

# The attempt to assess the fire risk of non-forest terrestrial ecosystems of Biebrza National Park – A case study

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## ABSTRACT

On 19th April, the largest wildfire of the entire history of Biebrza National Park broke out and consumed 5526 ha, mostly overdried grassland with sedges and reeds of Biebrza marshes. The very rapid spread of the fire in the open space, with the blowing wind changing directions and the inaccessibility of the area for fire-fighting vehicles were the main reasons of this third largest wildfire in Poland, after the tragic forest fires in Kuźnia Raciborska (9060 ha burnt) and Potrzebowice (5600 ha burnt) in the memorable year of 1992. After this event, activities were undertaken to develop a fire protection plan for the Biebrza National Park.

It took into account an innovative approach during the analysis of the existing fire risk, primarily regarding the non-forest terrestrial ecosystems composed of herbaceous vegetation, which constitutes as much as 61.2% of the park's area, and to propose protection methods adequate to the threat. The work was completed in the framework of the project entitled 'Development of the method for assessing the fire risk of non-forest ecosystems and the principles of fire protection for the Biebrza National Park – stage I,' commissioned for the Forest Research Institute by the Biebrza National Park, financed by the State Forests from the forest fund, in accordance with the contract EZ.0290.1.24.2020. The article presents a preliminary method of classifying the fire risk of non-forest ecosystems, considering the occurrence of the fires in the Biebrza National Park in the years 2007–2020 and the type of vegetation burnt.

This method, after supplementary field tests planned in 2021, will enable evaluation of the fire risk, which shall be a premise for the development of a fire protection plan.

## KEY WORDS

fire risk, non-forest ecosystems, classification method

## INTRODUCTION

The assessment of forest susceptibility to fire is made by determining the potential fire risk at the following levels: national – classification of the regional directorates of State Forests, regions (NUTS 2) and sub-regions (NUTS 3), regional – classification of the

forest districts (Fig. 1), national parks and poviats (districts) and local – classification of the stands. The method for classifying forest areas into the forest fire risk category and the method of the stand flammability classes, developed by the Forest Research Institute, are used to evaluate the fire risk (Ubysz et al. 2009; Szczygieł et al. 2017). The classification of the forest

district or national park areas in terms of fire risk is done in accordance with the regulation of the Minister of the Environment of 23rd March 2006 regarding the detailed rules for forest fire protection (Journal of Laws No. 137, item 923). The forest fire risk category (FFRC) comprehensively defines the potential susceptibility of the classified area to fire, taking into account the type of combustible material (percentage share of the most susceptible forest habitat types to fire), weather conditions and their impact on the moisture content of *Pinus sylvestris* L. the litter (indicator for the forests of Poland, determining the possibility of combustion initiation), anthropogenic pressure on the forest (average number of inhabitants per hectare of forest area) and the resultant above-mentioned factors affecting the actual risk, expressed in the density of the number of fires of the last ten years per thousand ha of forest area. The forest fire risk category (expressed in a three-level scale) determines the technical fire infra-

structure (forest surveillance, fire access roads, water supply points, firefighting equipment) and the organisation of fire protection in the classified area, and, consequently, the amount of financial outlays allocated for its maintenance.

The described method is a comprehensive, macroscopic fire risk analysis performed once per ten years. On the other hand, the method of the stand flammability classification enables one to determine the risk and map it at the local level, which also enables more effective management of the fire protection system. The forest habitat type, which is the basic taxonomic unit, was adopted as the basis for the forest flammability classification. It reflects, in conjunction with the type of soil cover, in a general sense, the fire behaviour of the combustible material, which is a fundamental feature of the fire risk assessment.

The method enables to classify stands into one of the three flammability classes: A – high flammabil-



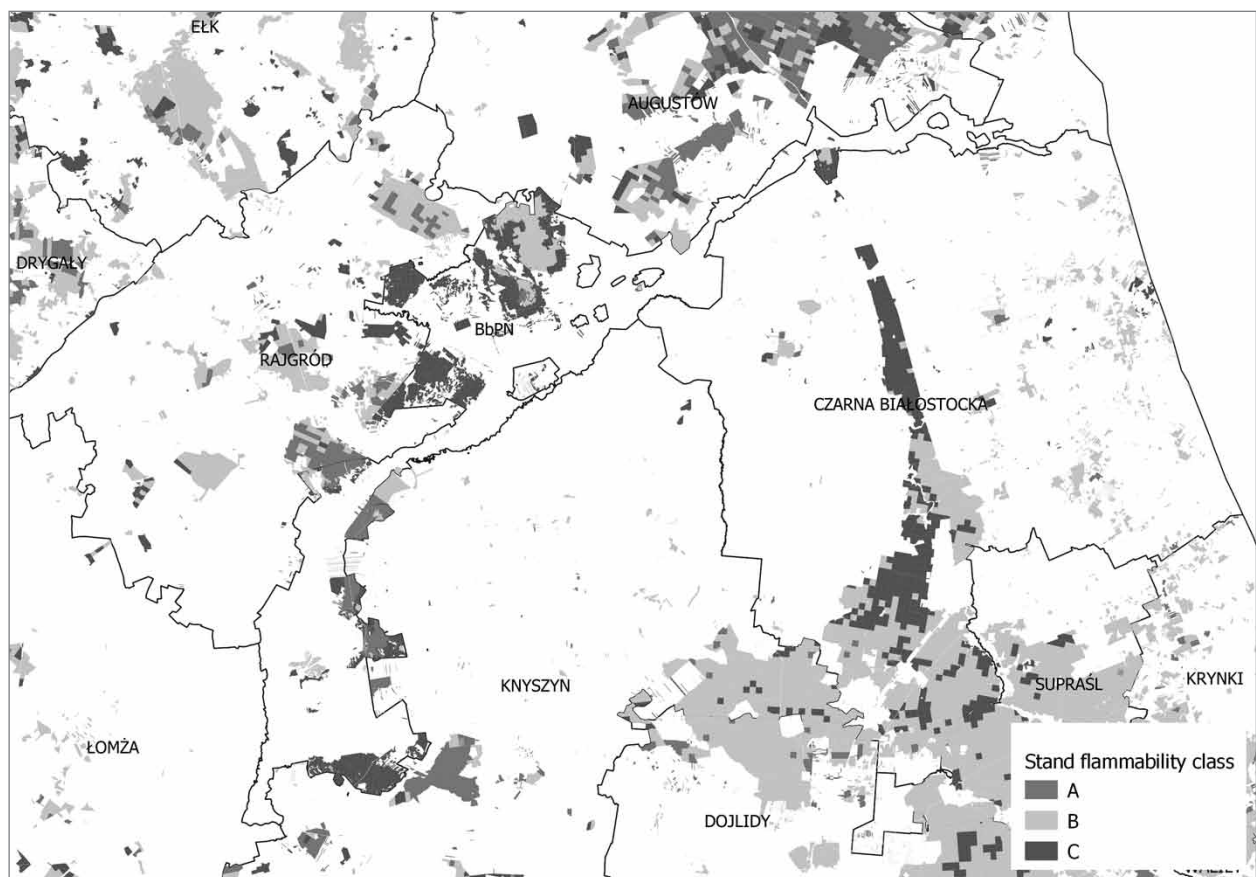
**Figure 1.** Forest fire risk category of Biebrza National Park and surrounding forest districts

ity class, B – medium flammability class and C – low flammability class. Flammability classes are usually for sub compartments and can be generalised up to the compartment level (Fig. 2) or forestry range. The presented methods for fire risk assessment apply only to forest ecosystems. In a situation when the classified area is not a forest, there is no appropriate and authorised method for fire risk evaluation. This applies in particular to such areas as the Biebrza National Park and other national parks, for example, the Narew, the Warta Mouth, or the mountain pastures of the Bieszczady National Park.

## MATERIAL AND METHODS

The purpose of the study was to develop a method for assessing and mapping the fire risk of non-forest terrestrial ecosystems located in the Biebrza National

al Park, which will be the basis for the organisation of the fire protection system. Due to the short duration of the first stage of the project (less than two months), it was assumed that the preliminary fire risk assessment of the non-forest terrestrial ecosystems of the Biebrza National Park shall be carried out on the basis of the actual occurrence of fires in the park in years 2007–2020, considering the types of vegetation burnt. In the classification of their susceptibility to fire, the flammability index was used (similarly to the method of stand flammability classification), which is the quotient of the percentage of the number of fires that occurred in a given type of vegetation to the percentage of the area covered with this type of vegetation. Data for analyses were obtained from the National Forest Fire Information System and numerical maps of plant communities of the Biebrza National Park.



**Figure 2.** Stand flammability classification of Biebrza National Park and surrounding forest districts

## RESULTS

### The occurrence of fires of non-forest ecosystems

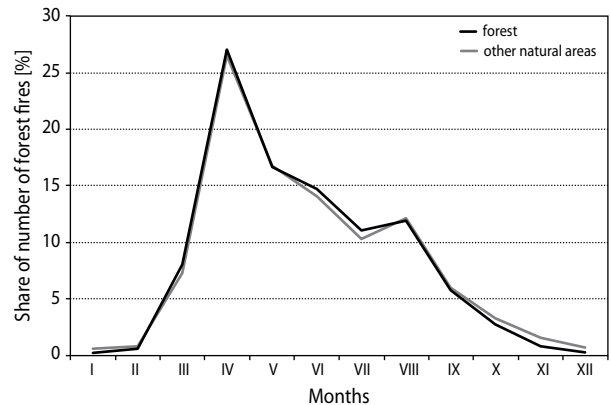
According to the data of the General Headquarters of the State Fire Service and the National Forest Fire Information System, six hundred and fifty thousand and fifty two fires of plant communities were recorded in Poland in years 2010–2020. Fires of non-forest ecosystems (which according to the General Headquarters of the State Fire Service include: unused agricultural areas, agricultural crops, meadows, stubble and fires arising during the harvesting of these crops and grass, lawns in non-agricultural areas, roadsides, trails and streets) were the most frequent among other types of fires and accounted for about 92% of the total number of events. Table 1 presents the number of fires of forests and non-forest ecosystems in particular years.

**Table 1.** Fires of forests and non-forest ecosystems and in years 2010–2020

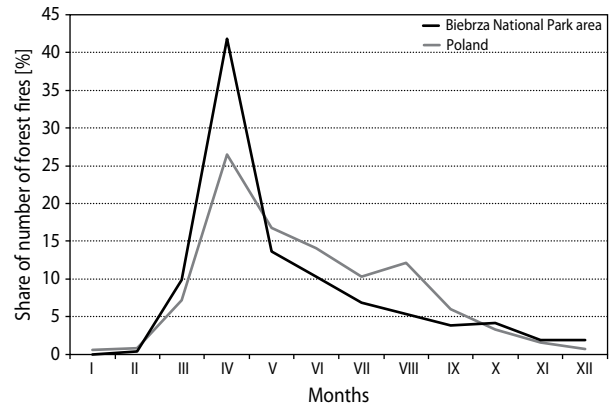
Year	Number of fires – non-forest ecosystem	Number of fires – forest ecosystem	Share of forest fires in the total number of events [%]
2010	43,542	2,975	6.40
2011	68,015	5,126	7.01
2012	84,952	5,752	6.34
2013	39,734	3,168	7.38
2014	57,501	3,603	5.90
2015	82,899	8,292	9.09
2016	36,407	3,545	8.87
2017	38,586	2,334	5.70
2018	48,765	5,947	10.87
2019	55,055	6,532	10.61
2020	47,922	6,250	11.43
Total	597,128	53,524	8.23

Due to the high variability of fire risk (especially in non-forest ecosystems), an analysis of the occurrence of fires in non-forest ecosystems and forests depending on the seasons was made on the basis of data from the years 2007–2020 collected in the National Forest Fire Information System. This system has been collecting data on forest fires and other natural areas (wildfires) since 2007, which results from the adopted EU division of plant community fires. A temporal

analysis of the occurrence of fires in these two groups of vegetation in the country is presented in Figure 3. Figure 4 shows a comparison of the occurrence of wildfires throughout the country and in the area of the Biebrza National Park (park area and the area up to 25 km from the park).



**Figure 3.** Temporal occurrence of forest and other natural surface fires in years 2007–2020 in Poland



**Figure 4.** Temporal occurrence of wildfires in Poland and in the Biebrza National Park in years 2007–2020

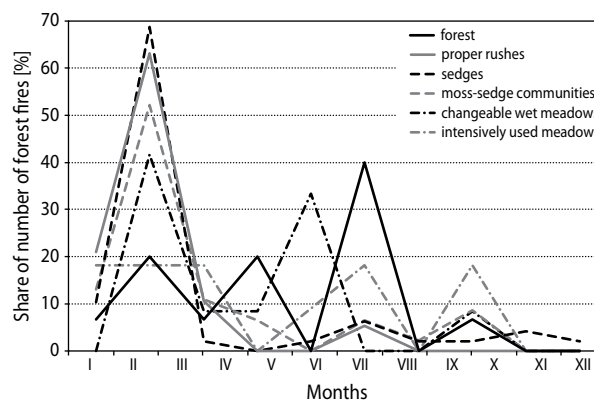
The distribution of fires throughout Poland is even for both groups of fires. There is a clear peak in the number of fires in the spring months, mainly April, and to a lesser extent May and June. Comparing the occurrence of wildfires throughout Poland and in the Biebrza National Park, a much greater dominance of spring fires in the park area is visible. More than 40% of all the fires occurred in April, and in the period from

March to June, in total, more than 75%. In the months of July to September, there were just over 15% of fires. In the case of fires in the Biebrza National Park, an analysis was also made regarding the occurrence of fires depending on the type of vegetation at the site of the fire. For this purpose, each of the fires was assigned a type of vegetation on the basis of data obtained from numerical maps provided by the Biebrza National Park. It was limited only to the basic type of vegetation, aggregating its types and subtypes. In addition, ruderal and trodden vegetation (*Artemisietea*, *Plantagin*) was aggregated with synanthropic vegetation near buildings, as communities under strong human pressure, as well as post-clearing communities, pre-overgrown post-fire areas (mainly perennials) and post-fire areas overgrown with shrubs (mainly willow, birch) as transitional communities. In total, one hundred and ninety fires occurred in the park in the analysed period; for one of them, it was impossible to determine the type of vegetation, because it occurred in a place where this type was not specified. The number of fires by aggregated types of vegetation is presented in Table 2.

**Table 2.** Numbers of fires by types of vegetation

Aggregated type of vegetation	Number of fires
Aquatic vegetation	2
Forest	15
Dense bushes	7
Proper rushes	19
Grass and herbal rushes	1
Mosaic of rushes and sedges	8
Sedges	48
Moss-sedge communities	46
Moss-marshes	3
Changeable wet meadows	12
Herbs	6
Fertile moist meadows	4
Fresh meadows	2
Pastures	3
Dry grasslands	1
Synanthropic vegetation near buildings, ruderal and trodden	1
Intensively used meadows	11

For types with at least ten fires, the analysis of their occurrence by month was performed (Fig. 5). It shows that in the case of rushes, sedges and moss-sedge communities there is a clear peak in the occurrence of fires in April. They occur almost only from March to May. For the remaining types of vegetation, the distribution of the number of fires is more even throughout the year. Forest fires in the Biebrza National Park constituted only about 8% of the total number of events.



**Figure 5.** Temporal distribution of fires by types of vegetation in the Biebrza National Park in years 2007–2020

### Initial method of fire risk assessment of non-forest ecosystems

In order to perform an initial classification of non-forest ecosystems, the share of the area occupied by individual aggregated types of vegetation and the share of the number of fires that occurred in these types of vegetation were determined. These values are shown in Table 3, which also includes the flammability index and an initial flammability class. It was established considering the values of the flammability index for the forest ecosystems of the Biebrza National Park, which in the majority (66.3%) were classified as low risk in terms of fire (class C). It was assumed that in the preliminary method of classification of non-forest ecosystems, areas occupied by vegetation types with a flammability index lower than 0.5 shall be classified as class c (low flammability). Those with a flammability index ranging from 0.5 to 1.5 were classified as class b (medium flammability). Class a (high flammability) includes areas with vegetation type with a flammability index greater than 1.5.

**Table 3.** Share of the area of aggregated types of vegetation, fire occurrence and flammability indexes and classes

Aggregated types of vegetation		Area [ha]	Area share [%]	Number of fires	Share of the number of fires [%]	Flammability indexes	Flammability class
no	name						
1	Aquatic vegetation	660.59	1.11	2	1.06	0.96	b
2	Forest	18,150.28	30.39	15	7.94	0.26	-
3	Dense bushes	1,836.83	3.08	7	3.70	1.20	b
4	Thickets of low birch	118.38	0.20		0.00	0.00	c
5	Proper rushes	3,517.59	5.89	19	10.05	1.71	a
6	Grass and herbal rushes	91.59	0.15	1	0.53	3.45	a
7	Mosaic of rushes and sedges	1,126.93	1.89	8	4.23	2.24	a
8	Sedges	9,954.75	16.67	48	25.40	1.52	a
9	Moss-sedge communities	9,326.90	15.62	46	24.34	1.56	a
11	Moss-marshes	3,267.51	5.47	3	1.59	0.29	c
15	Changeable wet meadows	5,433.22	9.10	12	6.35	0.70	b
16	Herbs	991.59	1.66	6	3.17	1.91	a
17	Fertile moist meadows	530.83	0.89	4	2.12	2.38	a
18	Fresh meadows	219.52	0.37	2	1.06	2.88	a
19	Pastures	291.45	0.49	3	1.59	3.25	a
20	Dry grasslands	370.01	0.62	1	0.53	0.85	b
21	Synanthropic vegetation near buildings, ruderal and trodden	88.21	0.15	1	0.53	3.58	a
22	Intensively used meadows	1,896.66	3.18	11	5.82	1.83	a
23	Communities of arable fields	222.39	0.37		0.00	0.00	c
24	Post fire and post clear-cut communities	1,346.82	2.26		0.00	0.00	c
28	Flooded grasslands	136.79	0.23		0.00	0.00	c
29	Communities of <i>Calamagrostis canescens</i>	143.71	0.24		0.00	0.00	c

According to the preliminary classification, among the non-forest ecosystems of the Biebrza National Park, the largest area (68.28%) is classified as class a (high flammability). Plant communities of medium flammability (class b) occur on 19.36% of the park area and 12.36% are ecosystems with low flammability (class c).

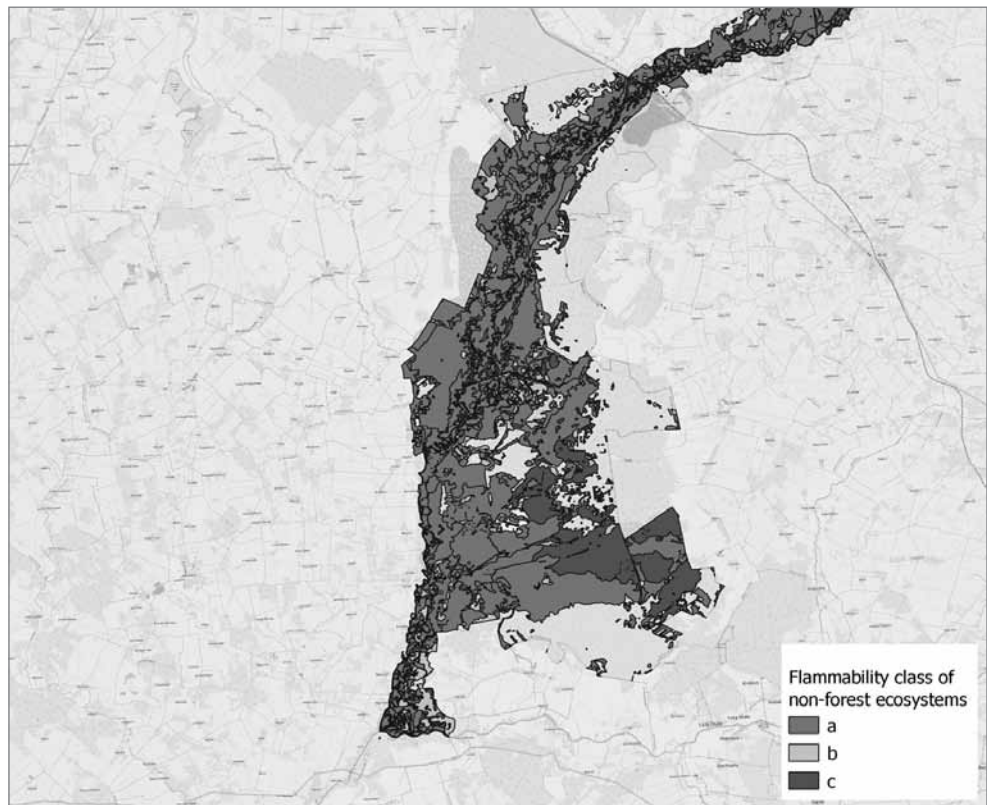
Table 4 shows the percentage of flammability classes of non-forest ecosystems in the lower, middle and upper basins of Biebrza National Park.

Figures 6, 7 and 8 present the classification of non-forest terrestrial ecosystems of the Biebrza National Park in individual basins.

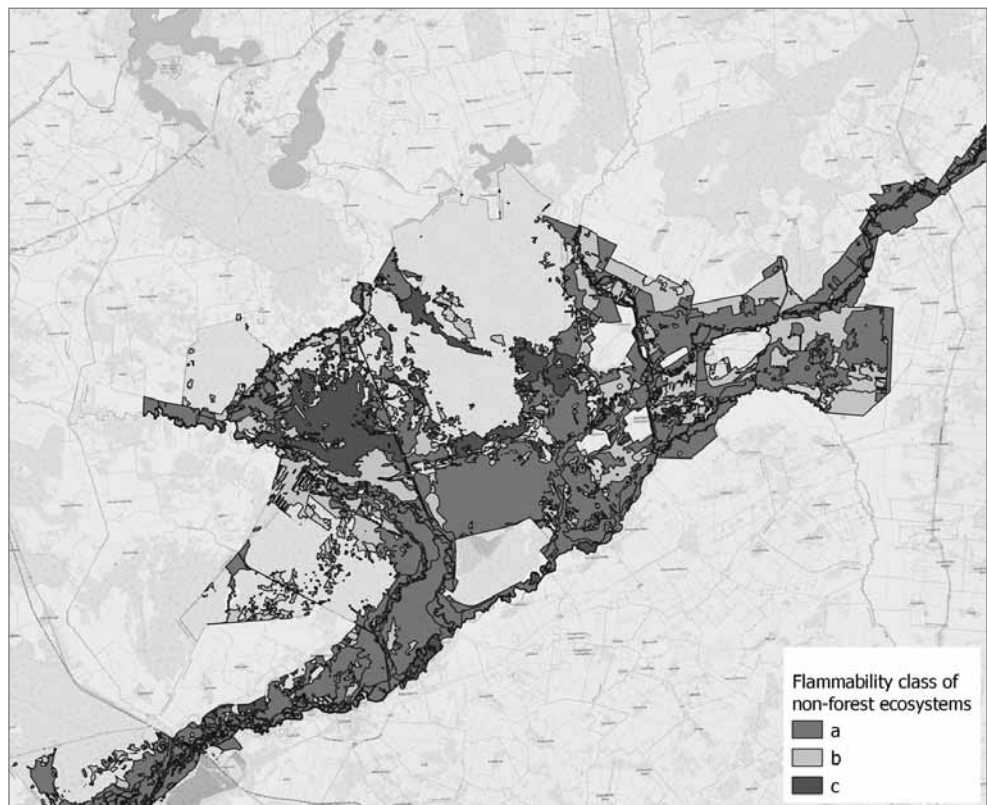
**Table 4.** Share of the area by the flammability classes of non-forest ecosystems in individual basins

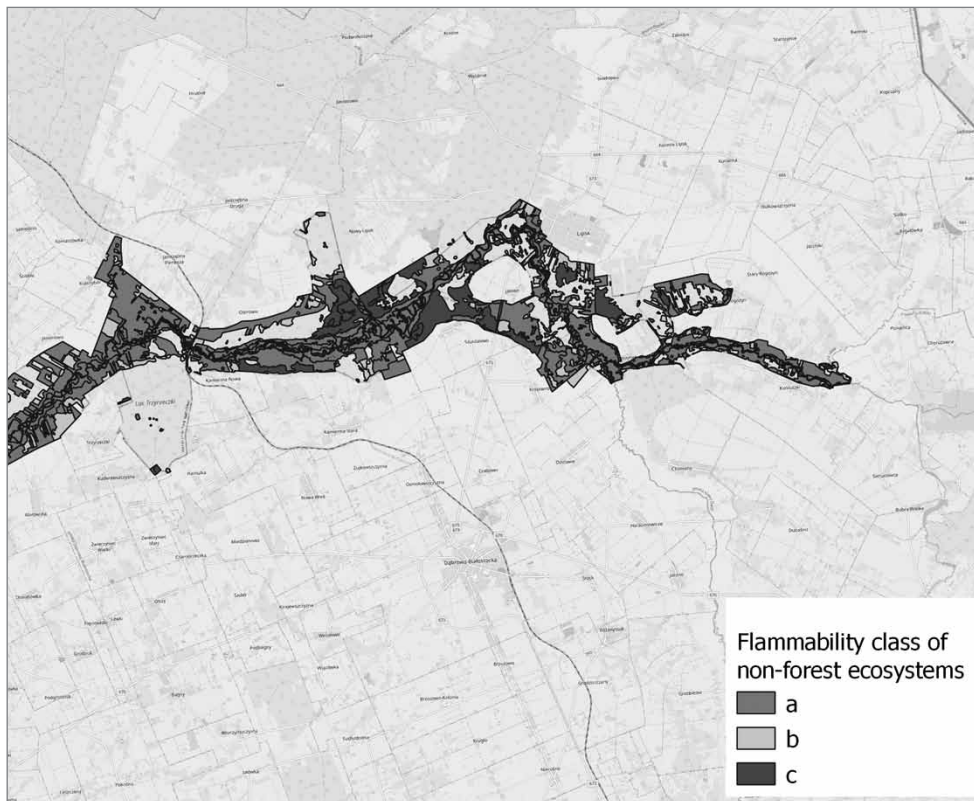
Flammability classes of non-forest ecosystems	Area share [%]		
	lower basin	middle basin	upper basin
a	75.78	60.31	73.80
b	10.62	28.54	13.41
c	13.60	11.15	12.79

**Figure 6.** Flammability classification of non-forest ecosystems – lower basin



**Figure 7.** Flammability classification of non-forest ecosystems – middle basin





**Figure 8.** Flammability classification of non-forest ecosystems – upper basin

## CONCLUSIONS

The performed analytical work has shown that non-forest terrestrial ecosystems of the Biebrza National Park are characterised by a high potential fire risk, as over 68% of their area is classified as the highest flammability class. For comparison, the forest ecosystems of the Biebrza National Park with the same degree of risk constitute only 13.2% of the total forest area.

It is non-forest ecosystems that determine the fire hazard of Biebrza National Park and it is primarily for them that the fire protection system should be planned, and not, as it was so far, that the basis for the organisation of protection was the fire risk of forest ecosystems. The planned field work, the purpose of which shall be to characterise the amount of potential flammable biomass (fire load) and its fire properties (heat of combustion, calorific value, volumetric density) shall not only improve the proposed method of assessing the potential fire risk of non-forest ecosystems, but shall also be helpful in forecasting fire spreading, which is important from the point of view of the organisation of extin-

guishing activities. It should be noted that the fire risk of non-forest ecosystems is highly variable depending on the season. It is influenced by the predisposition of vegetation to initiate combustion and its development. This predisposition to ignite is determined by the moisture content of the combustible material, which depends on the prevailing meteorological conditions. The fire risk of non-forest ecosystems is greatest in the spring, before vegetation starts, and decreases to a minimum level when it is in full bloom, due to the water content of the vegetation. However, it may increase in the event of prolonged drought. The fire protection system must be designed for the most unfavourable conditions, but a different level of its readiness may be considered depending on the actual degree of fire risk. On the basis of the fire risk assessment, a fire protection system of the Biebrza National Park shall be planned, taking into account: fire risk forecasting, fire detection, alarm and communication system, firefighting equipment, fire commuting, water supply, fuel breaks, preventive measures and modelling the spread of fires. The implementation of the fire protection plan should contribute to



the improvement of the effectiveness of fire protection, such a valuable and at the same time dangerous natural object in terms of fire, which has been shown not only by the last large-scale fire, but also confirmed by large-scale fires that occurred in the past.

#### **ACKNOWLEDGEMENTS**

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