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A new global review of bird atlases and their contribution to knowledge

P. Christy Pototsky & Will Cresswell*

Center of Biological Diversity, School of Biology, University of St. Andrews, Sir Harold Mitchell Building, Greenside Place, St Andrews, Fife, UK, KY16 9TJ

*Correspondence author: wrlc@st-andrews.ac.uk
orcid.org/0000-0002-4684-7624

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Capsule: Over 600 bird atlases projects have been implemented across 93 countries, with at least 380,000 participants. Bird atlases with larger geographical scope had greater research impact but those utilizing online data submission and so higher number of participants had lower research impact.

Aims: To provide a comprehensive global review of bird atlases, to explore the impact of bird atlases in research, and identify variables that influence impact.

Methods: A database of bird atlases was compiled. Variables were extracted including: overall survey effort (an index generated using PCA comprised of total survey area, number of participants, and number of data records); research impact (an index generated using PCA comprised of bibliometric measures extracted from Scopus and Google Scholar); geographical details; fieldwork, project and publication timing; fieldwork methods. We then used mixed linear models to explore how these variables differed across atlases, and which were predictors of research impact index.

Results: As of 2021, over 600 bird atlases projects have been implemented across 93 countries, with at least 380,000 participants worldwide. Total survey area, geopolitical scale, and number of atlas generations had significant positive relationships with research impact. Negative relationships were found between research impact and whether an atlas was published in English and the use of online data submission platforms like eBird. However, we found a significantly positive relationship between atlases using online data submission and our measure of survey effort.

Conclusions: Bird atlases have been undertaken all around the world at a wide variety of geopolitical scales, and are likely to be influential through widespread impact on knowledge, including research impact and citizen science involvement. Atlases utilizing online data submission generate more data and have a higher level of participant engagement but are less frequently cited by researchers in both scientific and grey literature.

Introduction

The use of volunteers in research ("citizen science") has become incredibly popular since the 1970s. This trend has developed in response to a wide range of factors, including large-scale environmental change, budget limitations of government programs, and an increasing desire from the public to be actively involved in science (Wright *et al.*, 2015). Ornithology is a scientific field well-known for its long tradition of the involvement of amateurs, for whom the observation of birds, or 'birding', is a passion (Sullivan *et al*., 2009). Within ornithology today, there are many highly organized citizen science communities reporting bird observations. One example of citizen science in ornithology comes in the form of bird atlases. Bird atlases combine citizen science, birding, and professional ornithology in a coordinated effort to produce maps of bird distributions at a wide range of spatial scales, from local to international (Donald & Fuller, 1998). Although distributional atlases can and have been completed for various groups of organisms, from plants to mammals, birds have become the most common study group, in part because many amateur observers can accurately identify bird species (Beck *et al*., 2018).

Distributional data, like those produced by bird atlases, are essential to documenting and conserving biodiversity. Large amounts of data are needed, however, to usefully inform conservation policy and direct conservation action. Despite some shortcomings, a citizen science approach is typically the most practical way to achieve the quantity of data, over a sufficient geographic extent, needed to accurately map species distributions (Tulloch *et al*., 2013). Bird atlases result in accurate maps without interpolation, distinguishing themselves from more traditional methods of mapping species distributions, which involve drawing lines between localities at the limits of a species' known ranges and filling in the gaps with at best, predictive modelling, and at worst, interpolation (Harrison, 1993).

Despite substantial variation in methodology, atlas projects share the ability to generate large, spatially explicit ornithological datasets, detailed maps of species presence/absence, breeding evidence, and/or abundance, as well as detailed habitat information for threatened species (Beck *et al*., 2018). In addition, many bird atlases were first conducted over 30 years ago, and there is now a tradition of repeating atlases in the same geographical area to quantify change. With the first atlas effort as a baseline, subsequent atlas generations add a new layer of value to the dataset (Gibbons *et al*., 2007; Beck *et al*., 2018). All of these outputs were largely unavailable at the scale and resolution produced by atlassing before the 1970s (Donald & Fuller, 1998).

Global systematic reviews of bird atlases have been performed previously by Donald and Fuller (1998), Gibbons *et al.* (2007), and Dunn and Weston (2008). These reviews have documented patterns in the approach of different bird atlases, as well as the application of atlas data and the rate at which atlases are cited in scientific literature. However, the most recent of these reviews was published in 2008 before major developments in citizen science efforts which may have a significant effect on public awareness and the utilization of atlas data, namely the growth of mobile devices and online citizen science platforms for easy submission of species' occurrence observations (Ball-Damerow *et al*., 2019). The recent development of web-based data-entry platforms like eBird, BirdTrack, Ornitho, and BirdLasser allow volunteers to access, manage and submit the data they collect in real-time through associated mobile applications on their smartphones (Lee & Nel, 2020). Ideally, this development should also serve to increase accessibility and allow data management to occur on a faster timescale allowing more efficient and timely conservation actions. However, there is little research at present of the implications of this paradigm shift on the utilization of these kind of data for scientific research applications and, ultimately, conservation action (Sullivan *et al*., 2017). Even without the use of online data submission, there are conflicting opinions on whether noisy, often unstructured, data that is produced by bird atlases and other citizen science projects effectively facilitate knowledge generation (Isaac *et al*., 2014; Sullivan *et al*., 2017; Bayraktarov *et al*., 2019).

Here we present a global review of bird atlases that have been performed between 1966-2021 and quantitatively assess which variables influence the utilization of atlases in research. Searches of bibliometric databases for the number of times an atlas is mentioned or cited allow us to generate a measure of the 'research impact' of an atlas. Different bibliometric databases, however, have different approaches, strengths, and limitations, and so we utilize both Scopus and Google Scholar in this investigation. Elsevier's Scopus is a well-established alternative to Thomson Reuter's Web of Science, selectively indexing academic and scholarly publications (Harzing & Alakangas, 2016). We chose Scopus over Web of Science due to Scopus' broader coverage of regional journals and inclusion of books (Calver *et al*., 2017). In comparison to both Web of Science and Scopus, Google Scholar is a much broader search engine and retrieves a lot of 'grey literature' (e.g. technical reports, theses, and preprints) that is not present in either of the other databases (Harzing & Alakangas, 2016; Calver *et al*., 2017). It is important to note that grey literature is not typically considered in traditional scientific citation indices and the usefulness of Google Scholar itself in systematic reviews is still subject to debate (Haddaway *et* *al*., 2015). But due to the relevance of grey literature for conservation practitioners (e.g. conservation NGO reports to government, legislation) and because many of the atlases we review here are grey literature documents themselves, we chose to utilize both Google Scholar and Scopus to increase coverage of literature utilizing atlas data or information (Haddaway & Bayliss, 2015). Thus, the research impact of atlases analyzed and discussed here does not just cover the peer-reviewed scientific literature, but a broader measure of an atlas's generation of knowledge.

We investigated potential atlas-specific predictors of research impact through linear modelling. The first variable of interest was whether an atlas utilized online data submission because we perceived that most new atlases are now utilizing this approach to increase engagement, but Lee and Nel (2020) found that the use of BirdLasser for data submission in the Southern African Bird Atlas 2 (SABAP2) changed the way participants behaved in data collection, submitting far more unstructured, *ad hoc* records. We therefore predicted that the use of online data submission would have a negative relationship with research impact because online atlases may be creating more but less useful data. The second variable was whether an atlas was published in English because language has been identified as a major barrier to the application of scientific knowledge in a complex way. The convergence on English as the lingua franca for global scientific activities means that, in general, information published in English is available to larger groups of users around the world, but, as a consequence, other languages are not equally published and information most relevant to conservation is less accessible to field practitioners and policy makers where English is not used in daily communication (Amano *et al*., 2016). Due to this barrier to the publication, visibility, and use of non-English science, we therefore predicted that atlases published in English would have a positive relationship with research impact in comparison to atlases not published in or translated to English. The third variable was atlas generation (initial atlas, repeated atlas, second repeated atlas, etc.) because repeated atlases are perceived to provide comprehensive data on range change which standalone atlases are unable to provide (Gibbons *et al*., 2007). We therefore predicted that each generation adds a significant layer of value to the overall dataset, resulting in a positive relationship with research impact. The fourth variable was write-up time, or the number of years in between the end of fieldwork and publication, because increasing time to publish data may result in decreasing relevance of the data to researchers. We therefore predicted that longer periods of write-up time result in significantly lower research impact. The fifth variable was the spatial extent of an atlas because larger atlas project encompass more researchers and the data are likely to be more widely applicable. We therefore predicted that atlases with greater total survey area would have higher research impact. The final variables of interest were minimum atlas grid area (some grid-based atlases utilize multiple sizes of sampling units to perform individual surveys and so the smallest grid size was recorded) and the ratio between minimum atlas grid area and total survey area because these determine the spatial resolution of sampling for an atlas and so the resolution of any conservation recommendations. We therefore predicted that coarser atlases (greater minimum atlas grid area and lower grid: area ratio) would have lower research impact because high resolution data is more tractable for species distribution modelling and conservation planning (Tulloch *et al*., 2013). We also considered potentially confounding effects, such as the number of years since publication because an atlas is more likely to have been cited as this increases, regional variation (continent of atlas) because Gibbons *et al*. (2007) found regional patterns in the methodologies of bird atlases, and finally, geopolitical scale because smaller-scale atlases or larger-scale atlases with coarse spatial resolution or patchy effort may not generate the data necessary to be useful for research (Tulloch *et al*., 2013).

Methods

Generating the atlas database: locating atlases

In order to investigate characteristics and methods of bird atlases, we compiled a global database of all the bird atlases we could find. Extensive Internet searches included using Web of Science, Google Scholar, commercial book websites (e.g. www.amazon.co.uk/ and www.nhbs.com/), Twitter, Facebook, Instagram, and the Global Biodiversity Information Facility (GBIF) to find mentions of atlases. Searches were conducted between January to April 2021. Search terms in different languages were developed throughout the compilation process to find non-English atlases (e.g. "Atlante degli uccelli", "Atlas de las aves", "Atlas ptaków"). Despite this concerted effort, it is certain that atlases have been missed and particularly local atlases with limited online dissemination. But considering the larger dataset we have produced compared to both Dunn and Weston (2008) and Gibbons *et al*. (2007), when considering atlases prior to their review dates, we suggest that we have sampled extensively and to the most complete degree to date.

Generating the atlas database: selecting and defining atlases

We largely followed the definition of a bird atlas provided by Dunn and Weston (2008): "a project that conducts or collates (or both) surveys of bird presence or abundance that includes a spatial mapping component, and covers a significant geographical area, such as a county or local government area, state, province, country or continent". Most recent atlases are generated using field observations from large numbers of volunteers, and here we specifically exclude any mapping exercise (atlas) conducted entirely by professional ecologists or researchers. For example, one of the earliest bird atlases, the Breeding Birds of North Dakota, field surveys were performed largely by one professional ornithologist, with assistance from other biologists (Stewart, 1975). This review therefore focuses only on atlases produced by volunteers but in some cases it was not always possible to determine whether volunteers were the primary fieldworkers.

Each discrete project with its own temporal demarcation, objectives, and survey effort was considered independent, even if they were performed in the same geographical region. For example, Cadman *et al*. (1987) documented breeding birds in the province of Ontario from 1981-1985, Cadman *et al*. (2007) documented breeding birds in Ontario in 2001-2005, and the ongoing Ontario Breeding Bird Atlas 3 (Purves, 2020) will cover breeding birds from 2021-2025. These three projects are considered discrete atlases and the latter two are considered "repeat atlases", in which atlases are performed at the same time of year and geographical location, but at a different point in time, often with slightly different methodology and research objectives. We refer to these discrete projects as different atlas "generations". Breeding and wintering atlases were not considered repeats of each other, as these cover different birds and have different objectives.

In some cases, it was difficult to categorise atlases spatially and temporally in the classes we present above, such as fixed survey periods and independent survey effort. We chose to define continuous projects (those with ongoing data collection and no fixed end-date) as atlases if they collected data specifically as an atlas and were separate from other surveys. Many local atlases, like the regional or county atlases produced in Britain, were included in our analysis even though the data produced in these projects were also used to produce the atlases covering the entirety of Britain and Ireland. A regional atlas project was thus considered its own atlas if a separate publication was produced. Indeed, many of these smaller atlases involved differing amounts of fieldwork years and/or smaller grid size than the larger scale atlas, further increasing their independence. In practical terms, these atlases were also included because they may have different scientific or conservation objectives than the national atlas and their data may be utilized in different research contexts. These issues of statistical independence were then dealt with by using a mixed model framework (see below).

Like Dunn and Weston (2008), specialized atlases including strictly migratory or seabird surveys were excluded, because these typically involve only expert ornithologists rather than volunteers. This choice does exclude a small number of atlases being produced in the Caribbean, such as the Seabird Breeding Atlas of the Lesser Antilles (Lowrie *et al*., 2012). Several atlases covering wintering, breeding, and migratory birds were included, because these involved a mix of volunteers and professional ornithologists performing fieldwork. Provisional or pilot atlases, such as the pilot surveys undertaken in Howard and Montgomery counties in Maryland prior to the first Maryland-DC atlas, were also excluded from our database, partly due to a lack of basic information (Klimkiewicz & Solem, 1978). Finally, we also stipulated that atlases should be produced from discrete projects that systematically collected and mapped new data. For example, Price *et al*. (2002) produced a North American atlas from broadscale bird monitoring scheme data, so was excluded. However, it was not always possible to distinguish between projects that produced new data and those that mapped pre-existing data or casual observations onto a grid, and it is likely that some atlases that fell into the latter category were included in our sample.

In many cases, very little information could be sourced on atlases online. Generally, an atlas was included if it could be shown to have been published (i.e. on a booksellers website), was underway presently, or even that a singular species map could be located online (i.e. from an ornithological society's webpage). Unfinished or "abandoned" atlases were excluded, such as the Yolo County (California) atlas, but completed yet unpublished atlases like the Friuli-Venezia-Giulia (Italy) atlas were included, because sufficient relevant information on these could often be extracted from websites or reviews (e.g. Fraissinet 2011). It is likely that some atlases that do not satisfy the requirements listed here were inadvertently included in our analysis due to a lack of information provided online and this represents one of the limitations of our study.

Generating the atlas database: extracting data from atlases

We extracted a several variables from each atlas (Table 1). Variables were extracted from a wide variety of sources, including full atlases, atlas excerpts, reviews, booksellers' descriptions, social media, and news articles.

Generating an atlas survey "effort index"

Correlation tests were run between all variables prior to statistical modelling. Logged area, logged number of data records, logged number of effort hours, and logged number of observers were highly correlated with one another (Spearman's correlation test > 0.60 between all variables). We combined logged area, logged number of data records, and logged number of observers variables using Principal Components Analysis to form a single score to measure overall survey effort as an index, with which all three variables showed a positive relationship. The first principal component accounted for 84% of the variance in the effort measurements. Due to low sample size, number of effort hours was excluded from this measure of effort, but number of effort hours was correlated with the principal component effort index by 0.81. The effort index correlated with logged area by 0.88, logged number of observers by 0.94, and logged number of records by 0.93.

Utilization of atlases in research: citation analysis

Citations are an imperfect but widely used measure of research impact, knowledge generation, and/or relevance (Aksnes *et al*., 2019). In order to determine the research impact, or the influence of an atlas on scientific and grey literature, all published atlases (n = 549 excluding unpublished works and non-continuous atlas projects currently undergoing fieldwork) were searched for in Scopus and Google Scholar using the title(s) of the publication or project as the search term in quotation marks (e.g. "European Breeding Bird Atlas 2: Distribution, Abundance and Change"). For atlases with more than one title (i.e. use of multiple languages), the Boolean operator OR was utilized; a full table of search terms is provided in the Table S1. Searches were performed in May and June 2021. For Google Scholar, the full text was searched for mentions of the atlas title. The Scopus database does not search the full text, but all fields were searched for atlas titles, which includes numerous aspects of a publication, including the abstract, references, and title. The number of search hits for documents containing the title of an atlas publication was treated as an index of the actual number of citations for an atlas. From this, we derived a citation rate using the number of search hits divided by the number of years since publication of the atlas. For Scopus, we were also able to collect the maximum yearly citation rate. Citation rates were not calculated for atlases published in 2021 or continuous/online atlases without a publication date.

Ten atlases were randomly selected and all papers produced by the search were inspected to determine whether the atlas was cited in the journal article or referred to within the document. The percentage of erroneous inclusions for a single search query ranged from 0% to 9% (mean % ± SE: 3 ± 1) for Google Scholar and from 0% to 11% (mean % ± SE: 1 ± 1) for Scopus. Only Google Scholar suffered from "stray citations" (a phenomenon where slight variations in referencing result in duplicate records for the same paper or publication); for this random sample, the percentage of duplicates ranged from 0% to 18% (mean ± SE: 1.7 ± 0.58) (Harzing & Alakangas, 2016). For Google Scholar, most searches returned the actual atlas publication, but this was not excluded from the index because the repetition was equal across all searches. These errors and biases support our decision to not rely on a single database to investigate citations and research impact of bird atlases.

Generating an atlas "research impact" index

All citation measures (Google Scholar number of search hits, Scopus number of search hits, Google Scholar average yearly citation rate, Scopus average yearly citation rate, and Scopus max yearly citations) were highly correlated with each other (Spearman's rank correlation test > 0.70 between all variables). As with our effort index, we combined these variables using Principal Components Analysis to form a single score to measure overall "research impact" as an index, with all variables showing a positive relationship. The first principal component accounted for 89.5% of the variance in the citation measures. The extracted research impact index correlated with Google Scholar number of search hits by 0.95, Scopus number of search hits by 0.96, Scopus average yearly citation rate by 0.98, Google Scholar average yearly citation rate by 0.88, and Scopus max yearly citations by 0.96.

Modelling atlas characteristics and research impact: statistical analysis

All analyses were performed using R 4.0.5 (R Core Team, 2021). Summary statistics are presented as means ± 1 standard error. We tested for differences in effort index between atlases using online data submission and those using manual data submission with a linear mixed model with years since publication (measure of temporal variation) and continent (measure of regional variation) as fixed effects. Atlases for which there were missing data for any of the variables in the models were excluded from analysis. We repeated this analysis looking at differences in effort index between atlas generations. For atlas generation, we pooled fourth and fifth generation atlases together (due to low sample size) and treated generation as a continuous numeric variable. Atlas projects that have no repeat (as of early 2021) were still treated as first-generation atlases.

For the second part of our analysis, we used mixed linear models to explore the influence of the eleven variables that were hypothesized to influence research impact index. The research impact index was log transformed to obtain normally distributed residuals, as was total survey area. Variables of interest, including whether an atlas utilized online data submission, whether an atlas was published in English, atlas generation, number of fieldwork years, write-up time, minimum atlas grid area, and atlas grid: total survey area ratio were inputted into a full model and no model selection was undertaken in order to include potentially confounding effects, such as the number of years since publication, regional differences (continent of atlas), and geopolitical scale. Atlas generation and geopolitical scale was also treated as a continuous variable. No interactions between variables were considered in order to avoid over-parameterization of the model. In order to increase sample size due to atlases with missing data, a model where effort index was replaced with logged survey area was produced, because these two variables were shown to be highly correlated in our Principal Components Analysis. Both models (high and low sample size) are presented to show that the overall results remain the same, although with some differences in statistical significance as might be expected with changes in statistical power. Possible non-linear effects for research impact due to citation curve were considered by running analyses with atlases published later than 2019 excluded and there was no difference in model results for the high sample size model. For the low sample size model, the results also remained the same, but only geographical scale remained statistically significant. Model fit was assessed by visual inspection of residuals plotted against fitted values and quantile plots and all were reasonable after log-transforming research impact index. Effect sizes for variables of interest were calculated by dividing the predicted value over the range of the data in the high sample size model, with all other parameters set to average values. Finally, predicted values were plotted using the ggplot2 package in R (Wickham, 2016) .

Results

Atlas characteristics

The database contains information on 603 atlases (see Appendix S1 for full details). Most atlases have been published as large books or journal articles, but a small percentage (3%) have been published as webpages only. Some have gone unpublished entirely, and some are in preparation for publication (as of early 2021). Descriptive statistics for the database are shown in Table 2. Sample sizes vary considerably and only 5% of atlases had all fields filled in for the variables listed in Table 1.

Geographical distribution of atlases

Atlases were carried out in 93 countries (Fig. 1), on a large range of geographical scale, from a 1 km^2 university campus (Matos & Luís, 2007) to an entire continent (Keller *et al*., 2020). In terms of geopolitical scale, 83% of atlases were on a regional or local scale (mean area covered in km^2: 56,393, range: 1-3,960,000, *n* = 455), 15% on a national scale (mean area covered in km^2: 52,693, range: 61-7,688,287, *n* = 91), and only 2% on a multi-national scale (mean area covered in km^2: 2,068,772, range: 41,445-3,960,000, *n* = 12) (Fig. 2). Despite particular effort placed on finding as many atlases as possible on a global scale, 89% of atlases were from Europe or North America (*n* = 536), with 104 atlases from within Italy alone. Following Italy, the top producers were the United States (93), the UK (81), and France (46). 86% of atlases in Europe and North America were regional or local atlases, whereas only 54% of atlases elsewhere (*n* = 67) were regional or local (Fig. 2a). For example, forty US states and Puerto Rico have carried out at least one statewide atlas, as well as numerous repeat atlases in the same geographic area and smaller scale county atlases.

Temporal and seasonal distribution of atlases

The database contained atlases published between 1970-2021. Twenty-two atlases were still collecting data as of early 2021, with six continuous projects (e.g. SABAP2 and the Nigerian Bird Atlas Project). Atlases have started data collection in every decade since the 1960s, with two peaks in the 1980s and the early 2000s (Fig. 2b). Most atlases collect data for five years, but the range is wide, with some data collection spread over several decades.

Most atlases do not collect data on distribution throughout the entire year: 70% of atlases focus only on breeding distribution, 22% mapped seasonal (i.e. breeding and wintering, or wet and dry season) or year-round distribution, and 8% mapped wintering distribution. There were no significant differences in area covered, length of fieldwork, grid size, or effort index between breeding and wintering atlases (see Table S2 for full details).

Sampling and spatial resolution of atlases

Most atlases use a grid system to structure sampling. The area, shape, size, and measurement unit of the grid cell vary to differing extents (Table 2). Where the grid shape was known (n = 501), 98% used square or rectangular blocks, but a few atlases used irregular polygons based on physical or ecological structures (e.g. Maffei *et al*. 2001) or hexagons (Castro-Prieto *et al*. 2020). Most grid-based atlases used kilometres, miles, hectares, or yards to measure cells. 18.5% of grid-based atlases defined sampling areas by minutes or degrees, which means the area of the grid cell may vary significantly throughout the survey area, depending on latitude. Only four atlases (< 1%) were found to not use a grid cell system at all, but collected data for point localities (e.g. Barrett *et al*. 2003)..

Organizational aspects of atlases

65% of atlases explicitly stated that volunteers were the primary data collectors. Where known (n = 547), atlases were organized and run by ornithological societies (62%), governmental organizations (12%), universities and other research institutions (11%), naturalist groups and conservation NGOs (7%), museums (5%), park and reserve organizations (2%), and project-specific groups (1%). Many atlases were highly collaborative, involving multiple organizations of differing types, but these percentages consider only the main organizing body.

Atlas "effort"

The total number of observers for the atlas database was 389,126 (n = 319 atlases). This value is a minimum, because many atlases reported minimum figures or did not report number of observers at all. The total number of data records reported was 126,912,197 (n = 168 atlases). Again, this is a minimum, as most atlases did not report summary statistics. Finally, only 67 atlases reported effort hours of participants, but the total number of hours invested in atlas projects was 3,587,087, or over 400 full calendar years of survey effort. On average, each atlas project represents 53,539 effort hours, or six full calendar years of survey effort (Table 2). Table 3 shows a ranking of the top ten atlases for effort index.

Online data submission

Where known (n = 550), 20% of atlases utilized some form of online data submission, whether this was by submitting data sheets online post-field survey or by submitting data in real-time from mobile data submission applications. Some of the most commonly used data portals or applications were BirdTrack, eBird, and the individual country or local portals hosted through NaturaList (e.g. www.faune-france.org). Atlases using online data submission had a significantly higher measure of our effort index, even when controlling for years since publication and regional differences, but with much residual variation (Table 4).

Repeat atlases

26% of atlases in our database were repeat atlases. We found that effort index significantly increases with atlas generation, even when accounting for temporal and regional variation (Table 5). Furthermore, third-generation atlases had significantly higher effort index values than second-generation atlases (Table 5).

Factors predicting atlas "research impact"

Log survey area and geopolitical scale were significant positive predictors of our research impact index in the high sample size model (overall $R^2 = 0.56$, Table 6; Figures 3a & 3b). Atlas generation was a marginally significant positive predictor. English as a publication language and the use of online data submission were significant negative predictors of research impact index (Table 6; Figure 3, Figure 3c). The effect size for using online data submission was a decrease in the average predicted research impact index with all parameters in the high sample size model set to their average value by 7.8%. For using English as a publication language, the average predicted research impact index with all parameters in the high sample size model set to their average value decreased by 4.5%. In addition, research index marginally significantly decreased with atlases produced in Asia and the Middle East (Table 6, Figure 3d). No other variables had a statistically significant effect (Table 6). The results were the same for the low sample size model except that only effort index, online data submission, and geopolitical scale remained statistically significant.

Discussion

In this study, we were able to identify and characterize 603 bird atlases, involving at least 700,000 citizen scientists. In comparison to the previous reviews performed by Gibbons *et al*. (2007) and Dunn and Weston (2008), we were able to identify 185 atlases that had been initiated since 2005, a similar number of atlases compared to Gibbons *et al*. (2007), and at least 152 more atlases from 2006 and before compared to Dunn and Weston (2008). The average profile of a bird atlas globally is a breeding bird atlas organized by an ornithological society that collects data for 6 years, with about 1,200 participants each contributing about 70 hours of total effort, takes 3 years to compile and analyze data for publication, over an area of about 8,000 km^2 with a minimum grid size of 70 km^2.

A small number of countries dominate the production of bird atlases in terms of numbers of atlases produced, namely Italy, the United States, and the United Kingdom (Fig. 1). In addition to long traditions of amateur participation in ornithology in these countries, this pattern may be due to the regional trends towards the production of urban atlases or atlases produced for states, counties, or provinces (Fig. 2). It is a note for future research to investigate whether urban or smaller-scale atlases have relatively more of less utility for conservation, whether in terms of legislation, species conservation status, or habitat management. One potential strength in local atlases is the ability to tailor data collection protocols to generate the most useful data in the local conservation context. For example, for the Kerala Bird Atlas in India, participants were asked to note the presence of invasive plant species in order to provide additional ecological data (Praveen & Nameer, 2021). Although atlases have been performed on all continents (excluding Antarctica), there are still large gaps in survey effort, particularly for Asia, Northern Africa, Central America, and parts of South America. We suggest that effort and funding should be focused on improving capacity in these regions to develop and implement bird atlas projects on at least a national geopolitical scale, particularly because citizen science initiatives can be a significant resource in countries with insufficient professional scientific capacity (Barnard *et al*., 2017). Another important process in developing capacity is the identification of champion individuals and relevant institutions to lead bird atlas projects. An example of these processes working successfully is the ongoing Nigerian Bird Atlas (Tende *et al*., 2016). However, the complexity engendered by the scale, effort, and organisation needed for a first generation national bird atlas in countries affected by political and/or socioeconomic instability should not underestimated.

Gibbons *et al*. (2007) found that atlas initiation had peaked in the 1980s, but we find nearly as many atlases began fieldwork in the 2000s (Fig. 2b). We suggest that any troughs and peaks in the initiation of bird atlases are associated with the interval between repeat atlases (and the smaller-scale county or regional atlases which may run concurrently with these national or international repeated atlases), which is, on average, about fourteen years (Table 2). In terms of seasonal distribution, most atlases document breeding birds; one of the benefits of this approach is that breeding bird atlases concentrate fieldwork into the shorter breeding season, in which highly mobile species are easier to locate, and have lower overall cost. They may also keep participants at a higher level of engagement for a shorter amount of time, with the added benefit of documenting breeding-specific behaviors. The documentation of breeding ranges and breeding-specific behaviors add additional biological meaning and context to atlas maps.

Before assessing the research impact of atlases, it is important to consider how research impact might be measured. How to deal with citation data and what database to use to evaluate scientific impact is a point of major discussion in the literature (Harzing & Alakangas, 2016; Waltman, 2016; Martín-Martín *et al*., 2018; Aksnes *et al*., 2019). Previous research has concluded that Google Scholar is not suitable to be used alone in systematic reviews (Haddaway *et al*., 2015). However, the clear need to incorporate grey literature, which often constitutes the majority of information available for conservation decision-making, into any measure of research impact for atlases led us to seek a method to use Google Scholar in conjunction with more rigorous bibliometric databases like Scopus (Haddaway & Bayliss, 2015). In this paper, we combined five different measures of citations (Google Scholar number of search hits, Scopus number of search hits, Google Scholar average yearly citation rate, Scopus average yearly citation rate, and Scopus max yearly citations) into one research impact index through Principal Components Analysis. Scopus and Google Scholar produce different citation counts: Google Scholar consistently produced higher numbers of citations, which is expected as more low-impact documents and grey literature is included in this database (Martín-Martín *et al*., 2018). However, given that the first principal component, (our "research impact index"), captured 89.5% of the variance in all citation measures, and all citation measures were highly correlated with each other and our research impact index, there is not a large difference between any of the citation measures utilized in this paper. The methodology used here combining citation measures from Google Scholar and Scopus with a Principal Components Analysis allows a multifaceted but straightforward approach to measuring research impact, or a measure of research impact that incorporates both academic and grey literature. Adopting this approach for future such reviews may remove concern about the validity of different databases being used or not by demonstrating that they give very similar relative values; however, this approach may only hold true in this sample of search terms and further research is needed.

The research impact modelling led to four key significant results. First, we found that research impact of an atlas significantly increases with increasing survey area and geopolitical scale (Fig. 3a & 3b, Table 6). These two variables correspond to spatial coverage. Atlases performed on a national or international scale had a significantly higher research impact, as well as atlases with increasing geographical extent. This relationship is best illustrated by the first European Breeding Bird Atlas (Hagemeijer & Blair, 1997), which had the highest research impact index by far (nearly double that of the second highest impact atlas), despite its coarse spatial resolution (50 x 50 km grid) and vast geographical diversity in terms of cultural, linguistic, economic, and scientific contexts. In addition, this publication has already been established as a fundamental reference for the entirety of Europe (Herrando *et al*., 2019).

Second, we found that repeated atlases had significantly greater research impact (Figure 3c, Table 6). We also found that repeated atlases have significantly higher survey effort (Table 5). Both results suggest that repeating atlases provides increased value, in terms of both higher participant engagement and increased scientific yield with each generation. This finding provides quantitative justification for repeating atlases.

Third, an unexpected result was that English as a publication language for atlases was a negative predictor for research impact (Fig. 3d, Table 6), given that English is considered the common mode of international scientific communication and language is often credited as a significant barrier to the transfer of scientific knowledge (Amano *et al*., 2016). It is also of interest that only 38% of atlases in our database could be shown to have been published in English or translated into English alongside another primary language. This may be largely influenced by the dominance of regional or local European atlases, particularly given that over 100 atlases were produced solely in Italy, none of which were found to have been translated to English. This is still meaningful however, as this relationship may also mean that data produced by bird atlases is being utilized mainly by local researchers who understand the publishing language and knowledge transfer is occurring within one country or language community. Our results suggest that where data can best be applied locally for conservation ends, then outputs are best in local languages.

Fourth, the use of online data submission was found to be a significant negative predictor of research impact, even with the number of years since publication controlled for in our model (Fig. 3, Table 6). 20% of atlases in our database utilized online data submission and we expect this percentage will only continue to increase in the coming years. The results of this study quantify and highlight a key trade-off that occurs in citizen science. Although the use of online data submission contributed to significantly lower measures of research impact, atlases utilizing online data submission also had significantly higher measures of survey effort (Table 4). Essentially, atlases using online data portals have higher engagement with participants but generate fewer research outcomes. As our survey effort index is highly correlated with number of data records and effort hours, we suggest that the use of online data submission in bird atlases has led to a real or perceived prioritization of data quantity over data quality, resulting in reduced scientific yield. Online data submission platforms like eBird and BirdLasser vastly increase data collection potential without higher levels of structure or data curation, representing a potential barrier to the efficient use of atlas data in science which has not yet been sufficiently explored (Bayraktarov *et al*., 2019; Lee & Nel, 2020). Our results suggest that the organizers of atlas projects utilizing online data submission should make data management for clear scientific or conservation outcomes a greater priority, as well as fostering a culture amongst participants of strict adherence to data collection protocols.

The research impact modelling also showed that some variables were not important. Atlases were not less likely to be cited depending on the spatial resolution, temporal resolution, or temporal relevance: we did not find the minimum grid size and/or minimum grid size: total survey area ratio, length of fieldwork in years, or write-up time (number of years between the end of fieldwork and publication) to be significant predictors of research impact. Tulloch *et al*. (2013), in contrast, found that increasing spatial resolution was significantly related to higher impact of an atlas on scientific literature, although regional variation or geopolitical scale were not accounted for in their modelling and they utilized a different sampling method to produce citation rates. Tulloch *et al*. (2013) also found no significant relationship between temporal resolution and scientific impact, suggesting that longer atlas projects do not necessarily produce more research. It is interesting that write-up time, essentially the time taken for collation, analysis, and synthesis of data produced by the atlas into a published book, was not a predictor of research impact. In some cases, write-up equaled or far exceeded the length of fieldwork, possibly decreasing the data's utility for practical application in conservation, given the current rate of climate range and changes in breeding distributions of birds in response to climate change. We expect that online data submission will have significant impact on write-up time, because computerization allows analysis to occur concurrently with data collection, although the sheer amount of data produced through this methodology may hinder this process.

Finally, we faced similar issues to previous reviews in generating sufficient sample sizes for modelling, as with Dunn and Weston (2008). We therefore urge atlas projects to maintain their online presence after the atlas is completed, to publish the data collection and analysis protocols, survey effort statistics, and to make raw survey data more easily accessible.

The analyses presented here should form the basis of a continuing assessment of the performance of bird atlases, particularly as data technologies change and subsequently pose or deconstruct barriers to its use as a primary tool in science and conservation. The next stage of research would be to quantify real conservation action that results from or is supported by data produced by bird atlases, because it may not be the case that research impact and conservation action are directly linked (Meijaard & Sheil, 2007; Knight *et al*., 2008; Shanley & López, 2009). Overall, we have seen that bird atlases have proliferated the globe over the past sixty years, with more atlases being performed with more participants and more data produced. The factors which determine the research impact of an atlas are not necessarily obvious or simplistic, but certain characteristics should be embraced by future atlases and these include repeating atlases over the same area at regular intervals, covering larger geographical areas, as well as publishing atlases in the local language rather than English. The use of online data submission needs to be carefully managed by atlas organizers because we have shown that this approach undermines, rather than enhances, the research impact of an atlas. However, the significant engagement benefits, and potentially much wider conservation gains through empowering and informing citizen scientists, provided by online data submission, may mean this is an acceptable trade-off.

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Table 1. List of variables extracted from each atlas where possible.

Geographical details
Specific location/region
Country
Continent (Africa, Asia/Middle East, Europe, North America, Australia/Oceania, South America)
Geopolitical scale (regional/local, national, multi-national)
Total area encompassed by atlas (km^2)
Publication details
Title of project/publication
Year of publication
Full reference
Write-up time: years between end of fieldwork and year of publication (by calculation)
Publication languages (including atlas summaries and available translations)
Organizational details
Host organization name
Host organization type (e.g. ornithological society, governmental organization, university/research institution)
Whether or not volunteers were used
Fieldwork period
Year fieldwork started
Year fieldwork ended
Total years of fieldwork (by calculation)
Fieldwork season (breeding, wintering, year-round)
Whether or not the atlas is continuous
Fieldwork methods
Whether or not the atlas was grid-based
Grid units (e.g. minutes, degrees, kilometres, yards)
Dimensions of grid cells (e.g. 10 x 10 km, 1 x 1 degree)
Area of each grid cell (km^2)
Grid shape (e.g. square, rectangle, irregular polygon)
Total number of grid cells
Whether or not online data submission was used
Online data portal name
Fieldwork outcomes
Number of observers
Number of data records
Number of effort hours
Number of observers per km^2 (by calculation)
Effort hours per observer (by calculation)
Total number of grid cells
Whether or not online data submission was used
Online data portal name
Repeat atlases
Generation (e.g. first atlas, second atlas, third atlas, etc.)
Inter-atlas interval (years; by calculation)

Table 2. Descriptive statistics for key variables from 603 bird atlases. Note: continuous atlas projects were cut off at 2021 to calculate fieldwork duration.

Variable	***n***	**Sample coverage (*n/603*)**	**Mean/median***	**SE**	**Range**
Fieldwork start year	572	95%	1996.5*	NA	1966-2021
Years of fieldwork	570	95%	6.08	0.17	1-40
Year of publication	534	89%	2002*	NA	1970-2021
Write-up time (Years between end of fieldwork and publication year)	503	83%	3.84	0.14	0-24
Number of observers	319	53%	1,220	412	1-120,000
Number of records	168	28%	755,430	228,401	1,107-28,642,048
Number of effort hours	67	11%	53,539	15,831	59-1,000,000
Number of effort hours per observer	59	9.8%	71.2	13.3	4.81-800
Area covered (km^2)	558	93%	8,836*	NA	1-1,100,000
Observers/km^2	304	50%	0.14	0.03	0.0001-8.57
Minimum grid unit area (km^2)	462	77%	68.7	11.3	0.04-2,500
Grid area: total survey area ratio	432	72%	0.01	0.001	0.000003-0.29
Total number grid squares	363	60%	1488	371	3-129,507
Inter-atlas interval (for repeats, years)	150	25%	14.0	0.56	0-35

Table 3. List of the top 10 atlases with highest effort index (*n* = 133) with fieldwork season, fieldwork time period, effort index value, and whether the atlas project utilized online data submission. For full references, see Appendix S1.

Region	Fieldwork Season	Fieldwork Period	Effort Index	Online Data Submission	Reference
Britain and Ireland	Year-round	2007-2011	3.95	Yes	Balmer *et al*. (2013)
Australia	Year-round	1998-2002	3.48	No	Barrett *et al*. (2003)
Southern Africa	Year-round	1987-1991	3.28	No	Harrison *et al*. (1997)
Southern Africa	Year-round	2007-Ongoing	3.22	Yes	Southern African Bird Atlas Project 2 (2021)
Australia	Year-round	1977-1981	2.74	No	Blakers *et al*. (1984)
France	Year-round	2005-2012	2.67	Yes	Issa and Muller (2015)
New South Wales and Australian Capital Territory (Australia)	Year-round	1982-Ongoing	2.52	No	Cooper *et al*. (2020)
Netherlands	Year-round	1978-1983	2.34	No	Bekhuis *et al*. (1987)
Ontario (Canada)	Breeding	2001-2005	2.19	No	Cadman *et al*. (2007)
Chile	Breeding	2011-2016	1.89	Yes	Medrano *et al*. (2018)

Table 4. Relationship between effort index with online data submission, number of years since publication, and continent. The model $F_{7,100} = 6.7$, $p < 0.001$, adjusted $R^2 = 0.27$. The intercept for continent is set to Africa. P values less than 0.05 are in bold.

Explanatory Variable	**Estimate ± SE**	***t***	***p***
(Intercept)	2.43 ± 1.45	1.68	0.10
Online data submission (Yes)	1.96 ± 0.40	4.89	**<0.001**
Years since publication	0.04 ± 0.02	2.06	**0.04**
Continent: Asia/Middle East	-4.88 ±1.74	-2.80	**0.006**
Continent: Australia/Oceania	-2.29 ± 1.56	-1.47	0.14
Continent: Europe	-4.09 ± 1.41	-2.90	**0.005**
Continent: North America	-3.21 ± 1.41	-2.28	**0.02**
Continent: South America	-2.61 ± 2.00	-1.31	0.19

Table 5. Relationship between effort index with atlas generation (first column includes all generations, the second column compares second and third generation atlases), number of years since publication, and continent. P values less than 0.05 are in bold. The intercept is set to Africa for continent. All atlas generations model: Adjusted R^2 = 0.25, $F_{7, 112}$ = 6.6, p < 0.001. Second and third generation atlas generations model: Adjusted R^2 = 0.17, $F_{4,36}$ = 3.0, p < 0.03.

Explanatory Variable	**All atlas generations**			**Second and third generation atlases**		
	Est. ± SE	*t*	*p*	Est. ± SE	*t*	*p*
(Intercept)	2.08 ± 1.49	1.40	0.16	-3.14 ± 2.11	-1.50	0.14
Atlas generation	1.02 ± 0.24	4.34	**<0.001**	2.05 ± 0.75	2.75	**0.009**
Years since publication	0.007 ± 0.01	0.51	0.61	0.03 ± 0.04	0.70	0.49
Continent: Asia/Middle East	-3.54 ± 1.75	-2.03	**0.05**	-	-	-
Continent: Australia/Oceania	-2.12 ± 1.54	-1.38	0.17	-	-	-
Continent: Europe	-4.27 ± 1.42	-3.00	**0.003**	-1.50 ± 1.21	-1.24	0.22
Continent: North America	-3.19 ± 1.42	-2.25	**0.03**	-0.21 ± 1.26	-0.16	0.87
Continent: South America	-1.24 ± 2.01	-0.62	0.54	-	-	-

Table 6. Relationship between log-transformed research impact index and 11 individual atlas characteristics. P values less than 0.05 are in bold. For both models, the intercept is set to Africa for continent. Low sample size model: *n* = 100, Adjusted $R^2 = 0.63$, $F_{14,85} = 12.8$, $p < 0.001$. High sample size model: *n* = 347, Adjusted $R^2 = 0.56$, $F_{15,323} = 30.1$, $p < 0.001$.

Explanatory Variable	**Low Sample Size Model**			**High Sample Size Model**		
	Est. ± SE	*t*	*p*	Est. ± SE	*t*	*p*
(Intercept)	-0.75 ± 0.78	-0.95	0.34	-1.47 ± 0.63	-2.34	**0.02**
Years since publication	0.01 ± 0.01	1.07	0.29	0.002 ± 0.004	0.41	0.68
Effort index	0.28 ± 0.07	4.22	**<0.001**	-	-	-
Log area	-	-	-	0.11 ± 0.02	5.53	**<0.001**
Online data submission (Yes)	-0.85 ± 0.21	-4.03	**<0.001**	-0.54 ± 0.12	-4.53	**<0.001**
Geopolitical scale	1.04 ± 0.24	4.39	**<0.001**	0.95 ± 0.10	9.46	**<0.001**
Years of fieldwork	-0.04 ± 0.04	-1.02	0.31	-0.01 ± 0.01	-0.81	0.42
English as publication language (Yes)	-0.14 ± 0.22	-0.65	0.51	-0.31 ± 0.08	-3.69	**<0.001**
Continent: Asia/Middle East	-	-	-	-1.62 ± 0.69	-2.36	**0.02**
Continent: Australia/Oceania	-0.73 ± 0.78	-0.94	0.35	-0.59 ± 0.68	-0.86	0.39
Continent: Europe	-0.66 ± 0.63	-1.04	0.30	-1.10 ± 0.61	-1.80	0.07
Continent: North America	-0.13 ± 0.64	-0.21	0.84	-0.55 ± 0.62	-0.89	0.38
Continent: South America	-0.20 ± 0.94	-0.21	0.83	-0.74 ± 0.88	-0.84	0.40
Atlas generation	0.18 ± 0.14	1.30	0.20	0.15 ± 0.07	2.12	**0.03**
Years between end of fieldwork and publication	-0.03 ± 0.24	-1.09	0.28	-0.01 ± 0.01	-1.21	0.23
Minimum grid area (km^2)	-0.00001 ± 0.001	-0.01	1.00	0.0001 ± 0.0001	0.81	0.42
Log grid area: total survey area ratio	-6.09 ± 3.85	-1.60	0.12	-2.36 ± 1.57	-1.50	0.13

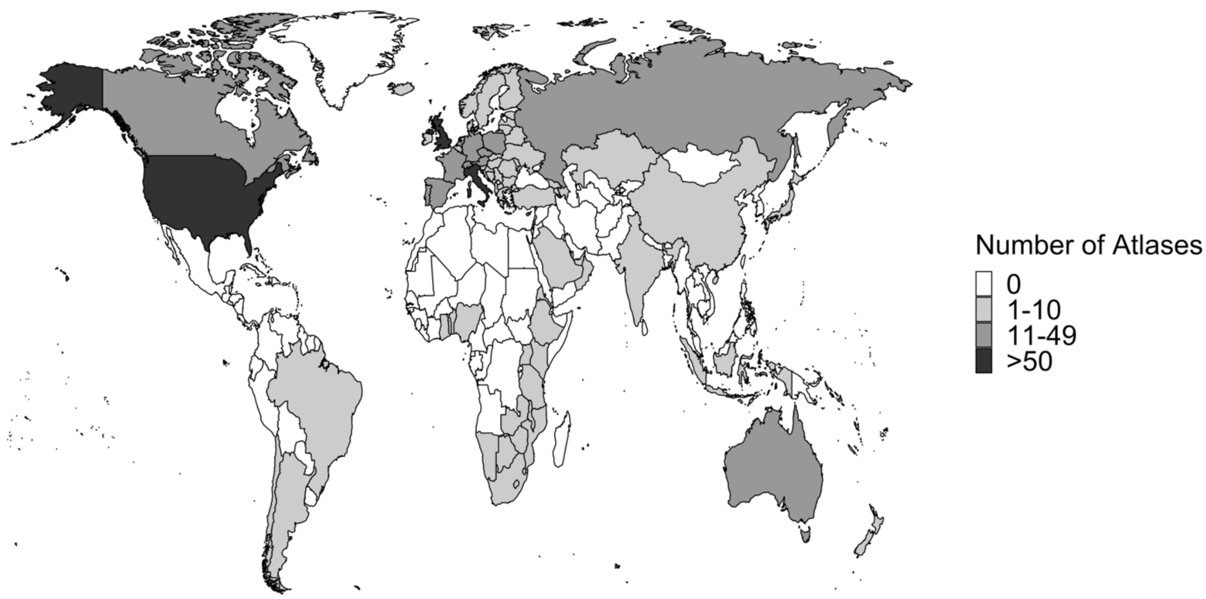

Figure 1. The number of atlases performed in each country. Note: this considers local atlases as well, so for some countries, this may mean that only a small geographical area of the whole country has been covered by an atlas. On the same note, some European countries have not produced their own national atlas but have participated in the continental atlas (EBCC) and are still shaded here. Antarctica excluded. Mercator projection.

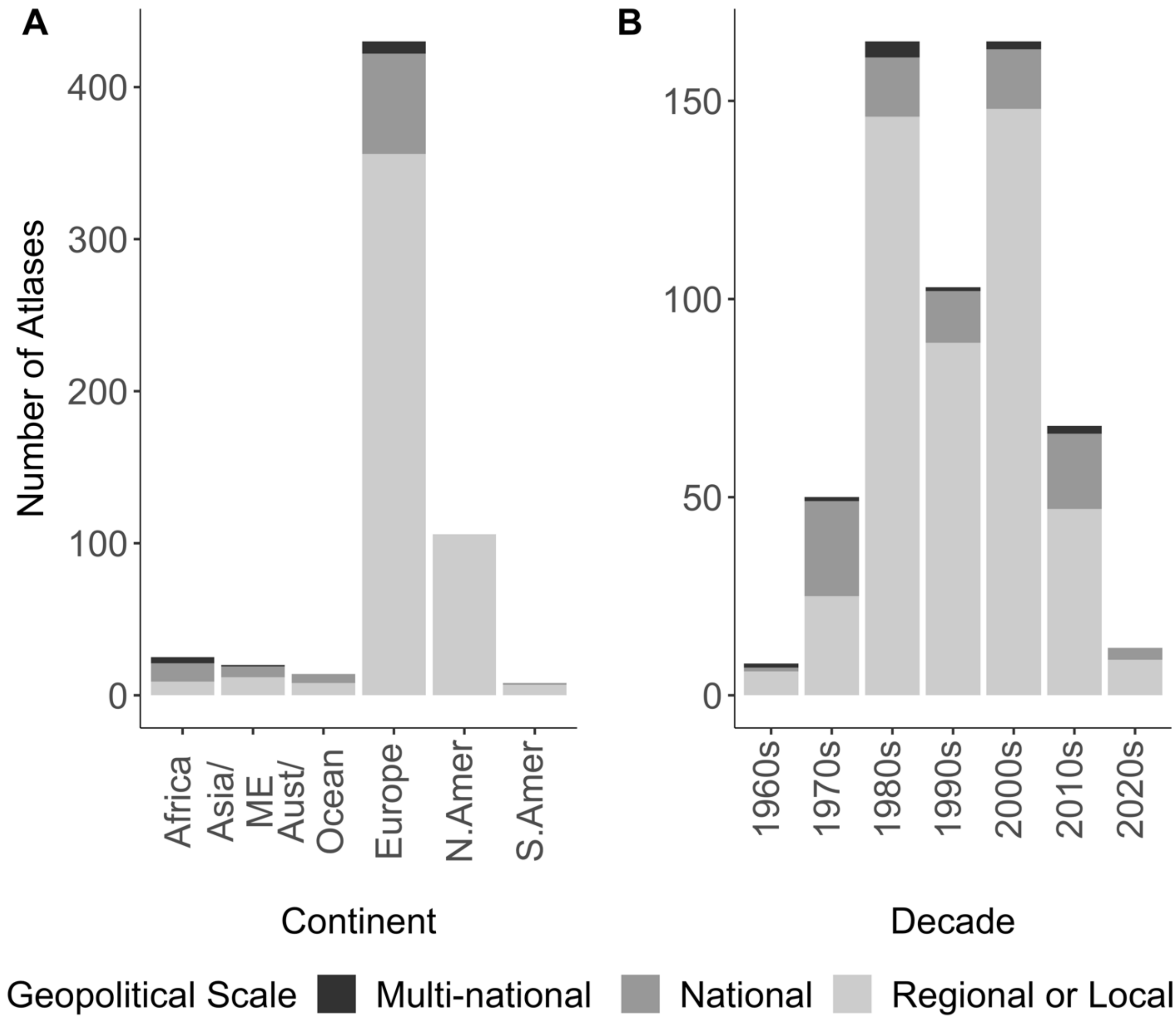

Figure 2. (a) Number of atlases performed around the world with geopolitical scale, n = 603. (b) The decade in which atlases were initiated with geopolitical scale, n = 572.

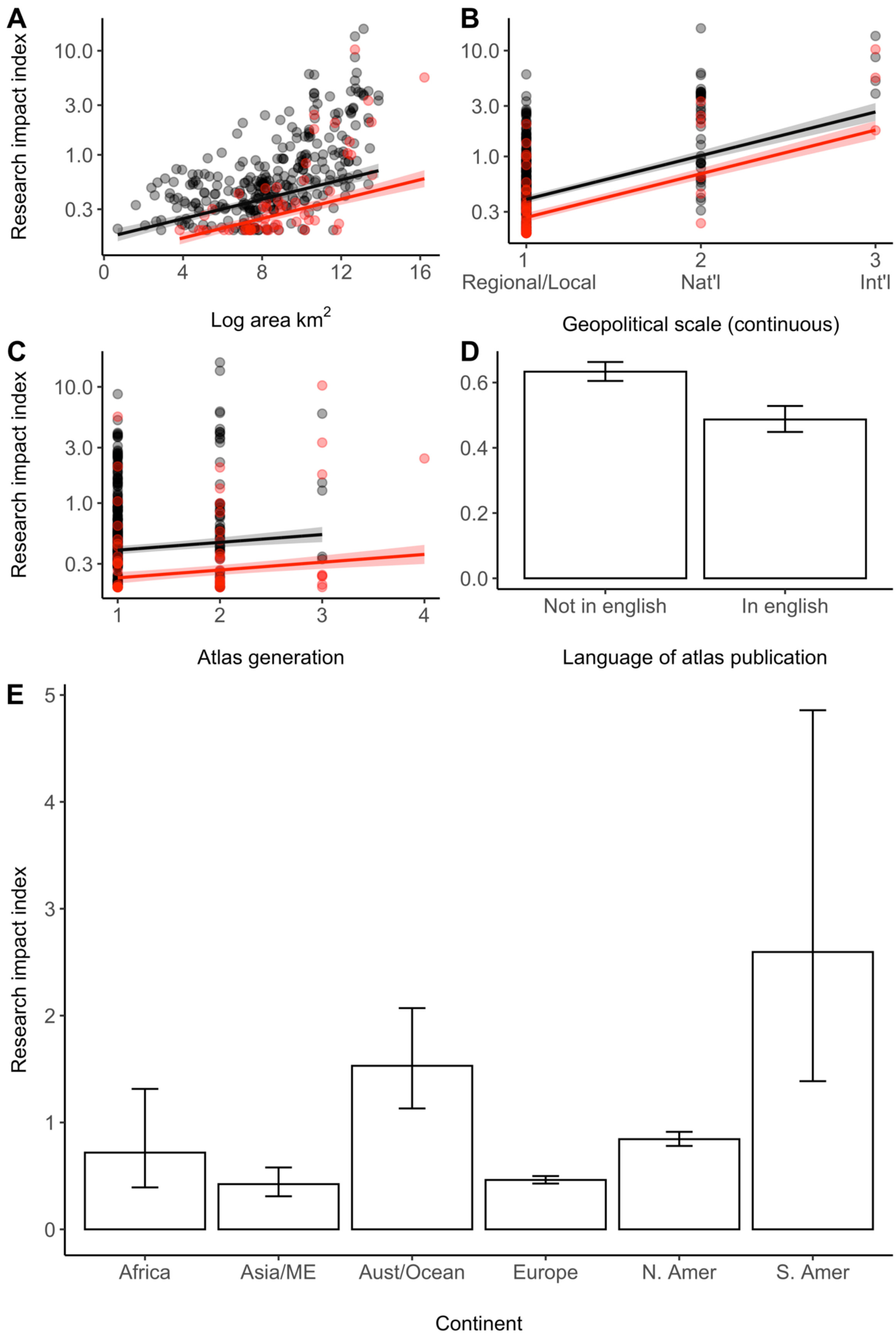
A
B
C
D
E
Research impact index
10.0
3.0
1.0
0.3
0
4
8
12
16
Log area km2
1
2
3
Regional/Local
Nat'l
Int'l
Geopolitical scale (continuous)
Atlas generation
0.6
0.4
0.2
0.0
Not in english
In english
Language of atlas publication
5
4
2
1
Africa
Asia/ME
Aust/Ocean
Europe
N. Amer
S. Amer
Continent

Figure 3. Modelled relationships for the final, high-sample size model (Table 6) of research impact for 339 bird atlases and (a) log area, (b) geopolitical scale, (c) atlas generation, (d) language of atlas publication, and (e) continent. Lines represent the predicted values from the high sample size linear model using median values for all other variables with continent set to Europe and publication language set to English. Red lines correspond to atlases utilizing online data submission and black lines correspond to atlases which did not utilize online data submission. Shaded areas or whiskers indicate one standard error.

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Table S1. List of search terms for Google Scholar and Scopus bibliometric analysis.

Atlas Survey Region	Publication Year	Search Term(s)
Adelaide	1977	"A bird atlas of the Adelaide region"
Adelaide	1994	"A second bird atlas of the Adelaide region"
Alabama	Online only	"Alabama Breeding Bird Atlas"
Alameda County	2011	"Alameda County Breeding Bird Atlas"
Alberta	1992	"The Atlas of Breeding Birds of Alberta" AND 1992
Alberta	2007	"The Atlas of Breeding Birds of Alberta: A Second Look"
Algarve	1994	"Breeding Birds of the Algarve"
Alicante Province	2015	"Atlas de las aves nidificantes en la provincia de Alicante"
Allier, Aveyron, Cantal, Haute-Loire, Lozère, Puy-de-Dôme	1987	"Atlas des Oiseaux Hivernants de l'Allier, Aveyron, Cantal, Haute-Loire, Lozère, Puy-de-Dôme"
Alsace	2017	"Atlas des oiseaux d'Alsace: nidification et hivernage"
Alto Vinalopó (Alicante)	2001	"Atlas de las aves nidificantes del Alto Vinalopó (Alicante)"
Ancona Province	2007	"Atlante degli uccelli nidificanti in Provincia di Ancona"
Andorra	2002	"Atles dels Ocells Nidificants d'Andorra"
Aquitane	1987	"Atlas des Oiseaux Nicheurs d'Aquitaine 1974–1984"
Aquitane	2020	"Atlas des oiseaux migrateurs et hivernants d'Aquitaine: Dordogne, Gironde, Landes, Lot-et-Garonne, Pyrénées-Atlantiques"
Aquitane	2015	"Atlas des Oiseaux Nicheurs d'Aquitaine"
Arabian Peninsula	2010	"Atlas of the Breeding Birds of Arabia"
Aragón	1998	"Aves de Aragón: Atlas de especies nidificantes"
Arizona	2005	"Arizona Breeding Bird Atlas"
Arkansas	Online only	"Arkansas Breeding Bird Atlas"
Arno River	2015	"Atlante degli uccelli nidificanti e svernanti nell'Arno in Provincia di Firenze"
Arran	2014	"Arran bird atlas 2007-2012: mapping the breeding and wintering birds of Arran"
Ascoli Piceno and Forma	2009	"L'Atlante degli uccelli nidificanti delle Province di Ascoli Piceno e Fermo"
Australia	Online only	"Atlas of Australian Birds" AND "birdata"
Australia	1984	"The Atlas of Australian Birds"
Australia	2003	"New Atlas of Australian Birds"
Australian Capital Territory	1992	"Birds of the Australian Capital Territory: an atlas"
Austria	1993	"Atlas der Brutvögel Österreichs"
Auvergne	2010	"Atlas Des Oiseaux Nicheurs d'Auvergne"
Ávila Province and Sierra de Gredos Mountains	1990	"Atlas de las aves nidificantes de la provincia de Ávila y Sierra de Gredos"
Avon	2012	"Avon Atlas 2007-11"
Barcelona	2017	"Atles dels Ocells Nidificants de Barcelona"
Barnsley	2018	"Atlas of Breeding Birds in the Barnsley Area 2006-2011"
Basel	1999	"Die Brutvögel beider Basel"
Bavaria	1987	"Atlas der Brutvögel Bayerns: 1979-1983"
Bavaria	2005	"Brutvögel in Bayern: Verbreitung 1996 bis 1999"
Bavaria	2012	"Atlas der Brutvögel in Bayern"
Bedfordshire	1979	"Bedfordshire Bird Atlas"
Bedfordshire	1994	"An atlas of the breeding birds of Bedfordshire 1988-92"
Bedfordshire	Online only	"Bedfordshire Bird Atlas"
Belgium	1988	"Atlas des Oiseaux Nicheurs de Belgique"
Benin and Togo	2019	"The Birds of Benin and Togo: An Atlas and Handbook"
Bergamo City	2006	Atlante degli uccelli di Bergamo: specie nidificanti e specie

		svernanti (2001-2004)
Bergamo Province	2015	"Atlante degli Uccelli Nidificanti in Provincia di Bergamo"
Berkshire	1996	"The Birds of Berkshire" AND "Standley"
Berkshire	2013	"The Birds of Berkshire Atlas and Avifauna"
Bielefeld	1991	"Die Vögel Bielefelds"
Bloemfontein	2001	"Atlas of Birds of Bloemfontein"
Bologna Province	2002	"Atlante degli Uccelli Nidificanti Nella Provincia di Bologna"
Botswana	1994	"Bird Atlas of Botswana"
Brescia City	2003	"Atlante degli uccelli nidificanti nella città di Brescia 1994–1998"
Brescia City	2015	"Atlante degli Uccelli svernanti nella Città di Brescia 2006-2011"
Brescia Province	1985	"Atlante Degli Uccelli Nidificanti in Provincia di Brescia"
Brescia Province	1990	"Atlante degli uccelli svernanti in provincia di Brescia"
Bretagne	1980	"Histoire et Géographie des Oiseaux Nicheurs de Bretagne"
Bretagne	1996	"Les oiseaux nicheurs de Bretagne 1980-1985"
Bretagne	2012	"Atlas des Oiseaux Nicheurs de Bretagne"
Britain and Ireland	1976	"The Atlas of Breeding Birds in Britain and Ireland"
Britain and Ireland	1986	"The Atlas of Wintering Birds in Britain and Ireland"
Britain and Ireland	1993	"The new atlas of breeding birds in Britain and Ireland: 1988-1991"
Britain and Ireland	2013	"Bird atlas 2007–11: The breeding and wintering birds of Britain and Ireland"
British Columbia	Online only	"British Columbia Breeding Bird Atlas" OR "BC Breeding Bird Atlas" OR "Atlas des oiseaux nicheurs de la Colombie-Britannique"
Brussels	1995	"Atlas des oiseaux nicheurs de Bruxelles 1989-1991"
Brussels	2007	"Oiseaux nicheurs de Bruxelles, 2000-2004: répartition, effectifs, évolution"
Bulgaria	2007	"Atlas of the Breeding Birds in Bulgaria" OR "Атлас на гнездящите птици в България"
Burgos Province	1996	"Atlas de las aves nidificantes de la provincia de Burgos"
Burgundy	2015	"Atlas des Oiseaux Nicheurs de Bourgogne"
Burren and Aran Islands	2002	"An Atlas of Breeding Birds of the Burren and the Aran Islands"
Butantan Institute	2018	"Instituto Butantan Bird Atlas"
Bute	2012	"The Birds of Bute: A Bird Atlas and Local Avifauna"
Cádiz Province	1992	"Guía de las aves de Jerez y de la Provincia de Cádiz"
Caithness	2016	"Birds of Caithness including the Breeding and Wintering Atlas 2007–2012"
Cambridgeshire	1994	"Atlas of the Breeding Birds of Cambridgeshire"
Cambridgeshire	2013	"Cambridgeshire Bird Atlas 2007–2011"
Campania	1989	"Atlante Degli Uccelli Nidificanti in Campania"
Campania	1999	"Atlante degli uccelli svernanti in Campania"
Canary Islands	2007	"Atlas de las Aves Nidificantes en el Archipiélago Canario"
Catalonia	2004	"Atles Dels Ocells Nidificants de Catalunya 1999–2002" OR "Catalan Breeding Bird Atlas 1999-2002"
Catalonia	2011	"Atles del ocells de catalunya a l'hivern 2006-2009" OR "Catalan Winter Bird Atlas 2006-2009"
Catalonia and Andorra	1983	"Atlas dels Ocells Nidificants de Catalunya I Andorra"
Central Mozambique	2005	"The Atlas of the Birds of Central Mozambique"
Chaco Province	1990	"Atlas ornitogeográfico de la provincia del Chaco, República Argentina"
Champagne-Ardenne	1992	"Les Oiseaux de Champagne-Ardenne" AND 1991
Champagne-Ardenne	2016	"Les Oiseaux de Champagne-Ardenne: nidification, migration, hivernage"
Chemnitz	2006	"Brutvogelatlas der Stadt Chemnitz"
Cheshire and Wirral	1992	"The breeding atlas of Cheshire and Wirral"
Cheshire and Wirral	2008	"Birds in Cheshire and Wirral: a breeding and wintering atlas"

Chile	2018	"Atlas de las aves nidificantes de Chile"
Chilika	2009	"Bird Atlas of Chilika"
Clackmannanshire	2013	"The Birds of Clackmannanshire"
Cleveland	2008	"The breeding birds of Cleveland"
Cluj-Napoca	2017	"Atlasul păsărilor Clujului"
Colonsay and Oronsay	2017	"The Birds of Colonsay and Oronsay: An Island Avifauna and Bird Atlas"
Colorado	1998	"Colorado Breeding Bird Atlas" AND 1998
Colorado	2016	"The Second Colorado Breeding Bird Atlas" OR "Colorado Breeding Bird Atlas II"
Connecticut	1994	"The Atlas of Breeding Birds of Connecticut"
Contra Costa County	2009	"Breeding Bird Atlas of Contra Costa County"
Cornwall	Online only	"Cornwall Bird Atlas"
Cossato	1997	"Atlante degli uccelli nidificanti a Cossato"
Cotswolds	1990	"An Atlas of Cotswold Breeding Birds"
Cotswolds	2009	"Birds of the Cotswolds: a new breeding atlas"
Cremona City	1994	"Gli Uccelli nidificanti e svernanti nella città di Cremona (1990-1993)"
Cremona City	2005	"Nidificanti e svernanti a Cremona tra 1990-1993 e 2001-2004"
Cremona City	2016	"Nidificanti e svernanti a Cremona nel ventennio tra 1990-1993 e 2010-2013"
Cumbria	2002	"The Breeding Birds of Cumbria: A Tetrad Atlas 1997–2001"
Cumbria	2015	"Cumbria Bird Atlas 2007-11"
Cyprus	2003	"Cyprus Breeding Bird Atlas"
Czech Republic	1995	"Atlas zimního rozšíření ptáků v České republice 1982-1985"
Czech Republic	1996	"Atlas Hnízdního Rozšíření Ptáků v České Republice 1985–1989"
Czech Republic	2006	"Atlas hnízdního rozšíření ptáků v České republice 2001-2003"
Czechoslovakia	1987	"Atlas hnízdního rozšíření ptáků v ČSSR 1973-1977"
Częstochowa	2008	"Atlas ptaków lęgowych Częstochowy 2003-2007"
Delaware	2000	"Birds of Delaware" AND "Hess" AND "2000"
Denmark	1976	"De Danske Ynglefugles Udbredelse"
Denmark	1998	"Fuglenes Danmark"
Denmark	2020	"Fugleatlas" AND "Moshøj" AND 2020
Deux-Sèvres	1995	"Atlas des oiseaux nicheurs des Deux-Sèvres"
Devon	1988	"Tetrad Atlas of the Breeding Birds of Devon"
Devon	2017	"Devon Bird Atlas 2007-2013"
Douai	2005	"Atlas des oiseaux nicheurs de Douai"
Durham	2000	"A Summer Atlas of the Breeding Birds of County Durham"
East Germany	1993	"Atlas der Brutvögel Ostdeutschlands"
East Glamorgan	Online only	"East Glamorgan Bird Atlas"
Emden	2007	"Brutvogelatlas Stadt Emden"
Entre Ríos Province	2006	"Atlas ornitogeográfico de la provincia de Entre Ríos"
Essen	1988	"Die Vögel von Essen und Mülheim an der Ruhr"
Essex	1996	"Tetrad atlas of the breeding birds of Essex"
Estonia	1993	"Eesti Linnuatlas"
Estonia	2018	"Linnuatlas. Eesti haudelindude levik ja arvukus"
Ethiopia and Eritrea	2009	"Birds of Ethiopia and Eritrea: An Atlas of Distribution"
Europe	2020	"European Breeding Bird Atlas 2: Distribution, Abundance and Change"
Europe	1997	"The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance"
Falkland Islands	1997	"Atlas of Breeding Birds of the Falkland Islands"
Famenne	1992	"Oiseaux nicheurs de Famenne Atlas de Lesse et Lomme"
Fife	2016	"The Breeding and Wintering Birds of Fife"

Fife	2003	"The Fife Bird Atlas"
Finland	1983	"Suomen Lintuatlas"
Finland	1998	"Muuttuva Pesimälinnusto" OR "Distribution, Number and Population Changes of Finnish Breeding Birds"
Finland	2011	"The Third Finnish Breeding Bird Atlas" OR "Suomen III Lintuatlas"
Flanders	2004	"Atlas van de Vlaamse Broedvogels 2000-2002"
Florence	1990	"Atlante degli uccelli nidificanti nel Comune di Firenze" AND 1990
Florence	2002	"Atlante degli uccelli nidificanti nel comune di Firenze : 1997-1998"
Florence	2009	"Atlante degli uccelli nidificanti nel comune di Firenze. Terza edizione: 2007- 2008"
Florence-Prato-Pistoia Plain	2020	"Atlante degli Uccelli Nidificanti e Svernanti nella Piana di Firenze-Prato-Pistoia e checklist 1983-2017"
Florida	1992	"The Breeding Birds of Florida" OR "The atlas of the breeding birds of Florida"
Foreste Casentinesi, Monte Falterona, Campigna National Park	2019	"Atlante degli uccelli nidificanti nel Parco nazionale delle Foreste casentinesi, Monte Falterona e Campigna (2012-2017)"
Forli City	2006	"Atlante Degli Uccelli Nidificanti a Forlì" AND 2006
Forli City	2020	"Atlante Degli Uccelli Nidificanti a Forlì 2015-2017"
Forli Province	1987	"Atlante degli uccelli nidificanti in provincia di Forli"
Forli-Cesena and Ravenna	2000	"Atlante Degli Uccelli Nidificanti Nelle Province di Forlì-Cesena e Ravenna (1995-1997)"
Forli-Cesena and Ravenna	2011	"Atlante Degli Uccelli Nidificanti Nelle Province di Forlì-Cesena e Ravenna (2004-2007)"
Formentera, S'Espalmador, S'Espardell Islands	1996	"Atlas de aves nidificantes de la isla de Formentera (Baleares)" OR "Atles dels aucells nidificants de l'illa de Formentera (Balears)"
Formosa Province	2014	"Atlas ornitogeográfico de la Provincia de Formosa, República Argentina"
Fort Richardson, Alaska	2005	"Breeding Bird Atlas of Fort Richardson, Alaska"
France	1976	"Atlas des Oiseaux nicheurs de France de 1970 a 1975"
France	1995	"Nouvel Atlas des Oiseaux Nicheurs de France 1985–1989"
France	1991	"Atlas des Oiseaux de France en Hiver"
France	2015	"Atlas des oiseaux de France métropolitaine"
Franche-Comté	1984	"Atlas des Oiseaux Nicheurs de Franche-Comté"
Franche-Comté	2018	"Les Oiseaux de Franche-Comté: Répartition, Tendances et Conservation"
Fribourg and Broye Vaudoise	1993	"Verbreitungsatlas der Brutvögel des Kantons Freiburg" OR "Atlas des Oiseaux Nicheurs du Canton de Fribourg"
Gard	1993	"Oiseaux Nicheurs du Gard"
Gard	2019	"Atlas des Oiseaux du Gard"
Gediz Delta, Western Turkey	2009	"Distribution of breeding birds in the Gediz Delta, Western Turkey"
Geneva	1983	"Les oiseaux nicheurs du Canton de Genève: atlas, historique, distribution, écologie"
Geneva	2003	"Atlas des oiseaux nicheurs du canton de Genève" AND 2003
Genoa	2005	"Atlante ornitologico della Città di Genova (1996-2000)"
Georgia	2010	"The breeding bird atlas of Georgia"
Germany	1993	"Atlas der Verbreitung und Häufigkeit der Brutvögel Deutschlands"
Germany	2014	"Atlas Deutscher Brutvogelarten"
Ghana	2014	"The Birds of Ghana: An Atlas and Handbook"
Gloucestershire	2013	"The birds of Gloucestershire" AND 2013
Grande Comore, Mohéli	2017	"Atlas des oiseaux nicheurs de la Grande Comore, de Mohéli et

and Anjouan		d'Anjouan"
Groningen	1992	"Vogelatlas van Groningen"
Grosseto City	2011	"Nuovo Atlante degli uccelli nidificanti a Grosseto (2009-2010)"
Grosseto City	2001	"Atlante degli uccelli nidificanti a Grosseto" AND 2001
Grosseto Province	1995	"Atlante degli uccelli svernanti in provincia di Grosseto. Inverni 1988/89 - 1993/94"
Gwent	1987	"The Gwent Atlas of Breeding Birds"
Halberstadt	2003	"Die Brutvögel von Halberstadt"
Halland County	2014	"Hallands Fågelatlas"
Halle	1989	"Brutvogelatlas von Halle und Umgebung"
Hamburg	2001	"Brutvogelatlas Hamburg"
Hampshire	2015	"Hampshire Bird Atlas 2007-2012"
Haryana and Delhi	2006	"Atlas of the Birds of Delhi and Haryana"
Helsinki	1998	"Helsingin Lintuatlas"
Herefordshire	2014	"The Birds of Herefordshire 2007 – 2012: An Atlas of their breeding and wintering distributions"
Hertfordshire	1982	"Hertfordshire Breeding Bird Atlas"
Hertfordshire	1993	"Breeding Birds of Hertfordshire"
Hertfordshire	2015	"Birds of Hertfordshire" AND "Hertfordshire Natural History Society" AND 2015
Hessen	2010	"Vögel in Hessen Die Brutvögel Hessens in Raum und Zeit Brutvogelatlas"
Hong Kong	2001	"The Avifauna of Hong Kong"
Hong Kong	2020	"香港鳥類分布調查2016-19" OR "The Hong Kong Bird Atlas 2016-2019" OR "香港鳥類分布調查: The Hong Kong Bird Atlas 2016-2019"
Hong Kong	Online only	冬季鳥類分布圖 2001-05 OR "Winter Bird Atlas 2001-05"
Humboldt County	2005	"Atlas of the Breeding Birds of Humboldt County, California"
Huntingdon and Peterborough	1988	"The Breeding Birds of Peterborough and Huntingdon, 1979-83"
Illinois	2004	"The Illinois Breeding Bird Atlas"
Indiana	1998	"Atlas of Breeding Birds of Indiana"
Indonesia	2020	"Atlas Burung Indonesia"
Iowa	1996	"The Iowa Breeding Bird Atlas"
Iowa	2015	"Iowa Breeding Bird Atlas II"
Island, King, Kitsap, and Kittitas Counties, Washington	2006	"Sound to Sage: Breeding Bird Atlas of Island, King, Kitsap, and Kittitas Counties, Washington"
Isle of Man	2006	"Manx Bird Atlas"
Italian Alps	1988	"Atlante degli uccelli nidificanti sulle Alpi italiane"
Italy	1993	"Atlante degli uccelli nidificanti in Italia"
Japan	2004	"鳥類繁殖分布調査報告書" OR "The National Survey on the Natural Environment Report of the distributional survey of Japanese animals (birds)"
Jasło	2002	"Ptaki Jasła liczebność, rozmieszczenie i ochrona"
Jelgava	2003	"The Breeding Bird Atlas of Jelgava district, Latvia"
Jura	1984	"Oiseaux nicheurs de la Haute Vallée de l'Orbe"
Kaliningrad	2018	"Atlas of breeding birds of Kaliningrad" OR "Атлас гнездящихся птиц Калининграда"
Kansas	2001	"Kansas Breeding Bird Atlas"
Kasane	2018	"Atlas of Birds of Kasane, NE Botswana"
Kent	1981	"The birds of Kent: a review of their status and distribution"
Kent	1998	"The Kent Breeding Bird Atlas for 1988–1994"

Kent	2017	"Kent Breeding Bird Atlas 2008–2013"
Kentucky	1996	"The Kentucky Breeding Bird Atlas"
Kenya	1989	"A bird atlas of Kenya"
Kenya	Online only	"Kenya Bird Map" OR "Kenya BirdMap"
Kerala	2021	"Kerala Bird Atlas"
Klaipeda	1999	"Klaipėdos krašto perinčių paukščių atlasas" OR "The Breeding Bird Atlas of the Klaipeda Region"
Krkonose/Karkonosze Mountains	1999	"Atlas ptaków lęgowych Karkonoszy (1991–1994)" OR "Atlas hnízdního rozšíření ptáků Krkonoš (1991–1994)" OR "Atlas hnízdního rozšíření ptáků Krkonoš (1991–1994) / Atlas ptaków lęgowych Karkonoszy (1991–1994)"
Krkonose/Karkonosze Mountains	2015	"Ptáci Krkonoš – atlas hnízdního rozšíření 2012–2014 / Ptaki Karkonoszy – atlas ptaków lęgowych 2012–2014" OR "Ptáci Krkonoš – atlas hnízdního rozšíření 2012–2014" OR "Ptaki Karkonoszy – atlas ptaków lęgowych 2012–2014"
La Rioja	1980	"Atlas Ornitológico de la Rioja"
Lake Constance Region	1983	"Die Vögel des Bodenseegebietes" AND 1983
Lake Constance Region	1992	"Die Entwicklung der Brutvogelbestände am Bodensee: Vergleich halbquantitativer Rasterkartierungen 1980/81 und 1990/91"
Lake Constance Region	2006	"Bodensee Brutvogelatlas 2000"
Lake Constance Region	2019	"Starke Bestandsveränderungen der Brutvogelwelt des Bodenseegebietes – Ergebnisse aus vier flächendeckenden Brutvogelkartierungen in drei Jahrzehnten"
Lancashire and North Merseyside	2001	"Atlas of the Breeding Birds of Lancashire and North Merseyside"
Lancashire and North Merseyside	2013	"The State of Lancashire's Birds: An atlas survey of the breeding and wintering birds of Lancashire and North Merseyside, 2007-2011"
Lancaster	1995	"An Atlas of Breeding Birds of Lancaster and District"
Latvia	1989	"Latvijas ligzdojošo putnu atlants"
Latvia	2021	"Latvijas Ligzdojošo Putnu Atlanti 1980-2017"
Lazio	2011	"Nuovo Atlante degli Uccelli Nidificanti nel Lazio"
Lazio	1995	"Atlante degli uccelli nidificanti nel Lazio" AND 1995
Lecce Province	2009	"Atlante degli uccelli nidificanti in provincia di Lecce"
Leeds	1994	"Atlas of Breeding Birds in the Leeds Area"
León Province	2008	"Atlas de las Aves Reproductoras de León"
Lesotho	1990	"The status and distribution of birds in Lesotho"
Lido di Ostia (Rome)	2006	"Atlante degli uccelli nidificanti nel centro urbano di Lido di Ostia"
Liguria	1989	"Atlante degli uccelli nidificanti in Liguria 1981-1986"
Liguria	1998	"Atlante degli uccelli svernanti in Liguria"
Limousin	1993	"Atlas des Oiseaux Nicheurs du Limousin"
Limousin	2013	"Atlas des Oiseaux du Limousin"
Lincolnshire	2020	"Lincolnshire bird atlas 1980-1999: an historical perspective"
Lithuania	2006	"Lietuvos perinčių paukščių atlasas" OR "Lithuanian Breeding Bird Atlas"
Livorno City	1994	"Atlante degli uccelli nidificanti a Livorno" AND 1994
Livorno City	2013	"Atlante degli Uccelli nidificanti a Livorno 2006-2013"
Łódź	2009	"Atlas ptaków lęgowych Łodzi"
Lombardy	1990	"Atlante Degli Uccelli Nidificanti in Lombardia 1983–1987"
Lombardy	1992	"Atlante degli uccelli svernanti in Lombardia"
Lombardy "low" Plain	2005	"Atlante degli uccelli nidificanti nella "bassa" pianura lombarda (Italia settentrionale)"
London	1977	"Atlas of breeding birds of the London area"
London	2002	"The Breeding Birds of the London Area"

London	2017	"The London Bird Atlas"
Los Alamos County	1992	"Atlas of the breeding birds of Los Alamos County, New Mexico"
Los Angeles County	2016	"LA County Breeding Bird Atlas" OR "Los Angeles County Breeding Bird Atlas"
Loudoun County, Virginia	2016	"Loudoun County Bird Atlas" OR "Results of the 2009-2014 Loudoun County Bird Atlas"
Louisiana	2000	"Louisiana Breeding Bird Atlas"
Lower Alentejo	1998	"Atlas das Aves Invernantes do Baixo Alentejo" OR "Atlas of the Winter Birds of Lower Alentejo"
Lower Saxony and Bremen	1985	"Atlas der Brutvögel Niedersachsens 1980 und des Landes Bremen mit Ergänzungen aus den Jahren 1976- 1979"
Lower Saxony and Bremen	1997	"Atlas der Brutvögel Niedersachsens 1981-1995 und des Landes Bremen"
Lower Saxony and Bremen	2014	"Atlas der Brutvögel in Niedersachsen und Bremen 2005-2008"
Lutsk District	1993	"The Atlas of Wintering Birds in Lutsk District"
Luxembourg	1987	"Atlas der Brutvögel in Niedersachsen und Bremen 2005-2008"
Lviv	1989	"The Atlas of Wintering Birds in the Lviv Region, Western Ukraine"
Madrid	2002	"Atlas de las aves invernantes de Madrid 1999- 2001"
Madrid	1994	"Atlas de las aves nidificantes en Madrid" OR "Atlas of Breeding Birds in Madrid"
Maine	1987	"Maine Breeding Bird Atlas" OR "Atlas of Breeding Birds in Maine"
Malawi	2008	"The Birds of Malawi: An Atlas and Handbook"
Mallorca and Cabrera	2010	"Atles dels aucells nidificants de Mallorca i Cabrera, 2003-2007"
Mallorca and Cabrera	1997	"Atles dels aucells nidificants de Mallorca i Cabrera (1983-1994)"
Malopolska	1992	"Atlas Ptaków Lęgowych Malopolski 1985–1991"
Malopolska	2000	"Atlas ptaków zimujacych Malopolski"
Malta	2009	"Malta Breeding Bird Atlas 2008"
Malta	2020	"Malta Breeding Bird Atlas 2018"
Manitoba	Online only	"Manitoba Breeding Bird Atlas" OR "Atlas des oiseaux nicheurs du Manitoba" OR "Atlas of the Breeding Birds of Manitoba"
Marin County	1993	"The Marin County Breeding Bird Atlas" OR "The Marin County Breeding Bird Atlas: A Distributional and Natural History of Coastal California Birds"
Maritimes (Nova Scotia, New Brunswick, Prince Edward Island)	1992	"Atlas of Breeding Birds of the Maritime Provinces" AND 1992
Maritimes (Nova Scotia, New Brunswick, Prince Edward Island)	2015	"Second Atlas of Breeding Birds of the Maritimes Provinces"
Marseille	2015	"Atlas des Oiseaux Nicheurs de Marseille"
Maryland and Washington, DC	1996	"Atlas of the Breeding Birds of Maryland and the District of Columbia" AND 1996
Maryland and Washington, DC	2011	"Second Atlas of the Breeding Birds of Maryland and the District of Columbia"
Massachusetts	2003	"Massachusetts Breeding Bird Atlas" AND 2003
Massachusetts	2017	"Massachusetts Breeding Bird Atlas 2"
Massif Central	1977	"Atlas des Oiseaux Nicheurs du Massif Central"
Mecklenburg County, North Carolina	2017	"Breeding Bird Atlas of Mecklenburg County, NC"
Mecklenburg-Vorpommern	2006	"Atlas der Brutvögel in Mecklenburg-Vorpommern"
Mecklenburg-Vorpommern	2015	"Zweiter Brutvogelatlas des Landes Mecklenburg-Vorpommern"
Meirionnydd	2012	"Birds of Meirionnydd/Adar Meirionnydd" OR "Birds of

		Meirionnydd" OR "Adar Meirionnydd"
Melbourne	1978	"A Bird Atlas of the Melbourne Region"
Mendrisiotto	1988	"Atlante Degli Uccelli Nidificanti nel Mendrisiotto"
Menorca	2016	"Atles dels Ocells de Menorca a l'Hivern 2007-2011"
Menorca	1997	"Atles dels ocells nidificants de Menorca"
Michigan	2013	"Michigan breeding bird atlas II" OR "The Second Michigan Breeding Bird Atlas"
Michigan	1991	"The Atlas of Breeding Birds of Michigan"
Midi-Pyrénées	1996	"Atlas des Oiseaux Nicheurs de Midi-Pyrénées" AND 1996
Midi-Pyrénées	2012	"Atlas des Oiseaux Nicheurs de Midi-Pyrénées" AND 2012
Minnesota	2017	"The First Minnesota Breeding Bird Atlas (2009-2013)" OR "Minnesota Breeding Bird Atlas"
Missouri	1997	"Missouri Breeding Bird Atlas"
Modena	1992	"Atlante Degli Uccelli Nidificanti in Provincia di Modena"
Moldova	2010	"Atlasul păsărilor clocitoare din Republica Moldova"
Monterey County	1993	"Atlas of the Breeding Birds of Monterey County California"
Moscow	2006	"Atlas: Birds of Moscow City and the Moscow Region"
Moscow	2014	"Atlas of the birds of Moscow City"
Mysuru City	2019	"Mysuru City Bird Atlas" OR "Mysuru City Bird Atlas (2014–2016): A systematic study of birds across space and time" OR "Mysore City Bird Atlas"
Napa County	2003	"Breeding Birds of Napa County, California"
Naples	2006	"Nuovo progetto Atlante degli uccelli nidificanti e svernanti nella città di Napoli (2001 – 2005)"
Naples	1995	"Atlante degli uccelli nidificanti e svernanti nella città di Napoli"
Naples	2020	"Terzo Atlante degli Uccelli Nidificanti e Svernanti della città di Napoli"
Napoli Province	2010	"Atlante degli Uccelli nidificanti in Provincia di Napoli 2007 – 2009"
Natal	1980	"Bird Atlas of Natal"
Navarre	1985	"Navarra Atlas de aves nidificantes (1982-1984)" OR "Atlas de Aves Nidificantes de Navarra"
Nebraska	2016	"The Second Nebraska Breeding Bird Atlas"
Nebraska	2001	"The Nebraska Breeding Bird Atlas 1984–1989"
Netherlands	1979	"Atlas van de Nederlandse Broedvogels" AND 1979
Netherlands	2002	"Atlas van de Nederlandse broedvogels 1998-2000"
Netherlands	2018	"Vogelatlas van Nederland"
Netherlands	1987	"Atlas van de Nederlandse Vogels" AND 1987
Neuchâtel	2007	"Atlas des oiseaux nicheurs du canton de Neuchâtel"
Nevada	2007	"Atlas of Breeding Birds of Nevada" OR "Nevada Breeding Bird Atlas"
Nevada County, California	2020	"Breeding Bird Atlas of Nevada County, California"
New Hampshire	1994	"Atlas of Breeding Birds in New Hampshire"
New Jersey	1999	"The Birds of New Jersey" AND 1999
New South Wales and Australian Capital Territory	2020	"An Atlas of the Birds of NSW & the ACT" OR "An Atlas of the Birds of New South Wales and the Australian Capital Territory"
New York	2008	"The Second Atlas of Breeding Birds in New York State"
New York	1988	"The Atlas of Breeding Birds in New York State"
New Zealand	1985	"The Atlas of Bird Distribution in New Zealand"
New Zealand	2007	"Atlas of bird distribution in New Zealand 1999-2004"
Nièvre	1994	"Atlas des oiseaux nicheurs de la Nièvre"
Nigeria	Online only	"Nigeria Bird Atlas" OR "Nigerian Bird Atlas Project" OR "Nigeria BirdMap" OR "Nigerian Bird Atlas"
Nord-Pas-de-Calais	1996	"Atlas de Oiseaux Nicheurs de la Region Nord-Pas de Calais"

Nord-Pas-de-Calais	2019	"Les Oiseaux nicheurs du Nord et du Pas-de-Calais"
Nordrhein-Westfalens	2012	"Die Brutvögel Nordrhein-Westfalens"
Norfolk	1986	"The Norfolk Bird Atlas" AND 1986
Norfolk	2011	"The Norfolk Bird Atlas Summer and Winter Distributions 1999-2007"
Normandy	2005	"Atlas des oiseaux de Normandie en hiver"
Normandy	1993	"Atlas des oiseaux nicheurs normands"
Normandy	2009	"Nouvel atlas des oiseaux nicheurs de Normandie"
North Holland	1990	"Broedvogels van Noord-Holland"
North Holland	2010	"Atlas van de Noord-Hollandse broedvogels"
North Wales	2013	"The Breeding Birds of North Wales / Adar Nythu Gogledd Cymru" OR "The Breeding Birds of North Wales" OR "Adar Nythu Gogledd Cymru"
North-East Scotland	2011	"The Breeding Birds of North-East Scotland"
North-East Scotland	1990	"The birds of north-east Scotland"
Northern Alabama	2002	"Northern Alabama Breeding Bird Atlas" OR "Northern Alabama Breeding Bird Atlas Results 1994-1997"
Northern Murcia	1996	"Atlas de las aves del norte de Murcia (Jumilla-Yecla)"
Northumbria	1997	"Atlas of Breeding Birds in Northumbria"
Northumbria	2003	"The Atlas of Wintering Birds in Northumbria"
Northumbria	2015	"Northumbria Bird Atlas"
Northwest Patagonia	2004	"Aves del noroeste patagónico"
Norway	1994	"Norsk fugleatlas"
Ohio	1991	"The Ohio Breeding Bird Atlas"
Ohio	2016	"The Second Atlas of Breeding Birds in Ohio"
Oklahoma	2004	"Oklahoma Breeding Bird Atlas"
Oklahoma	2017	"Oklahoma Winter Bird Atlas"
Olsztyn	2006	"Ptaki Olsztyna"
Oman	1998	"Breeding Bird Atlas of Oman"
Ontario	1987	"Atlas of the Breeding Birds of Ontario" 1987
Ontario	2007	"Atlas of the Breeding Birds of Ontario, 2001-2005"
Orange County	1997	"Atlas of Breeding Birds: Orange County, California"
Orange Free State	1987	"First Atlas of Bird Distribution in the Orange Free State"
Oregon	2001	"Oregon Breeding Bird Atlas"
Padua	1997	"Atlante degli uccelli nidificanti nella provincia di Padova" AND 1997
Padua	2019	"Nuovo Atlante degli Uccelli nidificanti in provincia di Padova (2006-2010)"
Palencia	1997	"Atlas de las Aves Nidificantes de la Provincia de Palencia"
Parc Natural del Montseny	2008	"Atles dels ocells comuns del Parc Natural del Montseny"
Parc Natural S'Albufera des Grau	2017	"Atles dels ocells nidificants al Parc Natural de s'Albufera des Grau"
Parco del Delta del Po	2009	"Atlante degli uccelli nidificanti nel Parco del Delta del Po Emilia Romagna"
Parco Lombardo della Valle del Ticino	2015	"Atlante degli Uccelli del Parco Lombardo della Valle del Ticino"
Parco Naturale Regionale di Veio	2019	"Atlante degli Uccelli nidificanti e svernanti nel Parco Naturale Regionale di Veio"
Parco nazionale del Vesuvio	2008	"Atlante degli uccelli nidificanti e svernanti nel Parco nazionale del Vesuvio"
Parco Nazionale della Val Grande	2020	"Atlante degli Uccelli nidificanti nel Parco Nazionale della Val Grande"
Parco Nazionale Dolomiti Bellunesi	1998	"Uccelli del Parco nazionale delle Dolomiti Bellunesi e delle aree immediatamente limitrofe Atlante degli uccelli nidificanti"

Parco Nazionale Dolomiti Bellunesi	2011	"Atlante degli uccelli nidificanti nel Parco Nazionale Dolomiti Bellunesi"
Parco regionale dell'Appia Antica	2008	"Atlante degli Uccelli Nidificanti Nel Parco regionale dell'Appia Antica"
Pardubice	2007	"Ptaci Pardubic"
Paris	2010	"Oiseaux Nicheurs de Paris: Un Atlas Urbain"
Paris	2020	"Atlas des oiseaux nicheurs du Grand Paris"
Parma Province	1995	"L'Avifauna Nidificante Nella Provincia di Parma"
Parque natural Baixa Limia-Serra do Xurés and LIC Baixa Limia	2005	"Guía de las aves del Parque natural Baixa Limia-Serra do Xurés y LIC Baixa Limia"
Pavia City	1998	"Atlante degli uccelli nidificanti a Pavia"
Pays de la Loire	2014	"Oiseaux nicheurs des Pays de la Loire"
Pays-d'Enhaut	1995	"Les Oiseaux du Pays- d'Enhaut, Canton de Vaud. Atlas des Oiseaux Nicheurs"
Pembrokeshire	1994	"Birds of Pembrokeshire: Status and Atlas of Pembrokeshire Birds"
Pembrokeshire	2010	"Atlas of breeding birds in Pembrokeshire"
Peneda-Gerês National Park	1996	"Atlas des Aves do Parque Nacional da Peneda Gerês"
Pennsylvania	1992	"Atlas of Breeding Birds in Pennsylvania" AND 1992
Pennsylvania	2012	"Second Atlas of Breeding Birds in Pennsylvania"
Piacenza	2001	"Atlante Degli Uccelli Nidificanti nel Piacentino"
Picardy	1995	"Atlas des Oiseaux Nicheurs de Picardie"
Piemonte and Val d'Aosta	2007	"Uccelli nidificanti in Piemonte eValle d'Aosta Aggiornamento della distribuzione di 120 specie"
Piemonte and Val d'Aosta	1988	"Atlante degli Uccelli Nidificanti in Piemonte e Val d'Aosta"
Piemonte and Val d'Aosta	1996	"Atlante degli Uccelli di Piemonte e Valle d'Aosta in Inverno (1986-1992)"
Pisa City	2018	"Atlante degli uccelli nidificanti nell'area urbana di Pisa"
Poitou-Charentes	2016	"Atlas des Oiseaux nicheurs du Poitou-Charentes"
Poitou-Charentes	2018	"Atlas des oiseaux en hiver du Poitou-Charentes "
Poland	2012	"Atlas pospolitych ptaków lęgowych Polski"
Ponor Mountains	2004	"Breeding bird atlas of the Ponor Mountains, western Bulgaria"
Pordenone	1987	"Atlante Degli Uccelli Nidificanti in Provincia di Pordenone (Friuli-Venezia Giulia) 1981–1986"
Portugal	2018	"Atlas das Aves Invernantes e Migradoras de Portugal"
Portugal	1989	"Atlas das Aves que Nidificam em Portugal Continental"
Portugal	2008	"Atlas das Aves Nidificantes em Portugal (1999-2005)"
Provence-Alpes-Côte-d'Azur	2009	"Atlas des Oiseaux Nicheurs de Provence-Alpes-Côte d'Azur"
Puerto Rico	2020	"The Puerto Rico Breeding Bird Atlas"
Puy-de-Dôme	1989	"Atlas des Oiseaux Nicheurs du Departement du Puy-de-Dôme"
Regensburg	2013	"Die Brutvögel der Stadt Regensburg und ihre Bestandsentwicklung von 1982 bis 2012"
Reggio Emilia	2002	"Atlante Degli Uccelli Nidificanti a Reggio Emilia"
Rhineland	1987	"Die Vögel des Rheinlandes. Bd. 3"
Rhineland	1990	"Die Vögel des Rheinlandes. Bd. 4"
Rhineland	2005	"Die Vögel des Rheinlandes. Atlas zur Brut- und Wintervogelverbreitung 1990-2000"
Rhode Island	1992	"The Atlas of Breeding Birds in Rhode Island"
Rhone-Alpes	2003	"Atlas des oiseaux nicheurs de Rhône-Alpes"
Rhone-Alpes	1977	"Atlas Ornithologique Rhone-Alpes"
Rimini	2007	"Atlante dei Vertebrati tetrapodi della Provincia di Rimini" AND "Gli uccelli nidificanti"

Riserva Naturale di Decima Malafede	2017	"Atlante degli uccelli nidificanti della Riserva Naturale Regionale di Decima-Malafede"
Riserva naturale di Monte Soratte	2016	"Gli Uccelli Nidificanti nella Riserva Naturale di Monte Soratte"
Riserva naturale regionale Montagne della Duchessa and neighboring area	2016	"Atlante degli uccelli nidificanti nella Riserva Naturale Regionale Montagne della Duchessa e nelle aree limitrofe"
Romania	1994	"Atlasul Provizoriu al Păsărilor Clocitoare din România"
Romania	2002	"Atlasul păsărilor clocitoare din România"
Rome	1996	"Atlante degli uccelli nidificanti a Roma"
Rovigo	2003	"Atlante degli Uccelli nidificanti in provincia di Rovigo"
Rutland	1992	"Rutland Breeding Bird Atlas"
Rutland	2012	"Rutland Breeding Bird Atlas: 2008-2011"
Ryazan	2016	"Гнездящиеся птицы города Рязани (Атлас распространения и особенности биологии)" OR "Nesting birds of the city of Ryazan (Atlas of distribution and features of biology"
Salamanca	1988	"Atlas Ornitólogico de la Provincia de Salamanca"
San Diego County	2004	"San Diego County Bird Atlas"
San Donà di Piave	2003	"Atlante degli uccelli nidificanti e svernanti a San Donà di Piave"
San Francisco	2003	"San Francisco Breeding Bird Atlas"
San Marino	2011	"Atlante degli Uccelli nidificanti nella Repubblica di San Marino (2007-2011)"
San Mateo County	2001	"San Mateo County Breeding Bird Atlas"
Santa Clara County	2007	"Breeding Bird Atlas of Santa Clara County, California"
Santa Fe Province	2011	"Atlas ornitogeográfico de la Provincia de Santa Fe, Argentina"
Saxony	1998	"Atlas der Brutvögel Sachsens"
Saxony	2013	"Brutvögel in Sachsen" AND "Steffens" AND "Nachtigall"
Serra da Malcata Nature Reserve	1998	"Atlas das Aves da Reserva Natural da Serra da Malcata"
Serra de Montejunto	1999	"Atlas das Aves que nidificam na Serra de Montejunto"
Sheffield Area	1985	"Birds of the Sheffield Area: Including the North-east Peak District"
Sheffield Area	2013	"Breeding Birds of the Sheffield Area including the North-East Peak District" AND 2013
Shizuoka Prefecture	1998	"静岡県の鳥類" AND 1998
Shizuoka Prefecture	2010	"静岡県の鳥類 第２版"
Shizuoka Prefecture	2020	"静岡県の鳥類 第３版"
Shropshire	2019	"The Birds of Shropshire" AND 2019
Shropshire	1992	"An Atlas of the Breeding Birds of Shropshire"
Sicily	1985	"Atlante degli uccelli nidificanti in Sicilia, 1979–1983"
Sicily	1993	"Uccelli e paesaggio in Sicilia alle soglie del terzo millennio"
Sicily	2008	" Atlante della Biodiversità della Sicilia Vertebrati terrestri" AND "uccelli"
Skåne County	2009	"Skånsk Vinterfågelatlas 2006-2008"
Skåne County	2013	"Skånes Fågelatlas"
Slovakia	2002	"Rozšírenie vtákov na Slovensku"
Slovenia	2019	"Atlas ptic Slovenije Popis gnezdilk 2002–2017"
Slovenia	1994	"Zimski Ornitoloski Atlas Slovenije"
Sofia City	1992	"Atlas of the breeding birds of Sofia City"
Solano County	2015	"Breeding Birds of Solano County"
Somerset	2014	"Somerset Atlas of Breeding and Wintering Birds 2007–2012"
Sonoma County	1995	"Sonoma County Breeding Bird Atlas"
South Carolina	2003	"The South Carolina Breeding Bird Atlas 1988–1995"
South Dakota	1995	"The South Dakota Breeding Bird Atlas" AND 1995
South Dakota	2016	"South Dakota Breeding Bird Atlas II"

South Moravian Region	1997	"Hnízdní Rozšíření Ptáků Jihomoravský Region"
South Tyrol	1996	"Atlas der Vogelwelt Südtirols"
South Tyrol	2011	"Atlante degli uccelli nidificanti dell'Alto Adige"
South-east Scotland	1998	"The breeding birds of south-east Scotland: a Tetrad Atlas 1988-1994"
South-east Scotland	2019	"Birds in South-east Scotland 2007-13"
Southern Africa	Online only	"Southern African Bird Atlas Project 2" OR "The second Southern African Bird Atlas Project" OR "SABAP2"
Southern Africa	1997	"The Atlas of Southern African Birds"
Southern Bohemia	1990	"Atlas Hnízdního Rozšíření Ptáků Jižních Čech 1985–1989"
Southern Mozambique	1999	"The atlas of the birds of Sul do Save southern Mozambique"
Southern Quebec	1996	"The breeding birds of Québec: atlas of the breeding birds of southern Québec"
Southern Quebec	2019	"Second Atlas of the Breeding Birds of Southern Québec"
Southern Saxony-Anhalt	1997	"Atlas der Brutvögel Sachsen-Anhalts Kartierung des Südteils von 1990 bis 1995"
Southwest Iceland	1994	"Utbreiða varpfugla á Suðtvesturland: Konnu n 1987-1992"
Southwestern Australia	1995	"Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of the Wheatbelt Avifauna"
Southwestern Cape Province	1989	"Atlas of the Birds of the Southwestern Cape"
Spain	1997	"Atlas de las Aves de España (1975–1995)"
Spain	2012	"Atlas de las aves en invierno en España 2007-2010"
Spain	2003	"Atlas de las Aves Reproductoras de España"
Steingrimsfjördur	1995	"Atlas of Breeding Birds in Steingrimsfjördur and Vicinity, NW Iceland: A Survey 1987–1994"
Strandja Mountains	1994	"Breeding bird atlas of the Strandja mountains, south-east Bulgaria"
Sudan	1987	"Distribution atlas of Sudan's birds with notes on habitat and status"
Suffolk	Online only	"Suffolk Bird Atlas"
Šumava and the Novohradské Mountains	2009	"Atlas Ptáků Šumavy a Novohradských Hor"
Surrey	2018	"Surrey Bird Atlas 2007-2012"
Sussex	2014	"The Birds of Sussex" AND 2014
Swaziland	1994	"Swaziland Bird Atlas 1985–1991"
Sweden	1999	"Svensk Fågelatlas"
Switzerland	1980	"Verbreitungsatlas der Brutvogel der Schweiz" OR "Atlas des Oiseaux Nicheurs de Suisse"
Switzerland and Liechtenstein	1998	"Verbreitung der Brutvögel in der Schweiz und im Fürstentum Liechtenstein 1993–1996" OR "Distribution des Oiseaux Nicheurs en Suisse et au Liechtenstein en 1993–1996"
Switzerland and Liechtenstein	2018	"Swiss Breeding Bird Atlas 2013–2016. Distribution and population trends of birds in Switzerland and Liechtenstein"
Tanzania	Online only	"Tanzania Bird Atlas"
Tasmania	1979	"Tasmanian Bird Atlas"
Tenerife	2003	"Atlas de las aves nidificantes en Tenerife"
Tennessee	1997	"Atlas of the Breeding Birds in Tennessee" OR "Atlas of Breeding Birds in Tennessee"
Texas	2001	"The Texas Breeding Bird Atlas"
Thames and Chiltern	Online only	"Thames and Chiltern Bird Atlas"
Ticino	1992	"Atlante Degli Uccelli del Ticino in Inverno"
Transvaal	1987	"Birds of the Transvaal" AND "Tarboton"
Trasimeno	2002	"Atlante degli uccelli nidificanti nel comprensorio del Trasimeno (1989-1998)"
Trento City	1998	"Atlante degli uccelli nidificanti nel comune di Trento"

Trento Province	2005	"Atlante degli Uccelli nidificanti e svernanti in Provincia di Trento"
Treviso	2007	"Nuovo Atlante degli Uccelli nidificanti in provincia di Treviso (2003-2006)"
Treviso and Belluno	1989	"Atlante Degli Uccelli Nidificanti Nelle Province di Treviso e Belluno, Veneto, 1983–1988"
Turin	2001	"L'Avifauna della Città di Torino: Analisi Ecologica e Faunistica"
Turkey	2019	"Türkiye Üreyen Kuş Atlası" OR "Breeding Bird Atlas of Turkey"
Tuscany	1997	"Atlante Degli Uccelli Nidificanti e Svernanti in Toscana 1982–1986"
Uganda	2005	"Bird Atlas of Uganda"
Umbria	1997	"Atlante ornitologico dell'Umbria" AND 1997
Umbria	2019	"Secondo Atlante Ornitologico dell'Umbria"
University of Aveiro Campus	2007	"Atlas das Aves Nidificantes do Campus da Universidade de Aveiro"
Upper Austria	2003	"Atlas der Brutvögel Oberösterreichs"
Upper Austria	2020	"Atlas der Brutvögel Oberösterreichs 2013-2018"
Valencia	1991	"Atlas de las Aves Nidificantes de la Comunidad Valenciana"
Varese	1988	"Atlante Degli Uccelli Nidificanti in Provincia di Varese, Lombardia, 1983–1987"
Varese	2007	"Atlante Ornitologico Georeferenziato della provincia di Varese"
Venezia	2000	"Atlante degli Uccelli Nidificanti in Provincia di Venezia"
Venezia	1996	"Atlante degli Uccelli Svernanti in provincia di Venezia inverni dal 1988/89 al 1993/94"
Venezia Province	2014	"Nuovo Atlante Uccelli nidificanti e svernanti in provincia di Venezia"
Verbano Cusio Ossola	2006	"Atlante degli uccelli nidificanti del Verbano Cusio Ossola"
Vermont	1985	"The Atlas of the Breeding Birds of Vermont"
Vermont	2013	"The Second Atlas of Breeding Birds of Vermont"
Verona	1991	"Atlante Degli Uccelli Nidificanti in Provincia di Verona (Veneto) 1983–1987"
Vicenza	1994	"Atlante Degli Uccelli Nidificanti Nella Provincia di Vicenza"
Victoria	1987	"Atlas of Victorian Birds"
Vienna	2009	"Die Vogelwelt Wiens: Atlas der Brutvögel"
Virginia	2001	"Breeding Bird Atlas of Virginia"
Voghera	2011	"Atlante degli uccelli nidificanti nel Comune di Voghera"
Vorarlberg	1991	"Atlas der Brutvögel Vorarlbergs" AND 1991
Vorarlberg	2011	"Atlas der Brutvögel Vorarlbergs" AND 2011
Voronezh	2013	"Атлас гнездящихся птиц города Воронежа/ Atlas of breeding birds in the city of Voronezh" OR "Atlas of breeding birds in the city of Voronezh" OR "Атлас гнездящихся птиц города Воронежа"
Vratza Mountains	2000	"Birds of the Vratza Mountains" AND "Breeding Bird Atlas"
Wallonia	2013	"Atlas des Oiseaux Nicheurs de Wallonie 2001-2007"
Washington	1997	"Breeding Birds of Washington State"
West Berlin	1984	"Brutvögelatlas Berlin (West)"
West Bohemia	1991	"Hnizdni Rozsireni Ptaku v Zapadoceskem kraji v letech 1985 az 1988"
West Brabant	2007	"Atlas van de West-Brabantse broedvogels"
West Germany	1977	"Atlas der Brutverbreitung westdeutscher Vogelarten Kartierung 1975"
West Germany	1982	"Atlas der Verbreitung und Häufigkeit der Brutvögel Deutschlands Kartierung um 1980"
West Glamorgan	1992	"An Atlas of Breeding Birds in West Glamorgan"
West Midlands	1970	"Atlas of breeding birds of the West Midlands"

West Virginia	1994	"The West Virginia Breeding Bird Atlas"
West Virginia	2021	"West Virginia Breeding Bird Atlas II"
Western Algarve	1987	"An atlas of wintering birds in the western Algarve"
Westphalia	2002	"Die Vögel Westfalens: Ein Atlas der Brutvögel von 1989 bis 1994"
Wiltshire	Online only	"Wiltshire Bird Atlas"
Wiltshire	2007	"Birds of Wiltshire" AND 2007
Wisconsin	2006	"Wisconsin Breeding Bird Atlas" OR "Atlas of the Breeding Birds of Wisconsin"
Yonne	1994	"Atlas des oiseaux nicheurs de l'Yonne 1979-1992"
Zambia	2008	"The Birds of Zambia: An Atlas and Handbook"
Zeeland	1994	"Broedvogels van Zeeland"
ZPS IT3341002 "Aree carsiche della Venezia Giulia"	2019	"Atlante degli Uccelli Nidificanti nella ZPS IT3341002 "Aree carsiche della Venezia Giulia""
Zurich	1991	"Brutvögel des Kanton Zürich"
Zurich	2009	"Zürcher Brutvogelatlas" OR "Brutvogelbestände im Kanton Zürich 2008 und Veränderungen seit 1988"

Table S2. Summary tables for models comparing characteristics of breeding and wintering atlases. The intercept for fieldwork season is set to Breeding atlases. P values less than 0.05 are in bold.

Table S2a. Relationship between log area with fieldwork season (Breeding or Wintering). $F_{1,426} = 1.1$, p = 0.30, adjusted $R^2 = 0.0002$.

Explanatory Variable	Estimate ± SE	*t*	*p*
(Intercept)	8.99 ± 0.14	66.0	**<0.001**
Fieldwork season: Wintering	0.56 ± 0.54	1.04	0.30

Table S2b. Relationship between number of fieldwork years with fieldwork season (Breeding or Wintering). $F_{1,434} = 0.2$, p = 0.67, adjusted $R^2 = -0.002$.

Explanatory Variable	Estimate ± SE	*t*	*p*
(Intercept)	5.71 ± 0.16	35.9	**<0.001**
Fieldwork season: Wintering	-0.26 ± 0.62	-0.43	0.67

Table S2c. Relationship between minimum grid size with fieldwork season (Breeding or Wintering). $F_{1,363} < 0.001$, p = 0.99, adjusted $R^2 = -0.003$.

Explanatory Variable	Estimate ± SE	*t*	*p*
(Intercept)	79.4 ± 14.73	5.39	**<0.001**
Fieldwork season: Wintering	0.48 ± 57.5	0.01	0.99

Table S2d. Relationship between effort index with fieldwork season (Breeding or Wintering). $F_{1,97} = 2.3$, p = 0.13, adjusted $R^2 = 0.01$.

Explanatory Variable	Estimate ± SE	*t*	*p*
(Intercept)	-0.10 ± 0.15	-0.66	0.51
Fieldwork season: Wintering	-0.90 ± 0.59	-1.53	0.13