*ECOSYSTEMS: ECOLOGY AND DYNAMICS, 2021, Vol. 5, No. 2, P. 100-114*

## DYNAMICS OF ECOSYSTEMS AND THEIR COMPONENTS

*UDC 556.14/.16; 574.42*

# EFFICIENCY OF ECOSYSTEMS REHABILITATION IN THE FLOODED PEAT BOGS IN THE DUBNA FLOODPLAIN, ACCORDING TO THE ANALYSIS OF THE DYNAMICS OF THE NESTING POPULATION OF THE COMMON CRANE (TALDOM URBAN DISTRICT, MOSCOW REGION)[1]

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Received May 01, 2021. After revision May 15, 2021. Accepted June 01, 2021.

Most of the bogs and peatlands of the Moscow Region have been fully transformed by agricultural activities that peaked in the 1920s-1980s. It heavily impacted the river valleys, where the river beds were regulated to ensure the discharge of surplus water from the drainage systems. Due to problems of degradation in the drained peat bogs and the adjacent territories affected by this drainage, rewetting and further ecological rehabilitation has been performed in this territory. This task is important for fire prevention in the reeds and peat bogs, preventing further release of greenhouse gases from drained peat bogs and the conservation of biodiversity especially in the protected areas and the surrounding drained peat bogs that are subjects to increased carbon release and fires.

Our studies were carried out in the Taldom Urban District of the Moscow Region from 2001-2020 in the Dubna bog massif. During this period the projects to keep water in the disturbed areas of the Dubna floodplain were implemented there. The projects were financed by the Manfred Hermsen Foundation (Germany).

The Common Crane is one of the indicator species of the state of wetland ecosystems, because it nests depends on wet habitat conditions. During 2020 in the Dubna floodplain we registered an increase in the number of its breeding population due to the climate changes that cause an increased bogging in the valley territories and the growth and stabilization of the free-flow groundwater level.

The occurrences of territorial pairs of the Common Crane during their nesting period and roosting stations during the autumn in flooded areas of the floodplain bogs, with no previous records, indicates that building of the dams to keep water in the oxbow lakes of the Dubna River was an effective measure.

By studying the distribution of Common Crane's territorial pairs throughout the wetland landscapes, we can draw conclusions about environmental changes and predict changes in the species composition of animal population to solve management problems of wetland ecosystems for preservation of their

[1] The study was carried out according to the Research Project of the Water Problems Institute of the Russian Academy of Sciences for 2018-2021 "Modeling and Forecasting of the Restoration Processes of the Waters and Ecosystems Quality Under Various Scenarios of Climate Change and Anthropogenic Activities" No. 0147-2018-0002), state registration No. AAAA-A18-118022090104-8.

biodiversity.
*Keywords:* peat bogs flooding, common crane, floodplain ecosystems, Dubna River, “Crane Land” Nature Reserve, biodiversity indicator species.
**DOI: 10.24411/2542-2006-2021-10086**

The Moscow Region is part of the Russian Federation with a high importnace for nature, especially bogs. The bogs are unique landscapes that have developed in a uniform way for millenniums. The coevolution of bog communities has produced a highly specific species composition of plants, animals and fungi, some of which can be found only in these bogs. The rewetted territories are ecologically close to the bogs and are difficult to study separately from them.

The agricultural activities cause permanent transformations in all types of wetland ecosystems. The river valleys are most affected, experiencing the pressure of almost the entire agricultural complex (Grinchenko, 2005a; Kuzmina, Treshkin, 2010). The anthropogenic impact affects other types of wetland landscapes as well, such as lakes and lakeside lowlands, overgrowing and waterlogged meadows, riverside bogged shrubs and bogged forest areas in the fields. When these eocsystems disappear, it reduces the habitat range for a number of animal species (Nikolaev, 2000). Many of the slightly disturbed wetland habitats are declared specially protected areas. Under modern conditions they are highly important for the preservation of biological diversity, especially in such developed and populated regions as the Moscow Region (Grinchenko, 2005b).

In the Moscow Region a thorough development of bogs and bogged territories took place during 1920s-1980s, when due to the peat cutting, road construction, agricultural development of new areas and improvement of forest productivity in the bogs (Photo 1) led to the complete drainage of most of the large peat bogs.

**Photo 1.** Drainage channel in the Dubna bog massif, May, 1980 (photo by V.A. Zubakin).

Some decades later the agricultural activities stopped in the exhausted or partially exhausted peat bogs, but the reclamation in most of those territories was not carried out. Before this

inefficiently drained lands had been abandoned, due to the difficulties and unprofitability of agriculture and forestry. The drainage of peat bogs affected neighboring wetlands as well. The river valleys were heavily impacted by the regulation and channelization of the river beds.

In 2002 and 2010 many of these territories were subject to major grass and peat fires. To reduce the fire hazard of these peatlands and to stop the further emission of greenhouse gases (GHG), the rewetting of these areas became necessary (Russian Federation Water Code, 2006).

Western Europe has been using various methods of rewetting peat bogs for many years. This study aims to restore bog vegetation that helps to accumulate peat and to re-establish and maintain the hydrological regime. In the rewetted peat bogs the main functions of the bog ecosystem begin to be restored again, reducing the danger of peat fires decreases, and preventing GHG been released (Minaeva, Sirin, 2011).

In Russia the first rewetting projects for the disturbed and fire hazardous peat bogs were implemented in specially protected areas and surroundings, where peat fires could seriously damage the natural bogs and the habitats of rare plant and animal species. The main task was to reduce the area and frequency of such fires. The works were carried out in the “Meshchyora” National Park (Zaderenko, 2004; Sirin et al., 2011), in the territory of a wetland area “Kama-Bakaldinskaya Group of Bogs” of international importance (Bakka et al., 2004), in the north of the Moscow Region, near the “Crane Land” State Nature Reserve (Grinchenko, 2005a, b, 2006, 2007; Grinchenko et al., 2017; Kamennova, Minaeva, 2018).

In the “Crane Land” reserve the first severe peat fire occurred in June 2000, on the site of peat cutting, near the bogs of the reserve, where a bunch of excavated roots caught fire. About 4 hectares of sphagnum bogs of the reserve were destroyed by the smoldering fire.

In the following years arson that caused dry grass to burn along the road and on the unmown meadows in the drained peat sites became regular. Due to the lack of water for extinguishing, the decision was made to cut off the drainage ditches in the peat bog and create reservoirs for water intake.

In 2001 the first project was implemented to keep water in the drainage system of the “Bublik” area (Dubna bog massif, “Severnoye” peat deposit), financed by the Manfred Hermsen Foundation (Germany).

A few years later arson happened in the reeds of the Dubna floodplain as well. A decision was made to retain water in the floodplain reeds, so the dams were built to block and reduce the flow from the oxbow lakes into the Dubna River bed and the channels, used for draining the bogs (Fig. 1). The project was supported by the Manfred Hermsen Foundation and NABU – Naturschutzbund Deutschland (Germany).

This was followed in 2011 by the implementation of a state program to flood the peat bogs in the Moscow region, in an area of 74 thousand ha. Around the “Crane Land” Nature Reserve the two sites (“Bublik” and “Ostrov”) of 750 hectares in total were flooded (Fig. 1).

In 2020 the state nature park “Crane Country” of regional importance was projected in the north of the Moscow Region. Its territory included the parts of flooded peat bogs, which will no longer be part of agricultural land use in the future. Therefore, we have two new tasks to attend to. The first one is long-term monitoring of species, ecosystem and landscape diversity, as well as the distribution of rare species in the flooded floodplain. The second is predicting the development of floodplain ecosystems and the potential for the conservation of its valuable fauna and flora.

The wetland ecosystems are complex and vary in terms of bird habitats, depending on hydrological and soil conditions. Many species are sensitive to any changes in these conditions; and can act as biological indicators to help us better determine the way the species community reacts to natural and anthropogenic impacts.

The ecological diversity of the nesting birds of wetlands can indicate both the ecological state of each area and its value for conservation. For example, in the Moscow Region the presence of the

Common Crane (*Grus grus*) proves the value of the local wetland ecosystems for conservation. The constant moisture content, mosaic landscape and high biodiversity are common in all of their nesting sites (Grinchenko, 2010; Kisileva, 2017).

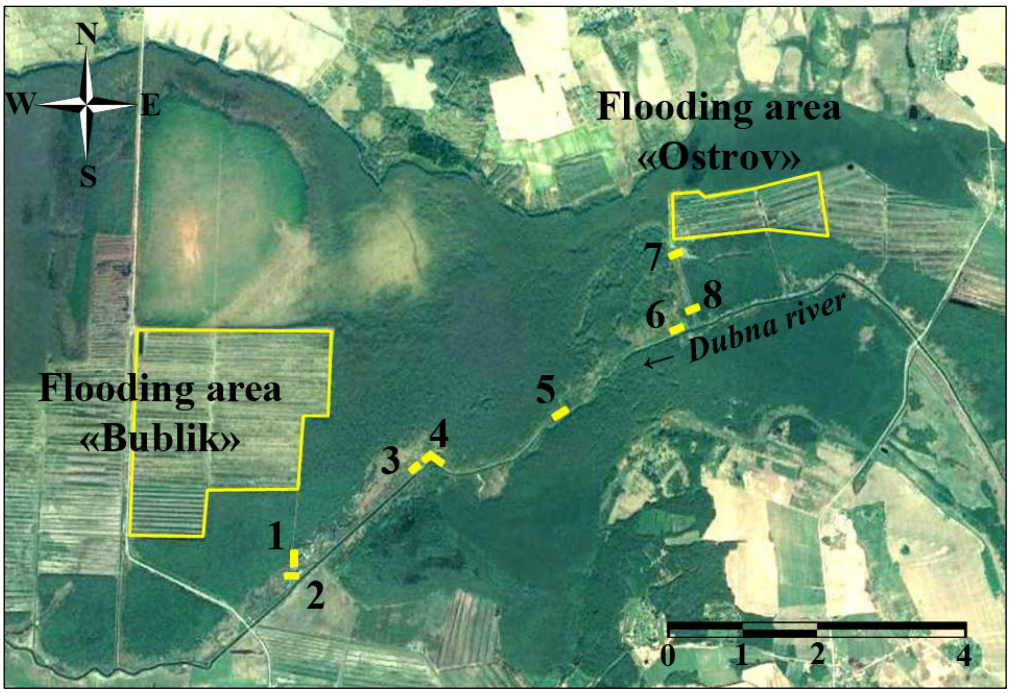


**Fig. 1.** Scheme of flooding areas and dams locations in the Dubna floodplain (the Google.Earth image is used as a background). *Legend:* 1 – the dam between the southwestern channel and the oxbow; 2 – the dam that blocks the flow from the channel; 3, 4 – the dams that block the flow from the oxbow; 5, 6 – the dams that block the flow from Lozynino oxbow; 7, 8 – the dams that block the northeastern channel flow.

An important criterion that marks the importance of a habitat is the proportion of nesting species from the Red List of the Russian Federation and the Moscow Region. The largest proportion of such species was registered in a complex of "high bogs and oligotrophic lakes" – 66.7%, and in the floodplain landscapes – 44.4% (including meadows, lowland bogs, bottom-land forests) (Flint, Mischenko, 1990). The latter type of landscape is very common in the Dubna floodplain, where we have been carrying out our long-term researches.

## Materials and Methods

The drainage of the Dubna bog massif started about 100 years ago (Grinchenko et al., 2017, 2020). The main task of the hydrotechnical amelioration, including the regulation of the river bed, that took place in the Dubna floodplain in 1928-1929, was to accelerate the passage of high water levels. After that the periods of high water levels decreased by about a month, and they started to come to their end in late April – early May, while many parts of the floodplain were not flooded at all (Pchelkin, 2003). The drainage effect of the Dubna river bed restructured the floodplain vegetation cover, the area of black alder forests increased, and the swampy peat accumulation turned into the forest-swamp (Svadkovsky, 1936).

The directed transformation of the Dubna lowland landscapes reached its peak in the late 1960s. By that time most of the bogs were drained and a significant part of the bogged forests in the Dubna

valley was destroyed, from Konstantinovo village to Sushchyovo village. However, these swamp forests are the nesting site of the Common Crane.

It is known that from 1958 to 1978 a decrease of the bogs area by 1.6 times in the center of European Russia caused a twofold decline in the number of cranes (Markin, Priklonsky, 1995). An analysis of the cartographic data for the periods before and after the amelioration of the Dubna lowland allows us to conclude that the number of breeding Common Cranes could have decreased there by more than 4 times (Grinchenko, 2011).

Today the Common Crane is on the list of species that require special protection measures for their habitats in Europe (Informative and Analytical Materials ..., 2008), and on the Red Lists of 39 out of 55 areas of the Russian Federation that are located in the European part of the country.

In the Moscow Region the habitats of Common Cranes are preserved in 16 specially protected areas of regional significance and in the "Zavidovo" State Complex. Their breeding population is considered to consist of 110-150 pairs in total (The Red List ..., 2018). About a 1/3 of it is concentrated in the north of the Moscow Region, in the Dubna lowland and its surroundings (Grinchenko et al., 2009), where the first nature reserve "Crane Land" was created in 1979, and a further whole complex of specially protected areas, in which the wetland ecosystems are preserved to date. In the 1980s the Nature Protection Squad (Druzhina) of the Biological Faculty of M.V. Lomonosov Moscow State University began its studies on the distribution and abundance of Common Cranes, using the direction-finding method (Markin, 1978; Zubakin et al., 1982). Since 2001 these studies have been carried out every year on 1-2 model sites (Kostolyginskoe Bog, Kunilovskoe Bog, Right Bank of the Dubna Floodplain, Left Bank of the Dubna Floodplain, etc.), as well as on new territories, where, according to our summer observations and some survey data, the cranes have been nesting (Grinchenko et al., 2009).

Among the model sites the "Right Bank of the Dubna Floodplain" stands out as the most disturbed area. It is exposed to draining of the deepened and straightened Dubna River; next to a drained peat bog named "Bublik" located nearby (Grinchenko et al., 2020).

The first project to restore the hydrological regime of the drained peat bogs around the floodplain was developed by the Taldomsky Hunting Entity in 2001. With the usage of removable round wooden shields (with a drain in their upper parts) installed in the concrete pipes across the ditches (Fig. 2), a system was created to seasonally control the water level in the ditches.

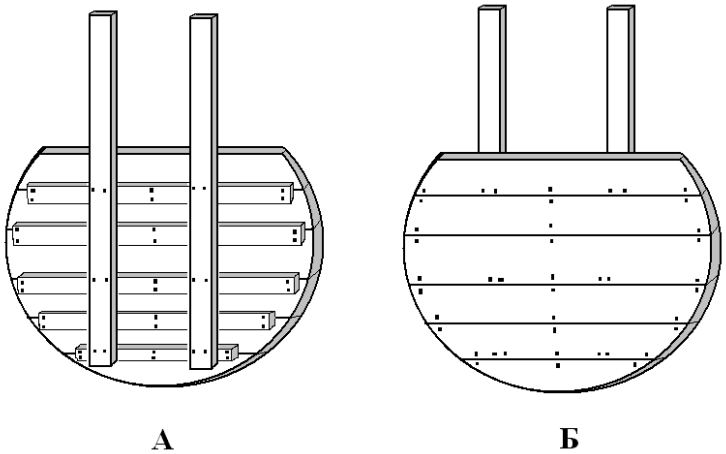


**Fig. 2.** Wooden shields for a partial blocking of the water flow in concrete pipes of the peat fields across the "Bublik" area: А – outer side, Б – inner side that adjoins the tube edges.

The shields helped to raise the groundwater level and waterlog the peatland and prevent wild fires (Photo 2). In 2011-2013 the peat bogs around the floodplain were flooded as part of the State Program. In 2016 we started a process of water retention in the Dubna floodplain. The aim of that work was to support the hydrological regime in the areas where Common Crane and Spotted Eagle *Aquila clanga* were nesting, prevent GHG being released and protect the territory from the fires. Between the bridge near Ostrov village and the bridge near Okayomovo village the earth fill dams were built with a usage of a T-130B Bulldozer (Fig. 1).

To determine the efficiency of the ecosystems rehabilitation in the flooded peat bogs of the

Dubna floodplain, in 2004-2009 and 2020 we carried a survey of breeding pairs of Common Cranes on the right (flooded) bank of the floodplain and the left (slightly disturbed) one. The censuses took place in April, when the pairs were actively vocalizing in the dawn. We performed 1-2 surveys in 2004-2009, and 4 in 2020.

The sites for our surveys were located along the Dubna River and the northern and southern boundaries of the bog plateau. Some of those sites were not available yearly due to the high water levels. Sometimes the strong wind or interfering natural sounds (such as water from the beaver dam, bird voices, woodpeckers) made it impossible to hear the cranes' duets. On the days of spring hunting, their vocalization reduced sharply due to the shooting and disturbance. Therefore, we were not able to hear all territorial pairs during one season, even when carrying out extra surveys on the same sites.

**Photo 2.** A wooden shield in a concrete pipe across the fields, June 2002 (photo by O.S. Grinchenko).

Considering the difficulty of direction-finding method and the birds' secrecy due to disturbance caused by spring hunting, we combined the data for the period from 2004 to 2009. The season of spring hunting did not take place in 2020, which allowed us a more comprehensive survey of all territorial pairs Common Cranes in the Dubna floodplain.

We assume that some pairs in 2004-2009 and 2020 were migratory. However, they occupied an area suitable for nesting for at least 6 days in 2020.

## Results and Discussion

The last cleaning of the Dubna river bed took place in 1984. It was the same year when an additional ditch was dug for draining adjacent peat fields at "Bublik" into the river. The ditch was

created close to one of the oxbows, which resulted in a drop of the oxbow water level. In 1986 a duct was formed between the oxbow and the channel, which we tried to block with poles made of willow. By 2001 the ditch was entirely blocked by beaver dams, overgrown with aquatic vegetation and silted up, but the flow from the oxbow did not stop. In 2016 a dam to block that flow was built between the channel and the oxbow. In 2018 another dam was built below to keep the water in the channel and rerouting its flow into the southwestern part of the floodplain (Fig. 3).

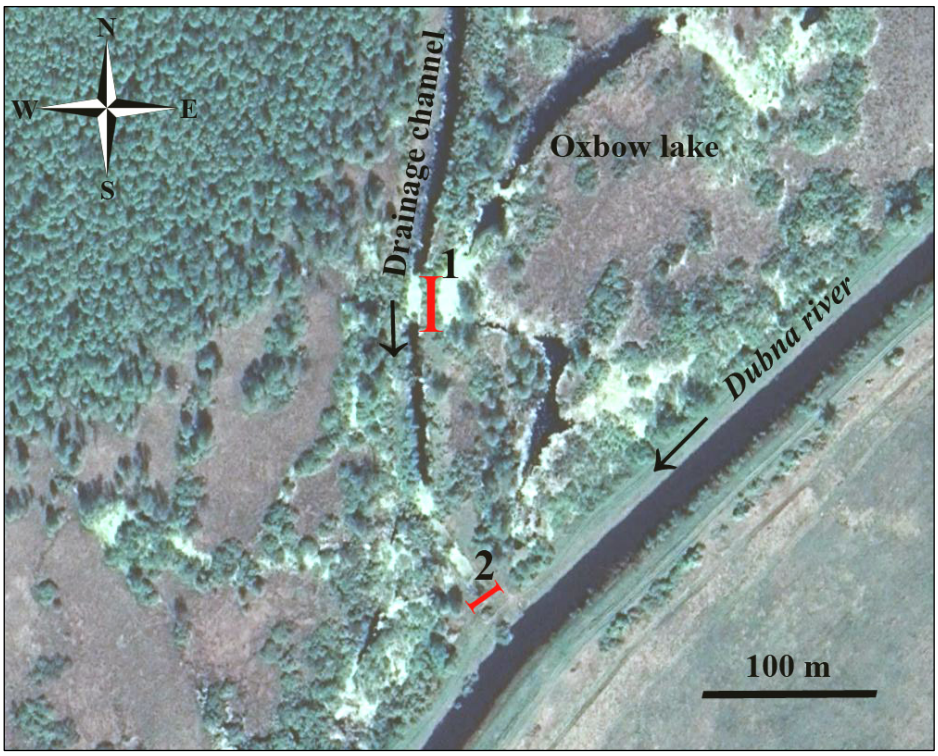


**Fig. 3.** Scheme of dam locations in the southwest of the Dubna oxbow (the Google.Earth image is used as a background). *Legend:* 1 – dam between the channel and oxbow, 2 – dam blocking ditch flow.

Six more dams were constructed in 2016-2018; four of them were restricting the flow from the Dubna oxbows (Fig. 1, dams No. 3-6; Photo 3, dams No. 3 and 4).

One more dam was blocking the drainage channel from the peat bog of the “Ostrov” area and rerouting the flow into the Lozynino oxbow (fig. 1, dam No. 7; photo 4).

The last dam was blocking this channel closer up to the Dubna River (Fig. 1; dam No. 8). Between the dams No. 7 and No. 8, a linear reservoir has formed with a high water level. These days it maintains the groundwater level in the surrounding black alder forests in the area of 60 hectares.

According to our observations, in 2004-2009 there were 8 territorial pairs of common cranes on the right bank of the Dubna floodplain (between “Bublik” and “Ostrov”) which was flooded later, and in the adjacent northern bogs in the 2000s. Eight more 8 pairs were found on the left bank during the same period (Fig. 4).

In 2020 we carried out the early morning census of cranes on various sites in the Dubna floodplain on the 8$^{th}$, 11$^{th}$, 12$^{th}$ and 13$^{th}$ of April; the pairs No. 1-7 were heard from different sites (Fig. 4). In total, the 12 territorial pairs of common cranes were registered on the right bank of the Dubna floodplain, and 11 of them were registered on the left bank. We assume that the reason for

the cranes' active vocalization was a decrease of disturbance factors due to closed spring hunting and the absence of people.

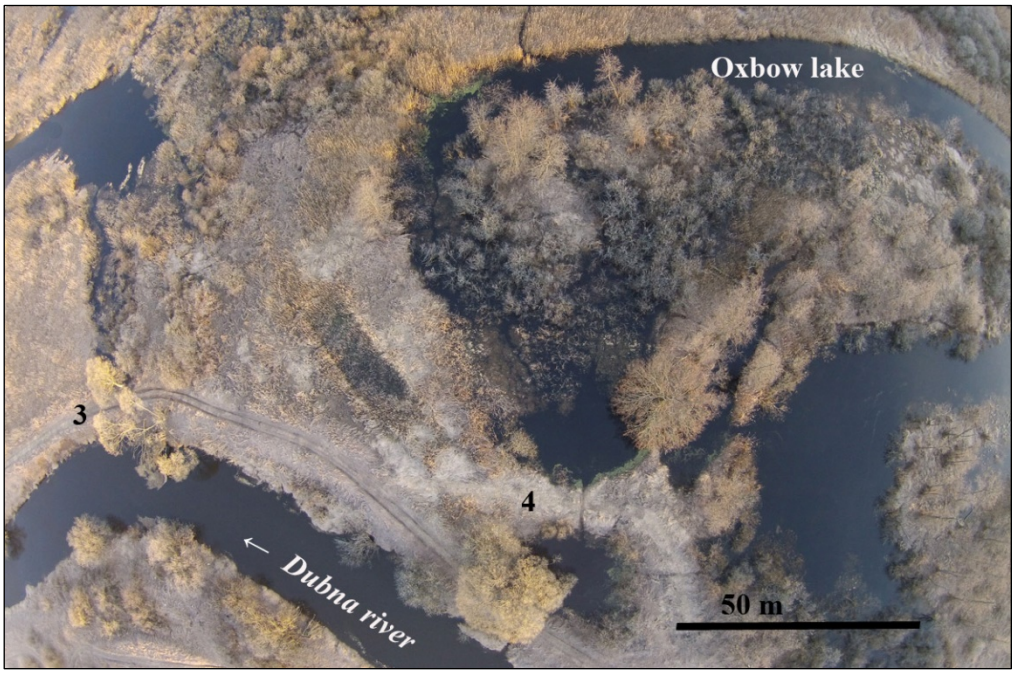


**Photo 3.** Dams No. 3 and 4 that cut off the water flow from the oxbows into the Dubna River, 4/11/2020 (photo by A.V. Makarov).

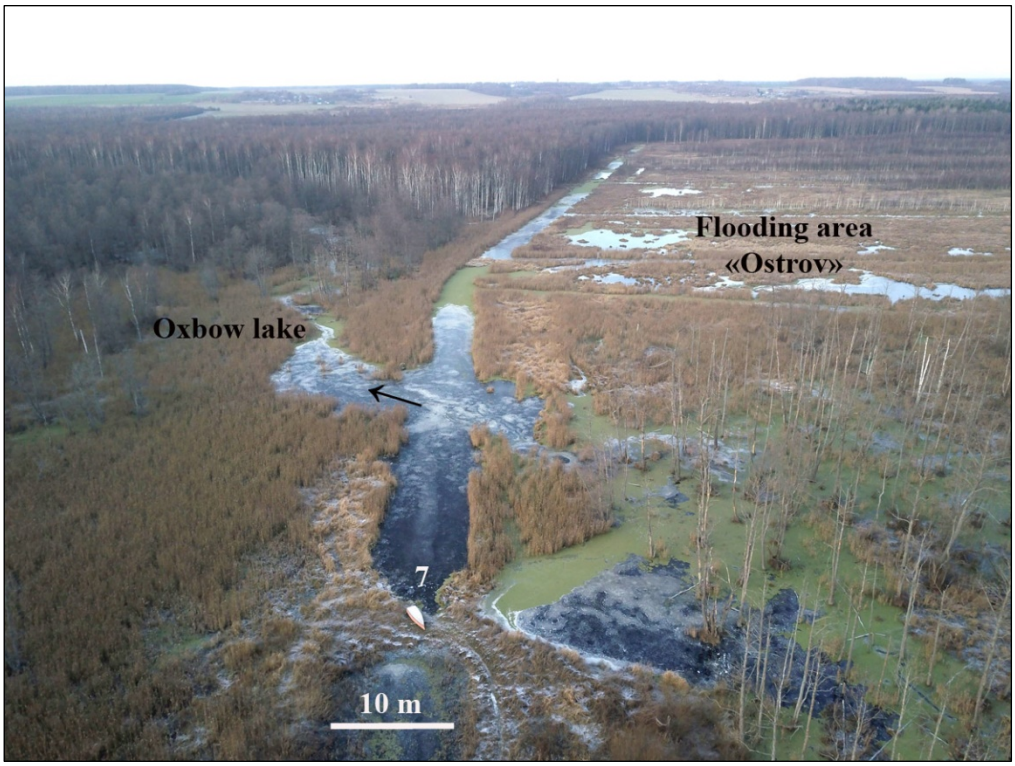


**Photo 4.** Dam No. 7 that redirects water into the oxbow, 11/23/2019 (photo by S.V. Pilipenko).

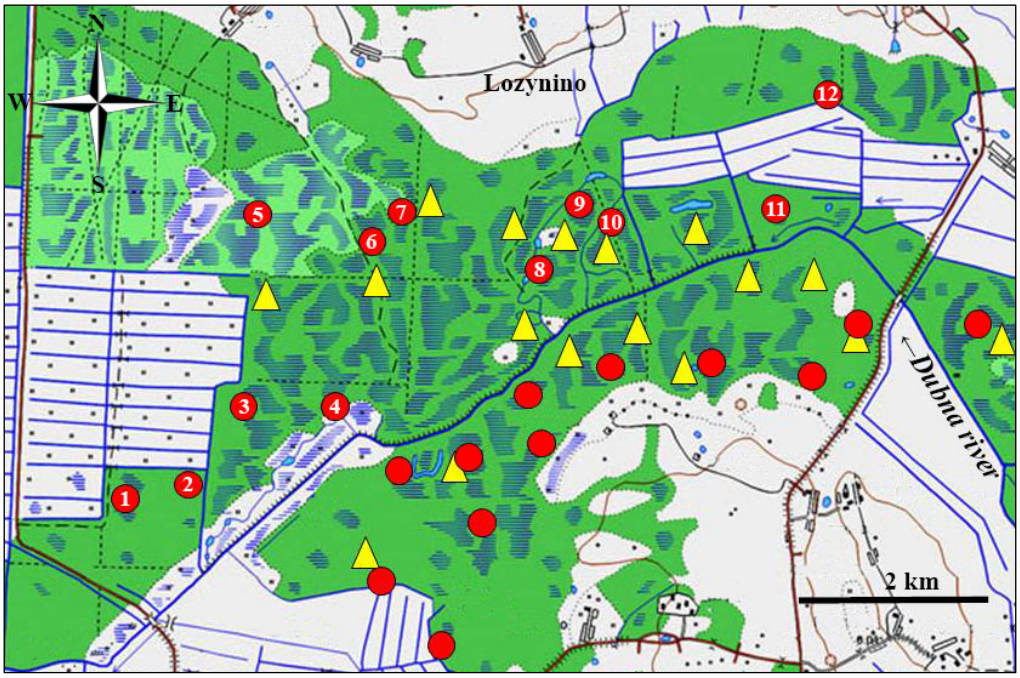


**Fig. 4.** Locations of the territorial pairs of Common Cranes in the Dubna floodplain. *Legend:* red circles – territorial pairs that were registered in 2020, yellow triangles – locations of pairs in 2004-2009.

The growing number of the breeding population in the Dubna floodplain in 2020 could be not only due to our rewetting activities, but also dut to the climate changes that are common for the southern taiga zone of Central Russia (Kuzmina, Treshkin, 2017, 2018). These changes cause an increase of bogging in the valley territories, an increase and stabilization of the free-flow groundwater level, and an increase of soil moisture level in the river valleys and catchment areas (Kuzmina et al., 2011). All of the above helps to preserve the traditional nesting areas of the common cranes, and causes the new waterlogged territories, suitable for their nesting, to appear.

The groundwater level rise has increased the area of habitats in the flooded Dubna oxbow area suitable for the Common Crane nesting. In 2020 four new territories were recorded. According to our observations in 2019, the cranes began to use the flooded oxbow lake in August-September as a roosting place, while forming their autumn migration flock.

## Conclusions

1. Agricultural activities in the middle of the XX century caused permanent changes in every type of wetland ecosystems. Peat bogs and river valleys were affected the most by this anthropogenic impact. Due to the degradation of drained peat bogs and the adjacent affected areas, the flooding and further ecological rehabilitation has been performed in this area.

2. One of the indicator species for the state of wetland ecosystems is the Common Crane, because these birds require wet conditions for nesting. In 2020 in the Dubna River floodplain the increase of The Common Cranes population was observed, which is partially due to climate change favouring bog formation of the valley areas, as well as the water level rise through our interventions.

3. Territorial pairs of the common crane were noted during the nesting period and roosting stations in the autumn in the rewetted area of the floodplain bogs, where these birds have not been

registered before It indicates that the construction of dams to keep water in the oxbow lakes of the Dubna River was an effective measure.

4. By studying the dynamics of distribution of the territorial pairs throughout the wetland landscapes, we can make conclusions about environmental changes and predict changes in the species composition of animal communities to solve management problems of wetland ecosystems for the conservation of their biodiversity.

*Acknowledgements.* The authors would like to thank their colleagues and friends who helped us with crane survey in spring of 2020: Ye.A. Akhatov, S.A. Dylyuk, D.B. Koltsov, A.V. Makarov, V.O. Mokiyevskiy, N.V. Mokiyevskaya, A.V. Sevryugin, A.V. Shcherbakov.

REFERENCES

1. Bakka AI., Kayumov AA., Shirokov AI. Model project for the restoration of bogs in the Nizhny Novgorod region: the first results *[Model'nyy proyekt po vosstanovleniyu bolot v Nizhegorodskoy oblasti: pervyye itogi] Restoration of peat bogs in Russia: significance for the regions. Proc. of the seminar [Vosstanovleniye torfyanykh bolot v Rossii: znacheniye dlya regionov. Materialy seminara]* / ed. A.I. Bakka. Nizhny Novgorod, 2004:21-25.
2. Russian Federation Water Code, created on 6/3/2006, No. 74-FZ (redacted on 12/8/2020) (with changes and additions that are available since 1/1/2021) *[Vodnyy kodeks Rossiyskoy Federatsii ot 03.06.2006 N 74-FZ (red. ot 08.12.2020) (s izm. i dop., vstup. v silu s 01.01.2021)]* Available at: http://www.consultant.ru/document/cons_doc_LAW_60683 (Accessed on 4/15/2021)].
3. Grinchenko OS. Assessment of the impact of hydromelioration on ecosystems of river floodplains in the humid zone *[Otsenka vozdeystviya gidromelioratsii na ekosistemy rechnogo gumidnoy zony] Assessment of the impact of changes in the regime of land waters on terrestrial ecosystems [Otsenka vozdeystviya rezhima vod sushi na nazemnyye ekosistemy]*. Moscow: Nauka, 2005a:194-213.
4. Grinchenko OS. Ecological criteria for regulating the regime of watering overdried peatlands in the floodplains of small rivers *[Ekologicheskiye normy*

REFERENCES

1. *Бакка А.И., Каюмов А.А., Широков А.И.* 2004. Модельный проект по восстановлению болот в Нижегородской области: первые итоги // Восстановление торфяных болот в России: значение для регионов: материалы семинара / Ред. А.И. Бакка. Н.-Новгород. С. 21-25.
2. Водный кодекс Российской Федерации от 03.06.2006 N 74-ФЗ (ред. от 08.12.2020) (с изм. и доп., вступ. в силу с 01.01.2021) [Электронный ресурс: http://www.consultant.ru/document/cons_doc_LAW_60683 (дата обращения 15.04.2021)].
3. *Гринченко О.С.* 2005а. Оценка воздействия гидромелиорации на экосистемы речных пойм гумидной зоны // Оценка влияния изменения режима вод суши на наземные экосистемы. М.: Наука. С. 194-213.
4. *Гринченко О.С.* 2005б. Экологические критерии регулирования режима обводнения переосушенных торфяников в поймах малых рек // Проблемы экологической безопасности Московской области. М. С. 137-141.
5. *Гринченко О.С.* 2010. Серый журавль (*Grus grus*) – вид-индикатор состояния экосистем водно-болотного комплекса // Орнитология в северной Евразии: Материалы XIII Международной орнитологической конференции Северной Евразии. Оренбург: Изд-во Оренбургского государственного университета, ИПК ГОУ ОГУ. С. 106.
6. *Гринченко О.С.* 2011. Редкие виды северного Подмосковья: серый журавль

*regulirovaniya rezhima obvodneniya pereosushennykh torfyanikov v poymakh malykh rekordov] Problems of ecological safety of the Moscow region [Problemy ekologicheskoy bezopasnosti Moskovskoy oblasti]*. Moscow, 2005b:137-141.

5. Grinchenko OS. Common crane (Grus grus) − an indicator-species of the state of ecosystems of the wetlands complex [*Seryy zhuravl' (Grus grus) − vid-indikator sostoyaniya ekosistem vodno-bolotnogo kompleksa*] *Ornithology in northern Eurasia [Ornitologiya v severnoy Yevrazii] Proc. of the XIII International Ornithological Conference of Northern Eurasia [Materialy XIII Mezhdunarodnoy ornitologicheskoy konferentsii Severnoy Yevrazii]*. Orenburg: Publishing House of the Orenburg State University, IPK GOU OSU, 2010:106.
6. Grinchenko OS. Rare species of the northern Moscow region: common crane (Grus grus) [Redkiye vidy severnogo Podmoskov'ya: seryy zhuravl' (Grus grus)] Materials of the Moscow Branch of the Russian Geographical Society *[Materialy Moskovskogo gorodskogo otdeleniya Russkogo geograficheskogo obshchestva. Biogeografiya, seriya 16]. Biogeography*. Series No. 16. Moscow: RAAS, 2011:31-39.
7. Grinchenko OS., Makarov AV., Skorodumova SS. Common crane in the north-east of the Moscow region [*Seryy zhuravl' na severo-vostoke Moskovskoy oblasti*] *Collection "Rare species of birds of the Non-Black Earth Center" [Sbornik "Redkiye vidy ptits Nechernozemnogo tsentra"] Proc. of the IV meeting "Distribution and ecology of rare bird species in the Non-Black Earth Center of Russia"*, the 12-13th of December, 2009, Moscow *[Materialy IV soglasheniya «Rasprostraneniye i ekologiya redkikh vidov ptits Nechernozemnogo tsentra Rossii»]*. Moscow: MPGU, 2009:177-182.
8. Grinchenko OS., Sviridova TV., Kontorshchikov VV. Long-term dynamics of ecosystems in the northern Moscow

(*Grus grus*) // Материалы Московского городского отделения Русского географического общества. Биогеография, серия 16. М.: РАСХН. С. 31-39.

7. *Гринченко О.С., Макаров А.В., Скородумова С.С.* 2009. Серый журавль на северо-востоке Московской области // Сборник «Редкие виды птиц Нечерноземного центра»: Материалы IV совещания «Распространение и экология редких видов птиц Нечерноземного центра России», 12-13 декабря 2009 г. М.: МПГУ. С. 177-182.
8. *Гринченко О.С., Свиридова Т.В., Конторщиков В.В.* 2020. Многолетняя динамика экосистем северного Подмосковья (обоснование создания природного парка «Журавлиный край») // Экосистемы: экология и динамика. Т. 4. № 1. С. 104-137.
9. *Гринченко О.С., Щербаков А.В., Любезнова Н.В., Кольцов Д.Б.* 2017. Эффективность реабилитации экосистем обводненных торфяников на основе анализа динамики растительности и авифауны (Талдомский район Московской области) // Экосистемы: экология и динамика. Т. 1. № 4. С. 23-39.
10. *Задеренко О.И.* 2004. Результаты разработки проектных предложений о восстановлении торфяных болот в НП «Мещёра» // Восстановление торфяных болот в России: значение для регионов: материалы семинара / Ред. А.И. Бакка. Н.-Новгород. С. 28-35.
11. *Зубакин В.А., Волошина О.Н., Олексенко А.И., Панчешникова Е.Е.* 1982. Серый журавль в Московской области и проблемы его охраны // Журавли в СССР. Л. С. 75-83.
12. Информационно-аналитические материалы по состоянию охраны растений, животных и их местообитаний в странах западной Европы и России (на примере Бернской Конвенции, Директивы по охране птиц и Директивы по охране природных местообитаний и дикой фауны и флоры). 2008. М. 100 с.

region (substantiation of the creation of the natural park “Crane Country”) [Mnogoletnyaya dinamika ekosistem severnogo Podmoskov’ya (obosnovaniye sozdaniya prirodnogo parka “Zhuravlinyy kray”)]. *Ecosystems: Ecology and Dynamics.* 2020;(4) 1:104-137.

9. Grinchenko OS., Shcherbakov AV., Lyubeznova NV., Koltsov DB. Efficiency of rehabilitation of ecosystems of watered peat bogs based on the analysis of the dynamics of vegetation and avifauna (Taldom district of the Moscow region) [Effektivnost’ reabilitatsii ekosistem obvodnennykh torfyanikov na osnove analiza dinamiki rastitel’nosti i avifauny (Taldomskiy rayon Moskovskoy oblasti)]. *Ecosystems: Ecology and Dynamics.* 2017;(1) 4:23-39.
10. Zaderenko OI. Results of the development of project proposals for the restoration of peat bogs in the nature park “Meshchyora” [*Rezul’taty razrabotki proyektnykh predlozheniy o vosstanovlenii torfyanykh bolot v NP “Meshchora”*] *Restoring peat bogs in Russia: significance for the regions: Proc. of the seminar [Vosstanovleniye torfyanykh bolot v Rossii: znacheniye dlya regionov. Materialy seminara]* / ed. A.I. Bakka. Nizhny Novgorod, 2004:28-35.
11. Zubakin VA., Voloshina ON., Oleksenko AI., Pancheshnikova YeYe. Common crane in the Moscow region and problems of its protection [Seryy zhuravl’ v Moskovskoy oblasti i problemy yego okhrany] *Cranes in USSR.* Leningrad, 1982:75-83.
12. Information and analytical materials on the state of protection of plants, animals and their habitats in Western Europe and Russia (on the example of the Berne Convention, the Directive on the protection of birds and the Directive on the protection of natural habitats and wild fauna and flora) *[Informatsionno-analiticheskiye materialy po sostoyaniyu okhrany rasteniy, zhivotnykh i ikh mestoobitaniy v stranakh zapadnoy*
13. *Каменнова И.Е., Минаева Т.Ю.* 2018. Проект «Восстановление торфяных болот в России в целях предотвращения пожаров и смягчения изменений климата»: опыт реализации и перспективы // Проблемы и перспективы устойчивого развития торфяного дела в России: материалы Международной научно-практической конференции, 17-19 сентября 2018 г., Тверь / Ред. О.С. Мисников, В.В. Панов. Тверь: Триада. С. 59-64
14. *Кисилёва Н.Ю.* 2017. Оценка достаточности территорий особой природоохранной значимости Изумрудной сети в еропейской России для серого журавля (*Grus gruc* L.) // Вестник ТвГУ. Серия «Биология и экология. № 2. С. 131-145.
15. Красная книга Московской области (издание третье, дополненное и переработанное). 2018 / Ред. Т.И. Варлыгина, В.А. Зубакин, Н.Б. Никитский, А.В. Свиридов. М.о.: ПФ «Верховье». 810 с.
16. *Кузьмина Ж.В., Каримова Т.Ю., Трёшкин С.Е., Феодоритов В.М.* 2011. Влияние климатических изменений и зарегулирование речного стока на динамику растительности долин рек // Использование и охрана природных ресурсов в России. № 2. С. 37-45.
17. *Кузьмина Ж.В., Трёшкин С.Е.* 2010. Антропогенное изменение пойменных экосистем и их охрана // Использование и охрана природных ресурсов в России. № 5 (113). С. 58-64.
18. *Кузьмина Ж.В., Трешкин С.Е.* 2017. Многолетние изменения основных метеорологических характеристик в зоне южной тайги европейской части России (бассейн Верхней Волги) // Использование и охрана природных ресурсов в России. № 3 (151). С. 56-65.
19. *Кузьмина Ж.В., Трешкин С.Е.* 2018. Многолетние изменения влажностно-температурного режима в зоне южной тайги европейской части России (бассейн верхней Волги) //

*Yevropy i Rossii (na primere Bernskoy konventsii, Direktivy po okhrane ptits i Direktivy po okhrane prirodnykh resursov mestoobit i dikoy fauny i flory)]*. Moscow, 2008:100.

13. Kamennova IYe., Minayeva TYu. The project "Restoring peat bogs in Russia in order to prevent fires and mitigate climate change": implementation experience and prospects [*Proyekt «Vosstanovleniye torfyanykh bolot v Rossii v tselyakh predotvrashcheniya pozharov i smyagcheniya izmeneniy klimata»: opyt realizatsii i perspektivy*] *Problems and prospects for sustainable development of peat business in Russia [Problemy i perspektivy ustoychivogo razvitiya torfyanogo dela v Rossii] Proc. of the International Scientific and Practical Conference*, the 17-19th of September, 2018, Tver [*Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii*] / eds. O.S. Misnikov, V.V. Panov. Tver: Triada, 2018:59-64
14. Kisilova NYu. Assessment of the sufficiency of territories of special nature conservation significance of the Emerald Network in European Russia for the common crane (Grus gruc L.) [Otsenka dostatochnosti territoriy osoboy prirodookhrannoy znachimosti Izumrudnoy seti v yeropeyskoy Rossii dlya serogo zhuravlya (Grus gruc L.)] *Herald of TvGU. Series: Biology and Ecology [Vestnik TvGU. Seriya «Biologiya i ekologiya]*. 2017;2:131-145.
15. The Red List of the Moscow Region (3d edition, supplemented and revised) [*Krasnaya kniga Moskovskoy oblasti (izdaniye tret'ye, dopolnennoye i pererabotannoye)*] / eds. T.I. Varlygina, V.A. Zubakin, N.B. Nikitsky, A.V. Sviridov. Moscow Region: PF "Verkhovye", 2018:810.
16. Kuzmina ZhV., Karimova TYu., Treshkin SE., Feodoritov VM. Influence of climatic changes and regulation of river flow on the dynamics of vegetation of river valleys [Vliyaniye klimaticheskikh izmeneniy i

Использование и охрана природных ресурсов в России. № 2 (154). С. 55-63.

20. *Маркин Ю.М.* 1978. Опыт учёта численности серого журавля методом пеленгования // Труды Окского Государственного заповедника. Вып. XIV. С. 374-378.
21. *Минаева Т.Ю., Сирин А.А.* 2011. Биологическое разнообразие болот и изменение климата // Успехи современной биологии. Т. 131. № 4. С. 393-406.
22. *Приклонский С.Г., Маркин Ю.М.* 1982. Изменение численности серого журавля в центре Европейской части РСФСР за двадцать лет // Журавли в СССР. Ленинград. С. 84-88.
23. *Пчёлкин В.В.* 2003. Обоснование мелиоративного режима осушенных пойменных земель. М.: Колос. 254 с.
24. *Свадковский Э.Г.* 1936. Регулирование реки Дубны. М. 251 с.
25. *Сирин А.А., Медведева М.А., Макаров Д.А., Маслов А.А., Юстен Х.* 2020 Мониторинг растительного покрова вторично обводненных торфяников Московской области // Вестник Санкт-Петербургского университета. Серия «Науки о Земле». Т. 65. Вып. 2. С. 314-336.
26. *Сирин А.А., Минаева Т.Ю., Возбранная А.Е., Барталев С.А.* 2011. Как избежать торфяных пожаров? // Наука в России. № 2. С. 13-21.
27. *Флинт В.Е., Мищенко А.Л.* 1990. Анализ местообитаний редких и исчезающих видов птиц в центре европейской части СССР // Редкие виды птиц центра Нечерноземья: Материалы совещания: «Современное состояние популяций редких гнездящихся птиц Нечерноземного центра СССР», 27-28 ноября 1989 г., Пущино. М. С. 5-10.

zaregulirovaniye rechnogo stoka na dinamiku rastitel'nosti dolin rek] *Use and Protection of Natural Resources in Russia [Ispol'zovaniye i okhrana prirodnykh resursov v Rossii]*. 2011;2:37-45.

17. Kuzmina ZhV., Treshkin SE. 2010. Anthropogenic changes in floodplain ecosystems and their protection [Antropogennoye izmeneniye poymennykh ekosistem i ikh okhrana] *Use and Protection of Natural Resources in Russia [Ispol'zovaniye i okhrana prirodnykh resursov v Rossii]*. 2010;5(113):58-64.
18. Kuzmina ZhV., Treshkin SE. Long-term changes in the main meteorological characteristics in the southern taiga zone of the European part of Russia (the Upper Volga basin) [Mnogoletniye izmeneniya osnovnykh meteorologicheskikh kharakteristik v zone yuzhnoy taygi yevropeyskoy chasti Rossii (basseyn Verkhney Volgi)] *Use and Protection of Natural Resources in Russia [Ispol'zovaniye i okhrana prirodnykh resursov v Rossii]*. 2017; 3 (151):56-65.
19. Kuzmina ZhV., Treshkin SE. Long-term changes in the humidity and temperature regime in the southern taiga zone of the European part of Russia (the upper Volga basin) [Mnogoletniye izmeneniya vlazhnostno-temperaturnogo rezhima v zone yuzhnoy taygi yevropeyskoy chasti Rossii (basseyn verkhney Volgi)] *Use and Protection of Natural Resources in Russia [Ispol'zovaniye i okhrana prirodnykh resursov v Rossii]*. 2018; 2 (154):55-63.
20. Markin YuM. The experience of counting the number of the common crane using the direction finding method [Opyt uchota chislennosti serogo zhuravlya metodom pelengovaniya] *Proceedings of the Oka State Reserve [Trudy Okskogo Gosudarstvennogo zapovednika]*. 1978;XIV:374-378.
21. Minayeva TYu., Sirin AA. Biodiversity of bogs and climate change [Biologicheskoye raznoobraziye bolot i izmeneniye klimata] *Advances in Modern Biology [Uspekhi sovremennoy biologii]*. 2011;(131) 4:393-

406.
22. Priklonskiy SG., Markin YuM. Changes in the number of the common crane in the center of the European part of the RSFSR for twenty years [*Izmeneniye chislennosti serogo zhuravlya v tsentre Yevropeyskoy chasti RSFSR za dvadtsat' let*] *Cranes in the USSR [Zhuravli v SSSR]*. Leningrad, 1982:84-88.
23. Pcholkin VV. Substantiation of the reclamation regime of drained floodplain lands [*Obosnovaniye meliorativnogo rezhima osushennykh poymennykh zemel'*]. Moscow: Kolos, 2003:254.
24. Svadkovskiy EG. Regulation of the Dubna River [*Regulirovaniye reki Dubny*]. Moscow, 1936:251.
25. Sirin AA., Medvedeva MA., Makarov DA., Maslov AA., Yusten KH. Monitoring of the vegetation cover of the re-watered peatlands of the Moscow region [Monitoring rastitel'nogo pokrova vtorichno obvodnennykh torfyanikov Moskovskoy oblasti] *Herald of Saint Petersburg University. Series: Earth Sciences [Vestnik Sankt-Peterburgskogo universiteta. Seriya: Nauki o Zemle]*. 2020;(65) 2:314-336.
26. Sirin AA., Minayeva TYu., Vozbrannaya AYe., Bartalev SA. How to Avoid Peat Fires? [Kak izbezhat' torfyanykh pozharov?] *Science in Russia [Nauka v Rossii]*. 2011;2:13-21.
27. Flint VYe., Mishchenko AL. Analysis of habitats of rare and endangered bird species in the center of the European part of the USSR [*Analiz mestoobitaniy redkikh i ischezayushchikh vidov ptits v tsentre yevropeyskoy chasti SSSR*] *Rare species of birds of the center of the Non-Black Earth Region [Redkiye vidy ptits tsentra Nechernozem'ya] Proc. of the Meeting "The current state of populations of rare nesting birds of the Non-Black Earth Center of the USSR"*, Pushchino, the 27-28th of November, 1989 *[Soveshchaniye: "Sovremennoye sostoyaniye populyatsiy redkikh gnezdyashchikhsya ptits Nechernozemnogo tsentra SSSR]*. Moscow, 1990:5-10.