# *NUMENIUS ARQUATA* (CHARADRIIFORMES, AVES) ABUNDANCE TRENDS IN AGROLANDSCAPES IN THE SOUTHERN REPUBLIC OF KARELIA (NORTHWEST RUSSIA)

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Olonets grasslands (61.041111° N, 32.931389° E) are the most extensive agrolandscapes in the Republic of Karelia (Northwest Russia), one of the largest spring stopovers of migrating birds in Northern Europe and a breeding area of farmland-associated birds. This territory is essential for the life of many bird species and is listed among international-level Important Bird and Biodiversity Areas of Russia. However, the preservation level of Olonets grasslands is rather low, since only spring hunting has been prohibited in a part of the Olonets grasslands (49 km$^2$) since 1993. Thus, the conservation status of this area and the bird protection measures have to be upgraded and a system should be set up for monitoring the abundance of Red Data Book and other threatened species, which use this territory in certain stages of their life cycle. One of such species is *Numenius arquata* (hereinafter – curlew), many populations of which have both declining abundance and shrinking distribution. This species uses the Olonets grasslands both as a spring migration stopover and as a breeding area. We analysed the curlew registrations obtained in the Olonets grasslands in April and May 1997–2023 during the transect censuses (both transect walks and surveys using a car). We compared these records with both local weather data and grassland use intensity. We also analysed the time dependence of curlew spring abundance on date and year of observations. The research hypothesis was that curlew's abundance decreased in cold spring seasons, in seasons with intensive grassland use, as well as over time. The latter supposition is based on the observations of a curlew population decline in the past decades in various parts of the species' range. The monitoring showed that this species is consistently present in the Olonets grasslands in April – May. Curlews, stopping over on migration, used the grasslands quite evenly, with no clear preference for any specific areas. In the case of breeding, however, they tended to choose the sites most inconvenient for agricultural treatments. The even distribution of curlews over the grasslands was probably due mostly to the individuals foraging in stopovers. In the surveyed part of the Olonets grasslands (49 km$^2$), the size of the local population breeding varied from 30 to 150 pairs in 1999–2023. In 2019–2023, it was 30–90 pairs. In the entire Olonets grasslands (180 km$^2$), the breeding curlew population varied from 100 to 1200 pairs at various years in 1999–2023, but it did not exceed 100–300 pairs in 2019–2023. During the stopping over on migration, the annual number of curlew individuals passing through the surveyed part of the Olonets grasslands was 90–750, while it was 150–2500 birds in the entire Olonets grasslands. So far, we have found no correlation between the total abundance of curlews in the study area and the intensity of grassland use, apparently because stopover and breeding sites are still available. On the other hand, the curlew abundance was lower in warmer spring seasons. Apparently, some curlews fly farther north in such seasons, whereas in colder seasons more birds settle on Olonets grasslands or linger on them on their migration route. Over 25-year retrospective, the total curlew abundance registered in the Olonets grasslands has decreased by 34.4%. In the study area, the negative trend in the species abundance was likely due not only to local but also to global processes, which have caused a decline in some other European populations as well. These birds probably face with certain problems on flyways or in wintering grounds, but more data are needed to verify this conjecture. The local-scope factors that may potentially affect curlew abundance include burning of last year's grass cover, farming intensification, predation, and human disturbance. By assessing possible future changes in the curlew abundance in the Olonets grasslands, we predict that in the coming 30–40 years this species is highly likely to become «endangered» in the study area. To prevent this from happening, it is necessary to conserve the sites where curlews can nest, strengthen the protection regime in the Olonets grasslands (preferably through designation of a high-status Protected Area), and raise public awareness of the need to conserve the species and reduce human disturbance.

**Key words:** agrolandscape, monitoring, Protected Area, protected species, wader

## Introduction

*Numenius arquata* (Linnaeus, 1758) (hereinafter – curlew) is a wader species assessed by the International Union for Conservation of Nature (IUCN) under the Near Threatened (NT) status (BirdLife International, 2023). Some populations of the nominate subspecies, *N. a. arquata* (Linnaeus, 1758), are included in the Red Data Book of the Russian Federation (Sviridova, 2021) under the status «subspecies populations with a decreasing abundance and distribution» (vulnerable species, status in Russia under IUCN classification is VU (Vulnerable) in conservation priority class III). Accordingly, the curlew is listed in the Red Data

Books of most regions in the Russian Federation inhabited by populations of *N. a. arquata*. In Russia, it is protected in at least 40 Protected Areas (PAs) under various statuses (Sviridova, 2021).

In the last edition of the Red Data Book of the Republic of Karelia (2020), the status of the curlew, as a rare species, is 3(NT). It is worth noting that the Republic of Karelia is located at the northern periphery of the species' range, but since the mid-XX century data have been accumulating that the curlew has been expanding its distribution northwards along the western coast of the White Sea (Lappo et al., 2014). At the same time, as stated in the literature, there is a strong deficit of data on the biology of *N. a. arquata* in the north of its range in general (Lappo et al., 2014) and in its Russian part in particular (Douglas, 2020). Thus, the relevance for monitoring of the curlew abundance in the Republic of Karelia arises from the following: (1) poor status of some *N. a. arquata* populations, (2) overall instability of peripheral populations, (3) importance of collecting data on species, distribution of which is changing, (4) poor knowledge of the *N. a. arquata* biology in the north of the Russian part of its range. Since all these aspects are of global importance, data on the curlew in the Republic of Karelia will be wanted both in Russia and abroad.

The monitoring of the *N. a. arquata* abundance in farmlands is important. Although apart from agrolandscapes curlews can nest in wet meadows and marshes, the farmlands are habitats occupied by *N. a. arquata* in the Republic of Karelia at the highest abundance (Zimin et al., 1998; Lapshin et al., 2012; Khokhlova et al., 2023). In 1990–2010, *N. a. arquata* individuals have reportedly been settling in farmlands more often in general than before (Sviridova, 2014). Besides, they actively use farmlands for extensive movements during the breeding period and migration (Zimin et al., 1998; Sviridova, 2021; Khokhlova et al., 2023).

In the Republic of Karelia, Lehtonen (1943) conducted the first studies to provide, among other things, data on the biology of the curlew. Among other results, Lehtonen (1943) found a more accurate delineation of the breeding range of the curlew in the Republic of Karelia. The first summarising review, focusing specifically on the avifauna in the southern Republic of Karelia, was produced by Neifeldt (1958) using data from the literature and original material collected during field trips in 1954–1955. Later, Zimin & Ivanter (1974) carried out extensive avifaunal research covering also the southern Republic of Karelia. These studies were then continued (Zimin et al., 1993, 1998; Artemyev et al., 2016).

Since 1993, spring bird aggregations have been studied in the Olonets grasslands. These data have been partially published, including some data on the curlew (e.g. Zimin et al., 2007; Lapshin et al., 2012; Artemyev et al., 2021; Khokhlova et al., 2023). However, most of the publications based on material from the Olonets grasslands are concerned to Anseriformes (e.g. Artemyev et al., 2009, 2019, 2020, 2022). The pool of data on the curlew in the Olonets grasslands has not yet been fully processed and synthesised.

The aim of this paper was to summarise and analyse data on the curlew abundance dynamics in the Olonets grasslands, southern Republic of Karelia, collected during a special monitoring in 1999–2023. For this purpose, we performed the following tasks: (1) collecting data on the abundance of curlews breeding in the Olonets grasslands and those using this area to stop over on migration; (2) analysing the collected data, including the correlations between abundance trends and selected factors. The working hypothesis was that the abundance of curlews decreased in colder spring seasons, at times of more intensive grassland use, as well as over time. The latter supposition is based on the observations of curlew abundance declining in the past decades in various parts of the species range (Douglas, 2020; Sviridova, 2021; BirdLife International, 2023). Additionally, we have planned to assess possible changes in the curlew abundance in the study area depending on the spring hunting pressure. Curlews are not a hunting target in the area, but they may be disturbed when birds of other species are hunted.

## Material and Methods

### *Study area and methods*

We conducted field surveys in 1999–2023 in farmlands in the Olonets district in the Republic of Karelia (Northwest Russia), situated near the town Olonets (Fig. 1), i.e. so-called Olonets grasslands (61.041111° N, 32.931389° E), as the most extensive agrolandscapes in the Republic of Karelia, covering about 180 km$^2$. Olonets grasslands are one of the largest spring stopovers of migrating birds in Northern Europe and a breeding area of many farmland-associated birds (Zimin et al., 2007). By considering the essential role in the life of many birds, the Olonets grasslands were listed among international-level Important Bird and Biodiversity Areas of Russia (http://www.rbcu.ru/programs/93/).

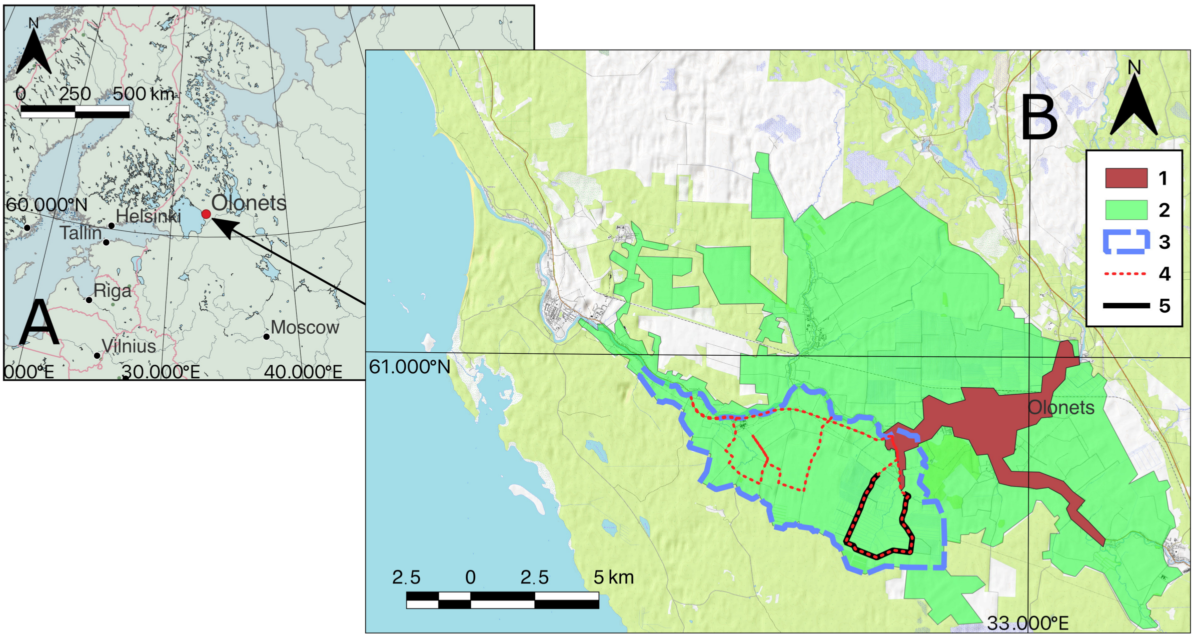


**Fig. 1.** The location of the study area and its key elements. Designations: A – the town Olonets on the map of Europe, B – key elements in the study area; 1 – the town Olonets and adjacent settlements, 2 – farmlands around the town Olonets, 3 – «Non-hunting zone» seasonal sanctuary, 4 – long-term car survey route, 5 – long-term walking survey route.

Over the study period, the situation for birds in the farmlands has changed, i.e. the conditions of the Olonets grasslands have improved considerably: reclamation channels were deepened; drainage pipes were cleaned; trees and shrubs were cut along the field edges. Besides, in the late XX century, the Olonets grasslands were predominantly covered in degenerating perennial grasses, whereas grain and row crops occupied less than 5% of the study area. During the XX century, the farmlands have been exploited more intensively; perennial grasses have been timely renewed; the proportion of grain and legume crops increased up to 15–20%. With the agriculture intensification, the anthropogenic pressure on birds increased accordingly (Zimin et al., 2007; Artemyev et al., 2022).

Being located on highly wet soils, the Olonets grasslands are covered by a net of reclamation channels. Their shores are being densely overgrown with shrub vegetation, represented predominantly by *Salix* sp. Their thickets are cut down periodically. At the end of the winter, strong winds blow snow off by opening the fields' surface. When snow begins melting, water accumulates in depressions. At Olonets grasslands' elevations devoid of snow, thawing of the upper soil layers begins earlier than in typical taiga habitats (Zimin et al., 2007).

In the study area, the spring hunting lasts normally ten days, usually at 01–10 May. However, in 1993, a 49 km$^2$ area of the Olonets grasslands (Fig. 1) was declared a termless local-scope seasonal sanctuary called the «Non-hunting zone». The conservation status of this area changed several times from a municipal-level sanctuary with a special protection regime to one, which has not any protection regime. After losing its Protected Area's status (in 1996), this part of the Olonets grasslands was no longer subject to a special protection regime but retained the «Non-hunting zone» status, so bird hunting is prohibited there in spring (Artemyev et al., 2022).

Additionally, the Olonets grasslands had for a long time been cleared by burning of last year's herbaceous vegetation. There is no custom of mowing after-grass there. Therefore, the dry grass has been burnt down in spring, including the protected parts of the fields. Burning of the after-grass started after its drying up, which depended on the spring weather. Therefore, the after-grass burning began in mid-April or in the third decade of April, by sometimes continuing until mid-May. In the Olonets district, all farming enterprises annually burn out 60–80% (about 55% on average) of their grassland areas (Zimin et al., 2007; Artemyev et al., 2022). The practice of after-grass burning in the grasslands was terminated in 2014 and not resumed later, although this practice has been used again in part of the Olonets grasslands in 2023.

A detailed description of the study area and methods was published in Zimin et al. (2007). The main sampling method was walking transect surveys. The walking survey route (9.5 km long) was along a road passing through farmlands typical in the Olonets district (Fig. 1). Fields with sown perennial grasses prevailed there, while areas of grain crop stubble or arable fields were less frequent. There were brooks flowing through the fields and a developed net of reclamation channels, which are usually full with water in April and early May. Surveyors walked the route in the morning, starting at 6:00–8:00 depending on the weather. As a rule, each survey tour took around 4 h. We counted curlews in strips (up to 50 m, 50–100 m, and 100–150 m wide) by registering individual birds, migrating aggregations and local pairs. The counting of birds by stripes provided the possibility of counting the number of birds per area. In 1999–2009, the routes were walked daily, and each other day since 2010.

An additional method was car transect surveys, meaning that a certain route through the Olonets grasslands (in total, 39.5 km), partially coincident with the walking transect (Fig. 1), was toured by cars during daytime (usually at 15:00–18:00). This way, we separately recorded local and migrating curlews to the maximum detectability distance. To design the car transect, we took into account data on the best possible view-ability of the studied area using binoculars from aboard the car. The conversion of the bird abundance per unit area was based on the area of plots viewed. The car surveys were usually toured daily, but in 2010, 2011, 2012, 2016, and in May 2017, they were conducted each other day. In 2018, 2019 and 2023, car transect surveys were conducted daily during the peak migration time, and every other day in the rest part of the study period every season.

To analyse the obtained data, we used material gathered in the Olonets grasslands from 21 April to 19 May in 1999–2019 and 2023. The studied area of the fields covered almost the entire «non-hunting zone», and accounted for about 20% of the total area of the Olonets grasslands (Fig. 1).

### *Data analysis*

The analysis was based on the absolute abundance of curlews registered on the counting routes. To allow us to compare those with data from other areas, we converted the absolute abundance of bird individuals to the relative abundance. The main studied parameter was the relative total abundance of resident and migrating curlew individuals recorded in the Olonets grasslands. The additional considered parameters were the maximal daily abundance and the peak abundance date in the form of the total number of monitoring days since the beginning of the year. When comparing the data collected by various methods, considering that the car transect (39.5 km) was much longer than the walking transect (9.5 km), we used the material from the 9.5-km long model section of the transect covered by both walking and car surveys (Fig. 1).

To estimate the curlew abundance in the studied part of the Olonets grasslands, we used data from both walking and car surveys. However, when extrapolating data on the bird abundance to the total area of the Olonets grasslands, we used the data from the walking surveys only as providing more accurate information. At the same time, we did not re-calculate the entire area of agrolandscapes (180 km$^2$), but only the area of sites suitable for nesting and stopovers of curlews (with a total area of 84.7 km$^2$), excluding too moisturised sites, roads, and sites overgrown with shrubs or occupied by vegetable gardens.

We analysed temperature effects on the total abundance of curlews using long-term data on air temperature data during the study period, which are openly available at https://rp5.ru. We used the temperature data (for 09:00 h) from the nearest weather station in the town Olonets. For calculations, we used the average values of the mean temperature for the period from 21 April to 19 May.

We analysed the use intensity of the Olonets grasslands on the model area surveyed with the walking transects using QGIS 3.30.2 Hertogenbosch software (QGIS.org, 2022), Google Earth Engine and Google Earth Engine Data Catalog plugins with an open access to historical Landsat 4, 5, 7, 8, and 9 satellite images (Gorelick et al., 2017). As an indicator of the Olonets grasslands use intensity, we used the proportion of cultivated farmlands on the basis of satellite imagery decoding. Data on bird abundance in relation to the spring hunting have been classified into three categories: period before the opening of the hunting season (before 01 May), period of the hunting season (01–10 May), and period after the closing of the hunting season (after 10 May).

The classifying of curlew individuals, feeding on the Olonets grasslands, to local breeding and migrant birds was difficult. The gregarious behaviour of the migrating birds at the stopovers was the main criterion for this purpose. To compensate a possible undercounting of the number of migrating curlew individuals, we applied the following formula to refine the classification during ex situ treatment of data for each study season:

$$N_{tr} = \frac{\sum_{x \in C}(\max Q_4 - E(Q_3))}{N_{all}} \times 100\%,$$

where $N_{tr}$ – the percentage of migrant individuals, $C$ – groups of consecutive surveys between days with below-median values of the bird abundance, $\max Q_4$ – the maximal value in $C$ groups within the fourth quartile, $E(Q_3)$ – the borderline maximal value of third quartile, $N_{all}$ – the total number of counted birds.

To compare the rate of changes in bird abundance over the study period, we used the following formula:

$$\Delta N = \frac{Me_{start} - Me_{end}}{Me_{start}} \times 100\%,$$

where $\Delta N$ – the rate of changes in bird abundance, $Me_{start}$ – the median of the total bird abundance in the first five study seasons, $Me_{end}$ – the median of total bird abundance in the last five study seasons.

All calculations were performed using the R v. 4.1.1 programming environment (R Core Team, 2021), and using RStudio 2021.09.1 Build 372 as the graphical shell (RStudio Builds, 2021). The obtained data series were tested for normality using the Shapiro-Wilk test and for being outlier-free using an «outliers» package (Komsta, 2022). Since most of the data series had a non-normal distribution, in most cases we chose the median as the measure of central tendency and the interquartile range as the measure of dispersion. For temperature indicators, we calculated an average value.

We analysed relationships between data series using Spearman's rank correlation and conducted comparisons between them using the Wilcoxon test for paired samples. To describe the dynamics of numerical attributes, we selected models using the «basicTrendline» package (Mei & Yu, 2020). Before constructing the abundance dynamics models, we tested the data series for autocorrelation in the R software (R Core Team, 2021) using the «acf» function with the lag ranging from 1 to the sample set length. During data pre-treatment, we considered the possibility of abundance parameters being influenced by the number of surveys. The number of surveys within the given time interval varied among years. But we detected no significant correlations between bird abundance in the Olonets grasslands and the number of surveys (Spearman's rank correlation, Rs = 0.38, p = 0.09).

## Results

In late April – May of each year, curlews visited the Olonets grasslands at a total density of 0.4–18.0 individuals per 1 km$^2$ (ind./km$^2$). The majority of the registered birds (73.8% median, varying from 40.0–90.6% among years) were migrants, which used the Olonets grasslands as a stopover. The others were local breeding birds. Curlews mostly appeared in the Olonets grasslands in mixed flocks with *Numenius phaeopus* (Linnaeus, 1758) or in small single-species flocks formed by several individuals to several dozen birds or, rarely, by several hundred individuals.

In 1999–2023, the abundance of curlews observed in one day on a walking transect varied from 3–153 individuals per route (9.5 km). On a complete car route (39.5 km), we daily recorded from several individuals to 460 birds. In 1999–2023, the size of the local bird population breeding in the thoroughly surveyed part of the Olonets grasslands (49 km$^2$) varied from 30–150 pairs per season. In 2019–2023, it was 30–90 pairs per season. We extrapolated these data to the entire area of the Olonets grasslands (180 km$^2$), keeping in mind their inhomogeneity and varying suitability for breeding and staging of curlews. As a result, we found that the size of the entire Olonets grasslands' breeding curlew population in 1999–2023 can be estimated at 100–1200 pairs depending on the year. We found that its size was 100–300 pairs per season in 2019–2023. The annual number of curlews migrating through the surveyed part of the Olonets grasslands was 90–750 individuals, and the estimated number of individuals on the entire area of the Olonets grasslands was 150–2500 birds.

When the curlews stayed in the Olonets grasslands, generally suitable for them as breeding and stopover sites, these birds occupied this territory quite evenly, without clear preference for certain zones. This is confirmed by our results that the bird density was nearly equal in various sampling strips easily viewable with binoculars (Fig. 2). According to our observations, when choosing the nesting sites, most curlew individuals prefer sites, which are most inconvenient for agricultural treatments.

The species' abundance trends remained relatively stable year-to-year throughout the study period (Fig. 3). The basis of the stationary group was formed predominantly by individuals occupying the Olonets grasslands for breeding. On the other hand, migrant individuals stopped over, changing one another. The most massive arrivals and departures were observed in April, with a gradual declining of migrating bird flows in May (Fig. 3).

Walking transect surveys revealed a steady decrease in the curlew abundance over the study period (Fig. 4). Over the 1999–2023 period, the dynamics of the median density values conformed to a linear model with the minimal Akaike information criterion (AIC) (Fig. 4). This model describes the variation of the interquartile range of values of the abundance of counted curlews (Fig. 5). Based on the walking transect surveys, the curlew abundance in the Olonets grasslands generally decreased over the 1999–2023 period by 34.4%. A predictive assessment of further potential changes in the bird abundance using models based both on median values (Fig. 4) and variability indices (Fig. 5) suggests that within the next 30–40 years the curlew can be highly likely recognised as an endangered species in the study area.

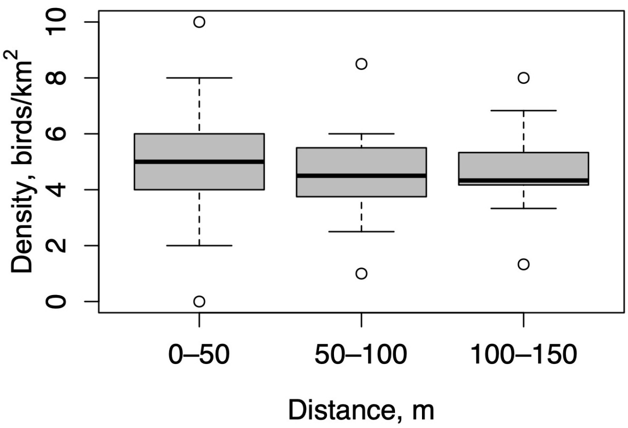


**Fig. 2.** The relative total abundance of curlews in various sampling strips based on results of walking transect surveys. The upper and lower borders of the boxes denote the first and third quartiles; «whiskers» denote the intervals, in which the vast majority of data fall, not exceeding the value of 1.5 interquartile range of values; the horizontal line denotes the median value; circles – outliers.

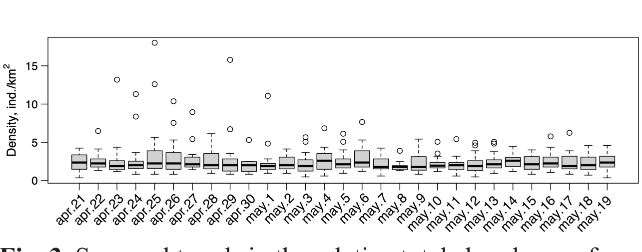


**Fig. 3.** Seasonal trends in the relative total abundance of curlews in agrolandscapes in the southern Republic of Karelia based on data from walking transect surveys in 1999–2019, and 2023. The upper and lower borders of the boxes denote the first and third quartiles; «whiskers» denote the intervals, in which the vast majority of data fall, not exceeding the value of 1.5 interquartile range of values; the horizontal line denotes the median value; circles – outliers.

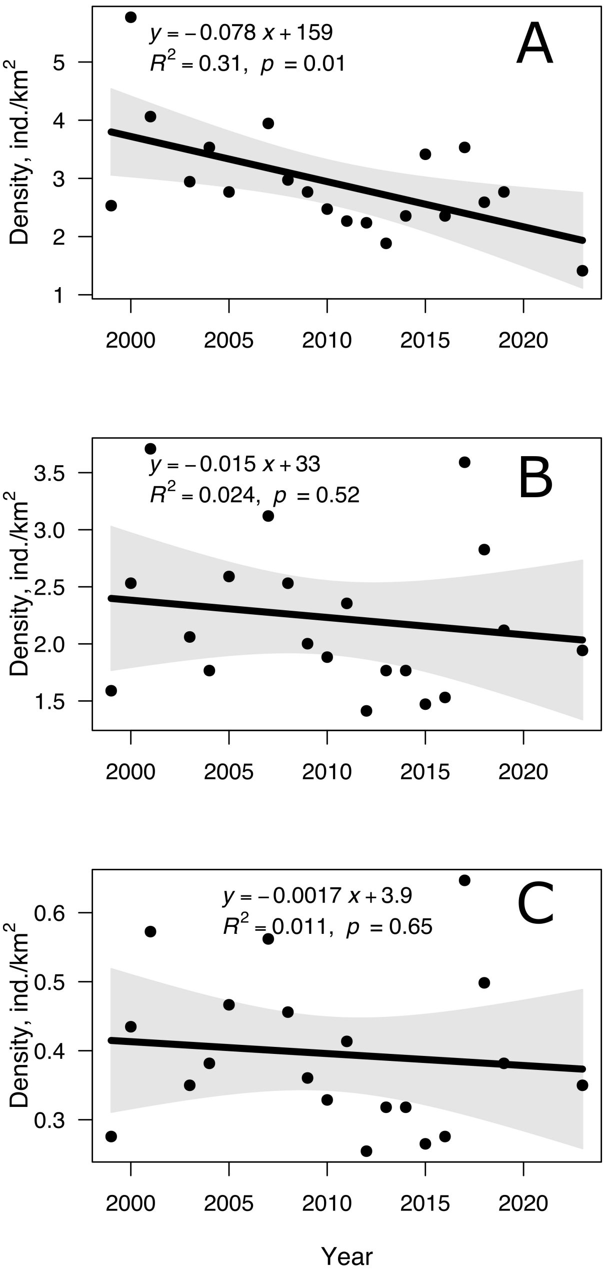


**Fig. 4.** Long-term trends in relative total abundance of curlews in agrolandscapes in the southern Republic of Karelia. Designations: A – based on the results of walking surveys at the 9.5 km long transect, B – based on the results of car surveys at the 9.5 km long transect section concurring with the walking transect, C – based on the results of car surveys at the 39.5 km long transect.

At the same time, car surveys of the same route surveyed during walking surveys (Fig. 1) revealed non-significant ($p = 0.52$) changes in the bird abundance, although the slope of the trend line also indicated a decline (Fig. 4). In general, the results obtained using car transect surveys on the model area, which was studied by both walking and car transect surveys, were in significant agreement with the results of walking transect surveys (Spearman's rank correlation: $Rs = 0.23$, $p < 0.01$), although the positive correlation was weak.

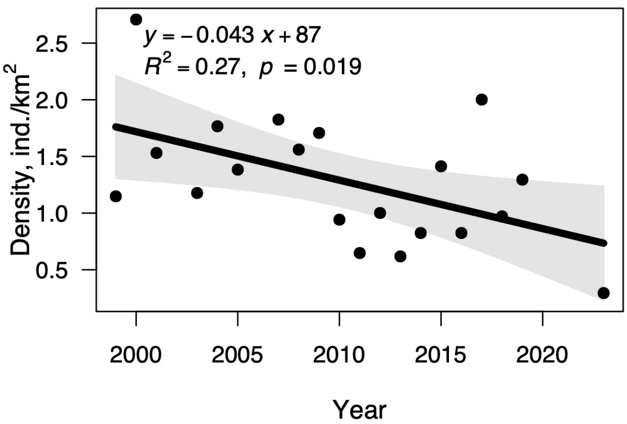


**Fig. 5.** Long-term variation of the interquartile range of values of the relative total abundance of curlews counted during walking transect surveys.

The dynamics of the relative total abundance of curlews was estimated based on the results of complete car transect surveys (Fig. 4). There were no regular patterns in the distribution of median values of the data series produced by car transect surveys. At the same time, the number of outliers in the data series from car surveys significantly exceeds the number of outliers in the data series from walking transect surveys (paired sample Wilcoxon test: $W_{20, 20} = 15$, p = 0.02).

The analysis of the correlation of the bird abundance to the temperature showed a significant negative correlation (p = 0.017) between the number of birds counted on the route and the mean values of air temperature during the observation period (Fig. 6). No correlation was found between the relative total abundance of curlews and Olonets grasslands' use intensity in either walking transect surveys (Spearman's rank correlation: Rs = -0.08, p = 0.75) or car transect surveys of the same routes (Spearman's rank correlation: Rs = -0.39, p = 0.09). We did not find any significant correlation between the migration passage rate (a day with the highest bird abundance) and Olonets grasslands' use intensity either (Spearman's rank correlation: Rs = 0.41, p = 0.07). Our analysis also showed that the spring bird hunting season had no significant effect on the curlew abundance in the «Non-hunting zone» (Fig. 7).

## Discussion

Monitoring of the spring abundance of curlews in the Olonets grasslands in the southern Republic of Karelia in 1997–2023 proved that this species was constantly present there in late April – May. Pioneer individuals arrive in the area at 05–17 April (Khokhlova et al., 2023). We found that the migration period can last until mid-May. The vast majority of the observed birds (about three quarters of all counted curlews on average) were migrant individuals, which use the Olonets grasslands as a stopover site during the migration. Accordingly, the local breeding curlews, accounted for about a quarter of all observed birds. The even distribution of curlews in the Olonets grasslands during the study period was apparently caused mostly by birds stopping during the migration for feeding.

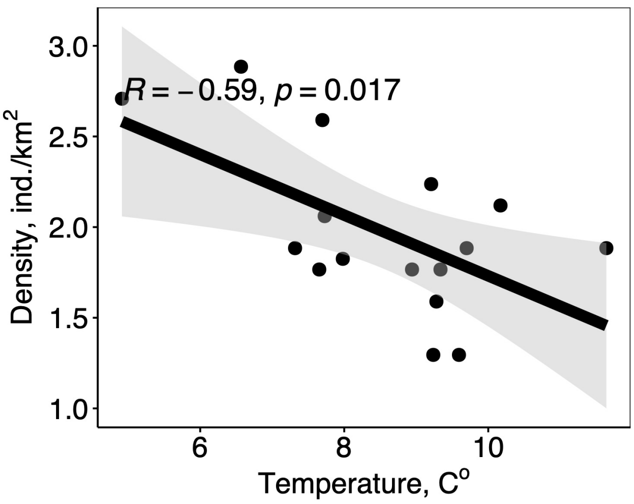


**Fig. 6.** The relationship between the relative total abundance of curlews and the mean air temperature over the annual sampling period based on data obtained at 9:00 from 21 April to 19 May in 1999–2023 (Pearson product-moment correlation).

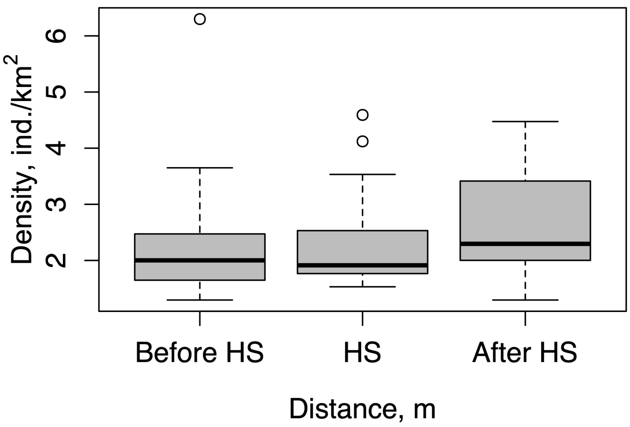


**Fig. 7.** The relative total abundance of curlews in the «Non-hunting zone» area before the opening of the hunting season in adjacent areas (Before HS), period of the hunting season (HS), and period after the closing the hunting season (After HS). The upper and lower borders of the boxes denote the first and third quartiles; «whiskers» denote the intervals, in which the vast majority of data fall, not exceeding the value of 1.5 interquartile range of values; the horizontal line denotes the median value; circles – outliers.

The breeding grouping of curlews in the Olonets grasslands can be considered quite large in European Russia. The density of curlew individuals using this area for breeding was even higher in the last years. For instance, 400–1200 curlew pairs were registered in the Olonets grasslands in late 1990s – early 2000s (Zimin et al., 2009). In the regions adjacent to the Republic of Karelia, Vologda Region (Butiev et al., 1998), Arkhangelsk Region (Butiev & Shitikov, 1998; Sviridova, 2020), and Leningrad Region (Noskov et al., 2016; Golovan & Khrabry, 2018), the curlew populations were relatively stable, but they did not form large breeding groups. In the Murmansk Region the curlew is rare (Noskov et al., 2016). In the centre of European Russia the abundance of breeding curlew groups is also relatively low; for instance, the size of breeding groups here varies from single pairs to several dozen pairs (e.g. Ivanchev, 2011; Tyulkin, 2012, 2020; Galchenkov, 2017; Bykov et al., 2018).

Our data on long-term trends in the abundance of the birds counted in the Olonets grasslands quite varied depending on the sampling method. The results of walking transect surveys pointed to a steady decline in the curlew abundance over the study period, whereas car transect surveys showed only a downward tendency in bird abundance, without any significant change. The lack of complete agreement between the curlew abundance indices produced by various methods can be caused by both the various time of the conducted surveys (walking transect surveys were performed in the morning, while car surveys during daytime) and the unequal performance of the various sampling methods in bird registration. We believe that the walking transect survey method more accurately represents the actual curlew abundance in the grasslands. This is indirectly evidenced by the fact that the bird density within various sampling strips was highly similar. In general, according to walking transect surveys, the total curlew abundance in the Olonets grasslands decreased by 34.4% over the 25 years.

On the other hand, the substantial length of the car transect, which is considerably longer than the walking transect, allows us a better chance to capture a short-term local rise in the bird abundance. This is also evidenced by the large number of outliers in the car survey data. As a rule, such local concentrations of birds were associated with the migration process. In addition to the migration, a short-term rise in bird density and appearance of actively moving individuals could be a consequence of mass destruction of nesting sites as a result of burning of the last-year's vegetation or other farmland treatments.

We also found a higher curlew abundance in colder spring seasons. A possible explanation is that in colder springs birds of northern curlew populations partially delay along the migration by migrating northwards at a later period. It is also likely that some curlew individuals in cold springs stay to nest southwards of their usual breeding sites, thus enlarging the size of local curlew population of the Olonets grasslands. However, both of these assumptions require further research. Regarding the influence of grassland use intensity, our data revealed no significant correlations of the curlew abundance with this factor. It appears that variations in the grassland use rate in the study have little impact on the breeding bird density of the curlew. For any type of observed exploitations, suitable nesting sites were retained in the Olonets grasslands. Even burning of the last year's vegetation allowed curlews to nest in the Olonets grasslands after the herbaceous cover had regenerated.

Thus, the decrease in the curlew abundance in the Olonets grasslands can hardly be attributed solely to the local conditions. Reasons for that should probably be sought in the situation along the entire migration ways and in wintering sites, as well as by comparing our findings with data from other regions used by the curlew. In European Russia, the abundance of nominate subspecies (*Numenius a. arquata*) decreased at least since 1970s–1990s (see Tomkovich & Lebedeva, 1998, 1999; Butiev, 2001). Since the 1980s, its decline was 5–30% (BirdLife International, 2015; Mishchenko et al., 2017). In many regions of European Russia, the curlew abundance continues declining, but in some areas its decrease has stopped in the early XXI century (Sviridova, 2021). In the northern European Russia, the curlew abundance has remained relatively stable in 2000–2020 (Noskov et al., 2016; Golovan & Khrabry, 2018; Sviridova, 2019, 2021). In southern regions of European Russia, however, especially in the Middle Volga Region, the bird abundance decreased considerably over 2000–2020 (Sviridova, 2021).

A more critical (than in European Russia) decrease in the curlew abundance has occurred in other European countries (BirdLife International, 2023; Rigal et al., 2023). In particular, a considerable decline of the curlew abundance was found in the United Kingdom (Harris et al., 2014; Hayhow et al., 2014), Ireland (Balmer et al., 2013; Booth Jones et al., 2022), and Estonia (Elts et al., 2013). Starting since the 1980s, a long-term decrease of this species' abundance has been observed in Norway, Sweden, and Finland, among which the curlew abundance has stabilised only in Finland in 2001–2012, whereas in Sweden and Norway its values are still declining (BirdLife International, 2015). A long-term abundance decline since the early 1980s has also been recorded in the Netherlands and Germany. The decline is still continuing in the Netherlands, while in Germany the curlew abundance became more stable (Hötker et al., 2007; BirdLife International, 2015). In some other European countries, a decrease in curlew abundance was also noted. In general, European population of the curlew decreased by 30–49% over the period 1980–2015. Thus, over 30 years, its European population lost around a third of its original size (BirdLife International, 2015).

In Central Asia, the decrease in abundance of the nominate subspecies has also been registered, while the abundance of breeding curlews in Eastern Siberia has likely remained stable (BirdLife International, 2023). An increase in abundance of the wintering curlew populations was observed all along the East Atlantic flyway (van Roomen et al., 2015), including the so-called Wadden Sea, a part of the North Sea, with a discontinuous series of intertidal flats near the coasts of the Netherlands, Germany, and Denmark (Laursen, 2005; Laursen & Frikke, 2013; Kämpfer & Fartmann, 2022), and the curlew population on the Adriatic coast, and in East Asia (BirdLife International, 2023). An increase in the curlew abundance in the mentioned wintering populations may indirectly evidence of the curlew abundance increase in some of the Russian breeding populations (BirdLife International, 2023). Other possible explanations or contributing factors for the discrepancy between breeding and wintering trends include data limitations and trends being obscured by a climate-mediated shift in the wintering range (Brown, 2015; BirdLife International, 2023). In general, the analysis of the compiled trend data indicates that during the last 15 years the size of the global curlew population declined by 26–34% (Hillis, 2003; Thorup, 2006; Wetland International, 2006; Eaton et al., 2007; BirdLife International, 2023).

Summing up, based on our data and the literature analysis, we suppose that the negative trends in the curlew abundance in the Olonets district in the Republic of Karelia are driven not only by local factors but also by certain global processes, which have caused a decline in some other European populations as well. These birds are likely affected by negative factors on the migration flyways or on wintering sites, although further research is needed to verify this assumption. It is also predicted that climate changes may have a detrimental effect on the curlews during the breeding seasons (Huntley et al., 2007; Renwick et al., 2012; Franks et al., 2017). Wetland area decline caused by climate warming is already considered a reason for a decrease in the abundance of waterfowl and shorebirds (e.g. Delany et al., 2009; Melnikov & Gagina-Scalon, 2014; Krivenko, 2021). The extension of renewable energy sources, such as wind farms, may also affect breeding curlew populations, but more studies are required on this matter as well (Pearce-Higgins et al., 2009). Furthermore, being susceptible to the bird influenza, curlews may be at risk during future outbreaks of the virus (Melville & Shortridge, 2006).

The local-scope factors that should be mentioned as producing a certain negative effect on the curlew abundance are the burning of the last year's herb vegetation, farming intensification, predation, and human disturbance. The first two factors are the most critical, especially herb cover burning, which damages all early nests and undermines the foraging resources available to curlews. The high mortality of eggs and chicks due to intensive agriculture (e.g. Tuellinghoff & Bergmann, 1993; Grant, 1997; Fisher & Walker, 2015), human disturbance (Boschert & Rupp, 1993) and high predation pressure (Berg, 1992; Colhoun et al., 2015; Zielonka et al., 2019) are the main risks in cultivated farmlands and other fragmented landscapes (del Hoyo et al., 1996; Valkama et al., 1999; Douglas et al., 2014). In the Olonets grasslands, curlews are being partially «saved» because they predominantly nest in areas inconvenient for agricultural treatments (e.g. tillage, harvesting), i.e. in the margins, amid rough terrain, near shrub stands. Exactly the loss of such marginal habitats and similar nesting sites, as a consequence of agriculture intensification and enhancement, was one of the main causes of the curlew abundance decline in Europe (Johnsgard, 1981; Baines, 1988; Berg, 1992; del Hoyo et al., 1996; Franks et al., 2017; Douglas et al., 2021). On the other hand, curlews cannot nest in areas put out of the agricultural use due to the fact that land gets rapidly overgrown by tall herbs, shrubs, and forest (Broyer & Roche, 1991; Melnikov, 2017; Sviridova, 2021; BirdLife International, 2023).

According to our data, the season of spring hunting on Anseriformes in the studied part of the Olonets grasslands did not have a significant impact on the curlew abundance. This is partly caused by the fact that our study has been carried out in the «Non-hunting zone», where hunting impact on birds is minimised. In areas, where the spring hunting is being performed, the disturbance factor is possibly more impactful for the birds, and the hunting negatively affects the local bird population in such territories. Spring hunting of curlews is prohibited in Russia. However, in the study area, poachers shoot some of them. Other curlews are undoubtedly under anxiety during the hunting season due to gunshots, vehicle and hunters on nesting sites and hunting-induced massive movements of *Anser* and *Barnacle* species. It is worth noting that hunting has been one of the causes of the abundance decline in some European curlew populations (Johnsgard, 1981). In addition, the natural predators in the Olonets grasslands, capable of ravaging the nests of curlews, are Corvidae, Accipitriformes and Falconiformes, as well as *Vulpes vulpes* (Linnaeus, 1758), *Nyctereutes procyonoides* (J.E. Gray, 1834), and Mustelidae (our data). However, some nests can be ravaged by dogs searching the Olonets grasslands, including the «Non-hunting zone», for wounded game during the hunting season and immediately after this.

The risks listed above are aggravated by the fact that both nests and broods of curlews remain threatened by external negative factors; for instance, eggs are incubated for 26–29 days, and the young chicks can fly only after 5–6 weeks of age (Sviridova, 2021). The high risks over such a long period result in a low reproductive success. Specialists are seriously concerned on a tendency to an increase in frequency of curlew nesting in crop lands, where the breeding success is highly unstable, down to zero (Sviridova et al., 2016). According to various authors (Sviridova et al., 2008; Brown, 2015; Baines et al., 2023), the breeding success in curlews varied depending on years and habitats from 26% to 97%, and in Europe the ratio of the juvenile individuals, starting to fly, per pair of adults varies from 0.27 to 1.05.

The low hatching and chick survival rates in breeding areas are considered the main causes of the decrease in the curlew abundance in 1980–2015, while the survival rate of adult birds is quite high (Brown, 2015). In some regions, the negative influence of the low reproductive success on the total abundance still remains «smoothed down» due to the long life span, typical for the curlew. Gradual ageing of birds in a population with low reproductive success may, however, be resulting in a substantial decline in the nearest future. In many regions of Russia, the abundance of breeding curlews is already now at or below the self-maintenance threshold (Sviridova, 2021). Our predictive assessments of potential future changes in the curlew abundance in the Olonets grasslands suggest that within the next 30–40 years this species is highly likely to become threatened in the study area.

Timely actions are needed to counteract the mentioned threats. Despite the fact that in the «non-hunting zone» we revealed no significant influence of hunting in adjacent areas on birds, as well as of the grassland use intensity, we cannot exclude the possible influence of these factors in the future. It is necessary to conserve curlew breeding habitats, strengthen the protection regime in the Olonets grasslands (preferably through designation of a high-status Protected Areas in the «non-hunting zone»), and widely promote the idea of the curlew conservation and reduce the human disturbance. The currently adopted measures for protecting the migratory bird stopover sites in the Olonets grasslands are insufficient, and they do not match their conservation value and the national and international importance for conservation of European migratory bird populations. To preserve them, proposals for a Protected Area establishment with a special protection regime have been developed (Artemyev et al., 2009, 2022), which can have a positive effect on the abundance of various bird species, including curlews.

## Conclusions

Olonets grasslands in the southern Republic of Karelia are an annual breeding and stopover area for the curlew, a Red Data Book species. Its population status has been of global concern since the 1980s. Since 1999 a decline in the curlew abundance has been found in the study area. The results of walking transect surveys showed that over 1999–2023 the total spring abundance of curlews in the Olonets grasslands decreased by 34.4%. The local breeding population of curlews is currently 100–300 pairs, and the abundance of curlews migrating through the Olonets grasslands is 150–2500 birds per year.

Our study has found no evidence that the decline in the curlew abundance depends on the grassland intensity use or bird disturbance during the spring hunting on Anseriformes. On the other hand, the curlew abundance is directly correlated with the local weather conditions, e.g. the curlew density in the Olonets grasslands was lower in warmer spring seasons.

The material collected through the surveys and analysis of the literature suggested that the negative trends in the curlew abundance in the study area are driven not only by local factors but also by some global-scale processes, which cause the abundance decline in other parts of the species range as well. Curlews are probably exposed to negative impacts along flyways or in wintering sites. But additional research is needed to verify this assumption. Other factors presumed to threaten various curlew populations include climate changes, promotion of renewable energy sources, and infections.

In stopovers and breeding areas, the curlew abundance can be affected by burning of last year's herb vegetation, farming intensification, predation, and human disturbance. A long time of both brooding and becoming self-sufficient by juveniles make birds sensitive to these threats. Being considered together, this leads to the low success in curlew reproduction, especially in agrolandscapes. The gradual ageing of birds in a population coupled with a low breeding success may lead to a critical decline in the curlew abundance in the nearest future (Sviridova, 2021). According to our assessments, the curlew abundance in the Olonets grasslands may be decreased to a minimum in the next 30–40 years, estimating this species at the endangered protection category. To counteract these negative predictions, a set of actions is needed to conserve the habitats suitable for curlew breeding, to strengthen the protection regime in the Olonets grasslands (preferably through establishment of high-status Protected Areas), and to promote public awareness of the need to preserve the curlew and reduce its disturbance.

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# ДИНАМИКА ЧИСЛЕННОСТИ *NUMENIUS ARQUATA* (CHARADRIIFORMES, AVES) В АГРОЛАНДШАФТАХ ЮЖНОЙ КАРЕЛИИ (СЕВЕРО-ЗАПАД РОССИИ)

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Олонецкие поля (61.041111° N, 32.931389° E) являются крупнейшими агроландшафтами Республики Карелия (северо-запад России), одним из мест наиболее массовой концентрации птиц на весенних миграционных стоянках в Северной Европе и местом гнездования видов, связанных с сельскохозяйственными угодьями. Эта территория играет важную роль в жизни птиц многих видов и включена в список Ключевых орнитологических территорий России международного значения. Однако уровень ее охраны невысок – на части Олонецких полей (49 км$^2$) с 1993 г. запрещена лишь весенняя охота. Поэтому необходимо повышение природоохранного статуса этой территории и мер защиты птиц, а также ведение мониторинга численности охраняемых и уязвимых видов, использующих ее на разных этапах годового цикла. Одним из таких видов является *Numenius arquata* (далее – кроншнеп), вид с сокращающейся численностью и распространением многих популяций. Этот вид использует Олонецкие поля как для остановки на весенней миграции, так и для гнездования. Мы проанализировали данные регистраций кроншнепов на Олонецких полях, полученных в апреле – мае в 1999–2023 гг. методами пеших и автомобильных маршрутных учетов. Эти данные мы сопоставили с данными по температуре воздуха и по уровню хозяйственной эксплуатации полей, а также проанализировали временную зависимость весенней численности кроншнепов от даты и от года наблюдений. Рабочая гипотеза заключалась в предположении, что численность кроншнепов снижается в сезоны с холодными веснами, в сезоны с интенсивной эксплуатации полей, а также с течением времени. Последнее предположение связано с отмеченным в минувшие десятилетия сокращением численности кроншнепов в разных местах видового ареала. Собранные данные показали постоянное присутствие особей этого вида на Олонецких полях в апреле – мае. Отмечено, что в период миграции кроншнепы равномерно использовали участки полей, в целом пригодные для их гнездования и остановок, не отдавая явного предпочтения каким-либо зонам. Однако в качестве мест гнездования они выбирали участки, наиболее неудобные для сельскохозяйственной обработки. По-видимому, равномерное распределение кроншнепов по полям было преимущественно обусловлено особями, кормящимися на миграционных остановках. Величина части местной популяции, гнездящейся в обследуемой зоне Олонецких полей (49 км$^2$), в 1999–2023 гг. изменялась от 30 до 150 пар. При этом в 2019–2023 гг. она составляла 30–90 пар. Гнездящаяся группировка кроншнепов на всех Олонецких полях (180 км$^2$) в 1999–2023 гг. насчитывала 100–1200 пар в разные сезоны. При этом в 2019–2023 гг. ее величина не превышала 100–300 пар. На миграции в обследуемой части Олонецких полей ежегодно останавливалось 90–750 особей кроншнепа, а на всех Олонецких полях в целом – 150–2500 особей. На настоящий момент не было выявлено зависимости общей численности кроншнепов в районе исследований от интенсивности эксплуатации полей, что, видимо, связано с сохранением мест, пригодных для миграционной остановки и гнездования. В свою очередь, было отмечено снижение численности кроншнепов в весенние сезоны с более теплой погодой. По-видимому, в такие сезоны часть кроншнепов улетает дальше на север. В более холодные сезоны больше птиц оседают на этих полях или задерживаются на них на трассе миграции. В многолетнем аспекте, за 25-летний период, было зарегистрировано снижение на 34.4% общей численности кроншнепов, регистрируемых на Олонецких полях. Видимо, негативная динамика численности кроншнепа на территории исследования была обусловлена не только местными факторами, но и глобальными процессами, вызывающими сокращение численности изученной и ряда других европейских популяций. Вероятно, эти птицы сталкиваются с определенными проблемами на путях миграции или зимовок, но это предположение требует проведения дальнейших исследований. Среди факторов местного значения, потенциально способных оказать негативное влияние на численность кроншнепов, следует назвать выжигание прошлогодней травы, интенсификацию сельскохозяйственных работ, хищничество и беспокойство птиц человеком. Наши результаты прогнозирования возможностей дальнейшего изменения численности у кроншнепов на Олонецких полях свидетельствуют о том, что в течение 30–40 лет изучаемый вид здесь с высокой вероятностью может перейти в разряд «исчезающие». Для предотвращения этого необходимо сохранять места, в которых кроншнепы могут гнездиться, усилить режим охраны полей (желательно с созданием особо охраняемых природных территорий высокого статуса) и проводить среди населения пропаганду охраны кроншнепа и снижения степени его антропогенного беспокойства.

**Ключевые слова:** агроландшафт, мониторинг, особо охраняемая природная территория, охраняемый вид, кулик