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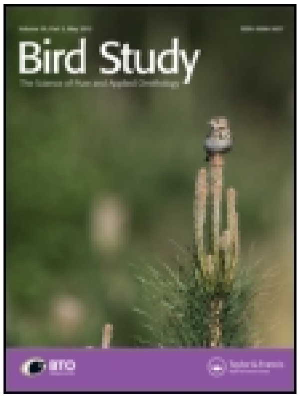

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Hunting and the fate of French breeding waterbirds

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Hunting and the fate of French breeding waterbirds

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Capsule French breeding populations of hunted waterbirds have more negative long-term population trends than closely related non-hunted species.
Aims To assess the relative fate of breeding populations of hunted and non-hunted waterbird species in France.
Methods We compared long-term population growth rates of hunted versus non-hunted waterbirds using two large-scale and long-term national surveys.
Results Waterbirds globally displayed long-term increases in population sizes most likely driven by their positive response to the implementation of numerous protected areas over remnant wetlands across the country since the early 1970s. In contrast, hunted species revealed more negative trends compared to non-hunted species.
Conclusion A causal relationship between hunting and population dynamics is not demonstrated here, but the results are consistent with species' breeding populations being negatively affected, on average, if they are hunted.

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Hunting is a widespread activity with more than 7,000,000 practitioners in Europe (FACE 2012; Fig. 1). Whether hunting is globally positive or negative for biodiversity is controversial. On one hand, hunting may play a positive role in controlling increasing populations of particular species such as introduced invaders (Booth 2008), pests for human economic activities or health (Artois 1997, Skonhoft & Olaussen 2005), or species for which natural predators have disappeared (Skonhoft *et al.* 2002, Baumann *et al.* 2005). On the other hand, numerous species are legally shot while they are neither a pest nor necessitate active population control. Understanding the potential impact of legal hunting is necessary especially in the context of current observed biodiversity declines (Butchart *et al.* 2010). Indeed, the cumulative direct or indirect effects of hunting, along with other pressures such as the effects of climate and agriculture intensification on farmland birds (Jiguet *et al.* 2010), might result in substantial negative effects on population dynamics.

Hunting is also an activity that provides significant social, cultural, economic and environmental benefits in different regions of the European Union. Therefore, the EU Birds Directive (79/409/EEC) recognizes hunting as a legitimate activity and provides a comprehensive system for the management of hunting, including a list of game species listed in Annex II (II/A allows hunting in all Member States; II/B allows hunting in listed Member States). These controls on hunting are intended to ensure a balance between the activity and the long-term interest of maintaining healthy and viable populations of game species, to ensure that this practice is sustainable. Member States do not systematically authorize the hunting of all listed species, and the number of hunted species varies between countries. In France, the 15 waterbird species listed in Annex II/A and all 23 listed in Annex II/B are hunted, which represents a total of 38 waterbirds (Fig. 1).

It is difficult to assess the true impact of hunting for each game species in the absence of intensive individual marking schemes (Gauthier *et al.* 2001). However, independent large-scale monitoring

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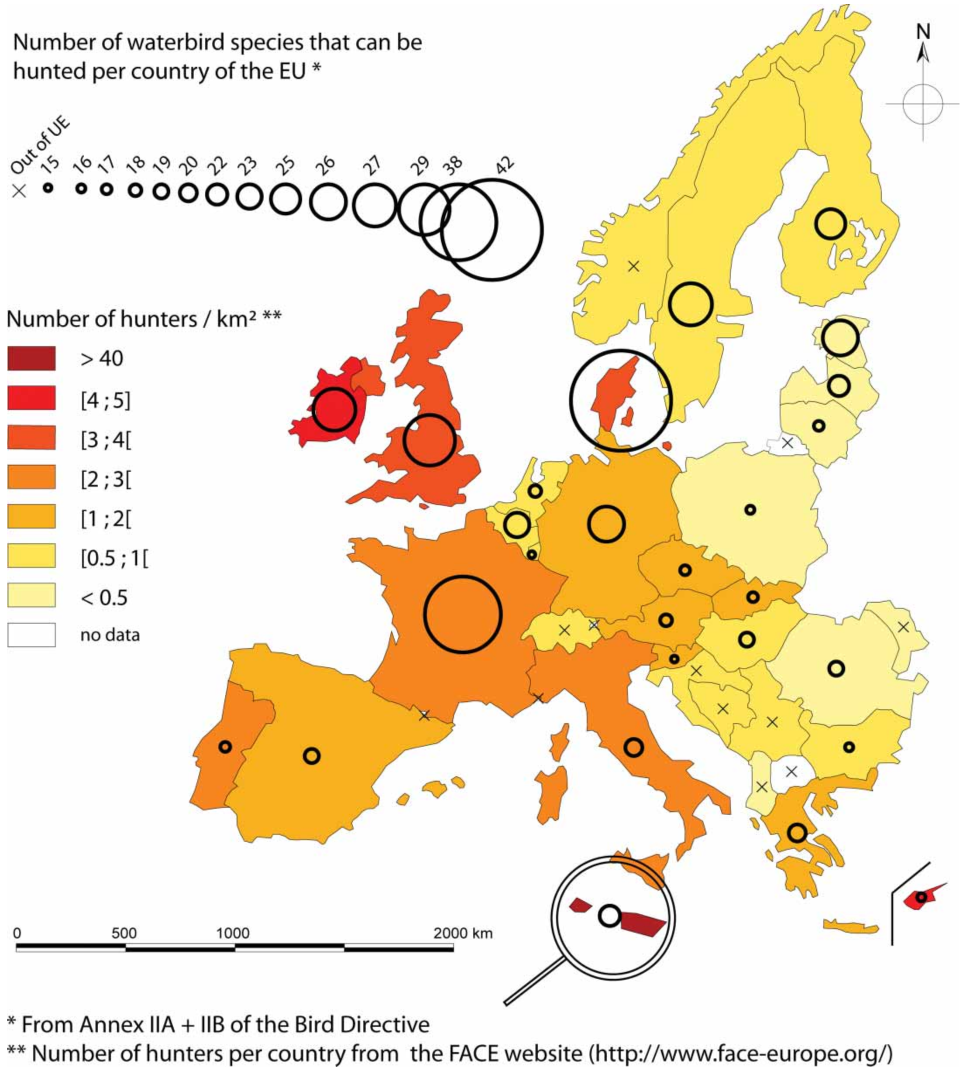

Figure 1. National density of hunters and number of waterbird species that can be hunted in European countries.

programmes can provide informative trends of breeding population sizes for hunted species, and these can be compared to those of close relatives which are not hunted. Breeding populations of common to rare breeding birds have been monitored by observers' networks for decades, enabling the assessment of individual species' trends (PECBMS 2011) and conservation status (i.e. the Red List of French breeding birds; IUCN France *et al.* 2011) and the production of various biodiversity indicators at European and national scales (Gregory *et al.* 2005, Dupuis *et al.* 2011, Jiguet *et al.* 2011). These monitoring programmes have the great advantage of providing independent assessments of spatial and temporal variations in the abundance of many species with a standardized protocol. Although causal determinants of population dynamics are difficult to infer from these data, they are highly relevant when the aim is to compare the fate of particular species groups (classified a priori) to investigate a specific question (Yoccoz *et al.* 2001), such as whether a species is hunted or not.

The aim of the present study is to estimate and compare long-term population growth rates of hunted versus non-hunted waterbirds in France in order to assess whether hunting may be correlated with trends in breeding population size. We expect most waterbirds to display long-term increases in population size as a positive response to the implementation of numerous protected areas over remnant wetlands across the

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country since the early 1970s (Donald *et al.* 2007). If recreational hunting has a negative impact on population dynamics, we expect hunted species to display more negative trends compared to non-hunted species.

To verify that the observed trends in breeding numbers of hunted and of non-hunted species are not driven by few particular species, we tested the robustness of the trends when excluding some species in a group randomly. Potential differences between the two groups could also arise from differences in the species' climatic affinities, if one group includes more cool-dwelling species which are known to have more negative population trends in the face of climate change (Jiguet *et al.* 2010). As a consequence, we also considered a measure of species climatic affinity as a predictor of population trends. Within game species, some are bred in captivity and released in large numbers to increase hunting opportunities. Such autumn population reinforcement could bias observed trends in spring breeding numbers. In the set of species we studied, this only applies to Mallards *Anas platyrhynchos*, and so we also verified that the results were not modified when excluding this species from the data set. Finally, rare species might also have distinct population dynamics because of their small population size, independently of hunting exposure, so we verified that the observed pattern was not driven by the rare breeding species (those with less than 50 breeding pairs in France).

METHODS

Our analyses focus on breeding waterbirds belonging to several taxonomic groups including both hunted and non-hunted species, here Anatidae, Rallidae within Gruiformes, and waders within the Charadriiformes. We considered all species with available data on breeding population sizes on the long term, with no a-priori selection of species. This represents a total of 30 species, listed in Table 1 with notes on their hunting status, start year of national monitoring and long-term population trends. Of these species, 19 are hunted, 11 are not. Only native species have been considered, so we did not include the Canada Goose *Branta canadensis* and the Ruddy Duck *Oxyura jamaicensis*. For the Common Teal *Anas crecca*, a survey of breeding pairs occurred only in 1976, 1979, 1982, 1990, 2000, 2006 and 2007, so the species was considered in the analysis with this temporally restricted data set. Nine hundred to 1000 pairs of Gadwall *Anas strepera* and 700–1300 pairs of Northern Shoveler *Anas clypeata* breed in France (estimates for year 2000, according to BirdLife International 2004), but unfortunately there is no relevant temporal survey of breeding numbers for these two ducks in France, so we could not consider them in the analyses. The estimates of breeding numbers for the Red-crested Pochard *Netta rufina* have also been re-evaluated recently using a new methodology accounting for detection probability (Defos du Rau *et al.* 2006), so that the long-term trends are not comparable, and so were not included here.

Counts of breeding birds came from two different sources: the national survey panel for rare breeding birds, which has been running in France since 1976 (Dupuis *et al.* 2011), and the national common breeding bird survey, which was launched in 1989 (Jiguet *et al.* 2011). The first scheme provided yearly counts of the number of breeding pairs for the country, while the second provided yearly population indices based on the monitoring of an unknown but fixed portion of the total breeding population within randomly selected 2 × 2 km squares, where volunteer observers count breeding birds each spring at fixed dates on ten fixed points (more details are available in Jiguet *et al.* 2011). Population indices are obtained by fitting a log-linear model with Poisson error to the counts and using the categorical year parameter estimates as indices of relative annual population sizes (more details in Jiguet *et al.* 2007). Counts obtained by the rare breeding bird panel were further transformed into indices with a baseline fixed to 1 for the initial year of 1976. For some species, data were not available for the whole study period, and their population indices were calibrated to equal the geometric mean of the indices of the other species in their first contribution year (for example, 1989 for many species surveyed by the BBS; see e.g. Loh *et al.* 2005).

We analysed the yearly breeding population indices with a mixed-effect model using the lme4 package in R 2.14.2 (R Development Core Team 2011). We first analysed separately the indices of hunted and of non-hunted species, to estimate the temporal trend in the average growth rate of these two groups, using mixed-effect model with a linear effect of year and random effects of species and of taxonomic genus nested within taxonomic family, in order to account for phylogenetic relatedness among species. We accounted for phylogenetic relatedness because closely related species might share common demographic parameters or the

Table 1. List of the 30 species considered in the analyses, with their scientific name, hunting status, the first year with available information on national breeding population size, number of kills declared during the 1998–99 survey of shooting bags (from ONCFS 2000), estimate of national breeding population size in the 2000s (from Dubois *et al.* 2008; with the rare breeding species excluded from some analyses marked with an asterisk *), Red List status of French breeding populations as reported by the IUCN France *et al.* (2011; CR, Critically Endangered; EN, Endangered; VU, Vulnerable; LC, Least Concern; NA, Non Applicable; and DD, Data Deficient) and European trends of breeding populations as reported in PECBMS (2011).

English name	Scientific name	Status	First year of survey	Shooting bag	National breeding population size	Red List status France	European population trend 1980–2009
Pintail	*Anas acuta*	hunted	1976		0–5*	NA	
Wigeon	*Anas penelope*	hunted	1976		0–2*	NA	
Mallard	*Anas platyrhynchos*	hunted	1989	1,561,100	30,000–60,000	LC	+53% Moderate Increase
Common Teal	*Anas crecca*	hunted	1976		200–500	VU	
Garganey	*Anas querquedula*	hunted	1976		250–300	VU	
Pochard	*Aythya ferina*	hunted	1976	43,600	3000–3500	LC	
Tufted Duck	*Aythya fuligula*	hunted	1976		1200–1500	LC	
Ferrugineous Duck	*Aythya nyroca*	protected	1976		0–2*	NA	
Goldeneye	*Bucephala clangula*	hunted	1980		0–1*	NA	
Common Eider	*Somateria mollissima*	hunted	1976		1–10*	CR	
Red-breasted Merganser	*Mergus serrator*	protected	1976		1–3*	NA	
Shelduck	*Tadorna tadorna*	protected	1976		3000	LC	
Greylag Goose	*Anser anser*	hunted	1976		141–162	VU	
Mute Swan	*Cygnus olor*	protected	1976		1500–2000	NA	+31%, Moderate Increase
Moorhen	*Gallinula chloropus*	hunted	1989	76,200	200,000–400,000	LC	+6%, Moderate Increase
Coot	*Fulica atra*	hunted	2001	133,100	100,000–150,000	LC	+51% Moderate Increase
Purple Gallinule	*Porphyrio porphyrio*	protected	1976		76–88	EN	
Water Rail	*Rallus aquaticus*	hunted	1976	30,300	10,000–20,000	DD	
Corncrake	*Crex crex*	protected	1976		490–560	EN	
Little Ringed Plover	*Charadrius dubius*	protected	2001		6000–7000	LC	
Ringed Plover	*Charadrius hiaticula*	protected	1976		120–180	VU	
Ruff	*Philomachus pugnax*	hunted	1976		0–3*	NA	
Redshank	*Tringa totanus*	hunted	2001		1400	LC	-51% Moderate decline
Common Snipe	*Gallinago gallinago*	hunted	2001	274,900	100–150	EN	-41% Moderate decline
Black-tailed Godwit	*Limosa limosa*	hunted	1976		130–150	VU	-45% Moderate decline
Lapwing	*Vanellus vanellus*	hunted	1976	435,700	15,000–17,000	LC	-52% Moderate decline
Eurasian Curlew	*Numenius arquata*	hunted	1976		1500–1800	VU	
Avocet	*Recurvirostra avosetta*	protected	1976		2800	LC	
Black-winged Stilt	*Himantopus himantopus*	protected	1976		2000–3000	LC	
Collared Pratincole	*Glareola pratincola*	protected	1976		49–66*	EN	

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capacity for adaptation, influencing the independence of different species' response of their population dynamics to pressures. We further assessed whether the temporal trends of non-hunted and of hunted species were robust to the change in the identity and number of species included within each group. To do so, we systematically removed an increasing number of species randomly from the initial pool, up to 14 (hunted group) or 7 (non-hunted group) species. We then re-estimated 100 temporal slopes for each random set of species of a group, and plotted these slopes against the proportion of removed species (see Appendix). If there is no effect of species' composition on the trends, the slopes will be relatively similar regardless which set of species is used.

To compare breeding population trends of hunted and non-hunted species, we also ran a complete model with all species including the hunting status of a species (hunted versus non-hunted), a linear year effect, the interaction between year and hunting status, together with the same random effects.

The previous mixed effect model was run again after including a supplementary predictor, the species thermal index, and its interaction with year. This measure of a species' climatic affinity was estimated as the average spring and summer monthly temperature of all atlas grid cells where a species breeds in Europe (atlas data from Hagemeijer & Blair 1997). Temperatures used were the mean monthly March to August temperature for the period 1950–2000 (data from the wordlclim database, http://www.wordlclim.org).

We completed our analyses by running models without the Mallard *Anas platyrhynchos*, because of a possible influence of the numerous captive-bred birds released before the hunting season on the population dynamics. We also ran models without the rare breeding species, those with less than 50 breeding pairs in France (see Table 1). This is a reasonable threshold of less than 100 mature adults.

RESULTS

Hunted species displayed no significant long-term linear changes in their breeding numbers (year effect in the mixed-effect model conducted on hunted species only; mean slope ± s.d. −0.011 ± 0.007, $t = -1.67$, d.f. = 510, $P = 0.095$, Fig. 2). Non-hunted species significantly increased their breeding numbers during the study period (year effect in the mixed-effect model conducted on protected species only; mean slope ± s.d., +0.033 ± 0.006, $t = 5.80$, d.f. = 344, $P <$ 0.001, Fig. 2). The test of robustness (i.e. the random exclusion of some species) shows that the slopes obtained are globally similar to those including the full set of species. Therefore, our general conclusions are not driven by a few particular species and are not strongly dependent on the species included in each group. Indeed, we found that while most temporal trends were negative for hunted species, very few combinations of non-hunted species produced negative trends (see Appendix). The trends of the two groups (hunted versus non-hunted) were significantly different (interaction hunting status : year in a mixed-effect model including all species; $t = 4.62$, d.f. = 856, $P <$ 0.001). Including a supplementary predictor related to the thermal preferences of the species did not modify the difference between the hunted and non-hunted groups (interaction hunting status : year, $t = 3.19$, d.f. = 853, $P = 0.001$). The interaction between hunting status and year remained unchanged when Mallard was excluded ($t = 4.58$, d.f. = 835, $P < 0.001$; model with thermal preferences, $t = 3.16$, d.f. = 832, $P = 0.002$) and when rare breeding species were excluded ($t =$ 4.34, d.f. = 588, $P < 0.001$; model with thermal preferences, $t = 1.87$, d.f. = 585, $P = 0.062$).

DISCUSSION

Using large-scale monitoring data we found that breeding waterbirds had positive population growth rates in France during the last two decades, probably reflecting the positive impacts of numerous conservation actions to protect wetlands (Dupuis *et al.* 2011). These began with the Ramsar convention in 1971 and the subsequent designation of nature reserves. There is other evidence of long-term increasing populations of breeding waterbird species following species protection (e.g. Ardeidae) and particular conservation measures of wetland habitats (see e.g. Donald *et al.* 2007, Lorrillière *et al.* 2010), but also of wintering wetland bird populations in France (Deceuninck & Jiguet 2007). However, the fate of French breeding waterbirds apparently varied according to the hunting status of the species. Indeed, hunted species' populations have not increased, and are doing comparatively worse, possibly to the point of having a negative trend, although this apparent negative trend was not statistically significant. This pattern was not confounded by the release of captive bred mallards into the wild, because we found similar results when excluding the mallard from the analysis, despite over 1 million mallards being released each year for hunting

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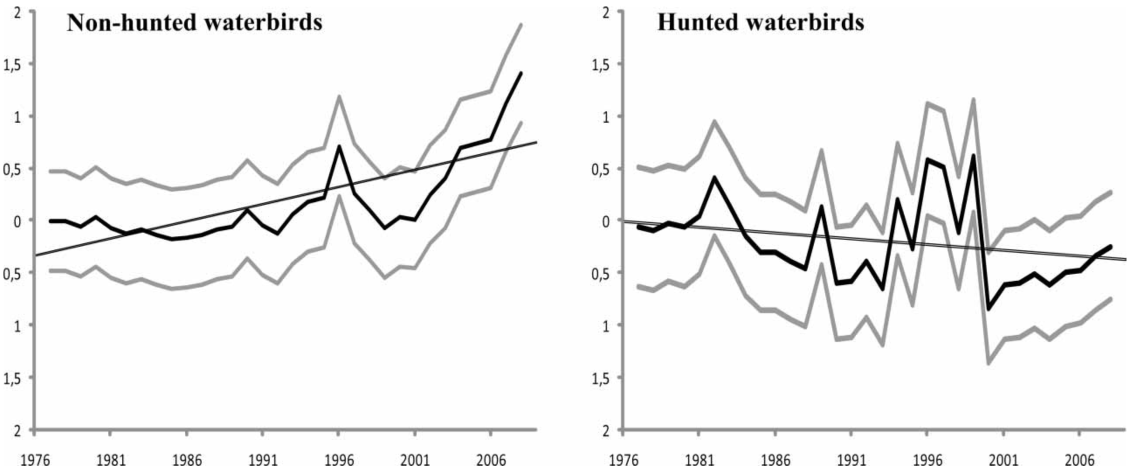

Figure 2. Long-term changes of French breeding waterbirds from 1976 to 2009 according to their hunting status (first year set to zero). Grey lines represent standard errors around the mean.

purposes (ONCFS 2000). This pattern was also not driven by the dynamics of rare breeding species, because the results remained unchanged when excluding all species with less than 50 breeding pairs in France (8 species; see Table 1).

Interpreting these results in terms of direct impacts of hunting on population trends is controversial. For instance, one could suggest that hunting has a 'positive' effect on waterbirds by regulating or controlling their population size, because hunted species are not increasing as much as non-hunted species. However, hunted wetland birds are not invasive species, or pests or increasing species that are missing natural predators. Moreover, some of them are even Red-Listed in France, with small, localized or declining breeding populations (IUCN France *et al.* 2011). In contrast to any 'positive' effect, one could thus conclude that hunting has a 'negative' impact relative to other species, or at very least, that hunted species' populations are probably being affected by hunting to some degree.

This analysis does not imply any causal relationship between hunting and population dynamics, for the following reasons. First, local breeders are not necessarily resident, and could winter outside of France. Thus they are not necessarily affected by autumn and winter hunting. Determining the wintering range of birds breeding in France would not be an easy task, even from ring recoveries, because most records would come from shot birds, which would bias the picture towards more actively hunted regions. However, recoveries of individuals ringed in France during the breeding season and further recovered elsewhere during a subsequent winter should provide a first rough picture of winter dispersion. For 15 hunted species with such ringing data, 93% (203 out of 219) were recovered or resighted in France (Table 2), supporting the residency hypothesis. Second, most migrant and wintering birds – eligible for hunting bags – are not local breeders, because France receives large number of migrants from northern Europe in winter (see e.g. Wernham *et al.* 2002, Bakken *et al.* 2006, Bønløkke *et al.* 2006, Fransson *et al.* 2008). Indeed, hunting species are often determined according to the available population sizes at the flyway level, not at the national level. However, local breeding pairs can be disturbed by hunting activities for different reasons. First, the hunting period starts at the first weekend of August on the maritime public domain, when some waders or ducks are still raising chicks. Second, local breeders in France can be directly impacted by harvesting or indirectly by disturbance on their future breeding grounds, although indirect effects via disturbance should affect non-hunted species as well, as long as they are present in France in winter. Moreover, assessing hunting effects on set of species may be blurred by confounding factors. For instance, declining habitat specialists (Skylarks *Alauda arvensis*, Grey Partridge *Perdix perdix* and Red-legged Partridge *Alectoris rufa*) or increasing habitat generalists (Blackbird *Turdus merula*, Wood Pigeon *Columba palumbus*) are both hunted although clearly other factors are influencing their overall population dynamics (Gregory *et al.* 2005).

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Table 2. Summary of ringing recoveries of individuals ringed in France during the breeding period (April–May–June) and recovered/resighted later on in the winter (period October–February), with the number of individuals recovered or resighted in France. The ratio between the two values provides a rough estimate of the sedentary nature of French breeding populations. For the Pintail, the reported individual was ringed on the 29 March.

English name	Scientific name	Ringed April–June and recovered October–February	Recovered in France
Pintail	*Anas acuta*	(1)	(1)
Wigeon	*Anas penelope*	1	1
Mallard	*Anas platyrhynchos*	36	32
Common Teal	*Anas crecca*	2	2
Garganey	*Anas querquedula*	0	
Pochard	*Aythya ferina*	8	8
Tufted Duck	*Aythya fuligula*	2	1
Goldeneye	*Bucephala clangula*	0	
Common Eider	*Somateria mollissima*	0	
Greylag Goose	*Anser anser*	33	29
Moorhen	*Gallinula chloropus*	4	4
Coot	*Fulica atra*	2	2
Water Rail	*Rallus aquaticus*	0	
Ruff	*Philomachus pugnax*	1	0
Redshank	*Tringa totanus*	10	8
Common Snipe	*Gallinago gallinago*	10	9
Black-tailed Godwit	*Limosa limosa*	5	5
Lapwing	*Vanellus vanellus*	74	71
Eurasian Curlew	*Numenius arquata*	28	28

Overall, estimating the positive or negative effects of hunting pressure relative to other global changes is difficult, particularly because surveys on shooting bags are scarce. In France, the most recent national survey of shooting bags concerned the 1998–99 hunting season and reported more than 31 million animals shot within 5 months (ONCFS 2000), including 5.2 million wood pigeons, 4.5 million thrushes and more than 1 million woodcocks. For instance, Julliard *et al.* (2003) did not reveal any global effect of hunting status on the fate of French breeding populations of common terrestrial birds, including species considered as pests (especially Corvidae) but also game birds subject to numerous releases of captive-bred individuals (partridges, pheasants). This analysis included other major drivers of population trends such as habitat specialization and sensitivity to climate change. In this context, linking breeding population dynamics in spring and summer and hunting pressure in autumn and winter is even more complex.

Long-term monitoring of European breeding birds provides valuable indices of population sizes and their temporal trends used to infer the conservation status of a species to be hunted in any EU country. However, some long-term declining species are still hunted in some countries. Since 1980, the Lapwing *Vanellus vanellus* has suffered a decrease of its European breeding population by −52%, the Redshank *Tringa totanus* by −51%, the Common Snipe *Gallinago gallinago* by −41% (see Table 1). All three are hunted during autumn and winter in France, while birds wintering in or migrating through France originate from various European breeding populations, as attested by ringing recoveries published in recent ringing atlases for Norway (Bakken *et al.* 2006), Sweden (Fransson *et al.* 2008), Denmark (Bønløkke *et al.* 2006), and the UK (Wernham *et al.* 2002). The breeding populations of some of the hunted waterbirds are red listed in France: breeding Common Teal, Garganey *Anas querquedula*, Greylag Goose *Anser anser*, Black-tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata* are considered as vulnerable to extinction by the IUCN, while Common Snipe is listed as endangered and Common Eider *Somateria mollissima* as critically endangered (IUCN France *et al.* 2011; see Table 1). To promote these breeding populations, a few solutions are available, depending on their acceptability by the different stakeholders of nature protection and management. A highly precautionary approach would consider keeping these species away from any hunting pressure, by a legal protected status. At least this could be considered for sites or regions where the red-listed species may be breeding. A second biologically sound action could be to restrict the hunting period or forbid hunting around breeding sites of these species. According to Article 7 of the EU Bird Directive, 'owing to their population level, geographical distribution and reproductive rate throughout the Community, the species listed in Annex II may be hunted under national legislation. Member States shall ensure that the hunting of these species does not jeopardise conservation efforts in their distribution area.' The hunting status of a given species in a given country should be subject to more regular periodic revision, and in theory, long-term large-scale declining species, at least, should not be part of hunting bags.

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REFERENCES

Artois, M. 1997. Managing problem wildlife in the 'Old World': a veterinary perspective. *Reprod. Fertil. Dev.* **9:** 17–25.

Bakken, V., Runde, O. & Tjørve, E. 2006. *Norsk ringmerkingsatlas*. Stavanger Museum, Stavanger.

Baumann, M., Babotai, C. & Schibler, J. 2005. Native or naturalized? Validating alpine chamois habitat models with archaeozoological data. *Ecol. Appl.* **15:** 1096–1110.

BirdLife International. 2004. *Birds in Europe: Population Estimates, Trends and Conservation Status*, BirdLife International (BirdLife Conservation Series 12), Cambridge, UK.

Bønløkke, J., Madsen, J.J., Thorup, K., Pedersen, K.T., Bjerrum, M. & Rahbek, C. 2006. *Dansk Trækfugleatlas*. Rhodos, Humlebæk.

Booth, C. 2008. *A deer mistake: the Victorian government's proposal to promote recreational deer hunting on farms. Invasive Species Council, Australia*. Downloaded at http://www.invasives.org.au/documents/file/reports/ISC_critique_a_deer_mistake.pdf

Butchart, S.H.M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Hockings, M., Kapos, V., Lamarque, J.-F., Leverington, F., Loh, J., McGeoch, M.A., McRae, L., Minasyan, A., Hernández Morcillo, M., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S.N., Symes, A., Tierney, M., Tyrrell, T.D., Vié, J.-C. & Watson, R. 2010. Global biodiversity: indicators of recent declines. *Science* **328:** 1164–1168.

Deceuninck, B. & Jiguet, F. 2007. *Le statut des oiseaux en France. Edition 2006.* LPO-MNHN, Rochefort, 24 pages.

Defos du Rau, P., Barbraud, C. & Mondain-Monval, J.-Y. 2006. Estimating breeding population size of the red-crested pochard (*Netta rufina*) in the Camargue (southern France) taking into account detection probability: implications for conservation. *Anim. Conserv.* **6:** 379–385.

Donald, P.F., Sanderson, F.J., Burfield, I.J., Bierman, S.M., Gregory, R.D. & Waliczky, Z. 2007. International conservation delivers benefits for birds in Europe. *Science* **317:** 810–813.

Dubois, P.J., Le Maréchal, P., Olioso, G. & Yésou, P. 2008. *Nouvel inventaire des oiseaux de France*. Delachaux & Niestlé, Paris.

Dupuis, V., Jiguet, F., Deceuninck, B. & Micol, T. 2011. *Etat et tendances des oiseaux nicheurs en France métropolitaine en 2011*. LPO-MNHN, Rochefort.

FACE. 2012. Federation of Associations for Hunting and Conservation of the EU. http://www.face.eu

Fransson, T., Österblom, H. & Hall-Karlsson, S. 2008. *Svensk ringmärkningsatlas*: *Vols. 1–3*. Stockholm.

Gauthier, G., Pradel, R., Menu, S. & Lebreton, J.D. 2001. Seasonal survival of greater snow geese and effect of hunting under dependence in sighting probability. *Ecology* **82:** 3105–3119.

Gregory, R.D., van Strien, A.J., Vorisek, P., Gmelig Meyling, A.W., Noble, D.G., Foppen, R.P.B. & Gibbons, D.W. 2005. Developing indicators for European birds. *Phil. Trans. R. Soc. B* **360:** 269–288.

Hagemeijer, W.J.M. & Blair, M.J. 1997. *The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance*. T & AD Poyser, London.

IUCN France, MNHN, LPO, SEOF & ONCFS. 2011. *La Liste rouge des espèces menacées en France - Chapitre Oiseaux de France métropolitaine*. Paris, France. Downloaded at http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Oiseaux_de_metropole.pdf

Jiguet, F., Gadot, A.-S., Julliard, R., Newson, S.E. & Couvet, D. 2007. Climate envelope, life history traits and the resilience of birds facing global change. *Glob. Change Biol.* **13:** 1672–1684.

Jiguet, F., Gregory, R.D., Devictor, V., Green, R.E., Vorisek, P., van Strien, A. & Couvet, D. 2010. Population trends of European birds are correlated with characteristics of their climatic niche. *Glob. Change Biol.* **16:** 497–505.

Jiguet, F., Devictor, V., Julliard, R. & Couvet, D. 2011. French citizens monitoring ordinary birds provide tools for conservation and ecological sciences. *Acta Oecol*, doi:10.1016/j.actao.2011.05.003.

Julliard, R., Jiguet, F. & Couvet, D. 2003. Common birds facing global changes: what makes a species at risk?. *Glob. Change Biol.* **10:** 148–154.

Loh, J., Green, R.E., Ricketts, T., Lamoreux, J., Jenkins, M., Kapos, V. & Randers, J. 2005. The living planet index: using species population time series to track trends in biodiversity. *Phil. Trans. R. Soc. B* **360:** 289–295.

Lorrillière, R., Boisteau, B. & Robert, A. 2010. Modelling spatial dynamics of recovering species: a case study with the Grey Heron *Ardea cinerea*. *Ibis* **152:** 118–126.

ONCFS. 2000. Enquête nationale sur les tableaux de chasse à tir. Saison 1998–1999. *Bulletin Technique et Juridique, Office National de la Chasse et de la Faune Sauvage* **251:** 1–216.

PECBMS. 2011. *Population Trends of Common European Breeding Birds 2011*. CSO, Prague.

R Development Core Team. 2011. R: *A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Skonhoft, A., Yoccoz, N.G., Stenseth, N.C., Gaillard, J.-M. & Loison, A. 2002. Management of chamois (*Rupicapra rupicapra*) moving between a protected core area and a hunting area. *Ecol. Appl.* **12:** 1199–1211.

Skonhoft, A. & Olaussen, J.O. 2005. Managing a migratory species that is both a value and a pest. *Land Economics* **81:** 34–50.

Wernham, C., Toms, M., Marchant, J., Clark, J., Siriwardena, G. & Baillie, S. 2002. *The Migration Atlas. Movements of the Birds of Britain and Ireland*. T. & A.D. Poyser, London.

Yoccoz, N.G., Nichols, J.D. & Boulinier, T. 2001. Monitoring of biological diversity in space and time. *Trends. Ecol. Evol.* **16:** 446–453.

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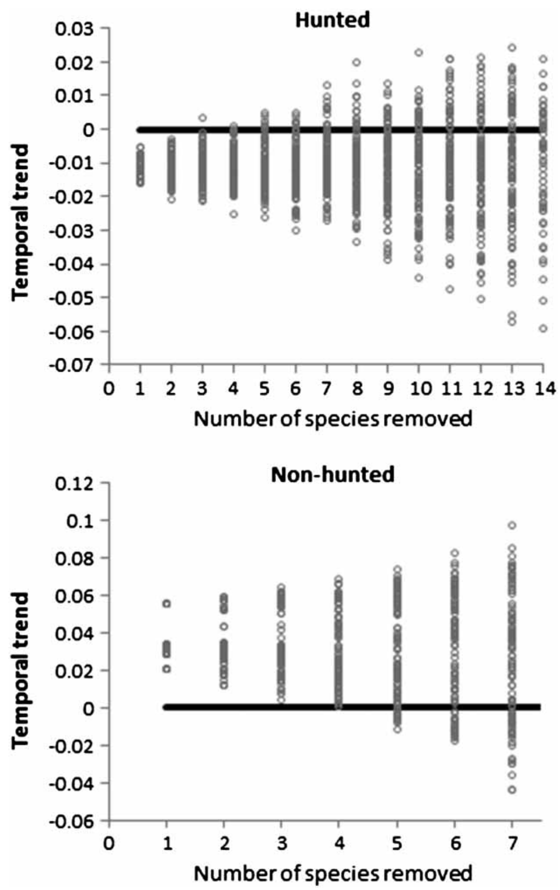
APPENDIX. ROBUSTNESS OF TEMPORAL TRENDS TO SPECIES SELECTION

We conducted a robustness analysis to assess whether the temporal trends of hunted versus non-hunted species were affected by the number and identity of the species considered. To do so, we ran the same model used to estimate the temporal trend of hunted versus non-hunted species but for different set of species. For each group, 100 slopes were calculated for different species removal, removing 1–14 (hunted group, out of 19) or 7 (non-hunted group, out of 12) species (see *x*-axis on the graphs below). The distributions of these slopes show that the trends of the group including hunted species are most generally positive while the trends of the non-hunted species are most generally negative. We can therefore be confident that our general results are not driven by only few species and not determined by the particular set of species considered within each group.



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