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A REVIEW OF MAJOR IMPACT FACTORS OF HOSTILITIES INFLUENCING BIODIVERSITY IN THE EASTERN UKRAINE (MODELED ON SELECTED ANIMAL SPECIES)

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A Review of Major Impact Factors of Hostilities Influencing Biodiversity in the Eastern Ukraine (Modeled on Selected Animal Species). Vasyliuk, O. V., Nekrasova, O. D., Shyriaieva, D. V., Kolomytsev, G. O. — We identified major factors (both direct and indirect), caused by the hostilities in Ukrainian ATO zone that adversely influence local biodiversity and environment. Damaged conservational territories (objects of nature conservation fund) were assessed. One of the most severe factors, the fires were studied using data from Terra MODIS remote sensing, resulting in a model of localization and spatial configuration of fires on natural and agricultural territories in ATO zone during June-September 2014. In that period, 2901 ignitions were registered in ATO zone, exceeding the numbers for previous four years. It was determined that 81 % of all of the ignitions happened on natural steppe and forest areas, 19 % in settlements. The fires damaged 18 % of forest area, 23 % of the steppe area and 14 % of arable lands of ATO zone. For two snake species of Red book of Ukraine — eastern *Elaphe dione* and more widespread *Hierophis caspius* — it was shown that most of the animals and their biotopes in Luhansk and Donetsk Regions of Ukraine are under threat. Far example, 65–82 % of 108 finds of these Colubridae registered in the eastern Ukraine are located in the ATO zone and near to hostilities. GIS models also showed that more than 50 % of biotopes, suitable for these snakes, are in the ATO zone or near it. Based on world-wide experience and our own observations, we safely assume that the events of 2014 in the ATO territory can possibly cause far-reaching adverse consequences for natural landscapes, local flora and fauna, and the massive local disappearance of plant and animal populations.

Key words: ATO zone, environmental impact, fires, GIS-modeling, damage to objects of nature conservation, Reptilia, Colubridae.

Обзор основных факторов влияния, возникших в результате военных действий на востоке Украины, на биоразнообразие (на примере модельной группы животных). Василюк А. В., Некрасова О. Д., Ширяева Д. В., Коломыцев Г. А. — Выделены основные факторы (прямые и косвенные) негативного влияния на биоразнообразие и местообитания, возникшие в результате военных действий в зоне антитеррористической операции (АТО). Проанализировано состояние повреждённых особо охраняемых природных территорий. Для одного из наиболее масштабных факторов — пожаров — было проведено исследование с использованием данных дистанционного зондирования Земли, Terra MODIS, в результате которого получена модель локализации и пространственной конфигурации пожаров на природных и сельскохозяйственных территориях в зоне АТО за период с 1 июня по 30 сентября 2014 г. За исследуемый период на территории зоны АТО зафиксирован 2901 случай возгораний, что превышает аналогичные показатели огнеопасных периодов предыдущих 4 лет. Обнаружено, что 81 % всех зафиксированных возгораний произошёл на участках с природной степной и лесной растительностью и полях, 19 % — в населённых пунктах, при этом огнём повреждено 18 % площади лесов, 23 % площади степей и 14 % площади пахотных земель зоны АТО. На примере двух видов пресмыкающихся, занесённых в Красную книгу — восточного *Elaphe dione* и более распространённого *Hierophis caspius* — было установлено, что большая часть животных и их местообитаний в Луганской и Донецкой областях Украины может пострадать. Так, 65–82 % из 108 зарегестрированных нами находок полозов на востоке Украины находится на территории зоны АТО. С помощью ГИС-моделирования было рассчитано,

что более 50 % пригодных для существования этих змей биотопов находится в зоне АТО или на границе военных действий. Анализируя мировой опыт и собственные наблюдения мы допускаем, что события 2014 г. в пределах зоны АТО могут вызвать появление долговременных негативных факторов, влияющих на природные ландшафты, флору и фауну, а также вызывать массовое локальное исчезновение популяций животных и растений.

Ключевые слова: АТО зона, влияние на местообитания, пожары, ГИС-моделирование, повреждение ООПТ, Reptilia, Colubridae.

Introduction

Flora and fauna of the Eastern Ukraine are highly endemic; there are also significant areas of natural landscapes and endemic biotopes. Natural territories of the region are mostly steppe ecosystems: central part of Donetsk Region and south of Luhansk Region are covered by rocky steppes of the Donet`s Ridge (Dubovik, 1970), at north of Luhansk Region there are coenoses of chalk flora (also steppe) and south of Donetsk Region is black soil flat steppes of Pryazovia. From west to east the region is transected by intrazonal biotopes of the Siversky Donets river valley. The river forms wide floodplain with meadows, forests and arenas with remnants of natural sandy steppes. This is where pine forests, in fact most of the region's forests are located.

In 2014 political and military hostilities, officially referred to as anti-terror operation (ATO), broke out on the territory of Luhansk and Donetsk Regions of Ukraine. It leads to numerous human losses and other negative consequences. Impact of several separate factors and events in the ATO zone was reviewed previously (Vasyliuk, Shyriaieva, 2014 a, 2014 b; Kolomytsev et al., 2014). Here we analyze the conservational aspect of the conflict, hardly touched upon by relevant governmental institutions, which do not find it an issue of priority among the aftereffects of war.

Analysis of separate environmental impact factors of the region allowed us to order them into a system. One of the most prominent factors, the fires, was studied using data from Terra MODIS remote sensing. This study aimed to model localization, spatial configuration and area of fires in natural and agricultural landscapes during active hostilities. The model allowed us to evaluate the areas and ratios of different types of biotopes damaged by fire (nominal categories: forest, steppe, agrolandscape), and categories of geobotanic zonation. We also conducted monitoring of two model reptilian species which were included in the Red Data book of Ukraine prior to the hostilities and forecasted the consequences of animal killing and destruction of their biotopes. The research of possible anthropogenic impact, particularly the impact of fires on snake populations were conducted before in Australia (McDonald et al., 2012), France (Lyet et al., 2009), USA (Beaupre, Douglas, 2012) etc. The selected species are useful in biological monitoring seeing as they are, as a rule not numerous, with their ranges fragmented, therefore destruction of their biotopes puts them in danger of extinction.

Material and methods

To see the whole picture of environmental impact factors we used remote sensing (RS) data, data from our own research and oral communications of responders from the conflict zone (e. g., information, given by employees of natural reserves of NAS of Ukraine).

To study the expansion of fires over territory of hostilities, as primary information were used spatial vector data with contours of forests (scale 1:50000; property of VAT "Vizikom", http://visicom.ua, open access), steppes (own data, Vasyliuk et al., 2012), data of Landsat 8 Global Fires I satellite imagery and RS data from Terra MODIS, https://earthdata.nasa.gov/firms, previously processed by RDC "ScanEx" http://scanex.ru/ru/index.html. In particular, we used currently available for remote evaluation of information about the localization of ignitions and areas of fires from June 1st to September 30th, because these data are currently available for remote evaluation. Data for mathematical modeling were given by ScanEx and it would therefore be necessary to briefly describe the underlying method of fires evaluation. The basic component of the service is based upon algorithm of automatic detection of fires using "heat" channels of satellite imagery MODIS. Information about fires (fire mask) is a product of automatic thematic classification of MODIS data— images from satellites Terra and Aqua. Time and interval of data collection depend on temporal period and date of satellite flight over the territory in question. In average, the periodicity is 4 times per 24 hr: the satellite orbits are constructed so that each of them flies over the same plot twice in a 24 hr (once at day and once at night). Algorithms of fires automatic detection are based on them strongly radiating in infra-red. Difference between temperatures of Earth surface and a burning plot changes the brightness of pixels, and information from other spectral channels helps masking the clouds. The Terra MODIS information that's used to detect fires is also used to create RGB pictures for visualizing overview imagery per 24 hr. Centers of fires are detected by infra-red channels of Terra MODIS with linear resolution of 1 km per pixel. It means that every singled out focus is visualized as a point in the centre of 1 km x 1 km pixel. The real fire can be localized somewhere on this plot and its true area can be less than that. Though the pixel (elementary observational plot) for infra-red channel is 1 km^2, in average MODIS finds open centers and smoldering fires on areas starting with 0.1 ha. Brighter centers with higher temperature of burning can be registered on a smaller ignition area. Estimating the fires' power is done by analyzing RS data. Automatic clusterization of thermal

locations provides approximate determination of the area of active ignition by contours around the points in a cluster. Clusters can be provisionally equaled to the burnt area. It is important to understand that data of automatic detection of fires using Terra MODIS products is selective but it allows assessing the scale and localization of fires.

The basic information (ignition localities of 2010–2014) was converted into frequencies of registered ignitions (calculated as monthly averages of number of daily registered fires divided by 1000 square kilometer of landscape). The fire frequencies for 3 data types (years: 2010–2014; months: June–September; landscapes: agriculture landscape, forest, steppe; conditional divide of territory to ATO- and non-ATO zones) were log-transformed. Differences were determined by analysis of variance (ANOVA) and partial t-test using PROC GLM and LSMEANS (SAS version 9.3).

To study the consequences of events in ATO zone for animals two snake species from the Red Data book of Ukraine (2009) are chosen because of their usefulness as model objects: *Hierophis caspius* (Gmelin, 1789) and *Elaphe dione* (Pallas, 1773).

Partly the data was collected directly before the hostilities, on field trips in 2010-2014 yr. Also relevant literature sources were used (Dotsenko, 2003; Kotenko, Kurjachii, 2008; Red Data book of Ukraine, 2009; Vedmederja et al, 2007). Database of spatial distribution of reptiles was created in OziExplorer v.4.95.4 m, and includes 56 finds of *H. caspius* and 52 of *E. dione* in Luhansk and Donetsk provinces. Only differently located points were taken into account.

For forecasts and search of the most suitable biotopes for the snakes before the events in ATO zone, program software DIVA GIS http://www.diva-gis.org is used, including 19 bioclimatic parameters (http://www.worldclim.org).

Biotope distribution of the Red Data book reptilian species is considered according to available classes of spatial data and categories: forest, open steppe and arena plots and agricultural landscapes or arable lands.

Results and discussion

Probable threats caused by events in ATO zone.

The information on negative impact on biodiversity and environment (habitats), caused by hostilities, is divided into two groups: direct and indirect effects. Among the indirect, the 6c, 7, 9, 10 ones are caused by temporary loss of state prohibitive control over violations and over technological processes.

Direct effects:

1. Mechanical damage to flora, fauna and habitats:
   - 1 a. Passage of heavy military machinery, including caterpillar vehicles;
   - 1 b. Strafing and explosions on natural territories:
     - 1 b-i. damage to landscapes;
     - 1 b-ii. destruction of plants and animals;
   - 1 c. Construction of fortifications and trenches:
     - 1 c-i. disfiguration of natural landscapes;
     - 1 c-ii. falling the trees for defensive constructions.

2. Air pollution during strafing by products of oxidation of explosives — toxic gases (SO_2, NO_2, NO_3, CO, aromatic alcohols, aldehydes, ketons) and relatively safe CO_2 in amounts up to a few tens of cubic meters per kilogram of explosives.

3. Destruction of forest shelter belt and planted greenery due to tactical intentional arson.

4. Killing the macrofauna "by mistake" around military bases in natural forests. Soldiers admit to profuse strafing at every rustle "in the dark" at nights that leads to extermination of many of big animals.

5. Interruptions in biological rhythms of animals due to noise environmental pollution. This factor was most important for animals during the mating season (beginning of summer), when the hostilities were already occurring on ATO zone territory.

Indirect effects:

6. Indirect chemical environmental pollution:

6 a. Infiltration of hazardous substances to environment due to destruction of their storage or industrial use facilities (e. g. objects of chemical industry) after shelling.

6 b. Damage or destruction of forests and plantations, acidification of soils by acidic rains caused by release of Sulfur and Nitrogen oxides into atmosphere during strafing.

Most sensitive to high quantities of SO_2 in atmosphere and sediments would be the pine forests and plantations (which account for the most part of local forests).

6 c. Pollution of water reservoirs and / or aquifers:

6 c-i. by communal, agricultural and industrial inorganic and organic wastes due to cessation of working of treatment plants;

6 c-ii. by Carbon and dust particles, methane, acidic and mineralized waters from mine waters after blackouts and flooding of mines. A prime example would be flooded mine "Yunkom" near Yenakievo town, where an experimental nuclear blast occurred in 1979. If fully flooded, it may become a source of reaction product of that nuclear blast to the surface and into natural ecosystems.

7. Uncontrollable expansion of fires over the natural territories. This impact factor is studied in more detail and the results are given below.

8. Changes in microclimate, fast progress of wind erosions, loss of topsoil, and subsequent emergence of dust dry winds, desertification after reduction of forested area (tree belts etc), induced by variable causes.

9. Extermination of natural resources due to illegal use by local people:

9 a. uncontrollable hunting of husbandry animals;

9 b. unauthorized use of wood resources;

9 c. anthropogenic transformation of landscapes with extermination of their biodiversity after:

9 c-i. usurpation of natural territories for subsequent agricultural or developmental uses. Par example, agriculture was illegally conducted upon 100 ha of Regional landscape park "Kramatorsky";

9 c-ii. extraction of coal by open-pit mining of shallow coal seams. This problem existed before the hostilities but after destruction of infrastructure of mining and energy the conditions became favorable for illegal industry.

10. Worsened sanitary conditions of forests due to impossibility of forestry engineering measures.

11. Changes in natural population structures of many species of local fauna in the hostilities zone and nearby:

11 a. changes in trophic chain structure when increased numbers of homeless pet animals occupied ecological niches in natural biotopes;

11 b. significantly increased population densities of macrofauna on separate plots due to migrations to intact natural territories currently free from hostilities. It should be noted that animals, driven to migrate, are more frequently killed by people and vehicles.

12. Threat of uncontrollable distribution of infectious diseases, such as rabies epidemic. Homeless pet animals that are driven into natural habitats may cause rabies epidemic and its transfer to wild predators.

Status of nature conservation territories in the ATO zone.

Objects of nature conservation fund (NCF) are key in preservation of biodiversity, which is why we find it appropriate to view in detail the factors influencing their functioning in ATO conditions.

As of September 1st, 2014 NCF of Luhansk Region consisted of 189 objects, 935.53 km^2 in total, and NCF of Donetsk Region consisted of 117 objects and territories 918.31 km^2 in total (Nature conservation..., 2013; Donbas..., 2008). More than half of the nature conservation objects of Luhansk Region and almost a third of the nature conservation objects of Donetsk Region are or were in the ATO zone. In particular, all of the local nature reserves (Luhansky and Ukrainsky Stepovy) and National nature parks (Sviati Gory and Meotyda) are located there.

We found no less than 33 objects of NCF to be damaged by hostilities (Kurjachii, Tupikov, 2008, 2009). Available information about current state of NCF objects is summa-

rized, examples of major negative influences, and sources of information about damage to nature conservation territories are given below.

1. Fires on nature conservation territories (both forests and steppes), caused by strafing and other hostilities related factors. This is the most frequent phenomenon of all registered. The ERS data (overlapping contours of NCF objects on Landsat 8 Global Fires I and ERS Terra MODIS data) confirms fire damages for Luhansky natural reserve ("Provalsky step" and "Tryohzibensky step" departments); RLPs "Donetsky Kriazh" and "Zuyivsky"; National natural park "Sviati Gory"; zakaznyks "Alioshkin bugor", "Balka Plos'ka", "Bilorichensky", "Volnukhinsky", "Yeremusovy skhyl", "Znam'iansky yar", "Nagolny kriazh", "Nagolchansky", "Novozvanivsky", "Obushok", "Pischany", "Natural object Murzine", "Skelev's Balka".

2. Strafing and explosions that cause mechanical damage of landscapes, flora and fauna, infiltration of chemical products of the explosion reactions into atmosphere and soils. Such impacts are detectable similarly to the fires by ERS data. Damage to the territories is observed in NNP "Sviati Gory", departments of Ukrainsky Stepovy reserve ("Kalmiuske" and "Kreydiana flora"), RLPs "Donetsky Kriazh" and "Slavyansky kurort", zakaznyks "Luhansky", "Pristenske", "Kreydiane", "Bilogorivsky", "Perevalsky".

3. Construction of fortifications that causes transformation and ruination of biotopes, and falling the trees in preserved forests. It happens in several of the conservational objects, such as natural reserve "Kreydiana flora" and RLP "Kramatorsky" (situated on a currently freed territory) (S. Lymansky, A. Tupikov, oral communication). Also, fortifications are erected outside of ATO zone in Kharkiv Region, in NNP "Dvorichansky" adjacent to Russian Federation (according to M. Kryvokhyzha).

4. Uncontrollable use of NCF resources (occupation of lands and hunting). It occurs in absence of state control. This was registered in RLPs "Kramatorsky" (100 ha plowed without permission) and "Izyumska luka" (illegal hunting towers) (A. Tupikov, V. Lovchynovsky, personal communication).

5. No longer functioning institutions of NCF in ATO zone. Central administrative building of Luhansky nature reserve is destroyed; in NNP "Khomutovsky step" the administration is occupied by hitmen; in RLPs "Donetsky Kriazh", "Zuyivsky" and "Kleban Byk" the administrations simply ceased to function. Staff, developments, documentation and archives are lost (S. Glotov, S. Lymansky, A. Tupikov, S. Natrus, L. Borovyk, V. Tymoshenkov, personal communication).

6. There is also unverified information about burials of those killed in action on RLP "Donetsky kriazh" territory. If these burials indeed happened, they would have been shallow due to complicated landscape and rocky soils, and contains of the graves will in time infiltrate local rivers.

Consequences of direct influences exemplified by fires.

The scale of fires is dissimilar to other negative factors of war on the territory in question, making them an important subject of research. Also, the accessibility of data for all of the ATO territory was favorable.

Significant increase in numbers of fires on natural territories of ATO zone in 2014 was caused by such factors coinciding:

— a lot of artificially planted pine plantations, which are the most fire-hazardous type of forests in Ukraine among forest massifs on the studied lands;

— dry season (June-August), here traditionally goes with increase in ignitions of dry vegetation;

— massive shelling and intentional arson for tactical purposes during hostilities that also increased the numbers of epicenters of fire expansion in regional natural massifs;

— partially mined forests, constant strafing and loss of state control over the region made it impossible for forces of Ministry of Emergency Situations or State Agency of forest resources of Ukraine to fight fires.

Our research revealed that during 1.06–30.09.2014 in ATO zone there were 2901 registered cases of ignition. In total, numerical quantitative fire indexes registered by satellite are 14.1 times more than likewise numbers for 2013 (208 cases of ignition), 5.2 and 5.9 times more than in 2012 and 2011 (566 and 501 cases of ignition respectively), 2.4 times more than in 2010 (fig. 1).

Comparison of numbers of fires in the ATO zone within same periods of last four years shows that there are common tendencies in dynamics of numbers of fires. Each year the daily numbers of ignitions increases in the middle of July and in the third decade of August. It can be related to locally traditional burning of vegetable matter on fields after harvest. Yet during 01.06–30.09.2014 there were spatially and temporally related to hostilities bursts in numbers of ignitions (fig. 2). Moreover, periods of fire hazard of 2010–2013 demonstrated higher density of ignitions outside of ATO zone on the studied territory (Luhansk and

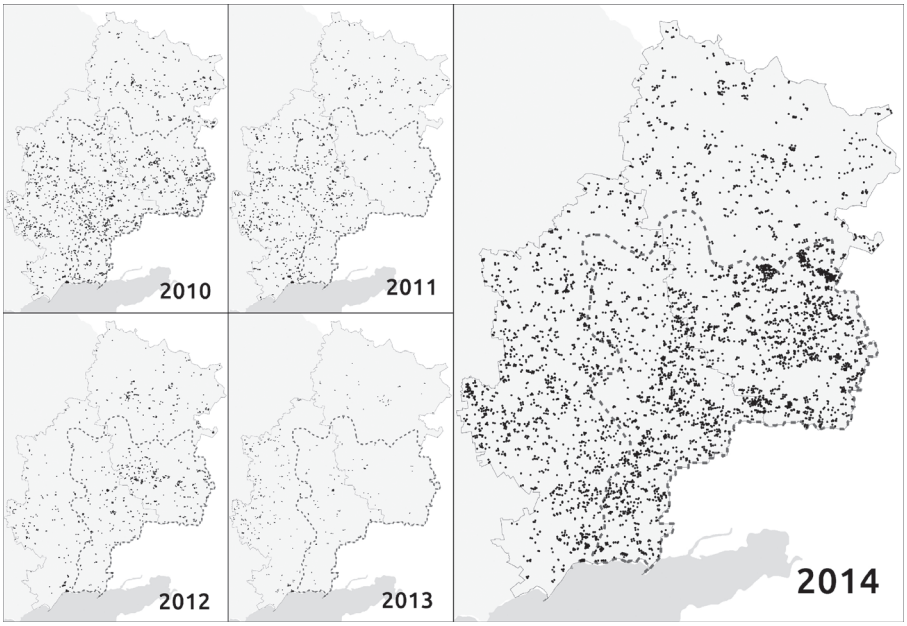

Fig. 1. Spatial distribution of ignitions in 2010–2014 on studied area (dotted line is ATO zone's limits in 1.06–30.09.2014).

Рис. 1. Пространственное распределение возгораний в 2010–2014 гг. на исследуемой территории (пунктирной линией выделена зона АТО по состоянию на период 1.06–30.09.2014).

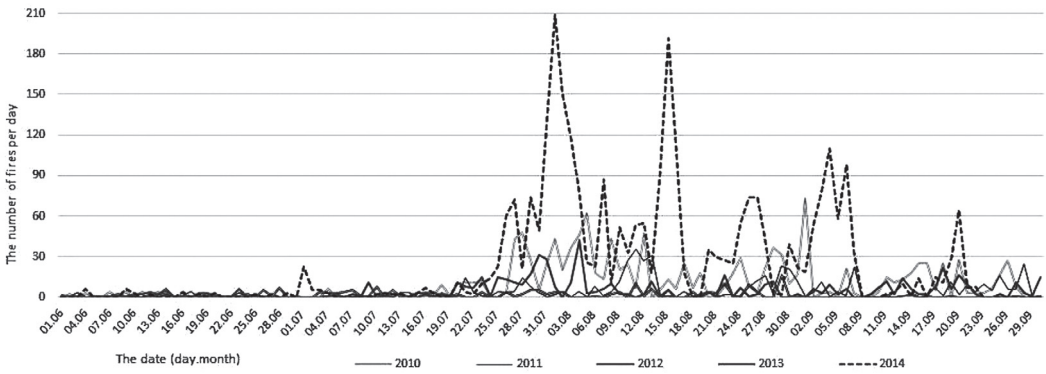

Fig. 2. Temporal distribution of numbers of ignitions in ATO zone in 2010–2014.

Рис. 2. Временное распределение количества возгораний в пределах зоны АТО за 2010–2014 гг.

Donetsk Regions). Inside ATO zone the areas of fields and settlements are quite smaller than in other parts of the Regions. Yet in 2014, most of ignitions were registered in the ATO zone. We suppose that main reason for this peak of observed ignitions is freedom of expansion both spatially and temporally, proving lack of fire protection and prophylactic measures. There are also separate localized peaks in ignitions, with higher frequency than overall yearly dynamics of the period in question. Research of these peaks reveals that they coincide with places and dates of massive shelling (as announced by National Security and Defense Council of Ukraine). Such are for example periods of hostilities, characterized by spatial clusters of localized ignitions near villages Dmytrivka (29.07.14) Nova Vilkhova (1.08.14) and Stakhanovetc (20.09.14) and town Chervonopartyzansk (3.08.14).

To test for different fire frequencies we accepted as H0 that the distinctions between fire frequencies are based on random events. For log-transformed fire frequency we generated general linear model (GLM) with coefficient of determination R-Square = 0.694. The overall F test is significant for years ($F = 17.73$; $p < 0.0001$), months ($F = 49.10$; $p < 0.0001$) and landscapes ($F = 13.24$; $p < 0.0001$). Comparison of 2010–2013 (before the conflict) dataset to 2014 dataset (time of hostilities) by t-test also shows statistically significant differences ($t = 6.13$; $p < 0.0001$). On the 2014 dataset GML calculates model with R-Square = 0.926, with statistically sound differences between months ($F = 61.41$; $p < 0.0001$) and between ATO zone and nearby areas ($F = 13.11$; $p = 0.0023$). "ATO zone" and "non-ATO zone" did not statistically differ in 2010–2013 ($F = 1.57$, $p = 0.2131$), but for 2014 (beginning of hostilities at ATO zone) there are such differences ($F = 13.11$; $p = 0.0023$). Analyzing landscape types separately shows that the nature of their fire damage in 2014 isn't similar to four previous years (for field: $p = 0.0007$; for forest: $p = 0.0017$; for steppe: $p = 0.0026$).

Based on GIS model of fires covering ATO zone, we calculated the total incinerated area of 2014. It amounts to 331,471.4 ha, of which 34,465.5 ha are spatially overlapping buildings and water basins. Thus, the model illustrates fire coverage of 297,006.0 ha, 14 % of ATO zone area of (fig. 3, 4).

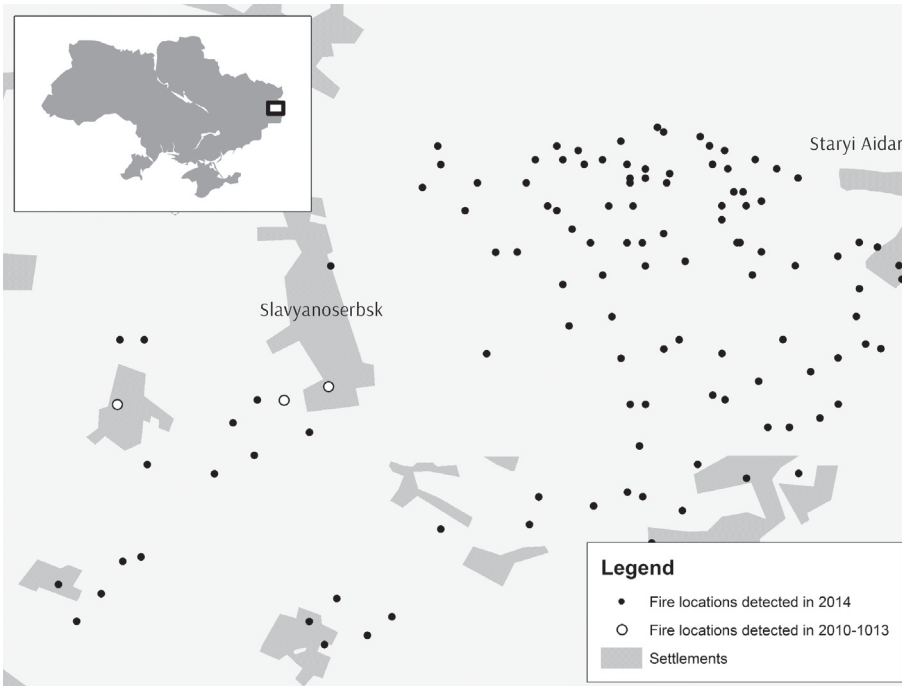

Fig. 3. Spatial local distribution of ignitions in 2010–2014 in the outskirts of Slavyanoserbsk, Luhansk Region.

Рис. 3. Пространственное распределение локальных возгораний в 2010–2014 гг. на окраине г. Славяносербск Луганской области.

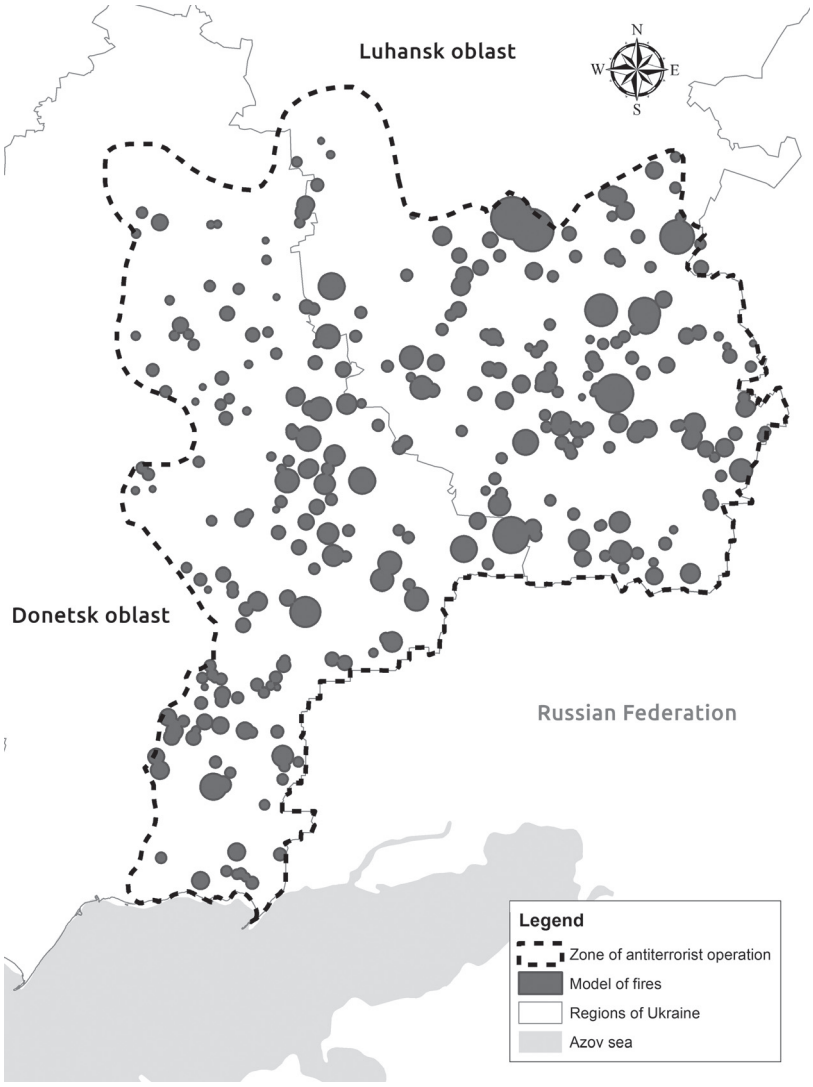

Fig. 4. Spatial model of the fire covered area in ATO zone in 2014.

Рис. 4. Пространственная модель пожаров в зоне АТО в 2014 г.

Research of localization of the registered ignitions shows that 81 % of all cases took places on forest and steppe areas and fields. Only 19 % of fires are related to territories of settlements.

Superimposing the contours of modeled burnt areas on available classes of spatial data allowed us to calculate distribution of said areas in these classes and the area of overlap.

Real areas of each landscape class that was damaged by fire would likely differ from our model, because our results are based on remote data, not on direct measuring. And yet this model allows gauging the scope of fires and breakdown of burnt area into classes of surface. The results are as follows: 36,226.2 ha of forests are damaged by fire, amounting to 18 % of forested area in ATO zone and 12.19 % of total burnt area; likewise damaged are 113,735.2 ha of steppes, that is 23.19 % of steppe area in ATO zone and 38.29 % of total burnt area; 147,044.6 ha of arable lands, which is 14% of arable area and 49.5 % of total burnt area. Thus, commensurate areas of natural and semi-natural territories are incinerated.

Spatial data on fires were also applied to map of geobotanic zonation of the lands. The ATO zone and, respectively, the zone of intensive fires in 2014, fully cover geobotanic

zones 133, 135, 136, 137 that make up the vegetation of rocky steppes of Donets Ridge and partly cover the zones 132, 138, 134 and 164. Ukrainian stony steppes are mostly located in ATO zones and 20 % of their total area suffered from fire during June-September 2014.

Most part of ATO zone's forests are artificially planted on sand arenas. Thus after the fires, there are exposed sands, unbound by vegetation and open for erosion. At the same time natural broadleaf forests in ravines are preserved on the studied territory, serving as centers of forest biodiversity. By creating artificial forest plantations, the forest companies frequently situated them near natural ravine forests. It was done to exploit natural moisture and shades of the existing forests for young artificial plantations. Thus, today natural ravine forest and artificial pine forest plantations are quite often combined into continuous forest massifs. Fires that easily expand in artificial pine plantings also obliterate natural broadleaf forests.

Possible aftereffects of events in Ukrainian East on local fauna, exemplified by snake species from Red Data book of Ukraine — *Elaphe dione* and *Hierophis caspius*.

Any factor's effect can be estimated and forecasted not only by its influence on environment but also on model animal species that depend on condition of their biotopes and have bio-indication properties.

Among representatives of fauna, one of groups sensitive to human impact are the reptilians. Even the smallest changes in environment conditions vastly alter population structure indices but direct destruction of some of the natural biotopes and animals may cause extinction of most rare snakes. The studied region is characterized by largest (compared to other regions of Ukraine) number of Red Data book snake species. In Luhansk and Donetsk Regions there are nine snake species, six of which are in Red book of Ukraine (2009): smooth snake *Coronella austriaca* Laurenti, 1768, Caspian whipsnake *Hierophis caspius* (Gmelin, 1789), Dione ratsnake *Elaphe dione* (Pallas, 1773), Blotched snake *Elaphe sauromates* (Pallas, 1814), *Vipera nikolskii* Vedmederja, Grubant et Rudaeva, 1986 and meadow adder *Vipera renardi* (Christoph, 1861). Dione ratsnake and Caspian whipsnake are most widespread of local Colubridae, and the former in Ukraine occupies the territories in question (fig. 5).

These snakes were protected in NCF areas: Luhansky natural reserve ("Provalsky step", "Stanichno-Luhansky" departments), Ukrainsky Stepovy natural reserve ("Khomutivsky step", "Kreydiana flora" departments), NNP "Sviati Gory", RLPs "Kramatorsky" and "Kleban Byk", etc (Kotenko, Kondratenko, 2005; Kotenko, Kurjachii, 2008; Zagorodniuk, Zayika, 2009).

According to literature data and our own observations, the territory in question was studied rather irregularly. At the same time different snake species also differ in distribution, density and overall population numbers due to specific distribution, biotope preferences and ecological plasticity.

All plots in Luhansk and Donetsk Regions (ATO zone included) can be classified by their plant communities and according to available classes of spatial data into four major groups:

1. Forest (trees and shrubbery overgrowth, tree belts, etc): 18 % of this biotope type are hypothetically damaged by fire.

Finds of *E. dione* in these biotopes (more frequently in shrubberies and forest outskirts) make up approx. less than 50 % of all finds (at ATO zone there were 33 of them). *H. aspius* was found mainly at outskirts (46 finds in ATO zone), nearly 17 % of all local finds.

2. Open steppe and arenas (including rocky slopes): 23 % of biotopes damaged by fire. *E. dione* finds in these biotopes amount to more than 50 % of all finds (33 of them in ATO zone), preferring anthropogenic territories (Zayika, 2009). *H. caspius* finds here make up 83 % of all (46 finds in ATO zone).

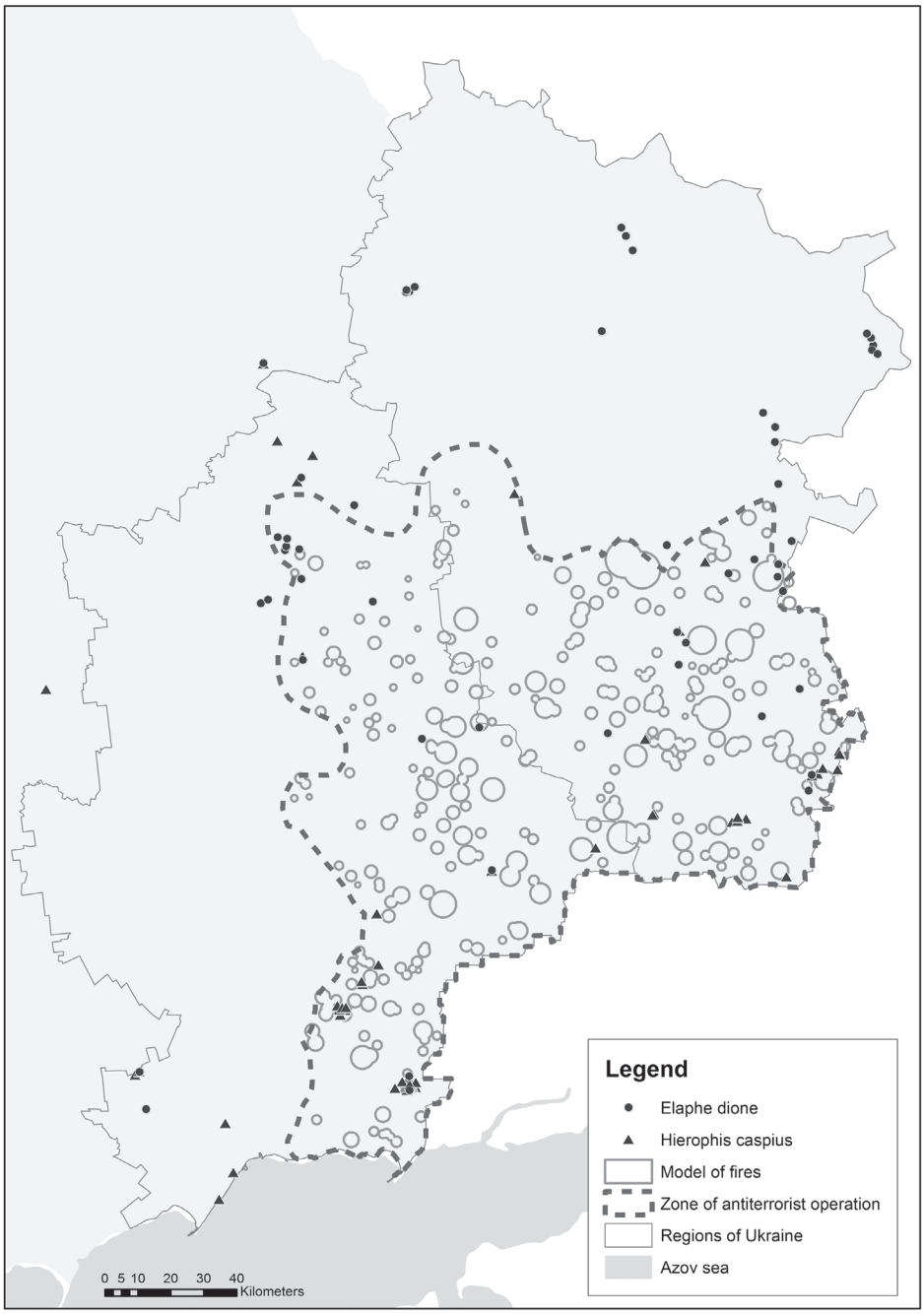

Fig. 5. Distribution of two snake species, *H. caspius* and *E. dione,* in Ukrainian East (ATO zone is indicated by dotted line, burnt area marked inside zone).

Рис. 5. Распределение двух видов змей, *H. caspius* and *E. dione,* на востоке Украины (зона АТО обозначена пунктирной линией, отдельно выделена территория пожаров внутри зоны).

3. Agricultural landscapes or arable lands. Approximately 14 % of them were damaged by fire, snake finds were sporadic in ecotone biotopes.

It should be noted that Eastern Ukraine experienced significant anthropogenic changes, which is why steppe and forest areas are fragmented and diffusely located, most of them delimited by agricultural landscapes. Most of local reptilians inhabit ecotone biotopes.

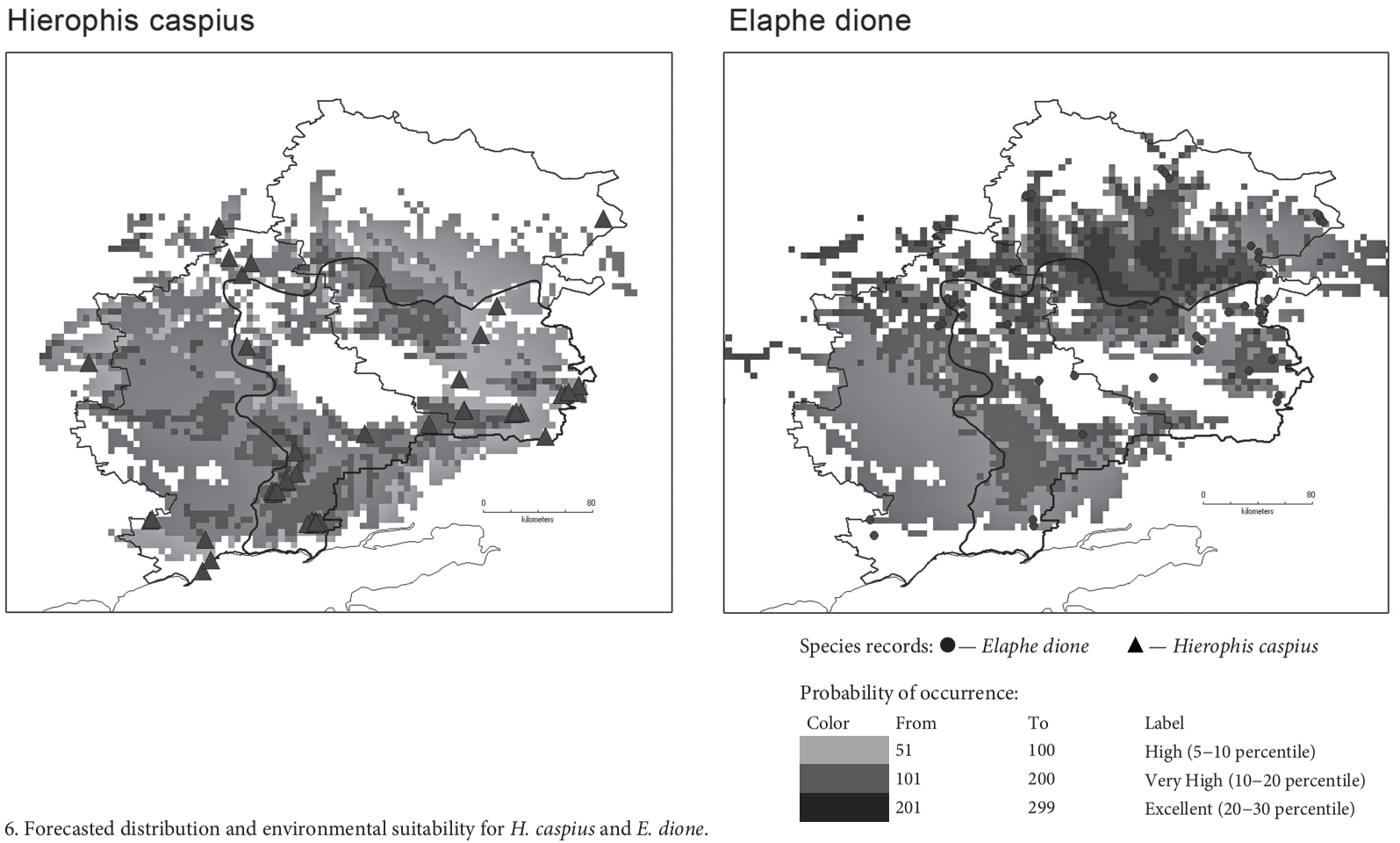

Fig. 6. Forecasted distribution and environmental suitability for *H. caspius* and *E. dione*.

Рис. 6. Прогнозируемое распространение и пригодность условий окружающей среды для змей: *H. caspius* и *E. dione*.

Dione ratsnake (conservation status: in danger of extinction; appendix III of Bern convention; needs protection) can be found not only in trees and shrubberies (tree belts, gardens etc.) but also in open biotopes (on rocky slopes, floodplains, steppe areas, denes, hills, ravines etc.; Kotenko, Kurjachii, 2008). It also gravitates to rural settlements and is therefore considered most ecologically plastic. Modeling shows that most suitable, "Excellent" habitats for this snake would be floodplains of Siversky Donets River (ATO northern border) where hostilities occur now (fig. 5). Other such areas would be plots on northwest of ATO zone ("Very High" and "High" suitability). Dione ratsnake's average numbers in 2008 in RLP "Kramatorsky" and nearby amounted to 0,67 specimen per km (Red Data book of Ukraine, 2009). According to GIS modeling Dione ratsnake could be found at more than 50 % of ATO area. In total nearly 65% of our finds occurred on this territory and near its limits (n = 52 finds in Ukrainian East; fig. 6).

At open steppe plots and arenas, Caspian whipsnake is more frequent (conservation status: vulnerable; appendix II of Bern convention; needs special protection). According to number of registrations (56 finds in Ukrainian East), Caspian whipsnake is quite typical a snake at south of Donetsk and Luhansk Regions. It also can be found in ravines, denes and anthropogenic ecosystems. It's common near Luhansk city, villages Stanichno-Luhansky and Granitne, etc. It is most easily found at rocky outcrops of denes and sloped riverbanks. It is partial to pastures, avoids thick high grass and is therefore rare on preserved steppe areas but may achieve high density on rocky steppe pastures, e. g. near settlements and farms (Kotenko, Kurjachii, 2008; Zagorodniuk, Zayika, 2009). According to GIS-modeling, most promising "Excellent" biotopes for Caspian whipsnake distribution would be northern and western parts of ATO area. In total, almost 82 % of finds are concentrated on ATO territory (56 finds on East; fig. 6), most of which was disturbed. Thus, almost 50% of biotopes, most promising for both Colubridae snakes, were ruined.

Conclusions

Hostilities in eastern Ukraine are now causing a lot of different ecological problems — from damaged natural territories to interrupted complex technological processes of regional industry. The effects are negative but the consequences of events of 2014 for local biodiversity are still an open question.

Most of such measurable threats for biodiversity are related either to mechanical damage to natural landscapes or to loss of state control over violations and technological processes on hostilities area. But indirect effects may cause just as significant biodiversity losses. Actual aftereffects of these processes are hard to evaluate now because in the near future there won't be any possibility of direct studies in ATO zone. Nevertheless, it is important now to outline directions of such research and forthcoming work on eliminating negative consequences and renewal. It is important to note that hostilities are located in a region with specific population structure: industrial agglomerations are set near massive under populated areas of Donets Ridge, with small settlements and single mines right next to natural territories. Thus, a lot of damage to territories outside of settlements is to the natural habitat.

Research of localization and spatial configuration of 2901 ignition cases during 1.06–30.09.2014 in ATO zone reveals significant damage to local natural landscapes: 18 % of forested areas and 23 % of steppe area. At the same time, areas of damaged natural and semi-natural (agricultural) territories are commensurate. Considering conservation of steppe biotopes (most characteristic natural complexes of the region), our results allow to draw conclusions about significant damage to regional rocky steppes that in Ukraine are endemic biotopes.

Particularly noteworthy is the extent of damage to forests, which are mostly artificially planted and cause a lot of local economic losses. At the same time, destruction of intrazonal forests is an essential factor influencing regional biodiversity because sylvan species inhabit rather small areas of Ukrainian east.

Analysis of results and world-wide experience of other experts allows us to presume that snakes are among animals most vulnerable to fire damage to the biotopes. Now 65–82 % of our finds (localities) of two Colubridae species in eastern Ukraine are located in ATO zone. Fires occurred during snakes' activity periods (summer-autumn, fig. 2), amplifying the negative effects. It can be assumed that more than 50 % populations of these Colubridae at eastern Ukraine likely will suffer to the point of local extinction, and their biotopes will for a long time become unsuitable.

Further processes on natural territories of ATO zone depend on the development of hostilities. Though for now the direct studies are impossible due to continuation of military conflict and lack of access to most of the area, the analyzed data on hostilities' effects on biodiversity and landscapes can be used for structuring future research.

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References

Beaupre, S. J. , Douglas, L. E. Responses of timber rattlesnakes to fire: lessons from two prescribed burns // Proceedings of the 4th Fire in Eastern Oak Forests Conference. — 2012. — P. 192–204.

Donbas Nature Reserve Areas. Scientific Information Reference Atlas / Eds S. S. Kurulenko, S. V. Tretyakov. — Donetsk, 2008. — 168 p. — Ukrainian : Донбас заповідний. Науково-інформаційний довідник-атлас.

Dotsenko, I. B. Catalogue of collections of the Zoological Museum of the NSNHM, NAS of Ukraine. The Snakes. — Kiev : NSNHM, 2003. — 86 p. — Russian : *Доценко И. Б.* Каталог коллекций Зоологического музея ННПМ НАН Украины. Змеи.

Dubovik, O. M. Materials of floral zoning of Donetsk forest-steppes // UBJ. — 1970. — **26** (3). — P. 279–283. — Ukrainian : *Дубовик О. М.* Матеріали до флористичного районування Донецького лісостепу.

Kolomytsev, G., Shyriaieva, D., Vasyliuk, O. The impact of fires in the zone of antiterrorist operation in Ukraine: assessment using RS and GIS data // Materiały konferencyjne GIS DZIŚ (Kraków, 17–18 listopada 2014). — Krakow, 2014. — P. 42–43.

Kotenko, T. I., Kondratenko, A. V. On the distribution on Elaphe dione (Reptilia, Colubridae) in Ukrainian // Vestnik zoologii. — 2005. — **39**, N 2. — P. 46. — Russian : *Котенко Т. И., Кондратенко А. В.* О распространении узорчатого полоза, Elaphe dione (Reptilia, Colubridae), в Украине.

Kotenko, T. I., Kurjachii, K. V. Finds of reptilian species that are proposed for inclusion in III edition of Red Data Book of Ukraine, in Donetsk oblast // Findings of animals of the Red Data Book of Ukraine / Ed. V. A. Kostiushin. — Kiev, 2008. — P. 152–170. — Ukrainian : *Котенко Т. І., Курячий К. В.* Знахідки у Донецькій області видів плазунів, запропонованих до включення у третє видання Червоної книги України.

Kurjachii, K. V., Tupikov, A. I. New information on Dione ratsnake (Elaphe dione Pallas, 1773) in Donetsk oblast // Ecological and nature conservation problems of industrial region: interag. coll. of scientific works / Ed. S. V. Bespalova. — Donetsk : DonNu, 2008. — 8. — P. C. 104–109. — Ukrainian: *Курячий К. В., Тупиков А. И.* Новые данные об узорчатом полозе (Elaphe dione Pallas, 1773) в Донецкой области.

Kurjachii, K. V., Tupikov, A. I. Essay of herpetofauna of RLP "Kramatorsky" // Ecological and nature conservation problems of industrial region. — Donetsk : DonNu, 2009. — N 1 (9). — P. 102–108. — Russian : *Курячий К. В., Тупіков А. І.* Нарис герпетофауни РЛП «Краматорський».

Lyet, A., Cheylan, M., Prodon, R., Besnard, A. Prescribed fire and conservation of a threatened mountain grassland specialist: a capture–recapture study on the Orsini's viper in the French alps // Animal Conservation. — 2009. —**12**(3). — P. 238–248.

McDonald, P. J., Luck, G. W., Pavey, C. R., Wassens, S. Importance of fire in influencing the occurrence of snakes in an upland region of arid Australia // Austral Ecology. — 2012. — **37** (7). — P. 855–864.

Nature conservation fund of Luhansk oblast. Handbook. Third ed. / Ed. O. A. Arapov. — Luhansk : Virtual'na real'nist Ltd., 2013. — 224 p. — Ukrainian: Природно-заповідний фонд Луганської області. Довідник.

Red Data book of Ukraine. Animals. — Kyiv, 2009. — 600 p. — Ukrainian : Червона книга України.

Vasyliuk, A. V., Kolomytsev, G. O., Balashov, I. A. The steppes in the structure of the Lugansk region forest estate: significance for the protection of biodiversity, threats and perspectives for the preservation // Problems of Ecology and Nature Protection of Technogenic Region. — 2012. — **12**, N 1. — P. 57–65. — Ukrainian : *Василюк О. В., Коломицев Г. О., Балашов І. О.* Степи у складі лісового фонду Луганської області: значення для охорони біорізноманіття, загрози та перспективи збереження.

Vasyliuk, A. V., Shyriaieva, D. V. War at eastern Ukraine threatens the biodiversity // Astrakhan. Vestn. Ekol. Obraz. — 2014 a. — **4**, N 30. — P. 80–88. — Russian : *Василюк О. В., Ширяева Д. В.* Война на востоке Украины угрожает биоразнообразию.

Vasyliuk, A. V., Shyriaieva, D. V. Fires in the war conflict area of Ukraine as a factor of impact on biodiversity : Abstract book of the Conference of young zoologists. (Kiev, Institute of zoology, November 14, 2014). — Kiev, 2014 b. — 27 p. — (Zoological courier; N 8). — http: // izan. kiev. ua/rmd/KMDZ14-abstr. pdf. — Ukrainian : *Василюк О. В., Ширяєва Д. В.* Пожежі в зоні АТО як фактор впливу на біорізноманіття.

Vedmederja, V. I., Zinenko, O. I., Goncharenko, L. A. Catalogue of collections of the Museum of Nature at V. N. Karazin's Kharkiv National University: Snakes (Reptilia: Serpentes). — Kharkiv, Ukraine, 2007. — 82 p. — Russian : *Ведмедеря В. И., Зиненко А. И., Гончаренко Л. А.* Каталог коллекций Музея природы Харьковского национального университета имени В. Н. Каразина: Змеи (Reptilia: Serpentes).

Zagorodniuk, I., Zayika, S. New records of rare species of snakes (Reptilia, Serpentes) in the Luhansk Region (Eastern Ukraine) // Vestnik zoologii. — 2009. — **43**, N 3. — P. 266. — Ukrainian : *Загороднюк І. В., Заїка С.* Нові знахідки рідкісних видів змій (Reptilia, Serpentes) на Луганщині (Східна Україна).

Zayika, S. Ecology and problems of conservation of Dione ratsnake in Luhansk oblast. — Ukrainian : *Заїка С.* Екологія і проблеми збереження полоза візерунчатого на Луганщини // Theses of the I International scientific conference of students, PhD students and young scientists "Fundamental and applied biological studies" (Donetsk, 23–26 February, 2009). — Donetsk : Veber, 2009. — P. 179–180.

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