

Effects of Oil Extraction and Recreational Load on Forest Bird Communities During the Post-Nesting Period

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Abstract: Effects of recreational load and oil extraction on forest bird communities during the post-nesting period are considered in the article. Ornithocomplexes from recreation areas, places of oil extraction and ecosystems with lower anthropogenic press (Nizhnyaya Kama National Park, Republic of Tatarstan, Russia) were compared based on several indices. The lowest values of Shannon's index, Berger-Parker's index, species diversity, total density of population and maximum species density were observed in the forest bird communities of undisturbed areas. The highest values of the above-said indices were found in the forest areas, suffering from active recreation. The places of oil extraction occupy an intermediate position when their values for each of the indices are considered. The evenness index was highest for bird communities, inhabiting undisturbed areas. It was demonstrated that the effect of recreational load and oil extraction on forest ecosystems can be retraced from the basic indices calculated for bird communities during the post-nesting period.

Key words: Recreation • Oil extraction • Anthropogenic transformation • Bird communities

INTRODUCTION

The Nizhnyaya Kama National Park was established in 1991. Currently, it is a unique natural complex of forests and meadows in the northeast of Tatarstan (Russia). The complex is located in the borderland between mixed forests, southern taiga and meadow steppes [1]. Its territory (26 601 ha) lies within the limits of plains in the Vyatka-Kama region characterized by dark conifer-deciduous and valley-hygrophytic-nemoral forests, as well as bogs. The complex also spans the Eastern Trans-Kama region with deciduous forests of High Transvolga [2].

The national park is located in the center of Nizhnekamsk Urban Settlement, having a population of more than one million people. Recreation is one of the permanent factors, exerting a strong negative influence on the ecosystems of the national park [3, 4]. Recreation causes a high degree of degradation in the lower layers of communities, most intensive consolidation of the upper soil horizons and, finally, replacement of primary forests by industrial forest plantations, which is followed by the development of meadow and ruderal communities [4, 5].

In addition, numerous oil fields have been actively developed in the territory of Bolshoy Bor (Yelabuzhsky District), which was incorporated into the national park, since the early 1960s. Due to the active oil extraction, the forest stands were destructed by heavy cuttings and large areas of sand were bared. As a result, the invasion of steppe and weed-ruderal plants occurred and a ramified system of various roads and glades was developed [6, 3].

The effect of anthropogenic factors on natural ecosystems is an extremely urgent problem of today's investigations. Bird communities are often used as indicator objects while analyzing anthropogenic transformation of ecosystems. Reacting to changes in the environment, they rapidly transform their population structure. This fact indicates the possibility of using major characteristics of bird communities for providing an insight into the state of the environment [7]. The most commonly used characteristics are the following: species diversity, population density, or a broad range of parameters [8-14].

Anthropogenic impact on bird communities is normally studied during the nesting period (May 15 - July 15). Nevertheless, it is not always possible to estimate the

degree of environmental disturbance and the influence of certain anthropogenic factors on ecosystems during this exact period of time. Thus, it was decided to study the bird community of some forest areas in the Nizhnyaya Kama National Park during the post-nesting period in order to find out whether it is possible to estimate the effect of such severe anthropogenic factors as recreation and oil extraction on ecosystems based on the characteristics of bird community after its nesting period.

MATERIALS AND METHODS

In order to study effects of oil extraction and recreation on the forest ecosystems of the Nizhnyaya Kama National Park, ornithological investigations were performed during the post-nesting period (August - September 2007) in the territory of oil extraction objects (Elabuga Forestry, places of oil extraction), forest areas with high recreational load (Naberezhnye Chelny Forestry, recreation areas) and undisturbed forest areas (Elabuga Forestry, control plots).

Transect routing along a fixed-width band (50 m wide) was carried out [15]. All birds, detected during the routing, were identified by their voice and external appearance. The results were further processed for per 1 km². Participation rate of each bird species in the community was measured. Species, making 10% of the total abundance, were considered as either dominants or subdominants [16]. To describe the population under consideration, routes of 32 km in length were walked. The species diversity of birds was estimated by means of the following indices: S - species diversity (number of species), H' - Shannon's index, E - evenness (Pielou's evenness index), 1/d - evenness of the dominance structure (Berger-Parker's index) [17]. Ornithofauna of different areas were compared using Jaccard's index of similarity (S_j) [18].

Enumeration of species and their Latin names are given according to L. S. Stepanyan's work [19].

RESULTS AND DISCUSSION

In all, 32 bird species were found over the period of investigation (Table 1). The lowest species diversity (6 species) was observed on the control plots (Elabuga Forestry); 20 species were registered at the places of oil extraction; and 24 species were found in the recreation areas (Naberezhnye Chelny Forestry). As it can be seen from the above data, there was a trend of increasing species diversity at the places of oil extraction

and in the recreation areas, which occurred due to birds, living in shrubs and on forest borders (such as European nightjar (*Caprimulgus europaeus*), tree pipit (*Anthus trivialis*), whitethroat (*Sylvia communis*) and spotted flycatcher (*Muscicapa striata*)), synanthropic birds (white wagtail (*Motacilla alba*), great tit (*Parus major*)) and carnivorous birds that either searched here for food and more favorable conditions for hunting or previously nested in the nearby (black kite (*Milvus migrans*), common buzzard (*Buteo buteo*), honey buzzard (*Pernis apivorus*), white-tailed eagle (*Haliaeetus albicilla*)). Interesting is that the places of oil extraction were also favored by grouse birds (western capercaillie (*Tetrao urogallus*), hazel grouse (*Tetrastes bonasia*)), which probably arises from these birds' manner of foraging for food. Comparable results, showing the lowest number of bird species in undisturbed areas and more bird species in areas, suffering from only minor disturbances, were achieved among other researchers [20]. Moreover, some forest bird species, such as common chaffinch, a dominant of breeding forest bird communities, move during their post-nesting period from forests to light biotopes, up to open areas [21].

The number of dominant species in the communities under study varied from 2 to 4 (Table 1) and their participation rate - from 45% (recreation areas) to 86.6% (control plots), accordingly. Great tit (*P. major*) was ubiquitously distributed (28.8-46.7%). The subdominant species were willow tit (*Parus montanus*) (16.8%) in the recreation areas, long-tailed tit (*Aegithalos caudatus*) (16.0%) and willow tit (*P. montanus*) (11.2%) at the places of oil extraction. Three subdominants were found on the control plots. They were pied flycatcher (*Ficedula hypoleuca*), European robin (*Erithacus rubecula*) and coal tit (*Parus ater*) (13.3% each). Judging by the dominance pattern, similar situation is observed in the recreation areas and at the places of oil extraction. What is more, the number of dominants and their participation rate in bird communities, inhabiting disturbed forest areas, tend to decrease during the post-nesting period due to the growing number and share of bird species, giving preference to forest borders and shrubs.

The density of some species was found to achieve its highest values in the disturbed areas. These species were great tit (*P. major*) (up to 136.7 ind./km²), willow tit (*P. montanus*) (up to 80 ind./km²) and long-tailed tit (*A. caudatus*) (up to 40 ind./km²). The density of all bird species from the undisturbed areas was low during the entire post-nesting period.

Table 1: Density (ind./km²) and participation rate (%) of forest birds, inhabiting the Nizhnyaya Kama National Park, during the post-nesting period.

Species	Recreation areas		Places of oil extraction		Control plots	
Black kite (<i>Milvus migrans</i>)	5	1.1%	2	0.8%		
Common buzzard (<i>Buteo buteo</i>)			16	6.4%		
Honey buzzard (<i>Pernis apivorus</i>)	1.7	0.4%				
White-tailed eagle (<i>Haliaeetus albicilla</i>)			8	3.2%		
Western capercaillie (<i>Tetrao urogallus</i>)			2	0.8%		
Hazel grouse (<i>Tetrastes bonasia</i>)			2	0.8%		
European nightjar (<i>Caprimulgus europaeus</i>)	11.7	2.5%	2	0.8%		
Black woodpecker (<i>Dryocopus martius</i>)	5	1.1%	2	0.8%	4	6.7%
Great spotted woodpecker (<i>Dendrocopos major</i>)	16.7	3.5%	4	1.6%		
Tree pipit (<i>Anthus trivialis</i>)	13.3	2.8%	2	0.8%		
White wagtail (<i>Motacilla alba</i>)			4	1.6%		
Eurasian jay (<i>Garrulus glandarius</i>)	18.3	3.9%	14	5.6%	4	6.7%
Spotted nutcracker (<i>Nucifraga caryocatactes</i>)	25	5.3%				
Common raven (<i>Corvus corax</i>)	1.7	0.4%				
Eurasian blackcap (<i>Sylvia atricapilla</i>)	3.3	0.7%				
Whitethroat (<i>Sylvia communis</i>)	3.3	0.7%				
Willow warbler (<i>Phylloscopus trochilus</i>)	10	2.1%				
Wood warbler (<i>Phylloscopus sibilatrix</i>)			2	0.8%		
Goldcrest (<i>Regulus regulus</i>)	8.3	1.8%				
Pied flycatcher (<i>Ficedula hypoleuca</i>)	6.7	1.4%			8	13.3%
Spotted flycatcher (<i>Muscicapa striata</i>)	26.7	5.6%				
European robin (<i>Erithacus rubecula</i>)	15	3.2%	8	3.2%	8	13.3%
Long-tailed tit (<i>Aegithalos caudatus</i>)			40	16.0%		
Marsh tit (<i>Parus palustris</i>)	18.3	3.9%				
Willow tit (<i>Parus montanus</i>)	80	16.8%	28	11.2%		
Coal tit (<i>Parus ater</i>)					8	13.3%
Blue tit (<i>Parus caeruleus</i>)	20	4.2%				
Great tit (<i>Parus major</i>)	136.7	28.9%	72	28.8%	28	46.7%
Eurasian nuthatch (<i>Sitta europaea</i>)	6.7	1.4%	6	2.4%		
Common treecreeper (<i>Certhia familiaris</i>)	13.3	2.8%	10	4.0%		
Chaffinch (<i>Fringilla coelebs</i>)	15	3.2%	20	8.0%		
Eurasian bullfinch (<i>Pyrrhula pyrrhula</i>)	13.3	2.8%	6	2.4%		

Table 2: Indices calculated for the ornithocomplexes of the Nizhnyaya Kama National Park during the post-nesting period.

Indices	Recreation areas	Places of oil extraction	Control plots
Total density of population (ind./km ²)	475	250	60
Shannon's index (H')	2.56	2.37	1.52
Species diversity (S)	24	20	6
Evenness (Ā)	0.81	0.79	0.85
Maximum species density (Nm) (ind./km ²)	136.7	72	28
Berger-Parker's index (1/d)	3.47	3.47	2.14

The total density of bird population was minimum on the control plots (60 ind./km²) (Table 2). It was more than four times higher (250 ind./km²) at the places of oil extraction and its highest value (475 ind./km²) was observed in the recreation areas. The above-stated increase in the total density of birds, living in the disturbed areas, happened, because the small-sized bird dominants became more numerous and as birds, inhabiting shrubs and forest borders, as well as synanthropic birds, moved to these areas. Other researchers also point out in their works that the

majority of small-sized bird species, either common or dominant, increase their abundance. They also provided evidence that the total density of bird population is higher at the places of oil extraction [20, 22, 23].

The lowest values of Shannon's index, Berger-Parker's index, species diversity, total density of population and maximum species density were observed in the forest bird communities of the control plots (Elabuga Forestry) (Table 2). Since the evenness index of these areas was also maximum, it can be concluded that the biocenosis under consideration was stable and undisturbed.

The highest values of Shannon's index, Berger-Parker's index, species diversity and maximum species density were found in the bird communities, suffering from active recreation (Naberezhnye Chelny Forestry).

The places of oil extraction occupy an intermediate position when their values for each of the above-discussed indices are considered. The results, showing that the indices get higher near the oil wells, agree with the data provided by other researchers [20, 22, 23]. The process at hand takes place, because synanthropic birds and birds, inhabiting forest borders and open areas, are attracted to the fauna of these territories and even increase the abundance of species within their populations. Similar values were registered in the Naberezhnye Chelny Forestry, because as a result of recreation there were formed many clearings, glades and roads. Thus, synanthropic bird species, as well as species, inhabiting open biotopes and forest borders, fly to these areas.

Jaccard's index of similarity (S_j) is another parameter, confirming that these areas are alike. The index attains maximum similarity (0.42) between the Naberezhnye Chelny Forestry and the places of oil extraction (other pairs demonstrated lower values--0.18 and 0.20).

CONCLUSIONS

Oil extraction in the territory of the Elabuga Forestry leads to penetration of open landscapes into the forest biotopes of the Nizhnyaya Kama National Park. On the one hand, this process favors a more complex mosaic of habitats, resulting in an overall increase of biodiversity as bird species, inhabiting open areas and forest borders, as well as bird synanthropes, are attracted to the area. On the other had, it affects abundance and diversity of birds, living in undisturbed ecosystems. Thus, the area of the national park becomes a less important accumulator of forests.

Numerous clearings, glades and roads that appeared in the Naberezhnye Chelny Forestry due to active recreation attract bird synanthropes, as well as birds, inhabiting forest borders and open areas. As a consequence, these territories are not so important in maintaining biodiversity of the forest communities. The high values of Jaccard's index of similarity are also confirming that these areas are alike (because open areas can be found here). Its higher values were achieved in the recreation areas, if compared to the places of oil

extraction, which is the evidence of lower disturbance in the former case and higher anthropogenic pressure in the latter one.

With modern technologies of oil extraction, the negative environmental impact is minimized. In this connection, the highest anthropogenic pressure on ecosystems is caused by the extension of open areas (drilling sites, pipelines, roads, glades, power lines), which produces an effect similar to that one of active recreation. This phenomenon should be taken into consideration while developing various oil extraction technologies. What is more, we should adhere to guidelines, minimizing allocation area of oil extraction objects and follow in the future these proposed land use plan amendments.

The investigation demonstrated that the effect of such severe anthropogenic factors as recreational load and oil extraction on forest ecosystems can be retraced from the basic indices calculated for bird communities during the post-nesting period.

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