EBBA2
European **B**reeding **B**ird **A**tlas

EBCC
European Bird Census Council
every bird counts

EBBA2 Methodology

1. Introduction

The European Bird Census Council, together with its partners across Europe, plans to produce a new atlas for breeding birds in Europe, to update the ground-breaking first atlas, whose data are now 30 years old. The European Breeding Bird Atlas 2 (EBBA2) methodology is fundamentally composed of a number of standards for data collection and provision to the European coordination for their appropriate management and analysis in order to achieve the objectives of the project:

- To document breeding evidence for all bird species at a resolution of 50x50 km.
- To estimate abundance for all bird species at a resolution of 50x50 km.
- To determine the changes in bird species distribution at a resolution of 50x50 km since the 1980s.
- To model fine-grained distribution for as many bird species as possible and project it at a resolution of 10x10 km.

2. Study area and period

The study area of the EBBA2 project covers all Europe (Figure 1). Countries included are: Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Georgia, Germany, Gibraltar, Greece, Hungary, Iceland, Republic of Ireland, Italy, Kazakhstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and Vatican City.

The time frame for the EBBA2 fieldwork focuses on the period 2013 to 2017. Any breeding bird observation collected during these five years is among the potential data sources for the EBBA2. Where necessary, data from outside this time period will be updated using information from on-going monitoring or expert knowledge in order to reflect the situation in 2013-2017 properly. This will probably be the case in countries that have finished a national atlas project recently, and in countries which do not achieve adequate coverage for the whole area during the study period.

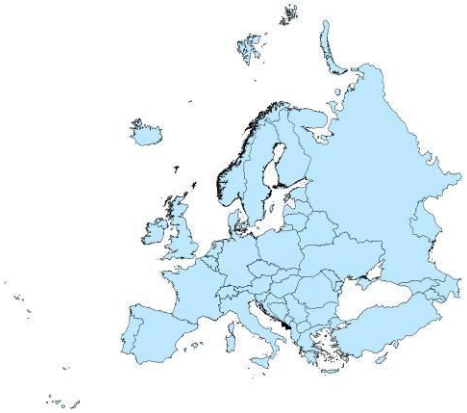


Figure 1. Map of the area covered by the EBBA2 project, which includes 52 countries and 11 million km^2. In addition to the area covered in the first European atlas, EBBA2 includes the whole of Turkey, Cyprus and the Canary Islands.

3. Data sources

The EBBA2 project is based on the joint efforts of fieldwork initiatives implemented in each country during the breeding seasons of the study period. As with the Pan-European Common Bird Monitoring Scheme (PECBMS), fieldwork for EBBA2 does not have to follow a common procedure in each European country. Therefore, the aim of this methodological paper is to define the information needed at European level.

EBBA2 will use actual field data wherever possible. Many field data sources could be considered as suitable pieces to build this huge project. National or regional breeding bird atlases whose study periods coincide totally or partially with that of EBBA2 are amongst the best data sources. EBBA2 thus offers a great opportunity to find synergies with atlas projects in European countries. However, there are other potential data sources for EBBA2, including casual records, often collected via on-line platforms, or more systematic breeding bird monitoring schemes. These could include generic breeding bird monitoring schemes ('common bird monitoring'), species specific schemes (e.g. census of colonial species or rare species census) or site monitoring (e.g. IBA monitoring). It is up to each national coordinator to decide which data source could provide better inputs for this pan-European project according to its data provision requirements, which are explained in detail in the next sections of this document. The European coordinators will be happy to answer any query about potential of various data sources at national level.

4. Data provision at 50x50 km

As in the first European Breeding Bird Atlas, EBBA2 attempts to show information on the characteristics of the species distribution at 50x50 km resolution. The methodological standards for data provision at 50x50 km consist of a number of common data fields and basic sampling practices designed to generate a structured EBBA2 database. There are four basic data fields with their own standardised codes: square, species, breeding evidence and abundance. In other words, these fields and their codes represent the common language for data exchange between the national and the European coordinators. Minimum standards for collecting field data and/or compiling information are provided. These standards are necessary to make data comparable across Europe.

4.1. 50x50km squares

Bird atlases usually show the species distribution on a regular subdivision of the territory by means of a grid of squares. The basic grid system implemented in EBBA2 is the Universal Transversal Mercator (UTM) grid. The 50x50 km UTM grid of the first European Breeding Bird Atlas (see EBBA1 on-line) is used also in EBBA2 (Figure 2).

The study area is divided in 5 217 squares. The majority of these are regular squares (2 500 km^2), but there are also irregular squares with an area larger or smaller than 2 500 km^2 (Figure 2). Each square has its own code (e.g. 34UFE3), and keeping this codification is essential for the appropriate data exchange between the national and the European coordinators. The EBBA2 grid at European and national levels can be downloaded (shapefile and kml files) and visualised (Google maps) from the EBBA2 website.

National coordinators are asked to provide information for as many 50x50 km squares as possible. In many countries, data for all squares can be provided, but in some countries data will be available only for a part of the total number of squares. In these later cases, it is highly desirable to focus fieldwork in a representative sample of 50x50 km squares in order to cover appropriately the different habitats within a country, ideally in a stratified random fashion for each study year. The EBBA2 coordinators are available to help national coordinators with sampling design.

We encourage national coordinators to provide the most complete species list for each reported square, but data for squares with incomplete lists (i.e. data available for only some species) are also useful. A simple measure of the completeness of the survey at each square based on expert knowledge will be asked; this measure will range from 1 to 5 (Table 1). A special effort will be carried out for modelling the species occurrence in non-surveyed areas (see 4.6. Final products from data provision at 50x50 km).

Table 1. Categories for evaluating the completeness of survey.

Category	Definition
1	0-20% of the habitats of the square have been well surveyed
2	20-40% of the habitats of the square have been well surveyed
3	40-60% of the habitats of the square have been well surveyed
4	60-80% of the habitats of the square have been well surveyed
5	80-100% of the habitats of the square have been well surveyed

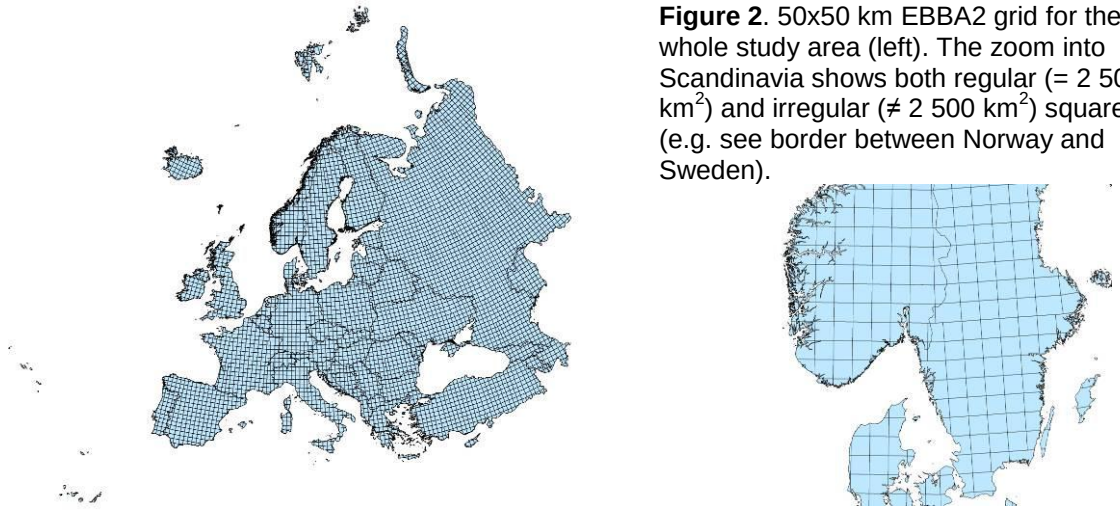


Figure 2. 50x50 km EBBA2 grid for the whole study area (left). The zoom into Scandinavia shows both regular (= 2 500 km^2) and irregular (≠ 2 500 km^2) squares (e.g. see border between Norway and Sweden).

4.2. Species

The EBBA2 species list contains all bird species that are certainly or at least very likely to be found breeding in the area covered by the new atlas. This list is available at the EBBA2 website, together with a cover letter with details on how to use it. Please, take a careful look at the excel file with the species list; within the framework of EBBA2, national coordinators should ideally adopt this species list and EBBA2 species codes for field data recording and provision to the European coordination. Before any data submission, national coordinators should check for potential differences between the national and EBBA2 species lists to keep integrity in species names and codification. Support from the EBBA2 coordination will be at the disposal of national coordinators.

We ask national coordinators to provide data for all breeding species recorded, including both native and non-native species. In the reporting form at 50x50 km squares, an expert based assessment will be made to distinguish 1) regular breeding (has probably or certainly bred in the square for all or the most of the last 5 breeding seasons) and 2) exceptional/occasional breeding (has probably or certainly bred only sporadically over the last 5 breeding seasons). In addition, if at all possible, 1) wild, 2) reintroduced (living in the wild but originated from reintroduction projects), 3) feral (living in the wild but descended from escaped/released (domesticated) individuals) and 4) park populations (currently depending on human support) should be differentiated and reported separately. For each square, these expert based evaluations could be made when the national coordinator consider that available data allows it, being always possible to update any data until the end of the data provision period.

4.3. Breeding evidence

Recording information about the likelihood that a bird species breeds in a particular square is an essential objective for a breeding bird atlas. One of the aims of EBBA2 is showing the breeding evidence for each species in every square, trying to model the species occurrence in non-surveyed areas (see Final Products).

Breeding evidence is represented by a series of categorised types of observation that allow interpreting if the species is a possible, probable or confirmed breeder at each square. For EBBA2 the 16 breeding codes of the first European atlas are used, with an additional code for species recorded during the breeding season but suspected to be non-breeders (Table 2). Atlas codes are also available at the EBBA2 website.

Table 2. EBBA2 breeding categories and codes.

0. Non breeding (species observed but suspected to be still on migration or to be summering non-breeder)
A. Possible breeding
1. Species observed in breeding season in possible nesting habitat
2. Singing male(s) present (or breeding calls heard) in breeding season
B. Probable breeding
3. Pair observed in suitable nesting habitat in breeding season
4. Permanent territory presumed through registration of territorial behaviour (song, etc.) on at least two different days a week or more apart at same place
5. Courtship and display
6. Visiting probable nest-site
7. Agitated behaviour or anxiety calls from adults
8. Brood patch on adult examined in the hand
9. Nest-building or excavating of nest-hole
C. Confirmed breeding
10. Distraction-display or injury-feigning
11. Used nest or eggshells found (occupied or laid within period of survey)
12. Recently fledged young (nidicolous species) or downy young (nidifugous species)
13. Adults entering or leaving nest-site in circumstances indicating occupied nest (including high nests or nest holes, the contents of which cannot be seen) or adult seen incubating
14. Adult carrying a faecal sac or food for young
15. Nests containing eggs
16. Nests with young seen or heard

These breeding codes should be used for data provision to EBBA2 coordinators. Breeding codes used at national level are generally very similar, but it is worth checking for possible differences to ensure a proper data exchange. If conversion between national and European atlas codes is necessary advice and help can be provided by the European coordinators.

Only the maximum atlas code (from 0-16) reported from each square will be reported to the European database, followed by an expert assessment from the national coordinator (4 categories: non-breeder (but recorded during the breeding period), possible, probable and confirmed breeder). The expert assessment does not always have to be consistent with the reported observed maximum breeding code since it may incorporate other sources of knowledge. For instance, a widespread non-migrating species for which only singing males (= possible breeding) have been recorded, can (with local knowledge) be considered as a confirmed breeder. A record of a singing male of a species known to sing on migration, will however be categorised as a non-breeder if the observation comes from the migration period in areas where the species has never been recorded breeding. The expert assessment can be also used in squares that have been only partially surveyed or even not surveyed at all if

a combination of old data and expert knowledge suggests that the species is currently present. In these cases in which there is a gap in coverage for the study period, a careful expert judgment on the species occurrence and breeding evidence (4 mentioned categories) will represent a very useful source of information for EBBA2.
Observed atlas code and expert assessment on the breeding probability should be provided by national coordinators per species and 50x50 km square. In squares located across the border between two or more countries the final value will be calculated by the European coordination on the basis of the reported breeding evidence at national level.

4.4. Abundance

EBBA2 attempts to incorporate an estimate of bird species abundance at every 50x50 km square. This information may represent a useful tool for calculating population sizes and allow comparisons across all Europe and with those made 30 years ago. The abundance classes in EBBA2 are the same semi-quantitative estimates used in the first European atlas, which were categorised on a logarithmic scale (Table 3). Abundance codes are also available at the EBBA2 website.

Table 3. EBBA2 abundance codes and categories for the assessments in 50x50km squares.

A	B	C	D	E	F
1-9 pairs	10-99 pairs	100-999 pairs	1 000-9 999 pairs	10 000-99 999 pairs	>100 000 pairs

In addition to the mentioned semi-quantitive estimates, in those cases for which more precise estimates are available, these could be provided too (optional). Such estimates will be helpful for improving the precision and accuracy of population estimates but EBBA2 abundance codes should be retained for comparability purposes (among squares in EBBA2 and with EBBA1).

These estimates of abundance can be generated for each square as the result of 1) direct counts, 2) statistical inference from a sample of counts and 3) expert assessment. The particular procedure used to produce these estimates should be decided at country level but guidelines will be provided by the European coordinators.

In cross-border squares national coordinators should provide a population estimate for the portion of the square that lies within their own country. In these cases the final value will be assessed by the European coordination on the basis of the estimates provided by the different national coordinators and then checked by the respective national coordinators.

4.5. Data provision for 50x50 km squares: Example

In total, 13 variables should be taken into account for the provision of 50x50 km squares data from the national coordinators to the European coordinators (Table 4). Information in one square can be independently managed from that of another at national level. Consequently, data provision can be made by sets of squares and not necessarily all together at the end of the atlas fieldwork. Data provision could be made on a yearly basis, allowing to update any information until the end of the data provision period.

Table 4. Example of form for the provision of 50x50 km square data with simulated data.

Square information				Species information									
Country	50x50 square	Years	Survey Compl. (1-5)	Species (or subspecies) Scien. name	Species (or subspecies) EBBA2 sp.code	Maximum observed atlas code	Breeding by expert assess.	Breed. status	Popul. type	Abund. code	Precise Abund.	Abund. Method	Comment
Russia	36VWK2	2015	2	*Parus major*	14640	15. Nests containing eggs	Confirmed	Regular	Wild	E. 10 000-99 999	--	3. Expert Assess	--
Russia	36VWK2	2015	2	*Picus canus*	08550	6.Visiting probable nest-site	Confirmed	Regular	Wild	B. 10-99	23-65	2. Statist. Inferen.	---
Russia	36VWK2	2012	1	*Bubo bubo*	07440	--	Possible	Regular	Wild	A. 1-9	--	3. Expert Assess	Inferred from old data

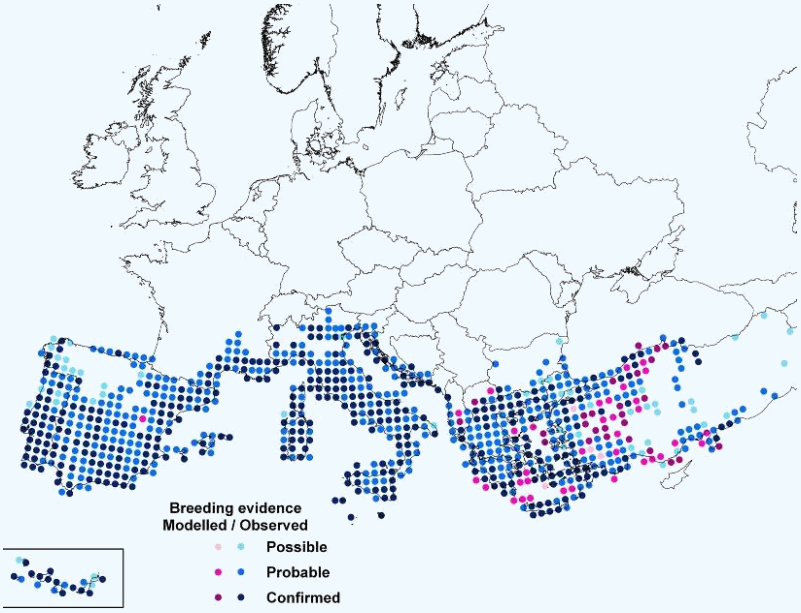
4.6. Final products from data provision at 50x50 km

Three main products will be obtained from data provision at 50x50 km. These products will essentially be presented in different maps with the aim to respond to the first three objectives of EBBA2:

- To document breeding evidence for all species at a resolution of 50x50 km (Final product 1).
- To estimate abundance for all species at a resolution of 50x50 km (Final product 2).
- To determine the changes in species distribution at a resolution of 50x50 km since the 1980s (Final product 3).

Final product 1

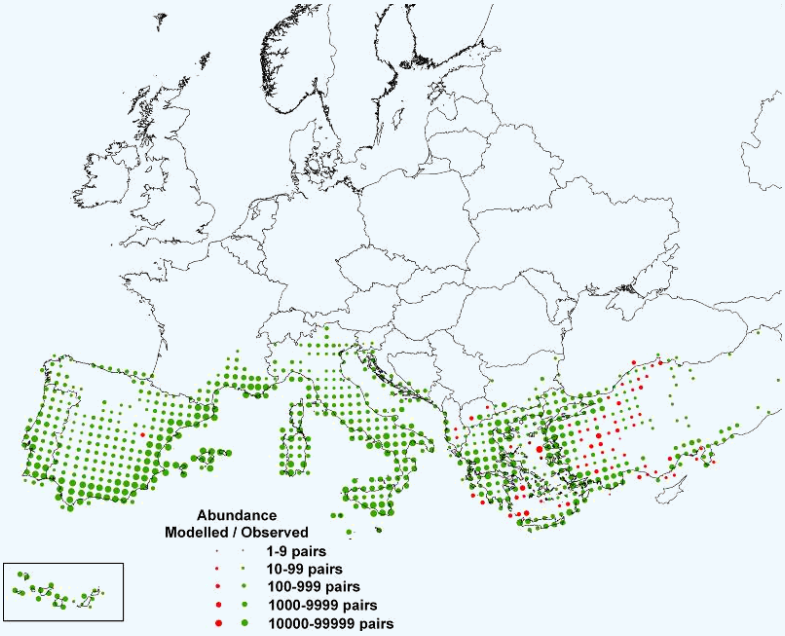
The final map will present breeding evidence for each square. A modelling approach will be used to predict occurrence in not or poorly surveyed squares.



EBBA2 simulated map for the breeding likelihood for the Sardinian Warbler *Sylvia melanocephala.* The project will attempt to show predictions of statistical models in non-surveyed squares as well as observed data.

Final product 2

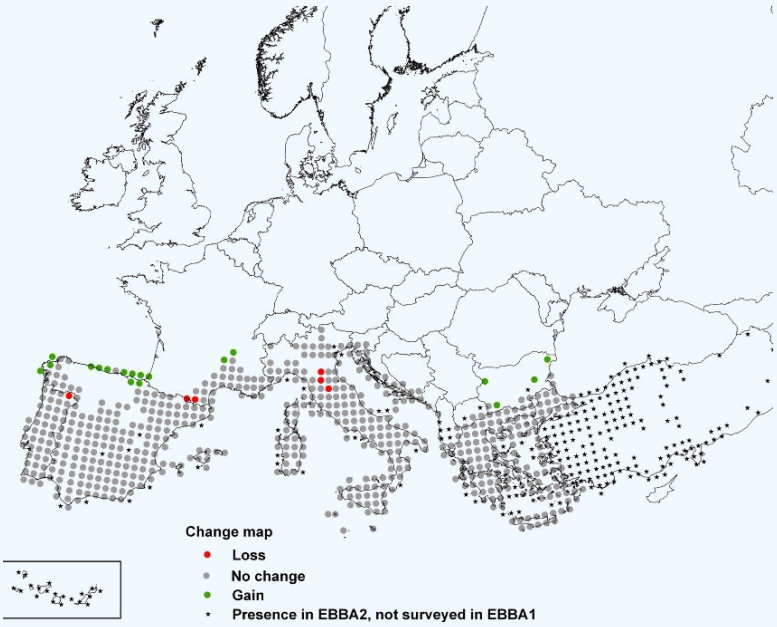
The final map will present abundance estimates for each 50x50 km square. A modelling approach will be used to predict abundance in not or poorly surveyed squares.



EBBA2 simulated abundance map for the Sardinian Warbler *Sylvia melanocephala.* The project will attempt to show predictions of statistical models in non-surveyed squares as well as observed data.

Final product 3

The data provision at 50x50 km will also be the basis for a map showing the change in species distribution between the first European Breeding Bird Atlas and the new atlas.



EBBA2 simulated map for the change in the species distribution between the two European atlases for the Sardinian Warbler *Sylvia melanocephala.*

5. Data provision for fine-grained maps

EBBA2 attempts to show information on species distribution at 10x10 km, which could be considered a fine resolution at European scale. It would be too ambitious to cover the whole of Europe in a 10x10 km grid but with a sampling approach modelling maps at such a resolution should be possible for many species. These fine-grained maps are based on statistical models that allow inference on the species occurrence in non-surveyed squares thanks to the knowledge about the patterns of species occurrence in a number of surveyed areas. The generation of these maps represents a new challenge at European level and they are expected to be a source of information of great interest for science and conservation.

Fine-grained maps show the probability of occurrence of a species. It is important to stress that as well as resolution and statistical inference, these maps differ conceptually from the others since they consider species occurrence during the breeding season, not taking into account breeding evidence (confirmed, probable, possible) or absolute abundance. However, it is important to outline that measures of occurrence shown in these maps can often be considered as a surrogate of the relative abundance of the species.

Fine-grained maps are produced by means of two consecutive processes: 1) gathering a list of species in a sample of 10x10 km squares, 2) modelling the probability of occurrence on the basis of variables that influence species occurrence (habitat, climate, etc.) and depicting the predictions of models in a grid of 10x10 km. The first point will be organised at national level, whereas the second will be done at European level.

5.1. 10x10 km squares

In order to achieve this aim in EBBA2, a sample of 10x10 km squares (or similar size; e.g. 11x12 km) should be surveyed. Differently from the 50x50 km approach, there is no particular requirement of grid type for this sampling and it is up to national coordinators to choose the most appropriate grid for each country. Therefore, countries may use their own grid system. However, as EU members are required to submit maps on the basis of a “new” ETRS89 10x10 km grid system in their respective countries (as part of the Birds Directive Article 12 reporting process in 2013, and again in 2019), EU countries are encouraged to use this grid. Information for the correct representation of the 10x10 km national grid in a GIS environment will be asked from national coordinators. It should be emphasized that, although recording field data as precisely as possible (e.g. 1x1 km, 2x2 km grids) would be highly recommended for knowing precise locations at national level and also to make sure that any conversions between grids will remain possible, very small-scale data are not needed on an European scale. EBBA2 coordinators may provide different grids (10x10 km and 1x1 km) to national coordinators, as well as advice on how to manage different grid systems.

5.2. 10x10 km Standardised Survey

Modelling successfully the probability of occurrence of a species depends on various factors but one of the most important ones is the degree of standardisation of the data. Consequently, EBBA2 provides procedures to standardise data that will come from very diverse situations depending on each country.

There could essentially be two approaches to obtain data useful for the Standardised Survey, one for countries that have a running monitoring scheme (Figure 3), and one for countries that do not (Figure 4). In both cases, the 10x10 km Standardised Survey has some basic common rules:

1. **Which 50x50 km squares should be selected?** Standardised surveys should be done in as many 50x50 km squares as possible. Select squares for which you provide data at 50x50 km level. If only some 50x50 km squares can be surveyed in this way it is preferable to select them in order to achieve a representative sample of the habitats within a country (ideally in a stratified random fashion). Anyway, in large countries or in those with low capacity even a small sample of 50x50 km squares with 10x10 km Standardised Surveys will be very useful.
2. **Which 10x10 km squares should be selected?** Once a particular 50x50 km square is selected, any 10x10 km square that is entirely within that 50x50 km square could be chosen. This will allow assigning unequivocally data from this survey to the 50x50 km form if necessary (Table 4).
3. **How many 10x10 km squares should be selected?** The number of 10x10 km squares to be surveyed should range from 1 to 5 (as many as possible for each 50x50 km square). They should preferably cover as many habitats as possible, but even 1 10x10 km square within the 50x50 km square will be very useful.
4. **Species list**. Only 1 list of observed species from 1 survey should be provided for each selected 10x10 km square, and there is no need of information on breeding evidence or abundance. However it is important to obtain this list from a survey that potentially includes all bird species and not from surveys of specific groups of birds. Only species considered being on migration when doing the survey should be excluded of the list.
5. **Time.** It is really important to standardise observations by controlling the effective time invested in species search in each 10x10 km square. Specifically, the time employed to generate the standardised species list should range between 60 and 120 minutes (as much as possible for each 10x10 km square), and come from only 1 year. It should be outlined that this time strictly refers to the effective time employed in species search and excludes that used by the observer when moving among surveyed areas within a square.
6. **Degree of completeness.** Depending on each case, data may come from different sites in a given 10x10 km square or just from one. However, it is also important to indicate an estimation of the completeness of the Standardised Survey (Table 1).
7. **When.** The Standardised Survey should be done in just one visit (one day), ideally when all potential breeders are present in the studied square (e.g. May/June, the optimum period depends on each region).
8. **Data sources.** Many surveys in which the time employed to collect a species list is recorded could be potentially used for filling the forms of the 10x10 km data provision (Table 5). These data sources could be classified depending on the field method: 1. Point count, 2. Line-transect, 3. Territory mapping and 4. Timed walked routes. The first three categories are well defined in the usual bird census nomenclature, while timed walked routes should be here understood as a highly flexible visit in which only time is controlled and there is no special requirement regarding the area covered, the speed, etc. This later category encompasses different possibilities, such as specific timed visits for atlas purposes, the timed species lists registered in many on-line platforms or censuses designed initially only for some species that are complemented with an additional simultaneous effort to

census all species for atlas purposes. Countries with running monitoring projects could use the first three data sources (e.g. Figure 3), and countries without these projects could use the fourth one (e.g. Figure 4). However, different combinations of methods could be very useful to increase the number of squares reported in EBBA2 (e.g. point count monitoring method used in 10x10 km squares covered by the monitoring project plus timed walked routes in 10x10 squares located in areas not covered by any monitoring project). The European coordinators will provide advice on a case by case basis.

As mentioned above, the Standardised Survey is the procedure adopted in EBBA2 to gather reliable data for generating fine-grained maps. This is undoubtedly the aim of this protocol within the context of the present atlas. Nevertheless, it should be highlighted that, in addition, this probably represents the first initiative to collect standardised field data for the whole of Europe. Thus, the Standardised Survey may considerably enhance future opportunities in robust data analysis for potential future research, and very particularly within the framework of a currently long-distant but desirable Third European Atlas.

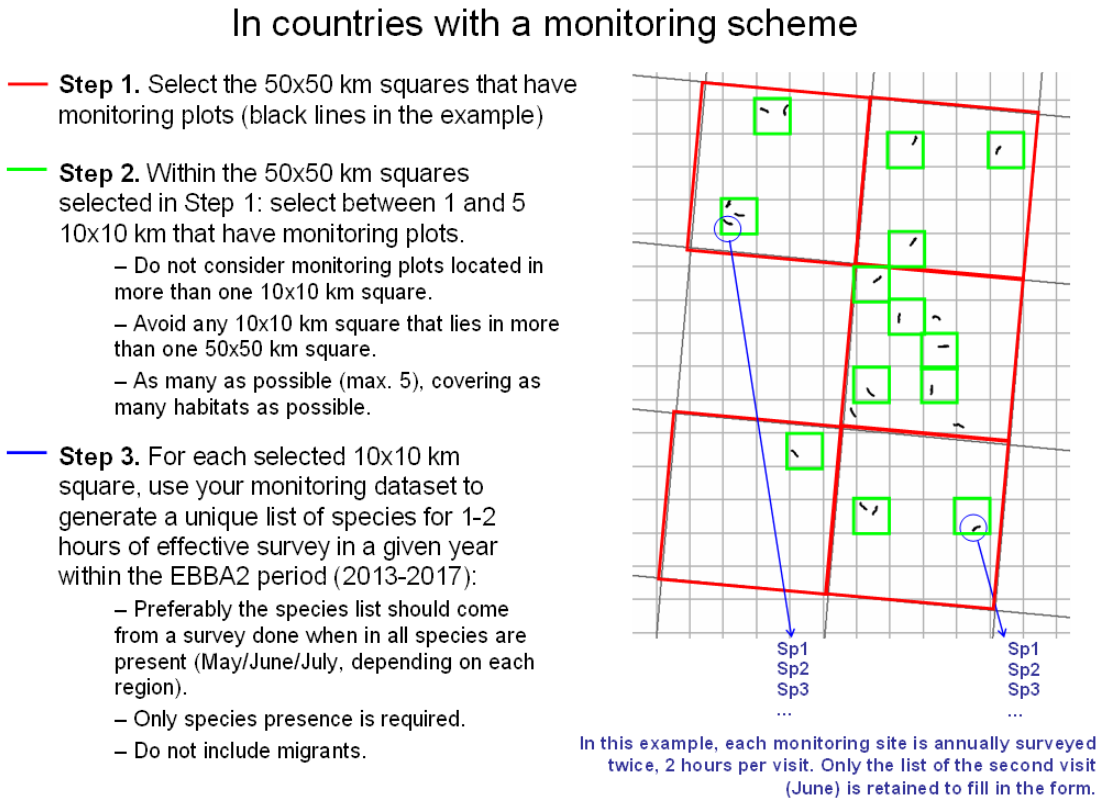


Figure 3. Example of the approach that can be followed to obtain standardised data at 10x10 km level in countries with running bird monitoring schemes during the atlas period (2013-2017).

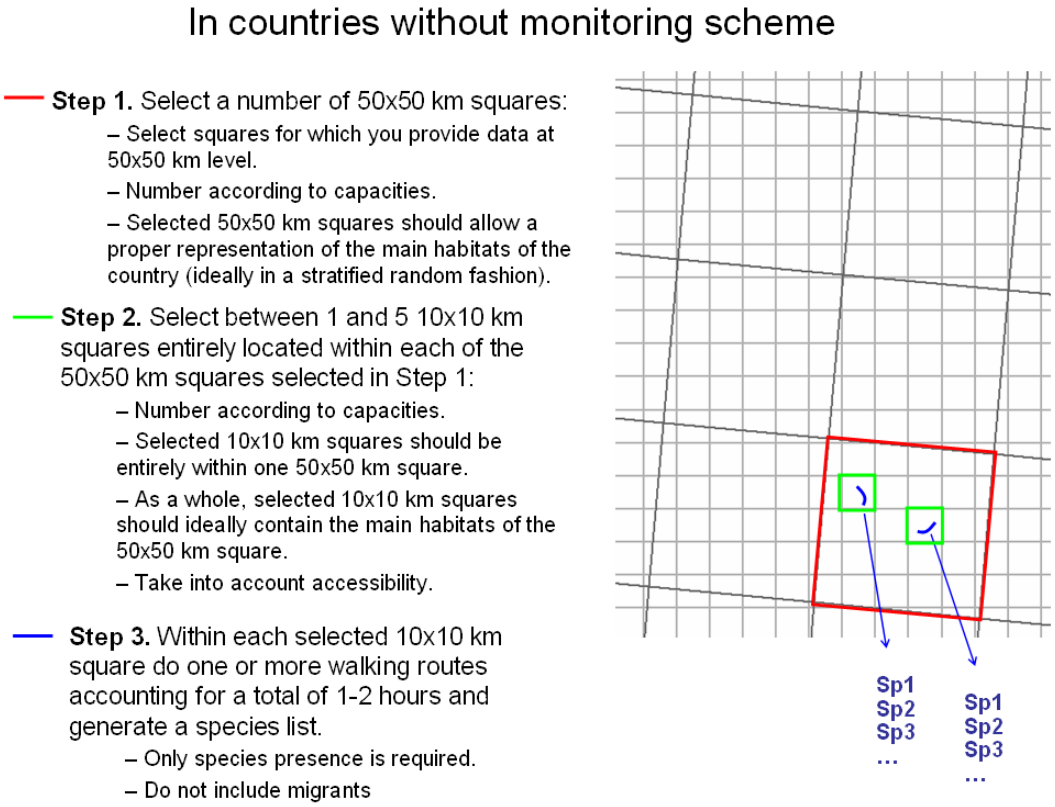


Figure 4. Example of the approach that can be followed to obtain standardised data at 10x10 km level in countries without running bird monitoring schemes during the atlas period (2013-2017). It is important to remark the high flexibility in the number of 50x50 km and 10x10 km squares to be surveyed, in order to adapt to different situations in different countries.

5.3. Data provision for 10x10 km squares

A specific form will be used for the provision of 10x10 km squares data from the national coordinators to the European coordinators (Table 5).

Table 5. Example of the form for the provision of data obtained in the 10x10 km Standardised Survey with simulated data. This survey should be made in 1-2 hours.

Information on the square survey								Species (or subspecies)	
Country	**Reference 50x50 square**	**10x10 km Grid System**	**10x10 km square**	**Date**	**Field Method**	**Time (minutes)**	**Survey compl. (1-5)**	**Scientific Name**	**EBBA2 sp. code**
Montenegro	34TCN2	ETRS89	E503N219	15.06.2014	4. Timed walked route	105 min.	2	*Parus major*	14640
Montenegro	34TCN2	ETRS89	E503N219	15.06.2014	4. Timed walked route	105 min.	2	*Lanius collurio*	15150

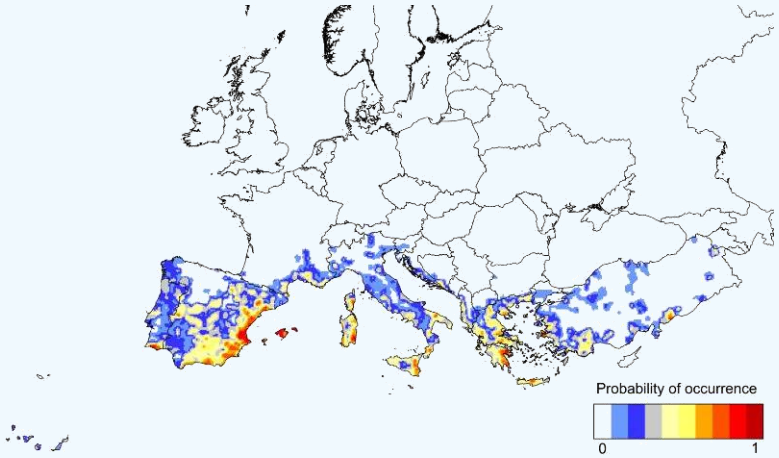
5.4. Final product from data provision at 10x10 km

The provision of data at 10x10 km resolution will allow to generate a map to respond to the fourth objective mentioned at the beginning of the document:

- To model fine-grained distribution for as many bird species as possible and project it at a resolution of 10x10 km (Final product 4).

Final product 4

The final map will present the probability of occurrence at 10x10 km resolution.



EBBA2 simulated high resolution map (10x10 km) for the Sardinian Warbler *Sylvia melanocephala*.