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Original article

French citizens monitoring ordinary birds provide tools for conservation and ecological sciences

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ABSTRACT

Volunteer-based standardized monitoring of birds has been widely implemented in Europe and North America. In France, a breeding bird survey is running since 1989 and offers keen birdwatchers to count spring birds annually during 5 min exactly on 10 fix points within a randomly selected square. The first goal of such breeding bird surveys is to measure temporal trends in order to detect possible species declines. Combining annual indices of species sharing ecological affinities or a protected/red list status further provides biodiversity indicators for policy makers. Because the sampling effort is similar among sites, and because the initial selection of monitored sites is random, the temporal trends can be considered representative of national trends, and spatial comparisons of the obtained metrics are possible. Species abundance, community richness but also community specialization and average trophic level can be estimated for each site and each year and further related to the wide range of habitat and landscape characteristics and to agricultural or forestry practices. The large number of sites allows overcoming the opposition between adaptive and passive monitoring, making such schemes fitted to adaptive monitoring. This provides opportunities to determine which type of management or practices favour biodiversity. The comparison of population fate or community dynamics across a wide range of climates and temperatures, e.g. from southern to northern Europe, revealed how European birds are already affected by climate change. Bird communities are shifting northwards, but at a slower rate than temperatures, while bird populations have larger growth rates away from their hot thermal limit. Finally, such large-scale long-term monitoring data on a complete taxonomic group (Aves) is original and offers the opportunity to compare different measures of biological diversity, such as taxonomic, phylogenetic and functional diversity. Such a citizen science scheme is an efficient scientific tool (numerous papers published in international peer-reviewed journals) which is furthermore highly cost-effective, with a reduced permanent staff in a state insitution coordonating the network and analysing the data, while a similar survey conducted by state staff only would cost more than one million euros annually. The future development of bio-economic dynamic models for providing scenarios of sustainable farming and logging to maintain biodiversity will further highlight the necessity of such volunteer monitoring for policy makers and decision planning. Scientific and logistic partnerships could be proposed to help developing such a monitoring scheme in China.

1. Introduction

In Europe, birds have been monitored for decades by keen observers (Balmford et al., 2005). Rare or emblematic species, such as raptors, water- or game-birds are especially the focus of schemes designed to track changes in their numbers. Indeed, collaborative research by networks of amateurs has a key role in ornithology and conservation science (Greenwood, 2007). While the classical approaches are based on monitoring rare species in most taxa, birds were the focus of an early implementation of monitoring schemes dedicated to ordinary species (Devictor et al., 2010b), namely the breeding bird surveys (BBS), which for example started in the 1960s in Sweden or United Kingdom (Wretenberg et al., 2006). These schemes offer amateur birdwatchers to count spring birds at fixed plots following a standardized protocol. The annually repeated counts at numerous sites provide the necessary data to estimate species temporal trends, and to provide expertise for assessing the fate of common species. Such work is especially successful where

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there is a strong partnership between the amateurs and professional scientists, based on their complementary roles. The participation of large numbers of volunteers enables data collection that would otherwise be impossible, and scientists provide the necessary sound statistical framework to make value of the survey data. This tight collaboration also facilitates democratic participation in societal decisions concerning biodiversity conservation. This is part of the so called citizen science, proposing scientifically sound practices and measurable goals for public education (Couvet et al., 2008). Citizen science provided valuable insights into large scale ongoing declines of common species in the ordinary nature (Krebs et al., 1999). The large number of sites allows overcoming the opposition between adaptive and passive monitoring (Lindenmayer and Likens, 2010), making such schemes fitted to adaptive monitoring.

In France, volunteer ornithologists started to count the common breeding species back in 1989, coordinated by the National Museum of Natural History (MNHN). This survey was consolidated in 2001 with a renewed sampling design and a wider appeal for participation. Scientists proposed a sound methodology to the motivated amateurs, who wished to contribute. In return, scientists published annual reports and analysed historical datasets. The revealed declines of the ordinary species were soon hung upon the front page of main national newspapers, illustrating how the contribution of bird amateurs was of interest to the whole society. Beyond these reports to the amateurs and the wider audience, the breeding bird survey data were also analysed and results published in the scientific literature, with numerous publications in international peer-reviewed journals. Ongoing science includes various PhD or post-doc works in conservation science, global change biology but also more fundamental ecology such as community dynamics and diversity patterns.

The aim of this paper is to focus on and give an overview of the French Breeding Bird Survey (FBBS), from the sampling design and monitoring protocol to the various conservation and scientific outputs. The usual outputs of such schemes are the provision of national species trends, as average long-term population growth rates, and the associated multiple species indicators. The different metrics obtained from bird records can be confronted with data on landscape, habitat and climate over national or continental spatial scales to tackle relationships between land use, practices and climate change and biodiversity.

Such schemes could be criticized for their lack of a-priori hypotheses, to be a waste of efforts. However, the large number of sites make it very powerful, able to test ad-hoc hypotheses (Yoccoz et al., 2001), readily as the effects of global change unfold, a necessity with fast and overarching global changes.

2. Methodological designs

2.1. Counting method

The FBBS started in 1989 based on volunteer skilled ornithologists counting birds following a standardized protocol at the same plot for several years. In each plot, a given observer monitors 10 point counts separated by at least 300 m. All individuals seen or heard are counted on these permanent points during a fixed period of 5 min. To be validated across years, the count must be repeated on approximately the same date of the year (±7 days within April to mid-June), the same time of the day (±15 min within 1–4 h after sunrise) and in the same order, by the same observer. A new sampling design was launched in spring 2001, for which surveyed plots were not freely chosen but selected randomly, ensuring that the sampled habitats were representative: each observer provided his home locality, and a 2 × 2 km plot to be prospected was randomly selected within a 10 km radius (i.e. among 80 possible plots). The national coordinator is in charge of the initial selection of sites to be monitored. Such a random selection ensures the survey of varied habitats across the whole country (including intensive farmlands, forests, suburbs and cities), despite being stratified by declared-volunteering observer density. Post-hoc verification that habitats are globally sampled according to their availability testifies that the obtained trends are representative of national trends. On each square, the observer also monitors 10 point counts, separated by at least 300 m, following the standardized protocol with two sampling sessions realized from 1st April to 8th May, then from 9th May to end of June - in order to detect both early and late breeders, with 4–6 weeks between both counts. Fig. 1 reports the spatial distribution of the 2000 plots surveyed at least once during 2001–2009.

2.2. Sampling design

For each point count, the surroundings within a fixed 100 m radius are classified by the observers themselves as belonging to one of a standardized list of habitats. This list is organized into a 4-levels land use description, adapted from the one developed by the British Trust for Ornithology (Crick, 1992). These habitat classes are especially used to determine the habitat preferences of the surveyed species, and estimate a habitat specialization index for each species (called Species Specialization Index, SSI; Julliard et al., 2003, 2006). Observers also report on meteorological conditions they encounter during the sampling session (clouds, rain, wind, visibility), which can locally influence the detected abundance, but should not bias the overall national dataset as long as such biases have no strong spatial structure (Bas et al., 2008).

2.3. Volunteer participation

When the scheme was restored in 2001, 150 new amateurs joined the network. Part of them had no previous experience of point counting but learned the method rapidly (Jiguet, 2009). Since 2001, 1.300 different observers have participated to the survey, and

Fig. 1. Spatial distribution of the 2000 squares monitored between 2001 and 2009 in continental France by the Breeding Bird Survey scheme.

numbers are still increasing year after year, now especially because of the local development of consolidated regional networks. The national scheme is composed of regional or departmental coordinating instances, federated by the national coordination at the MNHN. This structure ensures an efficient local recruitment of keen observers, and a local animation of the scheme, necessary to keep observers motivated. Fig. 2 presents the annual number of squares surveyed by volunteers, from 2001 to 2009. The Museum developed computer software for observers to computerize the BBS counts, which therefore arrive in a standardized format to integrate the national central database. All these information and the protocol (in French) can be found on a dedicated website, at http://www.vigienature.mnhn.fr/page/le-suivi-temporel-des-oiseaux-communs-stoc.

2.4. Breeding bird surveys in other countries

Within Europe, 37 countries conduct a monitoring program dedicated to common breeding birds. Various methods and sampling designs are used, but all schemes aim at estimating trends in population numbers. The counting methods include territory mapping, with three visits to plots in Switzerland (Kéry et al., 2005) or 5 to 10 visits in the Netherlands (van Turnhout et al., 2010). Some schemes use line transects, e.g. with two visits within 1 × 1 km squares in United Kingdom (Fuller et al., 1995), one visit along borders of a 2 × 2 km square in Sweden (Jiguet et al., 2010b). Point counts are not only used in France but also e.g. within 10 × 10 km squares in Spain (Del Moral et al., 2010) or within 2.5 × 2.5 km squares in Hungary (Szép and Gibbons, 2000). Totally random selection of surveyed sites is rare, stratified random as in France is more the rule (stratified by observer density, by habitat availability) but free choice is also used in some countries. Only Switzerland has a systematic sampling design monitoring (Kéry et al., 2005). In North America, the continent-wide BBS is based on 3 min point counts sampled along roadside survey routes (Sauer et al., 2011). Each survey route is 24.5 miles long with stops at 0.5 mile intervals. Another bird monitoring scheme, called Christmas Bird Count (CBC), started in 1900 and is dedicated to the survey populations of wintering birds (La Sorte and Thompson, 2007). Each individual count is performed in a "count circle" with a diameter of 15 miles. At least ten volunteers, including a compiler, count in each circle. They break up into small parties and follow assigned routes, counting every bird they see. In most count circles, some people also watch feeders instead of following routes. CBC can be held on any day from December 14 to January 5 inclusive.

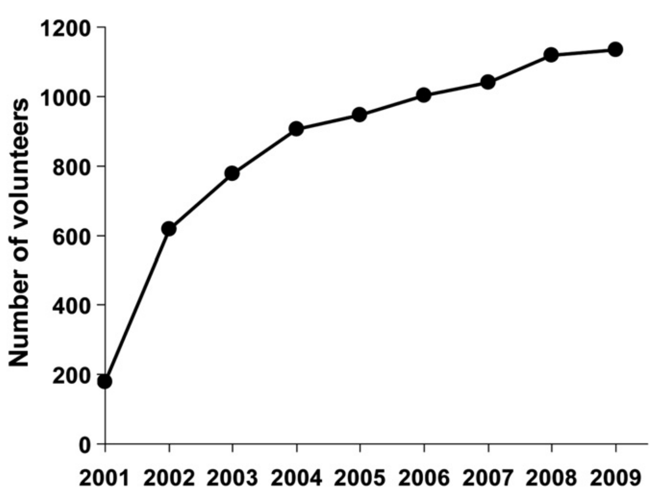

Fig. 2. Annual number of volunteers participating to the French breeding bird survey, 2001–2009.

3. Results and discussion

3.1. Species trends and indicators

The first direct output of the multiple-site multiple-year counts is the estimation of temporal changes in species numbers. The FBBS is able to produce estimates of average population growth rate for 160 bird species for France, that is for the most common breeding species – or at least those that are most detected by the observers. If this represents just more than half the number of species regularly breeding in France (about 300), this subset represents 99% of the individual birds present in France during the breeding season (Devictor et al., 2008a). Applying log-linear regression models with Poisson error to the counts, with site identity as a factor (or in mixed effects models as a random effect), considering a linear effect of year produces estimates of an average growth rate for the period, while considering a categorical effect of year produces annual index values to estimate the year to year variations in abundance - see van Strien et al. (2001) for further details.

One conservation question ensuing from the scheme was to understand which species were declining or increasing, and which traits were associated to species trends facing global change. Habitat specialization was first identified as a factor promoting decline (Julliard et al., 2003), as well as the additive effect of climatic specialization (Jiguet et al., 2007). Globally, farmland (Voříšek et al., 2010) and woodland (Gregory et al., 2007) birds are declining at a European scale, also mirrored at national levels (Reif et al., 2008; Seoane and Carrascal, 2008; Newson et al., 2009). Such species trends have also been used to propose a red list status for some common breeding species, because of their decreasing numbers in recent years without any reversal of these declines or of the suspected causes of decline.

These annual indices of species abundance can be combined into indicators accounting for the average fate of species sharing some ecological or biological traits. Hence, by first selecting species specialized to a given habitat type, fixing their annual indices to a common value in a given year, and calculating the geometric mean of the species index values for each year, we obtain the annual values of the indicator. For example, species can be combined according to their habitat specialization, producing indicators describing trends in farmland birds, woodland birds, urban birds. The Farmland Bird Index, obtained for common species (Gregory et al., 2005), has been adopted by the European Union (EU) as the structural indicator of sustainable development for biodiversity (Balmford et al., 2005). Hence, each member of the EU

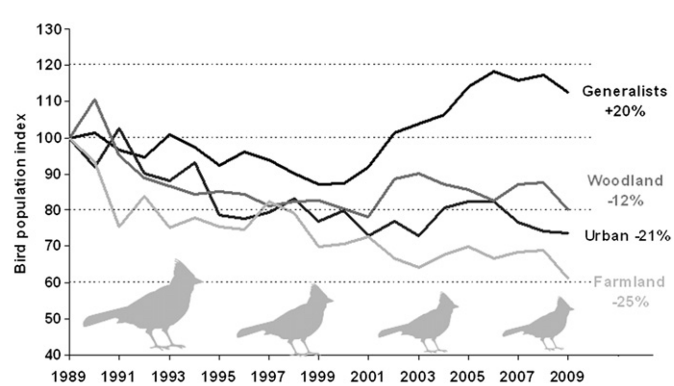

Fig. 3. French biodiversity indicators, as developed from trends of breeding bird populations according to the species habitat specialization, from 1989 to 2009.

has to provide this indicator in order to evaluate the fate of biodiversity. The French habitat indicators are presented in Fig. 3. In this representation, the values of the indicators have been fixed to 100 in 1989, the starting year. Species have been grouped according to their habitat preferences, with species inhabiting preferentially farmland ($n = 20$), woodland ($n = 18$), artificial habitats ($n = 13$) or those generalists with no marked habitat preferences ($n = 14$). Because the early BBS was less largely implemented, population trends are not available for all 150 on the early period, hence indicators were first developed using the 65 commonest species. Overall, breeding numbers of these species have decreased by an average 14% from 1989 to 2009, while the largest decline is noted for farmland birds: agricultural areas have lost a quarter of their common breeding birds during the last 20 years. Other indicators are proposed from the FBBS data. For example, we can plot the trends of all surveyed species listed in the Appendix I of the EU Bird Directive (79/409/EC), or those supporting a red list status on the International Union for the Conservation of Nature (IUCN) Red List (see Fig. 4) of French breeding birds (http://www.uicn.fr/Liste-rouge-oiseaux-nicheurs.html). As expected, Red List species are declining (15 species), though the FBBS trends were also used to determine the Red List status, so this is no surprise. However, the contrastingly better fate of the 23 common breeding species surveyed by the FBBS and concerned by the Bird Directive is encouraging for the efficiency of international conservation tools (Donald et al., 2007). Lists of species contributing to all these indicators can be found at http://www2.mnhn.fr/vigie-nature/spip.php?rubrique14.

3.2. Mapping species abundances and community metrics

As each site is sampled with the same effort each year (5 min $\times$ 2 sessions $\times$ 10 points per square), detected abundances or other metrics calculated from these numbers can be compared at a large spatial scale and used to obtain global maps of species relative abundance, of species richness, or average community specialization, trophic level. The principle is to model the spatial autocorrelation within the data and to use it in kriging models to obtain the predicted values for any site where no sampling occurred (Brotons et al., 2006). By kriging detected numbers, we obtain national maps of relative abundance for each species (Jiguet et al., 2005a), as shown in Fig. 5 for a southern (a – Cirl Bunting *Emberiza cirlus*) and a northern (b – Yellowhammer *E. cirtrinella*) passerine species. Superimposed to layers of protected areas across the country, we can estimate the proportion of a national population included within protected areas (Godet et al., 2007). The same holds true when considering species richness (Jiguet et al., 2006; Devictor et al., 2010a), while the design of the count data enables to obtain estimates of species richness from capture-recapture models correcting the data for potential variations of detection probability among sites and species (Jiguet et al., 2005b). By building the matrices of presence/absence of species within a square, with species as lines and the 10 point counts as columns, for each site and each year, we can also estimate the spatial and temporal changes of the estimated species richness, such as species turnover,

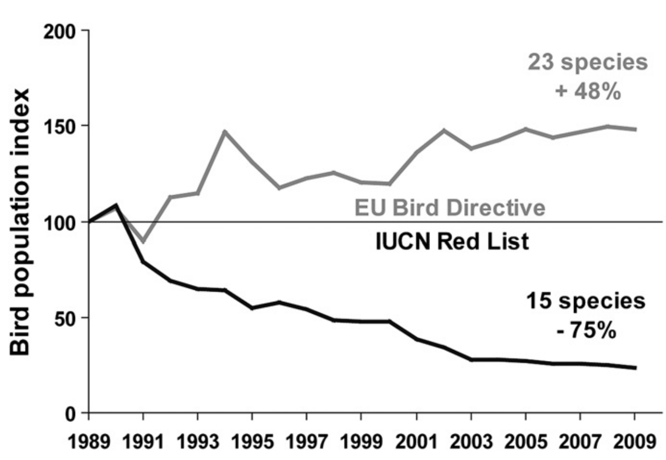

Fig. 4. Indicators of population trends for common breeding bird species listed in Appendix I of the EU Bird Directive, and listed as Vulnerable in the IUCN Red List for France.

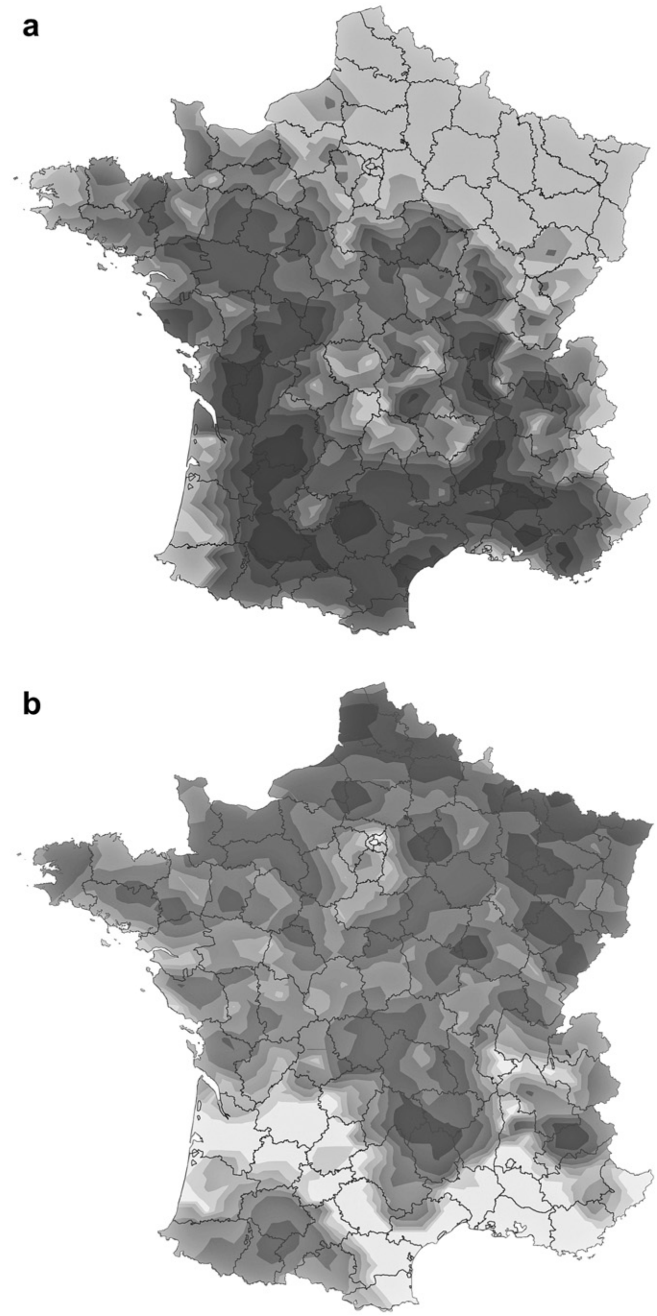

Fig. 5. Distribution of the relative abundance of two bunting species across France. Breeding numbers increase from pale grey to dark grey. (a) Cirl Bunting *Emberiza cirlus*, a southern species (b) Yellowhammer *E. citrinella*, a northern species – the abundances of the two species are negatively correlated.

local extinction and colonization rates (Boulinier et al., 1998; Devictor and Jiguet, 2007; Chiron et al., 2010).

Other community-related metrics can be estimated from the count data. Using the species habitat specialization indices (SSI), a community specialization index can be calculated as the average of the SSI of the detected species weighted by their local abundance (Julliard et al., 2006). The same is possible if considering a species trophic index (representing the position of a species within a trophic chain of 3 levels, those of vertebrates eating vegetables, invertebrates or vertebrates). The spatial distribution of this trophic level of bird communities is reproduced in Fig. 6, showing that communities in the main state-owned forests (Fontainebleau, Forêt d'Orléans, Forêt d'Orient…) or in wetlands (Camargue, Loire estuary, Rochefort marshes…) are of higher trophic levels than communities in large cereal plains (Champagne, Beauce) or in large cities (especially Paris but also Bordeaux, Lyon, Marseille). Even secondary forests, like the coniferous plantations in Landes and Gironde department, display a high trophic level typical of woodlands.

3.3. Land-use and practices

Bird data are collected across the entire national territory. As a consequence, sampled sites present a large variety of environmental conditions, including for example farmed lands with various agricultural practices, from extensive pastures to intensive cropland, under oceanic, Mediterranean, Alpine or continental bioclimates. The availability of bird data along such environmental gradients allows studying the response of this biodiversity compartment to various habitat parameters or human pressures. This includes the intensity of agricultural productions on species abundance (Bas et al., 2009), or a global assessment of low intensity agriculture (namely the High Nature Value farmland) where bird communities are more specialized and where the EU farmland bird indicator displays a contrastingly more favourable trend (Doxa et al., 2010). Ongoing works investigate the effects of Agri-Environmental Schemes on bird trends. Similarly, woodland birds are sensitive to forest fragmentation and the existence of wooded corridors between forest fragments, with higher species turnover in fragments connected by corridors (Boulinier et al., 1998). Such studies also tackled the effects of land cover change on bird communities. For example, urbanization induced community homogenization and populations of specialist species become increasingly unstable with increasing urbanization of the landscape (Devictor et al., 2007b). More generally, landscape disturbance and fragmentation favour habitat generalists (Devictor et al., 2008c), and induce functional homogenization of bird communities (Devictor et al., 2008a). Land use changes are a strong driving force in functional community composition and measuring bird community homogenization is a powerful tool for the assessment of the effects of landscape changes and thus aides sustainable land use planning.

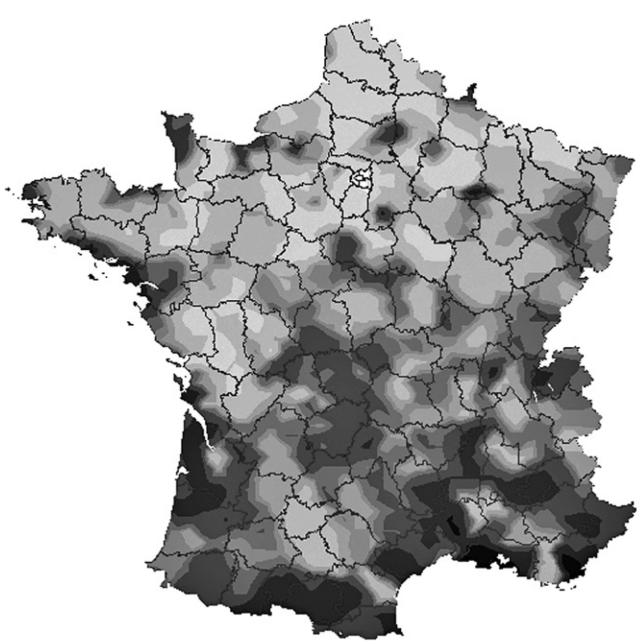

Fig. 6. Spatially-interpolated average trophic level of bird communities across France.

3.4. Climate change

Similarly, species or community fates can be studied along climatic gradients, and inform on the response of biodiversity to climatic variations. A major contribution of the FBBS was obtained by analysing the fate of bird species during an unprecedented heat wave in spring and summer 2003, when temperature anomalies reached an average 6° during August. First, species showing a depleted reproductive success during this extreme episode were those under long-term population decline (Julliard et al., 2004). Second, species with narrow thermal ranges showed the sharpest decreases in their population growth rate between 2003 and 2004 in locations with the highest temperature anomalies: geographically deduced thermal plasticity appears as a reliable predictor of the resilience of these endothermic species to extreme temperatures (Jiguet et al., 2006). The response of species to ongoing progressive climate warming is however better predicted by the upper limit of the thermal range in the same species (Jiguet et al., 2010a). The lower this thermal maximum, the more negative are the population trends and the less tolerant these species are to climate warming, regardless of the thermal range over which these species occur. By further collaborating with colleagues of other European countries where BBS are running, we tested whether and how species responses to climate change are related to the population locations within the species thermal range. We compared the average 20-year growth rates of 62 terrestrial breeding birds in three European countries – France, the Netherlands and Sweden. Populations breeding close to the species thermal maximum have lower growth rates than those in other parts of the thermal range, while those breeding close to the species thermal minimum have higher growth rates (Jiguet et al., 2010b). Indeed, bird populations are not just responding to changes in temperature at the hottest and coolest edges of the species range, but show a linear graded response across their European thermal range.

As for measuring the impacts of land use, scientists and policy makers are calling for the development of indicators on the impacts of climatic change on biodiversity. In a collaborative network of European BBS within the European Bird Census Council (www.ebcc.info), 20 countries provided data on long-term bird population trends to develop such an indicator. This indicator measures the divergence in population trend between bird species predicted by climatic envelope models to be favourably affected by climatic change and those adversely affected. It is the ratio of the index for species whose potential geographical ranges are expected to expand to that for those expected to contract because of climatic change. The indicator shows a rapid increase in the past twenty years, coinciding with a period of rapid warming (Gregory et al., 2009). Another indicator can be built by grouping species according to the characteristics of their thermal distribution in Europe, as this factor is responsible for long-term population trends (Jiguet et al., 2010a). Such an alternative is independant of the modelling of future ranges, hence of uncertainties related to variations and updates in forecasted climate changes. Using the French data, and grouping the 15 surveyed species with the lowest or largest values of thermal maximum, we obtain two groups which differential fate should be linked to the impact of climate change. The output of this indicator is presented in Fig. 7. The difference between the two groups ('high' and 'low' thermal maximum) is increasing with time, as found by Gregory et al. (2009) when using another way of grouping species. This testifies an increasing impact of climate warming on breeding birds in France. Both groups have however quite negative trends because they are mainly composed of habitat specialists too, hence the necessity to consider the difference between the two groups, not their respective trends per se.

Another study conducted on French breeding bird communities could well provide the policy arena with an indicator of adaptation of biodiversity to climate change. This work revealed that the thermal composition of bird community is changing, with local communities being more and more composed of species with preferences for higher temperatures. Back-crossing the temporal and spatial trends in such a community thermal index, this study provides an estimation of the northwards shift of bird communities in France to be compared to what would be expected if birds stayed at equilibrium with the changing climate. Overall, birds are following climate warming and are moving northwards, but not fast enough (Devictor et al., 2008b). Current developments of this study concern additional countries (Sweden, Czech Republic, Netherlands, United Kingdom and Spain) and another taxonomic group (butterflies) to see how findings on French birds can be generalized. Indeed, this kind of indicator was considered within the framework of Streamlining European 2010 Biodiversity Indicators (SEBI; http://biodiversity-chm.eea.europa.eu/information/indicator/). Considering climate change at the community level is certainly central to understand potential changes in functional biological diversity (Brotons and Jiguet, 2010).

A further way to study bird adaptation to climate warming with the BBS data is to infer the phenology of the breeding season from the count data (Crick and Sparks, 1999). Methods using the first observation or various quantiles have been largely used to tackle changes in bud opening or flowering for plants, migration or laying dates in birds. Using data from breeding bird surveys, we developed a new method proposing to fit a Gaussian distribution to the observed data, then applying a variable temporal shift to data of each other year and see which shift maximizes the superimposition of the two datasets, i.e. the fit of the global model (Moussus et al., 2009). This way, we can estimate the annual advance or delay in

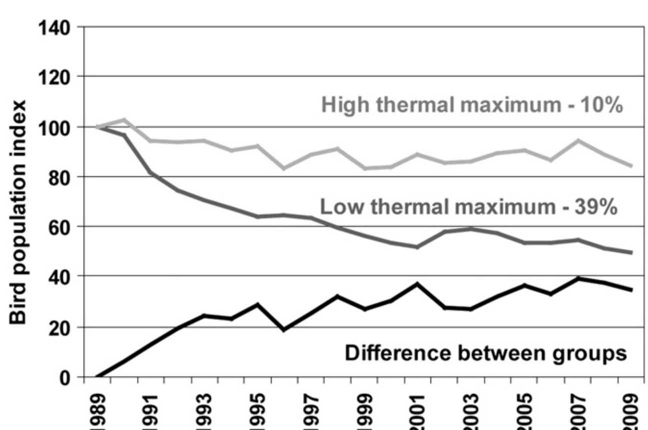

Fig. 7. An indicator of the potential impacts of climate change on French breeding birds. The difference between population trends of species with high and low thermal maximum is increasing.

the breeding season, or at least in the detection events of breeding birds – mainly spring singing males. The method was further refined, compared to other usual metrics in phenology (Moussus et al., 2010), while the phenological flexibility is to be compared among species life history traits – species displaying a high plasticity for habitat selection and/or climatic conditions might be also those more able to adapt their phenological cycles to climate change.

3.5. Bio-economic sustainability for farming and logging scenarios

The development of a productive agriculture challenges the maintenance of biodiversity in European farmlands (Butler et al., 2007). By necessity, agriculture nowadays aims at a more sustainable way of producing in order to reconcile its economical and ecological functions. To help with defining sustainable scenarios for agriculture and biodiversity, bio-economical models are developed to estimate the impact of public policies and financial incentives on both biodiversity preservation and farming production. Indeed, an ecological dynamic model can be calibrated with the FBBS data combined to agricultural statistics on land use (crop rotation), while the economical model relies on the optimization of the gross margin. Thereafter, different scenarios based on subsidies and taxes are modelled to study the impact of public policies on both biodiversity and agricultural economics. Scenarized changes in land use (crops *versus* grasslands, biofuels, fallows…) impact bird abundances and corresponding changes in the Farmland Bird Index or other metrics (community specialization, trophic level) can be estimated after having calibrated the relationship between agricultural statistics and species abundances. The bio-economical analysis reveals several solutions for the ecology-economy tradeoff, and suggests that many possibilities are available to develop multi-functional sustainable agriculture, while scenarios favouring the settlement of grasslands (either on their own or associated with cereals) provide better ecological functions than scenarios promoting the development of intensive cropping (Mouysset et al., 2011).

Similar bio-economical models can be proposed for logging and woodland biodiversity, while the joint impacts of climate change have yet to be incorporated in the modelling framework. Such models question the way to evaluate the ecological and economical dimensions and to rank habitat management decisions in order to assess the relevance of different policies, notably with respect to sustainability.

3.6. More on fundamental ecological patterns

There are few large-scale inventories of local community composition for a taxonomic group. Such datasets are however of great value for ecologists to underpin the structure and composition of communities, the congruence or mismatch of different diversity facets of biological groups. BBS datasets provide such opportunities, and the French common bird database was recently used to identify mismatches between taxonomic, phylogenetic and functional diversity, highlighting the need for integrative conservation strategies (Devictor et al., 2010a). Further trying to correlate such diversity with environmental variables at various spatial scales allowed understanding how do α, β and γ components of functional and phylogenetic diversity depend on environmental gradients across France (Meynard et al., 2011). The Rao quadratic entropy decomposition of diversity is used to calculate local, regional and turnover diversity for each diversity facet (de Bello et al., 2010), while spatial autoregressive models and partial regression analyses (Legendre and Legendre, 1998) are used to analyze the relationships between each diversity facet and environmental gradients (climate and land use; Meynard et al., 2011).

The structure of bird communities appears to be driven by species specialization itself, and habitat specialists are more abundant if the rest of the community is specialized, while the inverse is also true (Julliard et al., 2006). Bird communities appear very well defined along a specialist–generalist gradient, while this pattern probably becomes more apparent with habitat degradation. However, the more a species is specialized to habitat, the more its specialization is decreasing in time, revealing that the ongoing biotic homogenization is probably stronger than previously suspected, and that habitat specialists are becoming more generalists, which might be a way to adapt to a changing world (Barnagaud et al., 2011).

All these patterns provide very valuable information to understand the structure and composition of communities of a vertebrate taxon, for a better understanding of potential impacts and adaptations of biodiversity facing global changes.

3.7. Accounting for variations in detection probability

There is large body of work on the statistical approaches recently developed to analyze counts, especially on the way to address issues related to detection probabilities. In the FBBS, we use capture-recapture models to estimate species richness and community dynamics, but similar framework have been developed to obtain estimates of abundance using counts or presence–absence data (Kéry et al., 2005; Royle et al., 2007; Royle and Dorazio, 2008; Dupuis et al., 2011). Approaches accounting for detectability issues are currently actively developed and used with data from national BBS in North America or Switzerland (Royle et al., 2007; Kéry and Schmidt, 2008; Kéry and Royle, 2009). For example, binomial mixture models enable abundance estimation without individual identification, based simply on temporally and spatially replicated counts (Kéry et al., 2005). If interested in comparing relative abundances among sites or times with no variations in detection probability, uncorrected values are acceptable to identify ecological patterns and general responses (Bas et al., 2008). However, if estimates of absolute abundances are needed, or if the detectability of a species is known to vary in space or time along the studied gradients, the monitoring protocol should be carefully design to allow estimating corrected values. Such models are an important new approach for estimating abundance corrected for detectability only when repeated-count data are available. This implies a certain amount of temporal replicates to be collected locally within a short time period during which the population or community is supposedly closed. Ideally, three replicates, i.e. three sampling sessions on a same plot within a breeding season, should be obtained to perform occupancy models efficiently (MacKenzie and Royle, 2005). Another possibility to account for variations in detection probability is to use distance sampling methods, by reporting detected birds within distance belts and further estimating the decrease of detection probability with the distance to the observer to correct raw data (Bibby et al., 2000).

4. Conclusions

The success of the FBBS scheme largely relies on the animation of the network and extensive communication on the survey results. The regional structure ensures an efficient local implementation and increases the local political interest in the survey, while the national coordination guarantees the scientific quality of the method. The adoption of bird indicators as national and EU references for biodiversity further strengthen the need for such schemes. Revealing that the ordinary species, and not only rare taxa, are declining was efficient in catching attention to conservation concerns to the 'every day' nature. The numerous scientific publications produced with the FBBS data further convinced research authorities of the interest to fund research associated with the scheme. Four PhDs have been defended and five more are currently running using the FBBS data. The participation of volunteers to data collection is a very efficient way to collect high-quality data, with large savings for the public institution. Since the investment of volunteer time is equivalent to savings in administrative costs, Levrel et al. (2010) attempted to assign it a monetary value. If volunteers were no longer willing to participate in this biodiversity monitoring scheme, the French administration would have to invest between 100,000 and 770,000 € per year, depending on various scenarios (Levrel et al., 2010). It is also important to highlight the institutional conditions required to insure the long-term running of such monitoring programs. More precisely, there is work to do and money needed to check data, design web-based interactive interfaces to enter data, make sure the standardized protocol to collect data is correctly applied, write recommendations for volunteers, write reports and perhaps organize meetings to take stock with all involved organizations, release the outcoming results. A permanent structure must exist with people hired for that, and recurrent funding must be guaranteed. Such a team has been hired at MNHN since 2001 for that. The existence of such a team is a necessary condition to meet for such a project to be successful.

The existence of a reference network, providing national indicators, was highly incentive for reserve managers to implement the same survey methodology, in order to collect similar data and benefit from similar indices and indicators, directly comparable to the national references. The ordinary nature and the exceptional nature protected by reserve networks benefit from each other. Hence, nature reserves, national parks, state forest office, started to run BBS plots. First results from protected areas revealed that common but declining species benefit from protected areas (Devictor et al., 2007a).

The future developments of amateur bird surveys in France concern a garden birdwatch, open to any observer – not only skilled birdwatchers – with a simple protocol and a scientific coordination. A similar scheme is running in the Great Britain for 15 years (Cannon et al., 2005). The principle is simple: citizens are invited to provide a weekly maximum abundance of the commonest species in their garden. A list of the 20 commonest species is provided, completed by a further list of 30 more species. Observers first describe their garden, providing details on location, plants, domestic animals, surrounding habitats. The associated database will provide important information on the structure and composition of garden bird communities along urbanization gradients, and on the efficiency of corridors to stabilize bird communities in urban landscapes. Expected results are the winter displacement towards garden feeders of granivorous species which breeding numbers are declining (Siriwardena et al., 2007) because of agriculture intensification leading to a lower availability of wild seeds in farmed fields (Moorcroft et al., 2002).

There is growing evidence that biodiversity losses can have important consequences for human economies and well-being, through the loss of ecological resources and the associated services they provide (Sala et al., 2009). World leaders have thus pledged to achieve a significant reduction of the current rate of biodiversity loss, but few indicators are available to estimate the achievement of the targets (Balmford et al., 2005). A pan-European wild bird indicator has been produced and is being used to measure progress towards the stated aim of halting biodiversity loss. Within this experience, BirdLife International and the Royal Society for the

Protection of Birds (RSPB), supported by the 2010 Biodiversity Indicators Partnership (www.twentyten.net), plan to help with developing bird population monitoring schemes worldwide and to develop a global Wild Bird Index (see www.birdlife.org/action/science/indicators/common_birds.html). This framework could largely help with finding operational advices to start a breeding bird survey in e.g. China, while the scientific objectives of the survey, beyond the production of biodiversity indicators for stakeholders, could fund their bases on the French example, especially dealing with global change impacts and community dynamics. A first step could be to synthesize the existing bird monitoring schemes, standardize the survey methodologies when possible, and look at the potential for estimating large-scale population trends for some common or rarer species. A second step would be to mobilize volunteers to implement a BBS across China, by inviting birdwatching or nature conservation NGOs to join scientists. New bird population monitoring schemes could be initiated, benefiting from the important Chinese amateur labour force. Such developments could benefit from the help of French and other European teams, for a better and quicker scientific and public success.

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