ISSN 1995-4255, Contemporary Problems of Ecology, 2021, Vol. 14, No. 5, pp. 492–499. © Pleiades Publishing, Ltd., 2021.
Russian Text © The Author(s), 2021, published in Sibirskii Ekologicheskii Zhurnal, 2021, No. 5, pp. 613–622.

Ecological and Geographical Analysis of Ornithocomplexes of the Tobol–Irtysh Forest Steppe and Steppe of Western Siberia and North Kazakhstan in the First Half of Summer

S. A. Soloviev[a], * and L. G. Vartapetov[b], **

[a] *Omsk State University, Omsk, 644077 Russia*

[b] *Institute of Systematics and Ecology of Animals, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 630091 Russia*

**e-mail: solov_sa@mail.ru*

***e-mail: lev@eco.nsc.ru*

Received March 28, 2021; revised April 5, 2021; accepted April 6, 2021

Abstract—According to the results of bird counts carried out in 140 habitats over 12 years, a hierarchical classification and a structural graph of the similarity of ornithocomplexes in the lowland southwestern part of Western Siberia and North Kazakhstan have been compiled in the period from 1982 to 2002. The hierarchical classification contains ten types of bird populations. The similarity graph is built at the level of types and is represented by three rows (trends). One row consists of bird complexes of residential and recreational areas, the second from wetlands, and the third from forest, forest-field, and steppe habitats. The characteristics of taxa of the classifications contain information on the three most numerous bird species (leaders in abundance), their share in the community, population density, and the background species richness. Based on the assessment of the degree of coincidence of the similarity of bird communities and environmental factors, a hierarchy of the impact of the main anthropogenic and natural factors determining the formation of the bird population has been established.

Keywords: birds, ornithocomplexes, cluster analysis, environmental factors, correlation

DOI: 10.1134/S1995425521050152

INTRODUCTION

The summer population of birds in the lowland southwestern part of Western Siberia and North Kazakhstan remains poorly studied (Soloviev, 2012). This area is constantly affected by the development of agricultural and residential landscapes, as well as, with a high probability, climatic changes. According to the available forecast (Pavlov and Gravis, 2000), the southern boundary of permafrost in Siberia (and hence, to the south of the located natural zones) may move up to 600 km to the north by the middle of the 21st century. Possible aridization may cause desertification in the south of the area under consideration and further deforestation in its north. Therefore, it is so necessary to fix the current ecological state of bird communities in the south of Western Siberia in order to assess the ongoing and possible changes in ecosystems here. Quantitative assessments of bird populations by us and others, including those carried out on a landscape basis, serve to develop international systems of ornithological monitoring, mainly aimed at identifying population trends of nesting and migratory birds (Gregory, 2000; Svensson, 2000; Sanderson et al., 2006; Gregory et al., 2007). In Russia, the landscape-typological approach to ornithological monitoring is aimed at solving general problems of environmental monitoring, as well as the conservation and restoration of biological resources and biodiversity (Garmaev et al., 2016).

The purpose of the present article is a generalized ecological–geographical analysis of ornithocomplexes of the forest steppe and steppe of the southwestern part of Western Siberia and North Kazakhstan.

MATERIALS AND METHODS

To analyze the structure and organization of the bird population in the region under study, we used data on the number of birds collected during their counts in 1986–1988 and 1997 in the southern forest steppe, including in the city of Omsk and its environs. In the northern forest steppe of the Irtysh region, bird counts were carried out by the author in 1998–2001 and, in 1999 and 2002, in the northern steppe. Blinova and Blinov (1997) collected them in the forest steppe of the Tobol region in 1982–1984 and in the northern steppe of the Turgai meridional depression in 1986. In total, to characterize the bird population of the Tobol–Irtysh forest steppe and the steppe of Western

Siberia and North Kazakhstan, data on 140 bird habitats in the first half of summer (nesting period) were used. The total length of bird counting routes is more than 10570 km. In addition, for an additional 408 km, rare birds not found on the main routes were taken into account.

The methodology for counting birds is detailed in an article by Ravkin and Livanova (2008). To generalize information on the territorial heterogeneity of bird communities, as well as identify the main structure-forming environmental factors, nonlinear statistical methods, including cluster analysis, were used in the work. When describing the spatiotypological structure of the bird population, the results of the analysis of the similarity graph were used. The Jaccard–Naumov coefficient was used to construct it (for quantitative features). Structural graphs illustrate the change of communities by biotopes, allow one to identify the main trends (lasting, and not only local, changes) by significant connections between taxa of the performed classifications, and represent a modification of hierarchical classifications (taking into account not only the intragroup similarity of communities, but also their intergroup proximity). These methods help form a more representative and necessary set of structure-forming environmental factors and their indistinguishable combinations (natural regimes) that are sufficient for description. To assess the strength of the relationship between the heterogeneity of bird communities and the factors correlating with it, we used a linear qualitative approximation of the relationship matrices (one of the methods of regression analysis) (Ravkin and Livanov, 2008). A multiple assessment of the strength of the connection of all factors and regimes with the territorial heterogeneity of communities allows one to judge the degree of informativeness of the presented ideas and the correlation of the action of the factors with each other.

Environmental factors were identified based on the results of cluster analysis. For example, if the set of variants of the bird population is divided by similarity into three clusters, in which the first includes forest communities, the second includes territories where forested areas alternate with open ones, and the third is only open habitats, then we can assume that the heterogeneity of the sample coincides with the factor of afforestation. It is represented in the form of three visible nominal grades: high, medium, and low afforestation. In the future, these expert gradations can be used to assess the relationship with this factor of community variability. Natural regimes are also identified based on the results of cluster analysis, when the selected groups of ornithocomplexes are formed by indecomposable combinations of environmental factors.

The main objective of our study is related to the identification of spatial trends in the bird population and environmental factors that determine these changes. The results of the classification of the entire set of communities after one or two repeated aggregations were considered as dividing by population types.

The specific names of birds are given according to Stepanyan (2003). The materials and all basic calculations were processed using the programs of the laboratory of zoological monitoring of the Institute of Systematics and Ecology of Animals in Novosibirsk. K.V. Toropov took part in the summer of 1987, and we express our deep gratitude to him.

RESULTS

The bird population in the first half of summer is represented by three supertypes of ornithocomplexes: I. undeveloped land (except for recreational and ruderal); II. residential, recreational, and ruderal territories; and III. aquatic and semiaquatic communities. Further, the bird communities are united by similarity into ten types: forest field, floodplain forest meadow, meadow-steppe, field, low-bog, lake, Irtysh River, Protobolsk River, residential, landfills, and municipal waste-disposal sites.

Spatial and Typological Structure of the Bird Population

The spatial typological structure of bird communities in the Tobol–Irtysh forest steppe and the steppe of Western Siberia and North Kazakhstan for the first half of the summer can be represented in the form of three interconnected population systems: undeveloped land (one to four types), water and near-water communities (five to eight types) and built-up areas (nine and ten types) (Fig. 1). The structure graph is based on the previously published classification of bird communities in the Tobolo–Irtysh forest steppe and steppe of Western Siberia and North Kazakhstan (Solov'ev, 2012).

The first is formed by communities of forest-field, floodplain forest-meadow, meadow-steppe, and field types. The second is the population of birds of the lowland marsh, lake, and river: the Irtysh and Protobolsk types; the third is synanthropic ornithocomplexes. Due to the significant watering of sedge-reed lowland bogs in the region in the first half of summer, this type of bird population is attributed to the aquatic–semiaquatic group of habitats. In the first system, the leaders include (as the forest cover decreases) forest species (forest pipit, chaffinch, and gray warbler). Then they are replaced by birds of mosaic forest field habitats (magpie, rook, and field sparrow), followed by meadow–field species (lark, yellow wagtail, and lapwing).

Thus, the territorial heterogeneity of the birds in the vertical row of the graph coincides with a decrease in afforestation from above-floodplain split forests (type 1) to dried-up floodplain landfills (type 2). Then, changes in the spatial heterogeneity of the bird population occur to open field habitats (type 4) through slightly forested meadow–steppe variants of

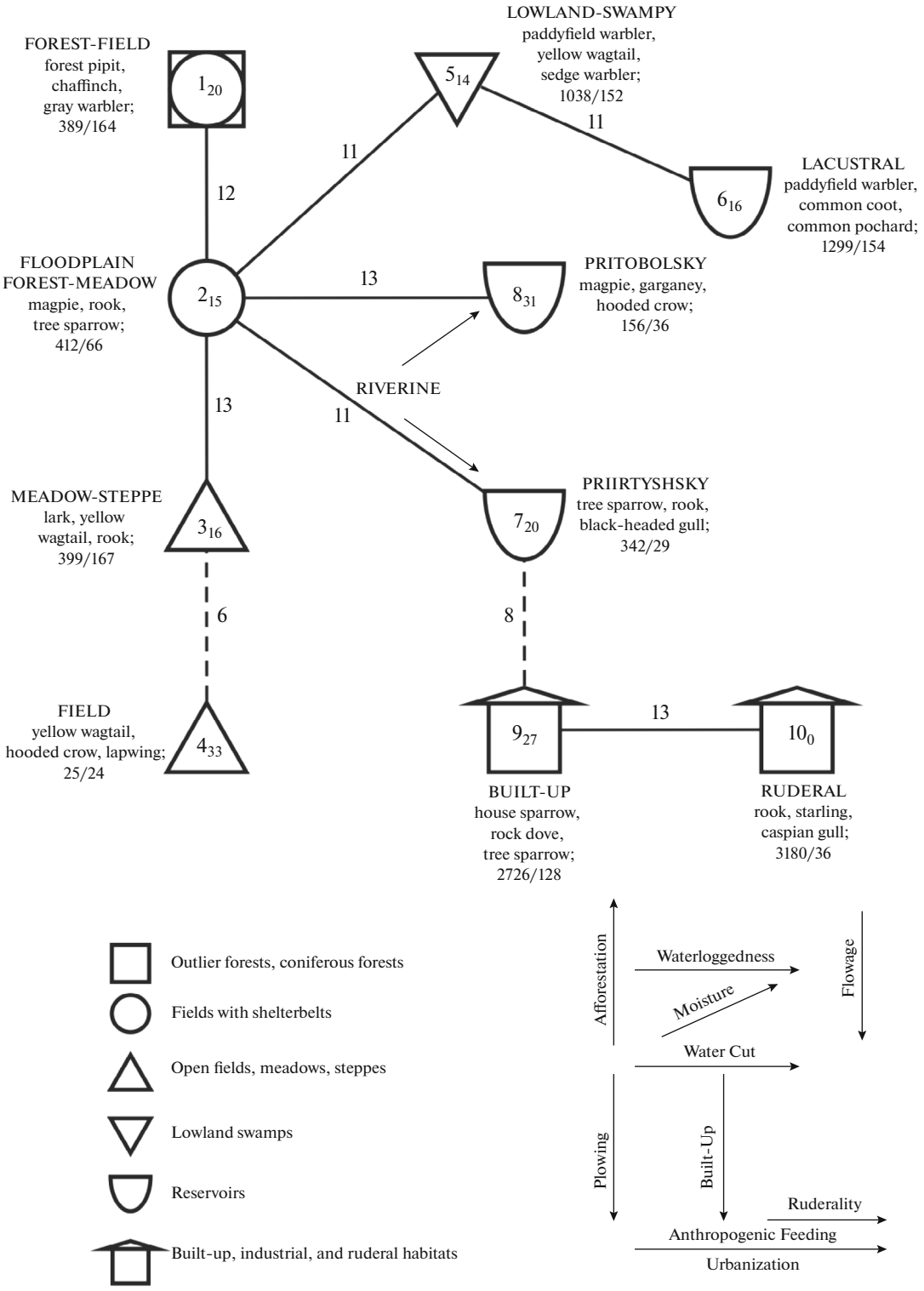

Fig. 1. Spatiotypological structure of the bird population of the forest steppe and steppe in the first half of summer (at the level of population types). Ornithocomplexes: (1) forest–field habitats, (2) partially forested habitats, (3) meadow–steppe, (4) field, (5) lowland swamp, (6) lake, (7) Irtysh River, (8) Pritobolsk River, (9) residential, and (10) landfills and landfills utilization of municipal waste. The numbers in Fig. 1. are type numbers and indices are the value of intratype similarity. The similarity of the classes is depicted approximately in the opposite scale (the greater the similarity between the classes, the smaller the distance). Numbers in circles, rectangles, etc. are type numbers; indices are values of intraclass similarity. Solid lines indicate strong resemblance. For each type, the leader species are indicated (on average, according to the variants of the bird population included in them). Arrows are the main directions of changes in communities and environmental factors.

the population (type 3). In the same direction, along this series, a change in bird communities associated with the agricultural transformation of landscapes (plowing) is traced.

Along with this, the diagram reveals the second group of types. It differs from the main series in terms of the degree of watering of habitats and the flow of water bodies. The diagonal row from floodplain meadow communities with areas of oxbows of the Irtysh passes to communities of low-lying bogs (type 5). Then, as the moisture content, bogginess, and waterlogging increase, this series ends with a lake type. As the moisture content, bogginess and waterlogging increase among the dominant species, the prevailing yellow wagtail is replaced by the coot and redhead, which dominate the lakes. In the fifth class of ornithocomplexes, the leaders also include the badger and the Indian warbler. The latter species is recorded in the lacustrine class, together with the coot and redhead. Also, from the second floodplain forest-meadow type, a number of changes were revealed to the group of watered, reed, and shrubby habitats. It is associated with the river Protobolsk type, where magpie, teal cracker, and hooded crow predominate on Tobol and along its banks. Completely different birds, including synanthropic birds (field sparrow, rook, and black-headed gull), lead on the anthropogenically transformed rivers of the Irtysh region. An increase in the flow of forest-steppe and steppe lakes and rivers is well-expressed among types of this group. From the 6th lake type, the increase in flow passes through the middle watercourse: the Tobol (a first-order tributary of the Irtysh River, type 8) to the Irtysh and its tributary Omi (type 7).

The third system of the structural graph at the bottom of the diagram is represented by the classes of the synanthropic population. Bird communities of residential habitats (type 9, house sparrow, rock dove, and field sparrow) with increased anthropogenic feeding capacity and shelter are replaced by ornithocomplexes of the ruderal type. This type differs significantly according to the list of leaders from the subsequent ruderal type (rook, starling, and gull). This subdivision of the structural graph is associated with the development and ruderality of forest-field and steppe landscapes. The artificially increased feeding of landfills and landfills for the disposal of solid domestic waste (type 10) united synanthropic and synanthropic species or, in general, near-aquatic species, which, in the course of microevolution, switch to the use of anthropogenic forages in the urbanized territory and in the suburbs (gull). On the previously established spatiotypological structure of the bird population of the East European and West Siberian Plains in the first half of summer, the class of landfills was also clearly identified due to the high density of the bird population there, their species richness, and the original set of edificators (Ravkin E.S. and Ravkin Yu.S., 2005). At the level of bird population types of the East European Plain, these researchers combined the ornithocomplex of landfills with the residential one, and on the spatial typological structure of the bird population of the West Siberian Plain, at the same classification level, they identified two ruderal types: taiga (with leaders: hooded crow, crow, and white wagtail) and forest-steppe (rook and starling, gull).

The main tendencies of territorial changes in ornithocomplexes of the forest steppe and steppe of Western Siberia and North Kazakhstan in the first half of summer during the nesting period are determined by afforestation, plowing, moisture content, swampiness, waterlogging, and flow of water bodies, as well as the built-up, ruderality, and anthropogenically increased food intake of habitats in cities and suburbs. Similar series of changes were identified by Zhukov (1997, 2006) for the bird population of the forest steppe of Central Siberia and Salovarov and Kuznetsova (2005) for the technogenic landscapes of the southern Baikal Region. They identified the same trends that determine the spatial change of bird communities in the form of anthropogenic impact, disturbance of phytocenoses, and soil cover. We are analyzing not reclaimed territories and operating sewage treatment plants at the site of the forest zone tracts, but vast urbanized and agricultural landscapes with almost 300 years of exploitation history located to the south and west, which determined a longer time for their development. At the same time, in the Tobol–Irtysh forest steppe and steppe, the degree of industrial–technogenic–residential and agricultural impact, as well as that at the developed mining sites in Central and Eastern Siberia, also causes the disturbance or destruction of the vegetation cover. A longer, less large-scale, and slower influence of this process in our case determines the appearance of very transformed (residential) ecosystems in place of the primary landscapes of the southwestern part of Western Siberia and North Kazakhstan, which differ significantly from natural ecosystems. For the last group of habitats of our region, this similarity was revealed only for the group of the most irrigated–degraded landscapes (floodplain forest-meadow habitats of the Irtysh). At the same time, in all cases, the significant similarity of the communities of these territories is determined by the participation of the field sparrow, which nests both in natural places and in the metal poles of villages and abandoned sprinklers in irrigation fields near the Irtysh and Om. We have revealed a significant similarity in the structure and appearance of the population of residential and industrial–technogenic habitats of the Tobol–Irtysh forest steppe and steppe, the forest steppe of Central Siberia, and technogenic landscapes of the southern Baikal Region. In comparison with the spatiotypological structures of the bird population in less disturbed territories, similar features were also noted in the region we examined, but significant differences were also found. For example, the territorial variability of ornithocomplexes in the northern taiga of Western

Siberia is mainly determined by afforestation, waterlogging, and built-up areas. Swampiness, productivity of biocenoses, floodplain regime, and provinciality also have a significant influence there (Vartapetov, 1998). When comparing our population structure with the one identified by Tsybulin (1999), a similarity for Northern Altai was found only in identifying trends in water cut and built-up areas, which determine the difference between communities of water bodies and settlements from other classes of the population. At the same time, the main changes in bird communities in Northern Altai are caused by the absolute height of the area, which determines the course of changes in the bird population and in Northeastern Altai (Ravkin, 1973). In the spatial typological structure of the bird population in the southern taiga of Western and Central Siberia, the influence of afforestation and moisture content, as well as a significant impact of the degree of forest degradation on the change in bird communities, was noted (Ravkin, 1984). A separate deviation was noted for the forest zone of the Ob region due to agricultural development in the form of plowing and deforestation. In the spatial typological structure of the bird population of the taiga interfluves of Western Siberia (Vartapetov, 1984), the communities of habitats disturbed as a result of landscape plowing and partial felling also form a deviation from the main series. It is completed by communities of tracts with low forest cover. In general, a separate trend in terms of the degree of technogenic disturbance of the territory of Vartapetov (1984) is not selected. In the agriculturally disturbed habitats of the forest-steppe and steppe of our region, the population of birds of agrocenoses is also distinguished separately—not by a deviation from the main series, but by its component characterized by a high degree of disturbance of the soil cover and a significant proportion of landscape forestation, which minimizes the influence of the latter. Only when the influence of forest cover decreases does the appearance of bird communities begin to be determined by the agricultural cultivation of lands with the creation of extensive monoagrocenoses. A comparison of our graph with the spatiotypological structure of the bird population of the Middle Urals (Livanov, 2003) with the dependence of the heterogeneity of its ornithocomplexes on seven trends revealed their significant similarity. This is determined by the inclusion in them of afforestation, water cut, build up, and industrial impact, which is similar to our plowing and ruderality. We also noted an extremely poor bird population for a separate class of degraded field habitats. At the same time, the similarity between the identified disturbed field and residential classes on the graph is slightly lower than for undisturbed forested, lacustrine, and bog landscapes.

Thus, the territorial heterogeneity of the bird population of the Tobol–Irtysh forest steppe and the steppe of Western Siberia and North Kazakhstan during the nesting period is determined by the influence of afforestation, waterlogging, swampiness, moisture, flow, build up, ruderality and anthropogenic feeding. A comparison of the identified spatiotypological structure of the population with those for other regions reveals a significant similarity in the territorial distribution of communities of less disturbed territories, which manifests itself in the similarity of the identified trends, in the order of replacement of some classes by others, and the bird species that determine them. When considering the natural boundaries in a number of weakly disturbed, the impact on the heterogeneity of the population of agricultural influence is traced, but a defining deviation from the main series of changes is not. In the structure identified by us, anthropogenic impact determines the significant deviations of the graph. This underlines its impact on the bird population, which manifests itself in a significant change of communities, even in rivers. At the same time, a significant variety of variants of residential–recreational and industrial–technogenic impact does not allow distinguishing the number of territorial changes in bird communities, with the exception of the artificially increased feeding of dumps and landfills for the disposal of solid municipal waste with a completely original set of leaders.

Spatial Organization of the Bird Population

The spatial organization of the population is understood as the general nature of its territorial and temporal heterogeneity in connection with the environmental factors that determine it. Revealing the spatiotemporal structure and classification of the bird population makes it possible to single out the factors and modes associated with the variability of ornithocomplexes in time and space. An individual and comprehensive assessment of the strength of the relationship between the variability of the bird population and environmental factors makes it possible to explain the basic principles of the formation of the bird population, including in anthropogenic habitats (Ravkin, 1984). Ultimately, the spatial organization of the bird population explains its orderliness with the help of environmental factors identified by methods of automatic classification. It is considered a measure of the relationship between environmental factors and the territorial heterogeneity of the bird population. This relationship is estimated as the value of the variance of the similarity coefficients taken into account (explained) by each of the selected factors and their sum, as well as indecomposable combinations of factors or anthropogenic natural regimes (Ravkin et al., 1994, Vartapetov, 1998).

In the first half of summer in the nesting period, according to the results of the identified classification and the spatiotypological structure, 11 factors were identified that determine the territorial variability of ornithocomplexes of the Tobol–Irtysh forest steppe and steppe for an individual assessment (Table 1).

We differentiated environmental factors by their genesis into two groups. Natural factors were identified in the first group. Among them, the most important factor is the feeding or trophic value of the tracts (15%). The significance of afforestation and water cut is somewhat lower (12 and 10%, respectively), and that of the tree species composition of forested areas is lower still (9%). Earlier it was determined that afforestation is the most significant factor determining the formation of ornithocomplexes in the forest zone of Western Siberia (Ravkin, 1978, 1984). In the study of the northern taiga of Western Siberia, a more significant influence of the composition of the prevailing tree species was found.

For the forest steppe and steppe studied by us in the southwestern part of Western Siberia and North Kazakhstan, the composition of the prevailing tree species also turned out to be significant among natural factors, but it turned out that for our region the factor of water content in the territory turned out to be more significant compared to the waterlogged territory of the northern taiga. This largely determines the distribution of the bird population in the lacustrine forest steppe, especially in the northern part, which is richest in lakes.

DISCUSSION

The hierarchy of the factors identified by us allows us to state that the thesis of Berg (1938) that "the forest-steppe is an area transitional between the forest in the north and the steppe in the south" and his second statement that "the steppe is a zonal phenomenon, representing an intermediate term between the forest and desert zones, and as such, are caused by climatic reasons: zonal distribution of climatic regions" (Berg, 1938) are not equivalent. At the end of the 20th and the beginning of the 21st century, the second thesis of L.S. Berg, that the investigated region is a single natural zone, or in our understanding a steppe zonobiome (including a forest steppe), was shown to be true. In the first half of summer, factors such as provinciality and zoning explain only 3% of the variance, which is determined by the widespread anthropogenic (agricultural–residential–technogenic) transformation of the region over a century. Nevertheless, the group of natural factors is the most significant in terms of the strength and generality of influence on the summer ornithocomplexes of the forest steppe and steppe studied by us. The joint influence of anthropogenic factors in our studies in summer is somewhat lower. Among the block of anthropogenic factors in the first half of summer in our region, the most significant are macrourbanization (anthropogenically increased forage and greenery), construction, and plowing of the territory. According to an individual assessment, macrourbanization and development turned out to be the most significant in comparison with all other natural and anthropogenic factors. The hierarchy of the influence of the main environmental factors revealed for the organization of the bird population of the Tobol–Irtysh forest steppe and steppe, as well as for the predominantly technogenic landscapes of the southern Baikal region, significantly differs from those for less transformed landscapes of the forest zone and mountains of southern Western Siberia by an increase in the impact of anthropogenic factors in comparison with natural ones. For example, earlier, when individually assessing the strength of the relationship between the variability of the bird population in the forest zone of Western and Central Siberia and environmental factors in the first half of summer, the degree of forest cover, which determines 61% of the population dispersion, is the most significant. The influence of the composition of forest-forming species, moisture, and productivity is three times lower, and anthropogenic impact is five times lower. The strength of the relationship between the variability of the bird population and

Table 1. Assessment of the strength and generality of the relationship of environmental factors with the heterogeneity of the bird population of the Tobol–Irtysh forest steppe and steppe in the first half of summer, % of the considered variance of the matrix of similarity coefficients

Factor, mode	Variance explained, %
	first half of summer (May 15 to July 15)
Natural, including:	39
afforestation	12
predominant species composition of forested areas	9
water cut	10
flow	8
provinciality	1
zoning	0.8
relief	3
forage or trophic value of tracts	15
Anthropogenic,	22
Including:	
built-up	21
plowing	4
macrourbanization (anthropogenically increased feeding and greening of residential habitats)	22
All factors	47
By classification	46
By structure	44
Total modes	50
Factors and modes	57
Multiple correlation coefficient	0.75

the relief and provincial differences is lower still. The rest determine, on average, three times the strength of the connection (composition of forest-forming species, productivity, relief, moisture, and anthropogenic influence).

CONCLUSIONS

In all known studies, spatial heterogeneity is primarily determined by the forest cover and the composition of the prevailing tree species (Ravkin, 1984; Vartapetov, 1984, 1998; Tsybulin, 1999). Apparently, the calculation of anthropogenic influence in the forest zone by Ravkin (1984) was carried out without urban bird complexes due to the lack of comparable data for them in the available sample in the Data Bank of the Institute for Economics and Economics, Siberian Branch, Russian Academy of Sciences, for the second half of the 1970s.

In our studies, with a significant number of forested landscape tracts, the afforestation factor is far from the most significant, like in the technogenic landscapes of the southern Baikal region. The agricultural and residential specificity of landscape degradation, to one degree or another, prevails everywhere in the region we surveyed, determining the greatest significance in the territorial heterogeneity of the bird population of forms of various anthropogenic impacts (building up and macrourbanization, according to their individual assessment). Therefore, real forest bird communities in the anthropogenically disturbed islands and sparse forest-steppe forests of Western Siberia are not formed. Afforestation and the composition of prevailing tree species, usually the most significant factors for undisturbed forest habitats, are inferior to forage, built-up areas, and other forms of anthropogenic influence in our analysis.

Therefore, in the first half of summer, during the nesting period, the territorial heterogeneity of the bird population of the Tobol–Irtysh forest steppe and steppe is most strongly influenced by natural factors. Factors of anthropogenic origin are less significant for determining the appearance of bird communities. First and foremost, this is macrourbanization in the form of artificially increased feeding and greenery of urban and rural areas and their development. It is known that large cities long ago acquired ornithogeographic significance in their regions (Il'ichev, 1984), and our calculations confirm this. Thus, the existence of the large city of Omsk and its suburban area with a population of more than 1 million people noticeably increases the degree of influence of anthropogenic factors on the formation of ornithocomplexes. The same main factors were previously identified to explain the spatial heterogeneity of ornithocomplexes in weakly disturbed areas of the forest steppe of Western and Central Siberia (Zhukov et al., 1985; Toropov et al., 1985; Zhukov, 2006) and in the forest zone of Western Siberia (Ravkin, 1984; Vartapetov, 1984, 1998). All of the above factors and their combinations (natural regimes) in the first half of summer explain 57% of the dispersion of the bird population.

Thus, when comparing the assessments of the strength and generality of the relationship of environmental factors with the heterogeneity of the bird population in less disturbed areas of the forest zone of Western and Central Siberia (Ravkin, 1984; Vartapetov, 1998), as well as the forest-steppe of the Ob region (Toropov et al., 1985) in the Tobol–Irtysh forest-steppe and steppe of Western Siberia and North Kazakhstan, the predominance of natural factors over anthropogenic ones was noted. For the formation of summer ornithocomplexes during the nesting period, anthropogenic factors become less significant in the study area than natural ones, but more significant than in the other regions of Western and Central Siberia, with the exception of the forest steppe of the latter.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflicts of interest.

Statement on the welfare of humans or animals. This article does not contain any studies involving humans or animals performed by any of the authors.

REFERENCES

Berg, L.S., *Priroda SSSR* (Nature of the USSR), Moscow: Uchpedgiz, 1938.

Blinova, T.K. and Blinov, V.N., *Ptitsy Yuzhnogo Zaural'ya: Lesostep' i step'* (Birds of the Southern Trans-Urals: Forest-Steppe and Steppe), vol. 1: *Faunisticheskii obzor i okhrana ptits* (Faunistic Overview and Bird Protection), Novosibirsk: Nauka, 1997. 296 s.

Garmaev E.Zh., Namzhilova, L.G., Ananin, A.A., and Beshentsev, A.N., Development of a program for monitoring biodiversity in specially protected natural areas in the Lake Baikal basin, *Geogr. Prir. Resur.,* 2016, no. 5, pp. 247–254.

Gregory, R.D., Development of breeding bird monitoring in the United Kingdom and adopting its principles elsewhere, *Ring,* 2000, vol. 22, pp. 35–44.

Gregory, R.D., Vorisek, P., Van Strien, A., Meyling, W.G., Jiguet, F., Fornasari, L., Reif, J., Chylarecki, P., and Burfield, I.J., Population trends of widespread woodland birds in Europe, *Biol. Conserv.,* 2007, vol. 149, pp. 78–97.

Il'ichev, V.D., *Upravlenie povedeniem ptits* (Bird Behavior Management), Moscow: Nauka, 1984.

Livanov, S.G., Spatial organization of the bird population in the Urals, *Sib. Ekol. Zh.,* 2003, no. 5, pp. 625–636.

Pavlov, A.V. and Gravis, G.F., Permafrost and modern climate, *Priroda,* 2000, no. 4, pp. 10–18.

Ravkin, Yu.S., *Ptitsy Severo-Vostochnogo Altaya* (Birds of North-Eastern Altai), Novosibirsk: Nauka, 1973.

Ravkin, Yu.S., *Ptitsy lesnoi zony Priob'ya* (Birds of the Ob Forest Zone), Novosibirsk: Nauka, 1978.

Ravkin, Yu.S., *Prostranstvennaya organizatsiya naseleniya ptits lesnoi zony (Zapadnaya i Srednyaya Sibir')* (Spatial Organization of the Bird Population of the Forest Zone (Western and Central Siberia)), Novosibirsk: Nauka, 1984.

Ravkin, E.S. and Ravkin, Yu.S., *Ptitsy ravnin Severnoi Evrazii: Chislennost', raspredelenie i prostranstvennaya organizatsiya soobshchestv* (Birds of the Plains of Northern Eurasia: Abundance, Distribution, and Spatial Organization of Communities), Novosibirsk: Nauka, 2005.

Ravkin, Yu.S. and Livanov, S.G., *Faktornaya zoogeografiya: Printsipy, metody i teoreticheskie predstavleniya* (Factorial Zoogeography: Principles, Methods, and Theoretical Concepts), Novosibirsk: Nauka, 2008.

Ravkin Yu.S., Vartapetov, L.G., Yudkin, V.A., Milovidov, S.P., Toropov, K.V., Tsybulin, S.M., Zhukov, V.S., Fomin, B.N., Adam, A.M., Pokrovskaya, I.V., Ananin, A.A., Panteleev, P.A., Blinov, V.N., Soloviev, S.A., Vakhrushev, A.A., et al., Spatial-typological structure and organization of the summer bird population of the West Siberian Plain, *Sib. Ekol. Zh.,* 1994, no. 4, pp. 303–320.

Salovarov, V.O. and Kuznetsova, D.V., *Ptitsy tekhnogennykh landshaftov Yuzhnogo Pribaikal'ya* (Birds of Technogenic Landscapes of the Southern Baikal Region), Irkutsk: Irkutsk. Gos. Univ., 2005.

Sanderson, F.J., Donald, P.F., Paln, D.J., Burfield, I.J., and van Bommel, F.P., Long term population declines in Afro-Palearctic migrant birds, *Biol. Conserv.,* 2006, vol. 131, pp. 93–105.

Soloviev, S.A., *Ptitsy Tobolo-Irtyshskoi lesostepi i stepi: Zapadnaya Sibir' i Severnyi Kazakhstan* (Birds of the Tobol-Irtysh Forest-Steppe and Steppe: Western Siberia and Northern Kazakhstan), vol. 1: *Prostranstvennaya struktura i organizatsiya naseleniya* (Spatial Structure and Organization of the Population), Novosibirsk: Sib. Otd. Ross. Akad. Nauk, 2012.

Stepanyan, L.S., *Konspekt ornitologicheskoi fauny Rossii i sopredel'nykh territorii v granitsakh SSSR kak istoricheskoi oblasti* (Abstract of the Ornithological Fauna of Russia and Adjacent Territories within the Borders of the USSR as a Historical Region), Moscow: IKTs Akademkniga, 2003.

Svensson, S.E., European bird monitoring: Geographical scales and sampling strategies, *The Ring,* 2000, vol. 22, pp. 3–23.

Toropov, K.V., Fomin, B.N., Kozlov, N.A., Tsybulin, S.M., Vartapetov, L.G., Blinov, V.N., and Zhukov, V.S., Spatial structure of the bird population (forest-steppe of the Ob-Irtysh interfluve and the Ob valley), in *Prostranstvenno-vremennaya dinamika zhivotnogo naseleniya (ptitsy i melkie mlekopitayushchie)* (Spatial-Temporal Dynamics of the Animal Population (Birds and Small Mammals)), Novosibirsk: Nauka, Sib. Otd., 1985, pp. 67–79.

Tsybulin, S.M., *Ptitsy Severnogo Altaya* (Birds of Northern Altai), Novosibirsk: Nauka, 1999.

Vartapetov, L.G., *Ptitsy taezhnykh mezhdurechii Zapadnoi Sibiri* (Birds of the Taiga Interfluves of Western Siberia), Novosibirsk: Nauka, 1984.

Vartapetov, L.G., *Ptitsy severnoi taigi Zapadno-Sibirskoi ravniny* (Birds of the Northern Taiga of the West Siberian Plain), Novosibirsk: Nauka, 1998.

Zhukov, V.S., Spatial structure and organization of the summer bird population in the forest-steppe of the Nazarovskaya depression (Central Siberia), *Sib. Ekol. Zh.,* 1997, no. 6, pp. 645–654.

Zhukov, V.S., *Ptitsy lesostepi Srednei Sibiri* (Birds of the Forest-Steppe of Central Siberia), Novosibirsk: Nauka, 2006.

Zhukov, V.S., Blinov, V.N., Vartapetov, L.G., et al., Spatial structure of the bird population (northern forest-steppe of Western and Central Siberia), in *Prostranstvenno-vremennaya dinamika zhivotnogo naseleniya (ptitsy i melkie mlekopitayushchie)* (Spatial-Temporal Dynamics of the Animal Population (Birds and Small Mammals)), Novosibirsk: Nauka, 1985, pp. 56–67.