Forest Europe growing life

Pilot Study:

Common Forest Bird Species Indicator

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1 Background

FOREST EUROPE Expert Level Meeting (ELM) in January 2015 decided to start the participatory process of updating pan-European indicators for sustainable forest management (hereinafter SFM). Based on this decision, The Advisory Group on Updating the Pan-European Indicators was established followed by two meetings in Madrid (11 February 2015 and 10 March 2015). Simultaneously, two online consultations with national focal points and stakeholders were organised. The updating work was accomplished at the workshop in April 2015 resulting, among other changes, three new quantitative indicators, namely 2.5 Land Degradation, 4.7 Forest Fragmentation and **4.10 Common Forest Bird Species** indicators, were presented at the next ELM in July 2015. ELM accepted all these new indicators and suggested them to be included in the updated set of Pan-European indicators for SFM.

Subsequently, the mentioned set of **Updated pan-European Indicators for SFM** was annexed to the Madrid Ministerial Declaration and endorsed by signatories. Within this annex, the indicator 4.10 was complemented with the footnote *"Requires further development and testing for consideration."* This requirement was transformed into the FOREST EUROPE Work Programme as the activity 4.2.3. *"Pilot studies on new indicators (2.5 Forest Land Degradation, 4.7 Forest Fragmentation, 4.10 Common Forest Bird Species) shall be elaborated to determine if data are available and reliable and if indicators are feasible for reporting".*

The short name of the adopted indicator 4.10 is "Common Forest Bird Species" and the full-text name is "Occurrence of Common Breeding Bird Species Related to Forest Ecosystems".

2 Conceptual Issues

Common Forest Bird Species indicator had been already developed at the pan-European level by the Pan-European Common Bird Monitoring Scheme (PECBMS), used, and accepted as biodiversity indicators (EU's Structural Indicator and Indicators of Sustainable Development of the EU). Birds are generally considered as good indicators of the overall health of the environment and can indicate sustainability of land use. Common bird species are preferred as indicators as they are widespread, relatively easy to identify and count, sensitive to land use and climate changes, and are popular with the public.

The indicator was discussed by the FOREST EUROPE Expert Group on Implementation of the Updated pan-European Indicators for SFM and the conclusions were taken into consideration also in this pilot study. Considering the existence of the common birds monitoring scheme, this chapter describes the methodology of PECBMS in the context of forest birds monitoring.

2.1 Field survey methods

Details of the field methods have been described in an extensive ornithological literature (Bibby et al. 2000, Gibbons & Gregory 2005, Voříšek et al. 2008) and the following text combines the main findings published in these sources as well as an experience from coordination of the Pan-European Common Bird Monitoring Scheme (hereinafter PECBMS, www.pecbms.info). Existing standardised methods used to count birds differ in their requirements on observers' effort, in complexity of data analyses and in the complexity and reliability of the outputs they produce. The objectives of each monitoring scheme have to be always considered when planning the use of one of the methods as well as practicalities (sampling design, availability of fieldworkers and their skills, capacity needed for data analyses, etc.). Although different in many aspects, the **field methods keep common standardisation in:**

Season and number of visits to sampling plots – the surveys take place during the breeding season, i.e. when birds reproduce and are more stable in time and place. Species differ in their phenology, for instance resident species usually start breeding activities earlier in the season than long-distance migrants. In order to capture the peak of the majority of species activity (both residents and migrants), the sampling plots are visited twice a season (line transect, point counts, see below) or even more times (territory mapping). Each scheme has its own rules reflecting specifics in the phenology of local and regional bird populations. Selected observation date has to be kept for the site also in further years, however, a few days flexibility is allowed if required due to weather conditions.

Weather – the counts in any scheme can be performed only when the weather does not constrain detection of birds in the field and/or does not affect adversely their activity.. Therefore, the survey cannot be done in heavy rain or strong wind.

Time – majority of bird species have their activity peak during the breeding season in early morning hours. Thus, the counts should be performed in this time of a day, from sunrise to, usually 10.00 a.m. Each year the site and the plot have to be counted approximately at the same time, i.e. the counts at a given plot should always start at the same time (minor flexibility, e.g. 30 min, is allowed). Early morning counts do not catch the species which are active in other parts of the day and nocturnal/crepuscular species (e.g. owls, nightjars). This has to be taken into account when analysing the data and information on these species must be taken with caution.

Survey effort – the effort invested to counting has to be standardised in order to avoid the situation when different numbers of birds counted reflect different effort rather than genuine changes in bird abundances. For the production of reliable population indices the effort has to be consistent across years at each sampling plot. Standardisation is achieved by fixed area being sampled (surface, number of points where birds are counted or the length of a line transects) and/or by fixed time spent in the field.

Observer effect – birds are detected and determined in the field visually and by hearing. Observers use binoculars but majority of birds, particularly passerines, are in the breeding season detected by hearing. In general, the recruited observers are skilled, however, their abilities to detect birds in the field may vary to some extent. While this may pose a challenge to mutual comparison of the data collected by different observers, differences among observers are less problematic in the case of production of relative population indices as long as observers consistently survey the same plots across the years. In the case that an observer is replaced by a new observer, it is recommended to assign a new plot to him/her. If a new observer takes over the old plot, such a plot should be considered as a new one in the data analyses.

There are three main field methods being used in large scale generic breeding bird monitoring schemes (for an overview of the methods used in European countries see Table 2):

1. Territory mapping – this is the method often considered to be the most precise and accurate. It is based on an assumption that all birds at a plot, usually of the size of few tens of hectares, can be detected and their territories mapped during repeated visits in a season. An observer walks slowly within the plot and records all the birds detected into detailed maps, together with the description of their behaviour. Specific codes are used for individual bird species and their types of behaviour. When records of each species from all visits in the season overlap in the map, one can identify individual territories of species and calculate abundance and density. However, it has been affirmed that the assumption that all birds at a plot can be detected, may not always be correct and the method has also several disadvantages, mostly linked to the fact that there is much subjectivity in recording and analysing the data. This method is very time consuming in the field and when analysing the maps. Therefore, territory mapping is used for detailed research of smaller areas but it is not very suitable for large-scale monitoring schemes. In the PECBMS, only two countries still use territory mapping in their generic schemes (see Table 2). In one country (the UK) the method was replaced by the line transect method to increase its representativeness.

2. Line transect method – birds are counted at the predefined route with fixed length, often of 1 km, but it could be longer. The length of the transect within a monitoring scheme is standardised and kept consistent across years and sites. An observer walks slowly along the route and counts all bird individuals seen or heard, birds flying over are recorded separately. Double counting of the same bird individual is avoided as much as possible. All birds, regardless of their distance from the transect, can be recorded. Results of this type of bird counting can be used for calculation of population relative indices, but hardly for the calculation of population densities because the area of observation is not measured. Most of the monitoring schemes, therefore, apply to so called 'distance sampling', when for each bird, also its distance from the transect line is recorded or each bird is allocated to several distance belts (e.g. 0-25 m from the transect, 25-50 m, 50-100 m, more than 100 m). Recording birds and their distance allows estimation of detection probability (detectability, see also below). Two visits per site are performed in order to catch the peak of the activity of resident species and migrants arriving later in the season. Ideally, the transect is a straight line

within a plot selected to be covered (see also selection of sampling plots). Some flexibility is allowed so that the line can follow paths or other structures enabling an observer to move along the transect. The transect line cannot be too close to the site edges and in the case there are more lines at the site, they should be at least 200 m or more one from each other to avoid double coverage of the same bird individuals and their territories. The method is less demanding than territory mapping, though it brings reliable data for generation of population indices and, if distance sampling is applied, also for estimation of densities and population sizes. The line transect method is mostly comparable with point counts method, both methods having advantages and disadvantages. A choice of the method depends on specific goals of a monitoring scheme and national specifics, including attitudes of observers. Comparisons of the line transect and point counts methods are available in Table 1.

3. Point counts method – the birds are counted from predefined points and, alike the line transect method, all birds seen or heard from the point are recorded. Duration of a counting session at each point is constant, usually 5 minutes per point, although up to 10 minutes can be used too. The duration of the counting session at each point is, however, strictly the same within a particular monitoring scheme. Such as in the case of the line transect, birds can be recorded without estimating the distance from an observer, or, more often, the birds are allocated to the one of several predefined distance bands, which allows estimating the detectability. Each sample plot is covered by a fixed number of points. The points can be organized along a transect, in this case the name "point count transect" may be used. Or the points could be distributed randomly or systematically within a plot (square). The number of points per a plot within a scheme is always fixed and it is usually up to 20 points. The points should not be too close one to each other, the minimum distance between points is 200 m, in most of the schemes it is 300 m or more.

Both, the line transect and point counts methods have their advantages and disadvantages (Table 1). Selection of the method as a monitoring scheme is a matter of proper consideration of the scheme goals and other circumstances, however, for production of relative population indices and their potential combination from several monitoring schemes, the selection of the method is less important as long as the method is consistent and standardized within the monitoring scheme.

***Table 1** Comparison of line transect and point counts (Gregory & Greenwood 2008)*

Line transects	**Point counts**
Suits extensive, open and uniform habitats	Suits dense habitats such as forest and scrub
Suits mobile, large or conspicuous species and those that can be easily flushed	Suits cryptic, shy and skulking species
Suits sites with populations of lower densities and more less species	Suits sites with populations of higher densities and richness of species

Line transects	Point counts
Covers the area quickly and efficiently recording many birds	Moving between points is time-consuming, but counts give enough time to spot and identify shy birds
Double counting of birds is of a minor issue, as the observer is continually on the move	Double counting of birds is a concern within the count period - especially for longer counts
Birds are less likely to be attracted to the observer (which may be favourable from the data representativeness viewpoint)	Birds may be attracted to the presence of observers at counting points (which may pose a minor problem to data representativeness)
Suited to situations with good physical and free legal accessibility	Suited to situations where physical or legal accessibility is restricted (it is easier to solve access to one point than to the entire transect)
Still suitable for bird-habitat studies, but less than point counts	Better suited for bird-habitat studies
Errors in distance estimation have smaller influence on density estimates (for the estimate of birds' detectability) because the area sampled increases linearly with the distance from transect line	Errors in distance estimation can have larger influence on density estimates (for the estimate of birds' detectability) because the area sampled increases geometrically with the distance from the transect point

2.2 Detectability

It has been generally accepted in ornithological literature, that an observer cannot count all the birds present at a surveyed site. Some individuals are non-active, hidden or are not detected by an observer because of other reasons. Thus, the situation that all birds were detected can be hardly achieved and a detection probability (detectability) can only be estimated. There is an extensive literature on modelling detectability (Bibby et al. 2000, Buckland et al. 2001) and the details go beyond the scope of this study. In principle, if the detectability is estimated, the number of birds counted can be adjusted and better estimate of the abundance can be obtained. As the detectability declines with increasing distance from an observer/transect line, it can be modelled using this information (Buckland et al. 2001). In addition, the information on presence (detection) or absence (non-detection) of birds during repeated visits can be used for estimating detectability. Majority of the generic breeding bird monitoring schemes contributing to PECBMS have incorporated the distance sampling into their designs (Voříšek & Škorpilová 2012) and use repeated visits at their sampling plots. Incorporation of detectability estimates into the routine calculations of the national population species indices is rare due to its complexity (Voříšek & Škorpilová 2012). However, national population indices would provide biased results only if there is a systematic variation in detectability of time, which is highly unlikely. Incorporation of detectability into the routine calculation of the national population indices remains a challenge, as it is demanding concerning both capacity and funding.

2.3 Selection of sampling plots

Entire territories of countries cannot be surveyed completely, therefore surveys based on selected sampling units (plots) have to be applied. A size of a sampling unit from one square km to maximum size of a square 10x10 km is the most typically used in the monitoring schemes in Europe. While a size of plots is not a big concern, **number of plots, as well as the way how they are selected, affect precision and accuracy of the results**[1] (Bibby et al. 2000, Voříšek et al. 2008).

The precision, measured by confidence limits, can be increased by increasing the number of sample plots. The width of confidence limits is inversely proportional to the square root of the number of sample plots (Voříšek et al. 2008). The gain, in terms of increased precision, resulting from a higher number and density of sampling plots may be not equal to increased costs (Voříšek et al. 2008). Thus, confidence intervals, which are routinely produced for species population indices and multi-species index (the new indicator), indicate how precise the results are. The precision in a form of confidence limits can also be measured in the multi-species indices (indicators, see below).

The way how sampling plots are selected affects the accuracy of the results. Ideally, the plots should be selected randomly. However, employing enough fieldworkers for randomly selected plots may be very difficult. Stratified random or systematic selections are also very good options to achieve representative results. Free (subjective) selection of plots, where fieldworkers freely decide where they will count birds, is the least desirable method because it may lead to such results which over- or under-estimate some regions or habitats. Free choice was the most common method in bird monitoring schemes established decades ago (1980s, 1990s). Most of these schemes have been replaced by new schemes applying more rigorous selection of sampling plots or schemes that apply post-stratification in the process of data analyses, thus, more recent data provide more representative results. The overview of the sampling design used in national monitoring schemes is available in Table 2.

2.4 Fieldworkers

Large-scale bird monitoring schemes require many skilled and dedicated fieldworkers, who are able to identify birds in a field (many birds are detected and identified by their song or calls only). Fieldworkers also have to observe the prescribed methodology strictly, have to

[1] **Precision** reflects a statistical variation among the sample units. For instance, when counting birds at several localities, we will hardly count the same numbers at all sites. They will be influenced by natural variation and errors made by an observer. Thus, we need several samples to average out the values and to get the value for the sampled area. The precision is expressed by confidence limits, the wider the limits, the less precise results we obtain.

Accuracy reflects over- or under-estimation of a sample. For example, preference of bird-rich plots will lead to over-estimation of the total population, which means that the results are biased or inaccurate. Contrary to precision, accuracy cannot be measured (we do not know the real number) and the only possibility to avoid biased results is to use a proper sampling method).

Thus, we could have the results, which are i) precise and accurate, ii) imprecise and accurate, iii) precise and inaccurate and iv) imprecise and inaccurate. Obviously the option iv) is the least desirable, the option iii) is also tricky as the narrow confidence limits could lead to a false conclusion that the results are very good.

submit data in time and keep surveying their sites for many years. Such demands would have been hardly achieved involving only professional ornithologists and, in fact, generic breeding bird monitoring schemes are an excellent example of the involvement of volunteer fieldworkers/citizen scientists. There has been a concern about the quality of data collected by volunteer fieldworkers, but this has not been justified and variation in competence exists within both the categories, professionals and volunteers (Voříšek et al. 2008). The coordinators of national bird monitoring schemes have their own ways to ensure fieldworkers with adequate skills that are recruited and motivated to contribute strictly in accordance with methodological guidelines. The contribution of amateur fieldworkers to research nature conservation has been evaluated, finding this model successful (Greenwood 2007). The data from volunteer based bird monitoring schemes, including those contributing to PECBMS, have been used in many peer-reviewed scientific papers (Gamero et al. 2017, Gregory et al. 2005, Inger et al. 2015, Stephens et al. 2016). As the ornithology and bird watching are very popular, it is less difficult to recruit and maintain volunteers for bird surveys than for other taxa, although it is more difficult in some countries than in the others. There are several thousands of fieldworkers contributing to the monitoring schemes in some western European countries but much less in some countries from eastern or southern parts of Europe (Table 2). A recent effort to build capacity in eastern and southern Europe (e.g. https://www.ebba2.info/2017/12/12/the-final-workshop-of-the-mava-project-in-croatia-preparing-for-the-real-data-submission/) including formal training and testing bird identification skills (https://www.birdid.no/) brings hope that more skilled fieldworkers will be available in the whole Europe in the near future.

2.5 Estimation of population trends and indices at the national level

Supranational species population indices are needed also for calculation of European indicators such as the Common Bird Index used by Eurostat (https://ec.europa.eu/eurostat/web/sdi/indicators) or SEBI by EEA (https://www.eea.europa.eu/data-and-maps/indicators/abundance-and-distribution-of-selected-species-7/assessment), or the newly introduced indicator 4.10 Common Forest Bird within the set of pan-European Criteria & Indicators for Sustainable Forest Management (hereinafter C&I for SFM). European species population such as adverse weather, observer's personal reasons, etc., may cause that not every plot is monitored every year. The missing values have to be handled properly, which is a typical problem of long-running large-scale monitoring schemes. Estimation of the missing values using statistical models is the standard way to cope with this issue (https://pecbms.info/methods/pecbms-methods/1-national-species-indices-and-trends/1-2-production-of-national-indices-and-trends/missing-values-i/). The most widely accepted method, which is also used in generic breeding bird monitoring schemes contributing to PECBMS, is based on a log-linear Poisson regression (a form of generalized linear modeling). Special program TRIM (Pannekoek & Van Strien 2001) has been developed for this purpose and made freely available by the Statistics Netherlands, an official statistical bureau of the Netherlands (https://pecbms.info/methods/questions-and-answers/question-2-1/). Recently, a new version of TRIM in R was developed and made available (https://pecbms.info/methods/software/trim/). The TRIM program produces the yearly population indices and their standard errors, which can be easily converted into 95% confidence limits and thus enable to measure the precision of indices. TRIM also produces trend values, additive and multiplicative trends (Pannekoek & Van Strien 2001). The multiplicative trend is commonly used to describe and interpret the long-term trend in a population. Its value 1 means there is no change in the population, values <1 indicate a decline and the values >1 indicate an increase. For instance, the trend 0.98 means 2% decline per year, the trend 1.05 means an annual increase by 5%. Based on a magnitude of change and its significance, TRIM produces a classification of trends into arbitrary categories (https://pecbms.info/methods/pecbms-methods/1-national-species-indices-and-trends/1-2-production-of-national-indices-and-trends/trend-interpretation-and-classification/).

The national population indices and species trends are calculated using the data from all plots, i.e. covering all habitats in a country. However, TRIM allows using covariates in the models and testing whether the trends are different in different covariate categories, e.g. habitat types (Pannekoek & Van Strien 2001). Also the habitat specific indices (i.e. for forest, farmland, and other) and trends can be calculated, i.e. such index is based on the data collected in a given habitat only. Studies in the UK suggest, however, that the composite multi-species indicators with species properly selected are robust in a comparison with habitat specific indices (Renwick et al. 2012).

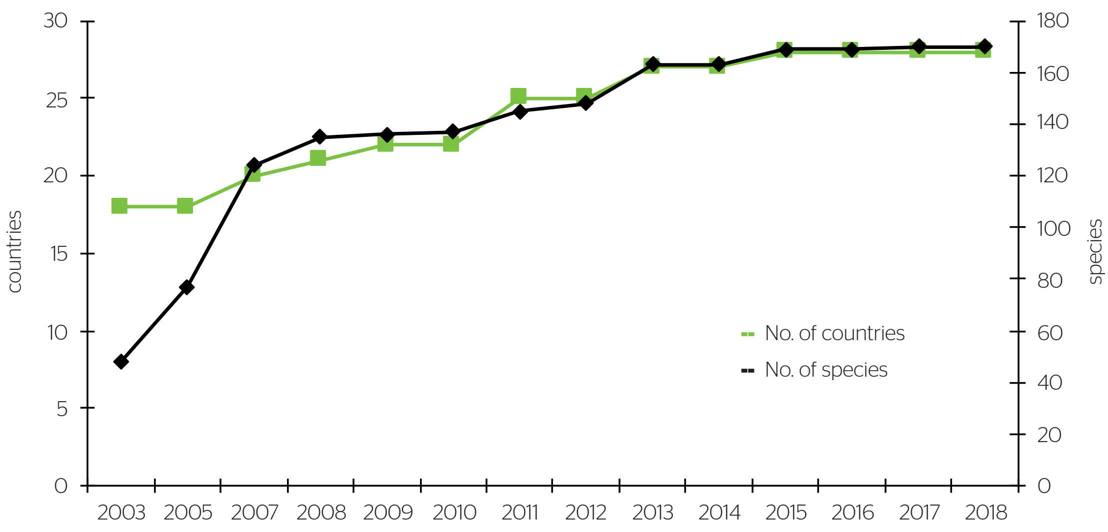
2.6 Calculation of the European population trends and indices

Supranational species population indices are needed also for calculation of European indicators such as the Common Bird Index used by Eurostat (https://ec.europa.eu/eurostat/web/sdi/indicators) or SEBI by EEA (https://www.eea.europa.eu/data-and-maps/indicators/abundance-and-distribution-of-selected-species-7/assessment), or the newly introduced indicator 4.10 Common Forest Bird Indicator within the set of pan-European C&I for SFM. European species population indices are calculated by PECBMS according to the procedure developed in the Statistics Netherlands (Van Strien et al. 2001). The procedure combines national population indices of individual species delivered by the coordinators of the national monitoring schemes (https://pecbms.info/methods/pecbms-methods/2-2-combining-national-data-into-supranational-outputs/). Combination of the national indices instead of using raw national data means that the collection of raw data from national schemes is not needed as long as the outputs are equivalent to those based on the raw data

(Van Strien et al. 2001). In other words, the national coordinators do not need to deliver detailed data from each survey at each site every year, but instead, they deliver national indices in the prescribed format. This avoids a need to have technology for handling huge data sets and minimises also difficulties linked with data ownership. As the particular national schemes commenced in different years (Table 2), the missing values pose the same problem as at the national level. These are, similarly to the situation at a national level, estimated using a modified version of the TRIM program (https://pecbms.info/methods/pecbms-methods/2-2-combining-national-data-into-supranational-outputs/). Since the populations of particular species are not distributed evenly across European countries, national populations differ in their sizes too. The size of the national population of each particular species, obtained from an independent source (BirdLife International 2015) is, therefore, used as the weighting factor when combining national population indices into the supranational ones. Alternative ways of weighting, e.g. by surface area, would pose a risk of ignoring large differences in national abundances of species and could lead to spurious results (https://pecbms.info/methods/questions-and-answers/question-3-5/).

When there are missing values from any country, indices from similar countries are used to estimate these missing national indices. For this purpose, PECBMS groups countries according to their expected similarities (incl. political and economic history) into groups that are hierarchically organized (https://pecbms.info/methods/pecbms-methods/2-2-combining-national-data-into-supranational-outputs/missing-values-ii/, http://www.ebcc.info/wp-content/uploads/2017/11/ComputationSteps2018.jpg). Because of the constraints in the software tool, all the species indices had to be calculated using the same structure of the groups. However, with a new RTRIM and conversion to the R environment generally, it will be also possible to make individual groups for particular species, where it would make sense.

Figure 1: *Increasing number of both countries providing data and species covered by the PECBMS*



2.7 Calculation of a multi-species index (indicator)

Production of multi-species population indices, used as indicators, is very similar at national and supranational scale.

Once species are selected for the index (e.g. farmland species or forest species, see below for details on species selection), the index is calculated as a geometric mean of indices of individual species contributing to the index (Gregory et al 2005, https://pecbms.info/methods/). Since 2018 update, the PECBMS has started calculating the indices with the use of MSI-tool developed in the Statistics Netherlands (Soldaat et al. 2017). The tool uses Monte Carlo simulations to produce the index, smoothed index and the confidence limits (https://pecbms.info/trends-and-indicators/indicators/). The outputs are comparable to previously used geometrical mean, but besides the smoothed curve, which is appropriate for long-term monitoring data, and production of the confidence limits, it also produces a trend value similar to that at species level, and it allows identification and testing change points (Soldaat et al. 2017, Gregory at al. 2019). The indicator produced using this approach is useful to indicate how the whole community of birds (e.g. forest birds) is doing. If it goes down, the bird community suffers loss. If it remains stable we have no evidence that numbers of birds in a group as a whole have changed (https://pecbms.info/methods/questions-and-answers/question-6-2/). There are also some alternatives to the geometric mean of population indices. These are, for example, species richness, Simpson index or Shannon index. However, as documented (Van Strien et al. 2012), the geometric mean performs the best in tests of the desired mathematical properties for biodiversity indicators.

It is important to perform data quality check when producing the indicators. The population indices of constituent species should be checked for their representativeness and precision. Particularly species with too large and imprecise fluctuations in their index values are suspicious. Also the data of species in case their index values goes very low (under 5%) or very high (more than 200%) should be checked carefully because they could affect the indicator. PECBMS performs data quality checks on a routine basis when calculating the supra-national indicators (https://pecbms.info/methods/pecbms-methods/3-multispecies-indicators/) and it is recommended for producers of the indicators at national level to perform similar data quality checks.

2.8 Species selection for indicators (indices)

Selection of species, which will contribute to the (common-bird) indicator, is one of the key elements in the production of wild bird indicators. The aim and policy relevance should always be considered when selecting species for the indicator. It is important to clarify whether an indicator is expected to be the proxy of wider environment, specific habitat type or a group of taxa. Also spatial and temporal scales have to be defined, for instance, species selection can be different for continental (European) indicator which takes into account habitats from the continental point of view, and for a national indicator, where national specifics (e.g. habitat types and sub-types, species habitat selection) play their role as well. Furthermore, a need for benchmarking (comparing the performance of individual countries in achieving the aims which an indicator is supposed to measure) has to be considered.

Species selected for an indicator should be characteristic for the given habitat, e.g. a forest. In the case there are several categories (e.g. forest or farmland) and habitat types (e.g. boreal forest or beech forest etc.) in Europe, each of them should be represented in species selection for the indicator. If the indicator is to be produced at national level too, dominant types and sub-types of the particular habitat in a country should be represented in the national version of the indicator.

Selection of species characteristic for the given habitat can be based on expert judgement or on quantitative data and criteria. The expert judgement selection is relatively easy as in situations when quantitative data on species habitat preference or avoidance are missing, this is the only way to select species. As any expert judgement, this method is quite subjective and sensitive to individual experts view. On the other hand, expert opinion would often be very close to the results of quantitative analyses (Reif et al. 2010).

Quantitative methods to identify species-habitat association include niche breadth quantifying how wide or narrow an ecological niche of each species is (Reif et al. 2008), species specialisation index (Devictor et al. 2008), relative habitat use (Larsen et al. 2011) or Jacob's index (Renwick et al. 2012). These approaches allow selecting species, which are more specialized in habitat type, but this species selection often does not cover all niches within the habitat. The approach based on a resource-use risk assessment (Butler et al. 2012, Wade et al. 2013, Wade et al. 2014) has been considered as the most reliable one for further development in the PECBMS produced indicators of forest and farmland birds. Wade et al (2014) compared the selected species for the PECBMS Common Forest Bird Indicator with the species selected using the algorithm based on the niche approach and identified overlaps but also gaps in the PECBMS species set. Missing species are those which, due to their biology, are poorly monitored using generic breeding bird monitoring schemes. Despite the fact that current indicators, including the Forest Bird Indicator, produced by the PECBMS, appear to be quite robust (Gregory et al. 2019), the use of the data from species-specific monitoring schemes is broadly advocated. Within the PECBMS, the effort aims to development of the niche-based approach further and production of more complete set of species, which would represent all resources available in a given habitat (e.g. food, nesting opportunities etc.) and will be properly sensitive too. In parallel, an effort to identify and explore new sources of data monitoring, especially from species specific monitoring scheme, is one of the priorities for PECBMS.

3 Questionnaire Survey

Identifying PECBMS as a possible source of data on the Common Forest Bird Species indicator, within the 2020 Questionnaire for Pan-European Quantitative Indicators for Sustainable Forest Management, the comments on methods and results were collected from national correspondents in the following structure:

Country comments:

The list and index of common forest bird species	
Forest bird species present in the European and regional list (http://foresteurope.org/13535-2/). Please describe the proposed updates, if any, or a national list.	
Reliability of the data and calculation of the index (http://www.ebcc.info/index.php?ID=634)	
Your interpretation of the trend in index	

Two countries provided comments on the national list, referring to national studies, without provision of more specific comments on the implementation of the indicator (https://www.birdlife.at/page/monitoring; https://www.birdlife.at/web/binary/saveas?filename_field=datas_fname&field=datas&model=ir.attachment&id=1236; https://www.sovon.nl/)

4 Data Availability

National data including national population trends and indices of species are owned by national monitoring schemes (Table 2). Any provision of national data to third parties must be approved by national coordinators of these schemes.

There are 28 countries contributing actively with their monitoring data to the PECBMS (Table 2, https://pecbms.info/methods/pecbms-methods/) with a potential to enlarge geographical coverage of the scheme in future. The ownership of the copyright to data and data access including rules for co-authorship of scientific papers within the PECBMS are defined by the Data access and co-authorship policies, approved by the network of national coordinators. Supra-national outputs, i.e. species trends and indices and the indicators are of open-access and are available freely at the PECBMS website, under the Creative Commons license CC BY-NC 4.0, (https://pecbms.info/use-of-the-results/data-access-policy/), or provided by the PECBMS coordination unit upon request. The PECBMS coordination unit provides also comments on data quality and interpretation and facilitates contact with national coordinators. In case that national data is requested, the PECBMS coordination unit either facilitates the contact with national coordinators, who must approve the use of their data, or is seeking the approval and comments from national coordinators.

5 Data Reliability

Data provided to PECBMS allow the production of reliable European trends and population indices on 170 bird species. Calculation of European indices using a sub-set of species from this total pool of species is straightforward because generic breeding bird monitoring schemes by their nature monitor all species and provide a large pool of species for the selection for the common-bird indices. Producing regional (supra-national) or national indicators is more complicated. Precision of data of individual species at national or regional level may not be satisfactory and selection of species may need to reflect regional or national specifics. In case that the niche-based approach for the selection of species is used, however, we can expect that species selection will reflect the resources and risks at supra-national and national level too. Then, the issue of data on species which are not properly monitored by generic breeding bird monitoring schemes persists. This has to be solved by identifying species specific monitoring schemes and obtaining data. National monitoring schemes are coordinated by national coordinators, who organize the schemes, define the field methods, sampling, collate and manage the data from fieldworkers, apply data quality control, analyse the data and publish the results. National coordinators also recruit fieldworkers, maintain their network and provide data to the PECBMS coordination unit located at the Czech Society for Ornithology (CSO) in Prague, Czech Republic. National monitoring schemes are exclusive owners of the copyright to the collected data.

The PECBMS coordination unit collates the data from national monitoring coordinators in a form of national species indices, performs data quality checks and calculates supranational species trends and indices, as well as multi-species indices (indicators). **PECBMS coordination unit routinely produces neither national indicators nor other national outputs.** An important role of the PECBMS coordination unit is the maintenance of the network of cooperating individuals and institutions across Europe, which comprises coordinators of national monitoring schemes, but also other stakeholders (European Commission incl. Eurostat, European Environment Agency, European Topic Centre on Nature Protection and Biodiversity, Centre of European Environment Agency, UNEP/AEWA Secretariat, etc.). PECBMS has established contacts with bird-monitoring experts in all European countries and liaises with the European Bird Census Council (EBCC) and other EBCC initiatives such as the European Breeding Bird Atlas (EBBA2, www.ebba2.info) or EuroBirdPortal (EBP, www.eurobirdportal.org). The PECBMS coordination unit is responsible for publication of the European outputs and communicating these further to policy makers and researchers. Feedback from the national coordinators is constantly received via emails, personal contacts and dedicated workshops and meetings. Representatives of the EBCC, BirdLife International, Royal Society for Protection of Birds (RSPB), British Trust for Ornithology (BTO), Dutch centre for field ornithology (SOVON) and CSO have their seats in the Steering & Technical Group, which supervises the programme and provides guidance. Advice and expertise is also provided by the Statistics Netherlands and its Wildlife Statistics Unit. See Figure 1 for an overview of roles and responsibilities in PECBMS.

Figure 1 Roles and responsibilities in the process of production of the European population bird indices and indicators in the PECBMS

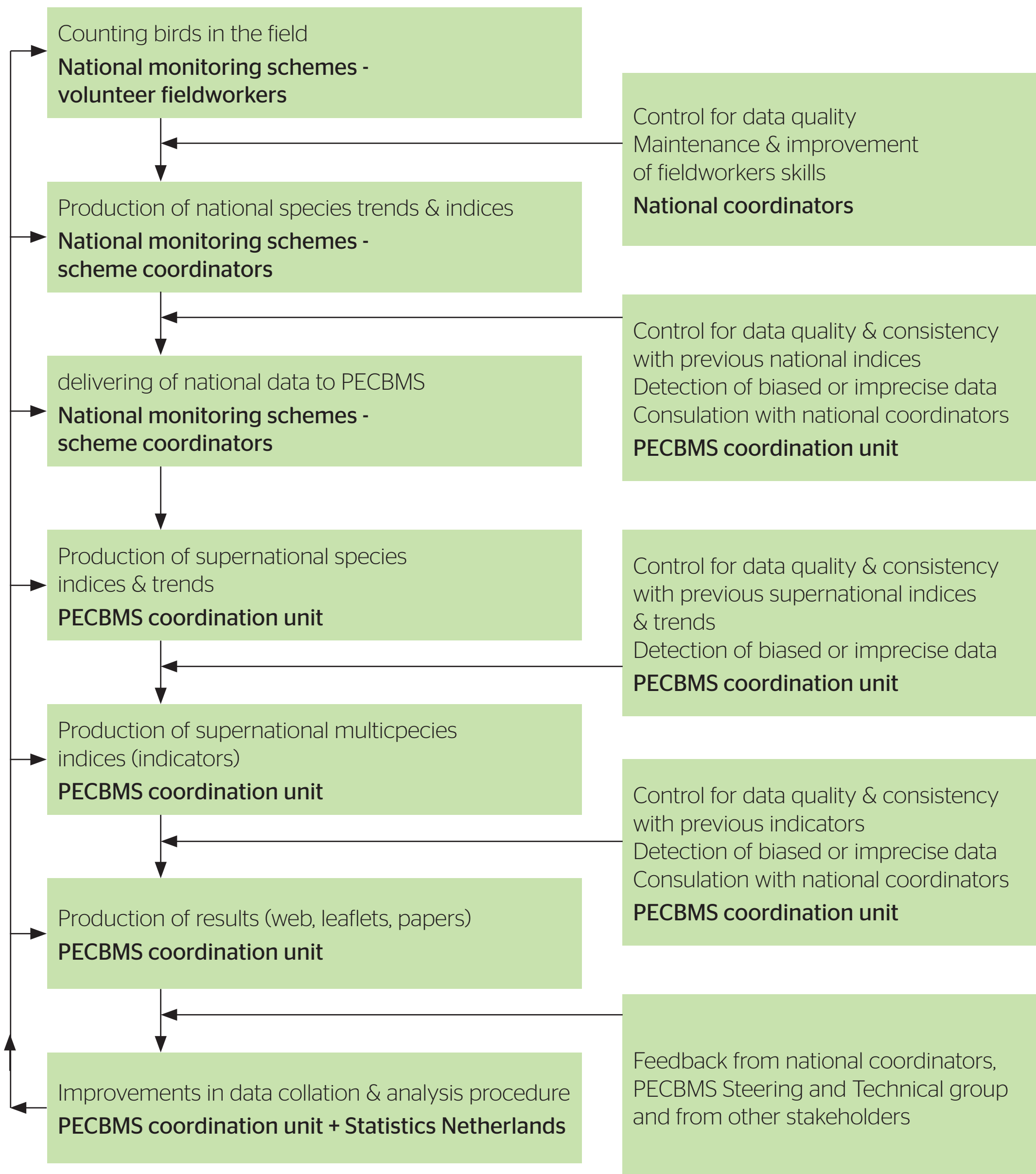


Table 2 Overview of generic breeding bird monitoring schemes in FOREST EUROPE signatory countries

FOREST EUROPE signatory country	Generic breeding bird monitoring scheme	Contributes to PECBMS	Start Year	Field survey methods	Selection of plots	Number of fieldworkers	Number of species	Info on habitat recorded in field	Comments
Albania	no								
Andorra	yes	not yet	2011	line transects	stratified random	14	129	no	Relatively low precision is due to small size of the country and a small number of sampling plots. The methods are however ok and the data should be more precise in near future.
Austria	yes	yes	1998	point counts	free choice	160	85	yes	
Belarus	yes	no	2007	line transects, point counts	random	25	20	yes	The scheme focuses on farmland species in farmland only.
Belgium	yes	yes	1990	point counts		505	134	yes	Monitoring is organised at regional level (Brussels, Wallonia, Flanders). First year refers to the scheme in Wallonia, other started in 1992 and 2007 resp.). Number of fieldworkers is the sum of all regions, number of species is the maximum value, info on habitat is not collected in all regions. The scheme in Flanders doesn't contribute to PECBMS yet.
Bosnia and Herzegovina	no								
Bulgaria	yes	yes	2004	line transects	stratified random	120	63	yes	
Croatia	yes	not yes	2015	point counts	stratified semi-random	30	30	yes	The scheme focuses primarily on delivery of data for the Farmland Bird Indicator.

FOREST EUROPE signatory country	Generic breeding bird monitoring scheme	Contributes to PECBMS	Start Year	Field survey methods	Selection of plots	Number of fieldworkers	Number of species	Info on habitat recorded in field	Comments
Cyprus	yes	yes	2006	line transects	other	18	45	yes	The scheme does not cover the northern part of the country.
Czech Republic	yes	yes	1982	point counts, line transects	free choice, stratified random	120	218	yes	The old scheme is being gradually replaced by a new one (line transect, stratified random selection of plots). Both schemes will run in parallel for several years and the data will be combined during this period.
Denmark	yes	yes	1975	point counts	free choice	345	143	yes	
Estonia	yes	yes	1983	point counts	free choice	60	90	yes	
Finland	yes	yes	1975	point counts, line transects, other	systematic, other	500	140	yes	There are three schemes, the number of fieldworkers is a sum, the number of species is the highest value from these three schemes. The other schemes started in 1982 and 1986.
France	yes	yes	1989	point counts	other	1000	150	yes	The old scheme was replaced by a new one.
Georgia	no								
Germany	yes	yes	1989	line transects, point counts, territory mapping	free choice, stratified random	1730	100	yes	Two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes.
Greece	yes	yes	2007	point counts	stratified random	122	233	yes	

FOREST EUROPE signatory country	Generic breeding bird monitoring scheme	Contributes to PECBMS	Start Year	Field survey methods	Selection of plots	Number of fieldworkers	Number of species	Info on habitat recorded in field	Comments
Holy See	no								
Hungary	yes	yes	1999	point counts	stratified random	1000	420	yes	
Iceland	no								
Ireland	yes	yes	1998	line transects	stratified random	300	55	yes	
Italy	yes	yes	2000	point counts	random	200	103	yes	
France	yes	yes	1989	point counts	other	1000	150	yes	The old scheme was replaced by a new one.
Latvia	yes	yes	1995	point counts, territory mapping	random, systematic, other	81	90	yes	There are three schemes, the number of fieldworkers is a sum, the number of species is the highest value from these three schemes.
Liechtenstein	no								
Lithuania	yes	yes	1994	point counts	stratified semi-random	35	70	yes	
Luxembourg	yes	yes	2002	point counts, territory mapping, line transect	random, stratified random	31	120	yes	There are two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes.
Malta	no								
Monaco	no								
Montenegro	no								

FOREST EUROPE signatory country	Generic breeding bird monitoring scheme	Contributes to PECBMS	Start Year	Field survey methods	Selection of plots	Number of fieldworkers	Number of species	Info on habitat recorded in field	Comments
Netherlands	yes	yes	1984	territory mapping, point counts, line transects	free choice, random, stratified random	3950	100	yes	
Northern Macedonia	no								
Norway	yes	yes	1995	point counts	free choice, stratified random	370	80	yes	There are two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes.
Poland	yes	yes	2000	line transects	stratified random	370	80	yes	There are two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes.
Portugal	yes	yes	2004	point counts	stratified random	120	64	yes	
Republic of Moldova	no								
Romania	yes	yes	2006	point counts	stratified semi-random	60	70	yes	
Russian Federation	yes	not yet	2006	line transects	other	67	226	yes	There are two schemes, regionally based, schemes in other regions probably exist too.
Serbia	yes	not yet	2010	line transects	stratified random			yes	Scheme in development.

FOREST EUROPE signatory country	Generic breeding bird monitoring scheme	Contributes to PECBMS	Start Year	Field survey methods	Selection of plots	Number of fieldworkers	Number of species	Info on habitat recorded in field	Comments
Slovak Republic	yes	yes	1194	point counts	free choice	46	100	yes	
Slovenia	yes	yes	2007	line transects	stratified non-random	30	29	yes	Scheme focused on delivery data for Farmland Bird Indicator.
Spain	yes	yes	1996	point counts, line transects	stratified random, other	2650	200	yes	There are four schemes, one of them is regional, the number of fieldworkers is a sum, the number of species is the highest value from these four schemes.
Sweden	yes	yes	1975	point counts, line transects	free choice, systematic	415	180	yes	There are two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes.
Switzerland	yes	yes	1999	territory mapping	systematic	200	75	no	
Turkey	no								
Ukraine	no								
United Kingdom	yes	yes	1966	territory mapping, line transects	free choice, stratified random	3000	111	yes	There are two schemes, the number of fieldworkers is a sum, the number of species is the highest value from these two schemes. Several others, species or habitat specific schemes exist.

Note:

The information about the existence of generic breeding bird monitoring scheme comes from regular updates resulting from PECBMS contacts with focal points in European countries. However, it may happen that a new scheme appeared in the country and was not reported to the PECBMS coordination team. In few cases, 'not yet' in the column 'Contributes to PECBMS' indicates that the scheme is likely to contribute to the PECBMS data set in the forthcoming years.

Indication that information about a habitat at survey plots is collected during the fieldwork should be interpreted with caution. The methods of habitat classification are not internationally standardised and each scheme has its own system of habitat categorisation (e.g. hierarchical coding system in the UK, Newson et al. 2005, or a simplified system of habitat categorisation used in the Czech Breeding Bird Monitoring Scheme, Reif et al. 2010). On the other hand, coordinates of the survey plots are available in most schemes, therefore an assessment of habitats using internationally standardised habitat classification (e.g. CORINE Land Cover) is possible.

The number of fieldworkers and the number of species monitored should be understood as indicative. The number of active fieldworkers usually changes from year to year and the number of species refers to species for which sufficient data for calculation of national population indices are available because the generic schemes, by their nature, collect data on all species.

6 Indicator Feasibility

6.1 Common birds as indicators

Birds are widespread, occur in all types of habitats, use a complex variety of natural resources and are sensitive to changes in the environment. Furthermore, birds are popular among general public, which makes the indicator message stronger in communication (Gregory et al. 2005). Because of popularity of birds, many people, including amateurs, are able to identify bird species in the field and using simple, though standardised field methods, to perform large-scale surveys on birds. Large-scale bird monitoring schemes are excellent representatives of successful citizen-science approach (Chandler et al. 2017, Greenwood 2007). Thanks to successful development of citizen science, reliable data on bird populations and species distribution exist. Therefore, birds are usually considered as good indicators of the overall biodiversity and state of the environment (Gregory et al 2005, Gregory & Van Strien 2010), particularly at larger spatial and temporal scales. Common species play an important role in ecosystems (Gaston 2010) and are good proxies for diversity and integrity of ecosystems (Vallecillo et al. 2016). Several studies support also the idea of umbrella species, i.e. species which indicate high species richness of other birds and other taxa (Mikusinski et al. 2001, Moller et al. 2017, Roberge et al. 2008).

However, studies exploring the correlation between birds and other taxa bring mixed results. The positive correlation is not always found (McMahon et al. 2012, Nagy et al. 2017) and in specific cases, e.g. indication of high nature value areas in farmland in Finland, other taxa (butterflies) perform better than birds (Makelainen et al. 2019). Weak correlation of bird data with other taxa found in some cases is related to the scale at which different taxa operate. While birds during their breeding season typically operate at spatial scale of hectares or few square kilometres (larger species such as some raptors require even larger ranges), invertebrates usually operate at a scale of tens or hundreds square meters.

The same applies to temporal scale – birds are relatively long-living and genuine changes can be detected at the scale of several years. On the other hand, birds are less prone to stochastic fluctuations than shorter living taxa. Thus, apart from data availability and quality, spatial and temporal scale of the indicator must be always considered when assessing an indication value of any taxa. Furthermore, studies assessing an indicator value, i.e. how a given taxon represents other taxa, usually considered species richness and diversity (Bucher et al. 2019, Makelainen et al. 2019, Roberge & Angelstam 2006) and much less frequently they focused on changes in population sizes (Herrando et al. 2016). However, index of population changes based on counts appears to have better mathematical properties required from an indicator than other measures such as species richness or diversity (Van Strien et al 2011). This makes the assessment of correlation of birds with other taxa for the purpose of the indicators more difficult and needs further explorations. Particularly a development of (Pan)European monitoring schemes for other taxa, e.g. butterflies, brings a hope that such analyses will be possible at larger scales too.

To conclude, birds as the indicators of the environment perform well, although the overall context should be always considered (Gregory et al 2005). When using changes in the abundance over larger spatial and temporal scales, an attention should be given to all variables potentially affecting bird numbers besides the quality of environment at sampling plots.

These variables usually include climatic variables, migration behaviour, bird species diet, nest type (e.g. open nest in a tree, tree cavity) etc. The variables have to be analysed in a more detailed way in order to understand the performance of the indicators' constituent species better (e.g. Gamero et al. 2017, Gregory et al. 2007, Jørgensen et al. 2015).

From the viewpoint of the pan-European C&I for SFM, the common bird species indicator is just one of ten biodiversity indicators. In combination with the others, the quality of which is also variable, it can indicate biodiversity reasonably well.

6.2 Interpretation of the common forest bird indicators

The interpretation of the common forest bird indicators needs to consider also the following:

1. Selection of the species for an indicator

In order to produce an indicator reflecting sustainability of forest management influencing species' habitats, each resource used by bird community in a region (e.g. each particular food resource, each particular type of nest habitat, etc.) should be represented at least by one species included in each indicator. Although the current PECBMS common forest bird indicators (https://pecbms.info/trends-and-indicators/indicators/) seem to be robust (Gregory et al. 2019), there is a need to identify species and resources missing in the current PECBMS data set, ideally using the resource-use risk assessment (Wade et al. 2014). Once the species missing[2] in the indicator are identified, monitoring data should be sought for, most likely from species-specific monitoring schemes. This has been already initiated within the PECBMS, which cooperates with Dr. Simon Butler, University of East Anglia, UK, the author of this approach. The selection of an optimal species set has to consider also the selection tailored to the needs of potential production of the indicators at regional (i.e. supra-national) and national level. Until the new indicators based on new species selection procedure are produced, the existing indicators can certainly be used as the indicators of biodiversity in forest habitats in Europe (at least as a type I indicator according to Gregory et al. 2005), but they should be interpreted with caution as indicators of sustainability of forest management. Sub-indicators based on species characteristics of distinct types of forests would also be desirable.

[2] Missing species are those that occur in the habitat and represent niches there. Nevertheless, the data on their numbers are not currently available because of the methodological limitations: these species are for instance nocturnal and therefore not recorded by generic breeding bird surveys. Or they are secretive and would need a species-specific field method, to be properly monitored. It is desirable to obtain monitoring data on these species too in order to get a complete coverage of resources in a forest habitat

The indicators should be always accompanied by the information on trends in individual species because a composite multi-species index may lead to ignorance of unfavourable conservation status of single species. Because the publishing of individual species indices would be too complex and extensive (tens of graphs with brief comments) for the purposes of the State of Europe's Forests report, the trends can be presented in simplified table format as a number of species in each trend category (decline, increase, stable, uncertain, see for instance the leaflet https://pecbms.info/leaflet2018/).

2. Representativeness at various spatial and temporal scales

The indicator should represent countries and time period concerned. Within the countries where monitoring schemes contributing to PECBMS are already in place, the monitoring data is assumed to be representative (see also the section Selection of sampling plots and Table 2). As the national monitoring schemes were established in different years, the more backwards, the fewer countries contributed to the PECBMS indicators (see also Table 2 for years when the schemes commenced).

The missing data for early years are being estimated based on the information from countries that provided data, using the complex hierarchical procedure in PECBMS (see the section Calculation of the European population trends and indices). The procedure applied is the best of the possible solutions; nevertheless, representativeness in early years (prior to 1990) would need to be evaluated more thoroughly. In the meantime, the values of indices and trends prior 1990 should be interpreted with caution. The more recent years, the more national schemes are in place and data is available from all main regions in Europe. Missing monitoring data can still be a problem at the national level in some cases (Table 2) and monitoring data are needed from eastern parts of Europe in order to get the coverage representative for the whole Europe. Setting up bird monitoring schemes in Albania, Belarus, Bosnia & Herzegovina, Georgia, Montenegro, Moldova, Russia, Serbia, Turkey and Ukraine is particularly important to achieve better geographical coverage.

3. Precision, baseline year & an effect of individual species on the indicator

As described in the section Calculation of the multi-species index (an indicator), the indicators are produced with confidence limits as a measure of precision. In order to avoid the effect of an imprecise species index on the indicator, the criteria to identify suspicious data are applied. The effect of single species data on the European common forest bird indicator was examined and the indicator was found robust to exclusion/inclusion of species (Gregory et al. 2019).

For the presentation purpose, it is desirable to produce the indicator with the first year of the time series as the baseline year (index value 100%). However, for an evaluation of the indicator performance, it is also desirable to produce the indicator with the last year as the baseline year. This allows testing whether the indicator is significantly improving or not (Gregory et al. 2019). Furthermore, a trend value for a predefined period (e.g. from the first to the last year, or last ten years etc.) can be calculated. Production of trend values has not been a routine part of the indicator production, but it is feasible to do it during the process of calculation of indicators using the MSI-tool (Soldaat et al. 2017).

4. Potential effect of other variables on the indicator

Variables other than the quality and amount of the forest habitat available should also be considered when interpreting the indicators. Specifically, in the case of the forest bird indicator, details about habitat quality within a sample plot (e.g. tree species composition, forest age, stocking level) should be considered from the sustainable forest management viewpoint. Furthermore, the migratory species indices may be influenced by mortality at their migration routes and/or wintering sites, all species may be affected by climate change, direct human persecution and natural enemies. The species also react differently according to their life history traits. Gregory et al. (2019) have explored the effect of long-distance migrants within the common bird indicators and found minor effect of the trends of sub-Saharan migrants at the European level. For the potential use of the indicators at the national level, research in this respect would need to be conducted at national level, using the national-specific information on migration strategies of bird species. Gregory et al. (2007) explored also the common forest bird species trends and found that, among others, ground or low-nesting species decline more than other species and also species feeding on invertebrates declined more than species with other feeding preferences. Such analyses are desirable to be reproduced using the updated data set in order to better understand the indicators and their relations to forestry and/or changes in forest habitats.

6.3 Further development of the common bird species indicator

The PECBMS products are still in development and implementation of the following activities should be considered (those improving the usability of the indicator within the context of pan-European C&I for SFM, for which consultations with FOREST EUROPE would be desirable, are indicated by asterisks):

Short-term:

- to finalise a new selection of forest bird species for the Forest Bird Indicator using the resource-risk assessment approach and to identify gaps in the already existing species data set, in the time being to use the existing species selection at the European level,
- to accompany each indicator produced and published by a summary of trends of constituent species,
- to consider accompanying each indicator with a version with last year as a baseline year*,
- to produce the indicators in a smoothed version with confidence intervals using the MSI-tool (Soldaat et al. 2017),
- to consider production of trend values for the indicators according to Soldaat et al. (2017)*,
- to analyse the needs for sub-indicators, e.g. for types of the forests or regions*,
- to analyse the needs for routine production of the national versions of the indicators*.

Mid-term:

- to identify data sources (species specific monitoring schemes) for filling the gaps in the species selection and to obtain the data,
- to clarify needs for the use of the site level data for potential analyses of site characteristics[3] and bird abundances*,
- to explore an effect of other variables on the trends of constituent species,
- to identify priority countries for the development of new monitoring schemes and to secure resources needed for the schemes*,
- to analyse possibilities for combining National Forest Inventories and national bird counting schemes*,
- to analyse possibilities for providing verified forestry data for each transect or point to help observers to understand what happened in forest*.

Long-term:

- to initiate setting up species specific schemes whenever needed,
- to build capacity for monitoring in countries where monitoring data is not available yet,
- to develop a routine procedure enabling incorporating detectability into routine calculation of population indices.

[3] From the viewpoint of the pan-European C&I of SFM, it is necessary to get more information on the influence of forest management on bird populations. It would require that the observers would record whether the areas adjacent to transects or points somehow changed since the last visit (e.g. they were felled completely or selectively, if yes, how large areas around the transects/points were cut, if they were afforested and how, etc.). Methodology for such recording could be developed in cooperation between PECBMS and a subsequent FOREST EUROPE expert group.

7 Conclusions

Based on the information presented in this study, it can be concluded that generic breeding bird monitoring schemes exist in 33 European countries, 28 of them contributing to PECBMS. Information on common forest bird species has been collected at national level since various starting years and it is has been organized under supervision of national coordinators and PECBMS Coordination Unit and its Steering & Technical Group. The trends in common forest bird species at the national level are not publically available, while trends in species populations at the regional level (i.e. for Central East, North, South and West Europe; these regions are no identical with (sub) regions used in the State of Europe's Forest report) have been calculated by PECBMS and made publicly available.

The multi-species index characterises population dynamics of common forest bird species that are (see chapter 6.1) considered a good proxy of the overall biodiversity trends, health of the environment and, indirectly, of the sustainability of land use. However, the information included in this index may be difficult to interpret without being complemented with the information on trends in particular (selected) species.

In the existing format, PECBMS products are already used and accepted as the biodiversity indicators for EU's Structural Indicator and Indicators of Sustainable Development of the EU, particularly as Eurostat's Common Bird Index and EEA's SEBI Abundance and distribution of selected European species.

Issue of the applicability of the Common forest bird species indicator to the SFM concept still remains open. On the one hand, the existing set of pan-European C&I for SFM still lacks an eloquent indicator of overall biodiversity (and the common forest bird species indicator can serve as its proxy), on other hand, this indicator is not clearly reflecting forest management practices. Population dynamics of the common forest bird species are influenced by many factors other than forest management, such as other land-uses and practices, especially in fragmented landscapes, climate change impacts, conditions during migration, etc. Forest management, especially in European countries, therefore remains only one of many factors influencing the indicator. To improve the understanding of the forest management effects on populations of common bird species, it would be desirable to complement the species records from sampling plots with the information on the state of forest on these plots and the surrounding area. This should be kept in mind when interpreting these data from the SFM viewpoint.

To improve the situation, further efforts and cooperation between PECBMS and a FOREST EUROPE expert group can be recommended. The relevance of the indicator for SFM monitoring and reporting should be carefully evaluated and reassessed again during the next revision of the set of pan-European C&I for SFM.

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