Changes in the ranges of breeding bird species in the European part of Russia during the last 20–30 years

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The publication of the second European Breeding Bird Atlas EBBA2 has made it possible to identify and quantify changes in the breeding ranges of birds in Europe in the 30-year period between the 1980s and the 2010s. Unfortunately, this analysis could not incorporate data from Russia and some other parts of Eastern Europe because of the differences in the methods and the considerable incompleteness of data in the first atlas. However, for the European part of Russia, information on the changes in the breeding ranges of birds was documented in the species texts included in the Atlas of the breeding birds of the European part of Russia, which was published in 2020 at the same time as EBBA2. This information allowed a qualitative assessment of changes over the last 30 years.

115 of the 415 species breeding in the territory of European Russia (ER) have shown changes in their ranges over the last 20–30 years. Among them, 89 species showed an expansion of the breeding range, 22 species a range contraction, and four species shifted their range completely. Range expansions or shifts to the north and, to a lesser extent, to the east, south and west clearly dominated. Nine species expanded their breeding range both to the north and south. The contraction of breeding ranges has occurred in roughly equal proportions due to a shift of the southern border to the north in some species and a shift of the northern border to the south in others, with several species having reduced their ranges in both the northern and southern parts.

A comparison was made with range change information for the same species in Europe west of Russia (EWR), i.e., the geographical area shown in the EBBA2 change maps. Around 75% of the species showing range changes in ER showed more or less consistent changes in EWR.

Among birds showing range changes in recent decades, the European breeding range of about 10 species is restricted, or almost restricted, to ER. In general, these species showed range changes along a west-east or northwest-southeast axis.

The study presents the first step of the analysis of changes in the breeding ranges of birds in ER. Identification of causes of the range changes will be a necessary further step, as well as detailed analyses at the species level.

The second European Breeding Bird Atlas (EBBA2) documented the distribution of breeding birds in Europe in the 2010s, including information from the easternmost parts of the continent (Keller et al. 2020). Its data also allowed a statistical analysis of changes in the distribution of birds in Europe over around 30 years by comparison with data from the first atlas, EBBA1 (Hagemeijer and Blair 1997). For the European part of Russia, a similar analysis was not possible, because the data from this region included in EBBA1 are patchy. Considering that the European part of Russia makes up about 38% of the land area of the continent, the picture of distribution change presented in EBBA2 was therefore far from complete.

This paper attempts to fill this gap by describing the trends in distribution change of bird species breeding in European Russia (ER) over the last 20–30 years, based on information collected for the Atlas of breeding birds of the European part of Russia (here called Russian Atlas, Kalyakin and Voltzit 2020). This atlas, for the first time in this region, was based on data on bird distribution in 50 × 50 km squares collected systematically as

part of EBBA2. Additionally, the species texts of the Russian Atlas documented changes in distribution for many species, and this information can be used for an overall view of the changes in the ranges of breeding bird species. In this study, we analysed the information presented by the authors of the species accounts included in the Russian Atlas.

1. Methods

The authors of the species accounts in the Russian Atlas (Kalyakin and Voltzit 2020) used their own data, results of literature analyses, reports of observers surveying squares in ER, and maps compiled on their basis. In preparing the species accounts, they followed the procedure proposed by the project coordinators. In particular, they noted the presence or absence of changes in the breeding ranges of birds detected during the last 20–30 years. These were almost always qualitative rather than quantitative assessments, allowing to judge the direction and only in some cases the extent of changes in breeding ranges. The authors of the species accounts also pointed out changes in the numbers of breeding birds, which are usually associated with changes in range boundaries, often preceding them. The accuracy of these estimates is likely inferior to that of the obtained statistical assessments of changes in breeding ranges in the western part of Europe, but the standardised procedure based on the analysis of the distribution maps provided a good framework for expert assessments (Kalyakin and Voltzit 2020). Further, in the absence of standardised distribution data from the past, expert judgement is the only approach that can be used to assess changes in distribution. As suggested by Reif et al. (2021), expert judgement can properly describe changes in bird populations, thus we believe that the approach used here is reasonable.

The aim of the current analysis is to identify general tendencies of range changes of birds breeding in ER and to compare the changes with the results for the western parts of the continent presented in EBBA2 (here called Europe west of Russia, EWR). The analysis was based on the information on changes in the breeding ranges included in the species accounts of the Russian Atlas, further analysed by the first and second authors (MK and OV) of this publication, additionally using their own data and data from the literature including those published after the publication of the Russian Atlas or during the final stages of its preparation for publication.

All species account authors were qualified professional ornithologists. They were invited to compile the atlas texts on the basis of their experience in the field and knowledge of the geographical regions in which the species breeds, as well as on the availability of relevant publications. The information was further checked by the atlas editors, who had access to all publications, including the ones that were not cited in the species accounts to save space. Overall, the atlas was based on the literature on the distribution of birds in the region published between 2005 and 2020 (1856 publications). These publications include regional studies directly devoted to the assessment of changes in bird ranges in the southern regions of ER (Belik et al. 2006, Belik 2013), the Arkhangelsk Region (Amosov 2020), central ER (Mishchenko 2014), as well as publications devoted to the results of long-term monitoring of bird populations in several regions (Yakovleva 2015, Voltzit et al. 2022). MK and OV also drew on the experience of participating in a series of six meetings on rare species of central European Russia (1989–2019). The participants and organisers of these meetings paid special attention to the analysis of the colonisation or disappearance of bird species in the 12 regions surrounding the Moscow Region (Butiev et al. 1990, 1998, 2000, 2009, Volkov et al. 2014, 2019). The results of the meetings allowed further assessment of the extent and direction of range changes for the whole of ER.

The information on changes in the breeding ranges of birds in ER was classified with regard to changes in the boundaries of the ranges: expansion (e.g., northward shift of the northern border of the range, eastward shift of the eastern border, etc.), complete range shift (movement of the entire species range by simultaneous shift of both southern and northern (or western and eastern) boundaries in the same direction, see Maggini et al. 2011), or contraction, i.e., a decrease in range size (e.g., northward shift of the southern border, or eastward shift of the western border). The types of range boundary shifts were considered in relation to four axes: north-south, west-east, northwest-southeast and northeast-southwest.

The species-specific comparison of range changes in ER and in EWR was based on the information presented in EBBA2, primarily on the change maps illustrating the extent and geography of changes in the breeding ranges of birds in the territory included in EBBA1 (maps available in Keller et al. 2020 and online under EBCC 2022). The comparison was based on expert assessment by MK and OV, facilitated by the fact that both the Russian and the European atlases used the same 50 × 50 km grid. The change indices presented in EBBA2 were also considered. Where the European range of a species has spatial discontinuities, the situation in ER was compared with changes in the part of the range that was spatially related to the range of the Russian population. Species not found outside the borders of ER or recorded outside its borders in only a few squares were not considered.

Table 1. Types of breeding range changes of birds in European Russia (ER) in the last 20–30 years. N, S etc. means expansion to the N, to the S, etc. N–, E–, etc. means contraction of the breeding range along its northern boundary, eastern boundary, etc.
Arten von Veränderungen der Brutgebiete von Vögeln im europäischen Teil Russlands (ER) in den letzten 20–30 Jahren. N, S usw. bedeutet Ausdehnung nach N, nach S usw. N–, E– usw. bedeutet eine Schrumpfung des Brutgebiets entlang der nördlichen bzw. östlichen Grenze usw.

Type of range change in ER	Number of species
Expansion to	*89*
north only (N)	38
north and northeast (N, NE)	3
northeast (NE)	2
north and to east (N, E)	10
east and northeast (E, NE)	1
east only (E)	3
northeast, east and southeast (NE, E, SE)	1
southeast (SE)	1
south only (S)	8
south and west (S, W)	2
west (W)	5
west and northwest (W, NW)	1
west and north (W, N)	1
west, north and east (W, N, E)	1
north and northwest (N, NW)	3
north and south (N, S)	7
all directions (N, E, S, W)	2
Shift of the range to (with contraction at the southern range boundary)	*4*
north and west (N, W)	1
north (N)	2
north and east (N, E)	1
Range contraction	*22*
at northern part (N–)	5
at western, northern and eastern part (N–, W–, E–)	1
at southern part (S–)	9
at southern and western part (S–, W–)	1
at northern and western part (N–, W–)	2
at northern and southern part (N–, S –)	3
at all parts (N–, E–, S–, W–)	1
Total	*115*

2. Results

2.1. Overview

We analysed all 415 species accounts included in the Russian Atlas and identified 115 cases in which the authors reported changes in the breeding ranges in ER. These species are listed in Appendix 1, which also lists the direction of range change in ER and comparisons between ER and EWR range changes for all but five species (or subspecies with distinct ranges) that were not breeding in other European countries.

We identified range changes of species in ER in the form of expansion, complete range shift, or contraction. Combined with the directions of boundary shifts provided by the species experts, we obtained 17 types of expansion, seven versions of contraction, and three versions of complete range shift. In total, there were 27 versions of range change (Table 1).

Overall, 89 species expanded their breeding ranges in ER, four species shifted their range completely, and 22 species experienced a contraction of their ranges. For the remaining 300 species of breeding birds in ER, no strong changes in range boundaries were documented.

The changes and their directions in Table 1 are presented as they were reported by the authors of the species accounts in the Russian Atlas. Some versions of change were found in single or two species only. In some species, the direction of change was described as N and NE, N and E etc. We summarised the assessments into the four main directions N, S, W, E (Table 2). Overall, movements of the range boundaries were more common along a north-south axis than an east-west one. Boundary shifts towards the northern sector dominated in particular for expanding species (70 cases vs 21 towards the S), whereas directions were more equally distributed for species with range contractions (12 vs 14 cases).

Below we describe the patterns of the range changes according to the type and directions of movement of the range boundaries, by grouping species according to the main directions, i.e. northward (movement to north, north and northwest, or north and northeast), eastward (movement to east, east and northeast, or east and southeast), and similarly southward and westward.

Table 2. Summary of directions of range boundary shifts for species that changed their breeding ranges in European Russia in the last 20–30 years. Reading examples: Species showing a boundary shift to N (row 1 in Table 1) are counted for the main direction N, species with shifts to N and NE (line 2 in Table 1) are counted for the main directions N and E, and the same for species with a boundary shift to N and E (row 3).
Zusammenfassung der Richtungen der Verschiebung der Arealgrenzen für Arten, die in den letzten 20–30 Jahren ihr Brutgebiet im europäischen Teil Russlands verändert haben. Lesebeispiele: Arten mit einer Arealverschiebung nach N (Zeile 1 in Tabelle 1) werden für die Hauptrichtung N gezählt, Arten mit Verschiebungen nach N und NE (Zeile 2 in Tabelle 1) werden für die Hauptrichtungen N und E gezählt, dasselbe für Arten mit einer Arealverschiebung nach N und E (Zeile 3).

Direction	Number of directions for species that colonised new areas either by range expansion or range shift		Number of directions for species that lost areas either due to range contraction or range shift	
	Range expansion	Range shift	Range contraction	Range shift
North	70	4	12	0
East	24	1	2	0
South	21	0	14	4
West	15	1	5	0

2.2. Changes in range within European Russia

2.2.1. Range expansion

Northward direction. Range expansion to the north was recorded for 38 species (Appendix 1). Additionally, range expansion to north plus northeast (Great White Egret, Common Tern and Syrian Woodpecker), to the northeast (Eurasian Blackbird and Northern Wren) and to the north and east (10 species) was detected in 15 species. The range expansions of Black Redstart (Fig. 1) and European Serin to the east included also expansion to the northeast. An expansion of the range boundary both to the north and northwest was noted for three more species (Caspian Gull, Savi's Warbler and Red-headed Bunting). Booted Warbler (Fig. 2) moved to the west, but in some instances also to the northwest. For Cetti's Warbler, expansion both to the north and to the west was recorded. Seven species showed an expansion of the range both to the north and to the south. Two species, Booted Eagle and Eurasian Oystercatcher, enlarged the area of their breeding ranges in all four directions (N, E, S, W). A complex situation has emerged with changes in the breeding range of the Lesser Spotted Eagle, with the forest-dwelling population expanding westwards and the Caucasian population moving northwest- and westwards. A total of 70 species thus showed more or less clear evidence of northward range expansion. This represents 61% of the number of species with range changes, 79% of the number of species with range expansion, or 17% of all breeding species of ER.

Southward direction. Consider the reverse trend, i.e., a southward expansion of the breeding range. As mentioned above, nine species expanded their range both to the north and to the south. Another eight species expanded their range southwards only, sometimes to a great extent: for Northern Hawk-owl, the boundary shift was estimated at 300 km (Sharikov 2020). Other such species include European Herring Gull and Mew Gull, Great Grey Owl (Fig. 3), Black Woodpecker, Meadow Pipit, Arctic Warbler (Fig. 4) and Coal Tit. The White-tailed Sea-eagle expanded southeastwards, and Barnacle Goose and Fieldfare southwestwards. One may also recall that the eastward dispersal of the European Serin also includes some movement to the southeast. Thus, considering not only southward but also southeastward expansion, expansion to the south as a whole was recorded for 21 species. This represents almost a quarter (24%) of all expanding bird species in ER, or 5% of all breeding bird species in ER.

Eastward direction. Three species and one population of another species have shown expansion to the east. During the last 20–30 years, the ranges of the forest («northern») population of Lesser Spotted Eagle has moved directly to the east. The Yellow-legged Gull was first discovered in Russia in the 2000s and its breeding was confirmed in the eastern part of the Black Sea coast in 2015 (Tilba and Filipov 2016), but one can only speak with great caution about the real eastward expansion of the range. Woodlark and Ortolan Bunting have advanced to the east to a greater extent. Besides this, Black Redstart has considerably expanded its range to the east and northeast. The first cases of expansion to the northeast, east and southeast of European Serin have already been mentioned above. We have also already mentioned 12 species expanding their ranges northeastwards, and three species whose northern and eastern ranges have expanded north- and northeastwards. Together with two species expanding their ranges in all directions, including eastwards (Booted Eagle and Eurasian Oystercatcher), White-tailed Sea-eagle

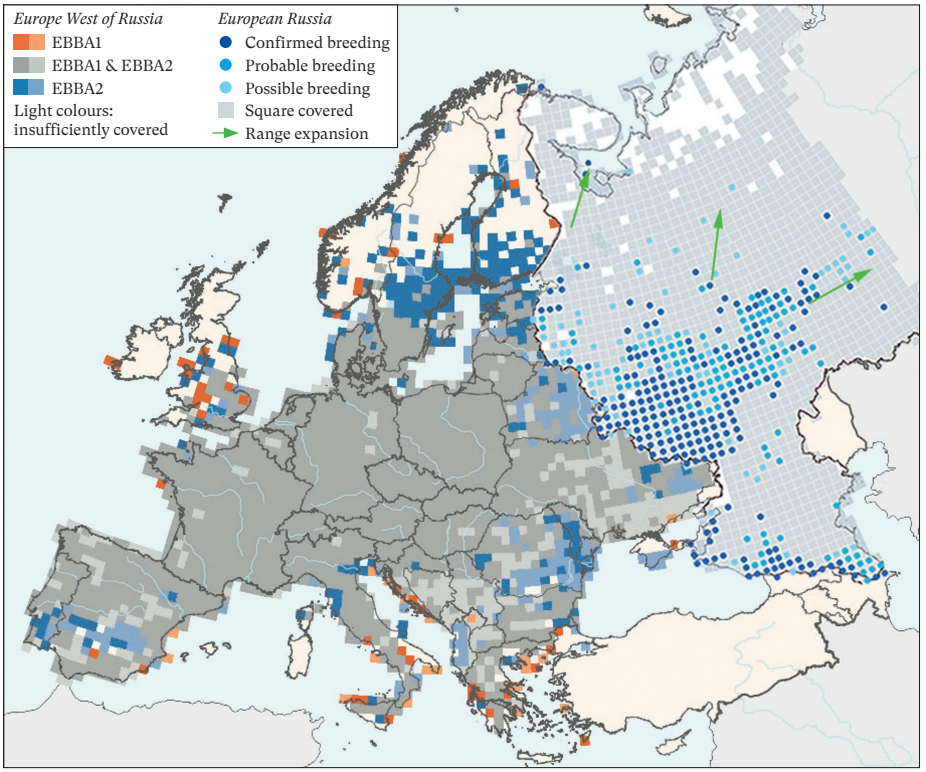

Figure 1. Breeding distribution (breeding evidence map) of the Black Redstart *Phoenicurus ochruros* in European Russia (Kalyakin and Voltzit 2020), combined with the change map from EBBA2 (Keller et al. 2020, EBCC 2022). The arrows indicate the direction of the range boundary changes within European Russia.
Brutverbreitung (Brutwahrscheinlichkeit) des Hausrotschwanzes Phoenicurus ochruros im europäischen Teil Russlands (Kalyakin und Voltzit 2020), kombiniert mit der Veränderungskarte aus EBBA2 (Keller et al. 2020, EBCC 2022). Die Pfeile zeigen die Richtung der Arealveränderungen innerhalb des europäischen Teils Russlands.

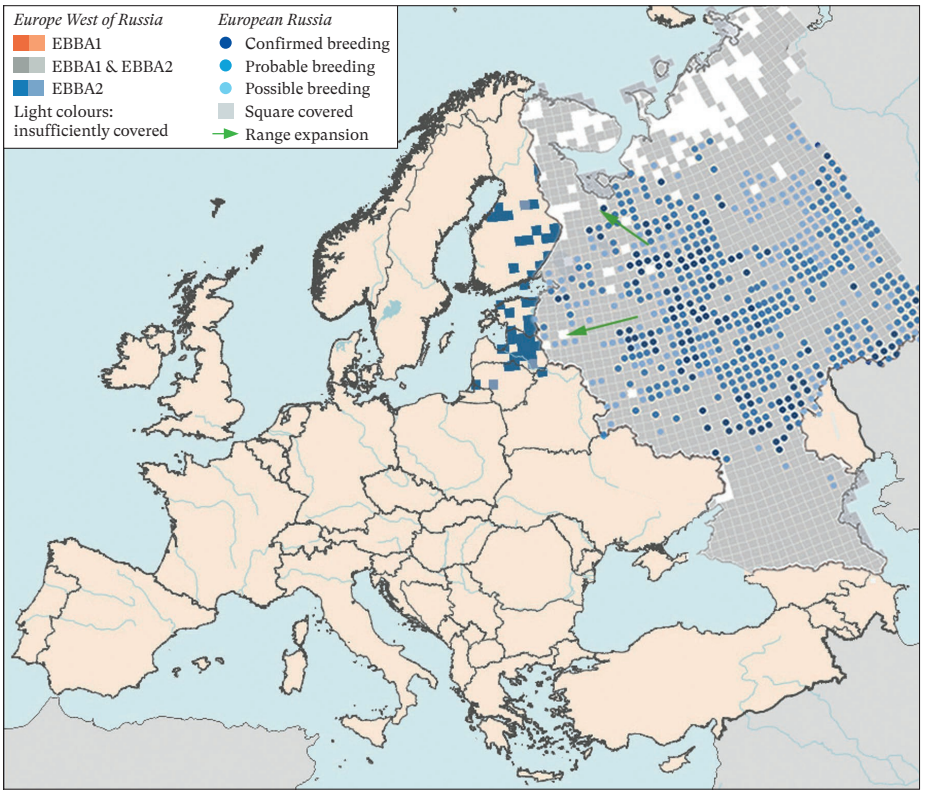

Figure 2. Breeding distribution (breeding evidence map) of the Booted Warbler *Iduna caligata* in European Russia (Kalyakin and Voltzit 2020), combined with the change map from EBBA2 (Keller et al. 2020, EBCC 2022). The arrows indicate the direction of the range boundary changes within European Russia.
Brutverbreitung (Brutwahrscheinlichkeit) des Buschspötters Iduna caligata im europäischen Teil Russlands (Kalyakin und Voltzit 2020), kombiniert mit der Veränderungskarte aus EBBA2 (Keller et al. 2020, EBCC 2022). Die Pfeile zeigen die Richtung der Arealveränderungen innerhalb des europäischen Teils Russlands.

increased its range southeastwards. This gives us a list of 24 species that moved more or less in eastward direction, which is almost as many as the species showing a southward movement, or 6% of the region's breeding birds.

Westward direction. A similar calculation of the number of species whose ranges extended in one way or another in a westerly, northwesterly, or southwesterly direction gives a total of 15 species (less than 4% of the region's species). Among these, in addition to the variants listed above, we note five species or subspecies that spread in a strictly westerly direction. These are the subspecies of Grey Wagtail, of Citrine Wagtail, and of Common Stonechat, and Orange-flanked Bush-robin and Little Bunting.

2.2.2. Complete range shifts

Four species showed a complete shift of their breeding range rather than an expansion towards a particular direction with no losses in other parts of their ranges. For example, the Gadwall range expanded in the north and west but contracted in the south. The Pine Grosbeak also showed a range contraction in its southern part, due to the retreat of its southern boundary to the north and northeast and expansion of the northeastern border of the range to the northeast. The ranges of Jack Snipe and Pallid Harrier shifted the southern boundary to the north, but at the same time moved to the north.

2.2.3. Range contraction

In total, 22 species showed a reduction in the size of their breeding ranges due to the disappearance of breeding individuals in some parts of their former range. Of these 22 species (Table 1), five species were found to have retreated southwards: Red-footed Falcon, Grey Partridge, Corncrake, Lesser Grey Shrike, and Pied Wheatear – the latter by 200 km. Common Little Bittern and, to a much greater extent, European Roller (Fig. 5) have reduced their range due to their disappearance from northern and western areas of their former distribution. For the Steppe Eagle, this has been at the expense of the northern, eastern and western parts of the former breeding range. A total of eight species have retreated to the south. The southern range boundaries shifted northwards for nine species (without a shift of the northern range boundary): Arctic Loon and Red-throated Loon, Northern Pintail, Willow Grouse, Black Grouse, Western Capercaillie, Hazel Grouse, Great Snipe, and Horned Lark. In the Siberian Jay, the range contracted in the southern and western parts of the breeding range. Thus, there is a disproportionate number of grouse species showing losses in the south; the same applies to both species of loons.

For the three species Horned Grebe, Greater Spotted Eagle and Saker Falcon, the decrease of the size of the breeding range was due to their disappearance from both northern and southern parts of their former range. Finally, Yellow-breasted Bunting has reduced its range markedly in all analysed areas, in parallel with the dramatic decline of its population size.

2.2.4. Extent of range change

It was not always possible to estimate the extent of range change from the available data; information was available for few species only. For example, the northern limit of the breeding range of European Greenfinch, Garden Warbler and Common Whitethroat has moved 250–300 km to the north, and of Hawfinch 400–600 km, over the period of approximately 30 years. The corresponding range boundary of Bearded Reedling has shifted more than 500 km to the north and east, the one of Eurasian Penduline-tit 300–500 km, of Marsh Tit not less than 200 km, and of Northern Wren 150 km. The Caspian Gull has expanded its range towards the north and northwest by at least 650–700 km. The southern boundary of the range of Arctic Loon and of the northern subspecies of Horned Lark shifted northwards by at least 250–300 km. Great White Egret, Black Redstart, Middle Spotted Woodpecker and Syrian Woodpecker have clearly expanded their ranges strongly to the north and northeast, and the Booted Warbler to the west and northwest, but no detailed numbers were found in the literature. On the other hand, the southern limit of the breeding range of the Northern Hawk-owl has shifted to the south by about 300 km, and for the Pied Wheatear, the southward retreat of the northern boundary of the range was estimated at about 200 km.

2.3. Comparison of the direction of change in the ranges between European Russia and Europe west of Russia

In Appendix 1 we briefly describe range changes between EBBA1 and EBBA2, i.e., for the area of EWR.

Of the 40 species whose ranges in ER have expanded (n = 38) or shifted (n = 2) in a strictly northern direction, four were excluded from the comparison due to their absence in EWR. The direction of range change coincided with that in EWR for 17 species, i.e., for less than half. However, when we examined the rest of the situations closely, the following became apparent. The ranges of nine species in this group (e.g., Common Greenshank or Green Sandpiper) reached the sea coast in northern Europe. They are therefore unable to disperse further north. Some of these species, e.g., Green and Wood Sandpiper or Garden Warbler, show slight losses at the southern edges of their ranges in EWR; in

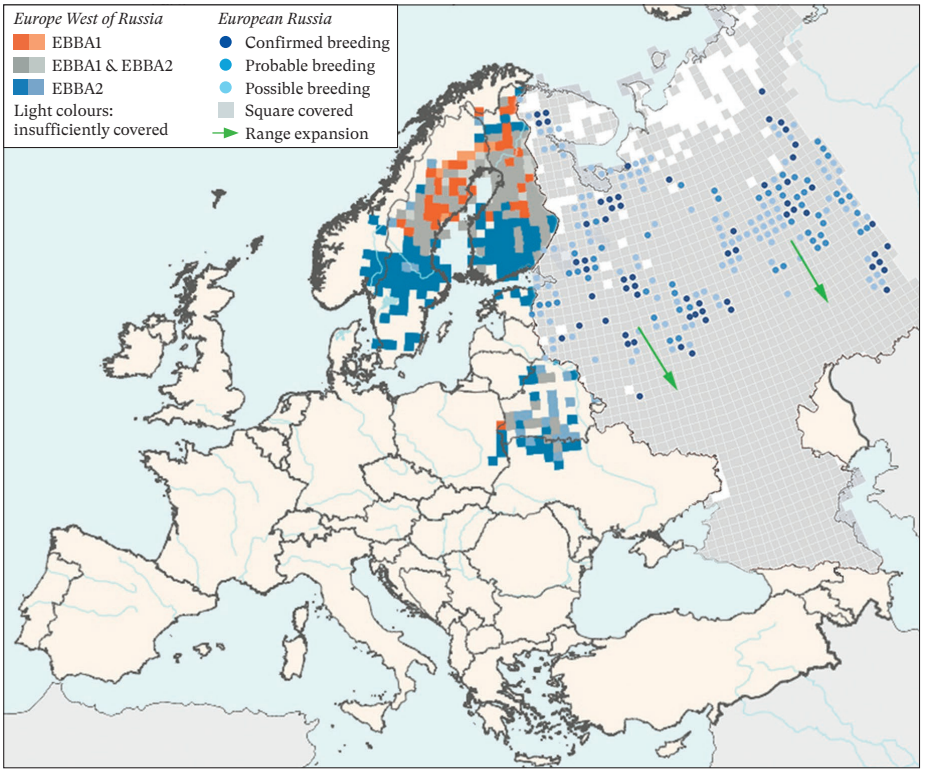

Figure 3. Breeding distribution (breeding evidence map) of the Great Grey Owl *Strix nebulosa* in European Russia (Kalyakin and Voltzit 2020), combined with the change map from EBBA2 (Keller et al. 2020, EBCC 2022). The arrows indicate the direction of the range boundary changes within European Russia. *Brutverbreitung (Brutwahrscheinlichkeit) des Bartkauzes Strix nebulosa im europäischen Teil Russlands (Kalyakin und Voltzit 2020), kombiniert mit der Veränderungskarte aus EBBA2 (Keller et al. 2020, EBCC 2022). Die Pfeile zeigen die Richtung der Arealveränderungen innerhalb des europäischen Teils Russlands.*

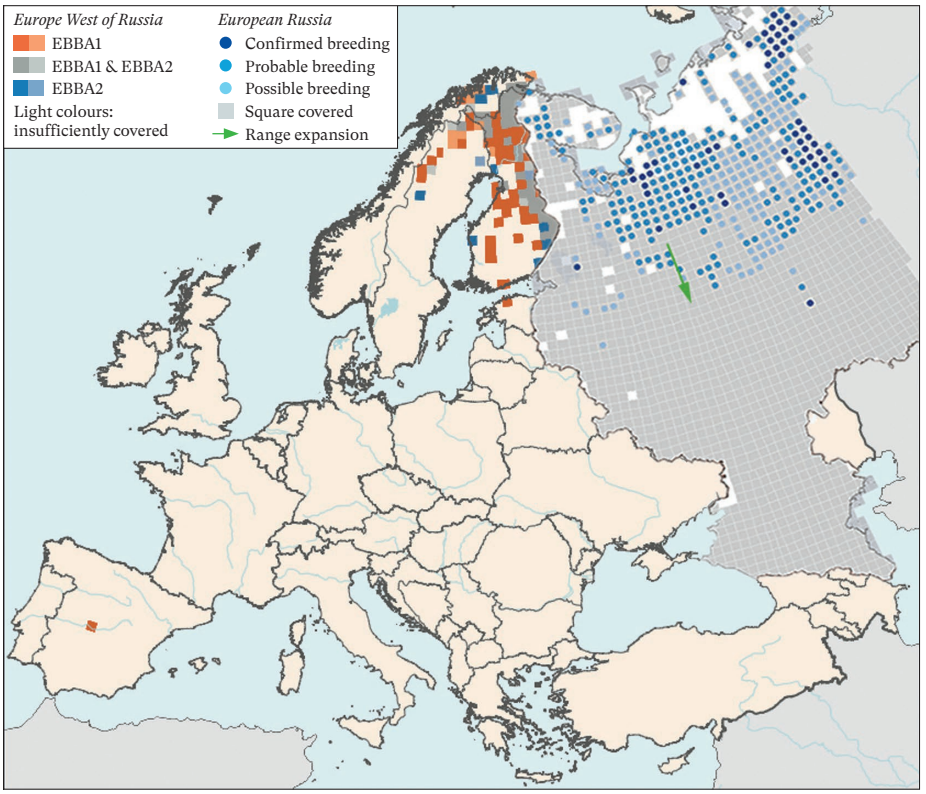

Figure 4. Breeding distribution (breeding evidence map) of the Arctic Warbler *Phylloscopus borealis* in European Russia (Kalyakin and Voltzit 2020), combined with the change map from EBBA2 (Keller et al. 2020, EBCC 2022). The arrows indicate the direction of the range boundary changes within European Russia. *Brutverbreitung (Brutwahrscheinlichkeit) des Wanderlaubsängers Phylloscopus borealis im europäischen Teil Russlands (Kalyakin und Voltzit 2020), kombiniert mit der Veränderungskarte aus EBBA2 (Keller et al. 2020, EBCC 2022). Die Pfeile zeigen die Richtung der Arealveränderungen innerhalb des europäischen Teils Russlands.*

the absence of the possibility of northward expansion, this resulted in slight range contractions. In this situation, we cannot judge the similarities and differences in the northward dispersal trends of the species in the two regions under comparison. Thus, we can only confidently speak of an inconsistent pattern of range change for 12 species.

The second most numerous group of species were birds whose range in ER was expanding (n = 17) or shifting (n = 1) to the north and east (here and below, we no longer mention the two species Booted Eagle and Eurasian Oystercatcher, whose range was expanding in ER in all directions; in EWR, the Booted Eagle behaved differently, while the Oystercatcher behaved in the same way as in ER). All but two species (Common Tern and Marsh Tit) from this group showed similar trends in range change in ER and in EWR (example Fig. 1). However, Common Tern did not have an opportunity for such dispersal, as the northern border of its range already reached the northern coast of the continent.

The small group of species whose range expanded east- and northeastwards in ER (Yellow-legged Gull, Woodlark, and Ortolan Bunting) showed the same patterns in EWR.

Moving further clockwise, there is only one species that dispersed to the southeast and was not yet discussed above, the White-tailed Sea-eagle. This species is expanding its range to the southwest in both ER and other parts of eastern Europe.

Species expanding south- and westwards in ER are more numerous (n = 10), five of which showing the same range change trends as in EWR (example Fig. 3) and five showing different trends (example Fig. 4). Another seven species fall into the north- and southward dispersal category, which we have already taken into account in our discussion of northward expanding species. Five of them extended their range southwards both in ER and EWR. In EWR, one of them, Eurasian Jay, does not have such an opportunity, as its range in the south reaches the sea coast, and only the range of European Pied Flycatcher has changed in ER differently than in EWR.

The last group is represented by three species that dispersed westwards, in addition to Booted Warbler (Fig. 2), which dispersed westwards and northwestwards, and to Gadwall, whose range shifted to the north and west. All of them dispersed westwards to EWR mostly in areas adjacent to ER. Two subspecies of Grey Wagtail and Common Stonechat also expanded to the west, but did not breed in EWR and therefore were not included in the comparison.

A comparison has also been made for species whose range in ER has contracted in recent decades. These are eight species whose ranges have decreased due to the retreat of their northern or both northern and western boundaries to the south (example Fig. 5); nine species whose ranges have decreased due to the retreat of their southern (and in one case western) boundaries to the north; and four species whose breeding ranges have decreased both in the south and the north (and for Yellow-breasted Bunting also to the west and to the east). One of these species did not breed in EWR. Of the remaining 21 species, only five show trends different from those of the same species' populations in EWR. These are four species whose ranges in Russia have retreated to the south, and one species whose range in Russia has declined due to the loss of its southern part (Red-throated Loon). Thus, the proportion of species with similar range changes in EWR and ER is quite high (76%).

3. Discussion

Using expert judgement and literature data, 115 species or 28% among the 415 species breeding in ER were identified to have undergone conspicuous changes in their ranges over the last 20–30 years. This highlights the dynamics of bird communities and the necessity to pay attention to such relatively fast changes in bird distribution. It is possible that our approach may have overlooked some cases of range change, particularly if they were small. It is also possible that the list of these 115 species included several species for which range changes were local, or for which the extent was overestimated by the experts. However, we are confident that we identified the most common patterns and did not overlook important cases of range shifts. It is likely that some of the observed changes represent an episode of relatively rapid range pulsation: there were fluctuations in the distribution of some species. For example, such pulsations of ranges within tens or more than a hundred kilometres were found in studies on the avifauna in the arid lower reaches of the Volga River (Belyachenko et al. 2016). Larger and longer periods of range changes may also be episodes in periodic fluctuations, but our data do not allow evaluating whether this is the case.

There were more species with range expansions in ER than with contractions and complete shifts in breeding ranges (89, 22, and 4 species, respectively). It should be emphasised that range contractions are much more difficult to detect than cases of range expansion (Keller et al. 2020). In the absence of repeated standardised surveys, documentation of range losses is even more difficult. Surveying certain areas periodically and in a standardised manner during the implementation of breeding bird atlas projects can provide a better basis for documenting change (Keller 2017). This is the value of the approach that has been implemented in much of Europe: the EBBA2 project has enabled direct, statistically supported comparisons of the status of bird ranges

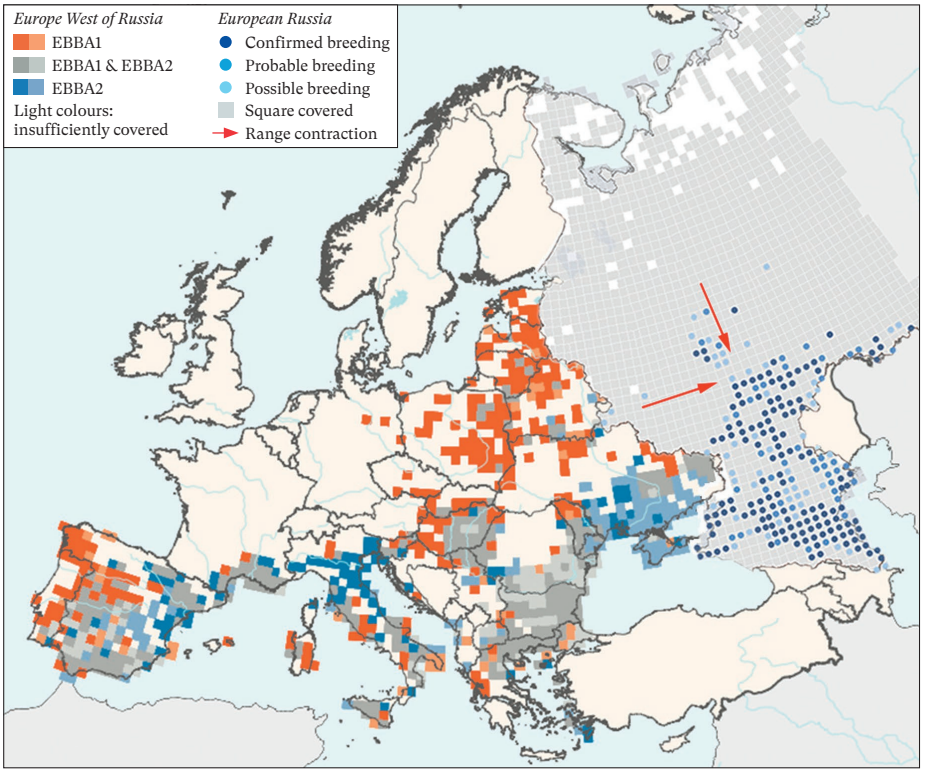

Figure 5. Breeding distribution (breeding evidence map) of the European Roller *Coracias garrulus* in European Russia (Kalyakin and Voltzit 2020), combined with the change map from EBBA2 (Keller et al. 2020, EBCC 2022). The arrows indicate the direction of the range boundary changes within European Russia.
Brutverbreitung (Brutwahrscheinlichkeit) der Blauracke Coracias garrulus im europäischen Teil Russlands (Kalyakin und Voltzit 2020), kombiniert mit der Veränderungskarte aus EBBA2 (Keller et al. 2020, EBCC 2022). Die Pfeile zeigen die Richtung der Arealveränderungen innerhalb des europäischen Teils Russlands.

over a 30-year period, using surveys of the same areas. This means that the next (second) atlas of breeding birds of ER will be extremely important both for identifying such changes in the territory of ER and for direct and reliable comparisons with the situation in EWR.

The main directions of dispersal or shifting of breeding range boundaries of birds in ER were found to be north and northeast. In addition to the northward expansions, range boundaries advanced also in all other directions. Because of the predominance of northward movements, the number of species with range changes along the north-south axis is markedly higher than the number of species with range changes along the west-east axis. It is clear that using only four axes when analysing the diversity of range changes is an abstraction of the most important trends. Actual changes in the ranges of specific species are clearly more complex.

The general pattern of directions in range change is somewhat different for species whose European breeding ranges are completely, or almost completely, restricted to ER. According to their ranges, the several dozens of these species can be grouped into an «east-northeastern» and a «southeastern» group. Species from both of these groups are present among the species showing range changes in the last 30 years. In contrast to the dominant direction to the north for species occurring in both ER and EWR, changes along an east-west axis dominated for the «east-northeastern» group of species, and a southeast-northwest axis dominated for the «southeastern» group. Most of the species restricted to ER have their core distribution areas outside Europe, and range changes could be affected by changes in the areas further east. The dominance of the east-west axis could also be related to the limited possibilities to expand the range further within Europe, because their ranges border the Ural Mountains, similar to the limits existing for species in the north of EWR.

Our comparison of patterns of range changes between ER and EWR has shown that in most cases they are similar. Among the 89 species for which we made such a comparison, for 15 species the comparison is not appropriate due to the presence of barriers in EWR that limit the ability of the species to disperse northwards, or both north- and southwards. Of the remaining 74 species, 58 (78%) showed the same range trends as in EWR. This similarity indicates that global changes in the distribution of individual species are likely to be largely determined by global factors. At the same time, there are also important differences in the range dynamics of some species in the Russian territory and in more western territories, due to geographical, climatic and landscape differences in these territories, as well as due to differences in the scale and variation of econom-

ic activity. It would be particularly interesting to examine the species with different trends in ER and EWR more closely, and to investigate the reasons for these differences.

Our relatively brief study was devoted to describing the patterns of change in the breeding ranges of birds in ER. The identification and analysis of the drivers of these changes is important and should be the subject of further research. It is clear that in addition to climate warming, birds are also affected by other factors, the most important of which is the diverse and large-scale human activity, which in one way or the other alters habitats, landscapes, vegetation, hydrology, and many other parameters. There are almost no natural barriers to bird dispersal in the vast territory of ER. The Ural Mountains extend meridionally, restricting to some extent the range of some species to the east. The nearly latitudinally oriented Caucasian ridge is a more important barrier to the southward and northward dispersal of some species. But the main area of ER lies to the west and north of these mountain systems and is a vast plain with a relatively well-defined zonal structure. Under these conditions, climate warming is likely to be one of the main drivers of the general tendency to shift breeding ranges to the north and northeast, as described in this study. Yet, human activity complicates the situation noticeably and may be the reason of multidirectional movements of the breeding range boundaries for particular species. Marked changes in forestry and agriculture (general or local increasing/decreasing of abandoned and ploughed areas, overgrowth by forests, or illegal forest cutting) occurred in Russia about 30 years ago and had their own dynamic during recent decades. The distribution of bird species has certainly been influenced by a complex combination of many factors.

In our opinion, the search for the reasons of changes in the ranges of breeding birds in the territory of ER should be carried out in an integrated manner, combining the analysis for individual species with analyses of factors affecting birds in general as well as of particular systematic groups in different regions and natural zones. These studies, as in the present work, will take advantage of the unique opportunity to analyse the situation on the whole continent, from the Atlantic Ocean to the Urals, investigating the common features of the existence of particular species in the western parts of Europe and in the Russian territory as well as identifying differences.

For example, long-term monitoring of the White-tailed Sea-eagle breeding population status in the Middle Volga and Volga-Kama regions (Bekmansurov 2019) showed that a chain of events, triggered by improved winter feeding conditions and probably a warming climate, was the likely cause of the species' population growth and range expansion. In the 21st century, more and more White-tailed Sea-eagles began to stay for the winter on their breeding grounds, leading to a start of breeding that, in the Volga region, was two weeks earlier compared to the second half of the 20th century. This, in turn, led to increased breeding success and population growth. Similar trends may have occurred in other European countries, where improved protection of the White-tailed Sea-eagle is an additional positive factor (Keller et al. 2020).

It is important to stress the obvious fact that changes in species abundance are inextricably linked to changes in the species' ranges. This means that tracking these changes during long-term monitoring should help to trace the onset of these changes and draw attention to the reasons for the changes. It will also be necessary to extend studies on distribution and population trends of birds beyond the geographical borders of Europe, as the ranges of many bird species breeding in ER extend to Asia – to regions where systematic studies like bird atlases are still lacking.

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Zusammenfassung

Kalyakin M, Voltzit O, Voříšek P, Herrando S, Keller V (2022) Arealveränderungen von Brutvogelarten im europäischen Teil Russlands in den letzten 20–30 Jahren. Ornithologischer Beobachter 119: 400–416.

Der zweite europäische Brutvogelatlas EBBA2 erlaubte es, die Veränderungen in den Verbreitungsgebieten der Brutvögel über die 30 Jahre zwischen den 1980er- und 2010er-Jahren zu identifizieren und zu quantifizieren. Leider konnte diese Analyse Daten aus Russland und anderen Gebieten in Osteuropa nicht berücksichtigen, da die Methoden der Datensammlung teilweise nicht kompatibel waren und die geografische Abdeckung in Osteuropa für den ersten europäischen Atlas sehr lückenhaft war. Für den europäischen Teil Russlands wurden Informationen zu Veränderungen in der Verbreitung jedoch in den Arttexten des russischen Brutvogelatlas dokumentiert, der wie der europäische Atlas im Jahr 2020 publiziert wurde. Diese Angaben erlaubten eine qualitative Beurteilung der Veränderungen über die letzten 30 Jahre.

Die Verbreitungsgebiete von 115 der 415 im europäischen Teil Russlands (ER) brütenden Vogelarten zeigten Veränderungen über die letzten 20–30 Jahre. 89 Arten zeigten eine Ausdehnung des Brutgebiets, 22 Arten eine Verkleinerung, 4 Arten eine Verschiebung des Brutgebiets. Ausdehnung oder Verschiebung der Brutgebiete dominierten, hauptsächlich Richtung Norden, zu einem geringeren Teil Richtung Osten, Süden und Westen. Neun Arten dehnten ihr Brutgebiet sowohl nord- wie südwärts aus. Verkleinerungen der Brutgebiete erfolgten ungefähr gleich häufig aufgrund einer Verschiebung der südlichen Verbreitungsgrenze Richtung Norden wie aufgrund einer Verschiebung der Nordgrenze Richtung Süden. Einige Arten zeigten eine Schrumpfung sowohl im nördlichen wie im südlichen Teil des Brutgebiets.

Die Informationen zu den Veränderungen wurden mit den Veränderungen der gleichen Arten in Europa westlich von Russland (EWR) verglichen, d.h. dem in den EBBA2-Veränderungskarten dargestellten Gebiet. Ungefähr 75 % der Arten, deren Brutgebiete sich in ER veränderten, zeigten ähnliche Veränderungen in EWR.

Unter den Vogelarten mit Verbreitungsänderungen in den letzten Jahrzehnten finden sich 10 Arten, deren Verbreitungsgebiet vollständig oder fast ausschliesslich auf das europäische Russland beschränkt ist. Diese Arten zeigten im allgemeinen Veränderungen entlang einer West-Ost oder Nordwest-Südost-Achse.

Diese Arbeit ist ein erster Schritt der Analyse der Veränderungen in der Verbreitung der Brutvögel in ER. In einem weiteren Schritt sollen die Ursachen für die Veränderungen sowie die Veränderungen auf Artebene genauer untersucht werden.

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Appendix 1. Bird species of European Russia (ER) whose breeding range has changed in the last 20–30 years: direction of range changes and comparison with the dynamics of their ranges in Europe West of Russia (EWR; according to EBBA2, Keller et al. 2020). N (or N+), S (or S+) etc. means expansion to the N, to the S, etc. N–, E–, etc. means contraction of the area of the breeding range in its northern part, eastern part, etc.; «no*» indicates directions of range changes in Europe and the European part of Russia that do not coincide, but the probable reason for the mismatch is the fact that northward (or southward) dispersal of these species in Europe is physically impossible as they have reached the sea coast. Systematic order of species within groups according to Russian Atlas (Kalyakin and Voltzit 2020).
Vogelarten des europäischen Teil Russlands (ER), deren Brutgebiet sich in den letzten 20–30 Jahren verändert hat: Angegeben sind die Richtung der Arealveränderungen und der Vergleich mit der Dynamik der Brutgebiete in Europa westlich von Russland (EWR; gemäss EBBA2, Keller et al. 2020). N (oder N+), S (oder S+) usw. bedeutet Ausdehnung nach N, nach S usw. N–, E– usw. bedeutet eine Schrumpfung des Areals im nördlichen Teil, im östlichen Teil usw.; «no» gibt an, dass die Richtung der Verbreitungsänderung in Europa und im europäischen Teil Russlands nicht übereinstimmt, wobei der wahrscheinliche Grund für die Nichtübereinstimmung aber die Tatsache ist, dass eine Ausbreitung dieser Arten nach Norden (oder Süden) in Europa nicht möglich ist, da sie die Küste erreicht haben. Systematische Ordnung der Arten innerhalb der Gruppen nach dem Russischen Atlas (Kalyakin und Voltzit 2020).*

Species		Direction of range boundary changes in ER	Direction of range boundary changes in EWR	Similarity of range dynamics in ER and EWR
Range expansion				
Black-necked Grebe	*Podiceps nigricollis*	N	redistribution in the former range	no
Great Crested Grebe	*Podiceps cristatus*	N	no change	no
Purple Heron	*Ardea purpurea*	N	no change	no
Ruddy Shelduck	*Tadorna ferruginea*	N	expansion of native range to the N	yes
Common Pochard	*Aythya ferina*	N	the northern boundary has shifted very slightly to the S, the southern boundary markedly shifted to the S	no
Osprey	*Pandion haliaetus*	N	new occurrences to W and NW (partly reintroductions)	no*
European Honey-buzzard	*Pernis apivorus*	N	shrunk slightly in the N	no
Eurasian Buzzard	*Buteo buteo*	N	shrunk in the NW (Norway, Sweden)	no
Eurasian Hobby	*Falco subbuteo*	N	slight expansion to the N	yes
Common Kestrel	*Falco tinnunculus*	N	no change	no*
Common Crane	*Grus grus*	N	widened to the W and slightly to the S and N	yes
Little Crake	*Zapornia parva*	N	global slight expansion to the NE	yes
Common Moorhen	*Gallinula chloropus*	N	expanded slightly to the N	yes
Common Coot	*Fulica atra*	N	slight expansion in the N	yes
Little Ringed Plover	*Charadrius dubius*	N	very slightly reduced in the northernmost of the range	no
Northern Lapwing	*Vanellus vanellus*	N	very slightly reduced in the N and W, advanced to the SW and SE	no
Black-winged Stilt	*Himantopus himantopus*	N	advanced to the N	yes
Green Sandpiper	*Tringa ochropus*	N	very weakly reduced in the S	no*
Wood Sandpiper	*Tringa glareola*	N	slightly reduced in the S	no*
Common Greenshank	*Tringa nebularia*	N	expanded to the S in the Baltic States and Belarus, disappeared in northern Ukraine	no*
Common Redshank	*Tringa totanus*	N	no change	no*
Black-tailed Godwit	*Limosa limosa*	N	noticeable reduction in the S, expansion to the NE	yes
Pallas's Gull	*Larus ichthyaetus*	N	except for ER, observed in Europe only in Ukraine, Moldova and Danube delta	ER
Black-headed Gull	*Larus ridibundus*	N	redistribution in the former range	no*
Little Tern	*Sternula albifrons*	N	redistribution in the former range	no

Species		Direction of range boundary changes in ER	Direction of range boundary changes in EWR	Similarity of range dynamics in ER and EWR
Northern Long-eared Owl	*Asio otus*	N	very slight expansion to the N, very slight contraction in W and S	no*
Eurasian Scops-owl	*Otus scops*	N	expansion to the N	yes
European Bee-eater	*Merops apiaster*	N	expansion to the N	yes
White-backed Woodpecker	*Dendrocopos leucotos*	N	advancing a little to the N in Finland and Baltic States	yes
Moustached Warbler	*Acrocephalus melanopogon*	N	a slight shift of the range towards the N	yes
Paddyfield Warbler	*Acrocephalus agricola*	N	in Ukraine expansion to the N and NE	yes
Barred Warbler	*Sylvia nisoria*	N	disappeared along the western and partly the northern boundary	no
Garden Warbler	*Sylvia borin*	N	the southern boundary has shifted to the N, in the very N some of the squares have disappeared	no*
Common Whitethroat	*Sylvia communis*	N	slight expansion to the N, disappeared along the southern boundary of the range	yes
Collared Flycatcher	*Ficedula albicollis*	N	slight redistribution in the eastern direction	no
Eurasian Treecreeper	*Certhia familiaris*	N	almost unchanged	no
European Greenfinch	*Chloris chloris*	N	expanded to the N in Fennoscandia	yes
Hawfinch	*Coccothraustes coccothraustes*	N	expanded to the N in Fennoscandia	yes
Great White Egret	*Ardea alba*	N, NE	expanded to the N, W and SW	yes
Common Tern	*Sterna hirundo*	N, NE	redistribution in the former range	no*
Syrian Woodpecker	*Dendrocopos syriacus*	N, NE	expanded to the N and NE	yes
Northern Wren	*Troglodytes troglodytes*	NE	very weakly expanded to the N	yes
Eurasian Blackbird	*Turdus merula*	NE	expanded to the NE in Fennoscandia and disappeared in part of the squares in its western parts	yes
Little Grebe	*Tachybaptus ruficollis*	N, E	expanded to the N	yes
Mute Swan	*Cygnus olor*	N, E	extended strongly to the S and SE, slightly to the E and N	yes
Common Shelduck	*Tadorna tadorna*	N, E	the northern population has expanded strongly to the S across Europe, the southern population slightly shifted to the N	yes
Pied Avocet	*Recurvirostra avosetta*	N, E	expanded in all directions	yes
Common Woodpigeon	*Columba palumbus*	N, E	reduced in the S in the Balkans, advanced slightly to the N in Finland	yes
Middle Spotted Woodpecker	*Leiopicus medius*	N, E	expanded to N, NW	yes
Common Stonechat	*Saxicola torquatus rubicola*	N, E	expanded to the N and E	yes
Bearded Reedling	*Panurus biarmicus*	N, E	expanded to the NE, disappeared from squares in the S	yes
Eurasian Penduline-tit	*Remiz pendulinus*	N, E	generally shifted range to the NE, widening the gap in central Europe	yes
Marsh Tit	*Poecile palustris*	N, E	redistribution in the former range	no

Species		Direction of range boundary changes in ER	Direction of range boundary changes in EWR	Similarity of range dynamics in ER and EWR
Black Redstart	*Phoenicurus ochruros*	E, NE	expanded strongly to the N, disappeared in some squares on the southern border	yes
European Serin	*Serinus serinus*	E, NE, SE	advanced to the N and NE, but disappeared in the SE	yes
Yellow-legged Gull	*Larus michahellis*	E	advancing to the N and NE	yes
Woodlark	*Lullula arborea*	E	advanced to the N in Finland and Sweden, to the NE in Ukraine	yes
Ortolan Bunting	*Emberiza hortulana*	E	has shrunk heavily in the S, W and N, expansion in E in areas adjacent to ER	yes
White-tailed Sea-eagle	*Haliaeetus albicilla*	SE	expansion in all directions	yes
European Herring Gull	*Larus argentatus*	S	slightly reduced in the S, redistribution in the rest of the former range	no
Mew Gull	*Larus canus*	S	slight contraction in the N	no
Northern Hawk-owl	*Surnia ulula*	S	slight expansion to the S	yes
Great Grey Owl	*Strix nebulosa*	S	expansion to the S	yes
Black Woodpecker	*Dryocopus martius*	S	slight expansion to the S	yes
Meadow Pipit	*Anthus pratensis*	S	slight contraction in the SE	no
Arctic Warbler	*Phylloscopus borealis*	S	contraction in the W	no
Coal Tit	*Periparus ater*	S	slight expansion to the E, disappeared in many squares on the periphery of the range in the S, W and N	no
Barnacle Goose	*Branta leucopsis*	S, W	no change	yes
Fieldfare	*Turdus pilaris*	S, W	contraction in the W and slight expansion to the S	yes
Grey Wagtail	*Motacilla cinerea melanope*	W	–	ER
Citrine Wagtail	*Motacilla citreola werae*	W	expansion to the W	yes
Common Stonechat	*Saxicola torquatus maurus*	W	–	ER
Orange-flanked Bush-robin	*Tarsiger cyanurus*	W	expansion to the W in Fennoscandia	yes
Little Bunting	*Emberiza pusilla*	W	slight expansion to the S in northern Fennoscandia	yes
Booted Warbler	*Iduna caligata*	W, NW	appeared in Finland and Baltic States	yes
Cetti's Warbler	*Cettia cetti*	W, N	noticeably advanced to the N and a little to NE	yes
Lesser Spotted Eagle	*Clanga pomarina*	W, N, E	reduced in the W, advanced to the S	yes
Caspian Gull	*Larus cachinnans*	N, NW	expansion to the N and NW	yes
Savi's Warbler	*Locustella luscinioides*	N, NW	expansion to the N in Fennoscandia	yes
Red-headed Bunting	*Emberiza bruniceps*	N, NW	–	ER

Species		Direction of range boundary changes in ER	Direction of range boundary changes in EWR	Similarity of range dynamics in ER and EWR
Eurasian Bittern	*Botaurus stellaris*	N, S	expanded to the N and the S	yes
Goosander	*Mergus merganser*	N, S	expanded strongly to the S, SW, and W	yes
Little Gull	*Hydrocoloeus minutus*	N, S	expansion to the NW, disappeared in the SE	yes
Whiskered Tern	*Chlidonias hybrida*	N, S	slight expansion to the NW	yes
Eurasian Jay	*Garrulus glandarius*	N, S	almost unchanged	no*
Greenish Warbler	*Phylloscopus trochiloides*	N, S	expansion to the W and N	yes
European Pied Flycatcher	*Ficedula hypoleuca*	N, S	range contraction in the S	no
Booted Eagle	*Hieraaetus pennatus*	N, E, S, W	contraction of the eastern part of the range in the N, NW, W and SW	no
Eurasian Oystercatcher	*Haematopus ostralegus*	N, E, S, W	expansion to S and N	yes
Whole range shift				
Gadwall	*Mareca strepera*	N, W+ S–	expansion to N, W and S	yes
Pallid Harrier	*Circus macrourus*	N+ S–	almost absent in Europe, started to breed in Finland, but disappeared in Ukraine and Moldova	yes
Jack Snipe	*Lymnocryptes minimus*	N+ S–	very weakly expanded in southern Finland, very marked contraction in the West (in Sweden)	no
Pine Grosbeak	*Pinicola enucleator*	N, E+ S–	significant contraction in W	yes
Range contraction				
Red-footed Falcon	*Falco vespertinus*	N–	contraction in the N and W	yes
Grey Partridge	*Perdix perdix*	N–	contraction in the S and W	no
Corncrake	*Crex crex*	N–	contraction in the W, expansion in the N	no
Lesser Grey Shrike	*Lanius minor*	N–	contraction in the N and W	yes
Pied Wheatear	*Oenanthe pleschanka*	N–	expansion to the NE, disappeared in the S	no
Steppe Eagle	*Aquila nipalensis*	N–, W–, E–	–	ER
Red-throated Loon	*Gavia stellata*	S–	redistribution in the former range	no
Arctic Loon	*Gavia arctica*	S–	contraction in the SE	yes
Northern Pintail	*Anas acuta*	S–	contraction in the S	yes
Willow Grouse	*Lagopus lagopus*	S–	contraction in the S	yes
Black Grouse	*Lyrurus tetrix*	S–	Slight contraction in the south (Alps) and stronger in central Europe	yes
Western Capercaillie	*Tetrao urogallus*	S–	contraction in the S (apart from mountain massifs)	yes
Hazel Grouse	*Bonasa bonasia*	S–	contraction in the S (apart from mountain massifs	yes
Great Snipe	*Gallinago media*	S–	slight contraction in the S	yes
Horned Lark	*Eremophila alpestris*	S–	the range of the northern population has contracted in the S	yes

Species		Direction of range boundary changes in ER	Direction of range boundary changes in EWR	Similarity of range dynamics in ER and EWR
Siberian Jay	*Perisoreus infaustus*	S–, W–	slight contraction in the S and W	yes
Common Little Bittern	*Ixobrychus minutus*	N–, W–	redistribution in the former range	no
European Roller	*Coracias garrulus*	N–, W–	contraction in the N	yes
Horned Grebe	*Podiceps auritus*	N–, S–	in southern countries has disappeared altogether	yes
Greater Spotted Eagle	*Clanga clanga clanga*	N–, S–	disappeared in the south, expanded further north	yes
Saker Falcon	*Falco cherrug*	N–, S–	contraction in the S and the N	yes
Yellow-breasted Bunting	*Emberiza aureola*	N–, E–, S–, W–	disappeared almost everywhere, one square left in Ukraine	yes