecosystems. Further investigation would be welcome to establish cost-effective assessments regarding species-specific adaptation to climate warming.

Toward a climate resilient N2K network

The importance of the EU Nature Directives to facilitate waterbird response to climate warming, mainly by actions promoting colonization of warm-dwelling species in protected areas, is perceptible between EU and non-EU countries (Gaget et al. 2018, Pavón-Jordán et al. 2020), as well as inside and outside the N2K network (Pavón-Jordán et al. 2015). We here demonstrate that community adjustment to climate warming was heterogeneous inside the N2K network, but that protection of sites targeting a specific community may help waterbird communities to adjust to climate warming and this adjustment was faster with a management plan. However, we caution that our analysis is correlative, while causal mechanisms would require further species-specific investigations to directly assess results of these site characteristics on species demographic parameters.

The N2k network has a great opportunity to shift its dynamic goals toward a climate resilient network. Historically, PA designation has mostly been focused on maintaining and improving local biodiversity targeted by the EU Nature Directives. Habitat connectivity is a major dynamic goal already targeted to facilitate species dispersal. In addition, protective actions might be used to improve species colonization or resilience against climate warming. With that aim, scientific evidence is required to explore the effectiveness of the conservation measures and to inform the ambitious EU Biodiversity Strategy for 2030. However, despite an outstanding intergovernmental organization structuring the N2K network, the lack of standardized reports on N2K conservation measures has jeopardized progress in quantifying conservation outcomes. Basic and critical information would be required, such as enforced conservation measures, threats, targets, financial means, spatial and temporal extent (Rodrigues and Cazalis 2020). The Biodiversity Strategy for 2030 emphasizes the need to help species to adapt to climate warming, which is welcome in view of the expected negative impacts of climate warming on waterbirds in the future (Nagy et al. 2021). We suggest that first move is integrating binding on-site management planning, including follow-up of the management plan implementation, to facilitate species communities adjusting to climate warming.

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Table 1: Temporal trends of CTI and CTI$_{SD}$ (95%CI), with the climatic debt and the number of sites (N) according to N2K characteristics and designation period (Early or Late designation, where early is <2000); the N2K characteristics specified that waterbird(s) were targeted (W), a management plan has been prepared (MP), LIFE funding has been obtained (LIFE). Pairwise comparisons are presented in Appendix 4. Trends significantly different from zero are indicated in bold.

N2K characteristics	trend [95%CI] (°C yr^{-1})			Debt (km)		N	
	Index	Early (<2000)	Late (>2000)	Early	Late	Early	Late
-	CTI	**0.019 [0.014;0.024]**	0.000 [-0.007;0.007]	223	351	55	134
	CTI$_{SD}$	**0.014 [0.007;0.022]**	0.005 [-0.002;0.011]				
W	CTI	0.002 [-0.005;0.010]	**0.011 [0.006;0.016]**	140	268	263	395
	CTI$_{SD}$	**0.014 [0.009;0.019]**	0.004 [-0.001;0.009]				
MP	CTI	**0.013 [0.007;0.018]**	0.006 [-0.001;0.013]	169	297	47	95
	CTI$_{SD}$	**0.014 [0.006;0.021]**	0.004 [-0.003;0.011]				
LIFE	CTI	**0.008 [0.001;0.016]**	-0.006 [-0.014;0.001]	288	415	49	96
	CTI$_{SD}$	**0.015 [0.008;0.022]**	0.005 [-0.002;0.012]				
W + MP	CTI	-0.004 [-0.012;0.004]	**0.017 [0.011;0.022]**	86	214	286	226
	CTI$_{SD}$	**0.013 [0.009;0.018]**	0.004 [-0.002;0.008]				
W + LIFE	CTI	**0.006 [0.002;0.011]**	0.004 [-0.002;0.010]	205	333	524	197
	CTI$_{SD}$	**0.014 [0.010;0.019]**	0.005 [-0.001;0.01]				
MP + LIFE	CTI	0.002 [-0.006;0.010]	0.000 [-0.008;0.008]	234	362	50	22
	CTI$_{SD}$	**0.014 [0.007;0.021]**	0.004 [-0.003;0.012]				
W + MP + LIFE	CTI	**0.012 [0.008;0.017]**	**0.010 [0.004;0.016]**	151	279	369	210
	CTI$_{SD}$	**0.014 [0.009;0.018]**	0.004 [-0.002;0.01]				

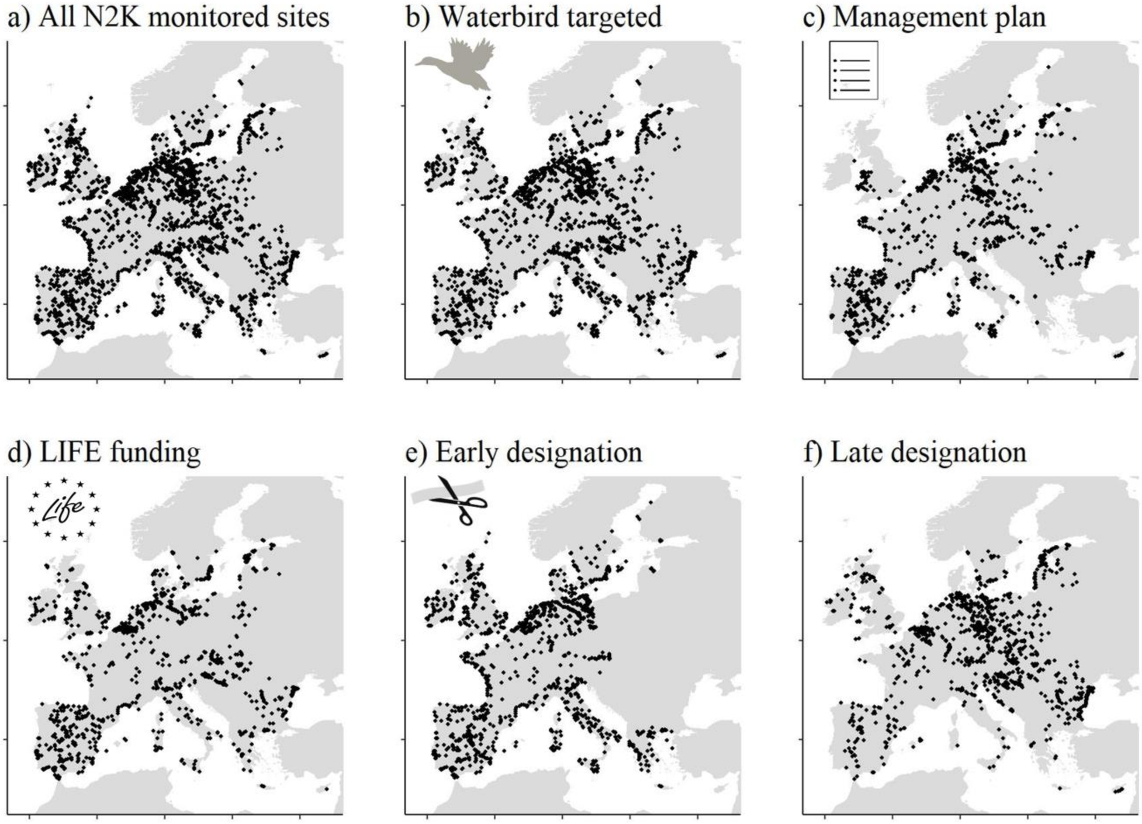

Figure 1: IWC sites that a) fall within a protected area (PA) under the Natura 2000 (N2K) network scheme and are included in the analysis following our data criteria (n = 3,018), for which the N2K characteristics include that b) waterbird(s) were targeted, c) management plan has been prepared, d) LIFE funding has been obtained and the designation was e) early or f) late, where early is <2000, the mid-year according to PA designation period (1982-2017).

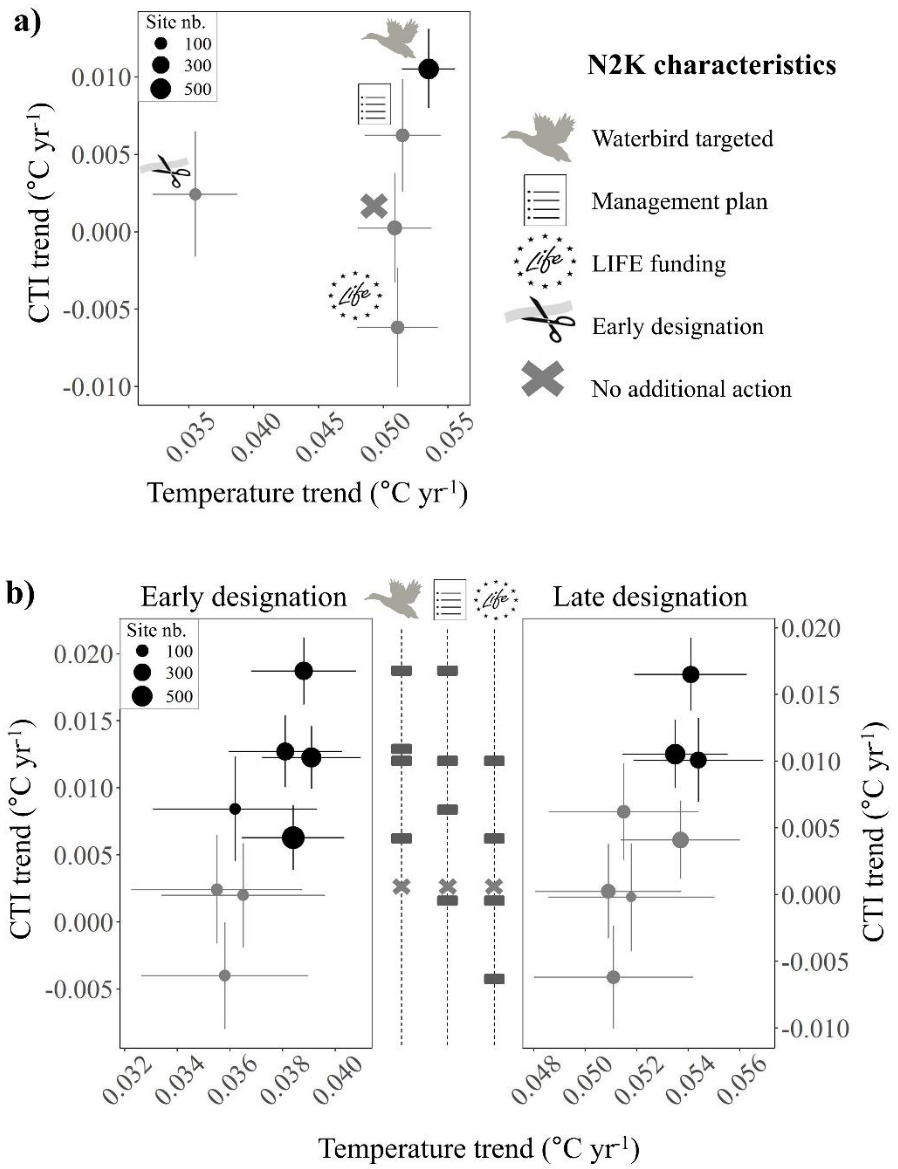

Figure 2: Estimated temporal trends of CTI and temperature in wetland sites protected under Natura 2000 (N2K) network sites that were monitored by the IWC. CTI trends that differ significantly from zero are shown in black, and those that do not differ from zero in grey. All temperature trends are different from zero and positive. Lines indicate ± standard error. Dot size corresponds to number of sites (reported in Table 1). Panel (a) shows the main effects of site characteristics aimed at waterbird species, having a management plan, having obtained LIFE funding, being designated early (<2000) as well as having none of these characteristics. Panel (b) shows the temporal trends in CTI and temperature for all the possible combinations of N2K characteristics where the bars in between the plots indicate which characteristics were taken using the symbols as explained in panel (a). Thus, the point with the fastest temporal trend in CTI is for sites targeting waterbirds with a management plan; the second point from the top denotes sites targeting waterbirds, etc. Note that to facilitate visual interpretation, the y-scales differ between early and late designated sites.

Pinpointing which protected area characteristics help community response to climate warming: waterbirds in the European Union’s Natura 2000 network

Appendix 1. Species information

The International Waterbird Census (IWC) targets all waterbird species since the end of the 1980s. Long-term monitoring has been conducted in Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom. However, gulls and shags were not systematically included in some national monitoring. A complete census was performed later in Romania (1999), Belgium (Flandre, 2000), Denmark (2001), United Kingdom (2002), Ireland (2002) and Sweden (still not full). We corrected the CTI to avoid a bias induced by the addition of these species over time, by centring CTI values per site (not reducing) before the monitoring change and adding these values to the average site CTI value of the years after the monitoring change (Gaget et al. 2020b). The $\mathrm{CTI}_{\mathrm{SD}}$ was not corrected (but see Gaget et al. 2020b).

Table S1. List of the species with their species temperature index (STI) and total number of birds counted over the 25-year period.

Species name	STI	Total abundance	Species name	STI	Total abundance
Actitis hypoleucos	23.157	13882	*Ichthyaetus melanocephalus*	9.306	216165
Anas acuta	16.897	1598034	*Larus argentatus*	4.578	6695899
Anas crecca	12.725	8708854	*Larus canus*	1.618	1713090
Anas platyrhynchos	-0.020	20788467	*Larus fuscus*	18.580	999113
Anser albifrons	2.533	8841023	*Larus marinus*	-2.492	261923
Anser anser	4.465	5105551	*Limosa lapponica*	19.227	916125
Anser brachyrhynchus	2.021	1111122	*Limosa limosa*	21.015	1368458
Anser erythropus	2.434	1355	*Mareca penelope*	16.530	15085930
Anser fabalis & serrirostris	-2.514	3024771	*Mareca strepera*	11.735	1228652
Ardea cinerea	18.734	489794	*Marmaronetta angustirostris*	5.954	296
Arenaria interpres	17.861	411282	*Melanitta fusca*	0.670	389784
Aythya ferina	11.336	4660585	*Melanitta nigra*	2.280	1756485
Aythya fuligula	10.452	6720177	*Mergellus albellus*	-1.579	215464
Aythya marila	0.428	2105733	*Mergus merganser*	-0.397	787884
Aythya nyroca	9.773	16767	*Mergus serrator*	-1.083	381289
Botaurus stellaris	18.395	2927	*Microcarbo pygmeus*	2.744	264738
Branta bernicla	2.863	6788806	*Netta rufina*	5.352	418354
Branta leucopsis	1.686	3390313	*Numenius arquata*	18.888	2959783
Branta ruficollis	1.097	417362	*Numenius phaeopus*	22.058	11416
Bubulcus ibis	22.960	223166	*Nycticorax nycticorax*	23.472	13259

Bucephala clangula	-1.105	1766062
Calidris alba	18.862	496630
Calidris alpina	11.831	13648117
Calidris canutus	19.078	3839071
Calidris maritima	-2.483	19034
Calidris minuta	22.774	148258
Casmerodius albus	21.856	186057
Charadrius alexandrinus	19.198	131230
Charadrius hiaticula	22.108	383072
Chroicocephalus genei	11.898	67716
Chroicocephalus ridibundus	6.582	9416624
Ciconia ciconia	22.949	41713
Clangula hyemalis	-2.500	1119744
Cygnus columbianus	2.437	119929
Cygnus cygnus	-1.491	456924
Cygnus olor	1.269	1551078
Egretta garzetta	21.263	358354
Fulica atra	5.865	16106076
Fulica cristata	22.590	1054
Gallinago gallinago	18.584	144440
Gallinula chloropus	16.307	359493
Gavia arctica	0.764	14561
Gavia stellata	3.054	27516
Grus grus	14.716	1206396
Haematopus ostralegus	15.341	6991052
Himantopus himantopus	22.126	88522
Hydrocoloeus minutus	3.700	9639
Ichthyaetus audouinii	11.453	15478
Oxyura leucocephala	1.270	11751
Pelecanus crispus	8.366	35467
Pelecanus onocrotalus	22.005	353
Phalacrocorax aristotelis	2.299	31441
Phalacrocorax carbo	18.408	2925140
Philomachus pugnax	22.963	33438
Phoenicopterus roseus	20.584	1648943
Platalea leucorodia	17.950	41599
Plegadis falcinellus	23.137	50634
Pluvialis apricaria	5.357	2459930
Pluvialis squatarola	18.836	1421314
Podiceps auritus	3.394	11078
Podiceps cristatus	10.083	1598172
Podiceps grisegena	2.273	2646
Podiceps nigricollis	17.998	448628
Porphyrio porphyrio	22.120	30385
Rallus aquaticus	4.524	25572
Recurvirostra avosetta	22.045	918636
Somateria mollissima	-7.529	3838707
Spatula clypeata	14.912	2612133
Sterna sandvicensis	12.381	28107
Tachybaptus ruficollis	18.596	391187
Tadorna ferruginea	8.880	5595
Tadorna tadorna	4.300	3048067
Tringa erythropus	21.035	29441
Tringa nebularia	23.157	30159
Tringa ochropus	21.099	11092
Tringa totanus	15.484	1011945
Vanellus vanellus	4.517	7245956

Appendix 2. Natura 2000 (N2K) network site characteristics.

Site characteristics were collected from eunis.eea.europa.eu/sites and ec.europa.eu/easme/en/life.

Waterbird targeted (n_{Yes}=2470, n_{No}=548 IWC sites). The N2K site designation may target bird species listed in Annex I of the Birds Directive and migratory species not listed in Annex I (Birds Directive, Article 4). All waterbird species studied are migratory species apart from the Red-knobbed Coot (*Fulica cristata*) and the Purple Swamphen (*Porphyrio porphyrio*) (Birdlife 2019), which are however listed in Annex I of the Birds Directive. A N2K site can be established without a waterbird target when the designation is under the Habitats Directive.

Management plan (n_{Yes}=1305, n_{No}=1713 IWC sites). The management plan of a N2K site is made by the relevant stakeholders to define the objectives needed to maintain or restore the conservation status of the habitats and species of community interest. Management plan date and measures (like habitat restoration, eradication of invasive species, translocation, prescribed burning or water management) are lacking from the site information in the large majority of the sites. We considered the management plan “In preparation” as not existing.

LIFE funding (n_{Yes}=1517, n_{No}=1501 IWC sites). From 1992 to 2016 included, 1234 LIFE funding events for environmental conservation were directed to 5,033 N2K sites, totalling 2.7 billion of Euros. The LIFE projects of the studied N2K sites targeted a large range of nature protection actions, mostly for wetland habitat and species conservation, and sometimes for other endangered habitats or species (e.g. lynx, raptors).

Designation period (n_{Early}=1643, n_{Late}=1375 IWC sites, range = 1982-2017). We used the first year reported among site classification, confirmation or designation, because some sites were already designated as PA under the Birds Directive before the N2K establishment in 1992. We compared early to late designation according to 2000, the mid-year of the 25-year monitoring period.

Appendix 3. Sensitivity analyses.

We conducted four additional sensitivity analyses (Appendix 3), to evaluate the robustness of our results to a number of analytical decisions. We checked: (1) whether CTI and CTI_{SD} trends were overly influenced by a few abundant species, by using species occurrence instead of abundance. (2) Whether the CTI and CTI_{SD} trends were affected by the geographical West-East EU accession gradient, by fitting models only with the subset of 11 countries in the EU before 1992 (n = 2,186 sites); (3) whether the community changes resulted from a decrease or an increase of species richness; and (4) whether the CTI trends associated with each N2K site protective action were correlated with the amount of protected wetland surface.

Hypotheses and methods

(1) The CTI and CTI_{SD} trends based on species abundance are usually similar to the trends based on species occurrence, but differences may suggest the impact of a few number of species (Devictor et al. 2008, Gaget et al. 2020b). The CTI and CTI_{SD} based on occurrence are the CTI and CTI_{SD} unweighted by species abundance (Gaget et al. 2020b).

(2) The temporal effect of the designation period before or after 2000 may be confounded with the geographical effect of the N2K North-East expansion due to EU country accession date. To investigate the potential influence of the geographical N2K extension we differentiated countries from their EU accession date. The monitored sites were located in 11 countries already inside the EU before 1992, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and the United Kingdom (n = 2,186 sites).

We conducted the complementary analyses (1) and (2) by using linear mixed-effects models investigating the linear temporal change of CTI and CTI_{SD} (abundance and occurrence), using all the sites or only the sites within the 11 countries already in the UE before 1992. The models included the main effects of the N2K characteristics (waterbird target, management plan existence, LIFE funding and designation period), of the year, and the two-way interactions between N2K characteristics and year. The site and the country were added as a random effect and the spatial autocorrelation was taken into account by including the IWC site coordinates as an exponential spatial correlation structure in the model[25].

(3) A CTI increase can be caused by an increasing abundance - and a colonization - of species with high STIs or a by a decreasing abundance - and an extinction - of species with low STIs.

To ensure that community changes were not driven by a decline of the species richness in an "extinction scenario", we assessed in a generalised linear mixed model (Poisson error distribution) the temporal trend of the species richness in relation to the N2K site characteristics. Fixed effects were all main effects and the two-way interactions between N2K characteristics and year. The site and the country were added as random effects while the spatial autocorrelation was taken into account by including the IWC site coordinates with an exponential spatial correlation structure in the model[25]. The correlation between the CTI trend and the species richness trend over years per N2K characteristics (n = 16 combinations) was assessed with a Spearman correlation.

(4) We investigated the differences of N2K site wetland surfaces between site N2K characteristics (waterbird target, management plan existence, LIFE funding and designation period), assuming higher wetland surfaces inside N2K sites designated for protection of waterbirds. We also investigated whether higher wetland surfaces correlated with more positive CTI trends, assuming that higher wetland surfaces may increase both habitat diversity and availability, improving waterbird colonization notably by warm-dwelling species. The N2K site wetland surfaces were extracted from the N2K database (eunis.eea.europa.eu/sites). We considered wetlands as 18 different habitat classes: Inland water bodies (Standing water, Running water); Bogs, Marshes, Water fringed vegetation, Fens; Salt marshes, Salt pastures, Salt steppes; Tidal rivers, Estuaries, Mud flats, Sand flats, Lagoons (including saltwork basins); Marine areas, Sea inlets; Ricefields; Marine and coastal habitats (general). The surface per site was computed from the site size and the proportion of wetland habitats. The dataset used for wetland surfaces investigations include 2925 monitored sites (93 sites without habitat proportions were deleted from the data). Note that on average (±SD) 80.8 ± 23.3 % of the IWC surface was included in the corresponding N2K site (based on 1,307 IWC sites with available polygons).

We conducted the complementary analysis (4) by first investigating the differences of wetland surface relative to N2K characteristics levels using generalized linear models (negative binomial error distribution) with the wetland surface as response variable and the N2K characteristics as fixed effects. Second, we investigated the CTI (abundance) linear trend using the same CTI model as described in Methods, adding the main effect of the log(wetland surface) and its interaction with year.

Results

(1) The CTI and $\mathrm{CTI}_{\mathrm{SD}}$ trends (Figure S1a and S1b) are fairly similar based on species occurrence (unfilled dots) or abundance (filled dots).

(2) The CTI and $\mathrm{CTI}_{\mathrm{SD}}$ trends (Figure S1a and S1b) remain mostly unchanged considering all the EU countries (black dots) or only those already in the EU before 1992 (grey dots). The temperature

trends were in general less positive in the EU Member States before 1992 (Figure S1b). However, the 95%CI of the CTI trends were considerably larger based on all countries (black dots) than on countries already in the EU before 1992 (grey dots) suggesting heterogeneous patterns of CTI trends in the countries that joint recently the EU, that could be due to geographical differences, including anthropogenic pressures (e.g. land-use change, harvesting) and differences of ecological characteristics (e.g. inland or coastal wetlands, species distribution).

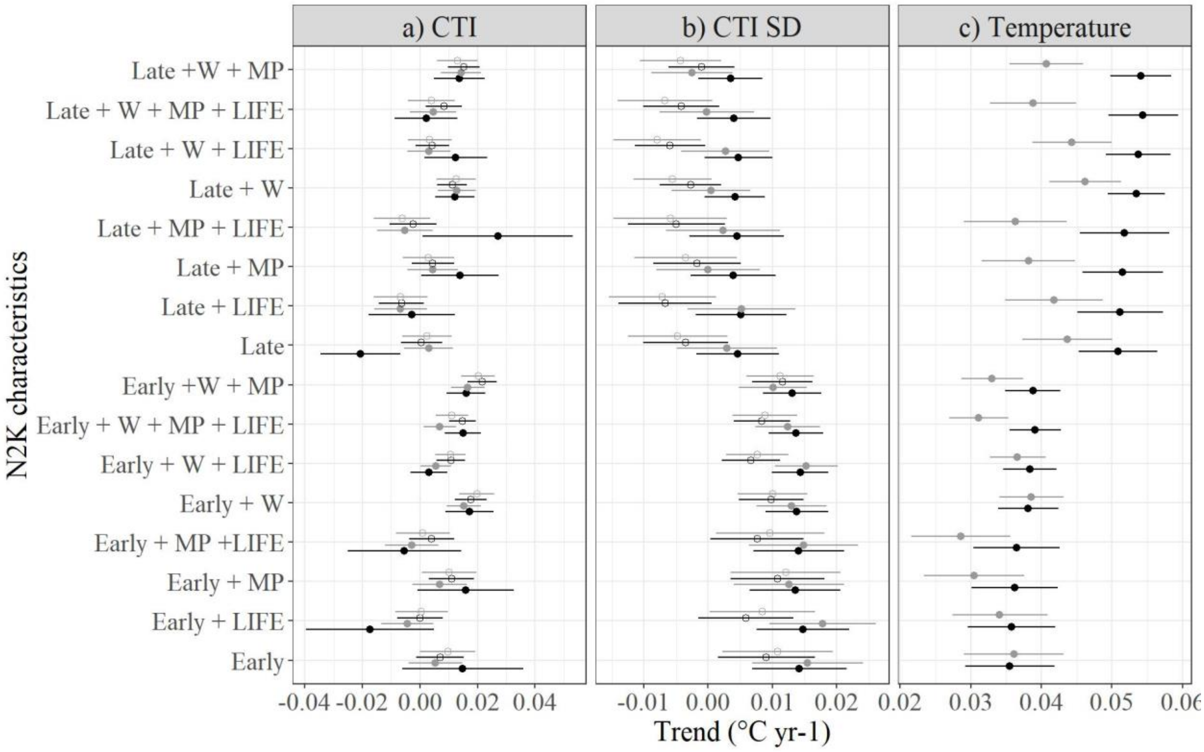

Figure S1: Parameter estimates (±95%CI) of the temporal trends of a) CTI, b) CTI_{SD} and c) temperature between N2K characteristics, based on all countries (black) or only the EU Member States before 1992 (grey), using abundance (filled dots) or occurrence data (unfilled dots). The N2K characteristics document whether waterbird(s) were targeted ([Yes/No]), a management plan has been prepared ([Yes/No]), LIFE funding has been obtained ([Yes/No]) and the period the protection was designated ([Early/Late], where early is <2000, the mid-year according to PA designation period (1982-2017). The EU Member States before 1992 were Belgium, Denmark, France, Germany, Greece, Ireland, Italy Netherlands, Portugal, Spain, and the United Kingdom.

(3) We find that in our case, a "colonisation scenario" is occurring, because the temporal trends of species richness per combination of N2K protective action were all positives (Figure S2) and correlated strongly to the CTI trends (Figure S3, $r_{Spearman} = 0.92$, $p < 0.001$).

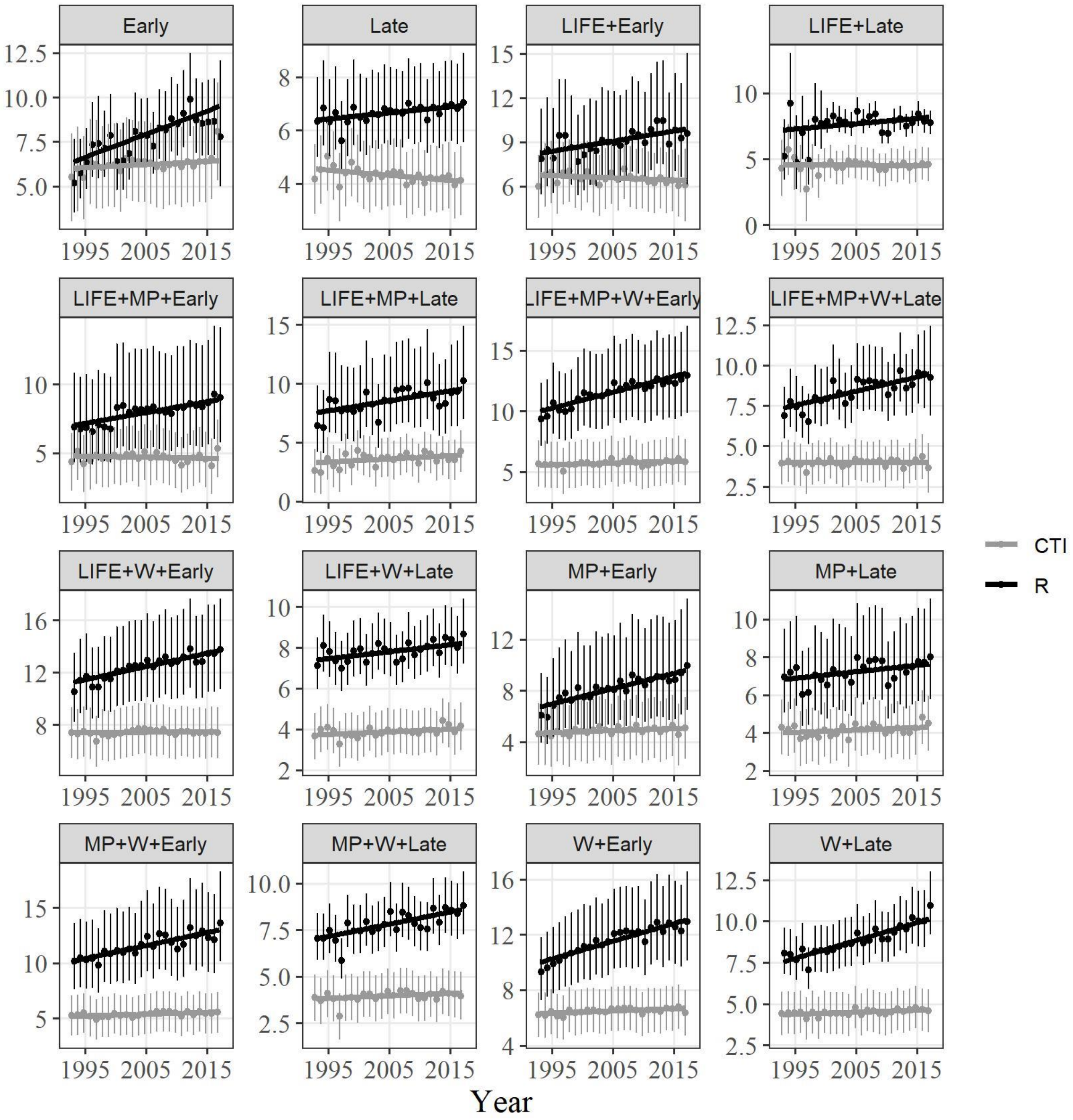

Figure S2: Temporal trend (±CI95%) of CTI (in grey) and species richness (R, in black) per combination of N2K protective action. Mean annual values (± 95% CI) have been generated by using the same model as for the linear trends, but changing year to a categorical variable.

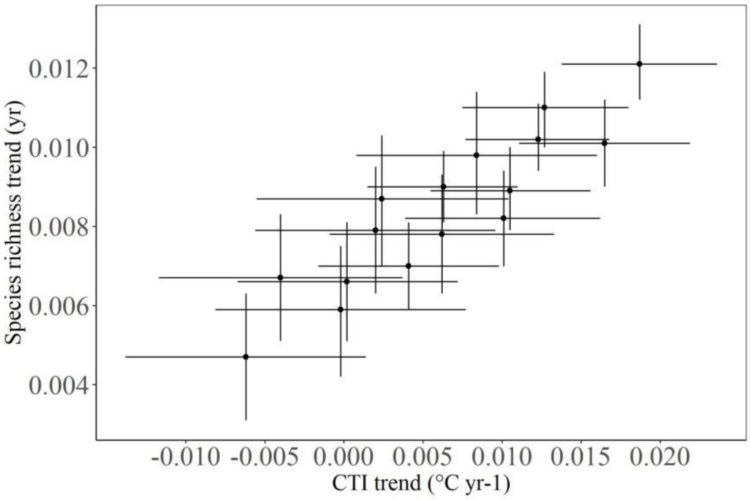

Figure S3. Temporal trend (±CI95%) of CTI and species richness per combination of N2K protective action. The temporal trends of species richness are all positives and correlated strongly to the CTI trends ($r_{Spearman} = 0.92$, $p < 0.001$).

(4) The wetland surface area was smaller in N2K sites designated for waterbird conservation (mean ± SD, 99 ± 414 km^2) compared to sites without waterbird target (132 ± 870 km^2) ($p = 0.03$); did not differ between sites with (105 ± 349 km^2) or without management plan (106 ± 643 km^2) ($p = 0.5$); was greater in sites with LIFE funding (104 ± 344 km^2) than in sites without a LIFE funding (107 ± 644 km^2) ($p = 0.03$); and was significantly smaller in sites designated before 2000 (78 ± 271 km^2) than in sites designated since 2000 (140 ± 750 km^2) ($p < 0.001$).

The wetland surfaces had a significant positive effect on the CTI average ($F_{1,2893} = 123.1$, $p < 0.001$) and temporal trend ($F_{1,34653} = 9.0$, $p = 0.003$). The results suggest that the community response to climate warming was higher when protected wetland surface next to the monitoring site was larger. The effects of the N2K characteristics on the CTI trend were similar than those estimated without adding the wetland surfaces in the model: CTI trends were more positive in protected sites targeted to protect waterbirds compared to protected sites not targeted to protect waterbirds ($F_{1,34653} = 8.4$, $p = 0.004$); more positive in protected sites with a management plan compared to CTI change in protected sites without a management plan ($F_{1,34653} = 4.9$, $p = 0.03$). Furthermore, CTI trends were more positive in protected sites without LIFE funding compared to CTI change in protected sites with LIFE funding ($F_{1,34653} = 7.2$, $p = 0.002$). Last, the CTI change in N2K sites established prior to 2000 (“early”) did not differ from N2K sites established after 2000 ($F_{1,34653} < 0.0$, $p = 0.9$).

Appendix 4. Pairwise comparisons of the CTI temporal trends according to the N2K characteristics; waterbird(s) were targeted (W), a management plan has been prepared (MP), the period the protection was designated (Late or Early, where early is <2000), or LIFE funding has been obtained (LIFE). The significant differences, after Bonferroni correction, are denoted in bold (α<0.05).

Pairwise comparisons			Estimate	SE	df	t	p
Early	/	Early + MP	-0.006	0.003	35536	-2.355	1.000
Early	/	Early + W	-0.010	0.003	35536	-2.983	0.343
Early	**/**	**Early + W + MP**	**-0.016**	**0.004**	**35536**	**-3.777**	**0.019**
Early	/	Late	0.002	0.003	35536	0.812	1.000
Early	/	Late + MP	-0.004	0.004	35536	-0.959	1.000
Early	/	Late + W	-0.008	0.005	35536	-1.711	1.000
Early	/	Late + W + MP	-0.014	0.006	35536	-2.529	1.000
Early + LIFE	/	Early	-0.006	0.003	35536	-2.483	1.000
Early + LIFE	/	Early + MP	-0.012	0.004	35536	-3.495	0.057
Early + LIFE	/	Early + MP + LIFE	-0.006	0.003	35536	-2.355	1.000
Early + LIFE	**/**	**Early + W**	**-0.017**	**0.004**	**35536**	**-3.815**	**0.016**
Early + LIFE	/	Early + W + LIFE	-0.010	0.003	35536	-2.983	0.343
Early + LIFE	**/**	**Early + W + MP**	**-0.023**	**0.005**	**35536**	**-4.511**	**0.001**
Early + LIFE	**/**	**Early + W + MP + LIFE**	**-0.016**	**0.004**	**35536**	**-3.777**	**0.019**
Early + LIFE	/	Late	-0.004	0.003	35536	-1.290	1.000
Early + LIFE	/	Late + LIFE	0.002	0.003	35536	0.812	1.000
Early + LIFE	/	Late + MP	-0.010	0.004	35536	-2.367	1.000
Early + LIFE	/	Late + MP + LIFE	-0.004	0.004	35536	-0.959	1.000
Early + LIFE	/	Late + W	-0.015	0.005	35536	-2.819	0.579
Early + LIFE	/	Late + W + LIFE	-0.008	0.005	35536	-1.711	1.000
Early + LIFE	/	Late + W + MP	-0.021	0.006	35536	-3.486	0.059
Early + LIFE	/	Late + W + MP + LIFE	-0.014	0.006	35536	-2.529	1.000
Early + MP	/	Early + W + MP	-0.010	0.003	35536	-2.983	0.343
Early + MP	/	Late + MP	0.002	0.003	35536	0.812	1.000
Early + MP	/	Late + W + MP	-0.008	0.005	35536	-1.711	1.000
Early + MP + LIFE	/	Early	0.000	0.004	35536	-0.122	1.000
Early + MP + LIFE	/	Early + MP	-0.006	0.003	35536	-2.483	1.000
Early + MP + LIFE	/	Early + W	-0.011	0.005	35536	-2.106	1.000
Early + MP + LIFE	**/**	**Early + W + MP**	**-0.017**	**0.004**	**35536**	**-3.815**	**0.016**
Early + MP + LIFE	/	Early + W + MP + LIFE	-0.010	0.003	35536	-2.983	0.343
Early + MP + LIFE	/	Late	0.002	0.004	35536	0.436	1.000
Early + MP + LIFE	/	Late + MP	-0.004	0.003	35536	-1.290	1.000
Early + MP + LIFE	/	Late + MP + LIFE	0.002	0.003	35536	0.812	1.000
Early + MP + LIFE	/	Late + W	-0.009	0.006	35536	-1.525	1.000
Early + MP + LIFE	/	Late + W + MP	-0.015	0.005	35536	-2.819	0.579
Early + MP + LIFE	/	Late + W + MP + LIFE	-0.008	0.005	35536	-1.711	1.000
Early + W	/	Early + MP	0.004	0.004	35536	1.012	1.000
Early + W	/	Early + W + MP	-0.006	0.003	35536	-2.355	1.000
Early + W	/	Late + MP	0.006	0.005	35536	1.324	1.000
Early + W	/	Late + W	0.002	0.003	35536	0.812	1.000

Early + W	/	Late + W + MP	-0.004	0.004	35536	-0.959	1.000
Early + W + LIFE	/	Early	0.004	0.004	35536	0.909	1.000
Early + W + LIFE	/	Early + MP	-0.002	0.005	35536	-0.436	1.000
Early + W + LIFE	/	Early + MP + LIFE	0.004	0.004	35536	1.012	1.000
Early + W + LIFE	/	Early + W	-0.006	0.003	35536	-2.483	1.000
Early + W + LIFE	/	Early + W + MP	-0.012	0.004	35536	-3.495	0.057
Early + W + LIFE	/	Early + W + MP + LIFE	-0.006	0.003	35536	-2.355	1.000
Early + W + LIFE	/	Late	0.006	0.004	35536	1.392	1.000
Early + W + LIFE	/	Late + MP	0.000	0.005	35536	0.013	1.000
Early + W + LIFE	/	Late + MP + LIFE	0.006	0.005	35536	1.324	1.000
Early + W + LIFE	/	Late + W	-0.004	0.003	35536	-1.290	1.000
Early + W + LIFE	/	Late + W + LIFE	0.002	0.003	35536	0.812	1.000
Early + W + LIFE	/	Late + W + MP	-0.010	0.004	35536	-2.367	1.000
Early + W + LIFE	/	Late + W + MP + LIFE	-0.004	0.004	35536	-0.959	1.000
Early + W + MP	/	Late + W + MP	0.002	0.003	35536	0.812	1.000
Early + W + MP + LIFE	/	Early	0.010	0.005	35536	1.960	1.000
Early + W + MP + LIFE	/	Early + MP	0.004	0.004	35536	0.909	1.000
Early + W + MP + LIFE	/	Early + W	0.000	0.004	35536	-0.122	1.000
Early + W + MP + LIFE	/	Early + W + MP	-0.006	0.003	35536	-2.483	1.000
Early + W + MP + LIFE	/	Late	0.012	0.005	35536	2.448	1.000
Early + W + MP + LIFE	/	Late + MP	0.006	0.004	35536	1.392	1.000
Early + W + MP + LIFE	/	Late + W	0.002	0.004	35536	0.436	1.000
Early + W + MP + LIFE	/	Late + W + MP	-0.004	0.003	35536	-1.290	1.000
Early + W + MP + LIFE	/	Late + W + MP + LIFE	0.002	0.003	35536	0.812	1.000
Late	/	Early + MP	-0.008	0.003	35536	-2.380	1.000
Late	/	Early + W	-0.012	0.004	35536	-3.128	0.211
Late	**/**	**Early + W + MP**	**-0.018**	**0.005**	**35536**	**-4.063**	**0.006**
Late	/	Late + MP	-0.006	0.003	35536	-2.355	1.000
Late	/	Late + W	-0.010	0.003	35536	-2.983	0.343
Late	**/**	**Late + W + MP**	**-0.016**	**0.004**	**35536**	**-3.777**	**0.019**
Late + LIFE	/	Early	-0.009	0.004	35536	-2.083	1.000
Late + LIFE	/	Early + MP	-0.015	0.005	35536	-3.179	0.177
Late + LIFE	/	Early + MP + LIFE	-0.008	0.003	35536	-2.380	1.000
Late + LIFE	**/**	**Early + W**	**-0.019**	**0.005**	**35536**	**-3.682**	**0.028**
Late + LIFE	/	Early + W + LIFE	-0.012	0.004	35536	-3.128	0.211
Late + LIFE	**/**	**Early + W + MP**	**-0.025**	**0.006**	**35536**	**-4.503**	**0.001**
Late + LIFE	**/**	**Early + W + MP + LIFE**	**-0.018**	**0.005**	**35536**	**-4.063**	**0.006**
Late + LIFE	/	Late	-0.006	0.003	35536	-2.483	1.000
Late + LIFE	/	Late + MP	-0.012	0.004	35536	-3.495	0.057
Late + LIFE	/	Late + MP + LIFE	-0.006	0.003	35536	-2.355	1.000
Late + LIFE	**/**	**Late + W**	**-0.017**	**0.004**	**35536**	**-3.815**	**0.016**
Late + LIFE	/	Late + W + LIFE	-0.010	0.003	35536	-2.983	0.343
Late + LIFE	**/**	**Late + W + MP**	**-0.023**	**0.005**	**35536**	**-4.511**	**0.001**
Late + LIFE	**/**	**Late + W + MP + LIFE**	**-0.016**	**0.004**	**35536**	**-3.777**	**0.019**
Late + MP	/	Early + W + MP	-0.012	0.004	35536	-3.128	0.211
Late + MP	/	Late + W + MP	-0.010	0.003	35536	-2.983	0.343
Late + MP + LIFE	/	Early	-0.003	0.005	35536	-0.517	1.000

Late + MP + LIFE	/	Early + MP	-0.009	0.004	35536	-2.083	1.000
Late + MP + LIFE	/	Early + W	-0.013	0.006	35536	-2.183	1.000
Late + MP + LIFE	**/**	**Early + W + MP**	**-0.019**	**0.005**	**35536**	**-3.682**	**0.028**
Late + MP + LIFE	/	Early + W + MP + LIFE	-0.012	0.004	35536	-3.128	0.211
Late + MP + LIFE	/	Late	0.000	0.004	35536	-0.122	1.000
Late + MP + LIFE	/	Late + MP	-0.006	0.003	35536	-2.483	1.000
Late + MP + LIFE	/	Late + W	-0.011	0.005	35536	-2.106	1.000
Late + MP + LIFE	**/**	**Late + W + MP**	**-0.017**	**0.004**	**35536**	**-3.815**	**0.016**
Late + MP + LIFE	/	Late + W + MP + LIFE	-0.010	0.003	35536	-2.983	0.343
Late + W	/	Early + MP	0.002	0.005	35536	0.410	1.000
Late + W	/	Early + W + MP	-0.008	0.003	35536	-2.380	1.000
Late + W	/	Late + MP	0.004	0.004	35536	1.012	1.000
Late + W	/	Late + W + MP	-0.006	0.003	35536	-2.355	1.000
Late + W + LIFE	/	Early	0.002	0.006	35536	0.296	1.000
Late + W + LIFE	/	Early + MP	-0.004	0.006	35536	-0.725	1.000
Late + W + LIFE	/	Early + MP + LIFE	0.002	0.005	35536	0.410	1.000
Late + W + LIFE	/	Early + W	-0.009	0.004	35536	-2.083	1.000
Late + W + LIFE	/	Early + W + MP	-0.015	0.005	35536	-3.179	0.177
Late + W + LIFE	/	Early + W + MP + LIFE	-0.008	0.003	35536	-2.380	1.000
Late + W + LIFE	/	Late	0.004	0.004	35536	0.909	1.000
Late + W + LIFE	/	Late + MP	-0.002	0.005	35536	-0.436	1.000
Late + W + LIFE	/	Late + MP + LIFE	0.004	0.004	35536	1.012	1.000
Late + W + LIFE	/	Late + W	-0.006	0.003	35536	-2.483	1.000
Late + W + LIFE	/	Late + W + MP	-0.012	0.004	35536	-3.495	0.057
Late + W + LIFE	/	Late + W + MP + LIFE	-0.006	0.003	35536	-2.355	1.000
Late + W + MP + LIFE	/	Early	0.008	0.006	35536	1.198	1.000
Late + W + MP + LIFE	/	Early + MP	0.002	0.006	35536	0.296	1.000
Late + W + MP + LIFE	/	Early + W	-0.003	0.005	35536	-0.517	1.000
Late + W + MP + LIFE	/	Early + W + MP	-0.009	0.004	35536	-2.083	1.000
Late + W + MP + LIFE	/	Late	0.010	0.005	35536	1.960	1.000
Late + W + MP + LIFE	/	Late + MP	0.004	0.004	35536	0.909	1.000
Late + W + MP + LIFE	/	Late + W	0.000	0.004	35536	-0.122	1.000
Late + W + MP + LIFE	/	Late + W + MP	-0.006	0.003	35536	-2.483	1.000